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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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# Standard Method for Particle-Size Analysis of Whiteware Clays[1]

This standard is issued under the fixed designation C 775; 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.

$\epsilon^1$ NOTE— Section 16 was added editorially in October 1997.

## 1. Scope

1.1 This method covers the quantitative determination of the distribution of particle sizes in kaolins and ball clays in the size range 44 to 0.1 µm by the sedimentation process. Particles are allowed to settle under normal gravitational forces and concentrations of particles in the size range 44 to 2 µm are measured using a hydrometer. Centrifuging is used to cause the smaller particles to settle more rapidly so that concentrations of particles in the size range 2 to 0.1 µm may be measured using a pipet.

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:*

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[2]

E 100 Specification for ASTM Hydrometers[3]

## 3. Terminology Definition

3.1 *equivalent spherical diameter*—the diameter of a spherical particle having the same density and sedimentation rate in the same fluid as the clay particles being tested.

## 4. Apparatus

4.1 *Stirring Apparatus*—A mechanically operated stirring device in which a suitably mounted electric motor turns a vertical shaft at a speed of not less than 10 000 r/min without load. The shaft shall be equipped with a replaceable stirring paddle made of metal, plastic, or hard rubber as shown in Fig. 1. The shaft shall be of such length that the stirring paddle will operate at not less than ¾ in. (19.0 mm) nor more than 1½ in. (38.1 mm) above the bottom of the dispersion cup. A special dispersion cup conforming to either of the designs shown in Fig. 2 shall be provided to hold the sample while it is being dispersed.

NOTE 1—A few clays are difficult to disperse and for these clays the use of a Waring blender[4] or equivalent is recommended.

4.2 *Centrifuge*—The centrifuge shall have bottles with a capacity of approximately 250 mL, and the rotational speed shall be closely controlled and measured using a tachometer. A timing device should be used to stop the centrifuge after predetermined time intervals.

4.3 *Hydrometer*—An ASTM hydrometer, graduated to read in either specific gravity of the suspension or grams per litre of suspension, and conforming to the requirements for Hydrometer 152H in Specification E 100.

4.4 *Sedimentation Cylinder*—A glass cylinder essentially 18 in. (457 mm) in height and 2½ in. (63.5 mm) in diameter, and marked for a volume of 1000 mL. The inside diameter shall be such that the 1000-mL mark is 360 ± 20 mm from the bottom on the inside.

4.5 *Sieve*—A No. 325 (45-µm) sieve conforming to the requirements of Specification E 11.

4.6 *Water Bath or Constant-Temperature Room*—A water bath or constant-temperature room for maintaining the clay suspension at a constant temperature during the hydrometer analysis. A satisfactory water tank is an insulated tank that maintains the temperature of the suspensions at a convenient constant temperature at or near 25°C (77°F). Such a device is illustrated in Fig. 3. In cases where the work is performed in a room at an automatically controlled temperature, the water bath is not necessary.

## 5. Records

5.1 *Dispersing Agent*—Dissolve 2 g of sodium hexametaphosphate (sometimes called sodium metaphosphate ($NaPO_3$)) in 1 L of distilled or demineralized water.

NOTE 2—Some fine-grained clays require more of the dispersant and up to 6 g/L of water may be added after trials have been run to determine the percentage of dispersant causing the maximum fluidity using a viscometer suitable for clay-water suspensions.

NOTE 3—Solutions of this salt, if acidic, slowly revert or hydrolyze back to the orthophosphate form with a resultant decrease in dispersive



[1] This method is under the jurisdiction of ASTM Committee C-21 on Ceramic Whitewares and Related Products and is the direct responsibility of Subcommittee C21.04 on Clays.

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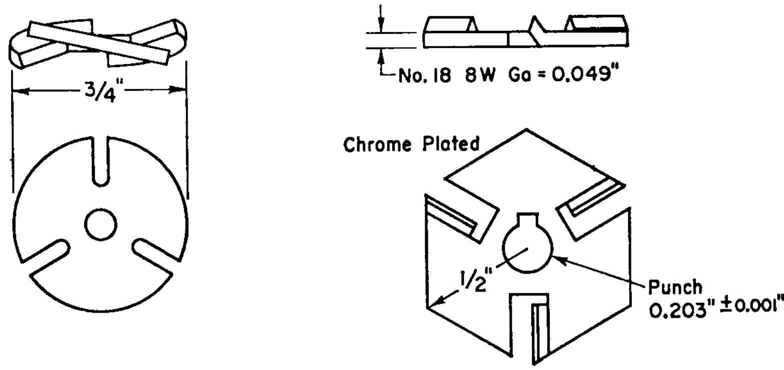
[2] *Annual Book of ASTM Standards*, Vol 14.02.

[3] *Annual Book of ASTM Standards*, Vol 14.03.

