Designation: ~~G175 – 03 (Reapproved 2011)~~ G175 – 13

Standard Test Method for Evaluating the Ignition Sensitivity and Fault Tolerance of Oxygen Pressure Regulators Used for Medical and Emergency Applications[1]

This standard is issued under the fixed designation G175; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

~~1.1 This standard describes a test method for evaluating the ignition sensitivity and fault tolerance of oxygen regulators used for medical and emergency applications.~~

1.1 For the purpose of this standard, a pressure ~~regulator is a device,~~ regulator, also called a pressure-reducing valve, ~~that~~ is a device intended for medical or emergency purposes ~~and~~ that is used to convert a medical or emergency gas pressure from a high, variable pressure to a lower, more constant working pressure [21 CFR 868.2700 (a)]. Some of these oxygen pressure regulators are a combination of a pressure regulator and cylinder valve. These devices are often referred to as valve integrated pressure regulators, or VIPRs.

~~1.3 This standard applies only to oxygen regulators used for medical and emergency applications that are designed and fitted with CGA 540 inlet connections or CGA 870 pin-index adapters (CGA V-1).~~

~~1.4 This standard provides an evaluation tool for determining the fault tolerance of oxygen regulators used for medical and emergency applications. A fault tolerant regulator is defined as (*1*) having a low probability of ignition as evaluated by rapid pressurization testing, and (*2*) having a low consequence of ignition as evaluated by forced ignition testing.~~

1.2 This standard ~~is not a design standard; however, it can be used to aid designers in designing and evaluating the safe performance~~ provides an evaluation tool for determining the ignition sensitivity and fault tolerance ~~capability~~ of oxygen pressure regulators and VIPRs used for medical and emergency ~~applications (Guide~~ applications. An ~~G128).~~ ignition-sensitive pressure regulator or VIPR is defined as having a high probability of ignition as evaluated by rapid pressurization testing (Phase 1). A fault-tolerant pressure regulator or VIPR is defined as having a low consequence of ignition as evaluated by forced ignition testing (Phase 2).

NOTE 1—It is essential that a risk assessment be carried out on breathing gas systems, especially concerning ~~oxygen compatibility (refer to Guides G63 and G94) and~~ toxic product formation due to ignition or decomposition of nonmetallic materials as weighed against the risk of flammability (refer to Guide G63 and ISO 15001.2). See Appendix X1 and ~~X2.1~~ Appendix X2 for details.

1.3 This standard applies only to:

1.3.1 Oxygen pressure regulators used for medical and emergency applications that are designed and fitted with CGA 540 inlet connections, CGA 870 pin-index adapters (CGA V-1), or EN ISO 407 pin-index adapters.

1.3.2 Oxygen VIPRs used for medical and emergency applications that are designed to be permanently fitted to a medical gas cylinder.

1.4 This standard is a test standard not a design standard; *This test standard is not intended as a substitute for traditional design requirements for oxygen cylinder valves, pressure regulators and VIPRs. A well-designed pressure regulator or VIPR should consider the practices and materials in standards such as Guides G63, G88, G94, and G128, Practice G93, CGA E-18, CGA E-7, ISO 15001, ISO 10524-1 and ISO 10524-3.*

NOTE 2—Medical applications include, but are not limited to, oxygen gas delivery in hospitals and home healthcare, and emergency applications including, but not limited to, oxygen gas delivery by emergency personnel.

[1] This test method is under the jurisdiction of ASTM Committee G04 on Compatibility and Sensitivity of Materials in Oxygen Enriched Atmospheres and is the direct responsibility of Subcommittee G04.01 on Test Methods.

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1.5 This standard is also ~~used~~intended to aid those responsible for purchasing or using oxygen pressure regulators and VIPRs used for medical and emergency applications ~~in~~by ensuring that selected pressure regulators are tolerant of the ignition mechanisms that are normally active in oxygen systems.

1.6 This standard does not purport to address the ignition sensitivity and fault tolerance of an oxygen regulator or VIPR caused by contamination during field maintenance or use. ~~Regulator~~ Pressure regulator and VIPR designers and manufacturers should provide design safeguards to minimize the potential for contamination or its consequences ~~(Guide~~ (see Guide G88).

NOTE 3—Experience has shown that the use of bi-direction flow filters in components can lead to accumulation and re-release of contaminants (refer to Guide G88-05 Section 7.5.3.8 and EIGA Info 21/08).

1.7 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

G63 Guide for Evaluating Nonmetallic Materials for Oxygen Service
G88 Guide for Designing Systems for Oxygen Service
G93 Practice for Cleaning Methods and Cleanliness Levels for Material and Equipment Used in Oxygen-Enriched Environments
G94 Guide for Evaluating Metals for Oxygen Service
G128 Guide for Control of Hazards and Risks in Oxygen Enriched Systems
D618 Practice for Conditioning Plastics for Testing
D4066 Classification System for Nylon Injection and Extrusion Materials (PA)
D6779 Classification System for and Basis of Specification for Polyamide Molding and Extrusion Materials (PA)

2.2 *Other ASTM ~~Manual:~~Documents:*[2]

Manual 36 Safe Use of Oxygen and Oxygen Systems
Smith, S. R., and Stoltzfus, J. M., "Preliminary Results of ASTM G175 Interlaboratory Studies," *Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres: Tenth Volume, ASTM STP* 1454, T. A. Steinberg, H. D. Beeson, and B. E. Newton, Eds., ASTM International, West Conshohocken, PA, 2003.
Smith, S. R., and Stoltzfus, J. M., "ASTM G175 Interlaboratory Study on Forced Ignition Testing," *Journal of ASTM International*, Vol. 3, No. 7, Paper ID JAI13542, pp. 314-318.

2.3 *Compressed Gas Association (CGA) Standards:*[3]

CGA E-4 Standard for Gas Pressure Regulators
CGA E-7 Standard for Medical Pressure Regulators
CGA E-18 Medical Gas Valve Integrated Pressure Regulators
CGA G-4 Oxygen
CGA G-4.1 Cleaning Equipment for Oxygen Service
CGA V-1 American National/Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections
CGA V-14 Performance Standard for Sealing Gaskets Used on CGA 870 Connections for Medical Oxygen Service

2.4 *United States Pharmacopeial Convention Standard:*[4]

USP 24 – NF 19 Oxygen monograph

2.5 *Federal Regulation:*[5]

21 CFR 868.2700 (a) Pressure regulator

2.6 *ISO Standards:*[6]

ISO ~~10524~~10524-1 Pressure regulators for use with medical gases — Part 1: Pressure regulators and pressure regulators with flow-metering devices ~~for medical gas systems~~
ISO 10524-3 Pressure regulators for use with medical gases — Part 3: Pressure regulators integrated with cylinder valves
ISO 15001 Anaesthetic and respiratory equipment – Compatibility with oxygen

2.7 *European Industrial Gas Association Documents:*[7]

EIGA Info 21/08 Cylinder Valves—Design Considerations

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Compressed Gas Association (CGA), 4221 Walney Rd., 5th Floor, Chantilly, VA 20151-2923, http://www.cganet.com.

