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**Standard Method of Test for**

**Plastic Fines in Graded Aggregates  
and Soils by Use of the Sand  
Equivalent Test**

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**AASHTO Designation: T 176-22**

Technically Revised: 2022

**Technical Subcommittee: 1a, Soil and Unbound Recycled Materials**



**American Association of State Highway and Transportation Officials  
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# Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

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## 1. SCOPE

- 1.1. This test is intended to serve as a rapid test to show the relative proportions of fine dust or claylike material in soils or graded aggregates.
- 1.2. The following applies to all specified limits in this standard: For the purpose of determining conformance with these specifications, an observed value or a calculated value shall be rounded off “to the nearest unit” in the last right-hand place of figures used in expressing the limiting value, in accordance with ASTM E29, Using Significant Digits in Test Data to Determine Conformance with Specifications.
- 1.3. The values stated in SI units are to be regarded as the standard.
- 1.4. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns 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.*
- 1.5. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

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## 2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
  - M 231, Weighing Devices Used in the Testing of Materials
  - M 339M/M 339, Thermometers Used in the Testing of Construction Materials
  - R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
  - R 76, Reducing Samples of Aggregate to Testing Size
  - R 90, Sampling Aggregate Products
- 2.2. *ASTM Standards:*

- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
- E29, Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standard:*

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances

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### 3. SIGNIFICANCE AND USE

- 3.1. This test method is used to determine the proportion of detrimental fines in the portion passing the 4.75-mm (No. 4) sieve of soils or graded aggregates.

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### 4. APPARATUS

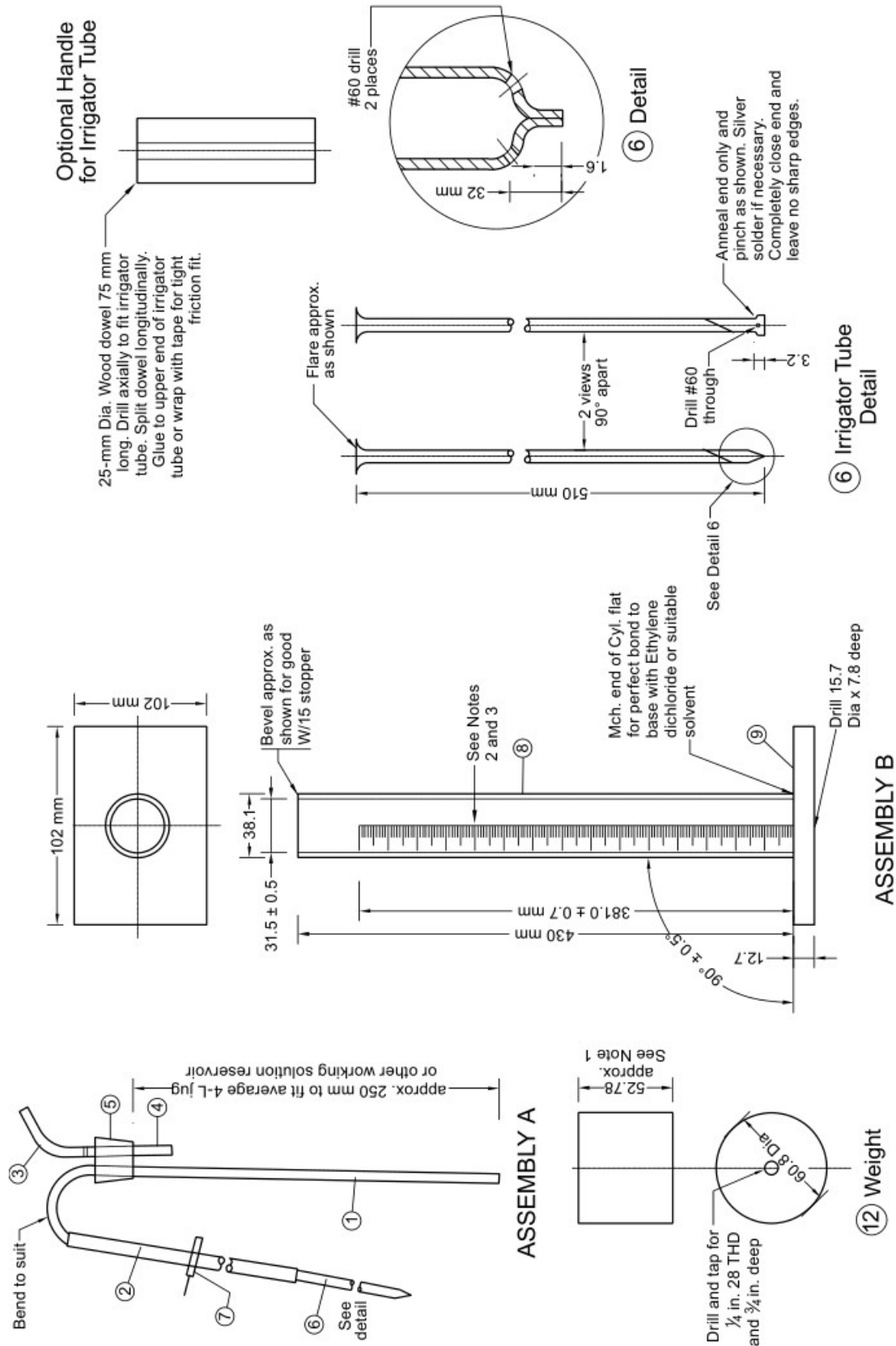
- 4.1. *Sand Equivalent Apparatus*—A graduated plastic cylinder, rubber stopper, irrigator tube, weighted foot assembly, and siphon assembly, all conforming to their respective specifications and dimensions shown in Figure 1. Fit the siphon assembly to a 4-L (1-gal) bottle of working calcium chloride solution (see Section 2.8) placed on a shelf  $915 \pm 25$  mm ( $36 \pm 1$  in.) above the work surface. In lieu of the specified 4-L (1-gal) bottle, a glass or plastic vat having a larger capacity may be used provided the liquid level of the working solution is maintained between 915 and 1170 mm (36 and 46 in.) above the work surface (see Figure 2).

