Designation: C 326 – 03

Standard Test Method for Drying and Firing Shrinkages of Ceramic Whiteware Clays[1]

This standard is issued under the fixed designation C 326; 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 linear shrinkage of ceramic whiteware clays, both unfired and fired.

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. Significance and Use

2.1 The purpose of this test is to obtain values of shrinkage after drying and firing of clays or bodies or both, under various processing conditions to enable designers to determine the proper size of mold or die so as to produce a predetermined size of fired ware.

3. Test Specimens

3.1 Test specimens shall be round bars approximately 0.75 in. (19 mm) in diameter by 5 in. (127 mm) in length.

3.2 Test specimens may be prepared either by casting or plastic forming, as circumstances require. At least ten specimens shall be prepared. For cast specimens the molds may be either one-piece, or two- or more-part molds; in either instance sufficient space shall be provided to allow solid casting without piping. Where plastic-forming is employed, the clay-water mass shall be brought to a consistency that permits the making of specimens rigid enough to allow careful handling without distortion immediately after the test specimen is made. Plastic-formed test specimens shall be made either by extrusion or by pressing in a suitable metal mold. Where a vacuum pugmill is used, a vacuum of not less than 25 in. (635 mm) Hg shall be maintained during the forming operation. Where no vacuum attachment is used, the plastic clay shall be thoroughly hand-wedged to eliminate entrapped air as a preliminary to forming test pieces.

3.3 The test specimens, cast or plastic-formed, shall be suitably identified and marked with shrinkage reference lines 4 in. (102 mm) apart on the long axis of the specimen. The shrinkage reference lines may conveniently be made with a gage with knife edges at zero and 4 in. (102 mm) and marking must be done as soon as the bars can be handled without distortion.

3.4 The marked specimens shall then be placed on a lightly oiled pallet with semi-circular grooves 0.40 in. (10.2 mm) in diameter and allowed to dry at 68 to 100°F (20 to 40°C) for 24h. The purpose of the semi-circular (half round) grooves is to maintain straightness of the bars during drying. During this preliminary drying period, the bars shall be turned 90° several times at 2-h intervals to eliminate possible warping in the vertical direction. After the initial drying period, the specimens shall be placed in a drying oven at 200 to 230°F (100 to 110°C) and further dried for 24 h.

3.5 The drying shrinkage of the test specimens should be determined in accordance with Sections 4 and 5. The specimens can now be fired according to a suitable firing schedule to the desired temperature and the procedures of Sections 4 and 5 applied to determine the total shrinkage.

3.6 The test bars must be clearly identified as to whether they were cast or extruded, and shrinkage data likewise identified because of slight differences in shrinkage between cast and extruded bars.

4. Shrinkage Measurement

4.1 Measure the distance between shrinkage reference marks on dried or fired specimens to the closest 0.004 in. (0.1 mm) with calipers of suitable accuracy. Record the average of at least ten measurements (one measurement on each of the group of ten or more specimens).

5. Calculation

5.1 Calculate the linear drying shrinkage as a percentage of plastic length, as follows:

$$S_d = \frac{L_p - L_d}{L_p} \times 100 \quad (1)$$

where:

S_d = linear drying shrinkage, %,
L_p = plastic length of test specimen, and
L_d = dry length of test specimen.

[1] This test method is under the jurisdiction of ASTM Committee C21 on Ceramic Whitewares and Related Products and is the direct responsibility of Subcommittee C21.04 on Raw Materials.

Current edition approved Oct. 1, 2003. Published November 2003. Originally approved in 1953. Last previous edition approved in 1997 as C 326 – 82 (1997)ε1.

5.2 Calculate the total linear shrinkage after drying and firing of clay shrinkage specimens as a percentage of plastic length, as follows:

$$S_t = \frac{L_p - L_f}{L_p} \times 100 \quad (2)$$

where:
S_t = total linear shrinkage after drying and firing, %,
L_p = plastic length of test specimen, and
L_f = fired length of test specimen.

5.3 When desired, volume shrinkage may be calculated from linear shrinkage, as follows:

$$\text{Volume shrinkage, \%} = [1 - (1 - S/100)^3]\,100 \quad (3)$$

where:
S = linear shrinkage, %.

5.4 The shrinkage factor is used to convert fired sizes to plastic sizes or mold sizes. Calculate as follows:

$$\text{Shrinkage factor} = L_p/L_f \quad (4)$$

where:
L_p = plastic length of test specimen, and
L_f = fired length of test specimen.

6. Precision and Bias

6.1 The direction of flow in forming influences the orientation of the clay particles and the shrinkage. The shrinkage value should be related to the method of forming as well as the dimension of the ware.

6.2 When the original reference points are 100 mm apart, the precision of the shrinkage measurement is ± 0.1 %.

6.3 Measurements of drying shrinkage on one dimension of specimens all formed by the same method should yield a standard deviation of 0.1 % or less.

6.4 Measurement of total linear shrinkage after drying and firing on one dimension of specimens should yield a standard deviation of 0.25 % or less.

7. Keywords

7.1 clay; drying shrinkage; firing shrinkage