Designation: C704/C704M – 15

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.

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*—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:*[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

D4285 Test Method for Indicating Oil or Water in Compressed Air

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

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]

3. Summary of Test Method

3.1 This test method measures the volume of material in cubic centimeters 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 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 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

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[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] 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.

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*—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 into consideration. Individually measure and choose all nozzle tubes to conform to a specified 4.8 mm inside diameter.

5.1.2 *Air Pressure*—Variation in the test air pressure statistically affected the abrasion values obtained on the glass plate. Air pressure as specified in 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 into consideration and use only gauges as specified in 6.1.5. It is also recommended that air gauges be recalibrated at frequent intervals.

5.2 Factors that were found to be rugged during the test method evaluation 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 7⁄8 in.] to 206 mm [8 1⁄8 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*—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 5⁄8 in.] and an outside diameter of 9.53 mm [3⁄8 in.]. Flare the tubing at one end to sit snugly inside a 9.53 mm [3⁄8 in.] tubing nut. This sleeve is glued or soldered in place inside the 9.53 mm [3⁄8 in.] tubing nut, and is used primarily to hold the glass tubing perpendicular to the test sample, 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 is inserted into a 15.9 mm [5⁄8 in.] outside diameter, 6.4 mm [1⁄4 in.] inside diameter rubber grommet with a thickness of 4.75 to 6.4 mm [3⁄16 to 1⁄4 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). 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 [4.59 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 venturi, ensuring a 2 mm [0.08 in.] gap between the venturi and the glass tubing.

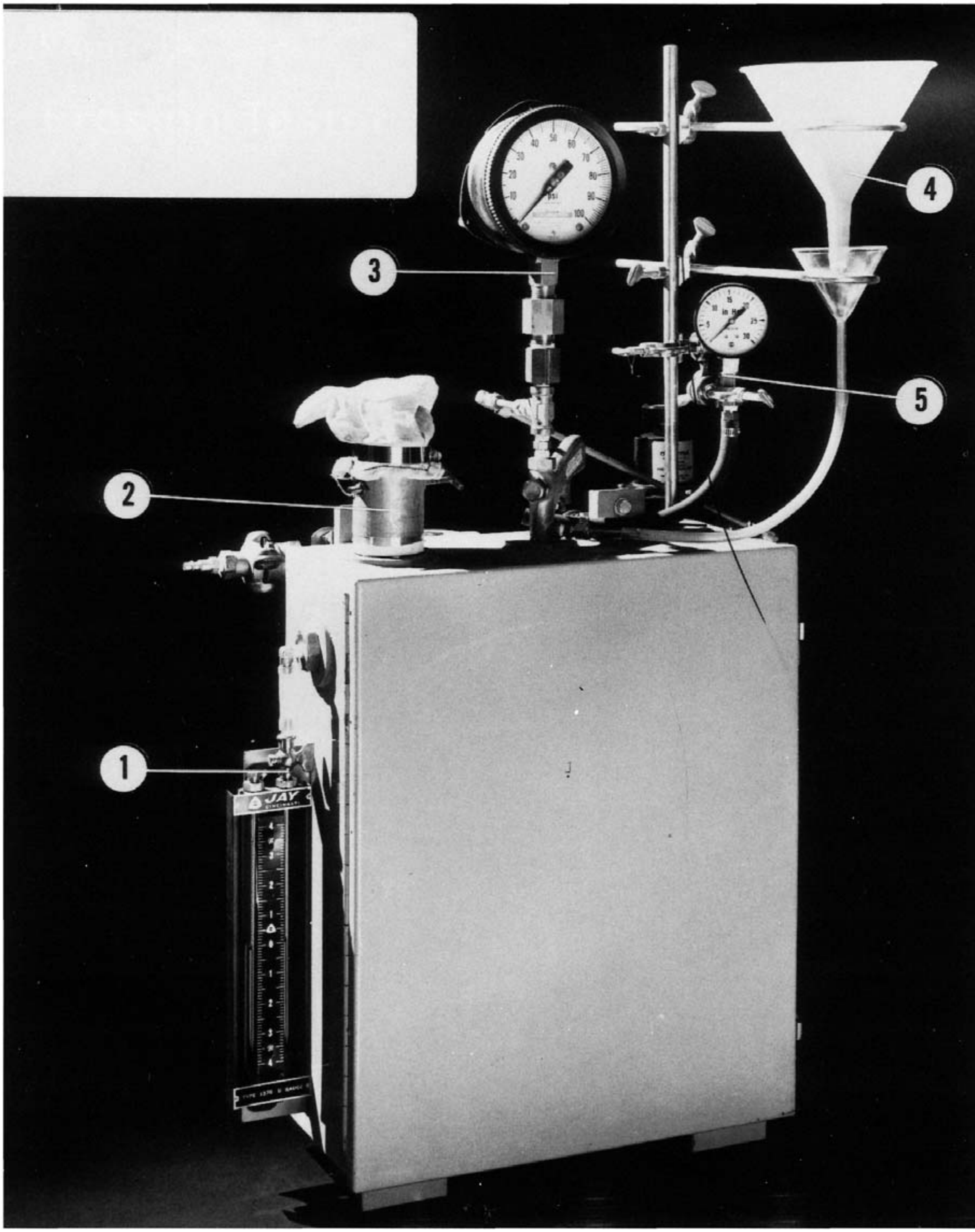
6.1.3 *Venturi*—The air generator nozzle dimensions are an inlet inside diameter of 2.84 to 2.92 mm [0.112 to 0.115 in.] and an outlet inside diameter of 2.36 to 2.44 mm [0.093 to 0.096 in.]. Inspect the air generator nozzle for wear before any test series and replace as necessary. The maximum inside diameter of the venturi chamber is 10 mm [3⁄8 in.]. Check the inside diameter periodically for wear (Fig. 4).

