

UL 674

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Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations

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UL Standard for Safety for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations, UL 674

Fourth Edition, Dated December 11, 2003

Revisions: This Standard contains revisions through and including April 13, 2006.

Summary of Topics

These editorial revisions to ANSI/UL 674 replace all references to UL 1020, the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, with reference to UL 60691, the Standard for Thermal-Links – Requirements and Application Guide. UL 1020 was withdrawn and superseded by UL 60691.

The following table lists the future effective dates with the corresponding reference.

Future Effective Dates	References
December 11, 2006	Paragraph 18.2.2.6, Section 45, and Tables 18.4 and 18.5.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revisions dated April 13, 2006 include a reprinted title page (page1) for this Standard.

The revisions dated April 13, 2006 editorially replace all references to UL 1020 with the reference to UL 60691.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfo.net/ulforeword.html>

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

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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, 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:

Page	Date
1-3	April 13, 2006
4-5	December 11, 2003
6	April 13, 2006
7-51	December 11, 2003
52	April 13, 2006
53-88	December 11, 2003
SA1-SA10	December 11, 2003
SB1-SB4	December 11, 2003

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DECEMBER 11, 2003
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ANSI/UL 674-2003

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UL 674

Standard for Electric Motors and Generators for Use in Division 1

Hazardous (Classified) Locations

The First edition combined the Ninth Edition of the Standard for Electric Motors and Generators for Use in Hazardous Locations, Class II, Groups E, F, and G, UL 674(A), and the Twelfth Edition of the Standard for Electric Motors and Generators for Use in Hazardous Locations, Class I, Groups C and D, UL 674(B).

The first edition was titled Electric Motors and Generators for Use in Hazardous Locations, Class I, Groups C and D, Class II, Groups E, F, and G. The second edition was titled Electric Motors and Generators for Use in Hazardous (Classified) Locations.

First Edition – August, 1978
Second Edition – June, 1989
Third Edition – April, 1994

Fourth Edition

December 11, 2003

The most recent designation of ANSI/UL 674 as an American National Standard (ANSI) occurred on October 29, 2003.

This ANSI/UL Standard for Safety, which consists of the Fourth edition with revisions through April 13, 2006, is under continuous maintenance, whereby each revision is ANSI approved upon publication. 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 <http://csds.ul.com>.

The Department of Defense (DoD) has adopted UL 674 on September 5, 1989. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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 set of revised requirements.

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INTRODUCTION

1 Scope

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

- a) Electric motors and generators; and
- b) Submersible and nonsubmersible sewage pumps and systems.

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

1.3 These requirements cover both horizontal and vertical machines that have fractional and integral horsepower ratings and are for use on alternating current (ac) or direct current (dc).

1.4 These requirements cover electric motors and generators for use only under the following atmospheric conditions:

- a) A minimum ambient temperature of minus 70°C (minus 94°F);
- b) An oxygen concentration not greater than 21 percent by volume; and
- c) A nominal barometric pressure of one atmosphere.

1.5 These requirements do not cover intrinsically safe motors and generators.

2 Components

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

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

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

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

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

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3 Units of Measurement

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

4 Undated References

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

5 Terminology

5.1 If the term "motor" is employed in the following text, it is to be understood that the requirement also applies to a generator. If the term "sewage pump" is employed in the following text, it is to be understood that the requirement also applies to a sewage pump motor.

5.2 Paragraphs in this standard that apply to Class I, Class II, or Class I and II locations are so identified by the following designation appearing after the paragraph numbers: (I), (II), or (I, II).

6 Class I, Zone, and Group Equivalency

6.1 Class I, Zone 1, Group IIA

6.1.1 Explosion-proof electrical equipment intended to be marked in accordance with 51.2 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group D hazardous (classified) locations.

6.2 Class I, Zone 1, Group IIB

6.2.1 Explosion-proof electrical equipment intended to be marked in accordance with 51.3 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group C hazardous (classified) locations.

6.3 Class I, Zone 1, Group IIB plus Hydrogen

6.3.1 Explosion-proof electrical equipment intended to be marked in accordance with 51.5 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group B hazardous (classified) locations.

CONSTRUCTION

7 General

7.1 (I, II) – A motor shall be totally enclosed, and it may be fan cooled.

7.2 A sewage pump shall employ materials that are acceptable for the particular use.

7.3 In addition to the requirements of this standard, a sewage pump shall comply with the applicable requirements in the standards given in Tables 7.1 and 7.2.

Table 7.1
Reference standards

Type of equipment	Standard used ^a	
	Enclosure requirements	Electrical requirements
Controls:		
Explosion-proof	UL 1203	UL 508
Ordinary location ^b	UL 508	UL 508
Intrinsically safe apparatus	UL 508	UL 913
^a See Table 7.2 for complete title.		
^b Applies to controls that are located outside of the hazardous location in which the pump is located.		

Table 7.2
Titles of reference standards

Standard	Title
UL 508	Industrial Control Equipment
UL 1203	Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
UL 913	Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous (Classified) Locations

8 Enclosure

8.1 General

8.1.1 (I) – The internal explosion pressure in a motor for Class I locations is influenced by the size and shape of the enclosure, its free internal volume, internal fans, and by the nature and concentration of the gas- or vapor-air mixture. This is particularly true of larger size motors.

8.2 Material

8.2.1 (I, II) – A motor enclosure shall be made of iron, steel, copper, brass, bronze, or aluminum or its alloys containing not less than 80 percent aluminum. A metal such as zinc or magnesium, or their alloys, is not acceptable.

