Designation: C 862 – 91 (Reapproved 1997)

# 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 and casting of castable refractory specimens using the tempering water determined in accordance with the consistency tests in Practices C 860. It does not apply to castable refractories intended primarily for gun application.

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 *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. Figs. 1-7*

## 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]

C 860 Practices for Determining and Measuring Consistency of Refractory Concretes[2]

## 3. Significance and Use

3.1 This practice is used in conjunction with the proper water content (Practices C 860) to further assure the production of uniform laboratory specimens with optimum properties for castable testing. The practice is used to standardize the 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, along with Practices C 860, 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.

## 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, mixing, casting test specimens, stripping molds, and testing specimens. Report laboratory temperature and relative humidity with physical test results if other than specified.

**FIG. 1 Manually-Operated Mechanical Mixer**

4.2 *Balances*, 100-lb (45-kg) capacity with sensitivity of 0.2 lb (90 g); 15-lb (6.8-kg) capacity with sensitivity of 0.02 lb (9 g); 4.5-lb (2-kg) capacity with sensitivity of 0.1 g.

4.3 *Castable Mixers*—Either a manually operated (Fig. 1) or an electrically operated mechanical mixer[4] 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 of refractory castable. The smallest batches required for casting 1-in. (25-mm) square bars can be mixed in 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 50 % because the water required

[1] This practice is under the jurisdiction of ASTM Committee C-8 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] Suitable mixers having various capacities are available from the Hobart Manufacturing Co., Troy, OH.

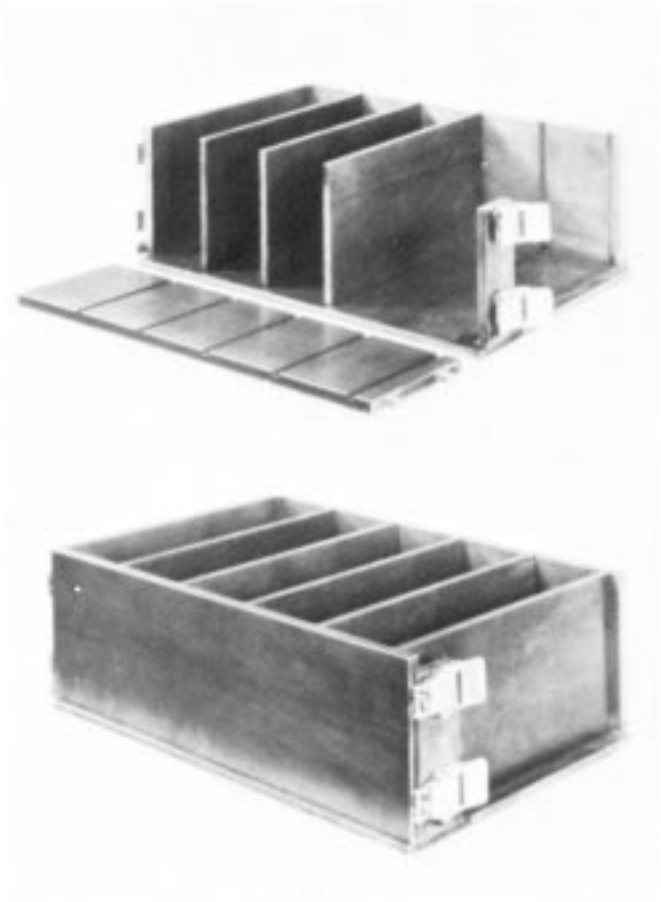


**FIG. 2 Five-Brick Gang Mold for Castable Refractories**

to wet the bowl surfaces changes more rapidly with decreasing volume loadings.

4.4 *Gang Molds*, metal, two or more sets, as shown in Fig. 2 and Fig. 3, for casting specimens to the size required for specific physical property testing (see Note 9). 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]

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.

4.5 *Calipers*, suitable for measuring internal longitudinal mold dimensions and subsequent specimen length size to the nearest 0.01 in. (0.3 mm).

