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Standard Practice for Collection of Coal Samples from Core[1]

This standard is issued under the fixed designation D5192/D5192M; 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 describes procedures for collecting and handling a coal sample from a core recovered from a borehole.

1.2 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in 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.

1.3 *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]

D121 Terminology of Coal and Coke
D388 Classification of Coals by Rank
D1412 Test Method for Equilibrium Moisture of Coal at 96 to 97 Percent Relative Humidity and 30 °C
D2013/D2013M Practice for Preparing Coal Samples for Analysis
D2796 Terminology for Megascopic Description of Coal and Coal Seams and Microscopical Description and Analysis of Coal (Withdrawn 1995)[3]
D4371 Test Method for Determining the Washability Characteristics of Coal
D4596 Practice for Collection of Channel Samples of Coal in a Mine

3. Terminology

3.1 *Definitions:*

3.1.1 For additional definitions of terms, refer to Terminology D121.

3.1.2 *borehole, n*—the circular hole through soil and rock strata made by boring.

3.1.3 *caves or washouts, n*—zones of increased hole diameter caused by rock fragments that fall from the walls of a borehole and can block the hole or contaminate the cuttings and which erode or abrade the sidewall of the borehole by the action of the drilling. These zones can affect the accuracy of certain geophysical logs (especially density). Corrections to other geophysical logs can be made if a caliper log is available. The most common causes of caves or washouts include soft or fractured lithologies, the presence of water-producing zones, and the downhole pressure of the drilling medium (fluid or air) that often causes differential erosion of various strata within the borehole.

3.1.4 *concretion, n*—*in a geological sense*, a mass of mineral matter found in rock of a composition different from its own and produced by deposition from aqueous solution in the rock.

3.1.5 *core, n*—*in drilling*, a cylindrical section of rock (coal) that is usually 5 to 10 cm in diameter, taken as part of the interval penetrated by a core bit and brought to the surface for geologic examination, representative sampling, and laboratory analyses.

3.1.6 *core barrels, n*—two nested tubes above the bit of a core drill, the outer rotating with the bit, the inner receiving and preserving a continuous section or core of the material penetrated. The following two types of inner barrels are commonly used.

3.1.6.1 *split-tube barrel, n*—a type of inner barrel consisting of two longitudinal halves of pipe bound together by reinforced tape at intervals along the barrel length that allows easy access to a relatively intact core (by cutting the tape). (This is the preferred barrel type for coal exploration, when available.)

[1] This practice is under the jurisdiction of ASTM Committee D05 on Coal and Coke and is the direct responsibility of Subcommittee D05.23 on Sampling.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

*A Summary of Changes section appears at the end of this standard

3.1.6.2 *solid-tube barrel, n*—a type of inner barrel consisting of a single solid-walled length of pipe in which removal of the core is accomplished by mechanical or hydraulic pressure at one end of the pipe thus extruding the core onto a core tray. (The core is likely to be less intact than when a split-tube barrel is used.)

3.1.7 *core sample, n*—that part of a core of rock or coal obtained so as to accurately represent a thickness of a unit penetrating by drilling.

3.1.8 *geophysical log, n*—a graphic record of the measured or computed physical characteristics of the rock section encountered in a borehole, plotted as a continuous function of depth. Measurements are made by a sonde, which contains the detectors, as it is withdrawn from the borehole by a wire line. Several measurements are usually made simultaneously, and the resulting curves are displayed side by side on the common depth scale. A common suite of logs used in coal exploration include caliper, density (gamma-gamma), natural gamma, and resistivity.

3.1.8.1 *caliper log, n*—a continuous mechanical measurement of the diameter and thus the rugosity of the borehole. The tool identifies zones where swelling or cavings (washouts) have occurred during drilling. The tool's value is in allowing qualitative or quantitative corrections to be made to other geophysical logs which are affected by borehole size (especially density).

3.1.8.2 *density log (gamma-gamma log), n*—measures electron density within lithologic units which is related to their bulk density. The wireline tool records the intensity of gamma radiation (in counts per second) from a nuclear source within the tool after it has been attenuated and backscattered by lithologies within the borehole. Due to the distinctly low density of coals, the density log is essential in coal exploration for identifying coal seams and coal-seam partings. The bias/resolution of density logs can be affected by source-detector spacing (closer spacing increases resolution), borehole size and irregularities (see *caves* or *washouts*), and the presence of casing and logging speed.

3.1.8.3 *natural gamma-ray log, n*—a record of the natural radioactivity of the lithologies encountered in the borehole environment. During recording of geophysical logs, the amount of natural radiation is recorded and presented in either counts per second (CPS) or American Petroleum Institute (API) units. Unlike many other log types, a representative natural gamma log can be obtained where borehole or fluid conditions, or both, are not optimal or where casing is present. The natural gamma log is most often used in the coal environment for identifying classic lithologies and differentiating coal seams and coal-seam partings.