6.1.4 *Air Supply*—Supply the abrasion gun with clean dry air in accordance with Test Method D4285. The use of appropriate drying 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. Recommended span is 0 to 1000 kPa [0 to 100 psig] based on an anticipated air supply pressure of 455 kPa [65 psig].

6.1.6 *Abrading Media*—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. 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.

[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,[1] which you may attend.

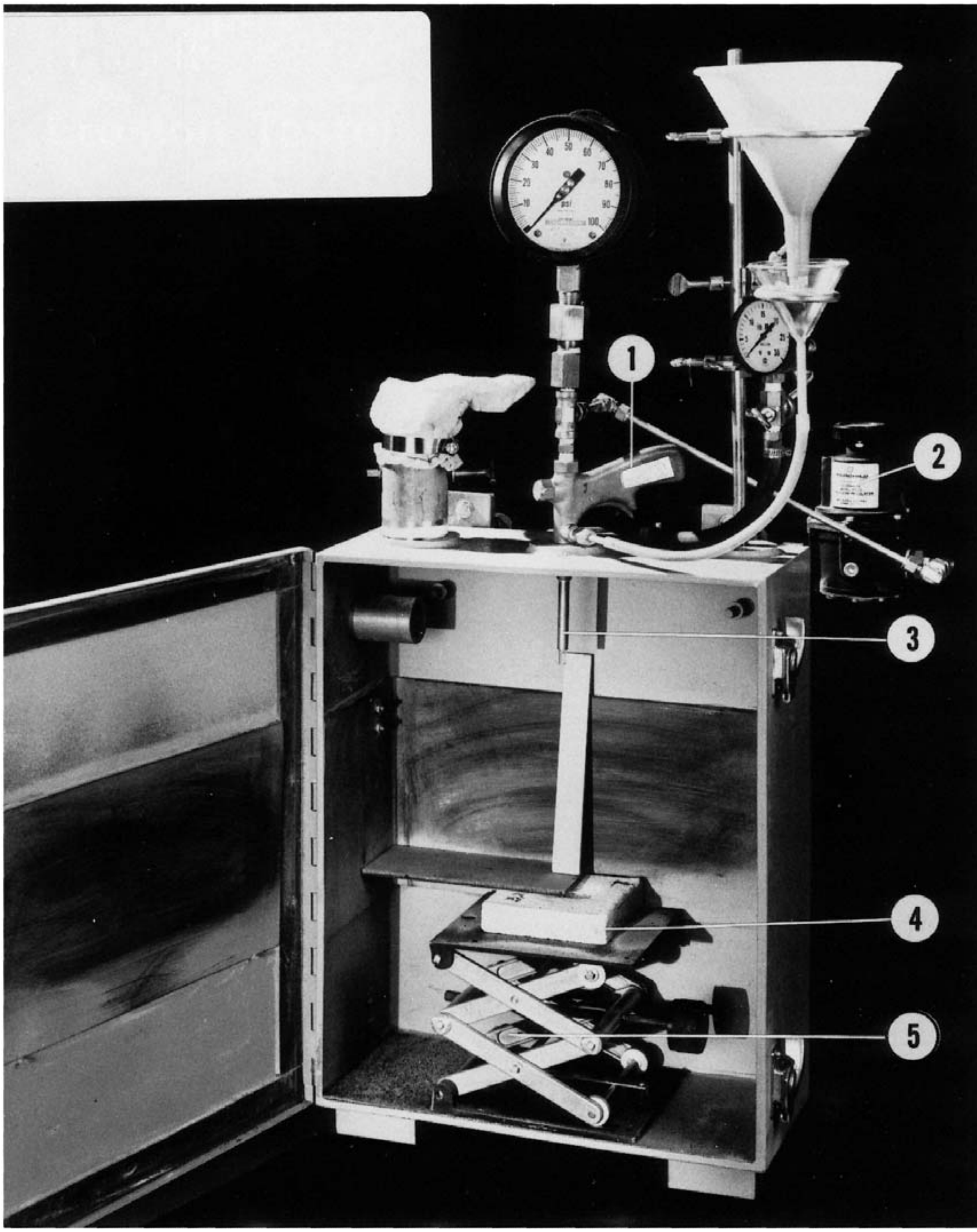


NOTE—Identified by number in this figure are: *(1)* cabinet pressure manometer, *(2)* dust collector vent, *(3)* test pressure gage, *(4)* grit feed tunnel, and *(5)* vacuum gage.

FIG. 1 Abrasion Tester

6.1.7 *Feeding Mechanism*—Two acceptable mechanisms for feeding the abrading media are shown in Fig. 5. The feed funnel 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 may be used to regulate the flow. Provide an air gap between the orifice and the gun supply funnel to allow secondary air to enter with the abrading media.

6.1.8 *Test Chamber*—A tightly sealed closure with a door to permit ready access for mounting and removing the test