4.6 *Indentation Marker*, as described in Fig. 5, and shown in Fig. 6 and Fig. 7, for use in establishing initial linear dimension and subsequent linear changes.

4.7 *Steel Rule*, capable of measuring dimensional changes of an 8-in. (203-mm) span to the nearest 0.01 in. (0.3 mm).

[5] Drawings of the manual mixer and 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 Refractories Research Center, Ohio State University, 2041 N. College Road, Columbus, OH 43210.

4.8 *Mold Lubricant*—Either paraffin or silicone-based oils can be used as a release or parting agent for coating molds.

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

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

4.11 *Timer*, signal-type, for periods up to 5 min.

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

4.13 *Oven*, for curing and drying, preferably forced draft rather than natural convection, with a capacity to hold ten 9-in. (230-mm) straight brick.

## 5. Sampling

5.1 Sufficiently dry castable should be batched to obtain at least a 10 % excess of material required to fill the gang molds and to eliminate use of both tailings and scrapings.

5.2 At the time of use, the dry sample should be between 70 and 80°F (20 and 27°C). Measure the temperature by inserting the full length of the dial-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 the same, 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 (Note 3) with a sample splitter to obtain a quartered sample of the desired batch size. Take precautions to prevent segregation.

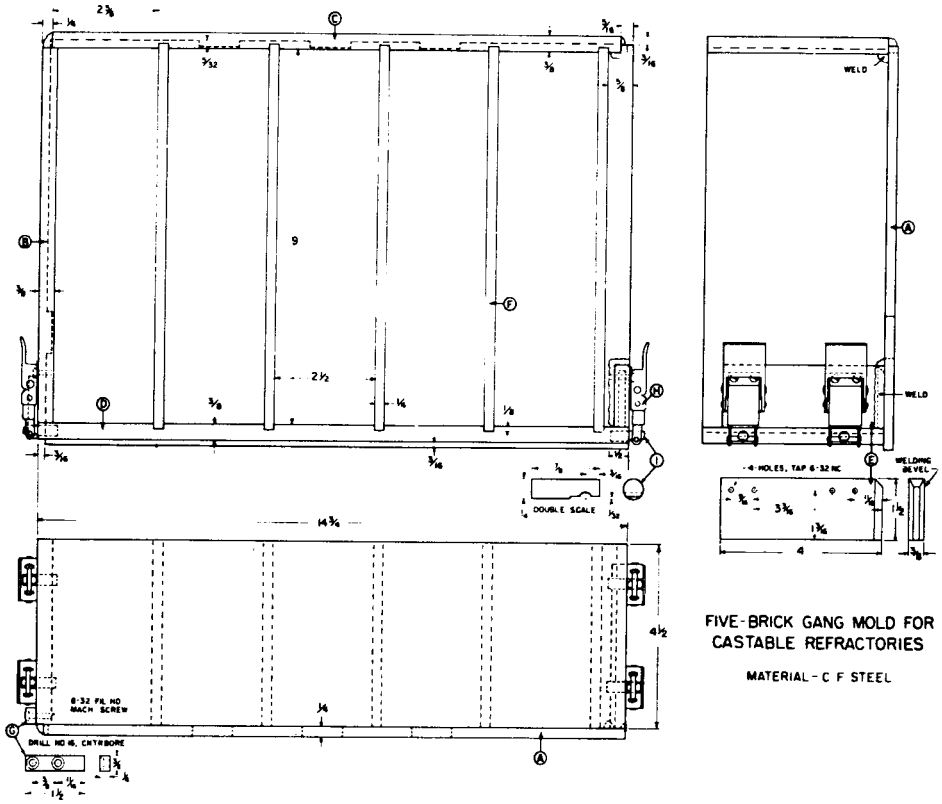
NOTE 3—When the castable mix consists of more than one bag or container, the contents should be combined and mixed thoroughly before being quartered.

