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Standard Test Method for Abrasion Resistance of Refractory Materials at Room Temperature[1]

This standard is issued under the fixed designation C704/C704M; 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.

~~ε1 NOTE—Section 2 was corrected editorially in August 2009.~~

1. Scope

1.1 This test method covers the determination of relative abrasion resistance of refractory brick at room temperature. This test method can also be applied to castable refractories (see Metric Dimensions, Practice C861 and Practice C865) and plastic refractories (see Practice C1054).

1.2 *Units*~~—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.~~ —When values are stated in both SI and inch-pound units, the units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, use each system independently of the other. Combining values from the two systems may result in non-conformance with the standard. Several values are stated only in SI units as a matter of convention and to permit comparison of results. Included are the abrading media weight (grams), specimen weight (grams), specimen weight loss due to abrasion (grams), and the resultant volume loss (cubic centimeters).

1.3 *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:*~~ *ASTM Standards:*[2]

A681 Specification for Tool Steels Alloy
C134 Test Methods for Size, Dimensional Measurements, and Bulk Density of Refractory Brick and Insulating Firebrick
C179 Test Method for Drying and Firing Linear Change of Refractory Plastic and Ramming Mix Specimens
C861 Practice for Determining Metric Dimensions of Standard Series Refractory Brick and Shapes
C862 Practice for Preparing Refractory Concrete Specimens by Casting
C865 Practice for Firing Refractory Concrete Specimens
C1036 Specification for Flat Glass
C1054 ~~Practice for Pressing and Drying Refractory Plastic and Ramming Mix Specimens~~ Practice for Pressing and Drying Refractory Plastic and Ramming Mix Specimens
D4285 Test Method for Indicating Oil or Water in Compressed Air

2.2 *American Society of Mechanical Engineers (ASME) Standard:*

B40.100 Pressure Gauges and Gauge Attachments

2.3 *ASTM Adjuncts:*

Abrasion Tester (1 dwg)[3]

[1] This test method is under the jurisdiction of ASTM Committee C08 on Refractories and is the direct responsibility of Subcommittee C08.03 on Physical Properties.

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[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 ASTM International Headquarters. Order Adjunct No. ADJC0704. Original adjunct produced in **1970**.~~

[3] Detailed prints for the construction of the test chamber are available at a nominal cost from ASTM International Headquarters. Order Adjunct No. ADJC0704. An acceptable test chamber can be made from a weatherproof electrical switch box.

3. Summary of Test Method

3.1 This test method measures the volume of material in cubic centimetrers abraded from a flat surface at a right angle to a nozzle through which 1000 g of size-graded silicon carbide grain is blasted by air at ~~448 kPa [65 psi].~~ a prescribed air pressure.

4. Significance and Use

4.1 This test method measures the relative abrasion resistance of various refractory samples under standard conditions at room temperature.

4.2 The abrasion resistance of a refractory material provides an indication of its suitability for service in ~~abrasion or erosive~~abrasive environments.

4.3 The results obtained by this test method could be different than those obtained in service because of the different conditions encountered.

5. Interferences (Factors known to Affect Results)

5.1 During development, a ruggedness test was performed using 114 by 114 by 12.7 mm [4½ by 4½ by ½ in.] float glass plates conforming to Specification C1036. Several factors were found to cause statistically significant effects on measured results (see Section 10).

5.1.1 *Nozzle Tube Inside Diameter*—~~v~~Variation in the inside diameter of the flint glass nozzle tube statistically affected the abrasion values obtained on the glass plate. Ideal glass tube inside diameter is 4.8 mm. Glass tube lots purchased as 7 mm outside diameter tube with a nominal 1.1 mm wall thickness can have inside diameters ranging from 4.6 mm to 5.0 mm. For the ruggedness test, flint glass tube inside diameters of 4.7 mm and 4.9 mm were used. Take the statistically significant effect of this small tube inside diameter variation ~~must be taken into consideration~~ into consideration. Individually measure and choose all nozzle ~~tube should be individually measured and chosen~~tubes to conform to a specified 4.8 mm inside diameter.

