Designation: D2419 – 14

Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate[1]

This standard is issued under the fixed designation D2419; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method is intended to serve as a rapid field-correlation test. The purpose of this test method is to indicate, under standard conditions, the relative proportions of clay-size or plastic fines and dust in granular soils and fine aggregates that pass the 4.75-mm (No. 4) sieve. The term "sand equivalent" expresses the concept that most granular soils and some fine aggregates are mixtures of desirable coarse particles, sand-size particles, and generally undesirable clay or plastic fines and dust.

NOTE 1—For fine aggregates containing clean dust of fracture (clay-size particles that are not clay minerals), test results will depend on the amount of fines present in the material. In this case other tests such as Methylene Blue Value (AASHTO T330) or X-Ray Diffraction (XRD) may be needed to determine if the fines are deleterious.

NOTE 2—Some agencies perform the test on material with a top size smaller than the 4.75-mm (No. 4) sieve. This is done to avoid trapping the clay-size or plastic fines and dust below flaky shaped 4.75 to 2.36 mm (No. 4 to 8) sized particles. Testing smaller top sized material may lower the numerical results of the test.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.2.1 Regarding sieves, per Specification E11 Section 1.2, "the values stated in SI units shall be considered standard for the dimensions of the wire cloth openings and the diameter of the wires used in the wire cloth. The values stated in inchpound units shall be considered standard with regard to the sieve frames." When sieve mesh sizes are referenced, the alternate inch-pound designations are provided for information purposes and enclosed in parentheses.

1.3 *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]

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C702 Practice for Reducing Samples of Aggregate to Testing Size

D8 Terminology Relating to Materials for Roads and Pavements

D75 Practice for Sampling Aggregates

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *AASHTO Standard:*

T 176 Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of Sand Equivalent Test[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *clay size*—that portion of the soil or aggregate finer than 0.002 mm (0.005 mm in some cases) (see Terminology D653).

3.1.2 *fine aggregate*—aggregate passing the 9.5-mm (⅜-in.) sieve and almost entirely passing the 4.75-mm (No. 4) sieve and predominantly retained on the 75-µm (No. 200) sieve (see Terminology D8).

3.1.3 *sand*—particles of rock that will pass the 4.75 mm (No. 4) sieve and be retained on the 0.075 mm (No. 200) sieve (see Terminology D653).

3.1.4 *sand equivalent*—a measure of the amount of silt, clay contamination, or clay-size aggregate particles in the fine aggregate (or soil) as determined by test (see Terminology D653). (For further explanation, see Section 4 and Section 5.)

[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.51 on Aggregate Tests.

Current edition approved June 1, 2014. Published September 2014. Originally approved in 1965. Last previous edition approved in 2009 as D2419 – 09. DOI: 10.1520/D2419-14.

[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] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

3.1.5 *soil*—sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks which may or may not contain organic matter (see Terminology D653).

4. Summary of Test Method

4.1 A measured volume of soil or fine aggregate and a small quantity of flocculating solution are poured into a graduated plastic cylinder and are agitated to loosen the claylike coatings or clay size particles from the sand particles in the test specimen. The specimen is then "irrigated" using additional flocculating solution forcing the claylike or clay size material into suspension above the sand. After a prescribed sedimentation period, the height of flocculated material is read and the height of sand in the cylinder is determined. The sand equivalent is the ratio of the height of sand to the height of flocculated material times 100.

5. Significance and Use

5.1 This test method assigns an empirical value to the relative amount, fineness, and character of claylike material present in the test specimen.

5.2 A minimum sand equivalent value may be specified to limit the permissible quantity of claylike or clay size fines in an aggregate.

5.3 This test method provides a rapid field method for determining changes in the quality of aggregates during production or placement.

NOTE 3—The quality of the results produced by this standard are dependant upon the competence of the personnel performing the procedure and the capability, calibration, and the maintenance of the equipment used. Agencies that meet the criteria of Practice D3666 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3666 alone does not completely assure reliable results. Reliable results depend on many factors: following the suggestions of Practice D3666 or similar acceptable guideline provides a means of evaluating and controlling some of those factors.

6. Interferences

6.1 Maintain the temperature of the working solution at 72 ± 5°F (22 ± 3°C) during the performance of this test.

NOTE 4—If field conditions preclude the maintenance of the temperature range, frequent referee 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 should be utilized for several materials even within a narrow range of sand equivalent values. Samples that meet the minimum sand equivalent requirement at a working solution temperature below the recommended range need not be subject to referee testing.

6.2 Perform the test at a location free from vibration. Excessive vibration may cause the suspended material to settle at a greater rate than normal.

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

6.4 Occasionally it may be necessary to remove a fungus growth from the working calcium chloride solution container and from the inside of the flexible tubing and irrigator tube. This fungus can easily be seen as a slimy substance in the solution, or as a mold growing on the inside of the container.

6.4.1 To remove this growth, prepare a cleaning solvent by diluting sodium hypochlorite solution (household chlorine bleach) with an equal quantity of water.

