



Member of the FM Global Group

**Examination Standard
for
Explosionproof Electrical
Equipment –
General Requirements**

Class Number 3615

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Foreword

This standard is intended to verify that the products and services described will meet stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of this standard is to present the criteria for examination of various types of products and services.

Examination in accordance with this standard shall demonstrate compliance and verify that quality control in manufacturing shall ensure a consistent and reliable product.

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1 INTRODUCTION

1.1 Purpose

This standard states testing and certification requirements for explosionproof electrical equipment.

1.2 Scope

This standard contains the basic requirements for the construction and testing of explosionproof electrical equipment. This standard is intended to be used in conjunction with FM Approvals Examination Standard 3600-Electrical Equipment for Use in Hazardous (Classified) Locations - General Requirements which includes the general requirements that apply to all types of hazardous (classified) location protection methods.

1.3 Basis for Certification

See FM Approvals Examination Standard 3600.

1.4 Basis for Continued Certification

See FM Approvals Examination Standard 3600.

1.5 Basis for Requirements

See FM Approvals Examination Standard 3600.

1.6 Effective Date

The effective date of this certification standard mandates that all products tested for certification after the effective date shall satisfy the requirements of this standard.

The effective date of this standard is eighteen (18) months after the publication date of the standard for compliance with all requirements.

1.7 System of Units

See FM Approvals Examination Standard 3600.

1.8 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies.

ANSI/ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

ANSI/ASME B46.1, *Surface texture (Surface Roughness, Waviness, and Lay)*

ANSI/UL 50, *Enclosures for electrical equipment, non-environmental considerations*

ANSI/UL 50E, *Enclosures for electrical equipment, environmental considerations*

FM Approvals Examination Standard 3600, *Electrical Equipment for Use in Hazardous (Classified) Locations – General Requirements*

FM Approvals Examination Standard 3610, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II and III, Division 1 Hazardous (Classified) Locations*

FM Approvals Examination Standard 3611, *Electrical Equipment for Use in Class I, Division 2; Class II, Division 2; and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*

ISO 965-1, *ISO general purpose metric screw threads - Tolerances - Part 1: Principles and basic data*

ISO 965-3, *ISO general purpose metric screw threads - Tolerances - Part 3: Limit deviations for screw threads*

ISO 4003, *Permeable Sintered Metal Materials - Determination of Bubble Test Pore Size*

1.9 Terms and Definitions

For purposes of this standard, the following terms apply:

Explosionproof — *Equipment enclosed in a case which is capable of: 1) withstanding an internal explosion of a specified gas or vapor-in-air atmosphere; 2) preventing the ignition of a specified gas or vapor-in-air atmosphere surrounding the enclosure due to sparks, flashes or internal explosion; and 3) operating at temperatures which will not ignite the surrounding atmosphere*

Flamepath — *The place where corresponding surfaces of two parts of an enclosure come together and prevent the transmission of an internal explosion to the atmosphere surrounding the enclosure*

Gap of Flamepath — *The distance between the corresponding surfaces of a flamepath measured perpendicular to the surfaces. For circular surfaces, this gap is defined as the difference between the two diameters (diametrical clearance)*

Note 1 – This definition does not apply to threaded flamepaths.

Length of Flamepath — *The shortest un-interrupted distance along a flamepath*

Note 1 – This definition does not apply to threaded flamepaths.

Note 2 – Interruptions of a flamepath may include o-ring grooves, oil grooves, and bolt holes.

Joint, Cemented — *A joint where the interface between the two mating surfaces is completely filled with cement so as to create a “no-gap” joint*

Joint, Flat/Flange — *A flamepath with a straight joint with parallel surfaces*

Joint, Spigot — *A joint with two or more flamepaths at right angles to each other*

Joint, Threaded — *The interface of internally and externally threaded components*

Rod, Operating — *A component normally of circular cross-section, used for transmitting control movements which may be rotary, linear, or a combination of both*

Shaft — *A component, normally of circular cross-section, used for transmitting rotary motion*

Volume, Internal Free — *All the unfilled space in an explosionproof enclosure, with the normally installed parts in place*

2 GENERAL INFORMATION

2.1 Certification Application Requirements

See FM Approvals Examination Standard 3600.

2.2 Required Documentation for Certification Examination

For the purposes of:

- a) assessing compliance of equipment with certification requirements.
- b) determining what test samples will be required for the test and examination program, and
- c) providing a means for design modification control, the manufacturer shall submit documents which give a full and correct specification of the critical construction aspects of the equipment. One copy of the following documentation as it pertains to the certification request should be assembled in an organized manner and submitted prior to scheduling of the test program. All documents shall identify the following:
 - the manufacturer's name
 - document number or other form of reference number identification, title, and
 - date of latest revision of document and/or the revision reference (i.e. number or letter indicating revision level)
 - Note 1:** A single certification drawing may be provided as an alternative to providing separate production drawings. However, the certification drawing must contain all of the detail required of production drawings.
 - Note 2:** Drawings in a language other than English may require partial translation for use in a certification program.
 - Marketing/Ordering Literature showing general specifications and functions of the equipment. This information is generally very useful in determining project.
 - Model Number Breakdown: An engineering drawing or sales specification sheet showing all model variations and options to be examined. Each model variation shall be uniquely identifiable by marking, or by distinctive model designation.
 - Instruction Manual(s) providing installation, operation and maintenance instructions.
 - Quality Control Procedures document(s) detailing routing testing and final inspection procedures.
 - Production Drawings, including (as applicable)
 - i) Electrical schematic(s);
 - ii) Specifications (rated voltage, current, power, etc.) for mains powered components;
 - iii) Final assembly drawing and parts lists;
 - iv) Sub-assembly drawings or piece-part drawings/assembly drawings sufficient to detail primary circuit components, operator controls, enclosure design and safety interlocks;
 - v) Casting, machining, and sub-assembly drawing as applicable to define all flameproof joints, wall thickness, materials, minimum acceptable joint tolerances, surface finish and flatness, coating or paint, conduit opening gauging requirements, potting materials, sealing materials, and gasket materials.

Note: If a component or sub-assembly which is critical to the explosionproof characteristics of the device being submitted is manufactured by an outside supplier, all of the preceding design information is still required. That supplier shall be required to forward design drawings to the certification agency, or the applicant shall prepare specification drawings detailing the inspection limits of acceptance on fabrication tolerances.

- vi) Protective Grounding Detail drawing(s) showing the method of protective grounding provided, including location, size, and marking.
- vii) Product label drawing(s) showing all required marking information. The label drawing should show proposed artwork indicating the manufacturer's name, address, model and serial numbers, equipment ratings, warning markings, and the certification agency's mark of conformity.

3 MARKING AND CONSTRUCTION REQUIREMENTS

3.1 Marking Requirements

In addition to the marking information required in accordance with FM Approvals Examination Standard 3600, explosionproof electrical equipment shall be marked with the following information:

3.1.1 Precautionary Information — the words:

“TO PREVENT IGNITION OF FLAMMABLE GASES OR VAPORS, DO NOT REMOVE COVER WHILE CIRCUITS ARE LIVE” or equivalent wording.

