Designation: ~~D291 – 07 (Reapproved 2012)~~ D291/D291M – 20

Standard Test Method for ~~Cubic Foot Weight~~ Bulk Density of Crushed Bituminous Coal[1]

This standard is issued under the fixed designation ~~D291;~~D291/D291M; 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 covers two procedures for determining the ~~cubic foot weight~~ bulk density of crushed coal less than ~~1~~37.5 mm~~½ in. (37 mm)~~ [1.5 in.] in size, such as is charged into coke ovens, as follows:

1.1.1 *Procedure A*—The cone procedure for determining an uncompacted ~~weight per cubic foot (cubic metre).~~bulk density.

1.1.1.1 *Standard Method*—Procedure employs the use of a 115 mm [4.5 in.] chute opening and a measuring box having dimensions of 305 mm x 305 mm x 305 mm [12.0 in. x 12.0 in. x 12.0 in.].

1.1.1.2 *Alternate Method*—Procedure employs the use of a 203 mm [8.0 in.] chute opening and a measuring box having dimensions of 203 mm x 203 mm x 305 mm [8.0 in. x 8.0 in. x 12.0 in.] for coals with a total moisture greater than 7 %.

1.1.2 *Procedure B*—The dropped-coal procedure for determining a compacted ~~weight per cubic foot (cubic metre),~~ bulk density, comparable to actual bulk densities attained in coke ovens.

1.2 This test method is not applicable to the testing of powdered coal as used in boiler plants, nor to the determination of ~~weights per cubic foot~~ the bulk density of coal in storage piles.

1.3 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values ~~given~~stated in ~~parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard. Mass may be expressed in metric values.~~each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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

1.5 *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.*

[1] This test method is under the jurisdiction of ASTM Committee D05 on Coal and Coke and is the direct responsibility of Subcommittee D05.15 on Metallurgical Properties of Coal and Coke.

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

D440 Test Method of Drop Shatter Test for Coal
D2234/D2234M Practice for Collection of a Gross Sample of Coal
D3038 Test Method for Drop Shatter Test for Coke
~~D3302~~D3302/D3302M Test Method for Total Moisture in Coal
D4749 Test Method for Performing the Sieve Analysis of Coal and Designating Coal Size

3. Significance and Use

3.1 This test method concerns the compaction of crushed coal to determine either its compacted or uncompacted ~~weight,~~ bulk density, for purposes such as charging coke ovens.

PROCEDURE A—CONE PROCEDURE FOR UNCOMPACTED ~~CUBIC FOOT (CUBIC METRE) WEIGHT~~ BULK DENSITY

4. Apparatus

4.1 *Measuring ~~Box,~~Box:* ~~of rigid construction, having inside dimensions of 12.0 by 12.0 by 12.0 in. (305 by 305 by 305 mm), and a volume of 1728 ± 5 in.^{3} (0.0283 m^3 ± 82 cm^3). The exact volume of the box shall be determined by water calibration.~~

4.1.1 *Standard Method,* of rigid construction, having inside dimensions of 305 mm x 305 mm x 305 mm [12.0 in. x 12.0 in. x 12.0 in.], and a volume of 0.02873 m^3 ± 0.00008 m^3 [1.000 ft^3 ± .003 ft^3]. The exact volume of the box shall be determined by water calibration.

4.1.2 *Alternate Method,* of rigid construction, having the inside dimensions of 203 mm x 203 mm x 305 mm [8.0 in. x 8.0 in. x 12.0 in.], and a volume of 0.01257 m^3 ± .00003 m^3 [0.4444 ft^3 ± 0.0012 ft^3]. The exact volume of the box shall be determined by water calibration.

4.2 *~~Cone,~~Cone:* ~~conforming to Fig. 1 for filling the box. This cone shall be 2 ft 0 in. (610 mm) high and 1 ft 8 in. (508 mm) in inside diameter at the top, with a circular opening 4½ in. (114 mm) in diameter at the bottom. A slide valve consisting of a sliding-plate shutter and its supports shall be welded to the bottom of the cone in such a manner that the valve may be opened and closed with ease by removing or inserting the shutter in its supporting slides. The cone shall be supported in a tripod frame having a circular opening at the top of about 1 ft 6 in. (457 mm) in diameter. This frame shall support the cone so that the top-side of the shutter shall be 1 ft 10 in. (559 mm) from the inside bottom surface of the box. (See Fig. 1.)~~

4.2.1 *Standard Method,* conforming to Fig. 1 for filling the measuring box. This cone shall be 610 mm [24.0 in.] high and 510 mm [20.0 in.] in inside diameter at the top, with a circular opening 115 mm [4.5 in.] in diameter at the bottom. A slide valve consisting of a sliding-plate shutter and its supports shall be welded to the bottom of the cone in such a manner that the valve may be opened and closed with ease by removing or inserting the shutter in its supporting slides. The cone shall be supported in a tripod frame having a circular opening at the top of 457 mm [18.0 in.] in diameter. This frame shall support the cone so that the top-side of the shutter shall be 560 mm [22.0 in.] from the inside bottom surface of the box. An example of the apparatus for the standard cone procedure is shown in Fig. 1.

