



Designation: **D4221–17** **D4221 – 18**

Standard Test Method for Dispersive Characteristics of Clay Soil by Double Hydrometer¹

This standard is issued under the fixed designation D4221; 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 provides an indication of the natural dispersive characteristics of clay soils by comparing the amount of particles finer than 2- μm as determined by this method compared to the amount of particles finer than 2- μm as determined by Test Method **D7928(1)**.² In order to do this comparison, two similar specimens must be obtained from the sample.

1.2 This test method follows the procedure given in Test Method **D7928** with the exception that the soil slurry is not mechanically dispersed and no dispersing agent is added.

1.3 This test method is applicable only to soils where the position of the plasticity index versus liquid limit plots (Test Methods **D4318**) falls on or above the “A” line (Practice **D2487**) and more than 12 % of the soil fraction is finer than 2- μm as determined in accordance with Test Method **D7928(2)**.

1.4 Since this test method may not identify all dispersive clay soils, other tests such as, pinhole dispersion (Test Methods **D4647/D4647M**), crumb (Test Methods **D6572**) (**3-5**) and the analysis of pore water extraction (Test Methods **D4542**) (**4-7**) may be performed individually or used together to help verify dispersion.

1.5 *Units*—The values stated in SI units are to be regarded as the standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this test method.

1.6 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice **D6026**.

1.6.1 The procedures used to specify how data are collected/recorded or calculated, in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user’s objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering design.

1.7 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*³

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedures)

¹ This test method is under the jurisdiction of ASTM Committee **D18** on Soil and Rock and is the direct responsibility of Subcommittee **D18.06** on Physical-Chemical Interactions of Soil and Rock.

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² The boldface numbers in parentheses refer to the list of references appended to this standard.

³ 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.

*A Summary of Changes section appears at the end of this standard

[D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction](#)

[D4220/D4220M Practices for Preserving and Transporting Soil Samples](#)

[D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils](#)

[D4542 Test Methods for Pore Water Extraction and Determination of the Soluble Salt Content of Soils by Refractometer](#)

[D4647/D4647M Test Methods for Identification and Classification of Dispersive Clay Soils by the Pinhole Test](#)

[D6026 Practice for Using Significant Digits in Geotechnical Data](#)

[D6572 Test Methods for Determining Dispersive Characteristics of Clayey Soils by the Crumb Test](#)

[D6913 Test Methods for Particle-Size Distribution \(Gradation\) of Soils Using Sieve Analysis](#)

[D7928 Test Method for Particle-Size Distribution \(Gradation\) of Fine-Grained Soils Using the Sedimentation \(Hydrometer\) Analysis](#)

3. Terminology

3.1 Definitions:

3.1.1 For definitions of common technical terms used in this standard, refer to Terminology [D653](#).

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *dispersive clays, n*—soils that deflocculate easily and rapidly without significant mechanical assistance in water of low-salt concentration.

3.2.1.1 Discussion—

Such soils usually have a high proportion of their adsorptive capacity saturated with sodium cation although adsorbed lithium and magnesium may also play a role (6). Such soils also generally have a high shrink-swell potential, have low resistance to erosion, and have low permeability in an intact state.

4. Summary of Test Method

4.1 This test method is used to determine the percent dispersion of a soil. In order to calculate the percent dispersion, two similar specimens are obtained from a representative sample and then a sedimentation (hydrometer) analysis is performed on each specimen to determine the amount of particles finer than 2- μm . The sedimentation analysis is performed following Test Method [D7928](#) for both specimens, except that one of the specimens is de-aired and is not mechanically or chemically dispersed.

4.2 The percent dispersion is calculated by dividing the percent passing the 2- μm size from the de-aired, not dispersed specimen by the percent passing the 2- μm size from the specimen that was dispersed and by multiplying the result by 100.

5. Significance and Use

5.1 Dispersive clays are those which normally deflocculate when exposed to water of low-salt concentration, the opposite of aggregated clays that would remain flocculated in the same soil-water system (3, 4, 7). Generally, dispersive clays are highly erosive, possibly subject to high shrink-swell potential, may have lower shear strength, and have lower permeability rates than aggregated clays.

5.2 When the percent dispersion equals 100, it indicates a completely dispersive clay-size fraction. When the percent dispersion equals 0, it indicates completely nondispersive clay-size fraction.

5.3 Available data (1) indicates that the test method has about 85 % reliance in predicting dispersive performance (85 % of dispersive clays show more than 35 % dispersion).

5.4 Since this test method may not identify all dispersive clays, design decisions based solely on this test method may not be conservative. It is often run in conjunction with the crumb test ([D6572](#)) (4, 7), the pinhole test ([D4647/D4647M](#)), or the analysis of the pore water extract ([D4542](#)) (4, 7), or combination thereof, to identify possible dispersive clay behavior.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personal performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice [D3740](#) are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice [D3740](#) does not in itself assure reliable results. Reliable results depends on many factors; Practice [D3740](#) provides a means of evaluating some of those factors.