6.4.2 After discarding the contaminated solution, fill the solution container with the prepared cleaning solvent: allow about 1 L 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 to stand overnight.

6.4.3 After soaking, allow the cleaning solvent to flow out through the siphon assembly and irrigator tube.

6.4.4 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.

6.5 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.

6.6 Working solution which is more than two weeks old shall be discarded.

6.7 Mixing and storage container(s) for solutions shall be thoroughly rinsed prior to mixing a fresh batch of solution.

6.8 Fresh solution shall not be added to old solution regardless of age.

7. Apparatus

7.1 A graduated transparent acrylic plastic cylinder, rubber stopper, irrigator tube, weighted foot assembly and siphon assembly all conforming to the respective specifications and dimensions shown in Fig. 1. See Annex A1 for alternative apparatus.

7.2 *Measuring Tin*—A cylindrical tin approximately 2¼ in. (57 mm) in diameter having a capacity of 85 ± 5 mL.

7.3 *4.75-mm (No. 4) Sieve,* conforming to the requirements of Specification E11.

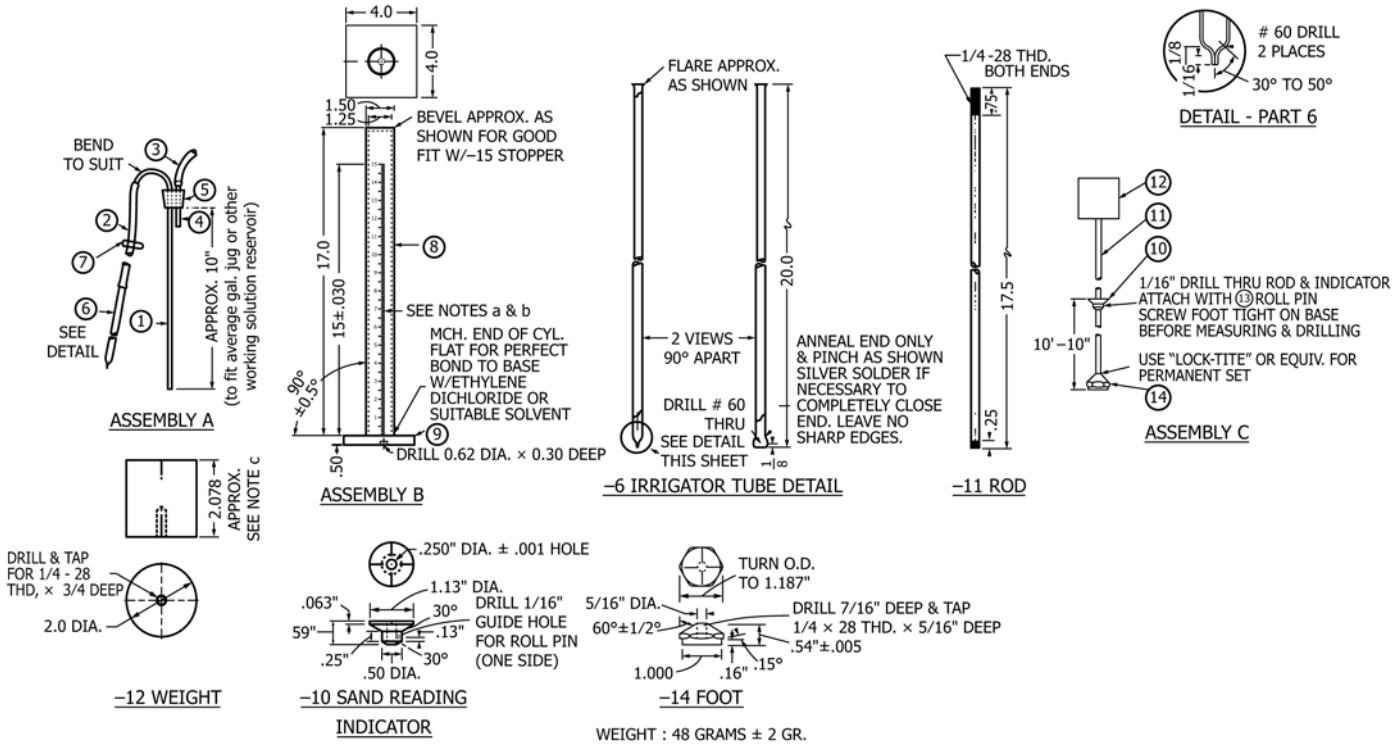
7.4 *Funnel,* wide-mouth, for transferring test specimens into the graduated cylinder.

7.5 *Bottles,* two 1.0-gal (3.8-L) to store stock solution and working solution.

7.6 *Flat Pan,* for mixing.

7.7 *Clock or Watch,* reading in minutes and seconds.

7.8 *Mechanical Sand Equivalent Shaker,* designed to hold the required graduated plastic cylinder in a horizontal position while subjecting it to a reciprocating motion parallel to its length and having a throw of 8 ± 0.04 in. (203.2 ± 1.0 mm) and operating at 175 ± 2 cpm. A typical apparatus is shown in Fig. 2. The shaker shall be securely fastened to a firm and level mount.



