INTERNATIONAL

Designation: D 6940 – 034

Standard Practice for Measuring Sifting Segregation Tendencies of Bulk Solids[1]

This standard is issued under the fixed designation D 6940; 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 practice covers an apparatus and procedure for simulating the segregation tendencies of bulk solids by means of the sifting mechanism.

1.2 Temperature- and humidity-sensitive bulk solids may need to be tested at different temperatures and moisture contents, as would happen in an industrial environment.

1.3 The maximum particle size should be limited to 3 mm, to reduce the likelihood of binding the slide gate.

1.4 This standard is not applicable to all bulk solids and segregation mechanisms: while sifting is a common segregation mechanism experienced by many bulk solids, other segregation mechanisms not evaluated by this standard might induce segregation in practice.

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

1.6 *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.*

[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. Referenced Documents

2.1 *ASTM Standards:* [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

3. Terminology

3.1 *Definitions*—Definitions of terms used in this test method shall be in accordance with Terminology D 653.

3.1.1 *funnel flow pattern, n*—a flow sequence in a bin or hopper characterized by having some bulk solids moving through stagnant bulk solids. In general, there is no flow along the hopper walls.

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

3.1.3 *sifting segregation, n*—a mechanism in which finer particles preferentially percolate into a zone within the bulk solid.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *collection cup*, *n*—a collection cup holds a sample of bulk solid once it is discharged from the apparatus.

3.2.2 *inner hopper*, *n*—the inner hopper is transparent. It has a steep inner conical section designed to sit within the outer hopper.

3.2.3 *outer hopper*, *n*—the outer hopper consists of a shallow transparent hopper designed to provide funnel flow for most bulk solids. It has an attached slide gate/guide cylinder and support legs.

3.2.4 *representative sample*, *n*—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: moisture, particle size distribution, raw material variation, method of production, aging, chemical composition.

4. Summary of Practice

4.1 A representative sample of a bulk solid is placed in the upper hopper of the apparatus.

4.2 The bulk solid is discharged to form a pile within the lower hopper, allowing segregation to take place.

4.3 The segregated material is discharged in a funnel flow pattern intended to recover zones of segregated material in a known sequence. Samples are collected from the discharge stream.

4.4 The samples 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 Sifting segregation can cause horizontal segregation (for example, center-to-periphery) within bins used to hold and transport bulk solids. This can affect final product quality in industrial applications.

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

5.3 Sifting, which is a process by which smaller particles move through a matrix of larger ones, is a common method of segregation. Four conditions must exist for sifting to occur:

5.3.1 *A Difference in Particle Size between the Individual Components*—This ratio can be as low as 1.3 to 1. In general, the larger the ratio of particle sizes, the greater the tendency for particles to segregate by sifting.

5.3.2 *A Sufficiently Large Mean Particle Size*—Sifting segregation can occur with a mean particle size in the 50 µm range and can become a dominant segregation mechanism if the mean particle size is above 100 µm.

5.3.3 *Sufficiently Free Flowing Material*— This allows the smaller particles to sift through the matrix of larger particles. With cohesive materials, the fine particles are bound to one another and do not enter the voids among the coarse particles.

5.3.4 *Interparticle Motion*—This can be caused during formation of a pile, by vibration, or by a velocity gradient across the flowing material.

5.4 All four of these conditions must exist for sifting segregation to occur. If any one of these conditions does not exist, the material will not segregate by this mechanism.

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 D 3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this practice are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

Practice D 3740 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 D 3740 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.

[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*, Vol 04.08volume information, refer to the standard's Document Summary page on the ASTM website.

6. Apparatus

6.1 The apparatus is shown in Fig. 1, and all critical dimensions are specified in Fig. 2. The apparatus consists of the following:

6.2 An upper hopper assembly consisting of an inner hopper seated within an outer hopper. This outer hopper provides support for the inner hopper, and has a slide gate to start/stop material flow. The outer hopper also has support legs, which mate to the lower hopper assembly.