5.1.2 *Air Pressure*—~~v~~Variation in the test air pressure statistically affected the abrasion values obtained on the glass plate. Air pressure as specified in ~~the~~this test method is 448 kPa [65 psi] measured by a gauge capable to ± 6.9kPa [± 1 psi]. For the ruggedness test, air pressure was maintained at values of 441 kPa [64 psi] and 455 kPa [66 psi] by the use of a calibrated master series pressure gauge. Take the statistically significant effect of this small air pressure variation ~~must be taken~~ into consideration and use only ~~calibrated~~ gauges ~~capable of maintaining 448 kPa [65 psi] air pressure be used.~~ as specified in 6.1.5. It is also recommended that air gauges be recalibrated at frequent intervals.

~~5.2 Factors which~~ 5.2 Factors that were found to be rugged during the test method evaluation ~~were~~ *were: (1) particle size variation of the silicon carbide grain between sizings of grain composed of 25% 20 mesh~~×~~ by 30 mesh and 75% 30 mesh~~×~~ by 50 mesh silicon carbide to one composed of 15% 20 mesh~~×~~ by 30 mesh and 85% 30 mesh~~×~~ by 50 mesh silicon carbide sizing, (2) nozzle to sample distance varying between 200 mm [7 ⅞ in.] to 206 mm [8⅛ ~~in],~~ i.n], (3) silicon carbide grit amount between 995 g and 1005 g, and (4)test operator.*

