Designation: C179 – 14

Standard Test Method for Drying and Firing Linear Change of Refractory Plastic and Ramming Mix Specimens[1]

This standard is issued under the fixed designation C179; 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 the drying shrinkage and of the combined drying and linear change of refractory ramming mixes and plastics.

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 *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]

C113 Test Method for Reheat Change of Refractory Brick

C134 Test Methods for Size, Dimensional Measurements, and Bulk Density of Refractory Brick and Insulating Firebrick

C181 Test Method for Workability Index of Fireclay and High-Alumina Refractory Plastics

C1054 Practice for Pressing and Drying Refractory Plastic and Ramming Mix Specimens

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

3. Significance and Use

3.1 This test method is useful in quantitatively rating or ranking both ramming and refractory plastics by their linear stability after heating.

3.2 This test method is also useful for determining whether a ramming or refractory plastic can be used in a specified application based on linear change criteria.

3.3 This test method excludes basic and carbon bearing materials.

3.4 This test method can produce data for the engineering and design of refractory installations. The linear change data can be used to determine the number of joints necessary to maintain integrity of ramming or refractory plastic in a large installation.

4. Apparatus

4.1 *Kiln,* electric or gas type, of such design that the flame, as coming directly from the burner, cannot impinge upon the test specimens.

4.2 *Measuring Device,* capable of being read to 0.02-in. (0.5-mm). A hooked rule, 12 in. (305 mm), is convenient to use and a suitable type is described in Test Methods C134. Other measuring devices, such as calipers or dial gages, of the same or better precision may also be used.

5. Test Specimens

5.1 *Number of Specimens*—A minimum of six specimens molded from the sample (see Note 1) of refractory plastic will be required. Half of the specimens shall be used for the test and the other half used as supporting pieces during the kiln heat treatment.

NOTE 1—For pressing and drying the specimens see Practice C1054.

5.2 *Measurement of Specimens*—Using the measuring device, measure the bar for all dimensions to the nearest 0.02-in. (0.5-mm). Label and make reference marks to indicate the exact length measurement points. Caution should be taken as deformation of the specimens may be caused by handling.

5.3 *Drying of Specimens*—Dry specimens should be dried as stated in Practice C1054, 6.6.

5.4 *Measuring Dried Specimens*—Measure specimens as stated in 5.2.

6. Procedure

6.1 *Placing Specimens in Kiln*—Place the dried specimens in the kiln in accordance with Test Method C113, with the

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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.

exception that the supporting brick shall consist of the three refractory plastic brick prepared for that purpose.

6.2 *Temperature Measurements*—Conduct temperature measurements in accordance with Test Method C113.

6.3 *Test Atmosphere*—At all temperatures above 1470°F (800°C), operate the kiln so that the atmosphere shall contain a minimum of 0.5 % oxygen with 0 % combustibles.

6.4 *Test Temperature Schedule*—Operate the kiln so as to conform to the appropriate heating schedule for the class of refractory being tested, as specified in Table 1 of Test Method C113.

6.5 *Measuring Fired Specimens*—After completion of the heating schedule, cool the specimens in the closed kiln to under 800°F (425°C) before removing to the air. After cooling to room temperature, remeasure them in accordance with 5.2. Record the fired length of each of the three test specimens.

7. Calculation and Report

7.1 *Drying Linear Change*—Calculate the drying linear change as a percentage based on the original length of the specimen as measured in 5.2. Calculate using Eq 1:

$$DLC = ((L_D - L_O)/L_O) \times 100 \quad (1)$$

where:

DLC = Drying Linear Change, %
L_D = dried length, in. (mm)
L_O = original length, in. (mm)

A negative value indicates shrinkage and a positive value, growth or expansion of the specimen. Report the average value for the three specimens to the nearest 0.1 %.

7.2 *Combined Linear Change Due to Drying and Firing*—Calculate the combined drying and firing linear change as a percentage based on the original length of the specimen as measured in 5.2. Calculate using Eq 2:

$$FLC = ((L_F - L_O)/L_O) \times 100 \quad (2)$$

where:

FLC = Combined Drying and Firing Linear Change, %
L_F = fired length, in. (mm)
L_O = original length, in. (mm)

A negative value indicates shrinkage and a positive value, growth or expansion of the specimen. Report the average value for the three specimens to the nearest 0.1 %.

