Designation: C 862 – 02

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

This standard is issued under the fixed designation C 862; 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 practice covers the mixing, casting and curing of monolithic refractory concrete specimens for use in further testing. It does not apply to monolithic castable refractories intended primarily for gunning applications.

1.2 The values given in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

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:*

C 133 Test Methods for Cold Crushing Strength and Modulus of Rupture of Refractories[2]

C 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory[3]

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) 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.

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[4] (Fig. 1) may be used for preparing castable batches for casting specimens. A 2-ft^3 (56.6-dm^3) mixing bowl or a 2½ -ft^3 (70.8-dm^3) concrete mixer has sufficient capacity to mix about 1 ft^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 (2.83-dm^3) bowl available with bench mixers. Size mixing bowl to contain from 50 to 75 % volume loading with the dry batch.

NOTE 1—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 *Gang Molds*—Metal, two or more sets, as shown in Figs. 2 and 3, for casting specimens to the size required for specific physical property testing (see Note 8). The front plate of the mold illustrated is held in place by quick-release clamps (50-lbf (222-N) pull exerted by each clamp) that permit emptying the mold by releasing the clamps and tapping the left end of the front plate, thereby parting all of the separator plates and loosening the cast-test specimens.[5]

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

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[2] *Annual Book of ASTM Standards,* Vol 15.01.

[3] *Annual Book of ASTM Standards,* Vol 04.02.

[4] Mixers having various capacities are available from the Hobart Manufacturing Co., Troy, OH and have been found to be suitable for this purpose.

[5] A list of materials and notes on construction of the 9-in. (230 mm) straight-brick gang molds are available at a nominal charge from the Orton Refractory Research Center, Westerville, Ohio.

FIG. 1 Five Quart Hobart Mixer

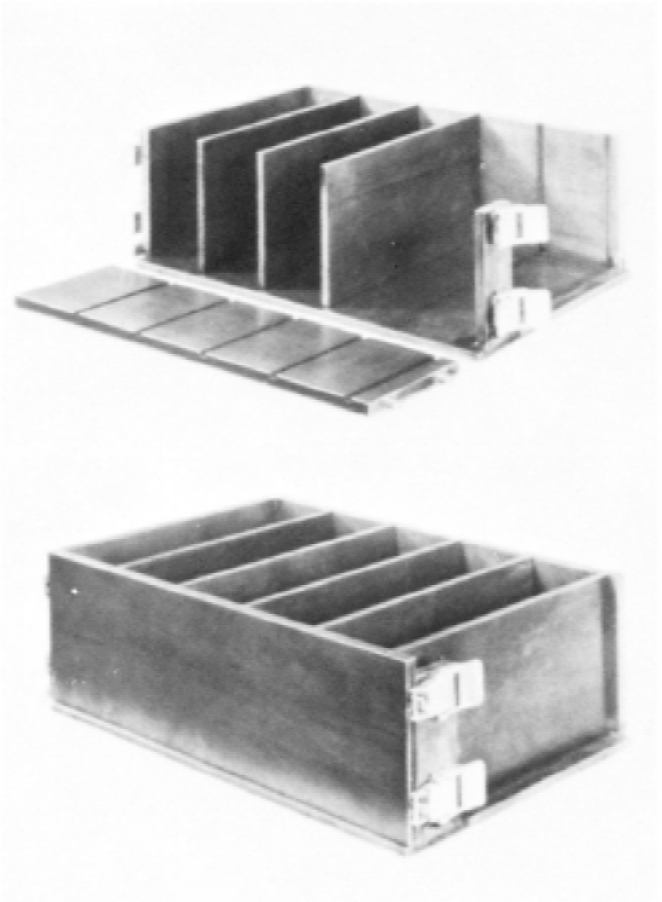


FIG. 2 Five-Brick Gang Mold for Castable Refractories

4.4.1 As an alternative design for 1 in. (25-mm) square bars, individual molds may be constructed out of 16-gage (1.588-mm) stainless-steel sheet and ganged in groups of five with a large rubber band on a glass base-plate.

4.4.2 There are commercially available molds from concrete testing suppliers and other sources. Molds may be reusable or for single use. Molds must be water tight, rigid, and removable.

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*—20-in. (510-mm) length of steel bar stock, 1½ by 3⁄16 in. (38 by 5 mm).

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, for periods up to 5 min. (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-mm.).

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.[6]

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

4.16 *Mixing Box*—Box of suitable size and strength to hand mix lightweight castable. Inside surface of box should not be water absorbent. Fig. 4 is a possible solution.