3.1.2 If the equipment was tested according to the EXCEPTION of Table 4, the label shall contain the statement:

“SEAL ALL CONDUITS WITHIN 18 INCHES” or equivalent wording. Where the explosion pressure has been determined with a length of conduit shorter than that specified in Table 4, the enclosure marking shall reflect that length in lieu of the 18 inches.

3.1.3 Equipment supplied with a factory-installed conduit seal shall be marked with the words:

“FACTORY SEALED, CONDUIT SEAL NOT REQUIRED” or equivalent wording.

3.2 Construction Requirements

3.2.1 Enclosure Mechanical Strength

Enclosure strength shall be sufficient to withstand the stresses resulting from internal explosions, hydrostatic overpressure tests, impact, and thermal shock. As a result of these tests, no damage or deformation shall occur that would weaken or jeopardize the explosionproof characteristics of the enclosure.

3.2.2 Enclosure Joints

Flamepaths of other than threaded joints shall have a surface finish not rougher than 250 micro-inches (6.3 micro-meters) in accordance with ANSI/ASME B46.1.

3.2.3 Flamepath Dimensions

The subject of flamepath dimensions has been researched by various international agencies and is well documented. This research developed maximum experimental safe gap (MESG) dimensions for explosionproof enclosures which have been tried and proved over many years.

A tabulation of flamepath length and gap dimensions of various joint types versus enclosure volume is given as Annex literature in this standard. The Annex Tables have been derived from IEC 60079-1.

The gap values given in the Annex Tables, or the additional margin of safety specified in this Section, yield a sufficient safety factor to assure confidence in the tested design for certification. The certification agency's procedure is to enforce performance requirements versus design requirements wherever possible. Therefore, testing required by this Standard is based on use of the tabulations as a guideline, as an alternative to requiring strict adherence to the table values in a product design. Designs not meeting these criteria shall be evaluated by the modified gap test methods specified for the type of joint design, according to the following paragraphs. Presented in this manner, a manufacturer can design a product using the Annex Tables and anticipate passing the certification agency's test program and other national and international test programs.

Note: No enclosure can be considered satisfactory based on meeting the Annex value alone, without testing, as factors such as enclosure geometry, internal parts proximity to flamepaths, pressure piling, environmental seal grooves, etc., have an effect that can be evaluated only by testing. The intent of these requirements is to incorporate into the design of the equipment a defined safety factor verified by tests.

3.2.3.1 Flat/Flange Joints: Flame propagation tests shall be conducted in accordance with 4.4.2 (compliant) unless either of the following two conditions exist. In those cases, flame propagation tests shall be conducted in accordance with 4.4.3 (modified) or 4.4.4 (nominal).

- The enclosure design maximum gap exceeds the gap specified for the flat/flange length values shown in the Annex Tables; or
- A maximum gap value is not shown in the Annex Tables

Modifications (ref. 4.4.3) for Flat/Flange Joints:

- Shimming to increase gap by 50% in excess of the design maximum gap.

3.2.3.2 Spigot Joints: In general, only the cylindrical portion of the joint is relied upon as a controlled flamepath.

Flame propagation tests shall be conducted in accordance with 4.4.2 (compliant) unless either of the two following conditions exist. In those cases, propagation tests shall be conducted in accordance with 4.4.3 (modified) or 4.4.4 (nominal). For those tests, flanged gaps of spigot joints, where the length of the joint L consists only of a cylindrical part (see Annex K) shall be enlarged to values of at least 0.04 in. (1 mm) for Group D, 0.02 in. (0.5 mm) for Group C and 0.01 in. (0.3 mm) for Group A or B.

- The enclosure design maximum diametrical gap exceeds the gap specified for the cylindrical portion joint lengths shown in the Annex Tables; or
- A maximum diametrical gap value is not shown in the Annex Tables.

EXCEPTION: Spigot joints having a flat flange portion greater than 0.25 inch (6 mm) in length and an internal chamfer less than 0.04 inch (1 mm) may rely on both the cylindrical portion and the flat/flange portions combined flamepaths. In such cases, the maximum gap or diametrical gap of any portion of the joint and the minimum combined flamepath length shall be used to evaluate the construction in the same manner as the basic spigot joints detailed previously.

Note: There is no relaxation on the required joint length for an interference-fit joint construction.

Modifications (ref. 4.4.3) for Spigot Joints:

- Shimming to increase diametrical gap by 50% in excess of the design maximum gap.

3.2.3.3 Threaded Joints: Flame propagation tests shall be conducted in accordance with 4.4.2 (compliant) unless the threaded joint has a number of engaged threads and/or a class of fit other than that specified in Annex J. In that case, flame propagation tests shall be conducted in accordance with 4.4.3 (modified).

Tapered threads shall meet the gauging requirements for conduit and are not required to be subjected to flame propagation testing.

Modifications (ref. 4.4.3) for Threaded Joints that do not comply with Annex J:

- Flamepath reduction by removing 30% of the effective thread engagement of the joint for Class 2 (6H/6g) or Class 3 (5H/4h) fit; or by removing 50% of the effective thread engagement for a Class 1 fit (7H/8g).

3.2.3.4 Field Wiring Entries (Supply Connections): The enclosure shall be provided with means for connection to an NEC recognized Class I, Division 1, wiring system.

1. **Modified NPT** (National Standard Pipe Taper) Openings (Suitable for Groups A, B, C and D Locations) shall be provided in not smaller than 1/2 inch trade size and not larger than 4 inch trade size. Acceptable conduit openings must provide for a 4 1/2 full threads of engagement with a minimum thread conduit or fitting. An opening meeting this requirement will have a deeper tapping than described in ANSI/ASME B1.20.1, "Pipe Threads, General Purpose (Inch)". Acceptable conduit openings will be within 0 to +3 1/2 turns deeper than nominal in lieu of the ±1 turn of nominal described in ANSI/ASME B1.20.1. A conduit stop, if provided, shall be smooth and rounded, having an inner diameter as specified in Table 1.
2. **NPS** (National Standard Pipe Straight) Openings (Suitable for Groups C and D) shall be provided in not smaller than 1/2 inch trade size and not larger than 4 inch trade size. Acceptable openings shall provide for at least 5 full threads of engagement with an NPS threaded fitting conduit. Acceptable openings must also provide an integral conduit stop at the inner end of the conduit opening. The conduit stop shall be smooth and rounded, having an inner diameter as specified in Table 1.

NPS threaded entries for other than supply connections may be provided on enclosures for Groups A and B if these openings are intended solely for the connection of accessories, such as a probe or operator, and not field wiring.

Table 1 - Throat Diameter of Conduit Stop

Trade Size of Conduit Opening (in.)	Throat Diameter of Conduit Stop			
	Minimum		Maximum	
	(in.)	(mm)	(in.)	(mm)
1/2	0.560	(14.22)	0.622	(15.80)
3/4	0.742	(18.85)	0.824	(20.93)
1	0.944	(23.98)	1.049	(26.65)
1 1/4	1.242	(31.55)	1.380	(35.05)
1 1/2	1.449	(36.81)	1.610	(40.89)
2	1.860	(47.24)	2.067	(52.50)
2 1/2	2.222	(56.44)	2.469	(62.71)
3	2.761	(70.13)	3.068	(77.93)
3 1/2	3.193	(81.10)	3.548	(90.12)
4	3.623	(92.02)	4.026	(102.26)

3. **Metric Entries:** Metric threaded entries in the enclosure shall have a tolerance class of 6H or better according to ISO 965-1 and ISO 965-3 and any chamfer or undercut is limited to a maximum depth of 2 mm from the external wall surface. Acceptable openings shall provide at least 5 full threads. The thread type and size shall be identified on the electrical equipment, for example M25 or M32.