8.2.2 (I) – The enclosure of a motor for use in Class I locations shall withstand internal explosion pressures without bursting or loosening at the joints.

8.2.3 (I, II) – To reduce the risk of percussion sparks all exposed metal parts of a portable motor or a cord-connected submersible sewage pump that may be struck by or strike against a foreign object shall be made of:

- a) Brass, bronze, or aluminum for a portable motor; or
- b) Brass or bronze for a cord connected submersible sewage pump motor.

Exception No. 1: The shaft need not comply with this requirement.

Exception No. 2: For a cord-connected submersible sewage pump provided with a guide-rail system that prevents the pump from contacting other objects while being raised or lowered into the wet pit, only metal parts that may contact the guide rail system and plumbing are required to be made of brass or bronze.

8.3 Thickness

8.3.1 (I, II) – Except as noted in 8.3.4, the minimum thickness of the enclosure walls shall not be less than that specified in Table 8.1.

Table 8.1
Thickness of enclosure

Maximum enclosure dimensions		Minimum thickness, inch (mm)		
Internal length of joint ^a , inches (mm)	Area ^{b,c} , square inches (dm ²)	Cast brass, bronze, copper, or malleable iron	Cast iron or aluminum	Sheet steel
13 (330)	240 (15)	0.093 (2.36)	0.125 (3.18)	0.058 ^d (1.47)
22 (560)	480 (31)	0.093 (2.36)	0.125 (3.18)	0.058 (1.47)
30 (760)	620 (40)	0.093 (2.36)	0.125 (3.18)	0.093 (2.36)
60 (1525)	1500 (97)	0.125 (3.18)	0.187 (4.75)	0.125 (3.18)
Over 60 (over 1525)	Over 1500 (over 97)	0.187 (4.75)	0.250 (6.35)	0.187 (4.75)

^a Circumference of frame-to-end shield joint.

^b This area is not the total area, but the area of each enclosure part such as the end shield or the stator frame.

^c The area of an end shield is considered to be the area of a circle. The area of a stator frame is considered to be the area of a cylinder.

^d A motor intended for installation where not subjected to mechanical or physical damage, such as with or within a supplementary enclosure, may have a thickness of not less than 0.042 inch (1.07 mm).

8.3.2 (I, II) – A machined or a threaded joint in the walls of a cast-metal enclosure, such as at the end shield-stator frame joint, shall have at least the thickness specified in Table 8.1 through the overlap with neither section less than 1/16 inch (1.6 mm) thick.

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8.3.3 (I, II) – For an enclosure consisting of different materials such as a steel stator frame and cast-iron end shields, the total thickness through the overlap shall not be less than the minimum required for either of the metals. A section through the overlap shall have a thickness of not less than 3/64 inch (1.2 mm) for a sheet-steel section and not less than 1/16 inch (1.6 mm) for a cast-metal section.

8.3.4 (I, II) – For a tube-cooled (totally-enclosed air- to-air cooled) motor in which the cooling tubes form part of the explosion-proof or dusttight enclosure, the tubes may be copper, brass, aluminum, or steel having a wall thickness of not less than 0.030 inch (0.76 mm) if:

- a) The tubes are protected against external mechanical damage by an enclosure having a minimum thickness as specified in Table 8.1; and
- b) The tubes are protected against the risk of electrical burn through by:
 - 1) An insulating barrier at least 0.028 inch (0.70 mm) thick between the tubes and any electrical component that is subject to arcing;
 - 2) A grounded metal barrier that will prevent any arcs from electrical parts from reaching the tubes; or
 - 3) Location of components so that no electrical component, including internal wiring, can contact the tubes.