[4] Available from U.S. Pharmacopeia (USP), 12601 Twinbrook Pkwy., Rockville, MD 20852.

[5] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

[6] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[7] Available from European Industrial Gas Association (EIGA), AISBL Avenue des Arts, 3-5-b-1210 Brussels, Belgium, https://www.eiga.eu/.

3. Summary of Test Method

3.1 This test method comprises two phases. A pressure regulator or VIPR must pass both phases in order to be considered ~~ignition resistant and fault tolerant.~~ignition-resistant and fault-tolerant.

3.2 *Phase 1: Oxygen Pressure Shock Test*—In this test phase, ~~fault tolerance is evaluated by testing~~ the ignition ~~resistance~~sensitivity of the pressure regulator design is evaluated by subjecting the pressure regulator or VIPR to heat from oxygen pressure shocks. The test is performed according to ISO ~~10524, Section 11.8.1,~~ 10524–1 Section 6.6 for oxygen regulators, which is similar to CGA ~~E-4.~~E-7 and ISO 10524–3 Section 6.6 for oxygen VIPRs.

3.3 *Phase 2: ~~Regulator Inlet~~ Promoted Ignition Test*—~~In this test phase, fault tolerance is evaluated by subjecting the regulator to the forced application of a positive ignition source at the regulator inlet to simulate cylinder valve seat ignition and particle impact events. The ignition source is representative of severe, but realistic, service conditions. The~~ The Phase 1 component test system is used for Phase 2 to pressure shock a ~~regulator upstream of its inlet~~ pressure regulator or VIPR so that an ignition pill is kindled to initiate combustion within the ~~regulator.~~pressure regulator or VIPR. The ignition source is representative of severe, but realistic, service conditions.

3.3.1 *Oxygen Pressure Regulator*—In this test phase, and for this component type, fault tolerance is evaluated by subjecting the pressure regulator to the forced application of a positive ignition source at the pressure regulator inlet to simulate cylinder valve seat ignition and particle impact events.

3.3.2 *Oxygen VIPR*—In this test phase and for this component type, fault tolerance is evaluated by subjecting the VIPR to the forced application of a positive ignition source at the cylinder connection port to simulate a shut-off valve seat ignition and particle impact events in the use (not cylinder filling mode) configuration.

4. Significance and Use

4.1 This test method comprises two phases and is used to evaluate the ignition sensitivity and fault tolerance of oxygen pressure regulators used for medical and emergency applications.

4.2 *Phase 1: Oxygen Pressure Shock Test*—The objective of this test phase is to determine whether the heat or temperature from oxygen pressure shocks will result in burnout or visible heat damage to the internal parts of the ~~regulator. Phase 1 is performed according to ISO 10524, Section 11.8.1.~~pressure regulator.

4.2.1 The criteria for ~~an acceptable~~a valid test are specified in ISO ~~10524, Section 11.8.1.~~10524–1, Section 6.6 for oxygen pressure regulators and ISO 10524–3, Section 6.6 for oxygen VIPRs.

4.2.2 The pass/fail criteria for a pressure regulator are specified in ISO ~~10524, Section 11.8.1.~~10524–1, Section 6.6 for oxygen pressure regulators and ISO 10524–3, Section 6.6 for oxygen VIPRs.

4.3 *Phase 2: ~~Regulator Inlet~~ Promoted Ignition Test*—~~The objective of this test phase is to determine if an ignition event upstream of the regulator inlet filter will result in sustained combustion and burnout of the regulator.~~

4.3.1 *Oxygen Pressure Regulator*—The ~~criterion for an acceptable test is either, (~~objective of this test phase is to determine~~1) failure of the regulator, which is defined as the breach of the pressurized regulator component (burnout) and ejection of molten or burning metal or any internal parts from the regulator, or (~~ if an ignition event upstream of the pressure regulator inlet filter will result in sustained combustion and burnout of the pressure regulator.~~2) if the regulator does not fail, consumption of at least 90 % of the ignition pill as determined by visual inspection or mass determination. Failure of the regulator at the seal ring does not constitute an acceptable test.~~

4.3.1.1 The criterion for a valid test is either, (*1*) failure of the pressure regulator, as defined in 4.3.1.2, or (*2*) if the pressure regulator does not fail, consumption of at least 90 % of the ignition pill as determined by visual inspection or mass determination.

4.3.1.2 Failure of the pressure regulator is defined as the breach of the pressurized regulator component (burnout), which may include the CGA 870 seal ring, and ejection of molten or burning metal or any parts, including the gauge, from the pressure regulator. See Appendix X6 Testing Pressure Regulators and VIPRs with Gauges. However, momentary (less than 1 s) ejection of flame through normal vent paths, with sparks that look similar to those from metal applied to a grinding wheel, is acceptable and does not constitute a failure.

4.3.2 *Oxygen VIPR*—~~Momentary (less than 1 s) ejection of flame through normal vent paths, with sparks that look similar to those from metal applied to a grinding wheel, is acceptable.~~The objective of this test is to determine if an ignition event upstream of the shut-off valve or within the shut-off valve will result in sustained combustion and burnout of the VIPR, while the VIPR is flowing oxygen in the patient-use direction.

4.3.2.1 The criterion for a valid test is either, *(1)* failure of the VIPR as defined in 4.3.2.2, or *(2)* if the VIPR does not fail, consumption of at least 90 % of the ignition pill as determined by visual inspection or mass determination. Although the intent and desired result is to provide sufficient energy to ignite the shut-off valve seat, ignition of the shut-off valve seat is not required for a valid test. See Rationale in Appendix X7.

4.3.2.2 Failure of the VIPR is defined as the breach of the pressurized VIPR component (burnout) and ejection of molten or burning metal or any parts, including the gauge, from the VIPR. See Appendix X6 Testing Pressure Regulators and VIPRs with Gauges. However, momentary (less than 1 s) ejection of flame through normal vent paths, with sparks that look similar to those from metal applied to a grinding wheel, is acceptable and does not constitute a failure.

4.3.3 There is no requirement that the oxygen pressure regulator or oxygen VIPR be functional after being subjected to the promoted ignition test.

NOTE 4—The criterion for both the pressure regulator and VIPR Phase 2 tests does not include evaluation of external hardware (such as plastic guards and bags) that could be subjected to a momentary ejection of flame through normal vent paths.