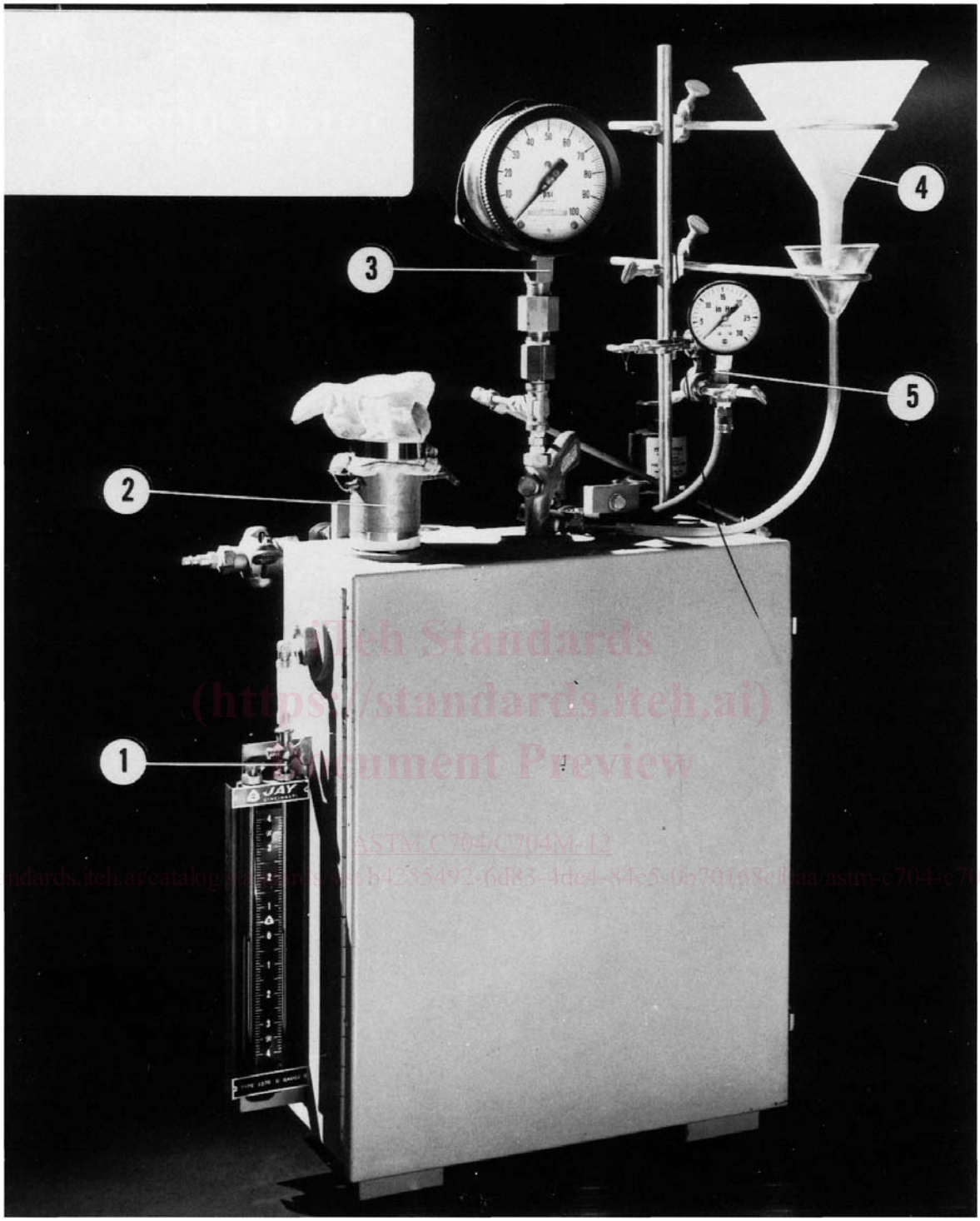
6. Apparatus

6.1 *Abrasion Tester*, used for measuring the abrasion resistance of refractory specimens, consisting of the following (Fig. 1 and Fig. 2):

6.1.1 *Blast Gun (Leitch Carco Gun Model LC-CG)*[4], modified for this equipment as shown in Fig. 3. Other sand blast gun models or types may affect test results.

6.1.2 *Nozzle*—~~A piece of glass tubing is used to replace the steel nozzle supplied with the sand-blast gun to permit control of nozzle size through nozzle replacement after each determination. Flint-glass tubing, 115 mm [4½ in.] long, 7 mm [0.276 in.] in outside diameter, with a measured 4.8 mm inside diameter, is used. This piece of glass tubing is held in place by a 70 mm [2¾ in.] long piece of stainless steel or copper tubing. The I.D. (inside diameter) of this tubing, which should be flared at one end to sit snugly inside a 9.53 mm [⅜ in.] tubing nut, should be 7.15 to 7.75 mm [⁹⁄₃₂~~ —Make the nozzle from a piece of flint-glass tubing, 115 mm [4 ½ in.] long, 7 mm [0.276 in.] ± 0.12 mm [0.005 in.] outside diameter, with a 1.1 mm [0.043 in.] ± 0.03 mm [0.001 in.] wall thickness. When the Carco Blast Gun is used, this will replace the steel nozzle supplied with the gun. Cleanly cut the ends of the glass tube and do not fire polish them. Check the length and diameter of each tube prior to use. The diameter may be checked by the use of a gage consisting of a tapered stainless steel rod with the 4.8 mm (³⁄₁₆ in.) diameter marked on the rod. The glass tubing is held in place by a 70 mm (2¾ in.) long piece of stainless steel or copper tubing with an inside diameter of 7.15 to 7.75 mm [⁹⁄₃₂ to ⅝ in.] and an outside diameter of 9.53 mm [⅜ in.]. ~~The O.D. (outside diameter) should be~~ Flare the tubing at one end to sit snugly inside a 9.53 mm [⅜ in.] tubing nut. This sleeve is glued or soldered in place inside the 9.53 mm [⅜ in.] tubing nut, and is used primarily to hold the glass tubing perpendicular to the test sample, ~~assuring~~ensuring a proper vacuum within the gun. The end of the glass tube through which the abrading media enters the nozzle in the venturi ~~chamber,~~chamber is inserted into a 15.9 mm [⅝ in.] outside diameter, 6.4 mm [¼ in.] inside diameter rubber grommet ~~of~~with a thickness ~~between~~of 4.75 to 6.4 mm

