Designation: C862 – 16

Standard Practice for Preparing Refractory Concrete Specimens by Casting[1]

This standard is issued under the fixed designation C862; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This practice covers the mixing, casting and curing of monolithic refractory concrete specimens under laboratory conditions for use in further testing. It does not apply to monolithic castable refractories intended primarily for gunning applications.

1.2 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.

1.3 Various specimen sizes are required for specific test methods. Refer to these test methods to determine the size and number of specimens, which will be required from the sample.

1.4 *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]

C133 Test Methods for Cold Crushing Strength and Modulus of Rupture of Refractories

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

3. Significance and Use

3.1 This practice is used to standardize mixing, mold conditions, placement and curing of refractory concrete specimens to be used for testing and evaluation under other test methods.

3.2 This practice standardizes laboratory conditions for producing refractory concrete specimens to minimize laboratory-to-laboratory variation and does not attempt to duplicate the conditions of field installations.

3.3 This practice can be used for the preparation of specimens used in referee testing.

4. Apparatus and Conditions

4.1 *Laboratory Conditions*—The laboratory ambient should be controlled between 70 and 80°F (20 and 27°C) (Note 1) and from 40 to 60 % relative humidity for preconditioning materials and equipment, batching and mixing casting test specimens, stripping molds, and testing specimens. Report laboratory temperature and relative humidity with physical test results if other than specified.

NOTE 1—A 5 to 6°F temperature difference can drastically change the set time of a mix. It is a good practice to always record ambient temperature conditions for each cast.

4.2 *Balances*—Appropriately sized scales having a sensitivity of 0.2 % of the related batch size.

4.3 *Castable Mixers*—An electrically operated mechanical mixer (Fig. 1) may be used for preparing castable batches for casting specimens. A 2-ft^3 (0.057-m^3) mixing bowl or a 2½-ft^3 (0.071-m^3) concrete mixer has sufficient capacity to mix about 1 ft^3 (0.0285 m^3) of refractory castable. The smallest batches required for casting 1-in. (25-mm) square bars can be mixed in a 0.10-ft^3 (0.0028-m^3) bowl available with bench mixers. Size mixing bowl to contain from 50 to 75 % volume loading with the dry batch. Castable water requirement variation becomes more significant as dry volume loadings drop below 40 % because the water required to wet the bowl surfaces changes more rapidly with decreasing volume loadings.

4.4 *Molds*—Typical molds are 9 by 2 by 2 in. and 2 by 2 by 2 in. made from metal, plastic or rubber and are watertight, rigid, and removable. There are commercially available molds from concrete testing suppliers and other sources. Molds may be reusable or for single use. Although brick-sized shapes may be cut with a diamond saw to obtain a specific size, it is preferable to fabricate the desired shape. The smallest mold dimension should be a minimum of three times the largest aggregate diameter, as specified in Practice C192/C192M. In some cases, when smaller specimens are required and grain sizing does not allow for smaller castings, cut specimens may be used. See Table 1.

[1] This practice is under the jurisdiction of ASTM Committee C08 on Refractories and is the direct responsibility of Subcommittee C08.09 on Monolithics.

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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.

FIG. 1 Five Quart Mixer

TABLE 1 Metric Mold Equivalents

Metric Equivalents											
in.	1/32	1/8	5/32	3/16	1/4	5/16	3/8	1/2	9/16	5/8	11/16
mm	0.8	3	4	5	6	8	10	13	14	16	17
in.	7/8	1 3/16	1 1/2	2 1/2	2 5/8	3 3/16	4	4 1/2	9	14 3/4	
mm	22	30	38	65	67	81	102	114	230	375	

4.5 *Calipers*—Suitable for measuring internal longitudinal mold dimensions and subsequent specimen length size to the nearest 0.01 in. (0.25 mm).

4.6 *Mold Lubricant*—Either paraffin or silicone-based oils can be used as a release or parting agent for coating molds. Other mold lubricants such as vegetable oils and petroleum-based oils can be used.

4.7 *Strike-Off Bar*—Straight edge tool (trowel, bar, or other) at least 2 in. wider than mold width.

4.8 *Thermometer*—Digital or dial-type, metal, with a range from 0 to 180°F (−18 to 80°C).

4.9 *Timer*—Signal-type. (A stop watch may be used.)

4.10 *Trowels*—6 in. pointing and 2 by 6 in. (51 by 152 mm) square, and a 10-in. (254-mm) stainless-steel spatula.