List of Material

Assembly	Part No.	Description	Stock Size, In.	Material
A		*Siphon Assembly:*		
	1	siphon tube	¼ diameter by 16	copper tube (may be plated)
	2	siphon hose	3⁄16 ID by 48	rubber tube, pure gum or equivalent
	3	blow hose	3⁄16 ID by 2	rubber tube, pure gum or equivalent
	4	blow tube	¼ diameter by 2	copper tube (may be plated)
	5	2-hole stopper	No. 6	rubber
	6	irrigator tube	¼ OD 0.035 wall by 20 SS tube, Type 316	
	7	clamp	Pinchcock, Day, BKH No. 21730 or equivalent	
B [A,B]		*Graduate Assembly:*		
	8	tube	1.50 OD by 17	transparent acrylic plastic
	9	base	¼ by 4 by 4	transparent acrylic plastic
C [C]		*Weighted Foot Assembly:*		
	10	sand reading indicator	1¼ diameter by 0.59	nylon 101 type 66 annealed
	11	rod	¼ diameter by 17½	brass (may be plated)
	12	weight	2 diameter by 2.078	C. R. steel (may be plated)
	13	roll pin	1⁄16 diameter by ½	corrosion-resistant metal
	14	foot	11⁄16 hex by 0.54	brass (may be plated)
	15	solid stopper	No. 7	rubber

[A] *Assembly B*—Accuracy of scale should be± 0.010 in. per tenth of an inch. Error at any point on scale should be± 0.030 in. of true distance to zero.
[B] *Assembly B*—Graduations on graduate should be in tenths of an inch. Inch marks should be numerically designated as shown. The inch and half-inch division lines should be approximately ¼ in. long. All division lines should be 0.015 in. deep with width across top 0.030 in.
[C] *Assembly C*—Weighted foot assembly should weigh 1000 ± 5 g.

Metric Equivalents

in.	mm	in.	mm	in.	mm	in.	mm
0.001	0.025	0.13	3.30	0.62	15.75	2	50.80
0.005	0.127	3⁄16	4.76	0.63	16.00	2.078	52.78
0.010	0.254	0.25	6.35	0.75	19.05	4	101.60
0.015	0.381	¼	6.35	¾	19.05	10.10	256.54
0.020	0.508	0.30	7.62	1	25.4	15	381.00
0.030	0.762	5⁄16	7.94	1 1⁄16	26.99	16	406.40
0.035	0.889	⅜	9.51	1.24	31.50	17	431.80
1⁄16	1.59	0.50	12.70	1¼	31.75	17.5	444.50
0.100	2.54	0.54	13.72	1.50	38.10	20	508.00
⅛	3.17	0.59	14.99	1½	38.10	48	1219.2

NOTE 1—The sand reading indicator and foot specified by ASTM Method D2419 – 69. Fig. 1, may be used where this equipment is previously available.

FIG. 1 Sand Equivalent Test Apparatus

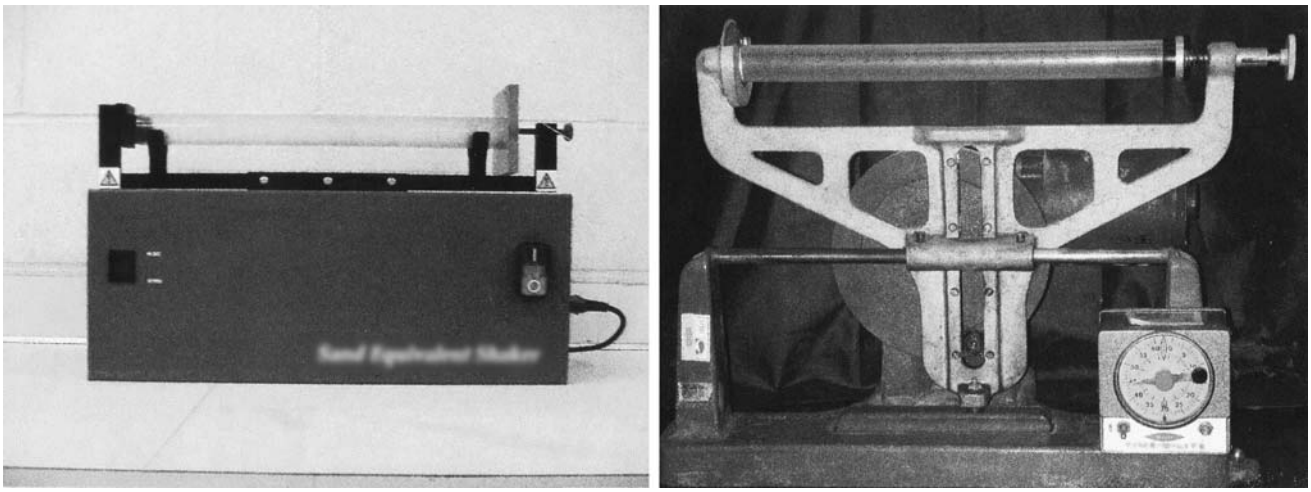


FIG. 2 Mechanized Shakers

NOTE 5—Moving parts of the mechanical shaker should be provided with a safety guard for protection of the operator.