7.3 The report shall include the following:

7.3.1 Workability of the refractory plastic determined in accordance with Test Method C181.

7.3.2 Firing temperature used or heating schedule from Table 1 of Test Method C113.

8. Precision and Bias

8.1 The precision of this test method is based on an interlaboratory study conducted in 2012. A total of five laboratories participated in this study in an effort to determine the intralaboratory and interlaboratory precision of this test method. Laboratories were asked to report three test results per material, and each test result was defined as a single analytical determination. Practice E691 was followed for the design and analysis of the data, except for the limited number of laboratories submitting results. All details are given in RR:C08-1024.[3] Two of the five laboratories had test results higher than the critical *h* and critical *k* values indicating some type of issue occurred, but the subcommittee decided to include these laboratory results anyway due to the limited number of laboratories already involved in the study.

8.1.1 *Repeatability, r*—The difference between repetitive results obtained by the same operator in a given laboratory, applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in 1 case in 20.

8.1.1.1 Repeatability can be interpreted as the maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

8.1.1.2 Repeatability limits are listed in Tables 1-3.

8.1.2 *Reproducibility, R*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories, using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in 1 case in 20.

8.1.2.1 Reproducibility can be interpreted as the maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

8.1.2.2 Reproducibility limits are listed in Tables 1-3.

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

8.1.4 Any judgment in accordance with 8.1.1 and 8.1.2 would normally have an approximate 95 % probability of being

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C08-1024. Contact ASTM Customer Service at service@astm.org.

TABLE 1 Linear Change (Green to Dry), %

Material	Average Linear Change, %[A] , *Xbar*	Repeatability Standard Deviation, *sr*	Reproducibility Standard Deviation, *sR*	Repeatability Limit, *r*	Reproducibility Limit, *R*
Air Bond (A)	–1.0727	0.0963	0.1235	0.2697	0.3457
Phos Plastic (B)	–0.4573	0.1684	0.3734	0.4716	1.0456
High Workable Phos Plastic (C)	–0.8840	0.0884	0.2546	0.2474	0.7128

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

TABLE 2 Linear Change (Dry to Fired), %

Material	Average Linear Change, %[A] , *Xbar*	Repeatability Standard Deviation, *sr*	Reproducibility Standard Deviation, *sR*	Repeatability Limit, *r*	Reproducibility Limit, *R*
Air Bond (A)	–0.1867	0.0532	0.2590	0.1490	0.7252
Phos Plastic (B)	–0.0947	0.1473	0.3320	0.4125	0.9296
High Workable Phos Plastic (C)	–0.0600	0.0463	0.2600	0.1295	0.7281

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

TABLE 3 Linear Change (Green to Fired), %

Material	Average Linear Change, %[A] , *Xbar*	Repeatability Standard Deviation, *sr*	Reproducibility Standard Deviation, *sR*	Repeatability Limit, *r*	Reproducibility Limit, *R*
Air Bond (A)	–1.2593	0.1052	0.2453	0.2945	0.6867
Phos Plastic (B)	–0.5520	0.1020	0.5504	0.2855	1.5410
High Workable Phos Plastic (C)	–0.9440	0.0809	0.0985	0.2264	0.2759

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

correct; however, the precision statistics obtained in this interlaboratory study (ILS) must not be treated as exact mathematical quantities that are applicable to all circumstances and uses. The limited number of laboratories reporting results guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply. Consider the repeatability limit and the reproducibility limit as general guides, and the associated probability of 95 % as only a rough indicator of what can be expected.

8.2 *Bias*—There was no accepted reference material at the time of this study suitable for determining the bias for this test method, therefore no statement on bias can be made.

8.3 This precision statement was determined through statistical examination of 135 results, from a total of five laboratories, on three different materials.

9. Keywords

9.1 linear change; plastic; ramming mix; refractory; shrinkage