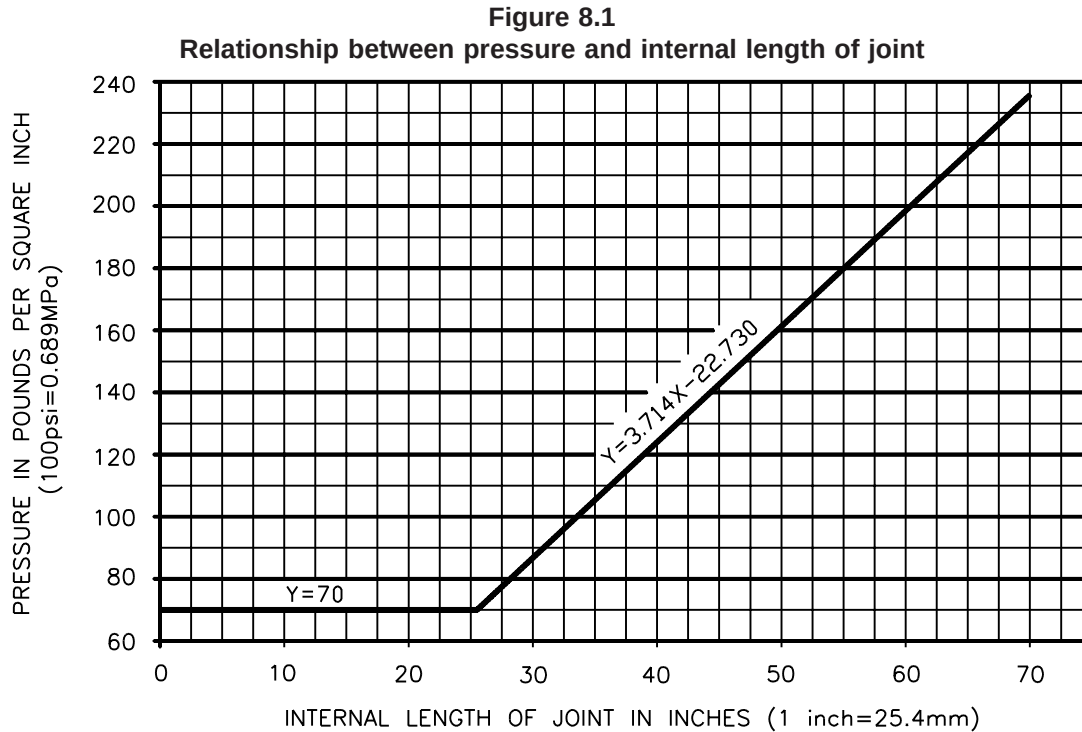
8.4 Strength, Class I locations

8.4.1 (I) – The ability of a motor enclosure to withstand internal explosion pressures shall be determined either by calculations or by the Hydrostatic Pressure Test on Enclosures, Section 33. The safety factor used for calculations shall be that specified in Table 8.2.

Table 8.2
Safety factors for calculations to determine strength of enclosure for Class I locations

Enclosure material of part	Safety factor for calculations
Cast metal	5
Fabricated steel	4
Bolt	3

8.4.2 (I) – For a line of motors being covered by tests on a representative motor or motors, the required strength shall be based on the maximum internal explosion pressure recorded during the tests or the pressure specified in Figure 8.1, whichever is higher. For a single motor (one frame size with one rating), the required strength shall be based on the maximum internal explosion pressure.



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8.4.3 (I) – The construction of a tube-cooled motor shall be such that the tubes cannot become dislodged from the main enclosure assembly. See Pull Test on Tubes, Section 44.

9 Joints in Enclosure

9.1 General

9.1.1 (I, II) – A joint in an enclosure shall be of the metal-to-metal type. A metal 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.

9.1.2 (I, II) – 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.

9.1.3 (I, II) – The width of a joint is to be measured with the mating parts in their most unfavorable position.

9.1.4 (I, II) – Except as noted in 9.2.3.1 – 9.2.3.3, 9.3.1 – 9.3.3, and 9.4.3.1 – 9.4.3.3, the width of a joint is to be measured from:

- a) The inside of the enclosure to the nearest edge of each bolt clearance hole and elsewhere if the bolt head is outside the enclosure; and
- b) The outside of the enclosure to the nearest edge of bolt clearance hole and elsewhere if the bolt head is inside the enclosure.

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9.1.5 (I, II) – For a rabbet joint a maximum chamfer of 3/32 inch (2.4 mm) may be provided at the corner to accept a 1/16 inch (1.6 mm) diameter "O" ring. The chamfer shall not reduce the minimum required metal-to-metal width of the joint.

9.1.6 (I, II) – Joints in a conduit box shall comply with the requirements in the Standard for Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations, UL 886.

Exception: (I) – 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.

9.1.7 (I, II) – Joints in a switch enclosure shall comply with the requirements in the Standard for Switches for Use in Hazardous (Classified) Locations, UL 894.

Exception: (I) – 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.

9.2 Class I, Group C or D locations

9.2.1 General

9.2.1.1 (I) – Except as noted in 31.8 and below, joints in a motor enclosure shall be as specified in Table 9.1.

Exception: (I) – 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.

9.2.1.2 (I) – The determination of free internal volume shall exclude any potting compounds.

9.2.2 Threaded joints

9.2.2.1 (I) – A threaded joint shall consist of the number of fully engaged threads specified in Table 9.2, but not less than five. Threads shall not be finer than specified in Table 9.2.

9.2.2.2 (I) – The engagement between a threaded shaft and a tapped hole in an enclosure is considered to be a threaded joint.

Table 9.1
Dimensions of joints in motor enclosures

Size of motor		Straight (flat or cylindrical) joint		Rabbet joint				
				Minimum total width of joint, inch	Minimum width of radial section, inch	Minimum width of axial section, inch	Maximum clearance at radial section, inch	Maximum diametrical clearance at axial section, inch
Free internal volume, inches ³	Internal length of joint ^a , inches	Minimum width, inch	Maximum clearance, inch					
65 or less	—	1/4	0.0015 ^b	1/8	3/64	3/64	0.0015	0.0015
300 or less	32 or less	3/8	0.0015	e	e	e	e	e
350 or less	32 or less	See Figure 9.1		3/8	3/64	—	0.0015	0.003
				1/2	3/64	—	0.002	0.003
				1/2	3/64	—	0.0015	0.004
				1/2	3/32	—	0.002	0.004
Over 350 ^c	Over 32 ^c	See Figure 9.1		3/4	1/16	1/16	See Figure 9.1 ^d	
				3/4	1/16	1/16	See Figure 9.1 ^d	

^a Circumference of frame-to-end shield point.

^b For a cylindrical joint, a diametrical clearance of 0.003 inch meets the requirement.

^c A motor enclosure having joints between the stator rings and a laminated-field-frame section fabricated under high pressure and held together by rivets, or channel-irons and welding, meets the requirement when it has a minimum joint width of 1/4 inch (6.4 mm) and a 0.0015 inch feeler gauge does not enter the joint width more than 1/8 inch at any point.

^d At the axial section, a diametrical clearance of twice the clearance specified in Figure 9.1 meets the requirement.

^e Requirements are identical to those of motor enclosures with free internal volumes of 350 inches³ or less.