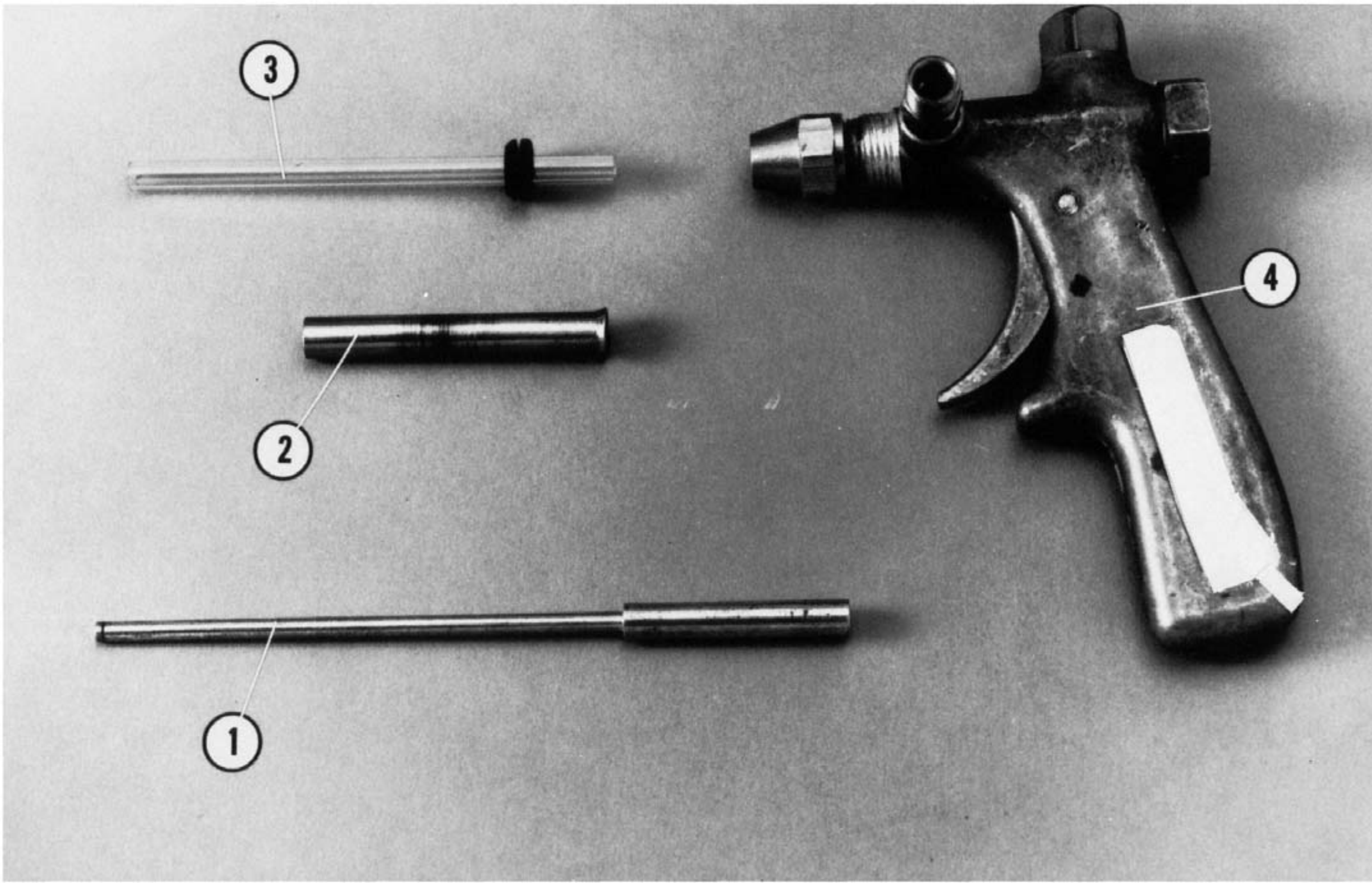
NOTE—Identified by number in this figure are: *(1)* sand blast gun, *(2)* air pressure regulator, *(3)* glass tube and metal stabilizing sleeve, *(4)* test sample, and *(5)* adjustable platform.

FIG. 2 Abrasion Tester

specimens. Cut a 13-mm [½ 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 [2¹⁄₁₆ in.] exhaust with a butterfly valve to regulate the cabinet pressure. Fig. 1 and Fig. 2show the design of an acceptable chamber.[3]

6.1.8.1 *Dust Collector*—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.



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. 3 Modified Blast Gun Breakdown

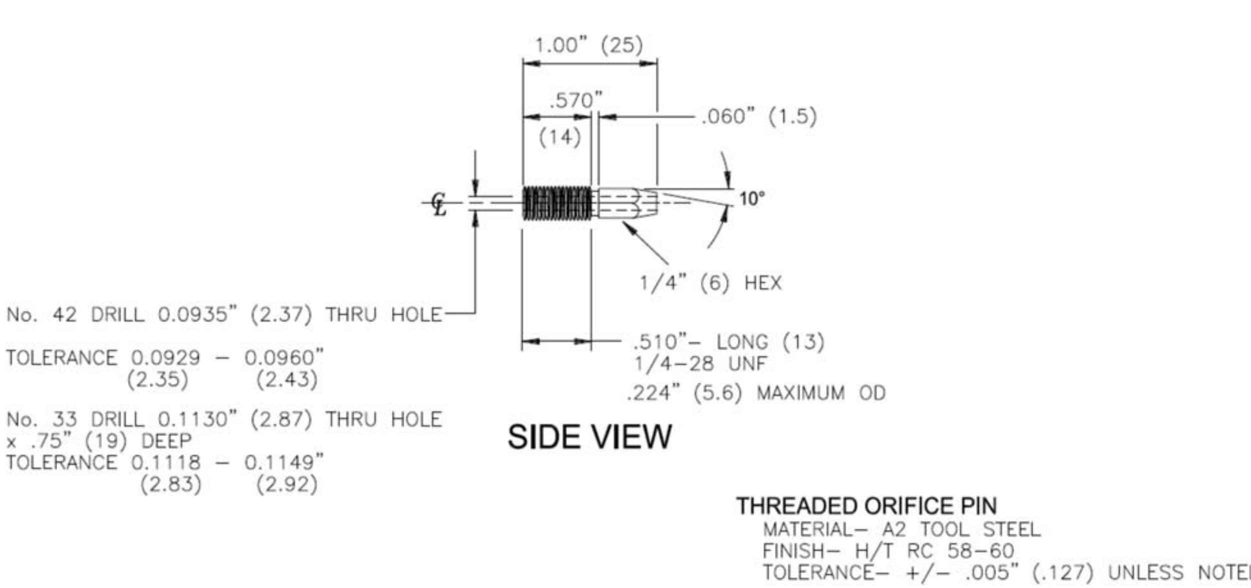


FIG. 4 Venturi Nozzle

6.1.9 *Vacuum Gauge*—Dial or digital test gauge meeting the requirements of ASME B40.100 accuracy grade 1A, ±1 % of the span. 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 for weighing the abrading media and test specimens. Typically a 2000 to 3000 g capacity balance is required.