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

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

5. Sampling

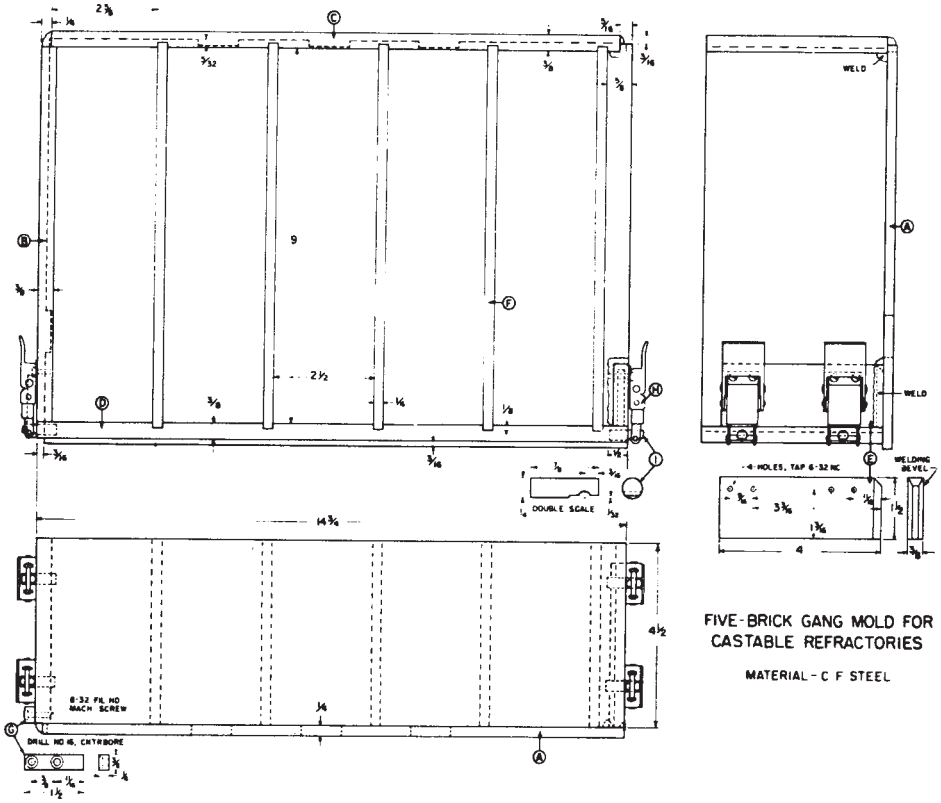
5.1 A sufficient amount of dry castable should be batched to overfill the gang molds by at least a 10 %. This should eliminate the use of both trailings and scrapings of wet castable.

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. Take precautions to prevent segregation.

[6] While there is no current specification for vibration table, ASTM C08 recognizes that the frequency and amplitude of the vibration table can affect the degree of consolidation of the sample. Current practice is to use an electric vibration table, which at least has a generally fixed frequency by the electric motor and the AC current.

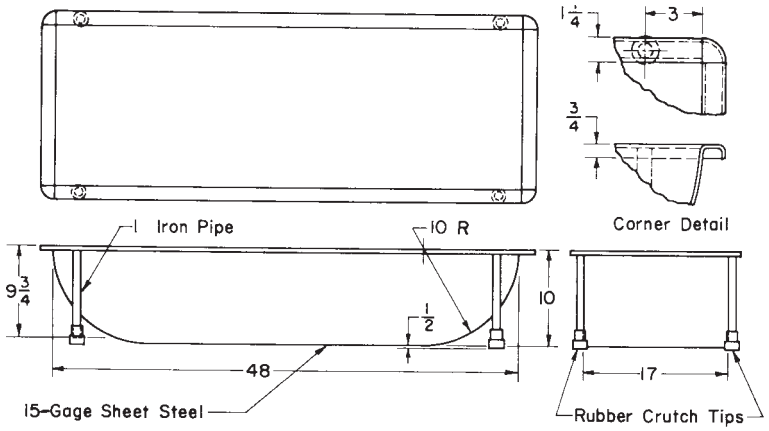


Metric Equivalents

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	

NOTE 1—Sizes other than 9-in. straights commonly used for physical testing are: 2½ by 4½ by 4½ in. (65 by 114 by 114 mm); 2 by 2 by 7 or 9 in. (51 by 51 by 178 or 230 mm); 1½ by 1½ by 4½ in. (38 by 38 by 114 mm); or 1 by 1 by 6 or 7 in. (25 by 25 by 152 or 178 mm). Dimensions are in inches.

FIG. 3 Detail Drawing for Gang Mold



NOTE 1—Dimensions are in inches.

FIG. 4 Mixing Box

NOTE 3—When the castable mix consists of more than one bag or

container, the contents should be combined and mixed thoroughly before being quartered.

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 manufacturers or referee's recommendations. Use potable water (Note 4) 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 4—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 5 and 6) or according to manufacturer's recommendations.

NOTE 5—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 6—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.

NOTE 7—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 C 192. In some cases, when smaller specimens are required and grain sizing does not allow for smaller castings, cut specimens may be used.

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 the 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*—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 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 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. Fill the molds with an excess of the mix and repeat the trowel spading. 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 (Note 8). 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.

NOTE 8—The cited procedure is applicable when filling deep molds, that is, brick molds as shown in Fig. 2 or larger. Hand placement of the castable can be used to fill and consolidate the material in shallow molds (normally 2 in. (50 mm) deep or less). Appropriate spading with the spatula should be used with the finger tamping to ensure consolidation of the material into the mold comers. Self flowing castables will not require spading, but will simply be poured into place.

6.5 *Curing Test Specimens*

6.5.1 Immediately after forming test specimens, enclose or cover them with an impervious membrane to prevent water evaporation.

6.5.2 Store the molded cast specimens at a temperature from 60 to 90°F (15.6 to 32.2°C) for 24 ± 0.5 h (Notes 9 and 10). 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 9—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 10—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 90-95°F (32.2 to 35.0°C). A current common practice in industry is to cure at 66-70°F (18.9 to 21.1 °C).

6.5.3 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, but for no longer than 24.5 h total curing time.

NOTE 11—**Caution:** If test specimens are removed from the molds in less than the specified time of 24 ± 0.5 h, 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 C 133) 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 12—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 C 133 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, initial and cured linear dimensions, and curing chamber temperature of the refractory concrete specimens. The curing temperature, humidity, and time should be reported if different than that specified. The maximum internal specimen temperature reached during the 24-h 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