Designation: D6128 – 22

Standard Test Method for Shear Testing of Bulk Solids Using the Jenike Shear Tester[1]

This standard is issued under the fixed designation D6128; 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 method [2]covers the apparatus and procedures for measuring the cohesive strength of bulk solids during both continuous flow and after storage at rest. In addition, measurements of internal friction, bulk density, and wall friction on various wall surfaces are included.

1.2 This standard is not applicable to testing bulk solids that do not reach the steady state requirement within the travel limit of the shear cell. It is difficult to classify ahead of time which bulk solids cannot be tested, but one example may be those consisting of highly elastic particles.

1.3 The most common use of this information is in the design of storage bins and hoppers to prevent flow stoppages due to arching and ratholing, including the slope and smoothness of hopper walls to provide mass flow. Parameters for structural design of such equipment also may be derived from this data.

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

1.4.1 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.

1.5 *Units*—The values stated in SI units are to be regarded as standard. No other units of measure are included in this standard

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

1.7 *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
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing
D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—For definitions of common technical terms in this standard, refer to Terminology D653.

[1] This testing 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.

Current edition approved Oct. 15, 2022. Published January 2023. Originally approved in 1997. Last previous edition approved in 2016 as D6128 – 16. DOI: 10.1520/D6128-22.

[2] This test method is based on the "Standard Shear Testing Technique for Particulate Solids Using the Jenike Shear Cell," a report of the EFCE Working Party on the Mechanics of Particulate Solids. Copyright is held by the Institution of Chemical Engineers and the European Federation of Chemical Engineering.

[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**

4. Summary of Test Method

4.1 A representative specimen of bulk solid is placed in a shear cell of specific dimensions. This specimen is preconsolidated by twisting the shear cell cover while applying a compressive load normal to the cover.

4.2 When running an instantaneous or time shear test, a normal load is applied to the cover, and the specimen is presheared until a steady state shear value has been reached.

4.3 An instantaneous test is run by shearing the specimen under a reduced normal load until the shear force goes through a maximum value and then begins to decrease.

4.4 A time shear test is run similarly to an instantaneous shear test, except that the specimen is placed in a consolidation bench between preshear and shear.

4.5 A wall friction test is run by sliding the specimen over a coupon of wall material and measuring the frictional resistance as a function of normal, compressive load.

4.6 A wall friction time test involves sliding the specimen over the coupon of wall material, leaving the load on the specimen for a predetermined period of time, then sliding it again to see if the shearing force has increased.

5. Significance and Use

5.1 Reliable, controlled flow of bulk solids from bins and hoppers is essential in almost every industrial facility. Unfortunately, flow stoppages due to arching and ratholing are common. Additional problems include uncontrolled flow (flooding) of powders, segregation of particle mixtures, useable capacity which is significantly less than design capacity, caking and spoilage of bulk solids in stagnant zones, and structural failures.

5.2 By measuring the flow properties of bulk solids, and designing bins and hoppers based on these flow properties, most flow problems can be prevented or eliminated.

5.3 For bulk solids with a significant percentage of particles (typically, one third or more) finer than about 6 mm, the cohesive strength is governed by the fines (-6-mm fraction). For such bulk solids, cohesive strength and wall friction tests may be performed on the fine fraction only.

NOTE 1—The quality of the result produced by this test method 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 test method 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 test method. However, users of this test method should recognize that the framework of Practice D3740 is appropriate for evaluating the quality of an agency performing this test method. Currently there is no known qualifying national authority that inspects agencies that perform this test method.

6. Apparatus

6.1 The Jenike shear cell is shown in Fig. 1. It consists of a base (1), shear ring (2), and shear lid (3), the latter having a bracket (4) and pin (5). Before shear, the ring is placed in an offset position as shown in Fig. 1, and a vertical force F_v is applied to the lid, and hence, to the particulate solid within the cell by means of a weight hanger (6) and weights (7). A horizontal force is applied to the bracket by a mechanically driven measuring stem (8).

6.2 It is especially important that the shear force-measuring stem acts on the bracket in the shear plane (plane between base and shear ring) and not above or below this plane.

6.3 The dimensions of the Jenike shear cells that have in the past been supplied by Jenike & Johanson, Inc. are given in the first two columns of the table in Fig. 4. These dimensions have been derived from English units. The standard size Jenike shear cell is made from aluminum or stainless steel, and a smaller 63-mm diameter cell made from stainless steel is also available. Since the actual dimensions are not believed to be critical, the same results could be obtained with a shear cell of the dimensions listed in the third column of the table in Fig. 4 or with other shear cells of different sizes provided that proportions of these dimensions are maintained approximately. In addition, the shear cell diameter must be at least 20 times the maximum particle size of the bulk solid being tested.