5. Apparatus

5.1 Both phases of this test ~~will~~shall be performed in a test system as specified by ISO ~~10524.~~10524-1 and ISO 10524-3.

5.2 Fig. 1 depicts a schematic representation of a typical pneumatic impact test system that complies with ISO ~~10524.~~10524-1 and ISO 10524-3.

5.3 The ambient temperature surrounding the pressure regulator or VIPR must be 70 ± 9°F (21 ± 5°C) for both phases of this test. For Phase 2 testing, the initial test gas temperature ~~can range from 50 to 140°F (10 to 60°C).~~shall be 140 ± 5.4°F (60 ± 3°C).

6. Materials

6.1 For both phases of testing, the ~~regulator must~~ pressure regulator or VIPR shall be functional and in its normal delivery condition and ~~must~~shall be tested as supplied by the manufacturer. ~~If a regulator is supplied with~~For further information, see Section 8.2.2.1 ~~a filter, perform the test with~~for pressure regulators and Section 8.2.3.1 ~~the filter installed. If a~~ for VIPRs. If a prototype or nonproduction unit is used to qualify the design, it ~~must~~shall be manufactured using design tolerances, materials, and processes consistent with a production unit. A possible total of eight pressure regulators or VIPRs will be ~~tested;~~tested: three in Phase 1 and five in Phase 2. If the ~~regulators~~ test articles from Phase 1 are undamaged, they may be reassembled and used for Phase 2.

6.2 *Ignition Pill Manufacture and Assembly*—Follow these steps to manufacture and assemble the ignition pill used for Phase 2 testing. Use the materials listed in Table 1 to manufacture the ignition pills. ~~Total~~ The total required energy for the ignition pill is 500 ± 50 ~~cal.~~cal (2093 ± 209 J) for pressure regulators and 200 ± 20 cal (837 ± 84 J) for VIPRs. See Appendix X7, Development of 200 Cal Ignition Pill for VIPRs. The ignition pill casing consists of a cup and layers of sheeting. The cup and sheeting shall be constructed of polyamide (PA66 or PA6). Both the PA66 and PA6 shall be procured using the appropriate classification per Classifications D4066, or D6779, or both. This classification shall be documented and made part of the quality record.

NOTE 5—The ignition pill was developed to simulate both particle impact events and cylinder valve seat ignition. Particle impact events are simulated by iron/aluminum powder within the ignition pill. Nonmetallic promoters within the ignition pill simulate cylinder valve seat ~~ignition.~~ ignition for pressure regulators. The nonmetallic promoters are also used to bind and kindle ignition of the metallic ~~powder.~~powder and the shut-off valve seat for VIPRs.

6.2.1 *Forming the Cup:*

6.2.1.1 Turn the ~~nylon~~polyamide rod (see Table 1) down to 0.28 +0/-0.0025 in. ~~OD~~ (7.11 +0/-0.064 mm) ~~OD.~~OD for the 500 cal pill and 0.188 +0/-0.0025 in. (4.78+0/-0.064mm) OD for the 200 cal pill.

6.2.1.2 Place the rod in the brass sealing fixture (Fig. 2), sand the rod face flat, and remove any noticeable burrs.

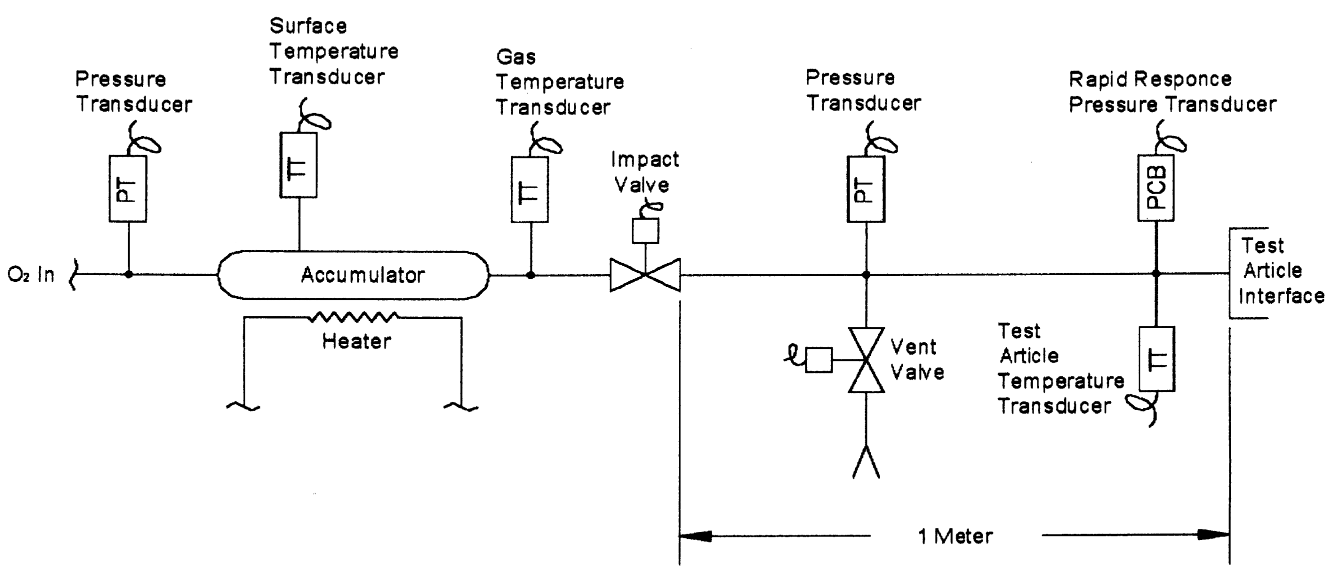


FIG. 1 Typical Test System Configuration

TABLE 1 Ignition Pill Materials and Characteristics

Materials for Phase 2 Ignition ~~Pill~~	~~Possible Source~~	~~Total Required~~ Energy
~~Nylon 6/6 rod stock~~	~~Cylinder valve seat~~	
~~Polyamide sheet (2 mil)~~	~~Cylinder valve stem lubricant~~	
~~Aluminum powder (325 mesh)~~	~~Contaminant from bottle~~	~~500 ± 50 cal~~
~~Iron powder (325 mesh)~~	~~Contaminant from bottle~~	

TABLE 1 Ignition Pill Materials and Characteristics

Materials for Phase 2 Ignition Pills (both 500 and 200 cal)	Standard or Specification	Representing Possible Source of Combustion Energy
Polyamide (PA66 or PA6) rod stock	D4066 or D6779, or both	Cylinder valve seat or shut-off valve seat
Polyamide (PA66 or PA6) sheet, 2 mil	D4066 or D6779, or both	Cylinder valve stem lubricant or shut-off valve stem lubricant
Aluminum powder (325 mesh)	≥ 99.5% Al	Contaminant from cylinder
Iron powder (325 mesh)	≥ 99.5% Fe	Contaminant from cylinder