TABLE 1 Screen Analysis for Abrading Media

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

7. Test Specimens

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.

7.2 Mold castable refractories in accordance with Practice C862. Fire specimens to the anticipated service temperature or a higher temperature, if specified, in accordance with Practice C865. One 100 by 100 mm (4 by 4 in.) or 114 by 114 mm (4.5 by 4.5 in.) face of each specimen is a free (not troweled, molded, or cut) face.

7.3 Mold plastic refractories and fire the specimens to the anticipated service temperature or a higher temperature, if specified, in accordance with Test Method C179 (see the sections on apparatus and test specimens). One 100 by 100 mm (4 by 4 in.) or 114 by 114 mm (4.5 by 4.5 in.) face of each specimen is a free (not troweled, molded, or cut) face.

8. Procedure

8.1 Dry the test specimens to a constant weight at 105 to 110°C [220 to 230°F] for a maximum of 4 h before testing.

8.2 Weigh the specimens to the nearest 0.1 g. Determine the volume of the specimens by measurement of length, width, and thickness to the nearest 0.5 mm [0.02 in.] in accordance with the apparatus section of Test Methods C134.

8.3 Place the nominal 100 by 100 mm (4 by 4 in.) or 114 by 114 mm [4.5 by 4.5 in.] face of the test specimens at a 90° angle to the glass nozzle with the surface to be abraded 203 mm [8 in.] from the tip of the glass nozzle. For brick samples test an unbranded surface. For monolithic refractory specimens, test the surface (that is, top free face or bottom mold face) that most accurately reflects the actual field situation. Normally, the free surface is the most appropriate test surface. Position the specimen such that the abrasion pattern is centered on the surface of the plate.

8.4 Turn on the air pressure. Regulate the air pressure to 448 kPa [65 psi]. Check the air pressure before and after the abrading media is run through the system.

8.5 Measure the cabinet pressure using the manometer and maintain the pressure in the chamber at 31.8mm [1¼ in.] of water by means of the butterfly valve in the exhaust vent.

8.6 After the air pressure to the gun and the chamber pressure have been adjusted, plug the opening of the gun supply funnel and read the vacuum gauge. If the vacuum gauge does not show a minimum vacuum of 380 mm (15 in.) of mercury, check the position of the glass tubing or the condition of the air-generator nozzle.

8.7 After obtaining the proper vacuum pressure, unplug the gun supply funnel and recheck the cabinet pressure before placing 1000 ± 5 g of dry abrading media in the main supply funnel. Do not completely fill or flood the gun supply funnel with material. When connected with the abrasion tester, ensure that the feed mechanism delivers the abrading media in the specified time of 450 ± 15 s.

8.8 Use the silicon carbide abrading media only once and then discard.

8.9 Remove the refractory specimens from the test chamber, blow off the dust, and immediately weigh to the nearest 0.1 g. If the samples are allowed to sit before being weighed, they may pick up moisture resulting in an inaccurate test result. In this case, dry the sample as in 8.1 prior to measuring.

9. Calculation and Report

9.1 From the initial weight and volume, calculate the bulk density of the specimens in g/cm^3.

9.2 Calculate the amount of abrasion loss from each specimen in cm^3, A, to the nearest 0.1 cm^3 as follows:

$$A = [(M_1 - M_2)/B] = M/B$$

where:

B = bulk density, g/cm^3 (to the nearest 0.1 g/cm^3),
M_1 = weight of specimen before testing, g (to the nearest 0.1 g),
M_2 = weight of specimen after testing, g (to the nearest 0.1 g), and
M = weight loss of specimen, g (to the nearest 0.1 g).