Field wiring entries not employing a conduit stop shall be smooth and well rounded at the interior end to reduce the likelihood of conductor insulation damage during installation.

All NPT field wiring entries, except those which must be used for installation, shall be supplied with metal plugs capable of providing at least 4 1/2 full threads of engagement. All metric wiring entries except those which must be used for installation, shall be supplied with metal plugs capable of providing at least 5 full threads of engagement.

The enclosure wall thickness shall provide for at least 4 1/2 full threads of engagement with any NPT conduit threaded per ANSI/ASME B1.20.1.

For enclosures intended for field installation of NPT entries, the enclosure wall thickness shall provide for at least 5 full threads of engagement with any NPT conduit threaded per ANSI/ASME B1.20.1.

NPT Conduit openings shall withstand the torque test specified in 4.2.

3.2.3.5 Rotating/Reciprocating Shaft Joints with Sleeve Bearings: Flame propagation tests shall be conducted in accordance with 4.4.2 (compliant) unless either of the following conditions exist. In those cases, flame propagation tests shall be conducted in accordance with 4.4.3 (modified) or 4.4.4 (nominal):

- The design maximum gap (diametrical clearance) exceeds the clearance specified for the joint lengths shown in the Annex Tables; or
- A maximum gap value is not shown in the Annex Tables

Modifications (ref. 4.4.3):

- Shimming to increase gap (diametrical clearance) by 50% in excess of the design maximum gap.

3.2.3.6 Rotating Shaft Joints with Ball or Roller Bearings (Required for Shafts Rotating at Over 100 RPM): Flame propagation tests shall be conducted in accordance with 4.4.2 (compliant) unless either of the following conditions exist. In those cases, flame propagation tests shall be conducted in accordance with 4.4.3 (modified) or 4.4.4 (nominal):

- The design maximum gap (diametrical clearance) exceeds the clearance specified for the joint lengths shown in the Annex Tables; or
- A maximum gap value is not shown in the Annex Tables

Modifications (ref. 4.4.3) for Rotating Shafts with Ball or Roller Bearings:

- Shimming to increase diametrical clearance by 50% in excess of the design maximum gap.
- Special Assembly to remove the bearings and wedge the shaft off-center in the bore to maximize the diametrical clearance to a value that would approximate the 50% increase obtained by special machining.

3.2.3.7 Flame Arresters and Breather/Drains: Flame arresters are required for air, gas, or liquid lines which enter electrical enclosures.

Note: Drains are required on installation for process control equipment that depend upon a single seal diaphragm or tube to prevent process fluids from entering the electrical conduit system.

When provided as part of the equipment assembly, flame arrester, breather, and drain devices shall conform to the following requirements:

- a) They shall be secured by staking, welding, peening, interference fit, or equivalent, to prevent inadvertent removal.

EXCEPTION: When the device is constructed with a male NPT thread according to ANSI/ASME B1.20.1 “pipe threads, general purpose (inch)” and is intended to be installed in an NPT conduit opening.

- b) Drains shall not require removal of any part of the fitting to drain liquid from the enclosure.

- Flame propagation tests shall be conducted in accordance with 4.4.3 (modified) or 4.4.4 (nominal):

Modifications (ref. 4.4.3) for Flame Arrestors:

- Flamepath Reduction to 50% of effective flamepath

Breathers and drains may be independently certified as an enclosure component by separate testing.

3.2.4 Joint Material — Non-Metallic Enclosures

Chemical Compatibility and Aging: Enclosure joint materials shall satisfy the requirements for chemical compatibility and aging according to FM Approvals Examination Standard 3600.

Flame Resistance: Enclosure joint material must be undamaged by the tests required according to 4.3 and be flame resistant according to 4.7.

3.2.5 Gaskets

3.2.5.1 Gaskets Not Relied Upon For Explosionproof Protection: If a gasket of compressible or elastic material is used to seal a joint, e.g., to prevent the ingress of moisture or dust (including protection as Dust-Ignitionproof) or to prevent the leakage of a process fluid, etc., it shall be applied as a supplement to, and not be included in the prescribed flamepath portion of the joint.

The following characteristics of the joint shall be maintained:

- The prescribed gap and/or length of the joint with the gasket installed shall be unchanged from the dimensions without the gasket installed.
- The secureness of a threaded part or cover shall not be dependent upon the gasket (the gasket shall compress into a groove or chamfer such that the threaded part or cover bottoms the same with or without the gasket in place). Some alternatives to accomplish the required degree of secureness are mechanical cover-locking provisions, or close tolerance threads of covers to afford a friction fit. With these alternative constructions, the tests of 4.4 are conducted with the threaded part or cover in the gasket seated position but without the gasket.

3.2.5.2 Gaskets Relied Upon for Explosionproof Protection: If a non-metallic gasket is used to cushion a lens, for example, it shall be considered a non-metallic enclosure material according to 3.2.4.

A gasket constructed of PolyTetraFluoroEthylene (PTFE) or similar material shall be installed to reduce the likelihood of cold flow.

3.2.6 Cements (i.e., Sealing Adhesives and Poured Seals)

Cements and sealing adhesives for inspection windows, poured seals, etc., in explosionproof enclosures shall be considered a non-metallic enclosure material according to 3.2.4.

EXCEPTION: For adhesives that do not increase the design gap of a flamepath, a final inspection procedure is required to check that the gap of each production unit is within design values, that the sealing material fills the joint as required, and that excess material is removed.

Adhesive materials are acceptable only for enclosure joints that are not intended to be disturbed during installation or repair.

The seal shall be of a material compatible with the insulation on any conductors passing through it.

The softening point of the seal material shall not be less than 93 °C (200 °F), nor less than the operating temperature conditions of the equipment; and,

The mechanical strength of a cemented joint or poured seal shall not rely entirely on the adhesive strength of a cement or adhesive material. Supplemental mechanical retention must be provided. The minimum length along a cemented joint, from inside to outside of the explosionproof enclosure, shall be as shown in Table 2:

Table 2 - Cemented Joint Length

<i>Minimum Joint Length in. (mm)</i>	<i>Free Internal Volume V in³ (cm³)</i>
≥ 0.12 (3)	V ≤ 0.73 (10)
≥ 0.24 (6)	0.73 (10) < V ≤ 6 (100)
≥ 0.39 (10)	V > 6 (100)

The thickness of a poured conduit or cable seal shall be at least equal to the inside diameter of the opening, but in no case be less than 5/8 in. (16 mm).

3.2.7 Flexible Cords and Bushings

Note: Flexible cords are only permitted for portable lighting equipment, portable utilization equipment, submersible pumps, etc.

Strain relief bushings for a flexible cord shall not be a flamepath. The cable entry shall be provided a poured seal according to 3.2.6.

