



Standard Test Method for Measuring the Minimum Fluidization Velocities of Free Flowing Powders¹

This standard is issued under the fixed designation D7743; 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 describes the apparatus and procedure needed for determining the minimum fluidization velocity of Geldart Group A powders and the minimum fluidization or complete fluidization velocity of Geldart Group B powders.

1.1.1 This test method is for powders that are readily or easily fluidizable and fall into the category of Group A and B of the “Geldart” classification. The fluidization of Geldart Group C powders will be addressed in another standard. This test method could apply to Geldart Group D particles but the focus of this document is towards Group A and B materials.

1.1.2 Geldart classification of powders is often defined by comparing the Sauter mean particle size with the difference between the particle density and the density of the fluidizing gas, as illustrated in [Fig. 1\(1\)](#).²

1.1.2.1 Group A powders are easily fluidized but there is a difference between the gas velocity where the bed is initially fluidized and the velocity where bubbles are first observed. For Group A powders, bed expansion can be considerable before any bubbles are observed. Group B powders are also easily fluidized; but there is no difference between the velocity where the bed is fluidized and the velocity at the onset of bubbling. The minimum gas velocity, where all of the particles are fully supported by the gas for Group B powders, is often referred to as the “complete fluidization velocity” instead of minimum fluidization velocity. Group C powders are cohesive and can be difficult to fluidize.

1.1.2.2 Group A powders can be distinguished from Group B powders by the response to deaeration. Group A powders deaerate relatively slowly whereas Group B powders deaerate almost instantaneously in fluidized beds.

1.1.2.3 Group A Powders that lie near or on the Group A/C boundary may be tested by this method. However, if the powders do not fluidize freely, test results should be considered invalid.

1.1.2.4 Temperature, moisture (water) content, particle size distribution, particle shape and sometimes other variables influence the Geldart classification of a powder. Deaeration testing specified in [1.1.2.2](#) is a more definitive test than simply using particle size and density differences as described in [1.1.2](#).

NOTE 1—A Standard Practice for deaeration testing is under development.

1.2 This test method should be performed in a laboratory under controlled conditions of temperature and humidity.

1.3 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice [D6026](#).

1.3.1 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 variations, the 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.

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

¹ This test method is under the jurisdiction of ASTM Committee [D18](#) on Soil and Rock and is the direct responsibility of Subcommittee [D18.24](#) on Characterization and Handling of Powders and Bulk Solids.

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² The boldface numbers in parentheses refer to a list of references at the end of this standard.

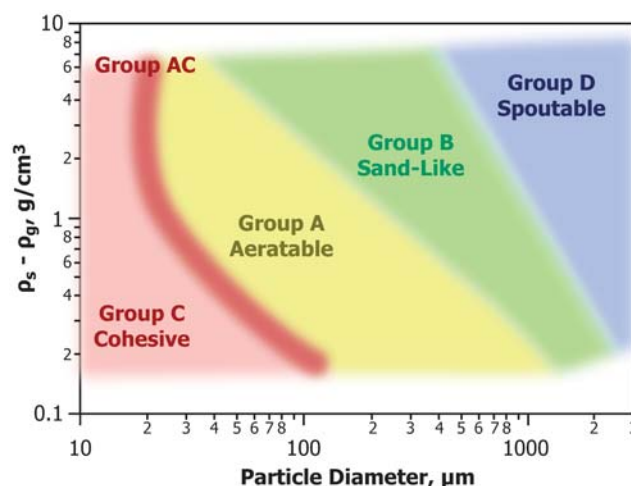


FIG. 1 Geldart Classification of Particles

1.5 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: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
- D3195 Practice for Rotameter Calibration
- D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- D6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

3.1 Definitions:

3.1.1 For common definitions of technical terms in this standard, refer to Terminology D653.

3.1.2 *complete fluidization velocity*, U_{cf} , *n—in powders and bulk solids*, the superficial gas velocity at which all particles in the bed are fully suspended by the gas.

3.1.3 *fluidized bed*, *n—in powders and bulk solids*, a bed of particulate matter fully suspended by a gas or liquid (liquid suspensions are not covered in this method).

3.1.4 *minimum bubbling velocity*, U_{mb} , *n—in powders and bulk solids*, the superficial gas velocity at which gas bubbles are first observed in a bed of powder.

3.1.5 *minimum fluidization velocity*, U_{mf} , *n—in powders and bulk solids*, the superficial gas velocity at which the bed is initially suspended by the fluid (or liquid).

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.

NOTE 2—At minimum fluidization, the pressure drop or differential pressure across the bed becomes relatively constant with additional gas velocity. The pressure drop at minimum fluidization corresponds to the mass of the bed times the gravitational constant divided by the bed cross sectional area.

3.1.6 *superficial gas velocity*, *n—in powders and bulk solids*, the calculated gas velocity if no particles were present, i.e., the gas volumetric flow rate divided by the cross sectional area with respect to the bed diameter.

3.1.7 *Sauter mean particle size*, *n—in powders and bulk solids*, the diameter of a sphere that has the same volume to surface area ratio as the particles being measured.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *differential pressure*, *n—the static pressure at one location referenced to the static pressure at another location separated by a known distance.*

3.2.2 *particle density*, *n—the density of a particle including internal voids and pores.*

3.2.3 *pressure drop*, *n—the same as differential pressure for this application.*

4. Summary of Test Method

4.1 Fluidize the specimen to eliminate any internal stresses that may have developed during filling, then terminate the fluidizing gas and allow the bed to deaerate naturally.