4.2.2 *Alternate Method,* [3] conforming to Fig. 2 for filling the measuring box. This cone shall be 470 mm [18.5 in.] high and 510 mm [20.0 in.] in inside diameter at the top, with a circular opening of 203 mm [8.0 in.] in diameter at the bottom. A slide valve consisting of a sliding-plate shutter and its supports shall be welded to the bottom of the cone in such a manner that the valve may be opened and closed with ease by removing or inserting the shutter in its supporting slides. The cone shall be supported in a tripod frame having a circular opening at the top of 457 mm [18.0 in.] in diameter. This frame shall support the cone so that the top-side of the shutter shall be 560 mm [22.0 in.] from the inside bottom surface of the box. An example of the apparatus for the alternate cone procedure is shown in Fig. 2.

[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.

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D05-2001. Contact ASTM Customer Service at service@astm.org.

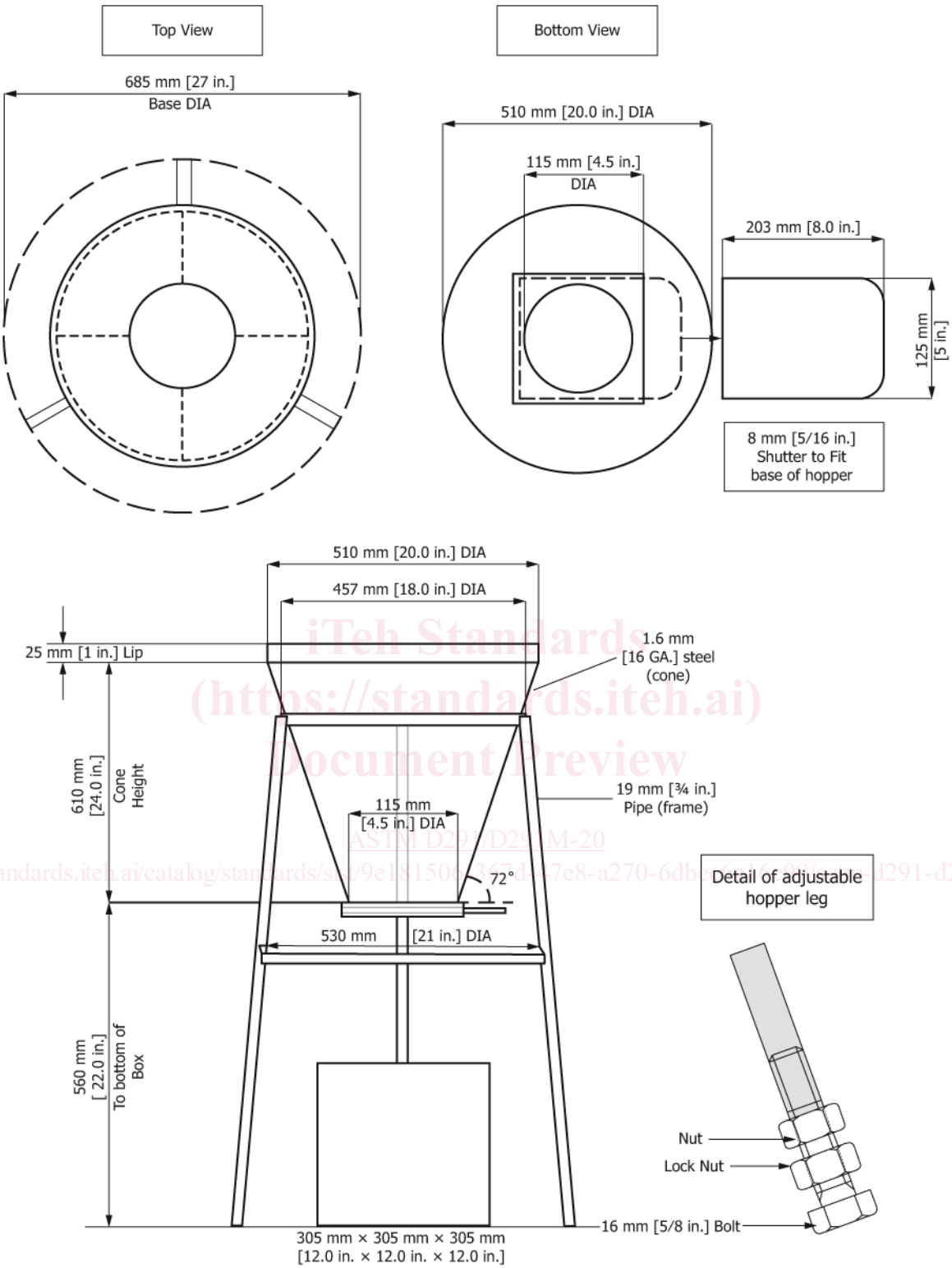

FIG. 1 Example of Apparatus for Cone ~~Proceedure~~Procedure: Standard Method

4.3 *Leveling Bar,* a steel strip ~~2 ft 6 in.~~ 760 mm [30 in.] long by ~~1~~37.5 mm~~½ in. wide (762 by 38 mm)~~ [1.5 in.] wide and approximately ~~3⁄16 in.~~5 mm [~~3⁄16 (5 mm)~~ in.] thick.

4.4 *Scales,* platform, capable of weighing up to ~~200 lb (100 kg)~~ 100 kg [220 lb] and sensitive to ~~0.1 lb (0.05 kg).~~0.05 kg [0.1 lb].

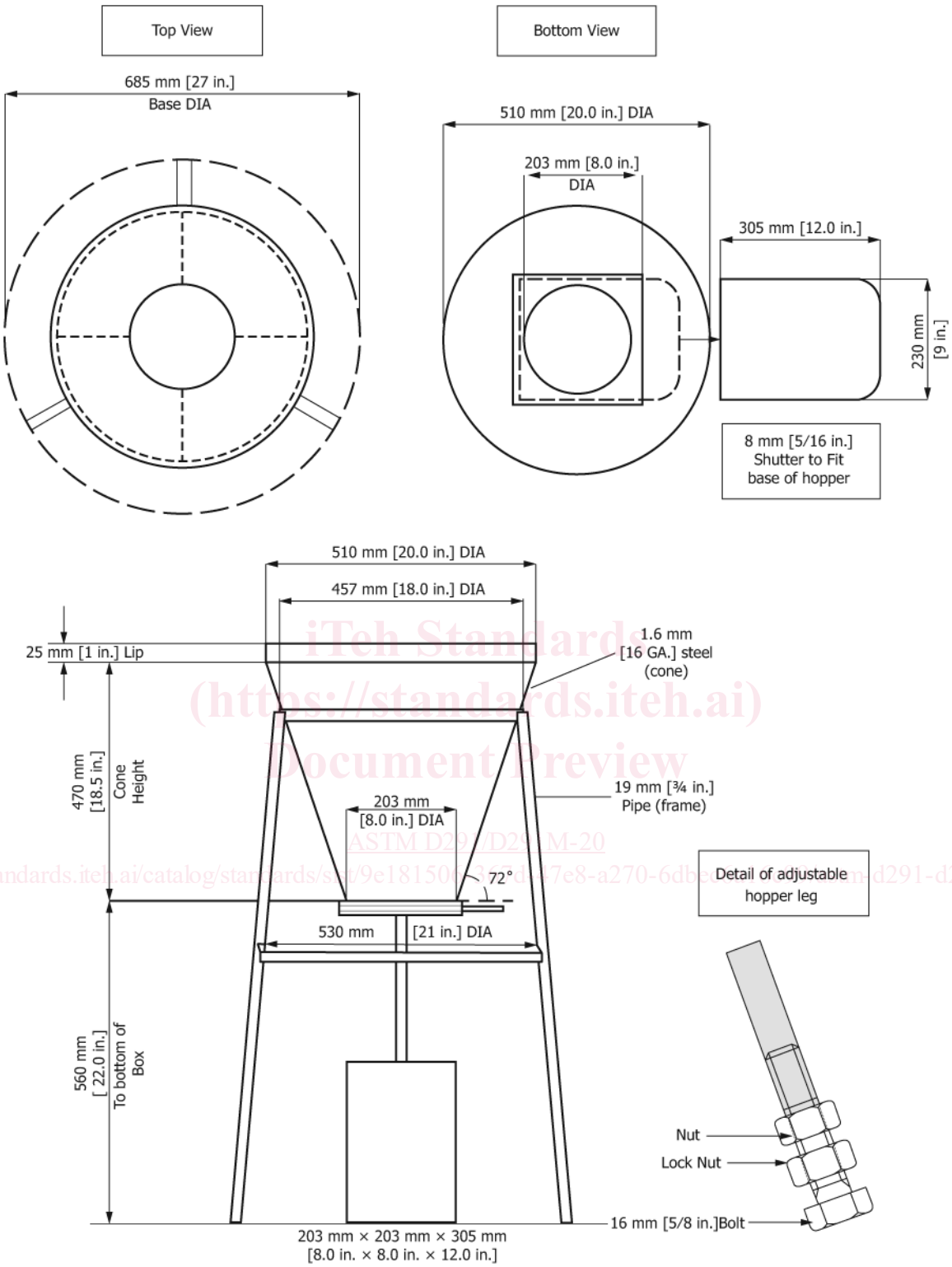

FIG. 2 Example of Apparatus for Cone Procedure: Alternate Method

5. Sampling

5.1 *Gross Sample*—For collecting gross samples of crushed bituminous coal, the ~~procedure~~procedures described in ~~Sections 7 and 8 of~~ Practice D2234/D2234M shall apply. During the period of collecting the gross sample, the increments of the sample shall be stored in a waterproof container with a tightly fitting cover in order to prevent the loss of moisture. The minimum number and

