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Standard Practice for Ultimate Analysis of Coal and Coke¹

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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.

1.2.1 All percentages are percent mass fractions.

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~~[D3177 Test Methods for Total Sulfur in the Analysis Sample of Coal and Coke \(Withdrawn 2012\)](#)~~³

~~[D3178 Test Methods for Carbon and Hydrogen in the Analysis Sample of Coal and Coke \(Withdrawn 2007\)](#)~~³

~~[D3179 Test Methods for Nitrogen in the Analysis Sample of Coal and Coke \(Withdrawn 2008\)](#)~~³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~~[D4916 Practice for Mechanical Auger Sampling \(Withdrawn 2008\)](#)~~³

~~[D5142 Test Methods for Proximate Analysis of the Analysis Sample of Coal and Coke by Instrumental Procedures \(Withdrawn 2010\)](#)~~³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 Determination of Carbon, Hydrogen and Nitrogen in Analysis Samples of Coal and Carbon in Analysis 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/D7430 Practice for Mechanical Collection and Within-System Preparation of a Gross Sample of Coal from Moving Streams Sampling of Coal \(Withdrawn 2008\)](#)~~

[D7582 Test Methods for Proximate Analysis of Coal and Coke by Macro Thermogravimetric Analysis](#)

3. Terminology

3.1 *Definitions:*

¹ This practice is under the jurisdiction of ASTM Committee [D05](#) on Coal and Coke and is the direct responsibility of Subcommittee [D05.21](#) on Methods of Analysis. Current edition approved Nov. 1, 2009; Jan. 1, 2015. Published December 2009; January 2015. Originally approved in 1974. Last previous edition approved in 2002; 2009 as [D3176-89\(2002\)](#); [D3176-09](#). DOI: [10.1520/D3176-09](#); [10.1520/D3176-15](#).

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.

3.1.1 *ultimate analysis*—in the case of coal and coke, the determination of ~~carbon and hydrogen~~ carbon, hydrogen, nitrogen, and sulfur 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: [D7430](#), [D2234/D2234M](#), [D6609](#), [D4596](#), ~~[D4916](#)~~, [D5192](#), and [D6883](#).

5.2 For coal, sample preparations shall be in accordance with ~~Practice~~ Practices [D2013](#) or ~~[D7256/D7256M](#)~~ [D7430](#). The analysis sample shall be the material pulverized to pass a ~~250- μ m~~ 250 μ m (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*~~ *Carbon, Hydrogen, and Nitrogen*—~~The carbon-carbon, hydrogen, and hydrogen~~ nitrogen determination shall be made in ~~accordance~~ accordance with Test ~~Methods~~ Method ~~[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](#)~~.

6.3 *Ash*—The ash determination shall be made in accordance with Test ~~Method~~ Methods [D3174](#) or Test ~~Methods~~ Methods ~~[D5142](#)~~ [D7582](#).

6.4 *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.

6.5 *Moisture*—The moisture determination shall be made in accordance with Test ~~Method~~ Methods [D3173](#) or Test ~~Methods~~ Methods ~~[D5142](#)~~ [D7582](#).

6.6 The ~~air-dry~~ air-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](#).