NOTE 1 2—Although only the inner hopper is used to contain the bulk solid being tested, placing this hopper inside the outer hopper provides a means to locate and support it, as well as a means to fill and empty the hopper (by using the slide gate). In addition, this outer hopper can be used for alternate test procedures that involve recycling material to and from a hopper of similar type. In this case a second inner hopper is also required.

6.3 A lower hopper assembly consisting of a second outer hopper. This outer hopper provides support for the upper hopper assembly, has a slide gate to start/stop material flow, and a guide cylinder for dispensing material into collecting cups. The outer hopper also has support legs to support the entire segregation tester.

6.4 A collecting cup with a minimum capacity of 55 mL, to collect samples as they discharge from the lower hopper. The collecting cups must fit within the apparatus.

7. Procedure

7.1 Clean the apparatus and allow all parts to dry.

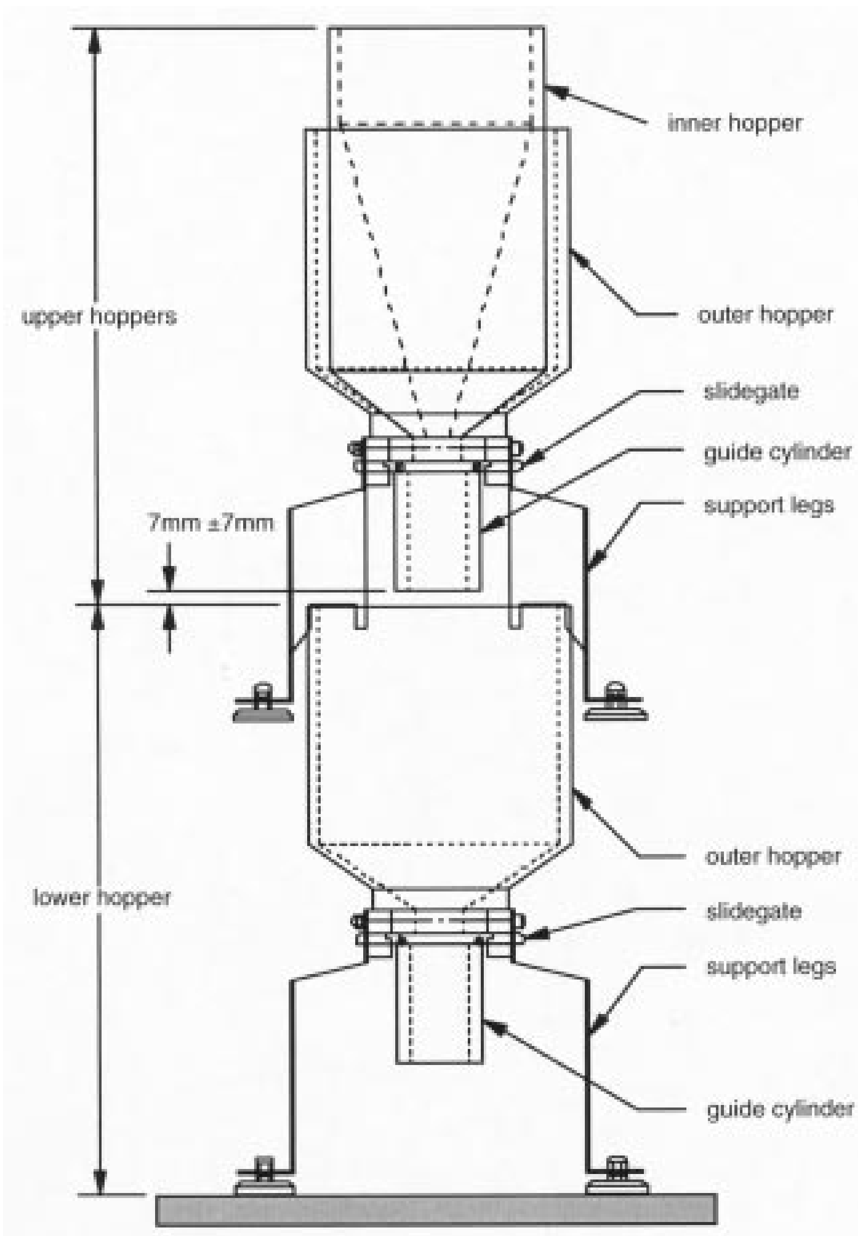

FIG. 1 Apparatus

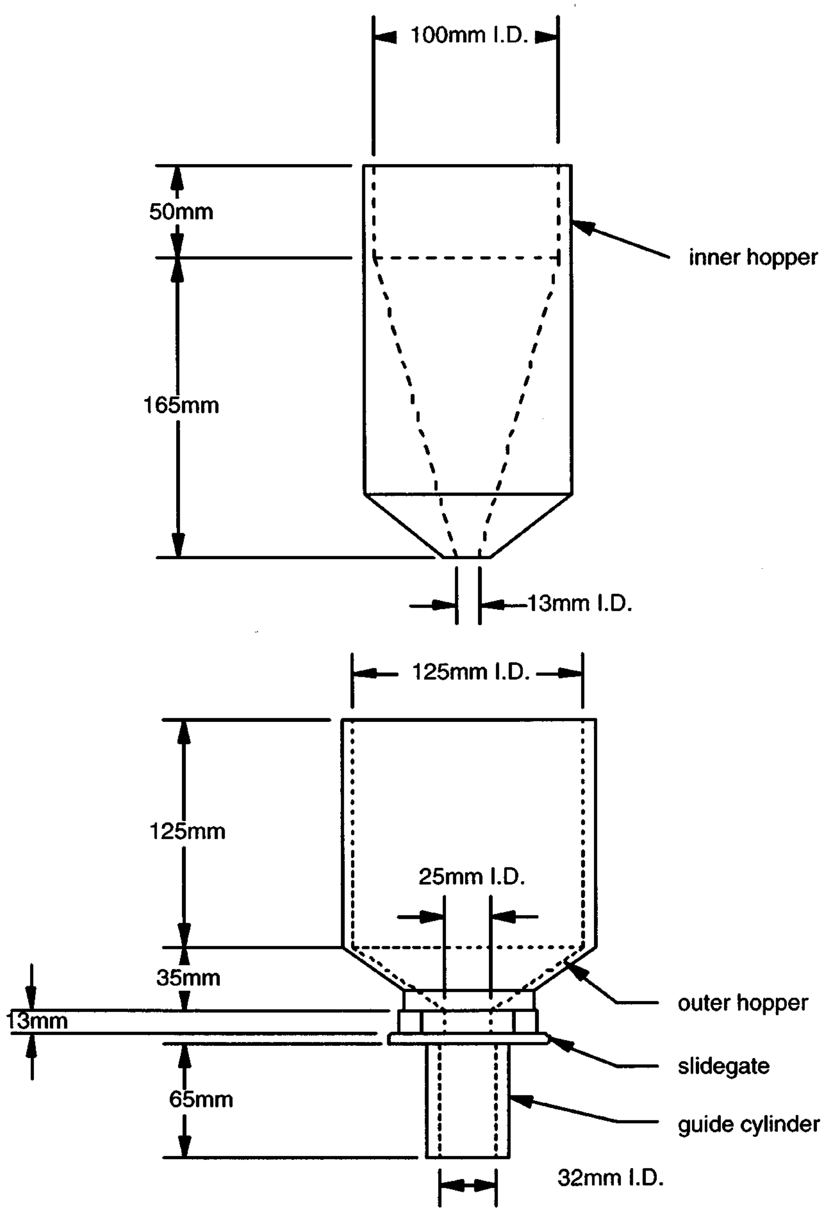

FIG. 2 Dimensions of Apparatus

7.2 With inner hopper removed, place one outer hopper on top of the other. Make sure that the centerlines of the two hoppers are aligned.

7.3 Place the inner hopper into the upper outer hopper.

7.4 Close the slide gates on both outer hoppers.

7.5 Place the apparatus on a table or bench that is free from vibration, in a suitable laboratory environment to approximate the industrial environment.