4.11 *Oven*—For curing and drying, preferably forced draft rather than natural convection, with a capacity to hold a minimum of one sample group of specimens (12 by 12 by 12 in.) (30 by 30 by 30 cm).

4.12 *Heavy Rubber Gloves*—For castables containing metal fibers.

4.13 *Scoop*—For transferring the castable from the mixer to the mold more easily.

4.14 *Vibration Table*—For use in 6.4.2.

4.15 *Sample Splitters*—The sample splitter opening shall be a minimum of 3 times the maximum grain size.

4.16 *Hoe*—Hand-held hoe for mixing lightweight castable.

4.17 *Humidity Cabinet*—A cabinet capable of maintaining a relative humidity of greater then 95 % within 90 to 95°F (32 to 35°C) is optional.

5. Sampling

5.1 A sufficient amount of dry castable should be batched to overfill the molds by at least 10 %. This should eliminate the use of both trailings and scrapings of wet castable.

5.2 At the time of use, the dry sample should be between 70 and 80°F (20 and 27°C). Measure the temperature (Note 2) by inserting the full length of the thermometer stem into the material until the reading is constant. Record and report with physical test results.

NOTE 2—It is recommended that in referee tests involving more than one laboratory, the temperature of the dry refractory concrete mix and mixing water be within the specified range, in all laboratories.

5.3 The contents of the container should be thoroughly mixed dry prior to water addition. When less than a full bag is required, reduce the contents of the sample container with a sample splitter to obtain a representative sample of the desired size. When the sample consists of more than one bag or container, the contents should be combined and mixed thoroughly before being sent through the sample splitter. Take precautions to prevent segregation.

6. Molding Test Specimens

6.1 *Water Addition*—Determine the amount of water to be used in the mix for casting test specimens in accordance with the manufacturer's or referee's recommendations. Use potable

water (Note 3) having temperature between 70 and 80°F (20 and 27°C). Report the temperature with any physical test results. Measure the water addition to the nearest 0.1 % by weight.

NOTE 3—Potable water is used only if soluble constituents do not affect castable properties significantly. However, filtered, deionized, or distilled water is preferred and should be sufficient and used in referee tests.

6.2 *Mechanical Mixing*—Add the weighed batch to an appropriately sized drum or paddle castable mixer (4.3). If dry batch has not been pre-mixed, dry mix for 1 min at slow speed. Operate the mixer at slow speed and add the required water to the mix within 1 min. Part of the water may be added to the mixer first, if the mix is already homogenous and dry mixing is not necessary. Continue to mix at slow speed for a total time of 3 to 5 min after water addition (Notes 4 and 5) or according to manufacturer's recommendations.

NOTE 4—For drum mixers, select the speed of rotation and drum angle to provide a cascading effect. For paddle type, a paddle speed should be selected to provide good mix agitation without throwing the batch out of the mixing zone.

NOTE 5—Batches should be homogeneous after mixing. Fast-setting mixes are normally mixed within 3 min. to provide adequate time for casting sound specimens. Lightweight castables and others may require the full 5 min. to reach homogeneity.

6.3 *Manual Mixing*—Manual mixing may be necessary for lightweight mixes having friable aggregate which may be broken by mechanical mixing. Place the weighed dry batch in a watertight mixing box and all of the required water. Mix by cutting into the material with the hoe, pulling it upward and forward, and continue until all the batch is piled at the end of the box. Then, standing at the opposite end, work the batch forward in the same manner, but by hoeing slices 2 to 3 in. (51 to 76 mm) thick, frequently pressing the mix with the back of the hoe. Continue the mixing in a rapid and intensive manner until the batch is homogeneous in appearance, but for a period not exceeding 3 to 5 min.

6.4 *Molding Test Specimens:*

6.4.1 *Obtain Initial Cast Length, if required*—Prior to filling each mold, use the calipers to obtain a measurement of the internal length to the nearest 0.01 in. (0.3 mm). Record this value to provide the basis for determining linear change of cured, dried, and fired specimens.

6.4.2 *Fill Molds*—After the 3 to 5 min. mixing has been accomplished, start the timer and begin filling the molds. Use a scoop/hand for cutting into the batch to get a good section and half fill the mold cavity. Consolidate the material in the molds by spading at close intervals with a square trowel, spatula, or finger tamping to ensure consolidation of the material into the mold corners. Self-flowing castables will not require spading, but will simply be poured into place. Fill the molds with an excess of the mix and repeat spading/tamping. Use the strike-off bar with a sawing motion to remove the excess mix, then smooth the exposed surface with a minimum amount of troweling. Complete the operation of filling the molds within 5 min. or at a rate of 1 min. per test specimen. Mechanical vibration should not be used unless specified by the manufacturer. Vibrate at a consistent amplitude and frequency.