For SI unit conversions: 1 inch = 25.4 mm, 1 inch³ = 0.0164 dm³

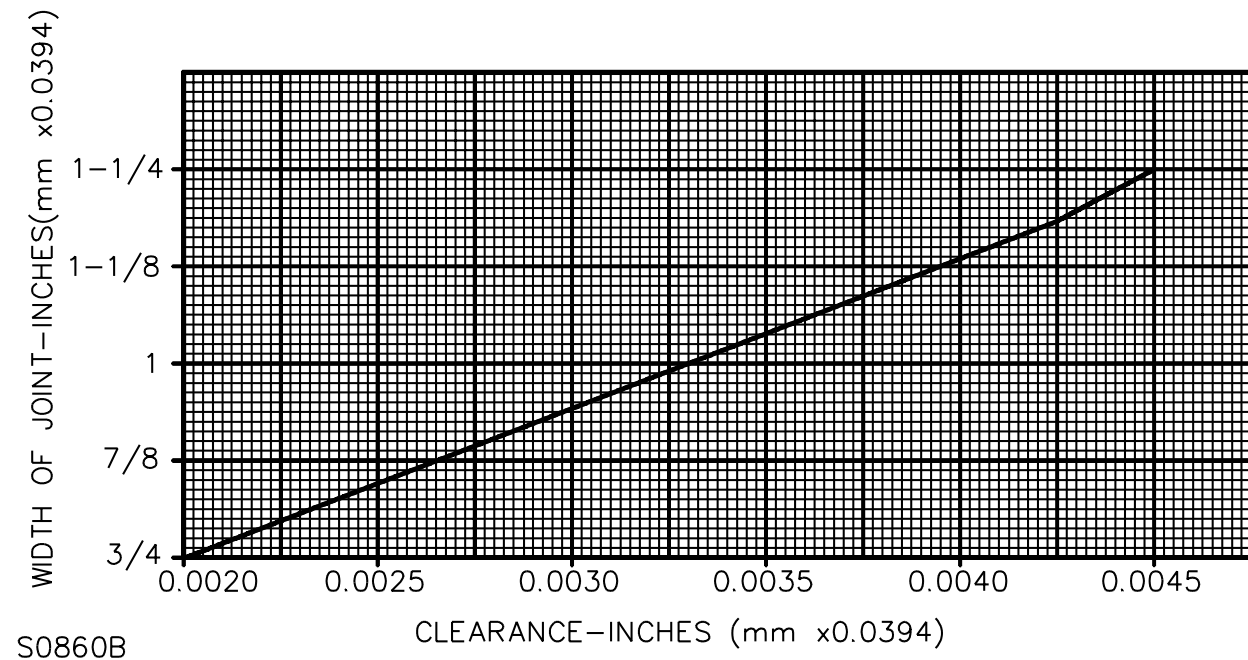
Table 9.2
Thread engagement

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

9.2.3 Bolts in joint width

9.2.3.1 (I) – A bolt may be located in a 3/4 inch (19.1 mm) or wider joint if the diametrical clearance between the bolt and its clearance hole is not more than 0.045 inch (1.14 mm), measured over the shank or major diameter of the threads, for a length of not less than one-half the required width of joint specified for the motor in Figure 9.1. In addition, the width of joint between the nearest edge of the clearance hole and the interior of the motor enclosure shall not be less than 1/2 inch (12.7 mm) if the bolt head is outside the enclosure, or the width of joint between the nearest edge of the clearance hole and the exterior of the enclosure shall not be less than 1/2 inch if the bolt-head is within the enclosure. See Figure 9.2.

Figure 9.1
Relationship between clearance and width of joint



S0860B

9.2.3.2 (I) – For a supplementary enclosure, such as a conduit box, device cover, and the like, or other part attached to the motor enclosure, a bolt may be located in a 3/4 inch (19.1 mm) or wider joint, if the construction complies with the requirements in 9.2.3.1. See Figure 9.2.

9.2.3.3 (I) – The bolt mentioned in 9.2.3.1 and 9.2.3.2 may be provided with a lock washer.

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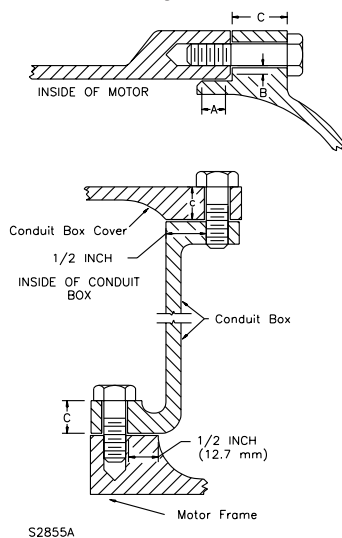
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9.2.4 Through-bolts

9.2.4.1 (I) – For a through-bolt that secures the end shields and passes through the enclosure, the length of path and the diametrical clearance between the unthreaded shank of the bolt and the clearance hole in the enclosure (or end shield) shall be as specified in Figure 9.1.

9.2.4.2 (I) – For a joint between a specially-machined nut and a machined surface on the end shield surrounding the bolt hole, the width of joint and the clearance shall be as specified in Figure 9.1. The width of joint is to be measured from the edge of the bolt clearance hole to the nearest outside edge of the nut. In addition, the nut shall fully engage not less than five threads of the through-bolt and a washer shall not be provided.