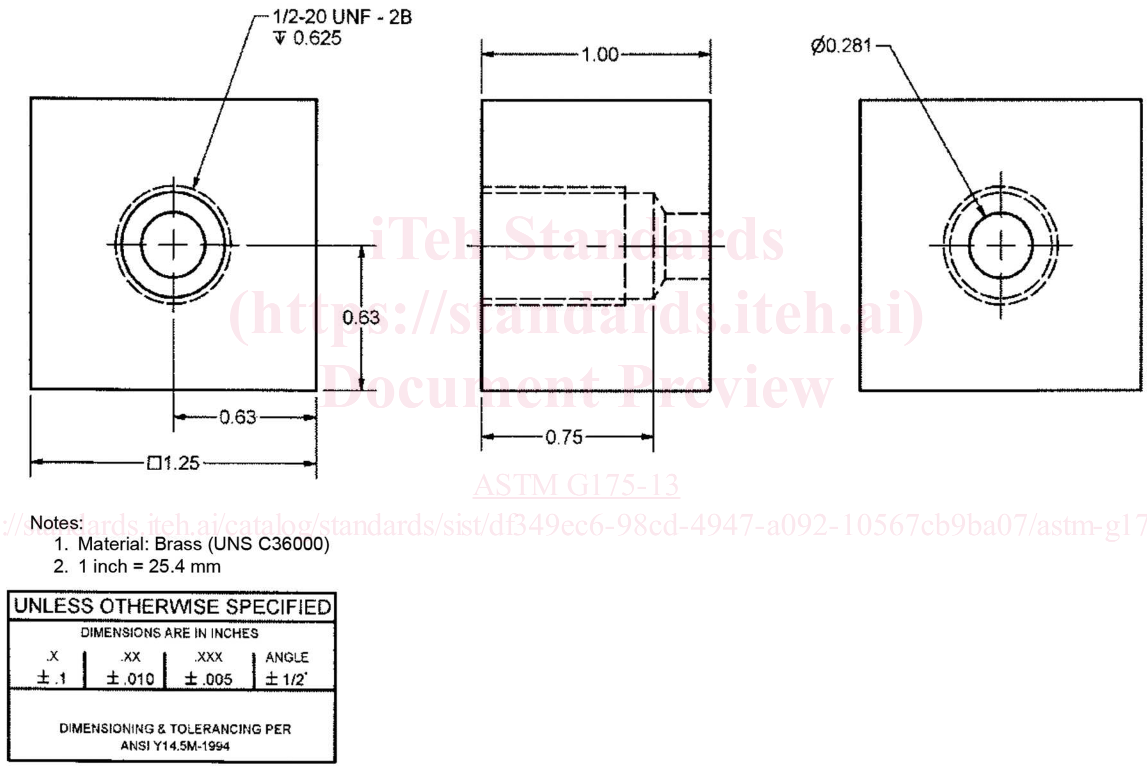


FIG. 2 Brass Sealing Fixture

NOTE 6—Fig. 3 shows the ~~nylon~~polymide rod held in the sealing fixture for sanding.

6.2.1.3 Use a 3⁄16 in. (4.76 mm) dia end mill to bore an ~0.06 in. (1.52 mm) deep cavity in the rod to form a ~~cup.~~cup for the 500 cal pill. Use a 5⁄32 in. (3.97 mm) dia end mill to bore an ~0.025 in. (0.64 mm) deep cavity in the rod to form a cup for the 200 cal pill.

6.2.1.4 Cut the cup from the rod.

NOTE 7—The cup should be slightly taller than 0.13 in. (3.30 ~~mm).~~ mm) for the 500 cal pill and slightly taller than 0.065 in. (1.65 mm) for the 200 cal pill. This is an initial pill height; the final pill height is achieved after sanding and is based on the required final pill weight.

6.2.1.5 Using a #69 drill, drill a hole completely through the center of the bottom of the cup. If necessary, square the bottom of the cup with a file to ensure it sits flat and will not tip over.

NOTE 8—The pill base and dimensions are shown in Fig. 4~~.~~ and Fig. 18 for the 500 and 200 cal pills, respectively.

6.2.2 *Sealing the Bottom of the Cup:*

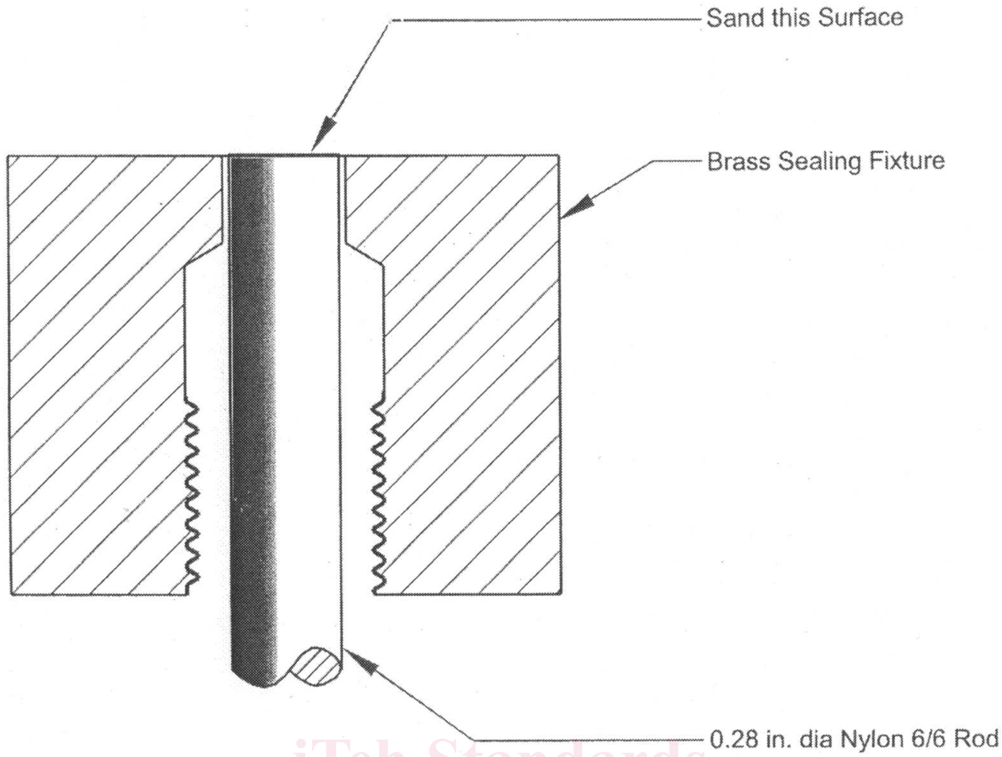


FIG. 3 ~~Nylon~~Polymide Rod in Sealing Fixture

6.2.2.1 Put the cup and ~~nylon~~polyamide push tool (Fig. 5) into the brass sealing fixture and adjust the push tool so that the top of the cup is just slightly below the surface of the sealing fixture.