3.1.8.4 *resistivity log, n*—a measure of the voltage differential of strata along the walls of a borehole when electrical current is passed through the strata. The resistivity log requires a fluid-filled hole to constantly provide a conductive medium between electrodes on the tool. The spacing between the electrodes determines the precision of the bed boundary relationships in much the same manner as with the density log. The resistivity log is useful primarily in conjunction with other log types. The logs are affected by casing, logging speed, electrode spacing, formation porosity, and resistivity changes in the borehole fluid.

3.1.9 *floor, n*—the rock material immediately underlying a coal bed.

3.1.10 *roof, n*—the rock material immediately overlying a coal bed.

3.1.11 *sonde, n*—an elongate cylindrical tool assembly used in a borehole to acquire a geophysical log.

4. Summary of Practice

4.1 At selected sites in a deposit of coal, a borehole is drilled and the core containing the coal and surrounding strata of rock is recovered.

4.2 The coal core is cleaned of drilling fluid, if necessary, properly described, and packaged so that loss of moisture is minimized. From this core, coal and roof and floor material of interest are collected for analysis and testing.

5. Significance and Use

5.1 A properly collected sample that includes the total coal bed interval provides a sample that is a representative cross section of the coal bed at the point of sampling. Core samples are taken for subsequent testing needed for evaluation of coal quality and characterization for commercial evaluations, for planning of mining operations to maintain coal quality, for the determination of coal rank in accordance with Classification D388, and for geologic coal resource studies.

NOTE 1—Because of the potential for lateral variability, a sample may not represent the quality of the coal bed at another sample point. The reliability of the data generated from core samples is dependent on the number and spacing of the sample points and the variability of the coal characteristics in a given area.

5.2 Moisture determined directly from a core sample shall be considered *questionable* in any core sample because of possible contamination from drilling fluids and groundwater. If a more representative estimate of the inherent moisture content of the core sample (with the exception of certain low-rank coals) is desired, the sample should be analyzed according to Test Method D1412.

6. Apparatus

6.1 *Steel Measuring Tape,* not less than 10 m [30 ft] long.

6.2 *Rock Hammer, Chisel, or Pick,* with file for sharpening.

6.3 *Water Source,* to provide fresh, clean water for rinsing drilling mud from cut surface of the core.

6.4 *Waterproof Marking Pencils* that are visible on coal, such as a yellow lumber crayon.

6.5 *Polyethylene Bags, Tubing, or Sheets,* 0.1 mm [4 mil] or thicker.

6.6 *Core Tray,* constructed of wood, plastic, or metal, onto which to extrude the core from the core barrel.

6.7 *Boxes for Core Storage,* constructed of wood, plastic, or coated cardboard or if the core is to remain stratigraphically oriented, use containers such as polyvinyl chloride (PVC) pipe.

6.8 *Tags and Waterproof Marking Pens,* for sample identification and for marking depths, orientation, and so forth, on the plastic sheeting.

6.9 *Notebook and Pencil,* or other means for record keeping.

6.10 *Waterproof Container,* to hold sample tag.

6.11 *Geophysical Logging Unit (optional),* consisting of recording equipment and sondes for high-resolution density and caliper logs and possibly gamma and resistivity logs.

7. Planning for Sampling

7.1 The objective of core sampling is to collect representative samples of the fresh, unweathered coal seam at each drilling location for subsequent testing needed for the evaluation the coal quantity and quality or commercial assessments. Obtain information such as geologic, topographic, and land ownership for locating suitable sites for drilling. Choose sites that will best satisfy the purpose of sampling. ASTM Manual 11[4] provides comprehensive technical information to help in planning successful coal coring and testing programs. Topics in Manual 11 include sampling coal cores; geophysical logging; compositing core data; analysis and evaluation of core data; and the prediction of as-mined coal quality.

NOTE 2—Practice D5192 and ASTM Manual 11 were developed and published simultaneously. In preparing the standard, a number of concepts and terms were encountered that required explanations and technical background in greater detail than was practicable within the scope of the proposed standard. Because no individual publication could be used to reference all the necessary topics, it became apparent that a reference manual needed to be compiled to facilitate the drafting of the core-sampling standard.

7.2 *Considerations Regarding Weathered Coal and Inherent Moisture*—Weathered coal is unsuitable for inclusion in core samples collected to secure fresh and unaltered material. Weathered coal typically contains anomalously low total moisture, yields low calorific value (as-received, dry and moisture-and-ash-free basis), and also produces atypical results for other tests. Additionally, weathered coal cannot be used for classification according to rank. Sampling to different depths and testing of the properties may be required to establish the depth at which unweathered coal can be obtained.

7.2.1 Obvious indications of weathering include, but are not limited to: (*1*) any discoloration or staining on broken coal surfaces or cleats, (*2*) presence of sulfate minerals resulting from oxidation of pyrite, (*3*) presence of gypsum (calcium sulfate) crystals, and (*4*) presence of dust, fine cracked and crazed coal surfaces, or (*5*) blocky, fragmented condition (slaking) of the coal resulting from loss of inherent moisture.