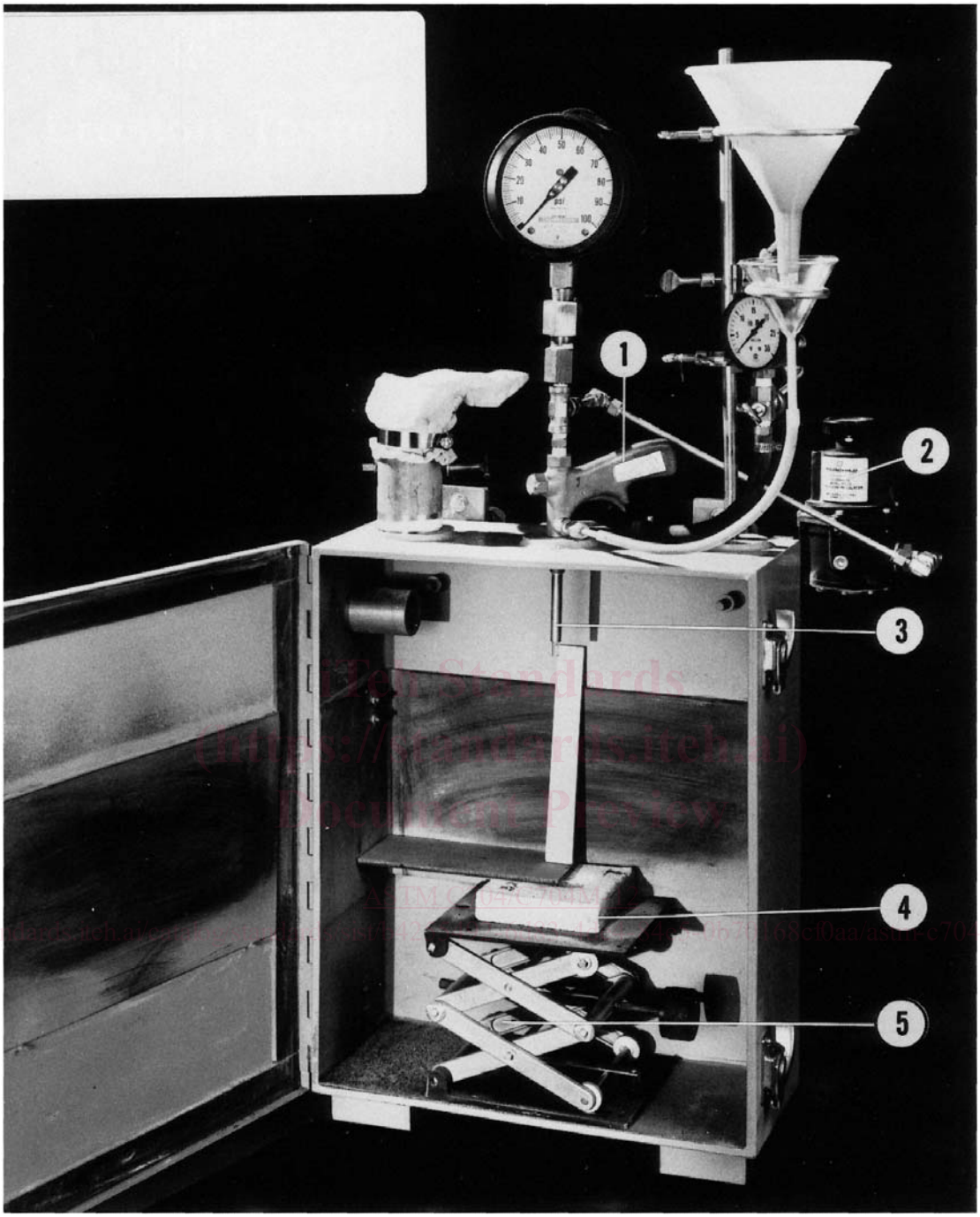
[4] The sole source of supply of the apparatus known to the committee at this time is Leitch & Company, 106 Abram Court, San Leandro, CA 64577. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.



