Designation: D7172 – 14

Standard Test Method for Determining the Relative Density (Specific Gravity) and Absorption of Fine Aggregates Using Infrared[1]

This standard is issued under the fixed designation D7172; 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 the relative density (specific gravity) and absorption of fine aggregates.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C125 Terminology Relating to Concrete and Concrete Aggregates

C128 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate

C566 Test Method for Total Evaporable Moisture Content of Aggregate by Drying

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

C702 Practice for Reducing Samples of Aggregate to Testing Size

C1252 Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)

D8 Terminology Relating to Materials for Roads and Pavements

D75 Practice for Sampling Aggregates

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

2.2 *AASHTO Standards:*[3]

T-84 Test Method for Specific Gravity and Absorption of Fine Aggregate

2.3 *Other Documents:*[4]

Operational Instructions

3. Terminology

3.1 *Definitions*—As defined in C125 and D8:

3.1.1 *Automatic Volumetric Mixer (AVM), n*—an automated unit to hold and agitate a volumetric flask while applying a vacuum to the flask.

4. Significance and Use

4.1 Bulk relative density (specific gravity) is the characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate including Portland cement concrete, bituminous concrete, and other mixtures that are proportioned or analyzed on an absolute volume basis. Bulk relative density (specific gravity) is used in the computation of voids in aggregate in C1252 and C29/C29M. Bulk relative density (specific gravity) determined on the saturated surface dry (SSD) basis is used if the aggregate is wet, that is, if its absorption has been satisfied. Conversely, the bulk relative density (specific gravity) determined on the oven-dry basis is used for computations when the aggregate is dry or assumed to be dry.

4.2 Apparent relative density (specific gravity) pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles that is accessible to water. This value is not widely used in construction aggregate technology.

4.3 Water absorption values are used to calculate the change in the mass of an aggregate due to water absorbed in the pore

[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 2006. Last previous edition approved in 2006 as D7172 – 06ε1. DOI: 10.1520/D7172-14.

[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.

[4] Available from ThermoFisher Scientific, 2555 Kerper Boulevard, P.O. Box 797, Dubuque, Iowa 52004-0797, U.S.A., or online at http://cp-thermofisher.kb.net/display/4/kb/article.aspx?aid=259320&n=1&docid=15899&tab=search.

spaces within the constituent particles, compared to the dry condition, when it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential. The laboratory standard for absorption is that obtained after submerging dry aggregate for approximately 24 hours in water. Aggregates mined from below the water table may have a higher absorption when used, if not allowed to dry. Conversely, some aggregates when used may contain an amount of absorbed moisture less than the 24 hours soaked condition: For an aggregate that has been in contact with water and that had free moisture on the particle surface, the percentage of free moisture can be determined by deducting the absorption from the total moisture content determined according to C566 by drying.

5. Apparatus

5.1 *Balance*—A balance or scale, conforming to the requirements of D4753, accurate and readable to within 0.1 % of the test sample mass at any point within the range of use.

5.2 *Thermometer*—Shall be capable of accurately measuring the temperature throughout a range of 0 to 50°C, and be readable to 0.5°C.

5.3 *Large Neck Volumetric Flask*—with a capacity of 500 mL.

5.4 *Timer*—capable of at least 5 min.

5.5 *AVM Unit (Automatic Volumetric Mixer)*—The unit shall perform an automated process for removing entrapped air. It shall consist of the following devices: an orbiting mixer that can securely hold a 500 mL large neck volumetric flask, a clamp and clamping rod capable of securely holding the neck of the volumetric flask, a vacuum pump, hose, and a stopper capable of fitting the mouth of the volumetric flask. (See Note 1.)

5.6 *Infrared Unit*—The device shall be automatically capable of detecting SSD using an infrared source and detector. It shall consist of an orbital mixer, water pump, infrared source, infrared detector, and a mixing bowl with a lid. The lid of the mixing bowl shall consist of two sapphire lenses and contain an injection nozzle for water injection. (See Note 1.)

NOTE 1—Units similar to the SSDetect formerly manufactured by Barnstead International[5] meet criteria described in Sections 5.3, 5.5 and 5.6

5.7 *Distilled Water.*

6. Sampling

6.1 Sampling shall be accomplished in accordance with Practice D75.

7. Preparation of Test Specimen

7.1 Obtain 1.5 kg ± 10 g of the fine aggregate from the sample using the applicable procedures described in Practice C702.

7.2 Dry it in a suitable pan or vessel to constant mass at a temperature of 110 ± 5°C. Allow it to cool to 23 ± 2°C.

7.3 Split the test sample according to Practice C702 into two 500 ± 5g samples. Discard excess.

8. Calibration

8.1 Calibration of the water pump and the infrared unit shall be performed once a month.

8.2 *Calibration of Water Pump:*

8.2.1 Fill the infrared device with distilled water per manufacturers' instructions.

8.2.2 Weigh a clean container. Place the container under the nozzle in the lid to collect the water. Position the container so as to minimize splashing. (See Note 2.)