Figure 9.2
Bolts in joint width



$$A + B = 1/2 \text{ inch (12.7 mm)}$$

$$C = 1/2 \text{ of required width of joint (see Figure 9.1) with diametrical clearance not over 0.045 inch (1.14 mm)}$$

9.3 Class I, Group B locations

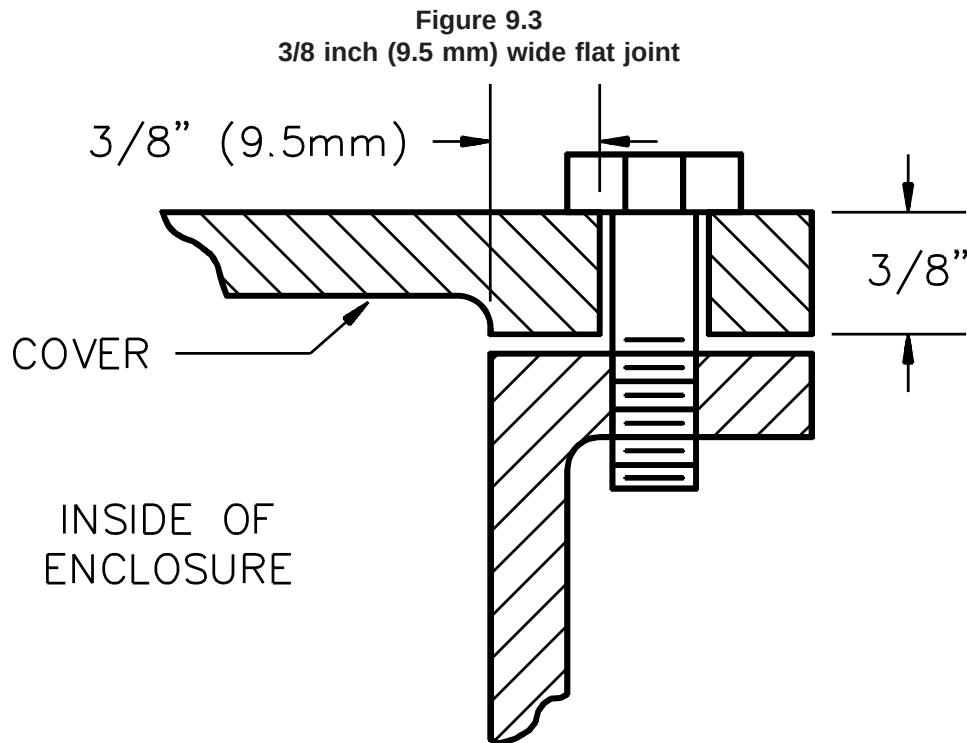
9.3.1 General

9.3.1.1 The width of a joint in an enclosure having a free internal volume of not more than 30 cubic inches (0.5 dm³) 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 9.3.

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Exception: For an enclosure having a free internal volume of not more than 6 cubic inches (0.1 dm³), 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 .



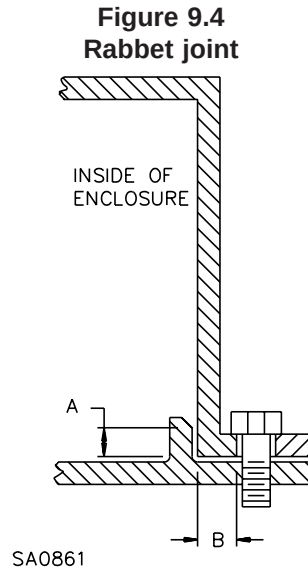
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9.3.1.2 The width of a joint in an enclosure having a free internal volume of more than 30 cubic inches (0.5 dm³) and not more than 100 cubic inches (1.6 dm³) shall not be less than 5/8 inch (15.9 mm). At a bolt hole, the width is to be measured from 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 9.4.

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$A + B = 1/2$ inch (12.7 mm) for Class I, Groups C and D enclosures having free internal volume not more than 300 cubic inches (4.92 dm³)

$A + B = 7/8$ inch (22.2 mm) for Class I, Group B enclosures having free internal volume not more than 100 cubic inches (1.64 dm³)

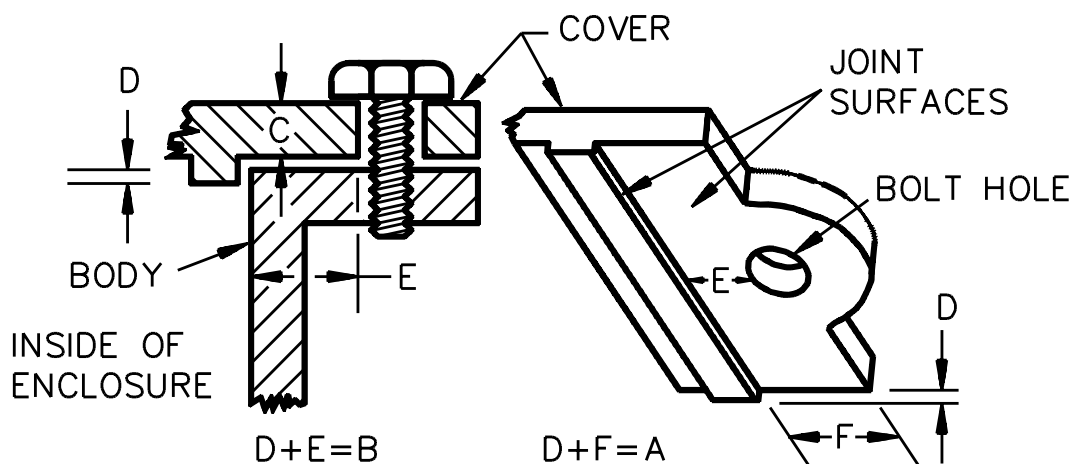
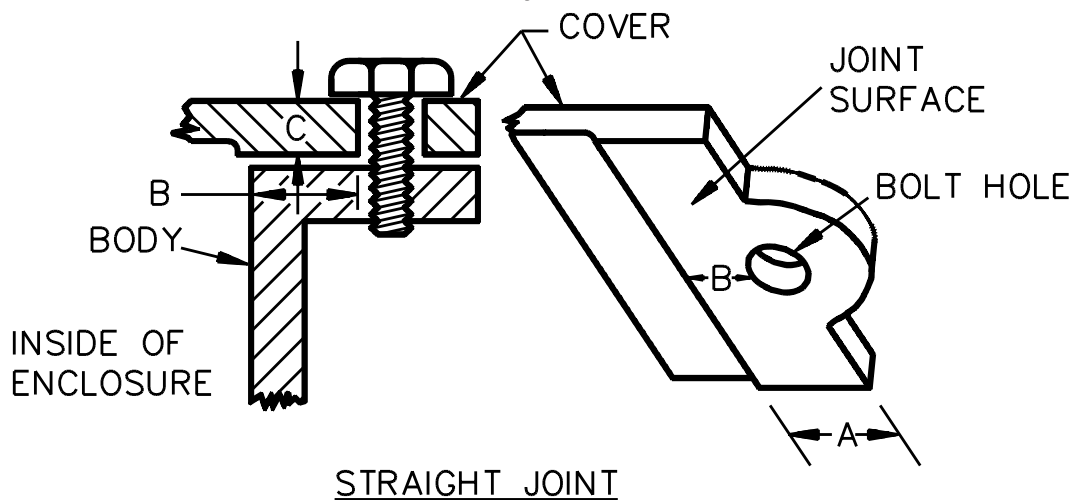
9.3.1.3 The width of a joint in an enclosure having a free internal volume of more than 100 cubic inches (1.64 dm³) and not more than 350 cubic inches (5.7 dm³) shall not be less than 1 inch (25.4 mm). At a bolt hole, the width shall be measured from the inside edge to the nearest edge of the bolt clearance hole. The clearance between the joint surfaces shall not be more than 0.0015 inch (0.038 mm).

