



Designation: **D6941—12 D6941 – 19**

Standard Practice for Measuring Fluidization Segregation Tendencies of Powders¹

This standard is issued under the fixed designation D6941; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This practice covers an apparatus and procedure for creating several specimens of a powder sample that, if the powder is one that segregates by the fluidization mechanism, should be different from one another.

1.2 A powder sample is fluidized then, after the fluidizing gas is turned off, it is separated into three or more specimens that can be analyzed for parameters of interest. The difference in these parameters between the specimens is an indication of the segregation potential of the powder.

1.3 Powders must be capable of being fluidized in order to be tested by this practice.

1.4 Temperature- and moisture-sensitive powders may need to be tested at different temperatures and moisture contents, as would happen in an industrial environment.

1.5 This standard is not applicable to all bulk solids and segregation mechanisms: while fluidization is a common segregation mechanism experienced by many fine powders, other segregation mechanisms not evaluated by this standard might induce segregation in practice. Practice **D6940** covers another common mechanism: sifting.

1.6 The extent to which segregation will occur in an industrial situation is not only a function of the powder and its tendency to segregate, but also the handling equipment (for example, bin design), process (for example, transfer rates), and environment.

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

1.8 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word Standard in the title of this document means only that the document has been approved through the ASTM consensus process.

1.9 *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.*

1.10 *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:*²

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

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

D6940 Practice for Measuring Sifting Segregation Tendencies of Bulk Solids

¹ This practice 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 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

3. Terminology

3.1 Definitions:

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

3.1.2 *fluidization, n—in powders*, the state in which a powder exhibits fluid-like properties.

3.1.3 *fluidization segregation, n—in powders*, a mechanism that causes vertical segregation, that is, horizontal layering of fine and coarse particles, as resulting from fluidization of the bulk solid.

3.1.4 *segregation, n—in powders*, a process through which blended or uniform powders or bulk solids become non-uniform, with regions of varying composition, for example, particle size.

3.1 Definitions:

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

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *high flow-rate, n—in powders*, the first stage flow-rate used to initiate fluidization.

3.2.2 *low flow-rate, n—in powders*, the second stage flow-rate used to maintain fluidization.

3.2.3 *representative sample, n—in powders*, a quantity of the bulk solid to be tested that is representative of that solid in an industrial application being studied. Parameters of interest that may affect whether or not a sample is representative include, but are not limited to: moisture, particle size distribution, raw material variation, method of production, aging, chemical composition.

4. Summary of Practice

4.1 A representative sample of a powder is placed in the test chamber.

4.2 Pressurized gas (usually air), which is blown from the bottom, is ramped up from zero to a pre-determined High Flow-rate, held there, ramped down to a pre-determined Low Flow-rate, then held there, all for specified times, creating a state of fluidization of the powder.

4.3 The airflow is ramped down to zero over a specified time.

4.4 The powder in the test chamber is divided into N specimens.

4.5 The specimens are then available to be tested for differences relevant to the application, for example, particle size or chemical assay.

5. Significance and Use

5.1 Fluidization segregation can cause vertical segregation within bins used to hold and transport powders. This can affect product quality or subsequent processes in industrial applications.

5.2 By measuring a powder's segregation tendency, one can compare results to other powders with known history, or determine if the given powder may have a tendency to segregate in a given process.

5.3 Fine powders generally have a lower permeability than coarse bulk solids and therefore tend to retain air longer. Thus, when a bin is filled with a fluidizable powder, the coarser particles settle or are driven into the bed while the finer particles remain fluidized near the surface.

5.4 Fluidization, which serves as a driving force for this mechanism of segregation, is likely to occur when fine powders are pneumatically conveyed into a bin, the bin is filled or discharged at high rates, or if sufficient air flow counter to the flow of powder is present within the bin.

NOTE 1—The quality of the result produced by this practice is dependent on the competence of the personnel 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 practice are cautioned that compliance with Practice [D3740](#) does not in itself assure 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 and/or inspection of soil and rock. As such it is not totally applicable to agencies performing this practice. However, users of this practice should recognize that the framework of Practice [D3740](#) is appropriate for evaluating the quality of an agency performing this practice. Currently there is no known qualifying national authority that inspects agencies that perform this practice.

6. Apparatus

6.1 The apparatus is shown in [Fig. 1](#). It consists of the following:

6.2 *Gas Supply with Flow Meter*—A supply of dry, non-toxic and non-flammable gas capable of fluidizing the powder is required. The recommended gas supply pressure is 170 kPa [25 psig] with a range from 100 to 200 kPa [15 to 30 psig]. The recommended gas supply flow rate is 10 000 cm³/min or higher. The gas flow rate shall be adjustable during the test. An automated controller may be used for this purpose.

