Designation: D3176 – 24

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. The values given in parentheses after SI units are provided for information only and are not considered 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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:*[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

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

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

D7430 Practice for Mechanical Sampling of Coal

D7582 Test Methods for Proximate Analysis of Coal and Coke by Macro Thermogravimetric Analysis

3. Terminology

3.1 *Definitions:*

3.1.1 *ultimate analysis*—in the case of coal and coke, the determination of carbon, hydrogen, nitrogen, and sulfur in the material, as found in the gaseous products of its complete combustion, the determination of 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 mass fraction and the mass fraction 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.

[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.

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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.

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, D5192, and D6883.

5.2 For coal, sample preparations shall be in accordance with Practices D2013 or D7430. The analysis sample shall be the material pulverized to pass a 250 µm (No. 60 US standard mesh) 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, Hydrogen, and Nitrogen*—The carbon, hydrogen, and nitrogen determination shall be made in accordance with Test Method D5373.

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

6.3 *Ash*—The ash determination shall be made in accordance with Test Methods D3174 or 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 percentages of 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 mass of the ash-forming constituents on ignition. By definition, oxygen calculated as a mass fraction 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 D3173 or D7582.

6.6 The 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 mass fraction 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.