Assembly	No. Reg.	Description	Stock Size	Material	Heat Treatment
A		Siphon Assembly			
	1	Siphon tube	6.4 dia × 400	Copper tube	
	2	Siphon hose	4.8 ID × 1220	Rubber tube	
	3	Blow hose	4.8 ID × 50.8	Rubber tube	
	4	Blow tube	6.4 dia × 50.8	Copper tube	
	5	Two-hole stopper	No. 6	Rubber	
	6	Irrigator tube	6.4 OD 0.89 wall × 510 stainless tube, type 316		
	7	Clamp	Pincock, Day, BKH No. 21730 or equivalent		
B		Graduate Assembly			
	8	Tube	38.1 OD × 430	Trans acrylic plastic	
	9	Base	12.7 × 102 × 102	Trans acrylic plastic	
C		Weighted Foot Assembly			
	10	Sand reading indicator	6.4 dia × 15.0	Nylon 101 Type 66	Annealed
	11	Rod	6.4 dia × 444	Brass	
	12	Weight	50.8 dia × 52.78	Cold rolled steel, or equivalent	
	13	Roll pin	0.16 dia × 12.7	Steel	
	14A	Foot - hexagonal top	30.2 OD	Brass	
	14B	Foot - circular bottom	25.4 OD		
	15	Solid stopper	No. 7	Rubber	

Notes: 1. "C" Weighted Foot Assembly to Weigh 1000 ± 5g.