NOTE 9—If the top of the cup is not situated in the sealing fixture just slightly below the surface, the heat of the soldering iron could deform the top of the cup.

6.2.2.2 Place one layer of polyamide sheet in the bottom of the cup and cover it with ~~Kapton tape,~~ polyimide tape (PI), with the adhesive side facing away from the pill.

NOTE 10—The ~~Kapton~~PI tape is used as a mold release and does not remain attached to the final pill. If the adhesive side faces the pill, it will add an undesired residue to the pill. The recommended PI tape for mold release is a 1 mil (25.4 micron) PI film with a single side coat of acrylic adhesive.

6.2.2.3 Seal the polyamide to the bottom of the cup using a soldering iron tip (Fig. 6). Ensure that heat is applied evenly around the perimeter of the inside cup bottom so as to melt the polyamide sheet to the bottom of the cup.

NOTE 11—The soldering iron temperature should be approximately 450°F (232°C).

6.2.2.4 Remove the ~~Kapton~~PI tape and the remaining polyamide sheet.

NOTE 12—The polyamide sheet should easily tear away from the bottom of the cup, leaving a disc of polyamide sealed to the bottom of the cup. If it does not, the ignition pill has not been sealed properly, and the procedure should be repeated.

6.2.3 *Filling the Cup:*

6.2.3.1 Place the cup on a scale capable of ~~a~~ resolution to 0.1 mg and zero the scale.

6.2.3.2 ~~Add~~ For the 500 cal pill, add 10 ± 1 mg aluminum powder and 3 ± 1 mg iron powder to the cup. For the 200 cal pill, add 6 ± 1 mg aluminum powder and 3 ± 1 mg iron powder to the cup. Put the aluminum powder in the cup first, then the iron.

NOTE 13—If too much iron is added to the pill, a magnetic spatula may be used to remove iron from the cup.

6.2.3.3 After filling the cup, push any metallic powder on the top surface of the cup into the cup.

NOTE 14—A small paintbrush can be used for this purpose. This is a critical step in making the pill, and it is important to ensure that no material remains on the surface to inhibit a proper heat seal.

6.2.4 *Sealing the Cup:*

6.2.4.1 Put the cup and the ~~nylon~~polyamide push tool into the brass sealing fixture and adjust the push tool so that the top of the cup is just slightly below the surface of the sealing fixture.

NOTE 15—If the top of the cup is not situated in the sealing fixture just slightly below the surface, the heat of the soldering iron could deform the top of the cup.

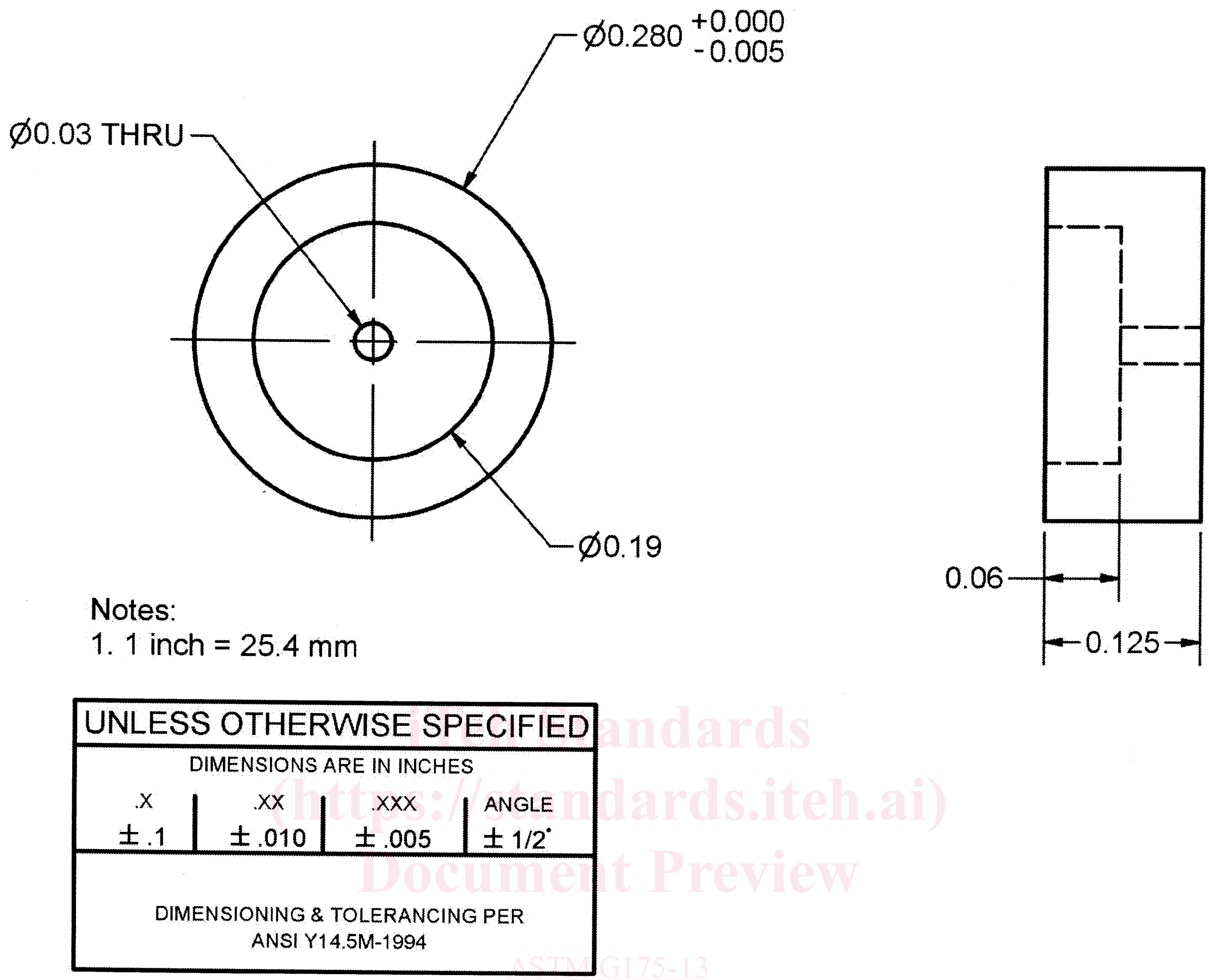


FIG. 4 Pill Base (500 cal)

6.2.4.2 Place one layer of polyamide sheet over the top of the cup, then cover the polyamide sheet with ~~Kapton~~PI tape.