~~FIdentified by number in this figure are: (G. 1) ca Abinet pressure manometer, (2) dust ciollector vent, (3) t Test pressure gage, (4) grit feed tunnel, and (5) vacuum gage.~~

NOTE—Identified by number in this figure are: *(1)* cabinet pressure manometer, *(2)* dust collector vent, *(3)* test pressure gage, *(4)* grit feed tunnel, and *(5)* vacuum gage.

[3⁄16 to 1⁄4 ~~in.]. The glass tube is placed through the sleeve in the tubing nut, snugging the grommet within the nut.. The nut is attached to the gun. If there is an insufficient fit between the grommet, the tubing nut and the gun assembly, adequate vacuum draw (see~~ in.]. The glass tube is placed through the sleeve in the tubing nut, compressing the grommet within the nut. The nut is attached to the gun. Fit the nozzle tightly into the grommet in order to achieve adequate vacuum (see 8.6~~) will be unattainable.~~). The glass tube is then positioned at a distance of 2 mm [0.08 in.] from the air-generator nozzle. This is done by using a brass rod, 4.5 mm [0.175 in.] in diameter with a shoulder 7.9 mm [5⁄16 in.] in diameter, 117 mm ~~[4.68~~[4.59 in.] from the tip and inserting this rod into the glass tube. This will allow the operator to push the glass tubing up until the rod touches the ~~nozzle, assuring~~venturi,



FIdentifiedG. 2 Aby number in this figureare: (1)sand blast gun, (2) air pressure regulator, (3) glass tube and m Tetalstabilizing sleeve, (4) test sample, and (5) adjustable platform.

NOTE—Identified by number in this figure are: *(1)* sand blast gun, *(2)* air pressure regulator, *(3)* glass tube and metal stabilizing sleeve, *(4)* test sample, and *(5)* adjustable platform.

ensuring a 2 mm [0.08 in.] gap between the nozzleventuri and the glass tubing.

6.1.3 *Venturi*—The air- generator nozzle shall havedimensions are an inlet inside diameter of from 2.84 to 2.92 mm [0.112 to 0.115 in.] and an outlet inside diameter of from 2.36 to 2.44 mm [0.093 to 0.096 in.]. The Inspect the air generator nozzle should be inspected for wear before any test series and replacedreplace as necessary. The maximum inside diameter of the venturi chamber should not exceed is 10 mm [⅜ in.] and should be checkedin.]. Check the inside diameter periodically for wear (Fig. 4).

6.1.4 *Air Supply*—The air line pressure shall be maintained at the desired pressure at the gun through the use of a calibrated master series suppressed range air gage indicating 6.9 kPa [±1 psi] mounted as close to the gun as possible. Only clean dry air should be used.

6.1.5—*Supply the abrasion gun with clean dry air in accordance with Test Method D4285. The use of appropriate drying*