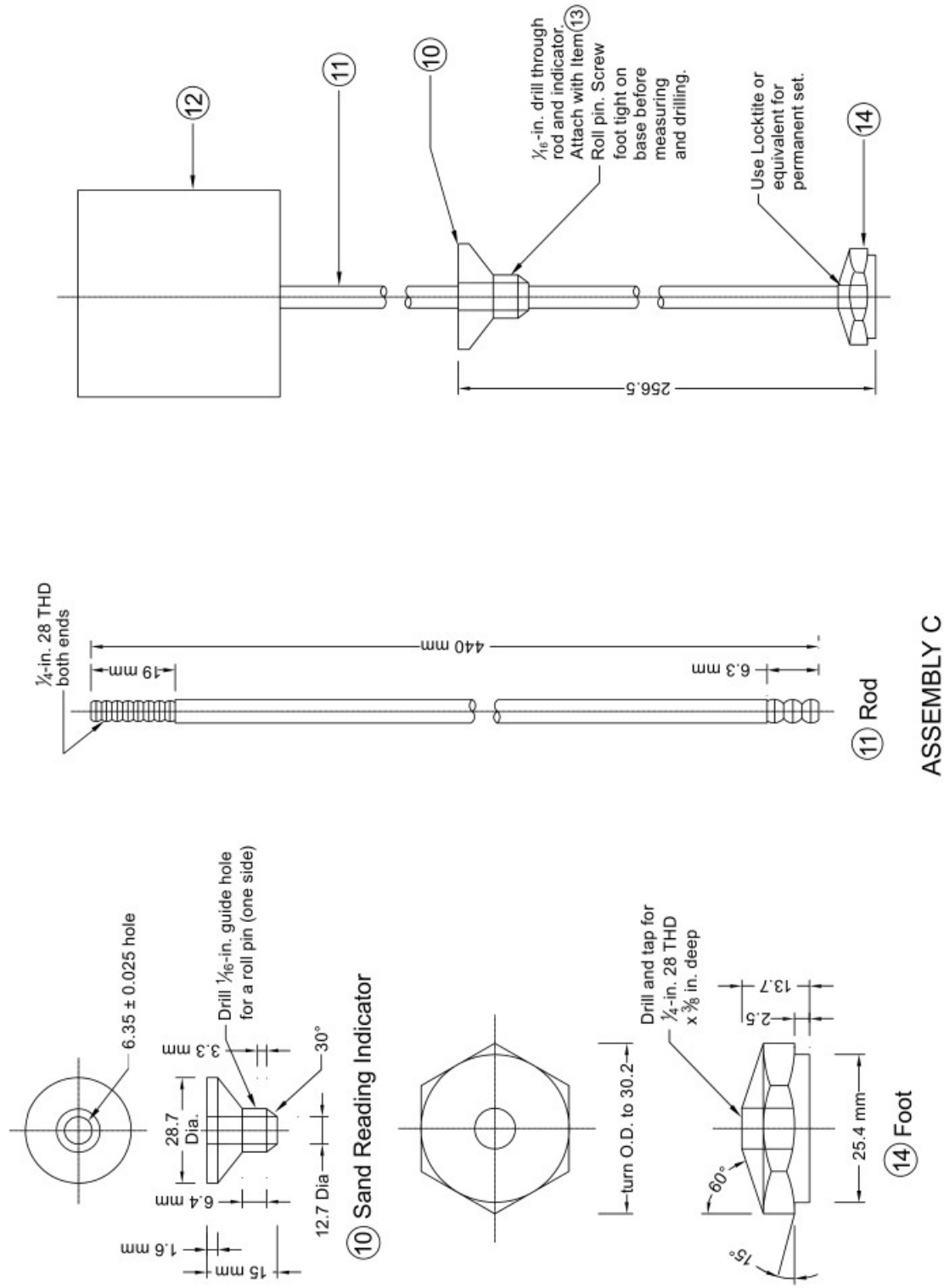
2. Graduations on graduate to be 2.54 mm apart and every tenth mark to be numerically designated as shown. Every fifth line should be approximately 9.5 mm long. All other lines should be approximately 5.5 mm long. Depth is to be 0.4 mm. Width is to be 0.8 mm across the top.
3. Accuracy of scale to be ±0.25 mm per 2.5 mm. Error at any point on scale to be ±0.75 mm of true distance to zero.
4. Glass or stainless steel may be substituted as a material type for the copper siphon and blow tubing.
5. Total height of foot (14A and 14B) to be 13.7 mm.

**Figure 1**—Sand Equivalent Apparatus (*continued on the following two pages*)



Note: All dimensions are shown in millimeters unless otherwise indicated.

**Figure 1**—Sand Equivalent Apparatus (*Continued on next page*)



Note: All dimensions are shown in millimeters unless otherwise indicated.

**Figure 1**—Sand Equivalent Apparatus (*Continued*)



**Figure 2**—Graduated Cylinder, Irrigator Tube, Weighted Foot Assembly, and Siphon

**Note 1**—An older model of a weighted foot assembly has a guide cap that fits over the upper end of the graduated cylinder and centers the rod in the cylinder; the foot of the assembly has a conical upper surface and three centering screws to center it loosely in the cylinder. The older model does not have the sand reading indicator affixed to the rod (Figure 1), but a slot in the centering screws of the weighted foot is used to indicate the sand reading. Apparatus with the sand reading indicator (Figure 1) is preferred for testing clayey materials.