9.3 Report the average of the individual results as the abrasion loss for that sample.

9.4 Record and report the time required for 1000 g of abrading media to flow through the gun.

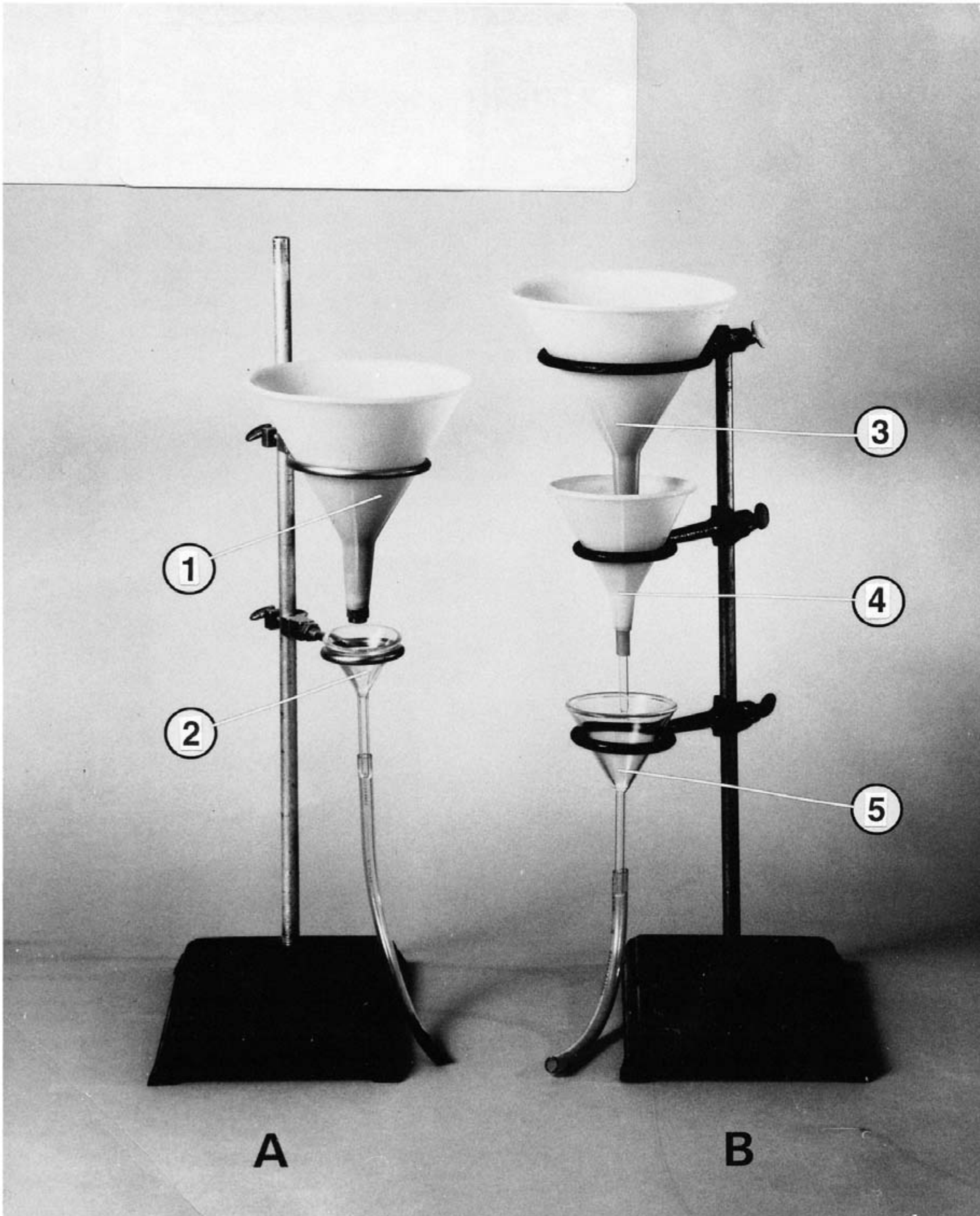
9.5 Report which surface was abraded.

9.6 If the test results in a hole completely through the sample, the test results are not valid. Report the results as a hole through the specimen.

10. Precision and Bias[5]

10.1 *Interlaboratory Test Data*—An interlaboratory study was completed among eight laboratories in 1999. Five different types of refractories, along with a float glass plate standard, were tested for abrasion resistance by each laboratory. The five types of refractories were a high-alumina brick, a silica brick, an abrasion-resistant castable, a super-duty fire brick, and a conventional high-cement castable. All specimens were 4.5 by 4.5 in. in cross section. Additionally, both castables were fired to 1500°F. Prior to testing, bulk density and sonic velocity were measured on all specimens to ensure uniformity. Specimens were then randomly selected for distribution to the participating laboratories.

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C08-1019.



NOTE—Identified by number in this figure are: *(1)* main supply funnel with metering insert, *(2)* gun supply funnel, *(3)* main supply funnel, *(4)* metering funnel, and *(5)* gun supply funnel.

FIG. 5 Feeding Mechanisms

10.2 *Precision*—Table 2 contains the precision statistics for the abrasion resistance results.

10.2.1 *Repeatability*—The maximum permissible difference due to test error between two test results obtained by one operator on the same material using the same test equipment is given by the repeatability interval (*r*) and the relative repeatability interval (% *r*). The 95 % repeatability intervals are given in Table 2. Two test results that do not differ by more than the repeatability interval shall be considered to be from the same population; conversely, two test results that do differ by more than the repeatability interval shall be considered to be from different populations.

TABLE 2 Precision Statistics for Abrasion Resistance

Material	Average Volume Loss, cm^3	Standard Deviation Within Laboratories, *Sr*	Standard Deviation Between Laboratories, *SR*	Repeatability Interval, *r*	Reproducibility Interval, *R*	Coefficient of Variation Within Laboratories, *Vr*	Coefficient of Variation Between Laboratories, *VR*	Relative Repeatability, %*r*	Relative Reproducibility, %*R*
High-alumina brick	4.19	0.39	0.71	1.08	1.98	9.22	16.85	25.80	47.19
Silica brick	22.17	2.64	4.62	7.40	12.95	11.91	20.86	33.36	58.41
Abrasion-resistant castable	8.36	0.87	1.89	2.42	5.29	10.35	22.59	28.99	63.24
Super-duty firebrick	25.48	4.25	7.81	11.90	21.86	16.68	30.64	46.70	85.80
Conventional high-cement castable	10.89	2.12	3.02	5.94	8.45	19.48	27.71	54.54	77.59
Plate glass standard	9.28	0.34	1.51	0.95	4.23	3.66	16.27	10.24	45.58

10.2.2 *Reproducibility*—The maximum permissible difference due to test error between two test results obtained by two operators in different laboratories on the same material using the same test equipment is given by the reproducibility interval (*R*) and the relative reproducibility interval (% *R*). The 95 % reproducibility intervals are given in Table 2. Two test results that do not differ by more than the reproducibility interval shall be considered to be from the same population; conversely, two test results that do differ by more than the reproducibility interval shall be considered to be from different populations.

10.3 *Bias*—No justifiable statement can be made on the bias of this test method because the value of the volume loss can be defined only in terms of a test method.

11. Keywords

11.1 abrasion resistance; blasted by air; castable refractories; glass plate; flat surface; monolithic refractory materials; refractory brick or shape; room temperature

SUPPLEMENTARY REQUIREMENTS

S1. Supplementary Procedure for Highly Abrasion Resistant Materials

S1.1.1 The requirements of this supplement apply only when specified in the purchase order.

S1.1.2 These requirements are designed for applications where increased precision is necessary for the abrasion resistance of the refractory material in order to reduce the variability of results obtained using the standard test procedure.