9.3.2 Bolts in joint width

9.3.2.1 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 dm³) when it complies with the requirements in 9.3.2.2 and 9.3.2.3.

9.3.2.2 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 9.3.2.5 and Figure 9.5.

Figure 9.5
Bolts in joint width



S2828D

RABBET JOINT

A = Required minimum width of joint (see Figure 9.1)

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

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9.3.2.3 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.

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

9.3.2.5 The requirements in 9.3.2.1 – 9.3.2.3 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 9.3.2.1 – 9.3.2.3, 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.

9.3.3 Threaded joints

9.3.3.1 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 9.3 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 31, Explosion Tests – Class I Locations, the minimum number of threads required shall be not less than specified in Table 9.4.

Table 9.3
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/6g)
8	1	(7H/8g)

^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 9.4
Threads required based upon enclosure volume

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

9.4 Class II locations

9.4.1 General

9.4.1.1 (II) – At other than a shaft opening, a gasket may be interposed between the metal-to-metal joint surfaces if the required metal-to-metal joint width and clearance are provided without the gasket in place.

9.4.1.2 (II) – A gasket used in a joint shall be formed of a material such as plant-fiber sheet-packing material or a material of similar characteristics that is not subject to appreciable aging or plastic flow in the temperature range in which the motor is intended to operate. A gasket shall be mechanically attached and protected from abuse. A minimum gasket contact width of not less than 3/16 inch (4.8 mm) shall be provided at all points around the joint.

9.4.1.3 (II) – A material that upon aging readily hardens or adheres to metal surfaces, or both, is not considered an acceptable gasket material. The attachment of a gasket by adhesive or cement is not acceptable.

9.4.1.4 (II) – Except as noted in 30.10, joints in a motor enclosure shall be as specified in Table 9.5.

Table 9.5
Dimensions of joints in motor enclosures

Straight (flat or cylindrical) joints				
	Minimum width, inch		Maximum clearance, inch ^a	
	3/16		0.002	
	1/4		0.003	
	3/8		0.004	
	1/2		0.005	
	5/8		0.006	
	3/4		0.007	
	7/8		0.008	
Rabbet joints				
Minimum total width of joint, inch	Minimum width of radial section, inch	Minimum width of axial section, inch	Maximum clearance at radial section, inch	Maximum diametrical clearance at axial section, inch
3/16	3/64	3/64	0.002	0.004
1/4	3/64	3/64	0.003	0.006
^a Diametrical clearance for cylindrical joint. For SI unit conversion: 1 inch = 25.4 mm				

9.4.2 Threaded joints

9.4.2.1 (II) – A threaded joint shall consist of at least three threads fully engaged. Threads shall not be finer than 32 threads per inch (25.4 mm).

9.4.3 Bolts in joint width

9.4.3.1 (II) – At a metal-to-metal joint between an inner bearing cap and an end shield, a bolt may be located in the required joint width if:

- a) The bearing cap is secured by bolts or studs extending through the end shield and engaging tapped holes in the bearing cap;
- b) The width of joint between the nearest edge of the clearance hole and the interior of the motor enclosure and the clearance between the joint surfaces complies with the requirements in 9.4.1.4;
- c) The diametrical clearance between each bolt or stud and its 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 3/8 inch (9.5 mm); and
- d) The width of the joint between the nearest edge of the clearance hole and the interior of the bearing chamber is not less than 7/64 inch (2.8 mm) with a clearance between the joint surfaces of not more than 0.002 inch (0.05 mm).

9.4.3.2 (II) – The bolts or studs mentioned in 9.4.3.1 may be provided with lock washers.

9.4.3.3 (II) – With respect to 9.4.3.1(a), if studs are used and they each engage at least three full threads in a tapped hole in the inner bearing cap and are mechanically secured against removal, the hole need not be bottomed.