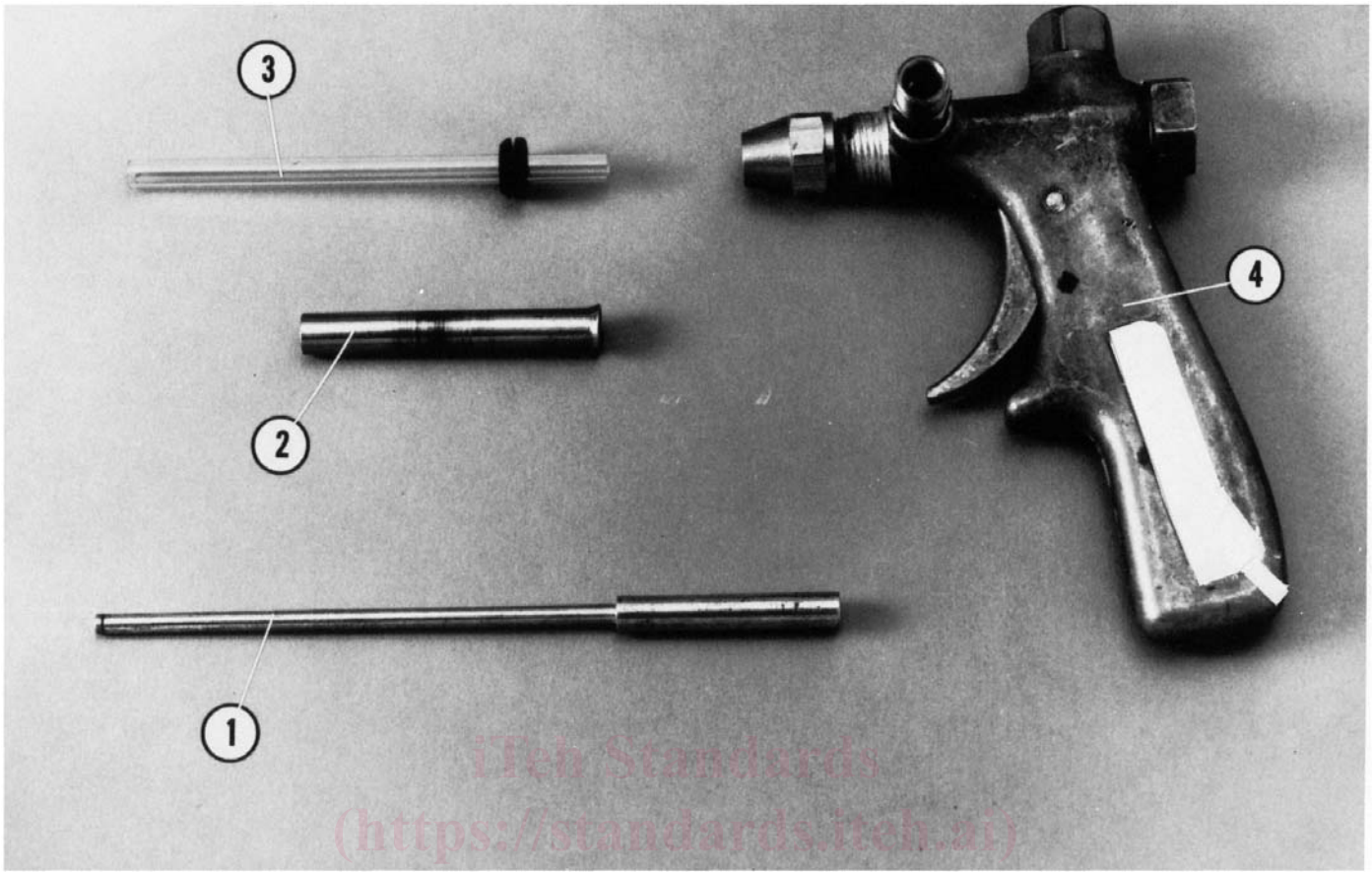


FIG. 3 Modentified by number in this figure are: (1) g Blasst Gube adjustment Brod, (2) metal stabilizing sleeve, (3) glass tube with grkdommet, awnd (4) sand blast gun.

NOTE—Identified by number in this figure are: *(1)* glass tube adjustment rod, *(2)* metal stabilizing sleeve, *(3)* glass tube with grommet, and *(4)* sand blast gun.

