Designation: C 181 – 03

Standard Test Method for Workability Index of Fireclay and High-Alumina Plastic Refractories[1]

This standard is issued under the fixed designation C 181; 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 workability index of fireclay and high-alumina plastic refractories by measuring the plastic deformation of a molded test specimen when subjected to impacts.

1.2 *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]

D 2906 Practice for Statements on Precision and Bias for Textiles

3. Significance and Use

3.1 Workability index serves as a measure of the facility with which plastic refractory materials can be rammed, gunned, or vibrated into place.

3.2 Workability index is commonly used to control consistency of plastics during manufacture. It has also been found useful for specification acceptance by the consumer.

3.3 The workability index determination can provide information for developing a plastic body. When a sample splits under impact at various water contents, it is an indication that the material is "short" or lacking in plasticity.

3.4 Determinations on samples that split during impact will be difficult to reproduce. If the sample splits, the measurement is not a true indication of deformation. This should be noted in the report.

4. Apparatus

4.1 *Rammer*—The apparatus shall consist of the device known as the rammer for refractories[3] (see Fig. 1). It shall consist essentially of a steel cylindrical mold 2.00 in. (50.8 mm) in inside diameter and 4.75 in. (120.6 mm) in length, supported in a vertical position on the same axis as a shaft to which shall be fastened a plunger that fits inside the mold. A 14-lb (6.4-kg) cylindrical weight slides on the same shaft and is arranged to fall a distance of 2 in. (51 mm) before engaging a collar fastened to the shaft. As shown in Fig. 1, the weight may be raised by a manually rotated cam. Provision shall be made to support the weight, thereby removing the load from the vertical shaft by the installation of two hooks (having a 10-32 screw thread) in the top side of the weight in a position that enables them to engage with pins (having an 8-32 screw thread) placed on each side of the upper portion of the framework, as shown in Fig. 1 and in detail in Fig. 2. A steel rule,[4] one edge graduated in 0.02-in. (0.5-mm) increments, shall be attached (Note 1) to the rammer so that the position of the end of the vertical shaft can be read. The portion of the rule to be used shall be adjusted so that when the vertical shaft is in the lowest position, its machined end is in alignment with the graduation on the rule that represents the exact distance

[1] This test method 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] 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] The rammer for refractories, Model 315-R, is available from Dietert Foundry Testing Equipment, 9190 Roselawn Ave, Detroit, MI 48204. Accessory parts required for conduct of this test and calibration of the rammer include:

Test Equipment	*Part Number*
Specimen tube	315-9
Cup pedestal	315-11
1.000 in. cup pedestal spacer block	315R-8
Stripping post	315-14
Specimen tube conditioner	315-30
Replacement swab for 315-30	315-02006
Liquid parting pattern spray	315-02007
Calibration Equipment	*Part Number*
Rammer foundation tester (includes impact rings, micrometer, and test anvil)	307
Replacement impact rings	307-3A
Master precision specimen tube	315-18

[4] A suitable rule is the Lufkin Rule Co. Rule No. 2103-R, which is 6 in. (152 mm) in length and must be cut off at each end so that the desired portion of the graduations aligns with the shaft.

FIG. 1 Apparatus for Workability-Index Test

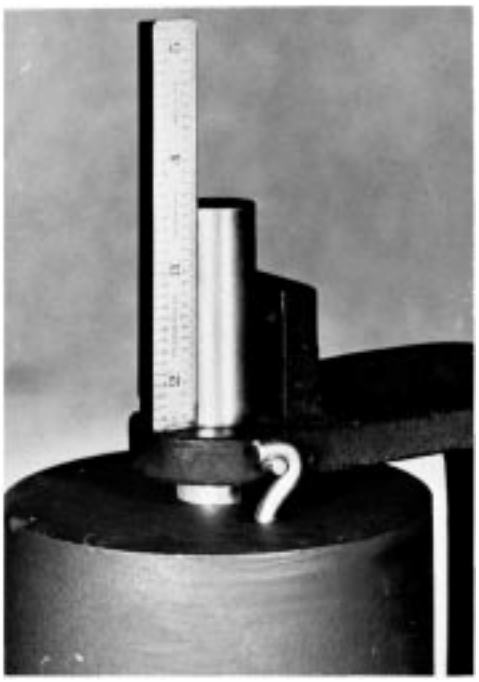

FIG. 2 Upper Portion of the Sand Rammer Showing Close-Up of Modifications Required

between the top and bottom of the bottom plate of the mold (approximately 1.7 in. (43 mm)). The upper end of the scale may be cut off flush with the top of the rod (see Note 1), which provides a rule of sufficient length for measuring the maximum distance obtainable between the ends of the mold (Note 2).

NOTE 1—One method of mounting the rule is to install in a vertical position a ⅜-in. (9.5-mm) square rod, 4⅛ in. (105 mm) in length, in that part of the framework which constitutes the top bearing for the shaft. One end of the rod is reduced to a ¼-in. (6.4-mm) round section for a length of ⅜ in., and this is threaded for a ¼-20 screw. A tapped hole, to receive the threaded rod, is made in the framework and on the center line (from front to back) of the apparatus. When tightening the rod in place, one face must be in a position so that the rule can be sweat-soldered to it as shown in Fig. 2.

NOTE 2—The apparatus as described in this section is capable of measuring workabilities up to about 32 %. For products of higher workability a suitable spacer block[5] may be installed under the specimen.