EXCEPTION: The power cord and all associated strain relief bushing components that form a flamepath shall be considered non-metallic enclosure materials according to 3.2.4.

3.2.8 Material Applied to Joint Surfaces for Corrosion Protection

A corrosion-inhibiting grease may be applied to metal joint surfaces if it does not harden with age, does not contain an evaporating solvent, and does not cause corrosion of the joint surfaces. Compliance is determined by evaluation of the grease manufacturer's product specifications.

Metal joint surfaces may be plated by electro or chemical depositing methods. Plating thickness shall not exceed 0.0003 inch (0.008 mm). Hot dip plating methods are not acceptable.

Paints or sealing materials shall not be applied to joint surfaces.

EXCEPTION: A sealing material may be applied to the surfaces of joints that are not intended to be opened during installation or service of the equipment. Such a sealing material must comply with the requirements for cements (reference 3.2.6).

EXCEPTION: A metallic paint or other conductive coating may be applied to threaded flamepaths including conduit openings if:

- that flamepath prevents flame propagation with the paint or coating in place;
- fit class remains within specified tolerances;
- resistance across the assembled joint does not exceed 0.003 ohms, with the resistance determined by dividing the voltage drop obtained across the joint by 50 when a 50 ampere ac or dc current is passed through the joint.

3.2.9 Joint Securing Fasteners

3.2.9.1 Removable Fasteners: Removable fasteners are those used for securing covers or components to the enclosure and may be subject to removal during installation, operation, inspection, or maintenance of the equipment. Removable fasteners shall have the following characteristics:

- When removed, no hole exists through the enclosure wall;
EXCEPTION: Bolts for cover securing may pass through the enclosure wall if minimum threaded engagement requirements are met.
- A minimum clearance of 1/2 the fastener nominal diameter between the fastener and the bottom of the tapped hole shall be provided. If cover bolts are provided with a washer, this requirement must be met with the washer removed;
- A minimum thickness around the fastener shall be of 1/3 the fastener nominal diameter or 1/8 inch (3.2 mm), whichever is greater;
- Bolts shall withstand the maximum specified torque for grade marking on the bolt head with no damage occurring to the bolt or the tapped hole threads.

3.2.9.2 Non-Removable Fasteners: Non-removable fasteners passing through the enclosure wall shall have the following characteristics:

- The fastener to enclosure wall joint shall comply with Section 3.2.3; and
- The fastener shall be secured by welding, staking, peening, or equivalent, to preclude inadvertent removal from the enclosure.

3.2.9.3 Nameplate Fasteners: Fasteners shall not penetrate an enclosure wall.

3.2.9.4 Rod and Shaft Retention: Provision shall be made for the securing of rods and shafts against inadvertent removal. The retaining means shall meet the requirements for enclosure materials. Retaining means relying solely upon set screws shall be duplicated, and each set screw alone shall provide the required degree of retention.

3.2.10 Enclosure Requirements for Outdoor Classified Locations

Explosionproof enclosures rated for outdoor use shall also be evaluated for outdoor locations in accordance with ANSI/UL 50 & ANSI/UL 50E with the following modifications:

Enclosure flamepaths shall be protected against corrosion, constructed of non-corrosive materials, or the effects of such corrosion shall be specifically addressed in the explosion testing.

3.2.11 Energized External Parts

Any energized part of explosionproof equipment not protected by the explosionproof enclosure (for example, external sensor electrodes) shall be protected using the Type of Protection Intrinsic Safety per FM Approvals Examination Standard 3610, or other applicable Type of Protection.

4 TESTS AND EVALUATION

4.1 General

4.1.1 This section describes the tests and required results to show equipment compliance to the requirements of Section 3. Unless otherwise specified, all tests are conducted under prevailing laboratory conditions with respect to temperature, humidity, and atmospheric pressure.

4.1.2 Sample Preparation

- Equipment shall be explosion pressure and flame propagation tested with normally installed internal components or equivalent dummy blocks in place. If the equipment is designed such that it can be used with all or part of the internal components removed, explosion pressure tests shall be conducted such that the maximum explosion pressure is obtained. This may involve conducting tests both with and without internal components in place.
- Any potting compound employed, except that for factory-installed seals, cemented joints, coil encapsulation or insulation, shall be removed for explosion pressure and flame propagation tests.
- Gaskets or seals provided in the enclosure joint surfaces only for outdoor or other environmental ratings shall be removed for flame propagation tests.

4.2 Conduit Opening Torque Test

4.2.1 The enclosure mechanical strength at NPT conduit openings (Ref. 3.2.3.4) shall be verified by a conduit opening torque test. Damage to the enclosure resulting from the torque test shall not negate the explosionproof properties of the enclosure. Torque test values as a function of conduit trade size shall be according to Table 3.

4.2.2 Each NPT conduit opening shall be fitted with a test plug/fitting tightened to the test value (Table 3). After tightening, the test plug/fitting shall be removed and the enclosure threads examined for compliance with 4.2.1. Alternatively, the test plug/fitting(s) shall remain in place during the subsequent tests required, with no damage to the enclosure resulting to otherwise cause unsatisfactory test results.

Table 3 - Conduit Torque Specifications

<i>Trade Size of Conduit</i>	<i>Torque</i>	
	<i>lb·ft</i>	<i>(N·m)</i>
<i>inches</i>		
½, ¾	67	(90)
1, 1¼ and 1½	83	(113)
2, 2½, 3, 3½, 4	133	(181)

4.3 Explosion Pressure Tests

These tests are designed to show that an enclosure, when installed in its normally assembled configuration is capable of withstanding an internal ignition of a specified atmosphere. These tests are also used to determine the maximum explosion pressure which is the basis of the hydrostatic test pressure.

A series of at least ten ignition tests shall be performed on each compartment. Compartments with field wiring entries may require additional series of tests (see Table 5). The tests shall use a representative gas for the highest gas group rating of the equipment, at the varying mixtures as outlined in Table 4. Each independent compartment of the equipment enclosure shall be filled with an atmosphere of the appropriate gas mixture. The internal gas mixture shall then be ignited and internal pressure readings taken. Ignition for each test series shall be initiated at the location shown in Table 5.

Factory Installed Conduit Seals: Equipment having a factory installed seal shall be subjected to explosion pressure, hydrostatic, and flame propagation tests on each side of the seal. Conduit lengths as shown in Table

5 entitled “Compartments with Conduit Openings Non-Incendive Components* and Conduit Trade Size ≤1½ Inches” shall be used for the explosion pressure tests on the conduit side of a seal. Explosion pressure tests of the conduit side of a seal may be waived if the seal is satisfactorily tested at the hydrostatic pressures shown in Table 8.

Explosion Pressure Measurement: Explosion pressure shall be measured by suitable transducer(s) and recording instrumentation. A low-pass filter with a 3db corner frequency at 5 kHz ±10% and shall be used in the input to the recording instrumentation to limit the band width.

The test results shall be considered satisfactory if there is no visible permanent deformation of any part that is critical to the explosionproof characteristics of the equipment.