## 6. Molding Test Specimens

6.1 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. An optional procedure for establishing an initial reference point is described in 6.3.

6.2 Immediately after mixing, start the timer and begin filling the molds. Use a scoop for cutting into the batch to get a good section and half-fill each 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. Complete the operation of filling the molds within 5 min or at the rate of 1 min per test specimen. Mechanical vibration should not be used.

NOTE 4—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

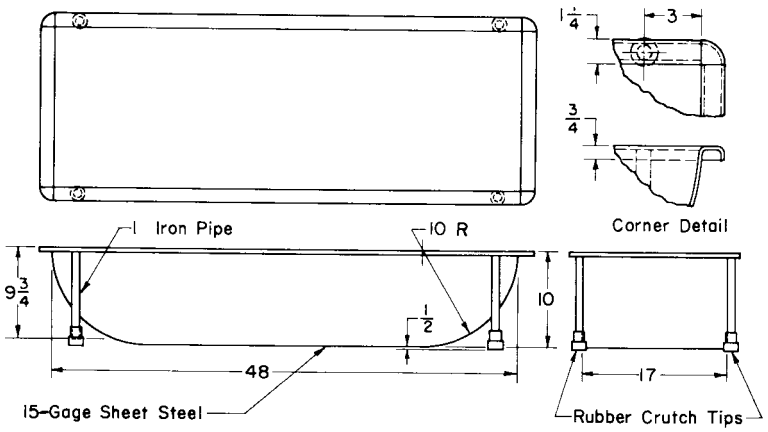



**Metric Equivalents**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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**

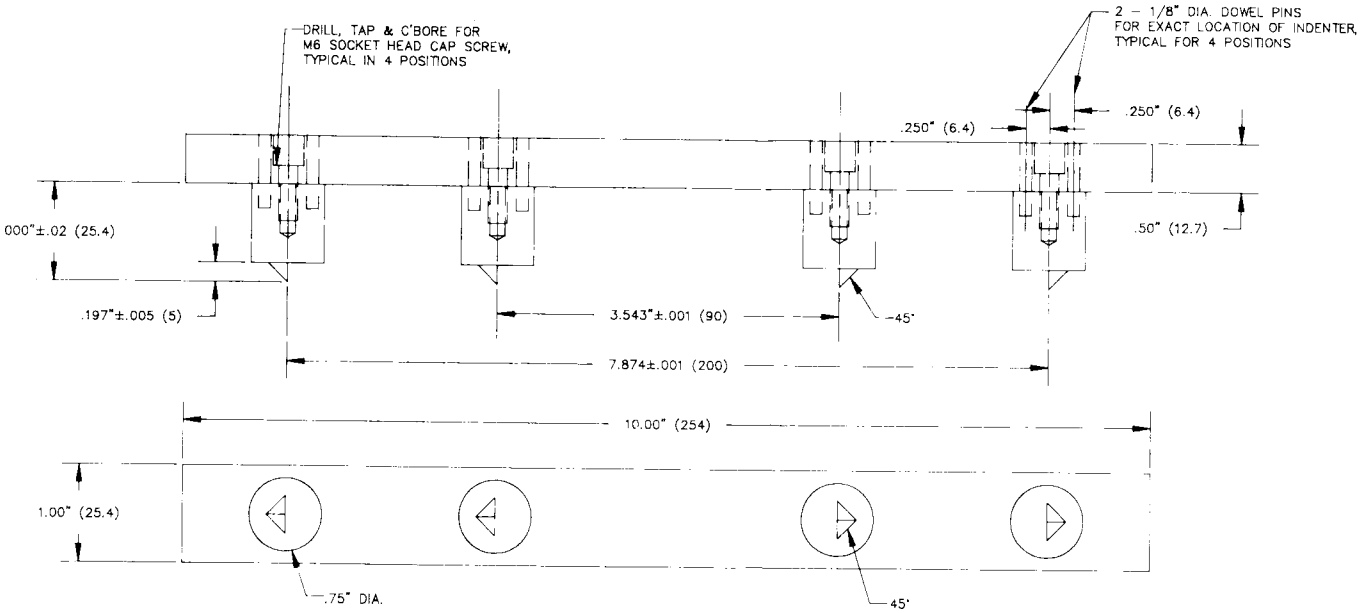



NOTE 1—Dimensions are in inches.