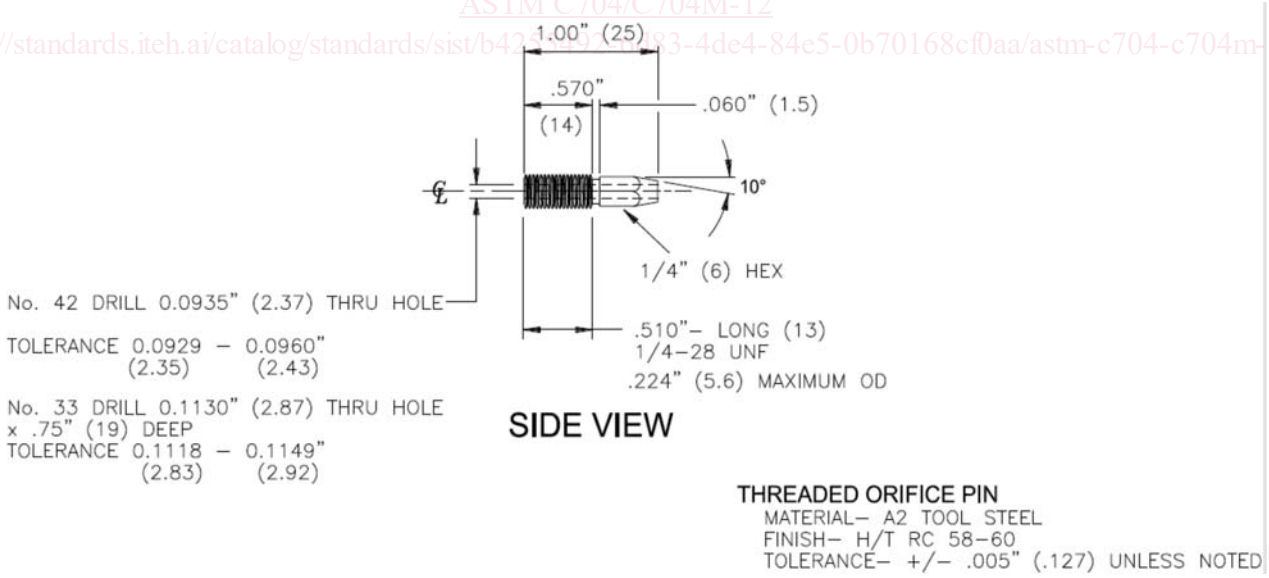


FIG. 4 Venturi Nozzle

equipment is necessary in order to achieve consistent results. Ensure that the air supply is able to supply an adequate volume of air such that the air pressure does not fluctuate during the test run. If the air supply is also connected to other equipment, ensure that the air supply is able to maintain consistent pressure throughout the test run, even when other equipment connected to the supply is operated. Consultation with an industrial professional in compressed air systems is recommended in setting up the air supply for the abrasion tester.

6.1.5 *Air Supply Pressure Gauge* —Affix a dial or digital test pressure gauge meeting the requirements of ASME B40.100, accuracy grade 3A, ±0.25% of the span, to a fitting on top of the gun as shown on Fig. 1. Dial to have a mirrored band for knife-edged pointer tip reflection to prevent parallax error. The minimum recommended diameter for dial type is 114 mm [4.5 in]. Recommended span is 0/1000 kPa [0/100 psig] based on an anticipated air supply pressure of 455 kPa [65 psig].

6.1.6 *Abrading Media*—~~No. 36 grit silicon carbide having a screen analysis as shown in~~ —New (unused), sharp (angular, jagged edged grains), No. 36 grit silicon carbide containing minimal foreign material and having a screen analysis as shown in Table 1~~.~~

~~6.1.6~~. *Verify the sizing of the grit by either user confirmation of the screen analysis or a certificate of conformance from the supplier. Take care to avoid segregation in large containers of abrading media. Splitting (possibly with use of a riffler) or another similar procedure and reblending may be necessary to obtain a grit sample conforming to the required screen analysis.*

6.1.7 *Feeding Mechanism*—Two acceptable mechanisms for feeding the abrading media are shown in ~~Fig. 4~~Fig. 5. The feed funnel ~~must contain~~ contains a suitable orifice to obtain a flow time of 450 ± 15 s while delivering 1000 g of abrading media into the gun supply funnel. Metal, glass, or plastic orifices ~~can~~may be used to regulate the flow. ~~There must be~~ Provide an air gap between the orifice and the gun supply funnel to allow secondary air to enter with the abrading media.