7.9 *Manually Operated Sand Equivalent Shaker*—(optional), as shown in Fig. 3, or equivalent, capable of producing an oscillating motion at a rate of 100 complete cycles in 45 ± 5 s, with a hand-assisted half stroke length of 5 ± 0.2 in. (12.7 ± 0.5 cm). The device shall be designed to hold the required graduated cylinder in a horizontal position while subjecting it to a reciprocating motion parallel to its length. The shaker shall be fastened securely to a firm and level mount. If only a few tests are to be run the shaker may be held by hand on a firm level mount.

7.10 *Oven,* of sufficient size, and capable of maintaining a temperature of 230 ± 9°F (110 ± 5°C).

7.11 *Filter Paper,* Watman No. 2V or equivalent.

8. Reagents and Materials

8.1 *Stock Solution*—The materials listed in 8.1.1, 8.1.2 or 8.1.3 may be used to prepare the stock solution. If the use of formaldehyde as the biocide is of concern, the materials in 8.1.2 or 8.1.3 should be used. 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.

8.1.1 Stock solution with formaldehyde.

8.1.1.1 *Anhydrous Calcium Chloride,* 454 g of technical grade.

8.1.1.2 *USP Glycerin,* 2050 g (1640 mL).

8.1.1.3 *Formaldehyde,* (40 volume % solution) 47 g (45 mL).

8.1.1.4 Dissolve the 454 g of calcium chloride in ½ gal (1.89 L) of distilled water. Cool and filter through ready pleated rapid filtering paper. Add the 2050 g of glycerin and the 47 g of formaldehyde to the filtered solution, mix well, and dilute to 3.78 L (1 gal).

8.1.2 Stock solution with glutaraldehyde.

8.1.2.1 *Calcium Chloride Dihydrate,* 577 g of A. C. S. grade.

NOTE 6—ACS 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.

8.1.2.2 *USP Glycerin,* 2050 g (1640 mL).

8.1.2.3 *1,5-Pentanedial (Glutaraldehyde),* 50 % solution in water 59 g (53 mL).

8.1.2.4 Dissolve the 577 g of calcium chloride dihydrate in ½ gal (1.89 L) of distilled water. Cool and add the 2050 g of glycerin and the 59 g of glutaraldehyde to the solution, mix well, and dilute to 1 gal (3.78 L).

NOTE 7—1,5-pentanedial, also known as glutaraldehyde, glutaric dialdehyde, and trade name UCARCIDE 250, may be obtained as "Glutaraldehyde Solution 50 %."[4]

8.1.3 Stock solution with Kathon CG/ICP.

8.1.3.1 *Calcium Chloride Dihydrate,* 577 g of A. C. S. grade.

8.1.3.2 *USP Glycerin,* 2050 g (1640 mL).

8.1.3.3 *Kathon CG/ICP*[5], 63 g (53 mL).

8.1.3.4 Dissolve the 577 g of calcium chloride dihydrate in ½ gal (1.89 L) of distilled water. Cool and add the 2050 g of glycerin and the 63 g of Kathon CG/ICP to the solution, mix well, and dilute to 1 gal (3.78 L).

8.2 *Working Calcium Chloride Solution*—Prepare the working calcium chloride solution by diluting one measuring tin (85 ± 5 mL) full of the stock calcium chloride solution to 1.0 gal (3.8 L) with water. 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 it instead of distilled or demineralized water except in the event of dispute.

NOTE 8—The effect of local tap water on sand equivalent test results may be determined by comparing the results of three sand equivalent tests using distilled water with the results of three sand equivalent tests using

[4] Available from Aldrich Chemical Company, P. O. Box 2060, Milwaukee, WI 53201 or Fisher Scientific, 711 Forbes Ave., Pittsburg, PA 15219.

[5] The sole source of supply of Kathon CG/ICP known to the committee at this time is Rohm and Hass Chemical Company, Independence Mall West, Philadelphia, PA 19105. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