~~weights~~mass of increments collected shall be in accordance with Table 2 of Practice D2234/D2234M. The minimum gross ~~weight~~mass of the sample shall be ~~300 lb (136 kg).~~140 kg [300 lb].

5.2 *Laboratory Sample*—The gross sample of coal shall be thoroughly mixed and subdivided, without crushing, into four ~~75-lb (34-kg)~~34 kg [75 lb] portions. This operation shall be done as quickly as possible to avoid loss of moisture, and the ~~cubic foot (cubic metre) weight~~ bulk density shall be determined immediately. If this determination cannot be made immediately, the samples shall be kept in waterproof containers with tightly fitting covers until the time for making the determination.

6. Procedure

6.1 Before filling the cone hopper, level it in its tripod on a solid floor. Pour the prepared sample into a pile on the floor and carefully flatten it to about ~~4 in. (100 mm) in thickness.~~ 100 mm [4 in.] in thickness using a rake or shovel. Avoid pounding of the pile with the back of the shovel. Take successive shovelfuls from uniformly distributed points in the ~~pile,~~pile and allow them to slide gently from the shovel into the hopper at different peripheral points. This will prevent segregation and packing while the hopper is being filled. Place about ~~75 lb (34 kg)~~34 kg [75 lb] of coal in the hopper.

6.2 Weigh the empty measuring box to the nearest 0.05 kg [0.1 lb]. Center the previously weighed ~~cubic foot (cubic metre)~~ measuring box under the valve of the cone. ~~Then remove~~ Remove the valve shutter completely, allowing all of the coal to flow into the box and overflow the edges. Loosen wet coal, not flowing freely from the hopper, by gently thrusting downward (or poke) through the coal to the valve with the leveling bar.

6.3 After filling the box, carefully level off the excess coal above the box edge by means of the leveling bar, and place the box on the platform scale and weigh it to the nearest ~~0.1 lb (0.05 kg).~~ 0.05 kg [0.1 lb]. Avoid jarring or shifting of the filled box until all excess coal is leveled off. Record the ~~difference in weight between~~ mass of the filled ~~and empty~~ measuring box to the nearest ~~0.1 lb (0.05 kg) as the uncompacted cubic foot weight.~~0.05 kg [0.1 lb].

~~NOTE 1—Aside from the character of the coal itself, moisture content and size distribution of the coal are the two main factors which affect the cubic foot weight. A moisture determination and sieve analysis of the coal should be reported along with the cubic foot weight for proper interpretation of the cubic foot weight. For directions for making these determinations, see the following:~~
~~*Moisture*—Test Method D3302.~~
~~*Sieve Analysis*—Method D4749.~~

6.4 Moisture and size distribution of the coal are the two main factors which affect the bulk density. It is recommended for proper interpretation that a moisture determination and sieve analysis of the coal be reported along with the bulk density result. For directions for determination of the total moisture, see Test Method D3302/D3302M. For directions for the determination of size distribution, see Test Method D4749. For the purposes of reporting both total moisture and size distribution associated with the bulk density results, the representative sample is taken to be the actual sample employed for the determination of the bulk density (see Section 5). The minimum gross sample masses required by Test Methods D3302/D3302M and D4749 will not apply.

6.5 For the purpose of simplifying communication between concerned parties in the reporting of the size distribution of the actual bulk density sample, it is recommended to employ the standard series of sieves identified in 6.1.2 of Test Method D4749 covering from within the actual topsize of the coal down to 6.3 mm (¼ in.). Other sieve sizes may be used.

7. Calculation

7.1 Calculate the uncompacted bulk density, BD_{uncomp}, to the nearest 0.05 kg/m^3 [0.1 lb/ft^3] as follows:

$$BD_{uncomp}, kg/m^3 [lb/ft^3] = (W_2 - W_1)/V_1 \quad (1)$$

where:

W_1 = the mass of the empty measuring box, kg [lb];
W_2 = the mass of the filled measuring box after leveling as described in 6.3, kg [lb]; and
V_1 = the measured volume of the measuring box as determined by water calibration as described in 4.1, m^3 [ft^3].

8. Report

8.1 Report the uncompacted bulk density, BD_{uncomp}, as calculated in Section 7 to the nearest 0.05 kg/m^3 [0.1 lb/ft^3].