S1.1.3 The requirements of this supplement modify or augment the requirements of Test Method C704/C704M. Follow all requirements of the supplement.

S1.1.4 Do not compare test results using the supplementary requirements to results obtained using the standard testing procedures.

S1.2 Interferences (Factors Known to Affect Results)

S1.2.1 A round robin study for these supplementary requirements is underway. No interference statements can be made at this time.

S1.3 Apparatus

S1.3.1 *Abrasion Tester (Modification of 6.1)*—See Fig. S1.1.

S1.3.2 *Blast Gun (Replaces 6.1.1)*, machined from a block of American Iron and Steel Institute (AISI) Grade A-2 (Specification A681, Type A-2; UNS T30102) tool steel in accordance with Fig. S1.2.

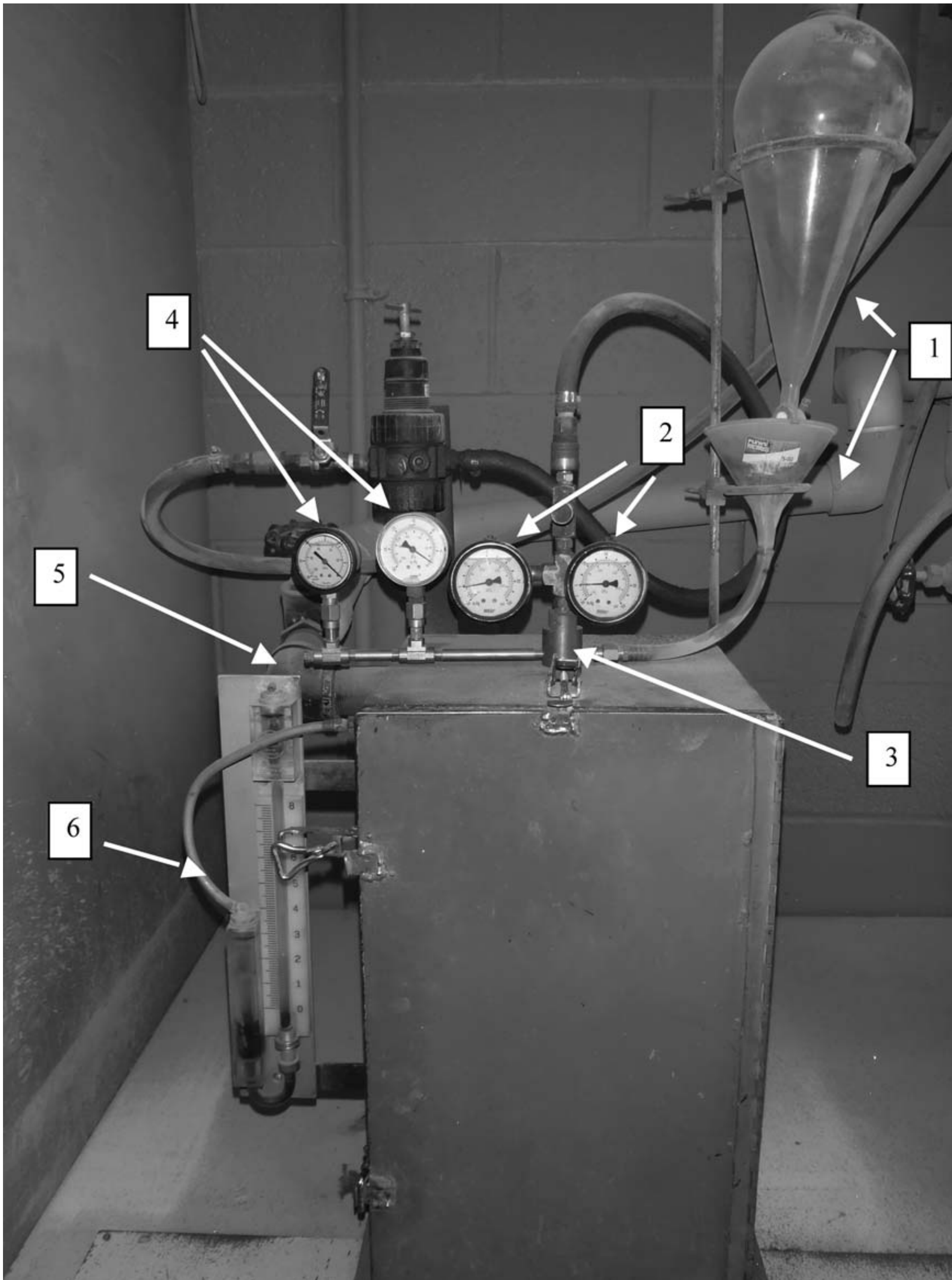
S1.3.3 *Air Supply Pressure Gauge (Modifies 6.1.5)*—Use two pressure gauges. If the readings on the gauges differ by more than 6.9 kPa (1 psi), recalibrate, repair, or replace the gauges. Use one gauge as the primary gauge; all pressure measurements are to be taken from that gauge. The second gauge is used only for verification. Ensure that there are not any flow obstructions between the gauge and the gun.

S1.3.4 *Feeding Mechanism (Replaces 6.1.7)*—Use a two funnel feeding mechanism to supply the abrading media to the gun as shown on the left side of Fig. 5. Ensure that the main supply funnel has sufficient volume to hold the required 1000 g of silicon carbide abrading medium. Provide an orifice approximately 4.5 mm (0.18 in.) in diameter to control the flow of silicon carbide. Size the orifice so that 1000 g of the abrading media flows through the funnel in 450 ± 15 s. Equip the gun supply funnel with a 4.06 mm [0.16 in.] inside diameter, 6.35 mm [0.25 in.] outside diameter hose fitting to connect to the feed line. Provide a gap between the two funnels to allow for air to be introduced to the particle stream. Connect the lower funnel to the feed inlet of the blast gun with clear flexible poly(vinyl chloride) tubing with an inside diameter of 6.35 mm [0.25 in.].