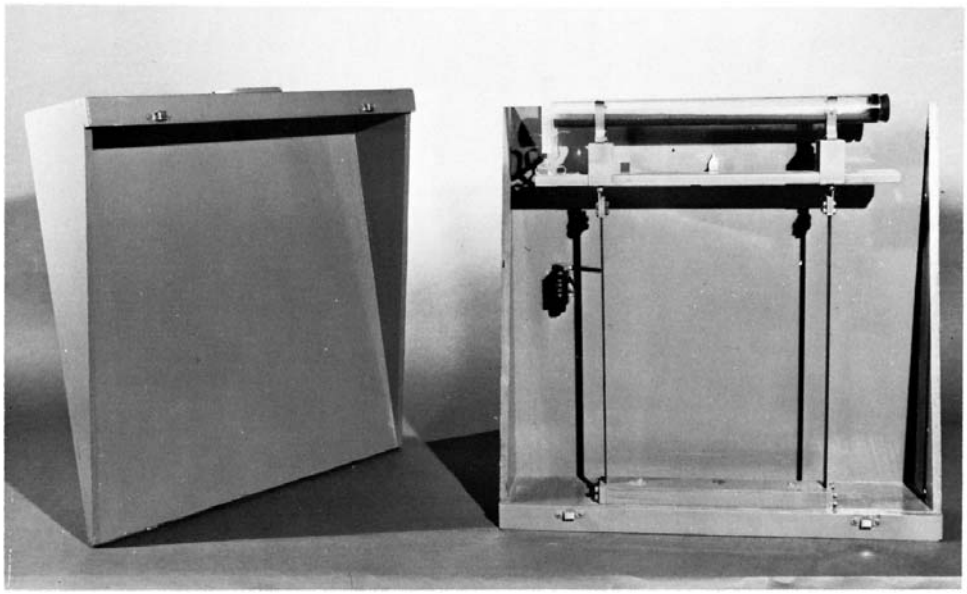


FIG. 3 Manually Operated Shaker

the local tap water. The six test specimens required for this comparison shall be prepared from the sample of material and oven-dried as prescribed in this test method.

9. Sample Preparation

9.1 Sample the material to be tested in accordance with Practice D75.

9.2 Thoroughly mix the sample and reduce it as necessary using the applicable procedures in Practice C702.

9.3 Obtain at least 1500 g of material passing the 4.75-mm (No. 4) sieve in the following manner:

9.3.1 Separate the sample on the 4.75-mm (No. 4) sieve by means of a lateral and vertical motion of the sieve, accompanied by a jarring action so as to keep the sample moving continuously over the surface of the sieve. Continue the sieving until not more than 1 weight % of the residue passes the sieve during 1 min. Perform the sieving operation either by hand or by a mechanical apparatus. When thoroughness of mechanical sieving is being determined, test by the hand method described above using a single layer of material on the sieve.

9.3.2 Break down any lumps of material in the coarse fraction to pass the 4.75-mm (No. 4) sieve. Use a mortar and rubber-covered pestle or any other means that will not cause appreciable degradation of the aggregate.

9.3.3 Remove any coatings of fines adhering to the coarse aggregate. These fines may be removed by surface-drying the coarse aggregate, then rubbing between the hands over a flat pan.

9.3.4 Add the material passing the sieve obtained in 9.3.2 and 9.3.3 to the separated fine portion of the sample.

9.4 Prepare test specimens from the material passing the 4.75-mm (No. 4) sieve portion of the sample by either the procedure described in 9.4.1 or 9.4.2.

NOTE 9—Experiments show that as the amount of material being reduced by splitting or quartering is decreased, the accuracy of providing representative portions is decreased. For this reason, it is imperative that extreme care be exercised when preparing the test specimens.

9.4.1 *Test Specimen Preparation, Procedure A:*

9.4.1.1 If it appears necessary, dampen the material to avoid segregation or loss of fines during the splitting or quartering operations. Use care in adding moisture to the sample to retain a free-flowing condition of the material.

9.4.1.2 Using the measuring tin, dip out four of these measures from the sample. Each time a measure full of the material is dipped from the sample, tap the bottom edge of the measure on a work table or other hard surface at least four times and jog it slightly to produce a measure of consolidated material level-full or slightly rounded above the brim.

9.4.1.3 Determine and record the amount of material contained in these four measures either by weight or by volume in a dry plastic cylinder.

9.4.1.4 Return this material back to the sample and proceed to split or quarter the sample, using the applicable procedures in Practice C702 and making the necessary adjustments to obtain the predetermined weight or volume. When this weight or volume is obtained, two successive splitting or quartering operations without adjustment should provide the proper amount of material to fill the measure, and therefore provide one test specimen.

9.4.1.5 Dry the test specimen to constant weight at 230 ± 9°F (110 ± 5°C) and cool to room temperature before testing.

NOTE 10—Sand equivalent results on test specimens that have not been dried will generally be lower than the results obtained on identical test specimens that have been dried. As a time-saving expedient, it is permissible to test most materials without drying when the sand equivalent value is used to determine compliance with a specification giving a minimum acceptable test value. If the resulting test value is lower than that specified, however, it will be necessary to rerun the test on a dried test specimen. If the sand equivalent determined from a test on one dried test specimen, is below the minimum specification limit, it will be necessary to perform two additional tests on dried test specimens from the same sample. The sand equivalent for a sample shall be determined in accordance with the calculation section.

9.4.2 *Test Specimen Preparation, Procedure B:*

9.4.2.1 Maintaining a free-flowing condition, dampen the material sufficiently to prevent segregation or loss of fines.

9.4.2.2 Split or quarter out 1000 to 1500 g of the material. Mix thoroughly with a hand trowel in a circular pan by scooping toward the middle of the pan while rotating it horizontally. Mixing or remixing should be continued for at least 1 min to achieve uniformity. Check the material for the necessary moisture condition by tightly squeezing a small portion of the thoroughly mixed sample in the palm of the hand. If a cast is formed that 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 and 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 which is more fragile and delicate to handle than the original. If the "as received" moisture content is within the limits described above, the sample may be run immediately. If the moisture content is altered to meet these limits, the sample should be put in the pan, covered with a lid or with a damp towel that does not touch the material, and allowed to stand for a minimum of 15 min.