NOTE 2—A 125-mL Erlenmeyer flask or similar container is recommended.

8.2.3 Follow manufacturers' instructions regarding initiation of an automatic preset number of injections from the nozzle into the test flask. (See Note 3.)

NOTE 3—A total of 3000 injections is recommended.

8.2.4 At the end of the collection cycle, remove the container and place it on a scale to obtain the total mass. Subtract the empty container mass obtained in step 8.2.2 from this value and enter the resulting amount into the Infrared device, per manufacturers' instructions.

8.3 *Calibration of Infrared Unit:*

8.3.1 Check and ensure that the water reservoir on the infrared unit is full. Turn on the power to the unit and allow it to warm-up per manufacturers' instructions.

8.3.2 Initiate infrared unit calibration routine per manufacturers' instructions.

8.3.3 Insert exactly 500.0 g of Ottawa Silica sand into the mixing bowl and initiate the calibration process. After the unit completes the calibration procedure, the unit will indicate the calibration result. (See Note 4.)

8.3.4 Return to the normal operation mode of the unit per the manufacturers' instructions.

8.3.5 Dry the Ottawa silica sand back to a constant mass at a temperature of 110 ± 5°C, so it can be used for future calibrations.

NOTE 4—A calibration material can be obtained from the unit manufacturer. When the calibration result is shown, it indicates that the calibration process is complete.

9. Procedure

9.1 Make and record all mass determinations to 0.1 g.

9.2 Determine the mass of a 500 mL, large neck volumetric flask filled to its calibration capacity with water at 23 ± 2°C. Record the mass and discard the water.

9.3 *Film Coefficient and Apparent Relative Density (Specific Gravity) Determination:*

9.3.1 Place approximately 250 mL of 23 ± 2°C water in the flask measured in 9.2.

9.3.2 Place the flask and water from 9.3.1 on a balance and zero the balance.

9.3.3 Set the timer to 5 min, start when instructed in 9.3.4.

[5] There is no source of supply of the apparatus known to the committee at this time. If you are aware of 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.

9.3.4 Obtain 500.0 g ± 0.1 g, of aggregate and record the mass. Transfer all of the aggregate into the flask with water from 9.3.2. Without zeroing the balance, record the mass on the balance from 9.3.2; make certain that the aggregate in the flask is covered with water. Start the five-minute timer from 9.3.3. A small amount of water can be added at this time to rinse the sides of the flask if necessary. Make certain not to overfill the flask, keeping the water level well below the calibration line. (See Note 5.)

NOTE 5—A funnel may be used to help transfer the sample into the flask.

9.3.5 Add a few drops of isopropyl alcohol or use a paper towel to remove bubbles if necessary to reduce error in reading the meniscus. (See Note 6.)

NOTE 6—An accurate meniscus determination is very important.

9.3.6 After the 5 min on the timer has elapsed, fill the flask with 23 ± 2°C water to the calibration mark.

9.3.7 Weigh and record the mass of the flask with its contents.

9.3.8 Place the flask containing the sample in the mounting bracket on top of mixer of AVM unit. Tighten the clamp around the top portion of flask and then insert the rubber stopper, with vacuum hose attached, into flask.

9.3.9 Turn the power switch for the AVM unit to the "on" position. Press the "start" button to begin the test. Mixer will begin to agitate material in flask. The mixer will operate for 3 min, then the vacuum pump will engage at a level of 56 cm Hg for another 3 min to remove air from the sample. The last 5 min of the test the vacuum pump will engage at a level of 69 cm Hg. This operation is entirely automated. The AVM will continue mixing during the entire period. The unit will stop automatically when testing is complete (~11 min).

9.3.10 After the unit has stopped mixing, remove the flask from mixing platform. Add a few drops of isopropyl alcohol or use a paper towel to remove bubbles if necessary to reduce error in reading the meniscus.

9.3.11 Fill the flask to the calibration mark with water.

9.3.12 Determine the total mass of the flask with the sample and water filled to the calibration mark.

9.3.13 Subtract the mass in step 9.3.7 from the mass in 9.3.12. Enter this value into the following equation to determine the film coefficient.

$$\text{Film Coefficient} = 52 + (4 * X) - (0.11 * X^2) \quad (1)$$

where:

X = the difference between the values determined in 9.3.7 and 9.3.12, g.