NOTE 2—Generally, clean, dry air is used. If air is not suitable (that is, it reacts with or adversely affects the powder being tested) another gas, such as nitrogen, may be used.

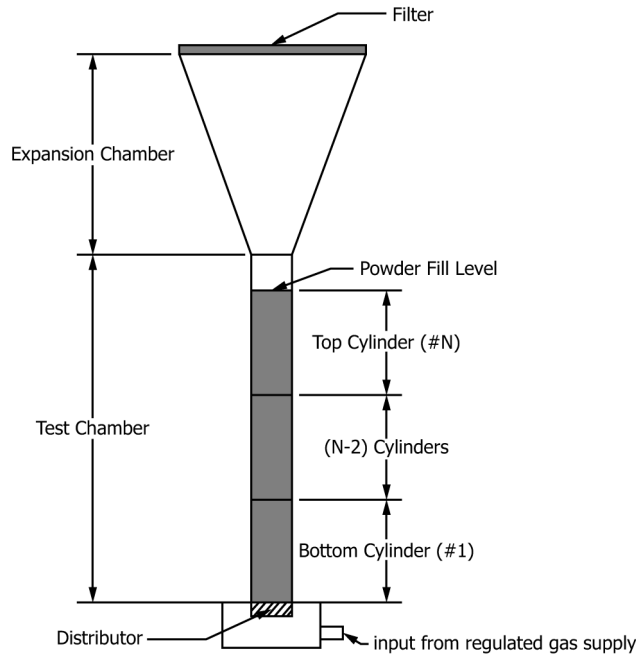


FIG. 1 Apparatus

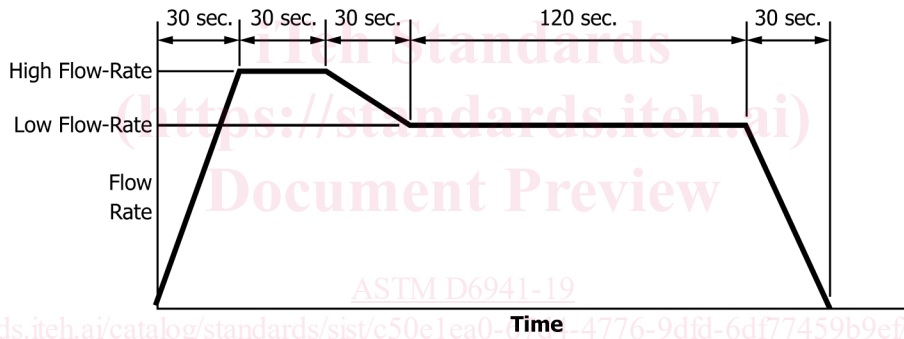


FIG. 2 Timing Profile

6.3 *Test Chamber*—This consists of three or more cylinders stacked above the distributor, which is at the top of the air supply plenum. These cylinders which, when stacked together have a total height of at least 195 mm, are connected at the top to a conical expansion chamber. The test chamber is where the powder sample is placed.

6.3.1 *Cylinders*—Each circular cylinder is transparent and has a diameter of 24 ± 1 mm I.D. They are stacked, identified as #1 (the bottom) to #N (the top). The bottom cylinder (#1) sits against the distributor in the air supply plenum. The top cylinder (#N) mates to the expansion chamber. The cylinders shall be held together in a manner that prevents separation during the test and prevents leakage. This method must allow separation of the cylinders upon completion of the test to allow specimen recovery.

6.4 *Expansion Chamber*—This conical extension of the test chamber allows the powder to disengage from the air stream. It must be sufficiently tall to prevent the expanded powder bed from contacting the filter at its top and sufficiently steep to cause the powder to slide back into the test chamber when the airflow is turned off.

6.5 *Filter*—The filter prevents powder from being blown out of the apparatus while allowing the gas to pass through. The filter material should be appropriate for the application and should not contaminate the powder (which may affect the analysis of the specimens), and should provide containment of the powder (from both a safety perspective and a loss of powder perspective).

6.6 *Distributor*—The distributor diffuses the air uniformly into the test chamber; therefore, a sufficient pressure drop across the distributor is required. The pore size of the porous media in the distributor does not have to be smaller than the smallest particle size of the test sample, but should be small enough to prevent particle seepage into the plenum.

NOTE 3—A sintered metal disk, such as 5 μ m filtration grade porous stainless steel sheet, may be an appropriate material for the distributor. Some cohesive powders do not fluidize well, and simply form an air channel through the test bed, allowing the air to flow past stationary powder. In this case additional airflow will not serve to fluidize the powder. If this occurs, this test is not valid. However, a distributor with a lower permeability may serve to distribute the air more uniformly, thereby reducing channeling.