6.2.4.3 Place a copper seal tip (Fig. 7) onto the tip of the soldering iron.

NOTE 16—The copper seal tip temperature should be approximately 450°F (232°C).

6.2.4.4 Hold the soldering iron perpendicular to the top of the cup, rotate the soldering iron slightly, and apply heat until the polyamide sheet is sealed to the top of the cup (Fig. 8). Let the cup cool for ~1 min before removing the remaining polyamide sheet and ~~Kapton~~PI tape. Repeat this process until the cup is capped with five layers of polyamide sheet (Fig. 9).

NOTE 17—If the cup is sealed properly, a disc of the polyamide sheet will be sealed to it and the remainder of the sheet will easily pull off. It is especially critical to ensure the first layer of polyamide sheet is completely sealed to the top of the cup, or else the pill contents will leak out and render the pill unusable.

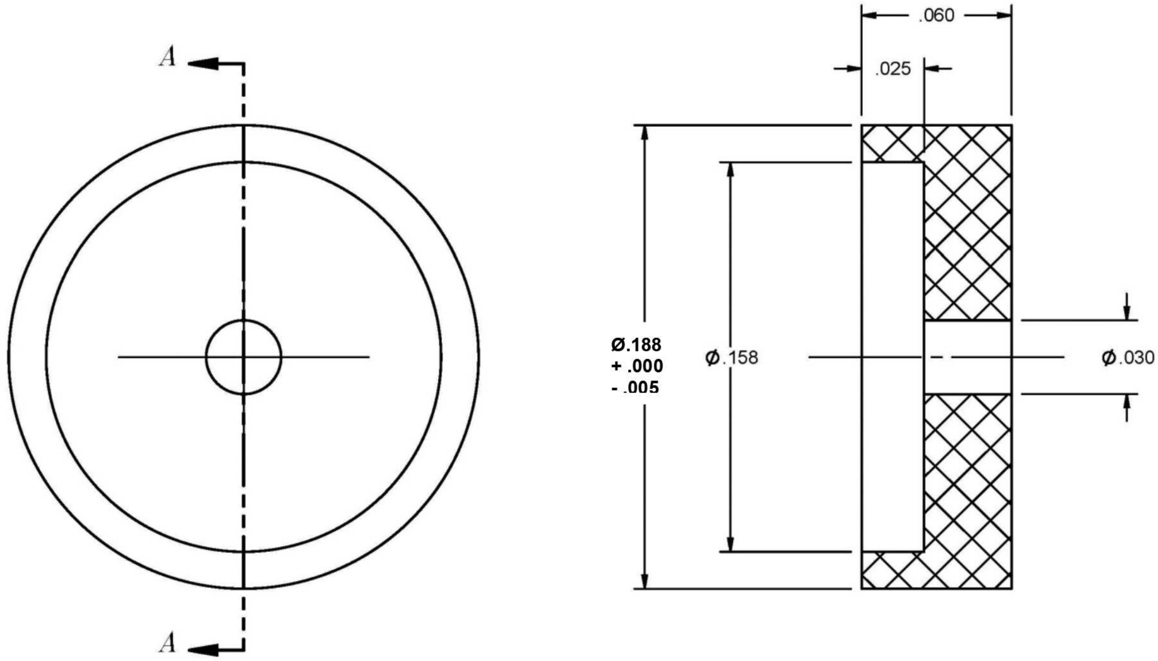
6.2.4.5 Once the pill is properly sealed and cooled, remove it from the brass sealing fixture. Place the pill upside down in the sealing fixture so that the pill bottom is exposed.

NOTE 18—Take care to ensure that the pill is properly squared in the fixture so that it can be properly sanded. If the pill is not squared in the sealing fixture, the cup bottom can be sanded open, thus exposing the metallic powder and ruining the pill.

6.2.4.6 Using a belt or palm sander, sand the pill until a final weight of 67 ± 1 mg ~~is achieved.~~ and 29 ± 1 mg is achieved for the 500 and 200 cal pills, respectively. Use the push tool to remove the pill from the sealing fixture.

6.2.5 *Storing the Pill*—The manufactured pills shall be stored in a dry atmosphere (e.g. in a desiccant container or in a sealed bag with a desiccant) for a minimum of 24 hours prior to use. Conditioning at 24/23/0 per Guide D618 has been shown to yield successful results for the polyamide materials in this application.

6.3 *Adapter Block and Pill Holder Manufacture*—Adapter blocks and pill holders for pressure regulators with CGA 540 inlet connections shall be made according to the drawings shown in Figs. 10 and 11. An alternative CGA 540 adaptor block and pill



Notes:
1. Material: Polyamide (PA66 or PA6)
2. Unless otherwise specified, dimensions are in inches
3. 1 inch = 25.4 mm

SECTION A-A

FIG. 18 VIPR Pill Base (200 Cal)

holder is provided in Fig. X4.1 and Fig. X4.2. Adapter blocks and pill ~~holders for regulators with CGA 870 pin-index adapters~~holders, adapter couplings and pill retainers for VIPRs shall be made according to the drawings shown in Figs. 12 and 13. Pill holders, adapter couplings and pill retainers for VIPRs shall be made according to the drawings shown in Fig. 16, Fig. 17, Fig. 19 and Fig. 20. All adapter blocks, pill holders, adapter couplings and pill retainers shall be constructed of Brass UNS C36000.

6.4 For Phase 1 testing, the minimum oxygen concentration shall be of 99.5 % purity and shall not contain more than 10 ppm hydrocarbons. For Phase 2 testing, the minimum oxygen concentration shall conform to USP 24-NF 19, Type 1, or shall be of 99.0 % purity. Oxygen of higher purity may be used, if desired.

7. Safety Precautions

7.1 This test can be hazardous. The test cell shall be constructed of fire- and shrapnel-resistant materials in a manner that shall provide protection from the effects of test system component rupture or fire that could result from ~~regulator~~ test article reaction or failure of a test system component. Normal safety precautions applicable to the operation and maintenance of high-pressure gas systems ~~must~~shall be followed when working with the test system.