9.4.4 Through-bolts

9.4.4.1 (II) – For a through-bolt that secures the end shields and passes through the enclosure, the diametrical clearance between the unthreaded shank of the bolt and the clearance hole in the enclosure (or end shields) shall not be more than 0.010 inch (0.25 mm) for a length of not less than 1/2 inch (12.7 mm).

9.4.4.2 (II) – For a joint between a specially-machined nut and a machined surface on the end shield surrounding the bolt hole, the width of joint shall not be less than 3/16 inch (4.8 mm). The clearance at the joint shall not be over 0.002 inch (0.05 mm) for a 3/16 inch wide joint and not over 0.003 inch (0.08 mm) for a 1/4 inch (6.4 mm) wide joint. The width of joint is measured from the bolt clearance hole to the nearest outside edge of the nut. In addition, the nut shall fully engage not less than five threads of the through-bolt and a washer shall not be provided.

9.5 Class I and II locations

9.5.1 Main poles and interpoles of a dc motor

9.5.1.1 (I, II) – A dc motor for Class I, Group D and Class II locations, with the main poles and interpoles fastened to the stator frame by bolts or studs, may have a distance from the edge of the pole piece to the bolt hole in the motor frame of not less than 1/8 inch (3.2 mm) if the diametrical clearance between the bolt and bolt hole is not more than 0.023 inch (0.58 mm) for a distance of not less than 1/2 inch (12.7 mm) of the unthreaded bolt shank. The pole piece shall be tightly clamped against the interior of the motor frame with a clearance of not more than 0.004 inch (0.10 mm). A lock washer may be used with the bolt. Metal shims may be provided in the joint between a pole piece and the stator frame.

9.5.2 Brush holders

9.5.2.1 (I, II) – A cap of a brush holder shall be provided with metal threads for engaging a metal brush holder mounted through the wall of the motor enclosure. For a motor for Class I locations the number and size of engaged threads shall be as specified in Table 9.2. For a motor for Class II locations, there shall be at least three full threads engaged, and the threads shall not be finer than 24 per inch (25.4 mm). The insulation provided between the brush holder and the enclosure, and on the brush-holder cap, shall be phenolic composition or the equivalent, and there shall be no exposed live parts. The joints between portions of a brush-holder assembly and between the assembly and the motor enclosure shall comply with the requirements specified for joints in the motor enclosure.

10 Holes in Enclosure

10.1 (I, II) – Other than as noted in 10.2, a hole in an enclosure for securing a part, such as a nameplate or a switch, shall be bottomed. The remaining thickness at the bottomed hole shall not be less than 1/16 inch (1.6 mm). In addition, for Class I locations, the remaining thickness at the bottomed hole shall be sufficient to withstand the internal explosion pressures as shown by calculations or by a hydrostatic pressure test.

10.2 (I, II) – A hole in an enclosure may be unbottomed if:

- a) The hole is closed by a metal pin or part that is press-fitted in the hole for a length of at least 3/8 inch (9.5 mm) for Class I locations and 3/16 inch (4.8 mm) for Class II locations. The pin or part shall be secured against removal by welding, peening, or the equivalent;
- b) The hole is closed by solid and continuous welding of the pin or part that is installed in the hole; or
- c) The hole is closed by a screw that:
 - 1) Does not have more than 32 threads per inch;
 - 2) Is secured against removal; and
 - 3) Engages at least five full threads for Class I locations and at least three full threads for Class II locations – for a self-tapping screw, the number of threads engaged is to be measured when the screw is seated.

11 Shaft Openings

111 General

11.1.1 (I, II) – A shaft opening in a motor enclosure shall be of the metal-to-metal type. See 9.1.1 for the roughness requirements for the metal surfaces forming the path.

11.2 Class I locations

11.2.1 (I) – Shaft openings in a motor enclosure shall be as specified in Table 11.1 for Class I, Group D motors, and in Table 11.2 for Class I, Group C motors. See Figure 11.1. Shaft openings in a motor enclosure for Class I, Group B motors are to comply with 11.2.5.

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.

Table 11.1
Shaft openings in motor for Class I, Group D

Size of motor		Straight path		Labyrinth path ^{a,b}		
				Minimum total length of path, inches	Minimum length of any section, inches	Maximum diametrical clearance at each section, inch
65 or less 350 or less	– 32 or less	1/4	0.015	–	–	–
		1	0.021	–	–	–
		1-1/4	0.023	–	–	–
		1-1/2	0.025	–	–	–
		1-3/4	0.027	–	–	–
More than 350	90 or less	2	0.029	–	–	–
		1-1/2	0.025	–	–	–
		2-1/2	0.030	–	–	–
More than 350	More than 90	–	–	2 ^c	1/4 ^c	0.025
		–	–	3 ^c	1 ^c	0.030

^a The labyrinth path is to consist of at least two sections.

^b The length of adjacent labyrinth-path sections shall be of different diameters with an offset not less than 1/8 inch (difference in diameters at least 1/4 inch) through two 90 degree turns.

^c The minimum labyrinth-path dimensions are to be provided with the rotor in any position permitted by the end play of the shaft. The adjacent sections of the path are not to be more than 0.80 inch apart at any position permitted by the end play.