9.4.2.3 After the minimum curing time, remix for 1 min without water. When thoroughly mixed, form the material into a cone with a trowel.

9.4.2.4 Take the tin measure in one hand and push it directly through the base of the pile while holding the free hand firmly against the pile opposite the measure.

9.4.2.5 As the can travels through the pile and emerges, hold enough hand pressure to cause the material to fill the can to overflowing. Press firmly with the palm of the hand, compacting the material until it consolidates in the can. The excess material should be struck off level with the top of the can, moving the edge of the trowel in a sawing motion across the brim.

9.4.2.6 To obtain additional test specimens, repeat the procedures in 9.4.2.3 through 9.4.2.5.

10. Preparation of Apparatus

10.1 Fit the siphon assembly to a 1.0-gal (3.8-L) bottle of working calcium chloride solution. Place the bottle on a shelf 36 ± 2 in. (90 ± 5 cm) above the working surface, (see Fig. 4).

NOTE 11—Instead of the 1.0-gal (3.8-L) bottle, a glass or plastic vat having a larger capacity may be used provided the liquid level of the working solution is maintained between 36 and 48 in. (90 and 120 cm) above the work surface.

10.2 Start the siphon by blowing into the top of the solution bottle through a short piece of tubing while the pinch clamp is open.

11. Procedure

11.1 Siphon 4 ± 0.1 in. (102 ± 3 mm) (indicated on the graduated cylinder) of working calcium chloride solution into the plastic cylinder.

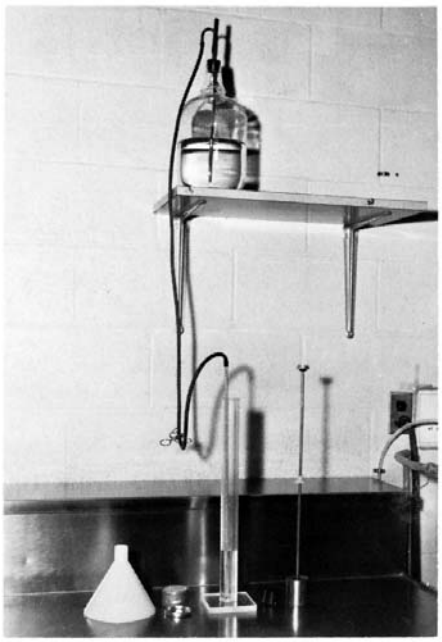


FIG. 4 Graduated Cylinder, Irrigator Tube, Weighted Foot Assembly, and Siphon

11.2 Pour one of the test specimens into the plastic cylinder using the funnel to avoid spillage (see Fig. 5).

11.3 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 specimen.

11.4 Allow the wetted specimen and cylinder to stand undisturbed for 10 ± 1 min.

11.5 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.

11.6 After loosening the material from the bottom of the cylinder, shake the cylinder and contents by any of the following three methods:

11.6.1 *Mechanical Shaker Method*—Place the stoppered cylinder in the mechanical sand equivalent shaker, set the time, and allow the machine to shake the cylinder and the contents for 45 ± 1 s.

11.6.2 *Manual Shaker Method:*

11.6.2.1 Secure the stoppered cylinder in the three spring clamps of the carriage of the hand-operated sand equivalent shaker and reset the stroke counter to zero.

NOTE 12—To prevent spillage, be sure the stopper is firmly seated in the cylinder before placing in the manual shaker.

11.6.2.2 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.