6.4 Besides the shear cell, the complete shear tester includes a force transducer, which is capable of measuring the shear

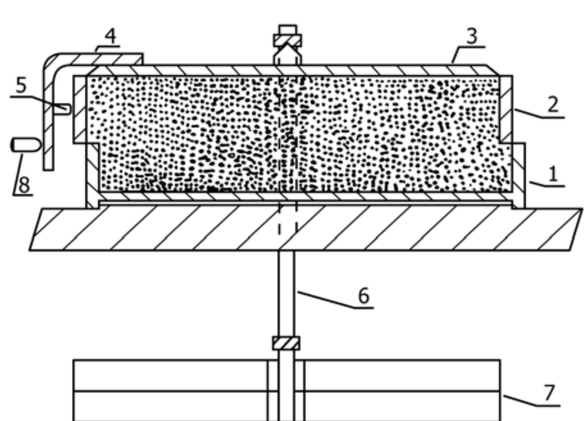

FIG. 1 Jenike Cell in Initial Offset Position

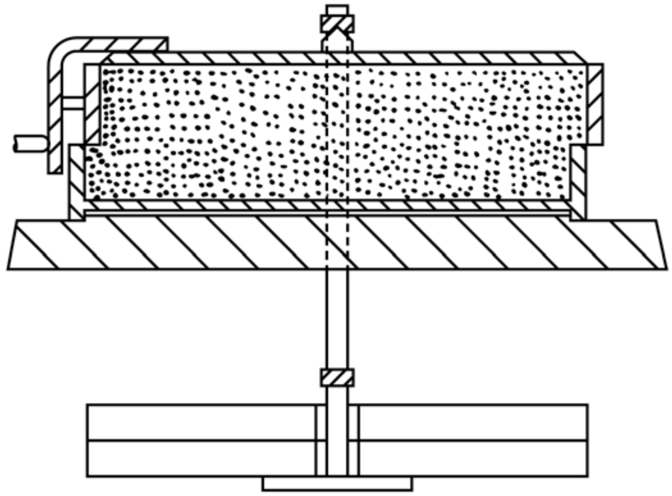

FIG. 2 Jenike Cell in Final Offset Position

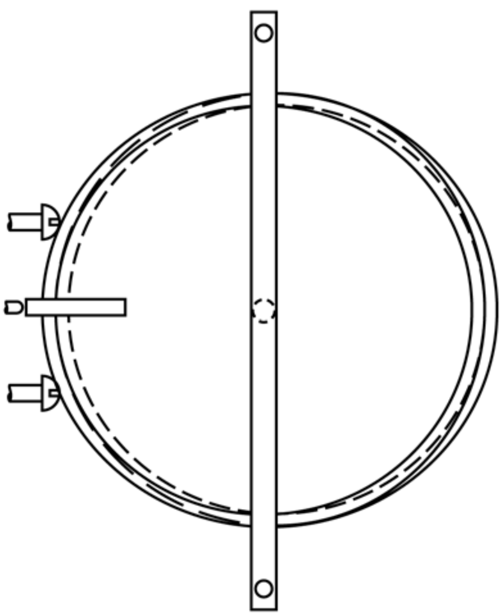

FIG. 3 Plan View of Jenike Cell Showing Offset

force F_s up to 500 N with a precision of 0.1 % of full scale, an amplifier to condition the signal from the force transducer and a recorder, a motor driving the force-measuring stem capable of advancing the stem at a constant speed in the range from 1 to 3 mm/min, a twisting wrench, a weight hanger, a time consolidation bench, an accessory for mounting wall material test plates, and a calibrating device. A spatula having a blade at least 50 % longer than the diameter of the shear cell, and at least a 10-mm width, is needed.

NOTE 2—The original Jenike shear tester has a speed of 2.72 mm/min when the power supply is 60 Hz.

6.5 As an alternative to the twisting wrench, some shear testers are supplied with a twisting device in which the twist is applied by means of a shaft passing through bearings. In this way, the likelihood of nonvertical forces or extra forces being generated during twisting is minimized. Another alternative is to have the motor pull the force-measuring stem instead of pushing it. When using any such alternative methods, it is essential that the user make sure that no measurement deviations are introduced.

6.6 The consolidation bench consists of several stations for time consolidation tests. One station is shown in Fig. 5. The station is equipped with a weight carrier (14) on which the weights may be placed and a flexible cover (15) to constrain the test cell and prevent any influence from environmental effects such as evaporation or humidification during time consolidation.

6.7 The arrangement for wall friction tests is shown in Fig. 6. For these tests it is convenient to have a special shear lid with a longer pin and bracket to permit a longer shear distance. Several coupons of typical wall materials should be available. When using the standard size shear cell, each coupon should be approximately 120 mm × 120 mm.

6.8 A device for calibrating the force transducer is shown in Fig. 7. It consists of a pivot (1) around which levers of equal length, (2) and (3) rotate. With counterweight (4) the device is balanced to have its neutral position as shown in the figure. Lever (2) exerts a force to the force-measuring stem corresponding to the weights (5) which are hung on the lever (3). The calibration curve is used to convert the recorder reading to the applied shear force.

6.9 A laboratory balance having a maximum capacity of at least 1 kg with a precision of 1 % or better is required.

7. Specimen Preparation

7.1 The laboratory used for powder testing must be free of vibrations caused by traffic or heavy machinery. Ideally, the room is temperature and humidity controlled, or, if this is not possible, maintain it at its nearly constant ambient conditions. Direct sunlight, especially on the time consolidation bench, is to be avoided.

NOTE 3—Temperature- and humidity-sensitive materials may need to be tested at different temperatures and moisture contents, because this often happens in industrial environments. The laboratory environment must approximate production for meaningful testing.