S1.3.5 *Test Chamber (Modifies 6.1.8)*—Use a 20 mm [13⁄16 in.] mounting hole. Attach the blast gun to the top of the chamber through the hole in the top and secure it in place with a nut. Ensure the gun is perpendicular to the specimen.

S1.3.6 *Vacuum Gauge (Modifies 6.1.9)*— Use two vacuum gauges. If the readings on the gauges differ by more than 6.9 kPa (1 psi), recalibrate, repair, or replace the gauges. Use one gauge as the primary gauge; all vacuum measurements are to be taken from that gauge. The second gauge is used only for verification. Affix the gauges to the blast gun as shown in Fig. S1.1. Ensure that there are not any flow obstructions between the gauge and the gun.

S1.4 Calibration



NOTE—Identified by number in this figure are: *(1)* grit feed funnels, *(2)* pressure gauges, *(3)* blast gun, *(4)* vacuum gauge, *(5)* exhaust port, and *(6)* cabinet pressure manometer.

FIG. S1.1 Modified Abrasion Tester

S1.4.1 Calibrate the abrasion tester at least once a week when the tester is used. Also calibrate the abrasion tester when replacing the gun, venturi, or any gauge and when using a new lot of silicon carbide or batch of glass tubes. Additionally, calibrate the abrasion tester any time an abnormality occurs in the test such as erratic results or a hole being worn in the glass nozzle.

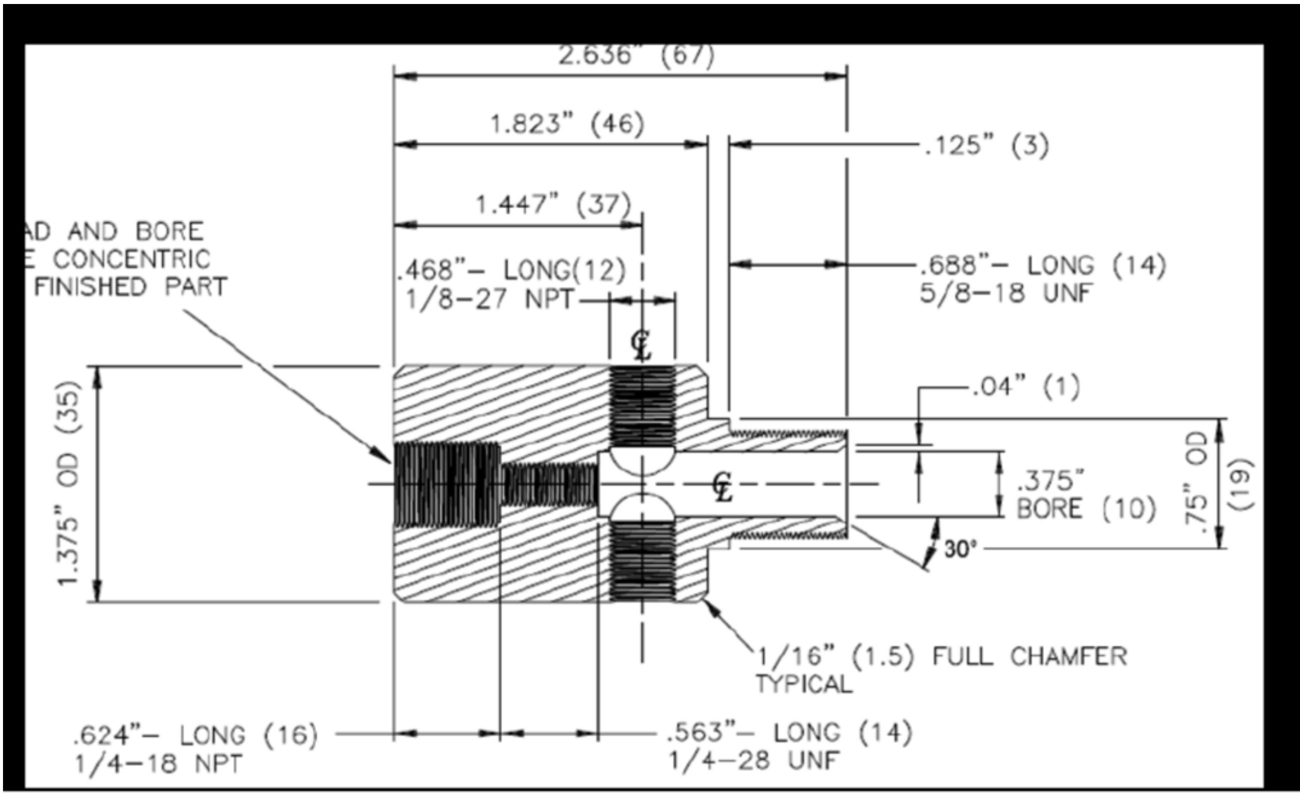


FIG. S1.2 Machined Block Blast Gun

S1.4.2 Calibration check specimens are 114 by 114 by 12.7 mm [4.5 by 4.5 by 0.5 in.] float glass plates conforming to Specification C1036, with a density between 2.48 and 2.51 g/cm^3. Confirm the density of the float glass plates by testing one plate in each batch. Due to small irregularities normally present in the shape of the glass plates, use of a water immersion method is suggested. Refer to Table 2 for the acceptable precision statistics for float glass plate.

S1.4.2 Calibration check specimens are 114 by 114 by 12.7 mm [4.5 by 4.5 by 0.5 in.] float glass plates conforming to Specification C1036, with a density between 2.48 and 2.51 g/cm^3. Confirm the density of the float glass plates by testing one plate in each batch. Due to small irregularities normally present in the shape of the glass plates, use of a water immersion method is suggested. Refer to Table 2 for the acceptable precision statistics for float glass plate.