7.1.1 Complete isolation of personnel from the test system is required whenever the test cell contains a ~~regulator~~ test article and is pressurized above atmospheric pressure with oxygen. Violent reactions between ~~regulators~~ test articles and high-pressure oxygen must be expected at all times. Test cell component failure caused by violent ~~regulator~~ test article reaction has produced shrapnel, flying ejecta, dense smoke, and high-pressure gas jets and flames inside the test cell. Test cell design and layout, test procedures, personnel access controls, and emergency shutdown procedures ~~must~~shall be designed with this type of failure expected at any time the test system contains oxygen.

7.1.2 Complete isolation can be assured by locating the test apparatus in an enclosure and behind a barricade. The operator should be stationed in a control room opposite the barricade from the test cell. Visual observation of the test cell shall be accomplished by an indirect means such as a periscope, mirrors, or closed-circuit television.

7.1.3 Equipment used in a high-pressure oxygen system ~~must~~shall be properly designed and rated for oxygen service. Proper design of high-pressure oxygen systems includes designing for minimum internal volumes, thereby limiting the magnitude of catastrophic reactions that may occur while testing a ~~regulator.~~ pressure regulator or VIPR. Components used in the test system, such as valves, pressure regulators, ~~gages,~~gauges, filters, and the like shall be fabricated from materials that have a proven record of suitability for high-pressure oxygen service. Examples of such materials are Monel 400, nickel, and selected stainless steels.

7.1.3.1 High-pressure oxygen systems require the utmost cleanliness ~~(Practice~~ (see Practice G93). Therefore, test system components should be designed to facilitate disassembly, thorough cleaning, and reassembly without compromise of the cleanliness level. Screening tests performed on nonmetallic materials have shown that the impact sensitivity of these materials can

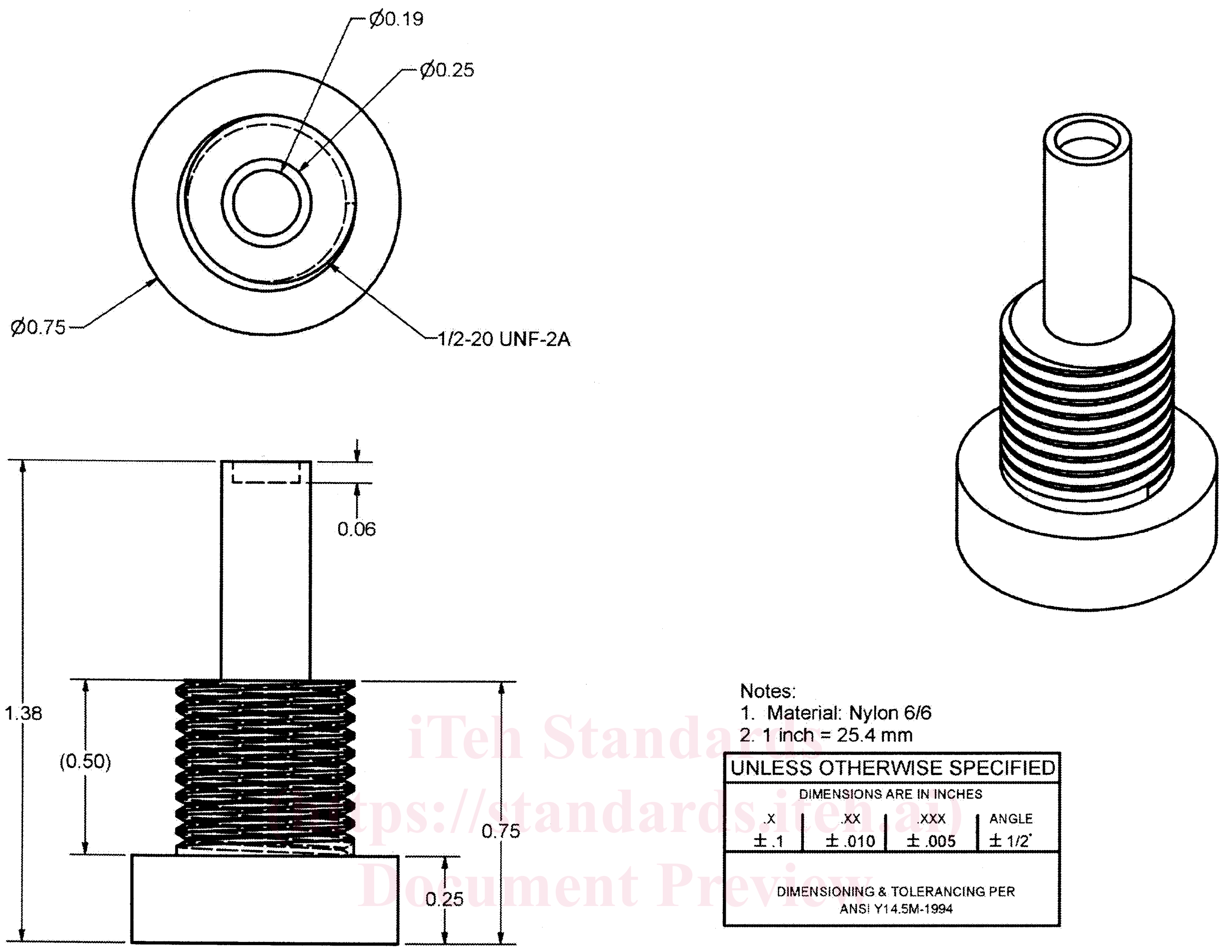


FIG. 5 ~~Nylon~~Polyamide Push Tool

vary from batch to batch. Because nonmetallic materials are usually the most easily ignited components in a high-pressure oxygen system, nonmetallic items to be used in this test apparatus such as seats, seals, and gaskets should be chosen from the best (that is, least sensitive) available batch of material. Preferably, two valves ~~shall~~should be provided between the high-pressure oxygen source and the ~~regulator~~ test article interface. These valves shall be closed, and the test cell and the volume between the two valves shall be continuously vented to atmospheric pressure, before personnel perform work on the ~~regulator.~~test article.

7.2 When testing is to be performed at an elevated temperature, normal safety precautions applicable to the operation and maintenance of electrical systems ~~must~~shall be followed.

7.3 **Caution:** Approved eye protection shall be worn in the test area at all times. Other protective equipment such as gloves and ear protection shall be required if the system vent is adjacent to the test system or if the audible levels are expected to be greater than the OSHA limits.

7.4 No personnel shall be permitted in the test cell when remotely controlled valves are operated or when testing is in progress.

