Designation: D2014 – 97 (Reapproved 2004)

Standard Test Method for Expansion or Contraction of Coal by the Sole-Heated Oven[1]

This standard is issued under the fixed designation D2014; 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 a large-scale laboratory test for obtaining information on the expansion or contraction of coal or coal blends during carbonization under specified conditions. This test method is applicable in the examination of coals or coal blends intended for use in the manufacture of coke.

1.2 The values stated in SI units shall be regarded as standard. Inch-pound units shall be accepted on an equivalent basis.

1.3 *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:*[2]

D2013 Practice for Preparing Coal Samples for Analysis

D2234/D2234M Practice for Collection of a Gross Sample of Coal

D3302 Test Method for Total Moisture in Coal

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Summary of Test Method

3.1 During the test, a measured thickness of coal about 102 mm (4 in.) is heated from the bottom surface while a force corresponding to 15.2 kPa (2.20 psi) is applied to the top surface through a piston. At the end of the test, the thickness of the coke is measured by observing the final position of the piston.

4. Significance and Use

4.1 The values determined in this test method indicate to what extent a given coal or coal blend will expand or contract during the carbonization process when evaluated in terms of pertinent experience with other coals and coal blends and processing conditions used in commercial-type coke ovens.

5. Apparatus

5.1 *Test Oven Assembly*, consisting of the following: either a single-chamber oven having approximately 280-mm (11-in.) width, 610-mm (24-in.) length, and 280-mm depth, or a double-chambered oven with two chambers each having approximately 280-mm width, length, and depth; a heating system to heat the charge(s) unidirectionally through the sole according to a controlled program; piston(s) arranged so that a constant load may be applied to the top surface of the charge; and suitable instrumentation so that appropriate temperatures and the position of the piston(s) may be measured. The auxiliary equipment includes apparatus facilitating the charging of the oven in a standard manner. The vertical partition of the double-chambered oven may be of 2-in. (51-mm) firebrick tile or equivalent.

5.1.1 *Carbonization Chamber*:

5.1.1.1 The sole shall be of silicon carbide tile, about 40 mm (1.5 in.) thick, 305 mm (12 in.) wide, and extending approximately 75 mm (3 in.) beyond the carbonization chamber at the front and back. Side, front, and back walls should be 40-mm firebrick tile or equivalent. It is appropriate to key the sole to the side and back tiles. The top edges of sidewalls shall be held in an adjustable steel framework so that the walls may be made and maintained precisely perpendicular to the sole. Hole(s) 6.35 mm (0.25 in.) in diameter shall be provided through the side of the oven to enable the placement of thermocouple(s) on the top surface of the sole in the center of the oven chamber(s).

5.1.1.2 In constructing the oven, the sides and ends of the carbonization chamber shall be surrounded with at least 200 mm (8 in.) of insulating refractories and the whole assembly encased in a suitable restraining structure of steel shapes and plates designed to provide dimensional stability.

5.1.2 *Sole-Heating System*:

5.1.2.1 The heating system shall consist of a group of electrical heating elements mounted under the silicon carbide sole and suitable equipment to provide automatic control. Heating elements may be either silicon carbide-type resistance elements or coils of heating wire enclosed in silica tubes. Elements shall be arranged to obtain minimum variation of temperature over the area of the sole. It is desirable to

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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.

incorporate a maximum number of supports for the silicon carbide sole tile. The brickwork and steelwork beneath the heating flues shall be of appropriate design to maintain rigidity of the oven under the temperature and load stresses of operation.

5.1.2.2 The thermocouple used for temperature control is located in a position which enables the sole to be heated in accordance with the sole temperature program shown in Table 1. The heating system shall be capable of reachieving the initial set point temperature of 554°C within 10 min of charging the oven and of heating the sole in accordance with the sole temperature program shown in Table 1.