**FIG. 4 Mixing Box**

(normally 2 in. (50 mm) deep or less). Appropriate spading with the spatula should be used with finger tamping to ensure consolidation of the material into the mold corners.

6.3 Impress two or four reference marks into the troweled surface as the specimen begins to set (generally from 5 to 20 min). Use the calibrated marking device with knife edges at a known separation, for example, 8.00 in. (200 mm) for a 9-in.




NOTE 1—Dimensions in parentheses are millimetres.
NOTE 2—Rods of 0.75 in. diameter should be made of D 2 tool steel or equal and hardened to a minimum of RC 50.

NOTE 3—Back spine should be of mild steel with the mating side of the part ground flat.

**FIG. 5 Indentation Marker for Making Reference Marks**

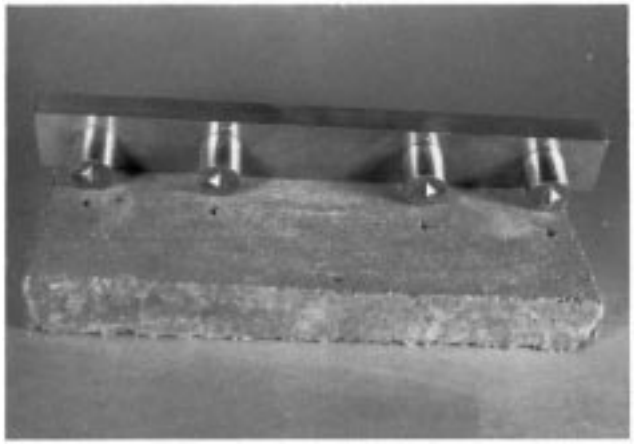


**FIG. 6 Indentation Marker for Making Reference Marks**

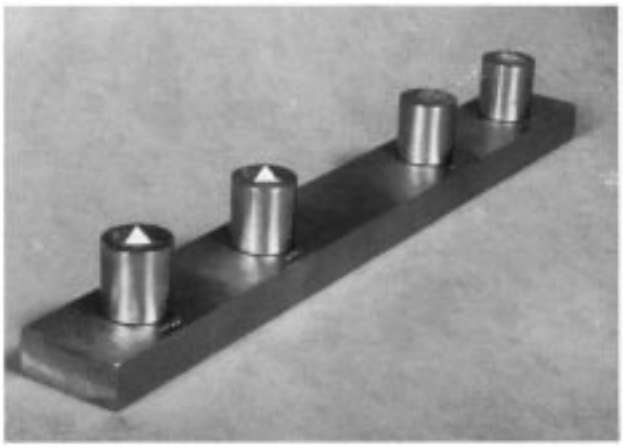


**FIG. 7 Indentation Marker for Making Reference Marks**

(228-mm) specimen. The distance between them is measured with a steel rule to the nearest 0.01 in. (0.3 mm) as the basis for determining total linear change.

## 7. Mixing Procedures

7.1 *Water Addition*—Determine the amount of water to be used in the mix for casting test specimens in accordance with the consistency test procedures in Practices C 860. Use potable water (Note 4) having a 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 weight % as determined previously (Note 5).

NOTE 5—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 used in referee tests.

NOTE 6—Check the consistency of each batch size by the ball-in-hand procedure and record the observation. Report any change in water percentage required to obtain the proper consistency.

7.2 *Mixing Large Batch for 9-in. (230-mm) Straights*—A large batch for casting ten 9 by 4½ by 2½-in. (230 by 114 by 65-mm) test specimens can be mixed in a mixing box or in a large electrically operated mixer (Note 6). Weigh not more than 100 lb (45 kg) of dry castable to the nearest 0.2 lb (90 g).