7.5 The test area shall be maintained safe and clean.

7.6 **Warning:** Oxygen vigorously accelerates combustion. Keep oil and grease away. Do not use oil or grease on ~~regulators, gages,~~test system valves, pressure regulators, gauges, or control equipment. Use only equipment conditioned for oxygen service by carefully cleaning to remove oil, grease, and other combustibles. Keep combustibles away from oxygen and eliminate ignition sources. Keep surfaces clean to prevent ignition or explosion, or both, on contact with oxygen. Always use a pressure regulator to reduce the pressure where possible. Fully reduce the ~~regulator before opening upstream cylinder valve.~~test system pressure regulator (set this regulator to deliver a pressure of 0) before opening the cylinder valve(s). All equipment and containers used shall be suitable and recommended for oxygen service. Never attempt to transfer oxygen from a cylinder in which it is received to any other cylinder. Do not mix gases in cylinders. Do not drop ~~cylinder.~~cylinders. Make sure ~~cylinder is~~cylinders are secured and positioned upright at all times. Keep the cylinder ~~valve~~valve(s) closed when not in use. Stand away from the cylinder valve outlet

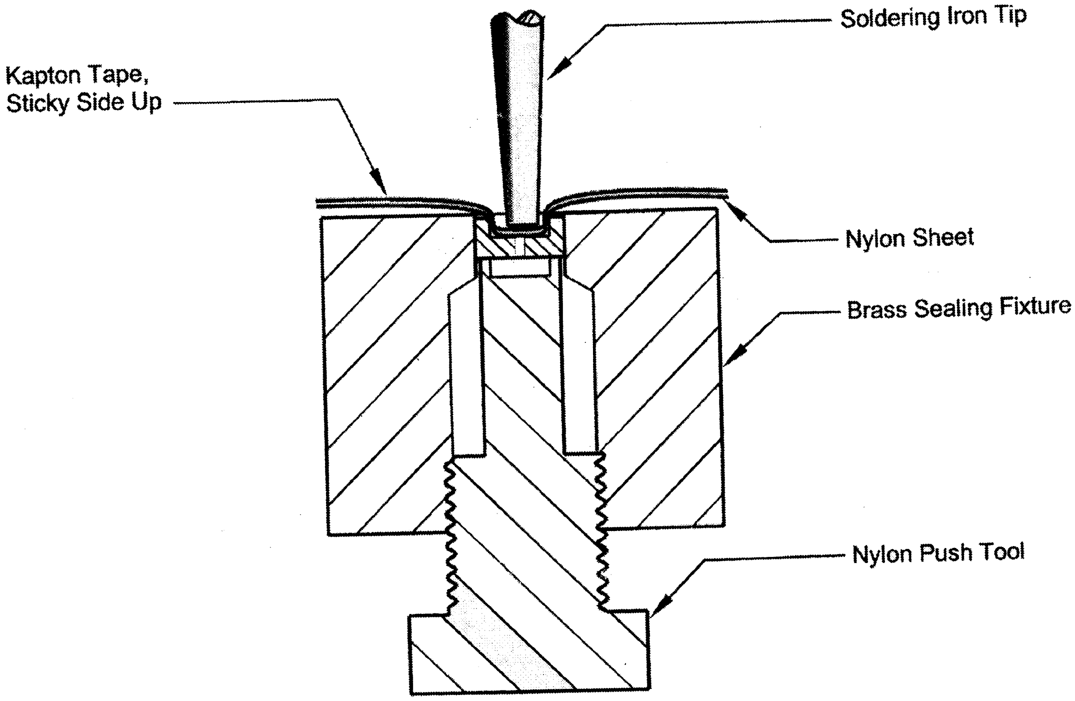


FIG. 6 Sealing the Bottom of the Cup

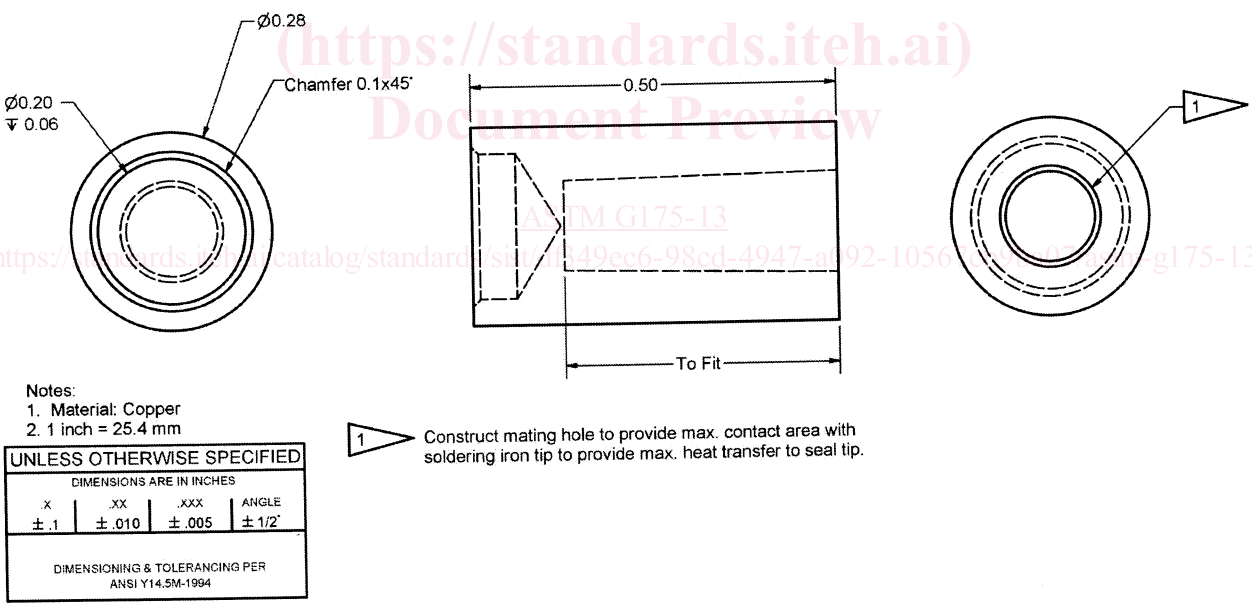


FIG. 7 Copper Seal Tip

when opening a cylinder valve. Keep ~~cylinder~~cylinders out of the sun and away from heat. Keep ~~cylinder~~cylinders away from corrosive ~~environment.~~environments. Do not use ~~an~~ unlabeled, dented, or damaged ~~cylinder.~~cylinders.

7.7 See Guides G63, G88, Practice G93, Guides G94, G128 and Compressed Gas Association publications G-4 and G-4.1 for additional information regarding safe practice in the use of oxygen.

8. Procedure

8.1 *Phase 1: Oxygen Pressure Shock Test*—~~Phase 1 is performed according to ISO 10524, Section 11.8.1.~~

8.1.1 Phase 1 is performed according to ISO 10524–1 Section 6.6 for oxygen pressure regulators.

8.1.2 Phase 1 is performed according to ISO 10524-3 Section 6.6 for oxygen VIPRs.