- 4.2. *Measure*—A tinned measure, having a capacity of  $85 \pm 5$  mL (3 oz), approximately 57 mm (2.25 in.) in diameter.
- 4.3. *Balance*—The balance shall have sufficient capacity, be readable to not more than 0.1 percent of the sample mass, and conform to the requirements of M 231.
- 4.4. *Funnel*—A wide-mouth funnel approximately 100 mm (4 in.) in diameter at the mouth.
- 4.5. *Timer*—A clock or watch reading in minutes and seconds.
- 4.6. *Mechanical Shaker*—A mechanical shaker having a throw of  $203.2 \pm 1.0$  mm ( $8.00 \pm 0.04$  in.) and operating at  $175 \pm 2$  cpm ( $2.92 \pm 0.03$  Hz) (Note 2). Prior to use, fasten the mechanical sand equivalent shaker securely to a firm and level mount.
- 4.7. *Manual Shaker*—A manually operated shaker, capable of producing an oscillating motion at the rate of 100 complete cycles in  $45 \pm 5$  s, with a hand-assisted half stroke length of  $127 \pm 5$  mm ( $5.0 \pm 0.2$  in.). The shaker shall be fastened securely to a firm and level mount by bolts or clamps if a large number of determinations are to be made.

**Note 2**—The mechanical shaker shall be used when performing reference sand equivalent determinations. Either the mechanical or manually operated shaker should be used in lieu of the hand method whenever possible.

- 4.8. *Stock Solution*—The materials listed in Sections 4.8.1, 4.8.2, or 4.8.3 may be used to prepare the stock solution. A fourth alternative is not to use any biocide, provided the time of storage of stock solution is not sufficient to promote the growth of fungi.
- 4.8.1. Stock solution with formaldehyde.
- 4.8.1.1. Anhydrous calcium chloride, 454 g (1.0 lb) of technical grade.
- 4.8.1.2. USP glycerin, 2050 g (4.515 lb).
- 4.8.1.3. Formaldehyde, (40 volume percent solution) 47 g (0.10 lb).
- 4.8.1.4. Dissolve the 454 g (1.0 lb) of calcium chloride in 1.89 L ( $\frac{1}{2}$  gal) of distilled water. Cool and filter it through ready pleated rapid filtering paper. Add the 2050 g (4.515 lb) of glycerin and the 47 g (0.10 lb) of formaldehyde to the filtered solution, mix well, and dilute to 3.78 L (1 gal).
- 4.8.2. Stock solution with glutaraldehyde.
- 4.8.2.1. Calcium chloride dihydrate, 577 g (1.27 lb) of A.C.S. grade.
- Note 3**—A.C.S.-grade calcium chloride dihydrate is specified for the stock solution prepared with glutaraldehyde because tests indicate that impurities in the technical grade anhydrous calcium chloride may react with the glutaraldehyde resulting in an unknown precipitate.
- 4.8.2.2. USP glycerin, 2050 g (4.515 lb).
- 4.8.2.3. 1.5-pentanedial (glutaraldehyde), 50 percent solution in water 59 g (0.13 lb).
- 4.8.2.4. Dissolve the 577 g (1.27 lb) of calcium chloride dihydrate in 1.89 L ( $\frac{1}{2}$  gal) of distilled water. Cool and add the 2050 g (4.515 lb) of glycerin and the 59 g (0.13 lb) of glutaraldehyde to the solution, mix well, and dilute to 3.78 L (1 gal).
- Note 4**—1.5-pentanedial, also known as glutaraldehyde, glutaric dialdehyde, and trade name UCARCIDE 250, may be obtained as glutaraldehyde solution 50 percent.<sup>1</sup>
- 4.8.3. Stock solution with Kathon CG/ICP.
- 4.8.3.1. Calcium chloride dihydrate, 577 g (1.27 lb) of A.C.S. Grade.
- 4.8.3.2. USP glycerin, 2050 g (4.515 lb).
- 4.8.3.3. Kathon CG/ICP, 63 g (0.14 lb).
- 4.8.3.4. Dissolve the 577 g (1.27 lb) of calcium chloride dihydrate in 1.89 L ( $\frac{1}{2}$  gal) of distilled water. Cool and add the 2050 g (4.515 lb) of glycerin and the 63 g (0.14 lb) of Kathon CG/ICP to the solution, mix well, and dilute to 3.78 L (1 gal).<sup>2</sup>
- 4.9. *Working Solution*—Working calcium chloride solution: Prepare the working calcium chloride solution by diluting one measuring tin full ( $85 \pm 5$  mL) of the stock calcium chloride solution with water until it reaches a total volume of 3.8 L (1 gal). Thoroughly mix solution by filling the bottle with approximately 2 L ( $\frac{1}{2}$  gal) of water. Add the stock solution and agitate vigorously for 1 to 2 min. Add the remainder of the water and repeat the agitation process. Use distilled or demineralized water for the normal preparation of the working solution. However, if it is