9.4 *Bulk Relative Density (Specific Gravity) and Percent Absorption Determination:*

9.4.1 Turn the infrared unit on and allow it to complete the 30-minute warm up period.

9.4.2 Place the empty, clean and completely dry bowl from the infrared unit on balance and record the mass of the bowl.

9.4.3 Place 500 ± 0.1 g of the sample into the bowl and record the mass of the bowl and sample.

9.4.4 Calculate and record the dry aggregate weight by subtracting the mass in step 9.4.2 from 9.4.3.

9.4.5 Place the bowl with the aggregate into the infrared unit, making certain that the notch in the front of the bowl fully engages in the notch in the front of the metal mounting plate. (Feel this with your finger at the bottom front of the bowl as placed.) Use the ring on the bowl to securely fasten the bowl to the plate by pressing down and turning the ring ¼ of a turn until tight. Next, place the top on the bowl and lightly press down to be certain it is engaged. The notch should be lined up in the front of the bowl. Then, close the lid to the infrared unit and latch in the front.

9.4.6 Ensure that there is distilled water in the reservoir in the unit.

9.4.7 Set the film coefficient to that determined in step 9.3.13. Press the enter button. The display will remind you to place sample in the unit. Press the start button. The system will automatically begin to determine the SSD point for the material. It will run for ¾ to 1½ hours depending on the absorption of the material being tested.

9.4.8 At the completion of the run, Press the OK button. Compare the film coefficient on the display with the measured film coefficient for that material to be certain it was entered properly. Press the OK button.

9.4.9 Open the unit; remove the lid to the bowl and store as directed by the manufacturer. Remove the bowl. Immediately place the bowl on the balance and record the mass. (See Note 7.)

NOTE 7—Be certain to determine the mass of the bowl immediately after removing the lid. This ensures that material is not allowed to dry.

9.4.10 Determine the amount of water absorbed by subtracting the mass in step 9.4.3 from 9.4.9.

10. Calculation

10.1 Calculate the bulk relative density (specific gravity) on the basis of mass of oven-dry aggregate, as defined in Test Method C128, as follows:

$$\text{Bulk relative density (specific gravity)} = A/(A + B - C + D) \quad (2)$$

where:

A = mass of oven-dry specimen in air, g (9.4.4)
B = mass of volumetric flask filled with water, g (9.2)
C = mass of volumetric flask with specimen and water to calibration mark, g (9.3.12)
D = mass of water absorbed, g. (9.4.10)

10.2 Calculate the bulk relative density (specific gravity) on the basis of mass of saturated surface-dry aggregate, as follows:

$$\text{Bulk relative density (specific gravity) (saturated surface - dry basis)} = \quad (3)$$

$$(A + D)/(A + B - C + D)$$

10.3 Calculate the apparent relative density as follows:

$$\text{Apparent relative density (specific gravity)} = E/(E + B - C) \quad (4)$$

where:

E = mass of oven-dry apparent specimen in air, g. (9.3.4)

10.4 Calculate the percentage absorption, as defined in Terminology C125, as follows:

$$\text{Water Absorption, percent} = (D/A) \times 100 \quad (5)$$

11. Report

11.1 Report the relative density (specific gravity) results to the nearest 0.001 and absorption to the nearest 0.01 %.

12. Precision and Bias

12.1 *Precision*—The estimates of precision of this test method (listed in Table 1) are based on results from a round-robin conducted by the National Center for Asphalt Technology.

The Gsb for the samples ranged from approximately 2.300 to 3.000, the Gsa ranged from approximately 2.6500 to 3.000 and the water absorption ranged from approximately 0.5 to 6.0 %. (See Note 8.)

NOTE 8—Results obtained using this test method may be different than those obtained using Test Method C128 and AASHTO T-84. These differences may also vary by material type.

12.2 *Bias*—since there is no accepted reference material suitable for determining the bias for this test method, no statement on bias is being made.

13. Keywords

13.1 absorption; aggregate; apparent density; apparent relative density; infrared; relative density; specific gravity

TABLE 1 Precision

	Standard Deviation (1S)[A]	Acceptable Range of Two Results (D2S)[A]
Single-Operator Precision		
Bulk specific gravity (dry)[B]	0.0125	0.035
Apparent specific gravity[B]	0.0066	0.019
Water absorption[B, %]	0.198	0.56
Multilaboratory precision		
Bulk specific gravity (dry)[B]	0.0213	0.060
Apparent specific gravity[B]	0.0085	0.024
Water absorption[B, %]	0.324	0.92

[A] These numbers represent, respectively, the (1S) and (D2S) limits as described in Practice C670. The precision estimates were obtained from a round-robin consisting of 12 labs with 12 different Thermolyne SSDetect units each testing 3 replicates of six materials. The complete results of the round-robin are reported in:
Prowell, B. D. and N. V. Baker, *Evaluation of New Test Procedures for Determining the Bulk Specific Gravity of Fine Aggregate Using Automated Methods*, Transportation Research Record 1874 Transportation Research Board, National Academy of Sciences, Washington, D. C. 2004. Pp. 11-18.
[B] The samples used for determination of the precision were chosen to represent a variety of different aggregate types; they included limestone, medium and high dust diabase, slag, rounded sand and crushed gravel.