~~6.1.7~~6.1.8 *Test Chamber*~~, consisting of a~~ —A tightly sealed closure with a door to permit ready access for mounting and removing the test specimens. ~~A 13-mm~~ Cut a 13-mm [½~~-in.] hole shall be cut~~ in.] mounting hole in the top of the test chamber to permit the vertical mounting of the blast gun such that the downward stream of abrading media will travel 203 mm [8 in.] from the glass nozzle tip to the test specimen. Equip the test chamber with a 52 mm [2 1/16 in.] exhaust with a butterfly valve to regulate the cabinet pressure. Fig. 1 and Fig. 2show the design of an acceptable chamber.[3]

~~6.1.7.1~~6.1.8.1 *Dust Collector*—~~A dust-collecting cloth or paper bag of adequate capacity may be used on the 52-mm [2 1/16-in.] exhaust port of the chamber. This port is equipped with a butterfly valve to regulate the pressure in the chamber during the test. Alternate dust handling systems such as venting to the outside are acceptable as long as the chamber pressure is maintained at the desired level.~~

~~6.1.7.2~~*Manometer*—~~During the test the chamber pressure shall be measured with a manometer (water, magnehelic or digital) having a scale such that 311 Pa [1¼ in.] of water may be readily measured. A 6-mm [¼-in.] inside diameter connector shall be mounted in the top of the chamber to permit manometer connection.~~ —A dust-collecting cloth or paper bag of adequate capacity may be used on the exhaust port of the chamber. Alternate dust handling systems such as venting to the outside are acceptable as long as the chamber pressure is maintained at the desired level.

6.1.8.2 *Chamber Pressure Manometer*—Water manometer, digital manometer, or magnehelic gauge with a span of 0 to 80 mm (0 to 3 in.) water based on an operating pressure of 32 mm (1¼ in.) water with an accuracy of ±2% of span. Install a ¼ npt(f) connection in the top portion of the test chamber for the chamber pressure connection.

6.1.9 *Vacuum Gauge*—Dial or digital test gauge meeting the requirements of ASME B40.100 accuracy grade 3A, ±0.25% of the span. Dial to have a mirrored band for knife-edged pointer tip reflection to prevent parallax error. The minimum recommended diameter for dial type is 114 mm [4.5 in.]. The recommended span is −100/0 kPa (−30/0 in. Hg). Connect the vacuum gauge to a T-fitting in the abrasive supply line.

6.2 *Balance*, capable of weighing the sample to an accuracy of ±0.1 ~~g, used~~g. Used for weighing the abrading media and test specimens. Typically a 2000 ~~g~~ to 3000 g capacity balance is required.

7. Test Specimens

~~7.1Test specimens shall be cut from refractory brick or shapes, or molded from monolithic refractory materials and measure from 100 by 100 by 25 mm [4 by 4 by 1 in.] to 114 by 114 by 65 or 76 mm [4½ by 4½ by 2½ or 3 in.]. Only the most abrasion resistant materials can be 25 mm [1 in.] thick since the test is invalid if a hole is eroded completely through the specimen.~~

~~7.2Castable refractories shall be molded in accordance with Practice~~

7.1 Cut 100 by 100 by 25 mm [4 by 4 by 1 in.] or 114 by 114 by 65 or 76 mm [4.5 by 4.5 by 2.5 or 3 in.] test specimens from refractory brick or shapes or mold them from monolithic refractory materials. Only the most abrasion resistant materials can be 25 mm [1 in.] thick since the test is invalid if a hole is eroded completely through the specimen.

TABLE 1 Screen Analysis for Abrading Media

ASTM Standard ~~Sieve No.~~ Sieve No.	Opening, µm	Retained, %
~~20~~	~~850~~	~~trace~~
20	850	trace
~~30~~	~~600~~	~~20 ± 2~~
30	600	20 ± 2
~~50~~	~~300~~	~~80 ± 3~~
50	300	80 ± 3
~~70~~	~~212~~	~~2 max~~
70	212	2 max
~~Pass No. 70~~		~~trace~~
Pass No. 70	. . .	trace