determined that the local tap water is of such purity that it does not affect the test results, it is permissible to use in lieu of distilled or demineralized water except in the event of dispute. Discard working solutions more than 30 days old.

- 4.10. *Straightedge*—A straightedge or spatula, suitable for striking off the excess soil from the tin measure.
- 4.11. *Oven*—A thermostatically controlled drying oven capable of maintaining a temperature of  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ). Oven(s) for heating and drying shall be capable of operation at the temperatures required, between  $100$  to  $120^\circ\text{C}$  ( $212$  to  $248^\circ\text{F}$ ), within  $\pm 5^\circ\text{C}$  ( $\pm 9^\circ\text{F}$ ), as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer used for monitoring the temperature of the oven, or for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least  $90$  to  $130^\circ\text{C}$  ( $194$  to  $266^\circ\text{F}$ ), and an accuracy of  $\pm 1.25^\circ\text{C}$  ( $\pm 2.25^\circ\text{F}$ ) (see Note 5).  
**Note 5**—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class; IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class; or dial gauge metal stem (bi-metal) thermometer.
- 4.12. *Quartering Cloth*—Quartering or splitting cloth, approximately  $600$  mm ( $2$  ft) square, nonabsorbent material such as plastic or oil cloth.
- 4.13. *Sieve*—A  $4.75$ -mm (No. 4) sieve conforming to the requirements of ASTM E11.
- 4.14. *Optional Handle for Irrigation Tube*—A  $25$ -mm diameter wooden dowel to aid in pushing the irrigation tube into firm materials. See Figure 1, Assembly B.

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## 5. TEMPERATURE CONTROL

- 5.1. The temperature of the working solution should be maintained at  $22 \pm 3^\circ\text{C}$  ( $72 \pm 5^\circ\text{F}$ ) during the performance of this test. If field conditions preclude the maintenance of the temperature range, frequent reference samples should be submitted to a laboratory where proper temperature control is possible. It is also possible to establish temperature correction curves for each material being tested where proper temperature control is not possible. However, no general correction curve should be utilized for several materials even within a narrow range of sand equivalent values. Samples that meet the minimums and equivalent requirement at a working solution temperature below the recommended range need not be subject to reference testing. The thermometer for measuring working solution temperature shall meet the requirements of M 339M/M 339 with a temperature range of at least  $16$  to  $34^\circ\text{C}$  ( $61$  to  $93^\circ\text{F}$ ) and an accuracy of  $\pm 0.75^\circ\text{C}$  ( $\pm 1.35^\circ\text{F}$ ) (see Note 6).  
**Note 6**—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Class Special; IEC 60584 thermocouple thermometer, Type T, Class 1; ASTM E2877 digital metal stem thermometer; or dial gauge metal stem (bimetal) thermometer.

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## 6. SAMPLING

- 6.1. Obtain a sample of the material to be tested in accordance with R 90.
- 6.2. Reduce the sample according to R 76.

- 6.3. Sieve the sample over a 4.75-mm (No. 4) sieve. All aggregations of fine-grained soil material shall be pulverized to pass the 4.75-mm (No. 4) sieve, and all fines shall be cleaned from the particles retained on the 4.75-mm (No. 4) sieve and included with the material passing the 4.75-mm (No. 4) sieve.
- 6.4. Split or quarter the material passing the 4.75-mm (No. 4) sieve to yield 1000 to 1500 g (2.2 to 3.3 lb) of material. Use extreme care to obtain a truly representative portion of the original sample (Note 7).