4.2 Incrementally increase the gas flow rate and record values of pressure drop as a function of gas flow rate.

4.3 Once the specimen is fully fluidized, incrementally decrease the gas flow rate and record values of pressure drop.

NOTE 3—The final asymptotic pressure drop at full bed suspension corresponds to the bed density or bulk density times the bed height and the acceleration of gravity.

5. Significance and Use

5.1 The data from this test can be used to determine the superficial gas velocity required to suspend a bed of powder in the fluidized state and the resulting pressure drop.

NOTE 4—The quality of the results produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that claim to

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 ensure reliable results. Reliable results depend on many factors: Practice D3740 provides a means of evaluating some of those factors.

Practice D3740 was developed for agencies engaged in the testing or inspection or both of soil and rock. As such it is not totally applicable to agencies performing this standard. However, users of this standard should recognize that the framework of Practice D3740 is appropriate for evaluating the quality of an agency performing this standard. Currently there is no known qualifying national authority that inspects agencies that perform this standard.

6. Apparatus

6.1 The test unit is shown schematically in Fig. 2.

NOTE 5—The fluidization chamber consists of a plenum, a bed of powder and a freeboard. A plenum consists of an expansion chamber for incoming gas and a porous media for gas distribution. The bed of powder is contained within a right circular cylinder. Any cylinder shape can theoretically be used, but the gas needs to be uniformly distributed. Since this is most easily accomplished using a right circular cylinder, this test method is limited to this apparatus. The freeboard is used to disengage entrained or elutriated particles (or at least provide an opportunity for them to disengage). The outlet port in the freeboard region should be equipped with filtering media to prevent the loss of powder to the environment.

6.2 Select porous media based on anticipated bed height and powder properties.

6.2.1 Select the pore size of the porous media to be small enough to prevent particle weepage into pores of the porous media.

NOTE 6—Porous media such as glass or quartz frits or sintered metal discs are commonly used. The pore size does not have to be smaller than the smallest size of the test specimen.

6.2.2 Seal the porous media to the plenum and fluidized bed chamber to ensure gas does not bypass the porous media.

NOTE 7—Typically, this can be done with adhesives or by welding.

6.3 Ensure that the inside diameter of the cylinder is at least 150 mm, preferably 200 mm or larger.

NOTE 8—Smaller columns can be used, but the column diameter needs to be noted in the report. Inner diameters of less than 150 mm may have results affected by wall friction.

6.3.1 Construct the cylinder of any material suitable for the environment in which the experiment is to be conducted.

NOTE 9—Typically, lab-scale units are constructed of Plexiglas™, acrylic or glass. Many of these materials are relatively brittle, so pressure relief devices need to be considered.

6.4 Ensure that the freeboard height is at least the same as the bed height when fully fluidized.

6.4.1 Ensure that the freeboard inside diameter is the same or larger than the inside diameter of the bed.

NOTE 10—In some instances, a freeboard region of greater diameter than the bed can be used to lower the superficial gas velocity to reduce the particle entrainment rate. The expanded freeboard region needs to be sufficiently above the bed such that an expanded bed does not move into this expanded freeboard region. For typical minimum fluidization testing, an expanded freeboard is not needed.

6.4.2 Choose for the filtering media for the outlet port in the freeboard region a fibrous cartridge, cellulose thimble, sintered metal filter, etc.

NOTE 11—Cyclone(s) can also be used if sized correctly.

6.4.3 Consider a pressure relief device in the freeboard assembly.

NOTE 12—Pressure relief can be done with pressure frangible, pressure relief disk, pressure relief valve or static fluid column, depending on the pressure drop across the filter media (pressure in the freeboard with respect to the ambient pressure).

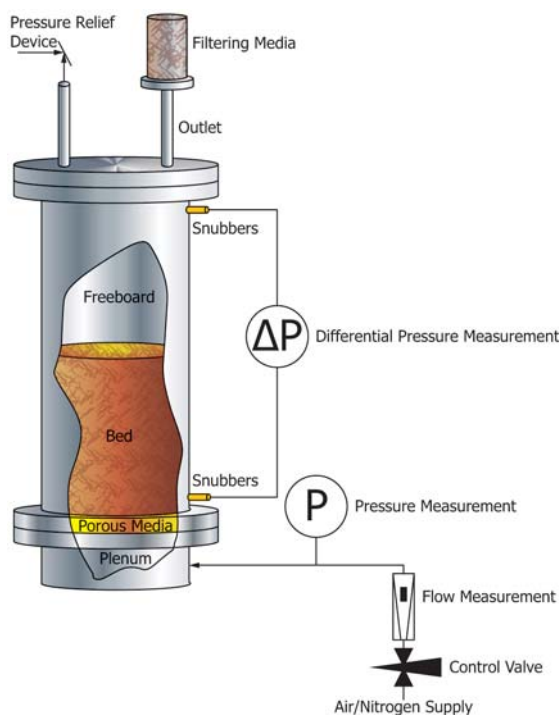


FIG. 2 Schematic of Test Apparatus for Measuring the Minimum or Complete Fluidization Velocity of Geldart Group B Powders