5.1.2.3 The temperature control thermocouple may be installed in the heating flue or in contact with the sole plate.

5.1.3 *Piston*—The piston assembly shall include a massive bottom plate of metal to which an upper steel assembly is rigidly attached. The bottom plate shall be 19- or 25-mm (0.75- or 1-in.) cast steel or cast iron in one piece with square edges. Dimensions are to be so chosen that the clearances between piston edges and chamber walls, ends, and sides, at the conclusion of a test (upper surface of coal at 500°C) are at least 3.2 mm (0.125 in.) but not as much as 9.5 mm (0.375 in.). A10- to 130-mm (4.5- to 5-in.) layer of insulating refractory shall be formed upon the steel plate, the sides being recessed somewhat within the piston edges. The upper steel assembly shall be rigidly fastened to the corners of the lower plate with steel supports. The upper steel assembly and corner supports shall be of adequate strength to permit application of the desired load and shall be fitted with appropriate hardware to permit ready placement into or removal from the carbonization chamber. A vertical hole, 13 mm (0.5 in.) in diameter, piercing the piston assembly, including lower plate shall be provided on the longitudinal center line for a thermocouple, about 200 mm (8 in.) from either the front or rear edge of the piston.

5.1.4 *Apparatus for Loading Piston*—Apparatus shall be provided so that a constant load of 15.17 ± 0.35 kPa (2.20 ± 0.05 psi) calculated over the measured area of the piston plate, may be applied to the piston during the test. The manner of applying this load is not critical. Examples of suitable procedures are (*1*) use of a hydraulic piston as shown in Fig. 1, (*2*) use of a hinged lever-arm system bearing on a fulcrum mounted on the upper steelwork of the piston structure, and (*3*) placement of sufficient additional dead weights on the piston itself. Whatever system is chosen should be characterized by rapid assembly for the prompt application of force after charging.

TABLE 1 Sole Temperatures Program

Time, (h) After Initial Setpoint of 554°C Achieved	Temperature, °C
0.00	554
1.00	685
2.00	777
3.00	840
4.00	889
5.00	921
6.00	943
7.00	950
from then on	950

6. Instrumentation

6.1 *Piston Movement*—The excursion of the piston from an initial reference position may be measured either manually, by observing the movement of an indicator, or automatically by means of an appropriate transducer and recording system. A preferred form of indicator is a witness point on a silica rod mounted on the upper surface of the lower piston plate and not connected in any way to the remaining piston structure. When using this design of indicator, no corrections need be made for expansion of the piston structure itself. Alternatively, the basic indicator may be mounted on the upper steel structure of the piston. In this event, any correction for piston expansion during a test, if necessary, shall be determined by appropriate preliminary calibration. Measurements of the position of the indicator may be made by directly observing the witness point with a cathetometer or by using a suitable mechanical or electrical system of magnifying movement. Apparatus of the latter type should be calibrated with an accurate cathetometer. Whatever type of indicator is used it shall be placed as close to the geometric center of the piston as possible.

6.1.1 Thermocouples shall be provided for measuring both the temperature of the top surface of the sole (maximum of about 950°C) and the temperature of the top surface of the coal (maximum about 500°C) (Note 2). The thermowell containing the sole couple shall be placed horizontally through the hole in the sidewall or endwall tile so that the thermowell lies flat with its tip near the geometric center of the sole. The thermowell containing the top surface thermocouple shall be placed in the vertical hole in the piston and adjusted so that its lowest point is flush with the lower surface of the piston plate.

NOTE 1—Type K Chromel-Alumel thermocouples have proven satisfactory in these applications. Quartz or porcelain is a satisfactory material for thermocouple protection tubing. Mild steel or stainless tubing may also be used but will require frequent replacement.

7. Accessory Equipment

7.1 *Auxiliary Apparatus*—Necessary auxiliary apparatus includes a sole cover plate, a charging hopper, and an adjustable leveling device:

7.1.1 *Sole Cover Plate*, conforming to the dimensions of the piston plate and consisting of a suitable metal framework containing either a layer of insulating brick or an equivalent layer of insulating refractory. It shall be placed on the sole overnight and during other short periods of nonoperation to reduce heat losses and facilitate maintenance of proper sole temperature before the start of a test.

7.1.2 *Hopper and Leveling Device*—Functionally adequate designs of hopper and leveling devices are shown in Fig. 2. The leveling device should be constructed so as to be quickly adjustable.

7.1.3 The provision of a permanently installed crane for handling the piston in and out of the carbonization chamber facilitates convenience of operation. A hood over the whole assembly is desirable for the removal and venting of carbonization gases.

8. Sampling

8.1 The gross sample shall be collected in accordance with Practice D2234/D2234M.