**Note 7**—Experiments show that as the amount of material being reduced by splitting or quartering is decreased, the accuracy of providing representative portions is reduced. It is imperative that the sample be split or quartered carefully. When it appears necessary, dampen the material before splitting or quartering, to avoid segregation or loss of fines.

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## 7. SAMPLE PREPARATION

- 7.1. Prepare the desired number of test samples by one of the following methods:
- 7.1.1. *Alternate Method No. 1—Air Dry:*
- 7.1.1.1. Split or quarter enough material from the portion passing the 4.75-mm (No. 4) sieve to fill the 85-mL (3-oz) tin measure so it is slightly rounded above the brim. While filling the measure, tap the bottom edge of the tin on the work table or other hard surface to cause consolidation of the material and allow the maximum amount to be placed in the tin. Strike off the tin with the spatula or straightedge so the material is level with the top of the measuring tin.
- 7.1.2. *Alternate Method No. 2—Pre-Wet:*
- 7.1.2.1. The sample must be in the proper moisture condition to achieve reliable results. This condition is determined by tightly squeezing a small portion of the thoroughly mixed sample in the palm of the hand. If the cast that is formed permits careful handling without breaking, the correct moisture range has been obtained. If the material is too dry, the cast will crumble and it will be necessary to add water, remix, and retest until the material forms a cast. If the material shows any free water it is too wet to test and must be drained and air dried, mixing it frequently to ensure uniformity. This overly wet material will form a good cast when checked initially, so the drying process should continue until a squeeze check on the drying material gives a cast that is more fragile and delicate to handle than the original. If the moisture content of the original sample prepared in Section 6.2 is within the limits described above, the test sample may be obtained immediately. If the moisture content is altered to meet these limits, the altered sample should be placed in a pan, covered with a lid or with a damp cloth that does not touch the material, and allowed to stand for a minimum of 15 minutes.
- 7.1.2.2. After the minimum 15-minute tempering period, place the sample on the splitting cloth and mix by alternately lifting each corner of the cloth and pulling it over the sample toward the diagonally opposite corner, causing the material to be rolled. When the material appears homogeneous, finish the mixing with the sample in a pile near the center of the cloth.
- 7.1.2.3. Fill the 85-mL (3-oz) tin measure by pushing it through the base of the pile while exerting pressure with the hand against the pile on the side opposite the measure. As the tin is moved through the pile, hold enough pressure with the hand to cause the material to fill the tin to overflowing. Press firmly with the palm of the hand, compacting the material and allowing the maximum amount to be placed in the tin. Strike off the tin with the spatula or straightedge so the material is level with the top of the measuring tin.

**Note 8**—Moist test specimens produce lower sand equivalent values than the corresponding over-dry specimens with almost no exceptions; therefore, if a dual specification encompassing both the

wet and dry methods of sample preparation is utilized, it will be necessary to determine the appropriate correction for each material because a standard correction does not appear possible. Either method can be employed with equal confidence, however.

- 7.1.3. *Reference Method (Mechanical Shaker)*—Obtain the 85-mL (3-oz) tin measure of material by one of the alternate methods, Section 7.1.1 or 7.1.2, above; then dry the test sample to constant mass at  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ) and cool to room temperature before testing.

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## 8. PROCEDURE

- 8.1. Start the siphon by forcing air into the top of the solution bottle through the bent copper, glass, or stainless steel blow tube while the pinch clamp is open. The apparatus is now ready for use.
- 8.2. Siphon  $101.6 \pm 2.5$  mm ( $4.0 \pm 0.1$  in.) of working calcium chloride solution into the plastic cylinder. Pour the prepared test sample from the measuring tin into the plastic cylinder using the funnel to avoid spillage (see Figure 3). Tap the bottom of the cylinder sharply on the heel of the hand several times to release air bubbles and to promote thorough wetting of the sample.