Table 4 - Test Mixtures

Group	Gas	Test Mixture Range (% by Volume in Air)
A	Acetylene	6.0-12.4
B	Hydrogen	22.6-38.2
C	Ethylene	4.4-9.9
D	Propane	3.0-6.5

Table 5 - Source of Ignition

Enclosed Electrical Equipment Location	Groups	Ignition Source from Enclosure Wall
Compartment with Conduit Opening(s)		
Incendive *Electrical Components and/or Conduit Trade Size ≥ 2”	A, B, C, D	18 Inches (46 cm) or by arcing component
Non-Incendive *Electrical Components and Conduit Trade Size ≤ 1½”	A, B, C, D	5, 10 and 15 feet (1.5, 3 and 4.5 m)
<i>EXCEPTION: Devices may be tested with 18 inches (or less) of conduit installed (to simulate actual installation) if the equipment label contains the appropriate limitations on a seal fitting installation in accordance with 3.1.2</i>		
Compartment without Conduit Opening(s)	A, B, C, D	Inside Compartment or at Enclosure Wall

*Reference FM Approvals Examination Standard 3611 for categories of “Non-Incendive Electrical Equipment”; a Non-Incendive Component is not capable of causing ignition under normal operating conditions.

4.4 Flame Propagation Tests

These tests are designed to show that an enclosure is capable of preventing propagation of an ignition to the surrounding explosive atmosphere.

4.4.1 General – A series of at least ten ignition tests shall be performed on each compartment. These tests shall be conducted in accordance with 4.4.2, 4.4.3, or 4.4.4, as applicable. Each independent compartment of the equipment enclosure shall be filled with and placed in an atmosphere of the appropriate gas mixture for the highest gas group rating. The internal gas mixture shall then be ignited. Ignition for each test series shall be initiated internal to or adjacent to the compartment under test.

4.4.2 Compliant joint dimensions – Testing of the nominal joint construction is conducted with test mixtures representative of the highest gas group rating using the mixtures from Table 4. Samples with other than threaded or cemented joints shall have tested gap of flamepath not less than 80% of the maximum design values and tested length of flamepath not more than 120% of the minimum design

values. Samples whose actual flamepath measurements fall outside of these values shall be modified to conform to these limits. Group A equipment shall also be subjected to the tests for Group B.

4.4.3 Modified joint dimensions – Flamepath joints shall be modified as specified for the particular joint construction in 3.2.3. The flame propagation tests are then performed on the modified flamepath sample using the mixtures as outlined in Table 4. When this method is employed, the test sample can be the same one used for the explosion pressure tests and the same tests can be used to comply with both the explosion pressure and flame propagation test requirements. When a gap of flamepath is increased to introduce a required safety factor, the actual tested gap shall not be less than 80% of the required increased gap. The tested length of flamepath shall not be more than 120% of the minimum design values. Samples whose actual flamepath measurements fall outside of these values shall be modified to conform to these limits. Group A equipment shall also be subjected to the tests for Group B.

4.4.4 Nominal joint dimensions – Testing of the nominal joint construction is conducted with a more sensitive gas mixture to introduce the required safety factor. Samples with other than threaded joints shall have flamepath gaps of not less than 80% of the maximum design values and flamepath lengths not more than 120% of the minimum design values. Samples whose actual flamepath measurements fall outside of these values shall be modified to conform to these limits.

Samples employing a non-measurable flamepath such as a sintered metal flame arrestor, shall have a maximum bubble pore size (determined per ISO 4003) of not less than 85% of the specified design maximum bubble pore size.

- Group D equipment is tested by conducting ten ignition tests with the Group C test gas.
- Group C equipment is tested by conducting ten ignition tests with the Group B test gas.
- Group B equipment is tested by conducting ten tests with a test mixture of 40% hydrogen/9.5% oxygen/balance air.
- Group A equipment is tested by conducting ten tests with a test mixture of 10% acetylene/6.7% oxygen/balance air. Group A equipment shall also be subjected to the tests for Group B above.
- Alternatively, equipment of Group A, B, C, or D may be tested by conducting ten tests with the test mixture as outlined in Table 4. However, both the test mixture and the surrounding atmosphere are to be pre-pressurized to not less than 1.5 atmospheres prior to initiation of the explosion. Group A equipment shall also be subjected to the tests for Group B.

4.4.5 High Ambient [Greater than 140°F (60°C)]: Electrical equipment, employing joint constructions other than threaded or cemented, and intended for use at an ambient temperature above 60°C, shall be subjected to the flame propagation tests under one of the following conditions:

- at a temperature not less than the specified maximum ambient temperature;
- at normal ambient temperature using the test mixture as outlined in Table 4, but at increased pressure according to the factors in Table 6;
- at normal atmospheric pressure and temperature using the test mixture as outlined in Table 4, but with the test gap additionally increased by the factors noted in Table 6.

Table 6 - Test Factors to Increase Pressure or Test Gap

<i>Temperature up to°C</i>	<i>Group D</i>	<i>Group C</i>	<i>Group A or B</i>
60	1.00	1.00	1.00
70	1.05	1.04	1.11
80	1.06	1.05	1.13
90	1.07	1.06	1.15
100	1.08	1.06	1.16
110	1.09	1.07	1.18
120	1.10	1.08	1.20
125	1.11	1.09	1.22

See 4.4 for possible additional safety factor.

4.5 Hydrostatic Tests

A hydrostatic test shall be performed on each separate compartment after explosion pressure tests have been completed to verify a margin of safety over and above the maximum recorded explosion test pressures. The hydrostatic type test pressure shall be in accordance with 4.5.1. Alternatively, the routine hydrostatic test pressure shall be according to 4.5.2. Gaskets and seals may be installed to minimize leakage during the test.

4.5.1 Hydrostatic Type Test

The hydrostatic test shall be conducted at a pressure equal to the highest ignition test pressure obtained from the Explosion Pressure Tests (see 4.3) multiplied by the safety factor shown in Table 7. The pressure shall be applied gradually and held for not less than 10 seconds at the required test pressure.

Table 7 - Hydrostatic Test Pressure Safety Margin

<i>Enclosure Material or Part</i>	<i>Safety Margin</i>	<i>Compliance*</i>
Metal Castings, non-metallic moldings	4	No visible permanent deformation
Fabricated Steel or Aluminum	2	No visible permanent deformation
Fabricated Steel or Aluminum	3	No rupture
Bolts	3	No visible elongation

*Visible permanent deformation may be permitted if the distortion does not affect the flameproof properties of the enclosure. Compliance is verified by inspection subsequent to the hydrostatic test or by repeating the ignition tests with satisfactory results.

Table 8 - Hydrostatic Pressures for Factory Installed Conduit Seals

Conduit Trade Size	Group A, B	Group C	Group D
½ thru 2	6000 psi (41.4 MPa)	1200 psi (8300 kPa)	600 psi (4140 kPa)
3 thru 6	4000 psi (27.6 MPa)	1200 psi (8300 kPa)	600 psi (4140 kPa)

4.5.2 Hydrostatic Routine Test

If each unit is tested by the manufacturer as part of the routine quality control program, the hydrostatic test pressure (for any enclosure material or part) shall be:

- 2 times the maximum recorded pressure developed in the ignition tests when the “pressure rise time” (Figure 1) is greater than 5 milliseconds, or
- 3 times the maximum recorded pressure developed in the ignition tests when the “pressure rise time” (Figure 1) is 5 milliseconds or less.