For SI unit conversion:

1 inch = 25.4 mm

1 inch³ = 0.0164 dm³

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Table 11.2
Labyrinth shaft openings in motors for Class I, Group C

Free internal volume, inches ³	Internal length of joint, inches	Minimum total length of path, inches	Minimum length of one labyrinth section, inch	Minimum length of other labyrinth section, inches	Minimum difference in diameters of labyrinth sections, inch	Minimum length of any labyrinth section, inches	Maximum diametrical clearance of each section, inch
350 or less	32 or less	1-1/8	1/8	1	1/8	—	0.021
		1-3/8	1/8	1-1/4	1/8	—	0.023
		1-5/8	1/8	1-1/2	1/8	—	0.025
		1-7/8	1/8	1-3/4	1/8	—	0.027
		2-1/8	1/8	2	1/8	—	0.029
More than 350	90 or less	1-5/8	1/8	1-1/2	1/4	—	0.025
		2-5/8	1/8	2	1/4	—	0.030
More than 350	More than 90	2 ^{a,b}	—	—	1/4	1/4 ^b	0.025
		3 ^{a,b}	—	—	1/4	1 ^b	0.030

^a The labyrinth path is to consist of at least two axial sections.

^b The minimum labyrinth-path dimensions are to be provided with the rotor in any position permitted by the end play of the shaft. The adjacent sections of the path are not to be more than 0.80 inch apart at any position permitted by that end play.

For SI unit conversion:

1 inch = 25.4 mm

1 inch³ = 0.0164 dm³

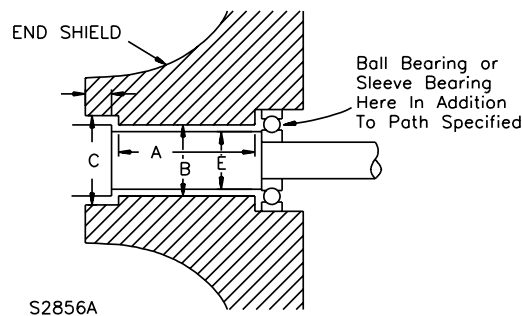
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Figure 11.1
Length of path excluding bearing



Additional Path of 1/8 inch (3.2 mm) Required at "C" for Class I, Group C Motors

Length at A,		Maximum diametrical clearance, inch (mm)			
inches	(mm)	B minus E		C minus D	
2	(50.8)	0.029	(0.74)	0.029	(0.74)
1-3/4	(44.5)	0.027	(0.69)	0.027	(0.69)
1-1/2	(38.1)	0.025	(0.64)	0.025	(0.64)
1-1/4	(31.8)	0.023	(0.58)	0.023	(0.58)
1	(25.4)	0.021	(0.53)	0.021	(0.53)

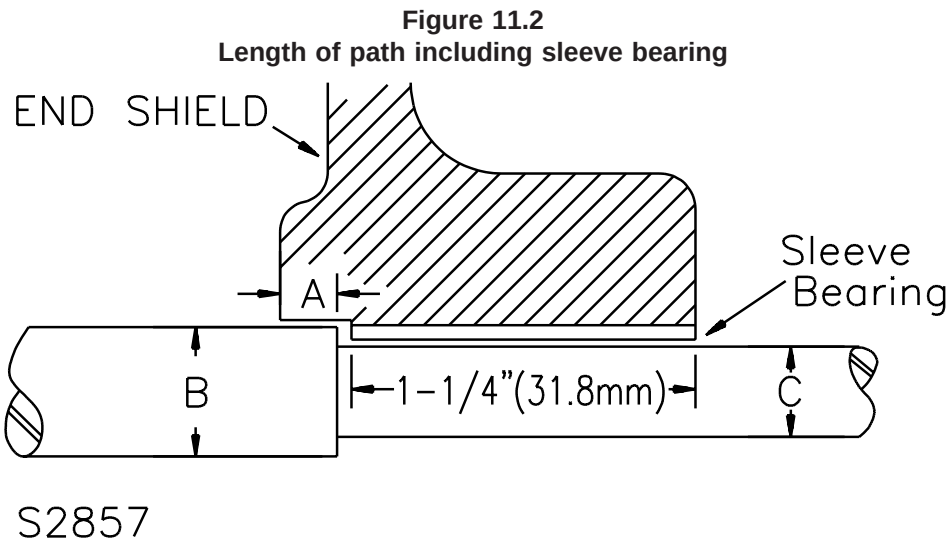
11.2.2 (I) – The shaft openings specified in Tables 11.1 and 11.2 shall be in addition to any protection offered by the ball bearings or sleeve bearings of the motor.

11.2.3 (I) – The length of the 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) are acceptable, if not of sufficient size to significantly affect 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. An opening for oil or grease shall be located outside the path in order not to nullify its effectiveness. If the required shaft path is located between the bearing and the outer surface of the motor, an oil or grease opening shall not be provided unless the construction of the opening provides a length of path not less than that required at the shaft opening.

11.2.4 (I) – If a path as specified in Table 11.1 or 11.2 is not provided in addition to the length of a 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 be either:

- 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 a motor 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 (3.2 mm)] through two 90-degree turns. See Figure 11.2. The labyrinth shall have a diametrical clearance of not more than 0.020 inch (0.51 mm) through a length of not less than:

- 1) 1/4 inch (6.4 mm) for a motor for Class I, Group D locations; and
- 2) 3/8 inch (9.5 mm) for a motor for Class I, Group C locations.



A = 1/4 inch (6.4 mm) for Class I, Group D motor,

A = 3/8 inch (9.5 mm) for Class I, Group C motor.

Diameter "B" Minus Diameter "C" not less than specified in Table 11.1 or Table 11.2.

11.2.5 (I) Shaft openings of motor enclosures for Class I, Group B motors are to comply with 11.2.1 – 11.2.4. Shaft openings may require longer lengths of path and/or tighter clearances to prevent the propagation of flame in the Explosion Tests – Class I Locations, Section 31.