11.6.2.3 Apply enough force to the right-hand spring steel strap during the thrust portion of each stroke to move the

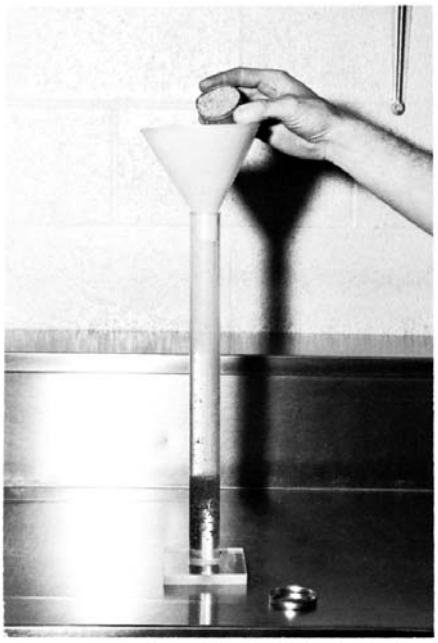


FIG. 5 Transfer of Samples from Measuring Tin to Cylinder

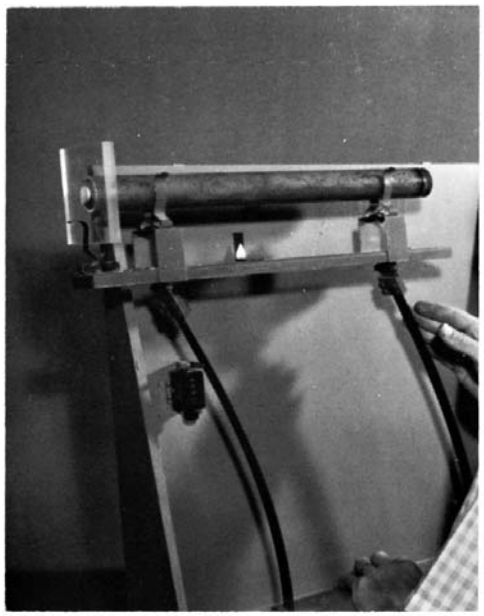


FIG. 6 Use of Manual Shaker

pointer to the stroke limit marker by pushing against the strap with the ends of the fingers to maintain a smooth oscillating motion (see Fig. 6). 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.

11.6.2.4 Continue the shaking action for 100 strokes.

11.6.3 *Hand Method:*

11.6.3.1 Hold the cylinder in a horizontal position as illustrated in Fig. 7 and shake it vigorously in a horizontal linear motion from end to end.

11.6.3.2 Shake the cylinder 90 cycles in approximately 30 s using a throw of 9 ± 1 in. (23 ± 3 cm). A cycle is defined as a complete back and forth motion. To shake the cylinder at this speed properly, it will be necessary for the operator to shake with the forearms only, relaxing the body and shoulders.

11.7 Following the shaking operation, set the cylinder upright on the work table and remove the stopper.

11.8 *Irrigation Procedure:*

11.8.1 During the irrigation procedure, keep the cylinder vertical and the base in contact with the work surface. Insert the irrigator tube in the top of the cylinder, remove the spring clamp from the hose, and rinse the 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 (see Fig. 8).

11.8.2 Continue to apply a stabbing and twisting action while flushing the fines upward until the cylinder is filled to the 15-in. (38.0 cm) graduation. Then raise the irrigator tube

FIG. 7 Using Hand Method of Shaking

slowly without shutting off the flow so that the liquid level is maintained at about the 15-in. (38.0-cm) graduation while the irrigator tube is being withdrawn. Regulate the flow just before the irrigator tube is entirely withdrawn and adjust the final level to the 15-in. (38.0-cm) graduation.

11.9 Allow the cylinder and contents to stand undisturbed for 20 min ± 15 s. Start the timing immediately after withdrawing the irrigator tube.

11.10 At the end of the 20-min sedimentation period, read and record the level of the top of the suspension as prescribed in 11.12. 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 suspension and the total sedimentation time. If the total sedimentation time exceeds 30 min, rerun the test using three individual specimens of

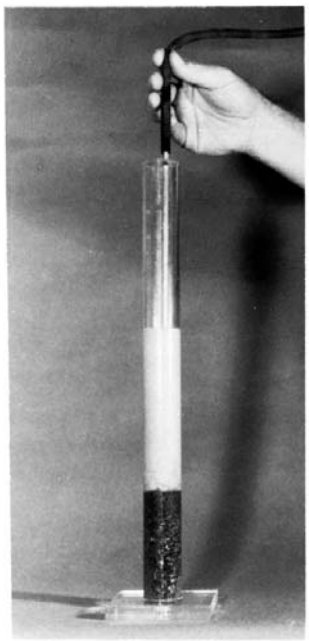


FIG. 8 Irrigation

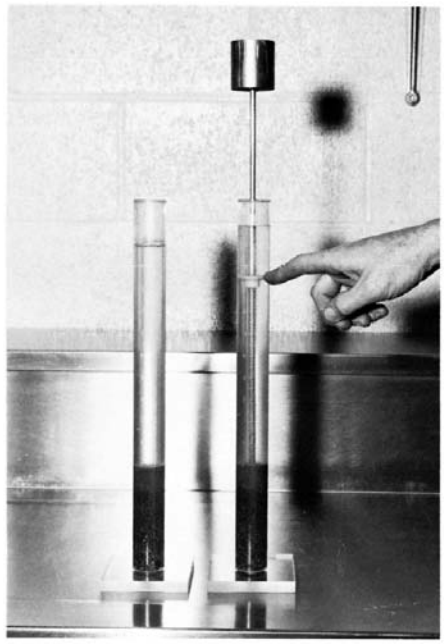


FIG. 9 Sand Reading

the same material. Record the suspension column height for the sample requiring the shortest sedimentation period as the "clay reading."

11.11 *Sand Reading Determination:*

11.11.1 After the suspension reading has been taken, place the weighted foot assembly over the cylinder and gently lower the assembly until it comes to rest on the sand. Do not allow the indicator to hit the mouth of the cylinder as the assembly is being lowered.

11.11.2 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 10-in. (25.4 cm) from the level indicated by the extreme top edge of the indicator and record this value as the "sand reading" (see Fig. 9).