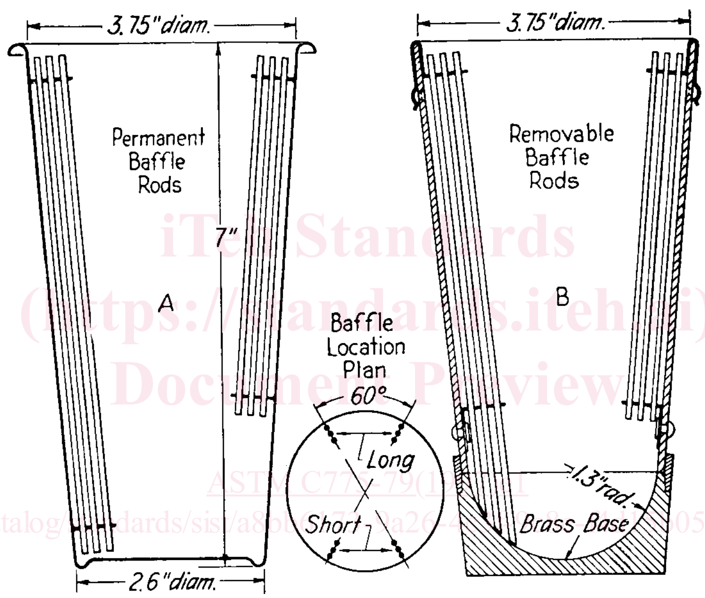
[4] Available from Waring Products Div., Dynamics Corp. of America, New Hartford, CT 06057.




Metric Equivalents

| | | | | |
|---|---|---|---|---|
| in. | 0.001 | 0.049 | ½ | ¾ |
| (mm) | (0.03) | (1.24) | (12.7) | (19.0) |

FIG. 1 Detail of Stirring Paddles






Metric Equivalents

| | | | |
|---|---|---|---|
| in. | 1.3 | 2.6 | 3.75 |
| (mm) | (33) | (66) | (95.2) |

FIG. 2 Dispersion Cups of Apparatus

action. Solutions should be prepared frequently (at least once a month) or adjusted to pH of 8 or 9 by means of sodium carbonate. Bottles containing solutions should have the date of preparation marked on them.

5.2 *Water*—All water used shall be either distilled or demineralized water. The water for a hydrometer test shall be brought to the temperature that is expected to prevail during the hydrometer test. For example, if the sedimentation cylinder is to be placed in the water bath, the distilled or demineralized water to be used shall be brought to the temperature of the controlled water bath; or, if the sedimentation cylinder is used in a room with controlled temperature, the water for the test shall be at the temperature of the room. The basic temperature for the hydrometer test is 25°C (77°F). Small variations of temperature do not introduce differences that are of practical significance and do not prevent the use of corrections derived as prescribed.

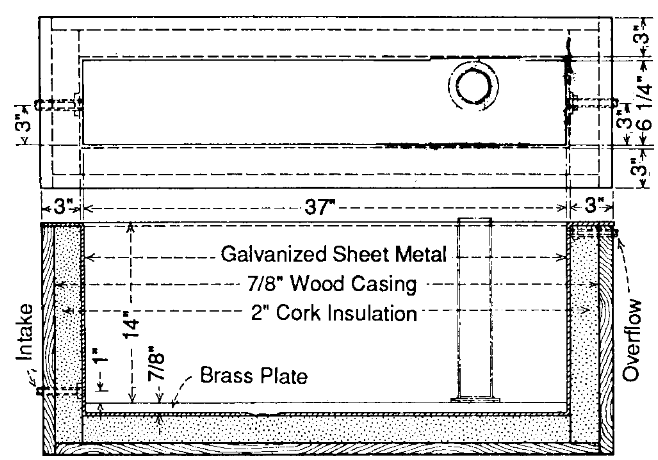



FIG. 3 Insulated Water Bath

**TABLE 1 Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specified Sizes[A]**

| Hydrometer 152H | | | |
|---|---|---|---|
| Actual Hydrometer Reading | Effective Depth, *L*, cm | Actual Hydrometer Reading | Effective Depth, *L*, cm |
| 0 | 16.3 | 31 | 11.2 |
| 1 | 16.1 | 32 | 11.1 |
| 2 | 16.0 | 33 | 10.9 |
| 3 | 15.8 | 34 | 10.7 |
| 4 | 15.6 | 35 | 10.6 |
| 5 | 15.5 | | |
| 6 | 15.3 | 36 | 10.4 |
| 7 | 15.2 | 37 | 10.2 |
| 8 | 15.0 | 38 | 10.1 |
| 9 | 14.8 | 39 | 9.9 |
| 10 | 14.7 | 40 | 9.7 |
| 11 | 14.5 | 41 | 9.6 |
| 12 | 14.3 | 42 | 9.4 |
| 13 | 14.2 | 43 | 9.2 |
| 14 | 14.0 | 44 | 9.1 |
| 15 | 13.8 | 45 | 8.9 |
| 16 | 13.7 | 46 | 8.8 |
| 17 | 13.5 | 47 | 8.6 |
| 18 | 13.3 | 48 | 8.4 |
| 19 | 13.2 | 49 | 8.3 |
| 20 | 13.0 | 50 | 8.1 |
| 21 | 12.9 | 51 | 7.9 |
| 22 | 12.7 | 52 | 7.8 |
| 23 | 12.5 | 53 | 7.6 |
| 24 | 12.4 | 54 | 7.4 |
| 25 | 12.2 | 55 | 7.3 |
| 26 | 12.0 | 56 | 7.1 |
| 27 | 11.9 | 57 | 7.0 |
| 28 | 11.7 | 58 | 6.8 |
| 29 | 11.5 | 59 | 6.6 |
| 30 | 11.4 | 60 | 6.5 |