4.1.1 *Mounting for Rammer*—The rammer shall be mounted on a 27-in. (686-mm) high concrete column, having a base measuring at least 8 by 11 in. (200 by 279 mm). Four ¼-in. (6.4-mm) bolts, at least 3 in. (76 mm) in length, shall be cast in the top of the column and shall be grouted with a suitable mortar. Variable results are obtained from the test unless the described mounting or an acceptable alternative mounting[6] is used for the rammer.

4.1.2 *Maintenance and Calibration*—As needed, depending on use, clean all moving parts and lubricate with SAE 10 oil. Make periodic checks of the height that the weight drops to insure the weight is being raised 2 in. (51 mm). Inspect the rammer to determine whether it and the foundation are producing full ramming energy. This is accomplished by using calibrated impact rings.[7]

NOTE 3—Variation in the smoothness and dimensions of the specimen tube may cause variation in workability values. For referee testing the specimen tube may require periodic comparison with a master precision specimen tube.[8]

5. Test Specimens

5.1 *Temperature of Plastic Refractory*— Since the workability index may vary with a wide spread of temperature, the temperature of the material to be tested must be between 65 and 75°F (18 and 24°C) to reduce this variable. Record temperature of material before forming the cylinder.

NOTE 4—As much as a 3-point change in the workability index may occur within the 10°F (6°C) stated range.

5.2 *Number of Specimens*—Five cylindrical test specimens shall be molded from the sample (Note) of plastic refractory.

5.3 *Molding of Specimens*—The interior of the mold shall be cleaned and coated with a light film of suitable parting agent[9] prior to the preparation of each specimen. To facilitate

[5] A suitable 1-in. (25-mm) spacer block is listed in footnote 4.

[6] An acceptable alternative mounting is available from Dietert Foundry Testing Equipment; use the rammer base, part no. 315-27, and the rammer pedestal, part no. 315-45.

[7] Part number 307 as provided by Dietert Foundry Testing Equipment, consists of a set of precision steel rings, a steel anvil and a micrometer, has been found suitable for this purpose. To determine full ramming energy, the anvil is positioned in the specimen tube locating hole in the base of the rammer. A test ring is then placed in the center of the anvil with the axis of the ring being horizontal. The ring is then subjected to 3 impacts of the rammer head. A measurement across the center of the deformed ring is then made and compared to the limits specified on the box containing the rings. Detailed instructions are included in the calibration kit.

[8] Part number 315-18 as provided by Dietert Foundry Testing Equipment, has been found suitable for this purpose.

[9] A suitable parting agent is provided by Dietert Foundry Testing Equipment, as described in footnote 4.

filling the mold, the sample shall be broken into pieces varying in size, the largest dimension being about 1 in. (25 mm). The sample weight shall be chosen to provide a sample height of 2.5 ± 0.1 in. (64 ± 3 mm). For a super-duty plastic, the sample weight is approximately 300 g; for an 85 to 90 % alumina plastic, approximately 375 g. After placing the material in the mold, it shall be subjected to ten impacts by turning the handle, which causes the weight to be raised 2 in. (51 mm) and then dropped upon the collar attached to the plunger shaft. The mold containing the sample shall then be upended and an additional ten impacts given to the specimen. The formed test specimen shall then be extruded from the mold by the use of a suitable auxiliary plunger.

6. Procedure

6.1 Remove the load on the plunger of the mold by suspending the weight from the framework. Do this by slightly rotating the weight while engaging the hooks on the pins in the framework. After raising the vertical shaft, place the test specimen on the bottom of the mold and lower the shaft until the plunger is in firm contact with the specimen. Obtain the length of the specimen to the nearest 0.02 in. (0.5 mm) by sighting on the rule and the end of the shaft. Disengage the weight from its support and carefully lower it until it is at rest in its normal position. Then apply three impacts from the weight to the test specimen. Read the final length of the specimen from the scale, and record the difference in inches or millimetres between the two measurements.

7. Calculation and Report

7.1 Calculate the percentage deformation for each of the five test specimens on the basis of the original length and report the average value as the workability index. The workability index shall be calculated by the following equation, and shall be rounded off to one decimal place.

$$W = \frac{L - L_1}{L} \times 100$$

where

L = length of specimen prior to deformation,
L_1 = length of specimen after deformation, and
W = workability index.

7.2 State the temperature of the sample, the specimen weight used, and whether any test specimen crumbled as a result of the three impacts.

8. Precision and Bias

8.1 *Interlaboratory Test Data*[10]—An interlaboratory test was run in 1975, in which two laboratories each tested ten specimens from each of two plastic materials: a super-duty and a high-alumina phosphate-bonded plastic. Samples were selected from the same container of plastic and tested in each laboratory at the same time. The components of variance for workability index results calculated by the procedures given in Practice D 2906 are as follows:

Within-laboratory component 4.1 % of the average
Between-laboratory component 5.1 % of the average

8.2 *Precision*—For the components of variance given in 8.1, two averages of test values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical difference listed as follows (for t = 1.96):

	Critical Difference, % of Grand Average of Workability Index	
Number of Samples in Each Average	Within-Laboratory Precision	Between-Laboratory Precision
3	6.6	15.6
5	5.1	15.0
10	3.6	14.6
15	2.9	14.3

8.3 *Bias*—No justifiable statement on bias is possible since the true value of the workability index cannot be established by an accepted reference material.

9. Keywords

9.1 refractories; refractory plastic; workability

[10] Supporting data are available from ASTM International Headquarters. Request RR: C 08 – 1003.