S1.4.3 Weigh the glass plate to the nearest 0.1 g prior to calibration.

S1.4.4 Prior to running the calibration, inspect all parts of the abrasion tester for wear. Replace any components that are worn prior to calibration.

S1.4.5 Place the glass plate into the abrasion tester in the same manner as a test specimen. Maintain the 203 mm (8 in.) spacing between the end of the glass nozzle and the surface of the glass plate. This can be achieved by using a second glass plate under the calibration plate as a spacer, or by adjusting the height of the sample holding platform. The glass plate may be placed in the abrasion tester with either face up.

S1.4.6 Run the abrasion test in accordance with 8.2 – 8.7 with the exception of setting the air pressure in 8.4 to the value obtained during the previous calibration.

S1.4.7 Weigh the plate to the nearest 0.1 g.

S1.4.8 Calculate the glass plate abrasion loss, A_G, to the nearest 0.1 cm^3 as follows:

$$A_G = [(M_{G1} - M_{G2})/B_G] = M_G/2.49$$

where:

2.49 = glass plate bulk density, g/cm^3,
M_{G1} = weight of glass plate specimen before testing, g (to the nearest 0.1 g),
M_{G2} = weight of glass plate specimen after testing, g (to the nearest 0.1 g), and
M_G = weight loss of glass plate specimen, g (to the nearest 0.1 g).

S1.4.9 The target abrasion loss of the glass plate is 9.3 ± 0.3 cm^3. Observe the abrasion pattern of the glass plate through the edge of the plate. The abraded area is to be uniform and symmetrical. A nonuniform, or unsymmetrical wear pattern indicates that the abrasion tester is not set up properly (for example, the nozzle is not perpendicular to the specimen plate, the nozzle is not securely fixed into place, the nozzle to specimen distance is incorrect, the air pressure is varying, etc.).

TABLE S1.1 Abrasion Loss, cm³

Material	Average,[A] $\bar{x}$	Repeatability Standard Deviation, S_r	Reproducibility Standard Deviation, S_R	Repeatability Limit, r	Reproducibility Limit, R
Low Cement Abrasion Resistant Castable	11.044	0.871	1.387	2.439	3.883
High Cement Abrasion Resistant Castable	9.890	1.334	1.334	3.736	3.736
Extreme Abrasion Resistant Castable	3.107	0.231	0.380	0.648	1.065

[A]The average of the laboratories' calculated averages.

TABLE S1.2 Glass Abrasion Loss, cm³

Material	Average,[A] $\bar{x}$	Repeatability Standard Deviation, S_r	Reproducibility Standard Deviation, S_R	Repeatability Limit, r	Reproducibility Limit, R
Low Cement Abrasion Resistant Castable	9.226	0.067	0.142	0.187	0.398
High Cement Abrasion Resistant Castable	9.233	0.067	0.110	0.187	0.308
Extreme Abrasion Resistant Castable	9.271	0.067	0.180	0.187	0.505

[A]The average of the laboratories' calculated averages.

Correct the problem and rerun the calibration test with a new glass plate. If the abrasion plate results do not meet the standard, adjust the air pressure to the gun and run the calibration procedure again using a new glass plate each time until an abrasion of 9.3 ± 0.3 cm^3 is achieved.

S1.4.10 Record the result of the calibration in a calibration log. Include the date of the calibration, the air pressure used, the calibration value, and the event that triggered the calibration in the log entry. This log may be kept either on paper or electronically.

S1.5 Procedure

S1.5.1 (*Replaces 8.4.*) Turn on the air pressure. Regulate the air pressure to the pressure indicated by the most recent calibration of the abrasion tester. Check the air pressure before and after the abrading media is run through the system.

S1.5.2 (*Replace 8.6.*) After the air pressure to the gun and the chamber pressure have been adjusted, plug the abrading media feed line by closing the opening of the lower funnel. If the vacuum gauge does not read a minimum vacuum of 380 mm (15 in.) of mercury, then check the position of the glass nozzle in the blast gun. If correcting the position of the glass nozzle does not correct the problem then check the condition of the venturi, the condition of the abrading media feed lines, and the blast gun. Replace any parts as necessary and calibrate the abrasion tester in accordance with Section 7 before proceeding.

S1.6 Calculation and Report

S1.6.1 (*Add to Section 9.*) Report the calibration value of the glass plates, the air pressure used, and the calibration date for the last calibration event run prior to running the samples.

S1.7 Precision and Bias

S1.7.1 The precision of this test method is based on an interlaboratory study conducted in 2013. A total of 23 laboratories participated in the study. Three different castable materials were tested. Each analyst was asked to report three test results. Practice E691 was followed for the study design; the details are given in RR:C08-1025.[6]

S1.7.1.1 *Repeatability Limit, r*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the *r* value for that material; *r* is the interval representing the critical difference between two test results for the same property, obtained by the same operator using the same equipment on the same day in the same laboratory.

(1) Repeatability limits are listed in Table S1.1 and Table S1.2.

S1.7.1.2 *Reproducibility Limit, R*—Two test results shall be judged not equivalent if they differ by more than the *R* value for that material; *R* is the interval representing the critical difference between two test results for the same property, obtained by different operators using different equipment in different laboratories.

(1) Reproducibility limits are listed in Table S1.1 and Table S1.2.

S1.7.1.3 The terms *repeatability limit* and *reproducibility limit* are used as specified in Practice E177.

S1.7.1.4 Any judgment in accordance with statements S1.7.1.1 and S1.7.1.2 would have an approximate 95% probability of being correct.

S1.7.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

S1.7.3 The precision statement was determined through statistical examination of 154 results, from a total of 23 laboratories, on 3 castable materials.

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C08-1025. Contact ASTM Customer Service at service@astm.org.