[A] Values of effective depth are calculated from the equation:

$$L = L_1 + \tfrac{1}{2}[L_2 - (V_B/A)]$$

where:

$L$ = effective depth, cm,
$L_1$ = distance along the stem of the hydrometer from the top of the bulb to the mark for a hydrometer reading, cm,
$L_2$ = overall length of the hydrometer bulb, cm,
$V_B$ = volume of hydrometer bulb, $cm^3$, and
$A$ = cross-sectional area of sedimentation cylinder, $cm^2$

Values used in calculating the values in Table 1 are as follows:
For hydrometer 152H:
$L_1$ = 10.5 cm for a reading of 0 g/L
= 2.3 cm for a reading of 50 g/L
$L_2$ = 14.0 cm
$V_B$ = 67.0 $cm^3$
$A$ = 27.8 $cm^2$

## 6. Hydrometer Test and Sieve Analysis

6.1 *Determination of Composite Correction for Hydrometer Reading*:

6.1.1 Equations for percentages of clay remaining in suspension, as given in Section 13, are based on the use of distilled or demineralized water. A dispersing agent is used in the water, however, and the specific gravity of the resulting liquid is appreciably greater than that of distilled or demineralized water.

6.1.2 Calibrate the hydrometer at 20°C (68°F). Variations in temperature from this standard temperature produce inaccuracies in the actual hydrometer readings.

NOTE 4—The amount of the inaccuracy increases as the variation from the standard temperature increases.

**TABLE 2 Values of *K* for Use in Equation for Computing Diameter of Particles Having a Specific Gravity of 2.60 in Hydrometer Analysis**

| Temperature, °C | *K* Values |
|---|---|
| 16 | 0.01457 |
| 17 | 0.01439 |
| 18 | 0.01421 |
| 19 | 0.01403 |
| 20 | 0.01386 |
| 21 | 0.01369 |
| 22 | 0.01353 |
| 23 | 0.01337 |
| 24 | 0.01321 |
| 25 | 0.01306 |
| 26 | 0.01291 |
| 27 | 0.01277 |
| 28 | 0.01264 |
| 29 | 0.01249 |
| 30 | 0.01236 |

6.1.3 Hydrometers are graduated by the manufacturer to be read at the bottom of the meniscus formed by the liquid on the stem. Since it is not possible to secure readings of the clay suspensions at the bottom of the meniscus, readings must be taken at the top and a correction factor applied.

6.1.4 The net amount of the corrections for the three items enumerated is designated as the composite correction, and may be determined experimentally.

6.2 For convenience, a graph or table of composite corrections for a series of 1° temperature differences for the range of expected test temperatures may be prepared and used as needed. Measurement of the composite corrections may be made at two temperatures spanning the range of expected test temperature, and corrections for the intermediate temperatures calculated assuming a straight-line relationship between the two observed values.



6.3 Prepare 1000 mL of liquid composed of distilled or demineralized water and the dispersing agent in the same proportion as will prevail in the sedimentation (hydrometer) test. Place the liquid in the sedimentation cylinder and the cylinder in the constant-temperature water bath, set for one of the two temperatures to be used. When the temperature of the liquid becomes constant, insert the hydrometer, and, after a short interval to permit the hydrometer to come to the temperature of the liquid, read the hydrometer at the top of the meniscus formed on the stem. For Hydrometer 152H, it is the difference between the reading and zero. Bring the liquid and the hydrometer to the other temperature to be used, and secure the composite correction as before.

## 7. Hygroscopic Moisture

7.1 When the sample is weighed for the hydrometer test, weigh out an auxiliary portion from 10 to 15 g in a small metal or glass container, dry the sample to a constant weight in an oven at 110 ± 5°C (230± 9°F), and weigh again. Record the weights.

## 8. Dispersion of Clay

8.1 Weigh out a sample of 50 g of air-dry clay. Place the sample in a 500-mL beaker and cover with 250 mL of the