NOTE 7—Insulating castables should be mixed manually unless it is known that mechanical mixing will be used for the field installation. Mechanical mixing and manual mixing are likely to provide different results for bulk density and other properties because of the friable nature of the lightweight aggregates.

7.2.1 *Manual Mixing*—Place the weighed dry batch in the mixing box and add all of the required water (7.1). 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.

7.2.2 *Mechanical Mixing*—Add the weighed dry batch to an appropriate drum or paddle castable mixer (4.3). Operate the mixer at slow speed and add the required water to the mix within ½ min. Continue to mix at slow speed for a total time of 3 to 5 min (Note 8).

NOTE 8—Select the speed of rotation and drum angle to provide a cascading effect in drum mixers. A paddle speed should be selected to provide good mix agitation without throwing the batch out of the mixing zone.

NOTE 9—Batches should be homogeneous after manual or mechanical 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.

7.3 *Bench Mixing Batches for Small Specimens*—Small specimens required for physical and refractory testing can be mixed in small batches in appropriately sized mixers (4.3) and bowls. The number of smaller specimens that can be cast per batch can be calculated on the basis of the specimen dimensions. Gloved hand-mixing of small batches in a large-mouth pot can be performed only if the batch is limited in size to allow complete mixing and casting within the time specified for mechanical mixing.

NOTE 10—Although brick 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 Method C 192.

NOTE 11—The dry bulk volume is much greater than the cast volume during initial start of mixing. To prevent loss of material from the bowl when starting the mixer, the dry bulk volume should not exceed approximately 50 % of the bowl volume.

NOTE 12—Gloved hand-mixing of small batches may require more tempering water than that required with mechanical mixing to obtain a good ball-in-hand consistency.

7.3.1 *Bench Mechanical Mixing*—Add the weighed dry sample to a selected mixer bowl. Start the mixer at slow speed and add the predetermined amount of water to the mixing bowl. After mixing for 1 min on slow speed, stop the mixer and scrape the dry material from the paddle and bottom and sides of the bowl (about 15 s required). Continue to mix at slow speed for a period not exceeding 3 to 5 min after initial water addition.

NOTE 13—The slow initial speed is used to prevent loss of material during mixing.

## 8. Curing Test Specimens

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

8.2 Store the molded cast specimens at a temperature from 90 to 95°F (32 to 35°C) for 24 ± 0.5 h (Note 14). A plastic closure 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 molds being tested should be considered minimal.

NOTE 14—The $C_2AH_8$, $C_3AH_6$, and $AH_3$ phases (abbreviated compounds: C|CxCaO, A|C$_x$Al$_2$O$_3$, H|CxH$_2$O) are generally the dominant products of hydration in this temperature range. Heat of hydration may cause the internal specimen temperature to increase above the chamber temperature, 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.

8.3 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 15—**Caution:** If test specimens are removed from the molds in less than the specified curing time of 24 ± 0.5 h, structural damage to the test specimens may occur.

## 9. Test Methods

9.1 Following the mold curing, remove specimens scheduled for determining dried and fired properties from the mold, measure and record the length of the cured specimen, then place in a 150°F oven and hold until all specimens have been inserted, increase temperature at 50°F/h (28°C/h) maximum from 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.

9.2 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 possible, 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 16—Refractory concrete specimens exposed to room air after drying have shown strength decreases as exposure time in room air increases, when tested in accordance with Test Methods C 133 or other strength test methods.

## 10. Report

10.1 Report the material casting water temperatures, batch size, mixing equipment, drum or paddle speed, mixing time, percent by weight casting water, ball-in-hand consistency, specimen size, initial and cured linear dimensions, and curing-chamber temperature (if other than specified) of the cast refractory-castable specimens. The maximum internal-specimen temperature reached during the 24-h curing period is also useful information in comparing results.

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