The procedure of 4.5.1 shall then be followed using these hydrostatic test pressures.

The manufacturer’s routine hydrostatic test capability shall be demonstrated initially and subject to follow-up audit inspection.

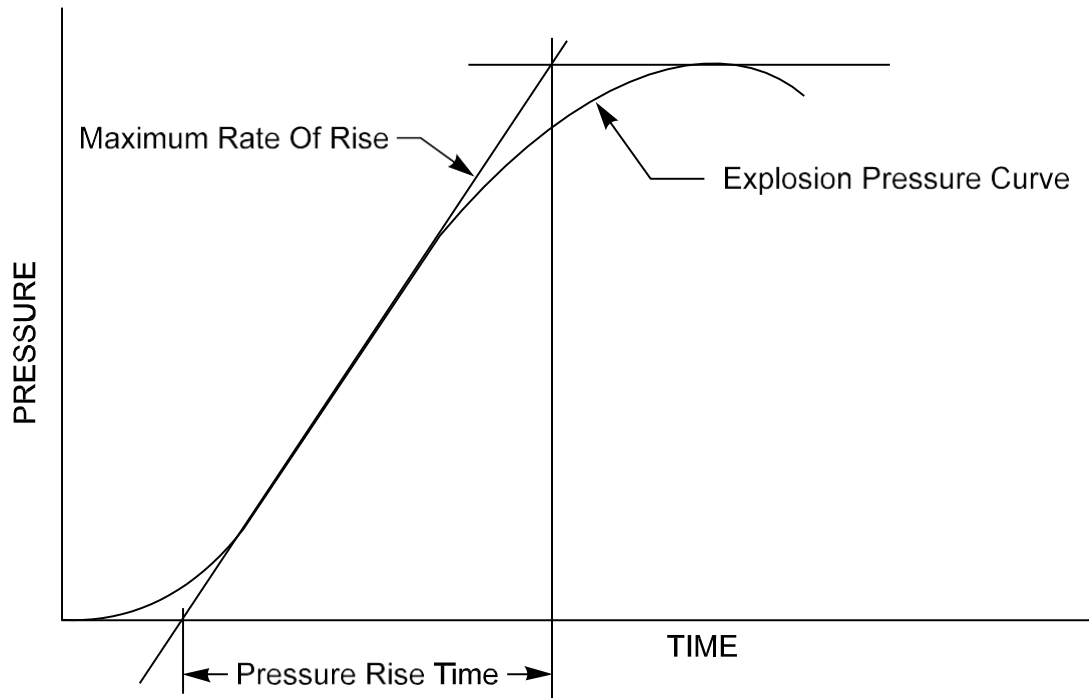


Figure 1 - Evaluation of Pressure Rise Time

4.6 Impact Test

Impact tests shall be performed in accordance with FM Approvals Examination Standard 3600. The impact test results shall be considered satisfactory if there is no damage to the equipment such that it would not satisfactorily withstand the required flame propagation tests (See 4.4). Non-impact tested parts may be used if necessary for hydrostatic tests (See 4.5).

4.7 Flammability Test

Non-metallic materials used as a joint material in explosionproof electrical equipment according to 3.2.4 shall not burn or support combustion for more than 1 minute when exposed to fire.

The flammability test shall be performed on all non-metallic parts that are critical to the explosionproof characteristics of the equipment.

The test shall be conducted in a draft free chamber. The test specimen shall be supported in a vertical position in the test chamber. The height of the natural gas flame of the burner shall be adjusted to 5 in. (12.7 cm) with an inner blue cone 1½ in. (3.8 cm) high (Figure 2). The burner shall be tilted to an angle of 20 degrees from the vertical and the flame applied to the sample so that the tip of the inner blue cone of the flame touches the test specimen at the point approximately 6 in. (15.2 cm) above its lower end. The flame shall be brought up to the material in such a manner that the vertical plane containing the major axis of the burner tube will be at right angles to the plane of the material being tested (see Figure 2). The flame shall be applied for 15 seconds, and then removed for 15 seconds until 5 such applications have been made.

The test specimen shall be a sample at least 10 in. × 10 in. (254 mm x 254 mm) with a thickness not greater than the minimum thickness of the actual part (or effective cemented joint length). As an alternative, the actual part may be tested directly if its size is such that the test flame impinges only on a flat surface, not on edges, etc. that could otherwise affect the burning rate.

The test results shall be considered satisfactory if the material did not burn through and did not support combustion for more than 1 minute after the fifth application of the flame.

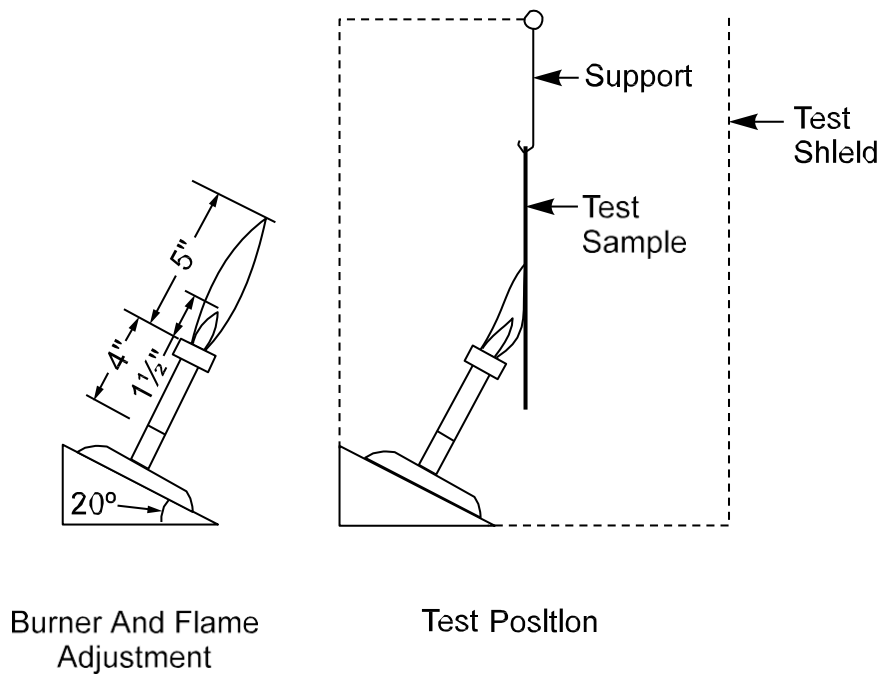


Figure 2 - Flammability Test Configuration

5 OPERATIONS REQUIREMENTS

See FM Approvals Examination Standard 3600.

6 BIBLIOGRAPHY

ANSI/NFPA 70®, National Electrical Code® National Fire Protection Association.