**Figure 3**—Transfer of Sample from Measuring Tin to Cylinder

- 8.3. Allow the wetted sample to stand undisturbed for  $10 \pm 1$  min. At the end of the 10-min soaking period, stopper the cylinder, then loosen the material from the bottom by partially inverting the cylinder and shaking it simultaneously.
- 8.4. After loosening the material from the bottom of the cylinder, shake the cylinder and contents by any one of the following methods:

- 8.4.1. *Mechanical Shaker Method (Reference Method)*—Place the stoppered cylinder in the mechanical sand equivalent shaker, set the timer, and allow the machine to shake the cylinder and contents for  $45 \pm 1$  s.
- 8.4.2. *Manual Shaker Method*—Secure the stoppered cylinder in the three spring clamps on the carriage of the hand-operated sand equivalent shaker and reset the stroke counter to zero. Stand directly in front of the shaker and force the pointer to the stroke limit marker painted on the backboard by applying an abrupt horizontal thrust to the upper portion of the right-hand spring steel strap. Then remove the hand from the strap and allow the spring action of the straps to move the carriage and cylinder in the opposite direction without assistance or hindrance. Apply enough force to the right-hand spring steel strap during the thrust portion of each stroke to move the pointer to the stroke limit marker by pushing against the strap with the ends of the fingers to maintain a smooth oscillating motion. The center of the stroke limit marker is positioned to provide the proper stroke length and its width provides the maximum allowable limits of variation. The proper shaking action is accomplished only when the tip of the pointer reverses direction within the marker limits. Proper shaking action can best be maintained by using only the forearm and wrist action to propel the shaker. Continue the shaking action for 100 strokes.
- 8.4.3. *Hand Method*—Hold the cylinder in a horizontal position as illustrated in Figure 4 and shake it vigorously in a horizontal linear motion from end to end. Shake the cylinder 90 cycles in approximately 30 s using a throw of  $229 \pm 25$  mm ( $9 \pm 1$  in.). A cycle is defined as a complete back and forth motion. To properly shake the cylinder at this speed, it will be necessary for the operator to shake with the forearms only, relaxing the body and shoulders.



**Figure 4**—Using Hand Method of Shaking

- 8.5. Following the shaking operation, set the cylinder upright on the work table and remove the stopper.
- 8.6. *Irrigation Procedure*—Insert the irrigator tube in the cylinder and rinse material from the cylinder walls as the irrigator is lowered. Force the irrigator through the material to the bottom of the cylinder by applying a gentle stabbing and twisting action while the working solution flows from the irrigator tip. This flushes the fine material into suspension above the coarser sand particles. Continue to apply the stabbing and twisting action while flushing the fines upward until the cylinder is filled to the 381-mm (15-in.) mark. Then raise the irrigator slowly without shutting off the flow so the liquid level is maintained at about 381 mm (15 in.) while the irrigator is being withdrawn. Regulate the flow just before the irrigator is entirely withdrawn and adjust the final level to 381 mm (15 in.). The final level of the liquid shall be between the top two graduations on the tube but shall not be above the 381-mm (15-in.) mark when the liquid is read at the bottom of the meniscus.

**Note 9**—For certain soils, particularly on crushed materials, the stabbing action may not be possible. For these materials, the irrigation technique is as follows: Continue to apply a twisting action as the irrigation tube is slowly withdrawn. As the tube is withdrawn, it is essential that as many fines be flushed upward until the cylinder is filled to the 381-mm mark.

- 8.7. Allow the cylinder and contents to stand undisturbed for 20 min  $\pm$  15 s. Start the timing immediately after withdrawing the irrigator tube.
- 8.8. At the end of the 20-min sedimentation period, read and record the level of the top of the clay suspension. This is referred to as the “clay reading.” If no clear line of demarcation has formed at the end of the specified 20-min sedimentation period, allow the sample to stand undisturbed until a clay reading can be obtained, then immediately read and record the level of the top of the clay suspension and the total sedimentation time. If the total sedimentation time exceeds 30 min, rerun the test using three individual samples of the same material. Read and record the clay column height of that sample requiring the shortest sedimentation period only.
- 8.9. After the clay reading has been taken, the “sand reading” shall be obtained by one of the following methods:
- 8.9.1. When using the weighted foot assembly having the sand indicator on the rod of the assembly, place the assembly over the cylinder and gently lower the assembly toward the sand. Do not allow the indicator to hit the mouth of the cylinder as the assembly is being lowered. As the weighted foot comes to rest on the sand, tip the assembly toward the graduations on the cylinder until the indicator touches the inside of the cylinder. Subtract 254 mm (10 in.) from the level indicated by the extreme top edge of the indicator and record this value as the “sand reading” (see Figure 5).