NOTE 13—See Annex A1 for the use of alternative foot apparatus and measurement procedure.

11.11.3 When taking the sand reading, use care not to press down on the weighted foot assembly since this could give an erroneous reading.

11.12 If the "clay reading" or sand reading falls between 0.1-in. (2.5-mm) graduations, record the level of the higher graduation as the reading.

12. Calculation and Report

12.1 Calculate the sand equivalent to the nearest 0.1 % as follows:

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

where:

SE = sand equivalent.

12.2 If the calculated sand equivalent is not a whole number, report it as the next higher whole number. For example, if the clay level were 8.0 and the sand level were 3.3, the calculated sand equivalent would be:

$$(3.3/8.0) \times 100 = 41.2 \quad (2)$$

Since this calculated sand equivalent is not a whole number it would be reported as the next higher whole number which is 42.

12.3 If it is desired to average a series of sand equivalent values, average the whole number values determined as described in 12.2. If the average of these values is not a whole number, raise it to the next higher whole number as shown in the following example:

12.3.1 Calculate SE values: 41.2, 43.8, 40.9.

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

12.3.3 Determine the average of these values as follows:

$$(42+44+41)/3 = 42.3 \quad (3)$$

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

13. Precision and Bias

13.1 *Precision*—The following estimates of precision for this test method are based on results from the AASHTO Materials Reference Laboratory (AMRL) Reference Sample program, with testing conducted using this test method and AASHTO Method T 176. There are no significant differences between the two methods. The data are based on the analyses of eight paired test results from 50 to 80 laboratories, with the range of average sand equivalent values for the samples varying from approximately 60 to 90.

13.1.1 *Single Operator Precision*—The single operator standard deviation has been found to be 1.5 for sand equivalent values greater than 80 and 2.9 for values less than 80 (1s).[6] Therefore, results of two properly conducted tests by the same operator on similar material should not differ by more than 4.2 and 8.2, respectively (d2s).

13.1.2 *Multi-laboratory Precision*—The multi-laboratory standard deviation has been found to be 4.4 for sand equivalent values greater than 80 and 8.0 for values less than 80 (1s).[6] Therefore, results of two properly conducted tests from different laboratories on similar material should not differ by more than 12.5 and 22.6,[6] respectively (d2s).

[6] These numbers represent, respectively, the (ls) and (d2s) limits as described in Practice C670.

13.1.3 Additional precision data is available from a study done by one state agency involving the circulation of pairs of samples to over 20 laboratories on three separate occasions. The range of average sand equivalent values for these samples varied from approximately 30 to 50; these were materials containing much more fines than the AMRL samples reported on in 13.1.1 and 13.1.2.

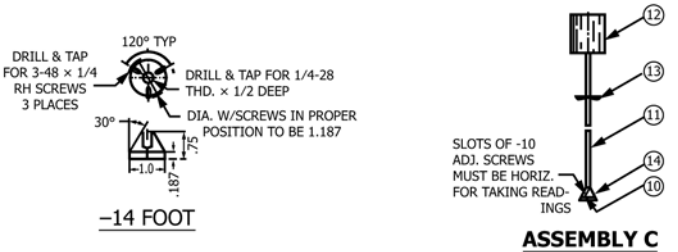
13.1.3.1 The Multi-laboratory standard deviation from these single agency tests was found to be 3.2 (1s). Therefore, within the laboratories of this agency, results of two properly conducted tests from different laboratories on similar material should not differ by more than 9.1 (d2s).

13.2 *Bias*—The procedure in this test method has no bias because the value of sand equivalent is defined only in terms of the test method.

ANNEX

(Mandatory Information)

A1. READING PROCEDURE FOR THE SAND READING WHEN THE 1969 SAND READING INDICATOR AND FOOT CONFORMING TO FIG. OF ASTM D2419 – 69 IS BEING USED



PART NO.	DESCRIPTION	STOCK SIZE	MATERIAL
14	Foot	1 dia by ¾	Bronze
13	Guide	1.50 dia by ¼	Brass
12	Weight	2 dia by 2.078	C.R.SH.
11	Rod	¼ dia by 17½	Brass
10	Adj. Screws	3-48 by ¼ RH	Brass

FIG. A1.1 1969 Weighted Foot Assembly from Test Method D2419 – 69

A1.1 *Differences in 1969 Equipment:*

A1.1.1 See Fig. A1.1 for the 1969 weighted foot (Assembly C) and the details of the 1969 Foot (Item 14).

A1.2 *Sand Reading Procedure* when 1969 foot assembly is used:

A1.2.1 After the clay reading has been taken, place the weighted foot assembly over the cylinder with the guide cap in position on the mouth of the cylinder and gently lower theassembly until it comes to rest on the sand. While the weighted foot is being lowered, keep one of the adj. screws (see Item 10 on Fig. A1.1) in contact with the cylinder wall near the graduations so that it can be seen at all times. When the weighted foot has come to rest on the sand, read and record the level of the horizontal slot of the adj. screw as the "Sand Reading" value.