IEC 60079-1, *Explosive Atmospheres – Part 1: Equipment protection by flameproof enclosures “d”*

ANNEX A

Reserved for Future Use

ANNEX B

Group D – Minimum Widths/Maximum Gaps

Metric (SI) Units

Length of Flamepath (mm)	Max Gap of Flamepath (mm) for Enclosure Vol (cm ³)		
	≤ 100	100 < V ≤ 2000	V > 2000
Type of Joint			
Flange & Spigot			
6 ≤ L < 12.5	0.15	–	–
12.5 ≤ L < 25	0.15	0.15	0.10
25 ≤ L	0.20	0.20	0.20
Shafts and Rods			
6 ≤ L < 12.5	0.15	–	–
12.5 ≤ L < 25	0.15	0.15	0.10
25 ≤ L < 40	0.20	0.20	0.20
40 ≤ L	0.25	0.25	0.25
Shafts with Ball / Roller Bearing			
6 ≤ L < 12.5	0.23	–	–
12.5 ≤ L < 25	0.25	0.23	0.15
25 ≤ L < 40	0.30	0.30	0.30
40 ≤ L	0.38	0.38	0.38

ANNEX C

Group D – Minimum Widths/Maximum Gaps

U.S. Customary Units

<i>Length of Flamepath (in.)</i>	<i>Max Gap of Flamepath (in.) for Enclosure Vol (in.³)</i>		
	Type of Joint	≤ 6	6 < V ≤ 120
Flange & Spigot			
0.25 ≤ L < 0.50	0.006	–	–
0.50 ≤ L < 1.00	0.006	0.006	0.004
1.00 ≤ L	0.008	0.008	0.008
Shafts and Rods			
0.25 ≤ L < 0.50	0.006	–	–
0.50 ≤ L < 1.00	0.006	0.006	0.004
1.00 ≤ L < 1.57	0.008	0.008	0.008
1.57 ≤ L	0.010	0.010	0.010
Shafts with Ball / Roller Bearing			
0.25 ≤ L < 0.50	0.009	–	–
0.50 ≤ L < 1.00	0.010	0.009	0.006
1.00 ≤ L < 1.57	0.012	0.012	0.012
1.57 ≤ L	0.015	0.015	0.015

ANNEX D

Group C – Minimum Widths/Maximum Gaps

Metric (SI) Units

Length of Flamepath (mm)	Max Gap of Flamepath (mm) for Enclosure Vol (cm ³)		
	≤ 100	100 < V ≤ 2000	V > 2000
Type of Joint			
Flange & Spigot			
6 ≤ L < 12.5	0.10	–	–
12.5 ≤ L < 25	0.10	0.10	0.08
25 ≤ L	0.10	0.10	0.10
Shafts and Rods			
6 ≤ L < 12.5	0.10	–	–
12.5 ≤ L < 25	0.10	0.10	0.08
25 ≤ L < 40	0.15	0.13	0.10
40 ≤ L	0.20	0.15	0.13
Shafts with Ball / Roller Bearing			
6 ≤ L < 12.5	0.15	–	–
12.5 ≤ L < 25	0.20	0.15	0.10
25 ≤ L < 40	0.23	0.20	0.15
40 ≤ L	0.30	0.23	0.20

ANNEX E

Group C – Minimum Widths/Maximum Gaps

U.S. Customary Units

<i>Length of Flamepath (in.)</i>	<i>Max Gap of Flamepath (in.) for Enclosure Vol (in.³)</i>		
	≤ 6	$6 < V \leq 122$	$V > 122$
Type of Joint			
Flange & Spigot			
$0.25 \leq L < 0.50$	0.004	–	–
$0.50 \leq L < 1.00$	0.004	0.004	0.003
$1.00 \leq L$	0.004	0.004	0.004
Shafts and Rods			
$0.25 \leq L < 0.50$	0.004	–	–
$0.50 \leq L < 1.00$	0.004	0.004	0.003
$1.00 \leq L < 1.57$	0.006	0.005	0.004
$1.57 \leq L$	0.008	0.006	0.005
Shafts with Ball / Roller Bearing			
$0.25 \leq L < 0.50$	0.006	–	–
$0.50 \leq L < 1.00$	0.008	0.006	0.004
$1.00 \leq L < 1.57$	0.009	0.008	0.006
$1.57 \leq L$	0.012	0.009	0.008

ANNEX F

Group B – Minimum Widths/Maximum Gaps

Metric (SI) Units

Length of Flamepath (mm)	Maximum Gap of Flamepath (mm) for Enclosure Volumes (cm ³)				
	Type of Joint	≤ 100	100 < V ≤ 500	500 < V ≤ 1500	1500 < V ≤ 2000
Flange					
6 ≤ W < 9.5	0.05	–	–	–	–
9.5 ≤ W < 15.8	0.05	0.05	–	–	–
15.8 ≤ W < 25	0.05	0.05	0.025	–	–
25 ≤ W	0.05	0.05	0.025	0.025	0.025
Spigot					
6 ≤ L < 12.5	0.05	0.05	–	–	–
12.5 ≤ L < 25	0.08	0.08	0.08	0.08	–
25 ≤ L < 40	0.08	0.08	0.08	0.08	0.08
40 ≤ L	0.10	0.10	0.10	0.10	0.10
Shafts and Rods					
6 ≤ L < 9.5	0.05	–	–	–	–
9.5 ≤ L < 12.5	0.05	0.05	–	–	–
12.5 ≤ L < 25	0.08	0.08	0.08	0.08	–
25 ≤ L < 40	0.08	0.08	0.08	0.08	0.08
40 ≤ L	0.10	0.10	0.10	0.10	0.10
Shafts with Ball / Roller Bearing					
6 ≤ L < 9.5	0.08	–	–	–	–
9.5 ≤ L < 12.5	0.08	0.08	–	–	–
12.5 ≤ L < 25	0.13	0.13	0.13	0.13	–
25 ≤ L < 40	0.13	0.13	0.13	0.13	0.13
40 ≤ L	0.15	0.15	0.15	0.15	0.15

ANNEX G

Group B – Minimum Widths / Maximum Gaps

U.S. Customary Units

Length of Flamepath (in.)	Maximum Gap of Flamepath (in.) for Enclosure Volumes (in. ³)				
	Type of Joint	≤ 6	6 < V ≤ 30	30 < V ≤ 90	90 < V ≤ 122
Flange					
0.25 ≤ W < 0.38	0.002	–	–	–	–
0.38 ≤ W < 0.63	0.002	0.002	–	–	–
0.63 ≤ W < 1.00	0.002	0.002	0.001	–	–
1.00 ≤ W	0.002	0.002	0.001	0.001	0.001
Spigot					
0.25 ≤ L < 0.50	0.002	0.002	–	–	–
0.50 ≤ L < 1.00	0.003	0.003	0.003	0.003	–
1.00 ≤ L < 1.57	0.003	0.003	0.003	0.003	0.003
1.57 ≤ L	0.004	0.004	0.004	0.004	0.004
Shafts and Rods					
0.25 ≤ L < 0.38	0.002	–	–	–	–
0.38 ≤ L < 0.50	0.002	0.002	–	–	–
0.50 ≤ L < 1.00	0.003	0.003	0.003	0.003	–
1.00 ≤ L < 1.57	0.003	0.003	0.003	0.003	0.003
1.57 ≤ L	0.004	0.004	0.004	0.004	0.004
Shafts with Ball / Roller Bearing					
0.25 ≤ L < 0.38	0.003	–	–	–	–
0.38 ≤ L < 0.50	0.003	0.003	–	–	–
0.50 ≤ L < 1.00	0.005	0.005	0.005	0.005	–
1.00 ≤ L < 1.57	0.005	0.005	0.005	0.005	0.005
1.57 ≤ L	0.006	0.006	0.006	0.006	0.006