6. Apparatus

6.1 Section 6 of Test Method [D7928](#) describes the equipment and tools needed for performing the sedimentation (hydrometer) analysis portion of this standard.

6.2 *Container*—An airtight, glass or equivalent inert container with enough capacity to hold the minus No. 10 (2.0-mm) specimen(s).

6.3 *Filtering Flask*—A 500-mL filtering flask with a rubber stopper and a side tube capable of withstanding a vacuum.

6.4 *Vacuum System*—A vacuum pump or water aspirator capable of producing a vacuum between 508 and 635 mm of Hg on the vacuum gauge.

7. Reagents

7.1 Section 7 of Test Method **D7928** describes the reagents needed for performing the mechanically and chemically dispersed sedimentation (hydrometer) analysis portion of this standard.

7.2 *Distilled Water*—Distilled or demineralized water with a pH between 5.5 and 7 is the only permissible test fluid for use in the sedimentation portion of the test. The use of tap water is not permitted.

8. Sampling

8.1 *General*—This test method does not address, in any detail, procurement of the sample. It is assumed the sample is obtained using appropriate methods and is representative of the material under evaluation. The testing agency must preserve all samples in accordance with Practice **D4220/D4220M**, Group B, except if the as-received sample does not meet those requirements. In which case, the water content of the sample does not have to be maintained. Section 9 of Test Method **D6913** gives additional information regarding sampling from different sources.

8.2 Follow the steps given in 8.4 of Test Method **D7928**, including the mass requirements given in Table 1 of that standard, to obtain the reduced sample from which the test specimens are to be obtained.

9. Preparation of the Test Specimens

9.1 *Specimen Procurement*—This standard presents two preparation methods to obtain the sedimentation specimens: moist and air-dried. Moist and air-dried refers to the condition of the sample as it is being reduced to an appropriate particle size and mass. The test shall not be performed on oven-dried soil. The air-dried method shall only be used on samples received in the air-dried state (**Note 2**). Since some fine-grained air-dried soils aggregate, a mortar and rubber covered pestle is used to break up aggregations. Care must be taken to avoid disintegration or reduction of individual particles. Use only enough force as necessary to break up the aggregations without destroying the individual particles. Additional guidance for splitting materials to obtain a representative specimen is given in Test Method **D6913**, Annex A2.

9.2 See 9.2 and 9.3 of Test Method **D7928** for the moist and air-dried preparation methods, respectively.

9.3 If the reduced sample contains particles larger than the No. 10 (2.0-mm) sieve, the soil must be separated using a No. 10 (2.0-mm) sieve. Process the entire reduced sample over the No. 10 (2.0-mm) sieve using a rubber scraper and, if needed, distilled water to aid in working the soil through the sieve. Check that the soil retained on the sieve does not contain aggregations of finer particles. Any aggregations should be broken and passed through the sieve. It is not necessary that the separation be totally complete, but the soil passing the sieve must be representative. The amount of soil passing the No. 10 (2.0-mm) sieve must be sufficient to obtain two specimens for sedimentation analysis and one water content determination.

9.4 If there is sufficient minus No. 10 (2.0-mm) soil, split or quarter this soil into at least three portions: one for the water content determination and two for the sedimentation analyses. The water content specimen must contain 50 ± 10 g of soil. If there is insufficient minus No. 10 (2.0-mm) soil, do not obtain a water content specimen. Obtain the dry mass of the minus No. 10 (2.0-mm) soil at the end of the test as discussed in 11.12 of Test Method **D7928**. See Note 11 in Test Method **D7928**.

9.5 If sufficient soil is available, immediately use one of the three specimens for determination of the water content in accordance with Test Methods **D2216** and record the water content, w_c to the nearest 0.1 %. Immediately place the other two specimens into separate airtight containers. If the water content is to be determined at the end of the test, immediately place the two specimens in air tight containers to prevent moisture change.

NOTE 2—Air drying causes irreversible changes to the clay particles that cause permanent flocculations and decreases the fine fraction. (8)

10. Procedure

10.1 *Mechanically and Chemically Dispersed*—Use one of the specimens stored in one of the containers to determine the amount of particles finer than 2- μ m in accordance with Test Method **D7928**. The stirring apparatus shall be used to disperse the specimen.

10.2 *Not Mechanically or Chemically Dispersed:*

10.2.1 Determine and record the moist mass of soil, M_m , equivalent to 25 g of dry soil, M_d , using the following equation:

$$M_m = M_d \times \left(1 + \frac{w_c}{100} \right) \quad (1)$$

where:

M_m = mass of moist soil, nearest 0.01 g,

M_d = mass of dry soil, nearest 0.01 g, and