**Figure 5**—Sand Reading

- 8.9.2. If an older model weighted foot assembly having centering screws is used, keep one of the centering screws in contact with the cylinder wall near the graduations so it can be seen at all times while the assembly is being lowered. When the weighted foot has come to rest on the sand, read the level of the centering screw and record this value as the “sand reading.”

- 8.10. If clay or sand readings fall between 2.5-mm (0.1-in.) graduations, record the level of the higher graduation as the reading. For example, a clay reading of 7.95 would be recorded as 8.0, and a sand reading of 3.22 would be recorded as 3.3.

**Note 10**—Samples obtained from aggregate proposed for use in hot-asphalt paving mixtures shall be prepared by oven-drying if acceptance of the material is based on tests on material that has passed through a hot-plant drier.

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## 9. CALCULATIONS

- 9.1. Calculate the sand equivalent (*SE*) to the nearest 0.1 using the following formula:

$$SE = \frac{\text{sand reading}}{\text{clay reading}} \times 100 \quad (1)$$

- 9.2. If the calculated sand equivalent is not a whole number, report it as the next higher whole number, as in the following example:

$$SE = \frac{3.3}{8} \times 100 = 41.3 \quad (2)$$

which is reported as 42.

- 9.3. If it is desired to average a series of sand equivalent values, average the whole number values determined as described above. If the average of these values is not a whole number, raise it to the next higher whole number, as in the following example: Calculated *SE* values: 41.2, 43.8, 40.9.

After raising each to the next higher whole number, they become: 42, 44, and 41.

The average of these values is then determined:

$$\frac{42 + 44 + 41}{3} = 42.3 \quad (3)$$

- 9.3.1. Since the average value is not a whole number, it is raised to the next higher whole number and the reported averages and equivalent value is reported as 43.

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## 10. PRECAUTIONS

- 10.1. Perform the test in a location free of vibrations; vibrations may cause the suspended material to settle at a rate greater than normal.

- 10.2. Do not expose the plastic cylinders to direct sunlight any more than is necessary.

- 10.3. *Removal of Organic Growth*—Occasionally, it may be necessary to remove an organic growth from the working calcium chloride solution container and from the inside of the flexible tubing and irrigator tube. This organic material can easily be seen as a slimy substance in the solution. To remove this growth, prepare a cleaning solvent by diluting sodium hypochlorite<sup>3</sup> with an equal quantity of water. Fill the solution container with the prepared cleaning solvent, allow about a liter of the cleaning solvent to flow through the siphon assembly and irrigator tube, then place the pinch clamp on the end of the tubing to cut off the flow of solvent and to hold the solvent in the tube. Refill the container and allow it to stand overnight. After soaking, allow the cleaning solvent to flow out through the siphon assembly and irrigator tube. Remove the siphon assembly from the solution container and rinse both with clear water. The irrigator tube and siphon assembly can be rinsed easily by attaching a hose between the tip of the irrigator tube and water faucet and backwashing fresh water through the tube.

- 10.4. Occasionally the holes in the tip of the irrigator tube may become clogged by a particle of sand. If the obstruction cannot be freed by any other method, use a pin or other sharp object to force it out, using extreme care not to enlarge the size of the opening.

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## 11. KEYWORDS

- 11.1. Clay soil; plastic fines; plasticity; sand equivalent.

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<sup>1</sup> Available from Aldrich Chemical Company, P.O. Box 2060, Milwaukee, WI 53201 or Fisher Scientific, 711 Forbes Ave., Pittsburgh, PA 15219.

<sup>2</sup> Kathon CG/ICP may be obtained from Rohm and Hass Chemical Company, Independence Mall West, Philadelphia, PA 19105. Kathon CG/ICP contains the following components: 5-chloro-2-methyl-4-isothiazolin-3-one; 2-methyl-4 isothiazolin-3-one; magnesium chloride; and magnesium nitrate.

<sup>3</sup> Household strength liquid bleach or its equivalent has been found satisfactory for this purpose.