APPENDIX B.

STANDARD TEST METHOD

INTERNATIONAL **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:

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

where:

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

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[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.

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

$$S_t = \frac{L_p - L_f}{L_p} \times 100 \tag{2}$$

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:

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

where:

S = linear shrinkage, %.

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

$$\text{Shrinkage factor } = L_p/L_f \tag{4}$$

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

INTERNATIONAL

Designation: C 373 – 88 (Reapproved 2006)

Standard Test Method for
Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products[1]

This standard is issued under the fixed designation C 373; 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 procedures for determining water absorption, bulk density, apparent porosity, and apparent specific gravity of fired unglazed whiteware products.

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 Measurement of density, porosity, and specific gravity is a tool for determining the degree of maturation of a ceramic body, or for determining structural properties that may be required for a given application.

3. Apparatus and Materials

3.1 *Balance*, of adequate capacity, suitable to weigh accurately to 0.01 g.

3.2 *Oven*, capable of maintaining a temperature of 150 ± 5°C (302 ± 9°F).

3.3 *Wire Loop, Halter, or Basket*, capable of supporting specimens under water for making suspended mass measurements.

3.4 *Container*—A glass beaker or similar container of such size and shape that the sample, when suspended from the balance by the wire loop, specified in 3.3, is completely immersed in water with the sample and the wire loop being completely free of contact with any part of the container.

3.5 *Pan*, in which the specimens may be boiled.

3.6 *Distilled Water*.

4. Test Specimens

4.1 At least five representative test specimens shall be selected. The specimens shall be unglazed and shall have as much of the surface freshly fractured as is practical. Sharp edges or corners shall be removed. The specimens shall contain no cracks. The individual test specimens shall weigh at least 50 g.

5. Procedure

5.1 Dry the test specimens to constant mass (Note 1) by heating in an oven at 150°C (302°F), followed by cooling in a desiccator. Determine the dry mass, *D*, to the nearest 0.01 g.

Note 1—The drying of the specimens to constant mass and the determination of their masses may be done either before or after the specimens have been impregnated with water. Usually the dry mass is determined before impregnation. However, if the specimens are friable or evidence indicates that particles have broken loose during the impregnation, the specimens shall be dried and weighed after the suspended mass and the saturated mass have been determined, in accordance with 5.3 and 5.4. In this case, the second dry mass shall be used in all appropriate calculations.

5.2 Place the specimens in a pan of distilled water and boil for 5 h, taking care that the specimens are covered with water at all times. Use setter pins or some similar device to separate the specimens from the bottom and sides of the pan and from each other. After the 5-h boil, allow the specimens to soak for an additional 24 h.

5.3 After impregnation of the test specimens, determine to the nearest 0.01 g the mass, *S*, of each specimen while suspended in water. Perform the weighing by placing the specimen in a wire loop, halter, or basket that is suspended from one arm of the balance. Before actually weighing, counterbalance the scale with the loop, halter, or basket in place and immerse in water to the same depth as is used when the specimens are in place. If it is desired to determine only the percentage of water absorption, omit the suspended mass operation.

5.4 After the determination of the suspended mass or after impregnation, if the suspended mass is not determined, blot each specimen lightly with a moistened, lint-free linen or cotton cloth to remove all excess water from the surface, and determine the saturated mass, *M*, to the nearest 0.01 g. Perform the blotting operation by rolling the specimen lightly on the wet cloth, which shall previously have been saturated with water and then pressed only enough to remove such water as will drip from the cloth. Excessive blotting will introduce error

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[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 C21.03 on Methods for Whitewares and Environmental Concerns.

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by withdrawing water from the pores of the specimen. Make the weighing immediately after blotting, the whole operation being completed as quickly as possible to minimize errors caused by evaporation of water from the specimen.

6. Calculation

6.1 In the following calculations, the assumption is made that 1 cm^3 of water weighs 1 g. This is true within about 3 parts in 1000 for water at room temperature.

6.1.1 Calculate the exterior volume, V, in cubic centimetres, as follows:

$$V = M - S \tag{1}$$

6.1.2 Calculate the volumes of open pores V_{OP} and impervious portions V_{IP} in cubic centimetres as follows:

$$V_{OP} = M - D \tag{2}$$

$$V_{IP} = D - S \tag{3}$$

6.1.3 The apparent porosity, P, expresses, as a percent, the relationship of the volume of the open pores of the specimen to its exterior volume. Calculate the apparent porosity as follows:

$$P = [(M - D)/V] \times 100 \tag{4}$$

6.1.4 The water absorption, A, expresses as a percent, the relationship of the mass of water absorbed to the mass of the dry specimen. Calculate the water absorption as follows:

$$A = [(M - D)/D] \times 100 \tag{5}$$

6.1.5 Calculate the apparent specific gravity, T, of that portion of the test specimen that is impervious to water, as follows:

$$T = D/(D - S) \tag{6}$$

6.1.6 The bulk density, B, in grams per cubic centimetre, of a specimen is the quotient of its dry mass divided by the exterior volume, including pores. Calculate the bulk density as follows:

$$B = D/V \tag{7}$$

7. Report

7.1 For each property, report the average of the values obtained with at least five specimens, and also the individual values. Where there are pronounced differences among the individual values, test another lot of five specimens and, in addition to individual values, report the average of all ten determinations.