6.4.2.1 When filling deep molds, that is, brick molds 4 in. (100 mm) deep or larger, fill the mold cavity halfway and consolidate the material in the molds by spading at close intervals with a square trowel or spatula held vertically, and with the blade turned to form an angle of 45° with the side of the mold. Spade along the length and then reverse the 45° angle for the next pass along the mold. Return to 6.4.2, filling the molds with excess material.

6.5 *Curing Test Specimens:*

6.5.1 Follow manufacturer's recommended curing instructions.

6.5.2 If no curing instructions exist, then cure as follows:

6.5.2.1 For Conventional (high cement) Castables, immediately after forming test specimens, enclose or cover them with an impervious membrane to prevent water evaporation.

6.5.2.2 For Low Cement Castables there typically is no difference whether they are covered or not.

6.5.2.3 For Ultra Low Cement and No Cement Castables, samples should remain uncovered.

6.5.3 Store the molded cast specimens at a temperature from 60 to 90°F (15.6 to 32.2°C) until set (typically overnight, around 15 hours) (Notes 6 and 7). For Conventional Castables, use of an impervious membrane is not required if a humidity cabinet capable of maintaining a relative humidity of 95 % or greater is used. The chamber should be large enough to permit free air circulation to remove heat developed during hydration. A forced-draft chamber is preferred to natural convection for circulation and a volume of free space equal to that of the specimens and mold being tested should be considered minimal.

NOTE 6—The CAH_{10}, C_2AH_8, C_3AH_6, and AH_3 hydrates (abbreviated compounds: C = CaO, A = AL_2O_3, H = H_20) are generally the dominant products of hydration in this temperature range. The hydration reaction may cause the internal temperature to increase above the chamber temperatures, particularly with larger specimens. Useful information can be obtained by casting thermocouples in the center of specimens so that the maximum temperature achieved during curing can be measured.

NOTE 7—The hydrate composition of the specimen will depend on the curing temperature. For this reason, the curing temperature is a determining variable in the development of green strength. Any comparison or referee testing must call out a specific temperature ±2°F. Testing has shown for conventional castables that the highest fired strengths are achievable when curing at 90 to 95°F (32.2 to 35.0°C). A current common practice in industry is to cure at 66 to 70°F (18.9 to 21.1°C).

6.5.4 Remove specimens to be tested for cured properties from the chamber and evaluate upon removing the molds, or return to the curing chamber until tested. Record cure time in hours. (**Warning—**If test specimens are removed from the molds before they are set, structural damage to the test specimens may occur.)

7. Test Methods

7.1 Following the mold curing, remove specimens scheduled for dried and fired properties from the mold. Measure and record the length of the cured specimen using the calipers to the nearest 0.01 in. (0.3 mm) and then place in a 150°F oven and hold until all specimens have been inserted. Increase the temperature at a minimum rate of 50°F/h (28°C/h) to 220 to 230°F (from 105 to 110°C) and hold for at least 15 h prior to testing or firing in a prescribed manner. Other drying methods

may be used (direct insertion to a 230°F oven for example) and must be mentioned in the report.

7.2 When room temperature strength measurements (Test Methods C133) are to be made after drying only, such strength measurements should be made within 2 h after removal from the drying oven. Should a longer room air exposure time be required, the specimens should be removed to or, alternatively, left in the drying oven held at 230°F (110°C) to satisfy the 2 h limit. A second acceptable alternative would be to store the dried specimens in a desiccator before testing.

NOTE 8—Refractory concrete specimens exposed to room air after drying have shown strength changes as exposure time in room air increases, when tested in accordance with Test Methods C133 or other strength test methods.

8. Report

8.1 Report the dry material casting water temperatures, batch size, mixing equipment, mixing time, percent by weight casting water, specimen size, cure time, initial and cured linear dimensions, and curing chamber temperature of the refractory concrete specimens. The curing temperature and humidity should be reported if different than those specified. The maximum internal specimen temperature reached during the curing period is also useful information in comparing results.

8.2 Referee testing should specify the exact procedure used by both parties.

9. Keywords

9.1 casting; curing; mixing; monolithic; refractories; refractory castable; refractory concrete; specimen preparation