ANNEX H

Group A – Minimum Widths / Maximum Gaps

Metric (SI) Units

Length of Flamepath (mm)	Maximum Gap of Flamepath (mm) for Enclosure Volumes (cm ³)				
	Type of Joint	≤ 100	100 < V ≤ 500	500 < V ≤ 1500	1500 < V ≤ 2000
Flange					
6 ≤ W < 9.5	–	–	–	–	–
9.5 ≤ W < 15.8	0.02	0.02	–	–	–
15.8 ≤ W < 25	0.02	0.02	0.02	–	–
25 ≤ W	0.02	0.02	0.02	0.02	0.02
Spigot					
6 ≤ L < 12.5	0.05	0.05	–	–	–
12.5 ≤ L < 25	0.08	0.08	0.08	0.08	–
25 ≤ L < 40	0.08	0.08	0.08	0.08	0.08
40 ≤ L	0.10	0.10	0.10	0.10	0.10
Shafts and Rods					
6 ≤ L < 9.5	0.05	–	–	–	–
9.5 ≤ L < 12.5	0.05	0.05	–	–	–
12.5 ≤ L < 25	0.08	0.08	0.08	0.08	–
25 ≤ L < 40	0.08	0.08	0.08	0.08	0.08
40 ≤ L	0.10	0.10	0.10	0.10	0.10
Shafts with Ball / Roller Bearing					
6 ≤ L < 9.5	0.08	–	–	–	–
9.5 ≤ L < 12.5	0.08	0.08	–	–	–
12.5 ≤ L < 25	0.13	0.13	0.13	0.13	–
25 ≤ L < 40	0.13	0.13	0.13	0.13	0.13
40 ≤ L	0.15	0.15	0.15	0.15	0.15

ANNEX I

Group A – Minimum Widths / Maximum Gaps

U.S. Customary Units

Length of Flamepath (in.)	Maximum Gap of Flamepath (in.) for Enclosure Volumes (in.³)				
	≤ 6	6 < V ≤ 30	30 < V ≤ 90	90 < V ≤ 122	122 < V ≤ 360
Flange					
0.25 ≤ W < 0.38	–	–	–	–	–
0.38 ≤ W < 0.63	0.0008	0.0008	–	–	–
0.63 ≤ W < 1.00	0.0008	0.0008	0.0008	–	–
1.00 ≤ W	0.0008	0.0008	0.0008	0.0008	0.0008
Spigot					
0.25 ≤ L < 0.50	0.002	0.002	–	–	–
0.50 ≤ L < 1.00	0.003	0.003	0.003	0.003	–
1.00 ≤ L < 1.57	0.003	0.003	0.003	0.003	0.003
1.57 ≤ L	0.004	0.004	0.004	0.004	0.004
Shafts and Rods					
0.25 ≤ L < 0.38	0.002	–	–	–	–
0.38 ≤ L < 0.50	0.002	0.002	–	–	–
0.50 ≤ L < 1.00	0.003	0.003	0.003	0.003	–
1.00 ≤ L < 1.57	0.003	0.003	0.003	0.003	0.003
1.57 ≤ L	0.004	0.004	0.004	0.004	0.004
Shafts with Ball / Roller Bearing					
0.25 ≤ L < 0.38	0.003	–	–	–	–
0.38 ≤ L < 0.50	0.003	0.003	–	–	–
0.50 ≤ L < 1.00	0.005	0.005	0.005	0.005	–
1.00 ≤ L < 1.57	0.005	0.005	0.005	0.005	0.005
1.57 ≤ L	0.006	0.006	0.006	0.006	0.006

ANNEX J

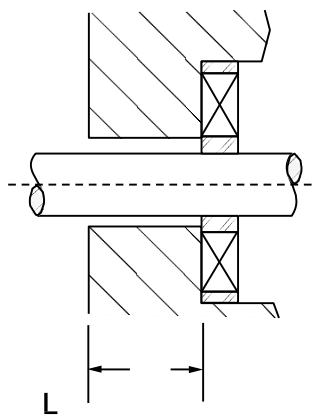
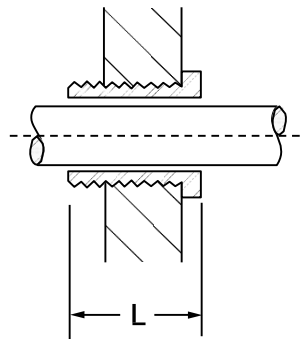
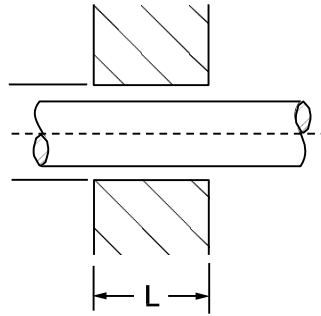
Threaded Joint Groups A, B, C, and D

- Thread pitch for both tapered and parallel threads shall not be finer than that shown in the following table.
- Taper threads shall engage 4½ full threads minimum.
- Parallel (straight) thread engagement shall conform to the following:

Gas Group	Permitted Thread Pitch	Minimum Thread Engagement		
		Fit Class		
		3 (5H/4h)	2 (6H/6g)	1 (7H/8g)
A	≤ 20 thds / in. (≥ 1.27 mm/thd)	6	7	8
B	≤ 32 thds / in. (≥ 0.79 mm/thd)	5	6	7
C & D	≤ 32 thds / in. (≥ 0.79 mm/thd)	5	5	5

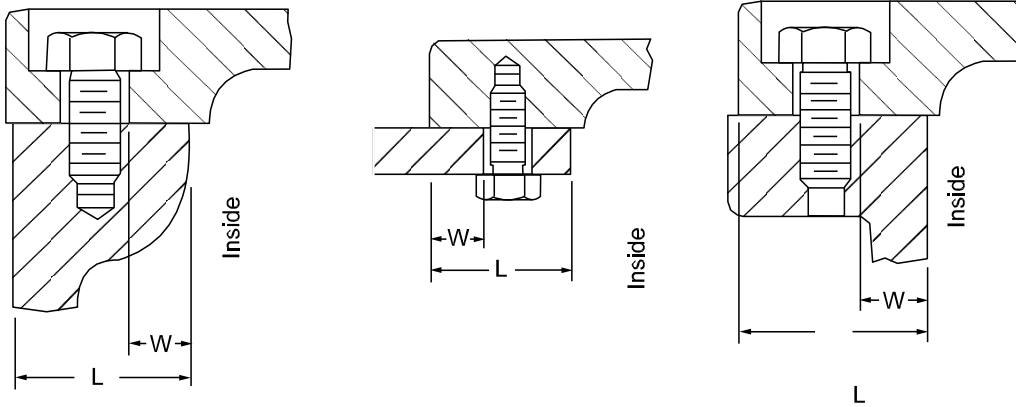
ANNEX K

Shaft / Rod – Sleeve / Bearing Joints



ANNEX K (Continued)

Flamepath Measurements A, B, C, D Flat / Flange Joints



Spigot Joints

