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Standard Practice for
Ultimate Analysis of Coal and Coke[1]

This standard is issued under the fixed designation D3176; 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 the term ultimate analysis as it is applied to the analysis of coal and coke. The information derived is intended for the general utilization by applicable industries, to provide the basis for evaluation, beneficiation, or for other purposes.

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

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]

D346 Practice for Collection and Preparation of Coke Samples for Laboratory Analysis

D2013 Practice for Preparing Coal Samples for Analysis

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

D3172 Practice for Proximate Analysis of Coal and Coke

D3173 Test Method for Moisture in the Analysis Sample of Coal and Coke

D3174 Test Method for Ash in the Analysis Sample of Coal and Coke from Coal

D3177 Test Methods for Total Sulfur in the Analysis Sample of Coal and Coke

D3178 Test Methods for Carbon and Hydrogen in the Analysis Sample of Coal and Coke (Withdrawn 2007)[3]

D3179 Test Methods for Nitrogen in the Analysis Sample of Coal and Coke (Withdrawn 2008)[3]

D3302 Test Method for Total Moisture in Coal

D4239 Test Method for Sulfur in the Analysis Sample of Coal and Coke Using High-Temperature Tube Furnace Combustion

D4596 Practice for Collection of Channel Samples of Coal in a Mine

D4916 Practice for Mechanical Auger Sampling (Withdrawn 2008)[3]

D5142 Test Methods for Proximate Analysis of the Analysis Sample of Coal and Coke by Instrumental Procedures (Withdrawn 2010)[3]

D5192 Practice for Collection of Coal Samples from Core

D5373 Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Laboratory Samples of Coal and Coke

D6609 Guide for Part-Stream Sampling of Coal

D6883 Practice for Manual Sampling of Stationary Coal from Railroad Cars, Barges, Trucks, or Stockpiles

D7256/D7256M Practice for Mechanical Collection and Within-System Preparation of a Gross Sample of Coal from Moving Streams (Withdrawn 2008)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *ultimate analysis*—in the case of coal and coke, the determination of carbon and hydrogen in the material, as found in the gaseous products of its complete combustion, the determination of sulfur, nitrogen, and ash in the material as a whole, and the calculation of oxygen by difference.

NOTE 1—Moisture is not by definition a part of the ultimate analysis of coal or coke but must be determined in order that analytical data may be converted to bases other than that of the analysis sample.

NOTE 2—Inasmuch as some coals contain mineral carbonates, and practically all contain clay or shale containing combined water, a part of the carbon, hydrogen, and oxygen found in the products of combustion may arise from these mineral components.

4. Significance and Use

4.1 Summarizing the ash content and the content of the organic constituents in a specific format under the heading, *Ultimate Analysis*, provides a convenient and uniform system for comparing coals or cokes. This tabulation used with that of *Proximate Analysis* (Practice D3172) permits cursory valuation

of coals for use as fuel or in other carbonaceous processes and of cokes for metallurgical purpose.

5. General Requirements

5.1 Coal sample collection shall be in accordance with any of the following Guides or Practices as appropriate: D2234/D2234M, D6609, D4596, D4916, D5192, and D6883

5.2 For coal, sample preparations shall be in accordance with Practice D2013 or D7256/D7256M. The analysis sample shall be the material pulverized to pass a 250–µm (No. 60) sieve in accordance with Practice D2013.

5.3 Coke sampling and preparation shall be in accordance with Practice D346.

6. Specific Requirements

6.1 *Carbon and Hydrogen*—The carbon and hydrogen determination shall be made in accord with Test Methods D3178 or D5373.

6.2 *Sulfur*—The sulfur determination shall be made in accordance with Test Methods D3177 or D4239.

6.3 *Nitrogen*—The nitrogen determination shall be made in accordance with Test Methods D3179 or D5373.

6.4 *Ash*—The ash determination shall be made in accordance with Test Method D3174 or Test Methods D5142.

6.5 *Oxygen*—There being no satisfactory direct ASTM test method for determining oxygen, it shall be calculated by subtracting from 100 the sum of the other components of the ultimate analysis. The result so obtained is affected by errors incurred in the other determinations of the ultimate analysis and also by the changes in weight of the ash-forming constituents on ignition. By definition, oxygen calculated as a weight percentage of the analysis sample according to this procedure does not include oxygen in the mineral matter or in the ash, but does include oxygen in the free water (moisture) associated with the analysis sample. See Section 7 of this practice for calculating and reporting results on other bases.

6.6 *Moisture*—The moisture determination shall be made in accordance with Test Method D3173 or Test Methods D5142.

6.7 The aire-dry loss or total moisture determination shall be made in accordance with Practice D3302.

7. Calculation and Report

7.1 The results of an ultimate analysis may be reported on any of a number of bases, differing from each other in the manner by which moisture is treated.

7.2 To avoid ambiguity and provide a means for conversion of data to bases other than the reported basis, it is essential that except for data reported on a dry basis, an appropriate moisture content be given in the data report.

7.3 It is recommended that, for data reported on the as-received basis (or any other moist basis), a footnote or some other means be used in the report to indicate whether the hydrogen and oxygen values reported do or do not include the hydrogen and oxygen in the free water (moisture) associated with the sample.

7.4 Procedures for converting ultimate analysis sample data to other bases are presented in Table 1.

7.4.1 Hydrogen and oxygen on the as-determined basis include hydrogen and oxygen in free water (moisture) associated with the analysis sample. However, hydrogen and oxygen values reported on other moisture-containing bases may be reported either as containing or as not containing the hydrogen and oxygen in water (moisture) reported on that basis. Alternative conversion procedures are shown in Table 1.

7.5 An example of ultimate analysis data tabulated for a hypothetical coal on various bases is given in Table 2.

8. Precision

8.1 The permissible differences between two or more determinations shall not exceed the values listed in the precision section of the specific test method for the parameter determined.

9. Keywords

9.1 ash; carbon; coal; coke; hydrogen; nitrogen; oxygen; sulfur; ultimate analysis