8. Precision and Bias

8.1 This test method is accurate to ±0.2 % water absorption in interlaboratory testing when the average value recorded by all laboratories is assumed to be the true water absorption. The precision is approximately ±0.1 % water absorption on measurements made by a single experienced operator.

9. Keywords

9.1 apparent porosity; apparent specific gravity; bulk density; fired whiteware products; water absorption

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JIS

JAPANESE INDUSTRIAL STANDARD

Heat resistant ceramic tablewares

JIS S 2400-1991

① Tableware – Heat-resistant materials
② Heat-resistant materials – Ceramics

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JAPANESE INDUSTRIAL STANDARD JIS

Heat resistant ceramic tablewares

S 2400-1991

1. Scope

This Japanese Industrial Standard specifies heat resistant ceramic tableware, hereafter referred to as the "tableware", for table and kitchen use under direct fire or in the oven.

Remarks 1. The phrase heat resistant ceramic tableware refers to a single body of ceramic ware, and excludes the lid if not integral with the body, knobs, and grips.

2. The corresponding International Standards to this Standard are as follows:

ISO 6486/1	Ceramic ware in contact with food - Release of lead and cadmium - Part 1: Method of test
ISO 6486/2	Ceramic ware in contact with food - Release of lead and cadmium - Part 2: Permissible limits

2. Classification

Tableware shall be classified according to the use, as given in Table 1.

Table 1. Classification

Class	Use	Thermal shock resistance °C
Direct fire (high heat resistance)	Applied directly to the flame for the purpose of heat cooking, and durable under rapid heating and cooling.	min. 280
Direct fire	Applied directly to the flame for the purpose of heat cooking.	min. 150
Oven (max. 300°C)	Not applied directly to the flame for the purpose of heat cooking, and durable under cooking in an oven at max. 300°C.	min. 150
Oven (max. 200°C)	Not applied directly to the flame for the purpose of heat cooking, and durable under cooking in an oven at max. 200°C.	min. 120

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3. Quality

3.1 Appearance Tableware shall not have significant penetration (1), pinholes, foreign material, or stains harmful to appearance, and shall be stable. For products with a penetrating pattern or a material where penetration is unavoidable, it is permissible if there is no interference to use.

Note (1) Penetration refers to cracking in the glaze layer. The glaze layer is the layer of glassy glazing agent generated on the surface of the product after baking by applying a glazing agent to the base.

3.2 Thermal shock resistance When tested as given in 4.1, there shall be no defects such as penetration or separation of the glaze layer or peeling, cuts, crazing or cracking of the base. Penetrations in products allowed in 3.1, unless they interfere with use, shall not be considered defects.

3.3 Elution quantity of hazardous substances When tested as given in 4.2, the elution quantity of hazardous substance shall comply with the Standard reference for foods, additives, etc. based on the Food Sanitation Law (1947, Law No. 233).

4. Test methods

4.1 Thermal shock test Place the samples for 1 h in a constant temperature container preliminarily heated to the test temperature difference (difference between the heating temperature and the water temperature) given in Table 2 for the class of the samples, immediately place in the water tank at 24 ± 3°C (2), allow the samples to cool to the water temperature, remove and examine for defects of the glaze layer and base.

Table 2. Test temperature differences

Class	Test temperature difference °C
Direct fire (high heat resistance)	280 to 290
Direct fire	150 to 160
Oven (max. 300°C)	150 to 160
Oven (max. 200°C)	120 to 128

Note (2) The water tank shall be large enough to cool all heated samples, when the samples are inserted there shall be no piling on the bottom of the water tank, and the depth from the water surface to the samples shall be at least 15 mm. The quantity of water shall be such that when cooling the samples the water temperature does not rise above 29°C.

4.2 Elution quantity test of hazardous substances The elution quantity test of hazardous substances shall be in accordance with the test method of the Standard reference of foods, additives, etc. (December, 1959, Notification of Ministry of Health and Welfare No. 370, Food additives and the like, Standard reference No. 3, devices and containers, package D 1) based on the Food Sanitation Law.

For calculation of the elution quantity (μg/cm^2) of hazardous substances in a shallow container, place the container on millimeter grid graph paper, draw the profile along the edge, and use the apparent surface area thus obtained.

5. Inspection

Tableware shall be inspected for compliance with the specifications of 3. The inspection may be carried out using any effective sampling method.

6. Marking

Tableware shall be marked on the body of the product or on the minimum packaging unit with the following:

(1) Class

(2) Manufacturer's name, or its abbreviation

7. Cautions for handling

Tableware for direct fire (high heat resistance) and for direct fire use shall contain a caution not to use for deep frying, etc.

Reference Standard:

JIS K 0121-General Rules for Atomic Absorption Spectrochemical Analysis

S 2400-1991
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Japanese Text

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