7.6 Obtain a representative, one liter sample of the bulk solid to be tested. The maximum particle size should be limited to 3 mm, to reduce the likelihood of binding the slide gate.

7.7 Carefully spoon or scoop the bulk solid into the upper inner hopper. Free fall of material into the hopper should be minimized.

7.8 Open the upper slide gate to the full open position, allowing all of the material to fall into the lower hopper below.

7.9 Cohesive materials may not readily flow though this apparatus. For moderately cohesive materials that flow poorly though this apparatus, some light tapping on the hopper may be required to maintain flow. Extremely cohesive materials, which do not flow with light tapping, should not be tested to avoid damage to the apparatus (further, extremely cohesive materials generally do not readily segregate).

7.10 When the upper inner hopper is empty, close the upper hopper slide gate, remove the upper hopper assembly and set it aside.

7.11 With the lower hopper slide gate still closed, place a collecting cup over the open end of the guide cylinder so that the bottom of the cup is in contact with the bottom of the guide cylinder.

NOTE 23—The bottom of the guide cylinder must remain in contact with the base of the cup.

7.12 With the cup and guide cylinder together, open the lower hopper slide gate and allow the guide cylinder to fill.

NOTE 34—Do not lower the cup at this time. Doing so will result in material spillage and will void this practice.

7.13 When the guide cylinder is full, close the lower hopper slide gate completely, then lower the collecting cup.

7.14 Discharge from the lower outer hopper will be in a funnel flow pattern for most bulk solids. An exception might occur for free flowing, low friction materials such as beads or glass spheres. If the material is sliding along the walls during discharge ("mass flow"), then the test results will not be valid; in this case, roughen the hopper surface (for example, attach sandpaper) and begin the procedure again.

7.15 Discharge the sample in the collecting cup into a properly identified sample jar.

7.16 Repeat 7.11-7.15 until the lower hopper is empty. Approximately 19 samples will be obtained.

8. Analysis of Samples

8.1 If needed, use appropriate sample splitting methods to reduce the size of the samples in each of the sample jars to a suitable size for analysis. Use proper subdivision techniques, such as the use of a rotary riffler.

NOTE 45—Collecting sub-samples from the sample jars by scooping or thieving may be prone to errors. Analysis of multiple samples from a single location yields further confidence in the results.

8.2 Analyze the samples with respect to the parameters of interest: for example, particle size, particle shape, chemical assay, bulk density, color, solubility, or any other differences that may affect the suitability of the bulk solid.

8.3 The trend from the beginning to the end of discharge is an indication of segregation potential. Normally, if sifting segregation has occurred upon filling, fines discharge initially, with increasing coarse to the end.

NOTE 56—In some cases, the very last sample may also be high in fines, for a variety of reasons. For example, if the initial zone of fines exceeds the diameter of the outlet, not all fines will discharge at the beginning, and may discharge at the very end. Another reason for fines at the end is due to sifting of the material from the moving flow channel into the stagnant zone during discharge; this layer often discharges at the very end. (To investigate this later scenario, scoop material directly into the lower outer hopper in a way to maintain a good blend in the hopper, then continue from 7.11. If the last sample is fine, segregation within the flow channel is occurring.)

8.4 The difference between the first and last samples can be used as an indicator of segregation potential when a single-valued result is needed for comparison of different samples.

NOTE 67—Generally the last collection cup will not be as full as the other cups. If the last cup of material is less than half the volume of the other cups, then the reported difference should be the difference between the first and last full cups (that is, next to last cup).

8.5 Segregation test results for a new bulk solid should be compared to prior tests on other bulk solids, whose segregation properties are well known and understood.

9. Precision and Bias

9.1 Report the following information:

9.1.1 Date test was run,

9.1.2 Operator,

9.1.3 Name of project or client including project number if used,

9.1.4 Generic name of bulk solid tested,

9.1.5 Temperature and relative humidity of room where tests performed,

9.1.6 Number of jars collected,

9.1.7 Number of last full jar, and

9.1.8 Any observations of interest during running of tests, including the need for tapping to initiate or maintain flow.

10. Keywords

10.1 bulk solids; segregation; sifting