7.2.2 For coal resource assessments, the collection of samples containing their full complement of inherent moisture is essential. However, that condition may not always be readily discernable. A simple field test can be used to qualitatively identify seemingly fresh coal that has lost some inherent moisture but has not yet obviously weathered. A light coating of water is sprayed or wiped onto the surface of the coal, and the rate at which it disappears is observed. Rapid disappearance (typically within a few seconds) indicates absorption and demonstrates that the coal contains less than its full complement of inherent moisture. Slower disappearance (taking perhaps a minute or more) is characteristic of evaporation and suggests that the pores are filled with moisture. To account for variations in field conditions such as temperature, humidity, different absorption rates by different coals, and so forth, the test is applied to a number of coal pieces both before and during the sample collection process.

7.3 A core approximately 47 mm [1.87 in.] in diameter yields a sufficient sample for most purposes. Minimum sample mass requirements for analytical tests, such as washability testing, may dictate a sample mass that can only be obtained from larger diameter cores or multiple separate cores.

NOTE 3—The diameter and length of the core (or number of separate cores) required to obtain a desired mass of sample may be estimated from the density of coal, approximately 1.3 g/cm^3 to 1.35 g/cm^3. The selected diameter of the core can have an effect on the representativeness of subsamples obtained from the core sample for various types of testing. As an example in washability testing, the diameter of the core should be at least three times the largest dimension of the topsize of any subsamples to be obtained from the core sample. For information on determining the washability characteristics of coal, see Test Method D4371 and the report by Wizzard.[5]

A larger diameter core can also be necessary to obtain a more representative sample if the quality of the coal varies greatly from layer to layer in the seam.

7.4 *Increment Sampling*—Where differences of coal quality parameters exist among different layers or benches in the same coal seam or where the seam is thick, it is best to sample and analyze the seam in vertical increments.

7.4.1 *Compositing*—Data obtained from the separate analyses of the vertical core increments can be composited by calculation, preferably by sample mass if sufficient information such as core length and density has been measured for each increment. Alternatively, a composite sample of the entire seam can be produced by combining representative splits of the increments by increment thickness for the determination of whole core characteristics. The use of an ash/density relationship for the specific geographic area and seam being studied can be helpful in validating direct density measurements. Extreme care and cross-checking should be exercised when combining a sample composite for analysis or when calculating a composite analysis from the analysis of increments. Some coal quality parameters are not additive in a linear fashion and cannot be accurately determined by calculated compositing. Fusion temperatures of ash and Hardgrove grindability and Gieseler fluidity indices are examples of physical properties that are nonadditive and best determined on whole samples.

7.5 *Sampling Plans for Different Purposes:*

7.5.1 Variations in the purpose of sampling and in conditions encountered in the field may preclude the establishment of rigid procedures covering every sampling situation. Therefore, formulate a plan taking into account the conditions of drilling, the purpose of the sampling, and the known

[4] *Manual on Drilling, Sampling, and Analysis of Coal, ASTM MNL 11,* ASTM, 1992.

[5] Wizzard, J. T., "The Reliability of Using Channel Samples to Represent Run-of-Mine Coal Washability," Technical Report TR-82/3, Department of Energy, Pittsburgh Energy Technology Center.

characteristics of the coal seam. Characteristics include lateral or vertical variations in coal quality and occurrences of persistent mineral parting or concretions within a seam.

7.5.2 *Sampling Plan for Classification According to Rank:*

7.5.2.1 A minimum of three, but preferably five or more, whole-seam samples with 100 % core recovery are required to characterize the rank of the coal in a given area in accordance with Classification D388. Core samples containing weathered coal are unsuitable for the determination of standard rank.

7.5.2.2 All roof and floor rock, all mineral partings more than 10 mm [3⁄8 in.] thick, and mineralized lenses or concretions (such as sulfur balls) more than 13 mm [1⁄2 in.] thick and 50 mm [2 in.] wide shall be excluded from the sample. Angular or wedge-shaped mineral lenses or concretions that are not continuous shall be excluded from the samples if the volume exceeds that of a parting 10 mm thick. (Refer to Practice D4596.)

8. Core Recovery

8.1 *Recovery for Classification According to Rank and Some Other Purposes*—The recovery of 100 % of the entire seam is not possible on every core under even the best of field conditions. However, useful information such as apparent rank can many times be obtained from cores where less than 100 % of the seam has been recovered. When portions of the interval have been lost, the following information should be recorded: (*1*) the percent recovery and (*2*) the estimated location and thickness of the lost intervals. Use of data from cores that represent less than 100 % of the total seam thickness shall be identified as such and used with caution.

8.2 *Determining Recovery From Comparison of Geophysical Logs and Core*[4]—The most reliable measurement of coal seam thickness can be obtained from deflections on the high-resolution density log and the caliper log. If the roof and floor lithologies are other than sandstone, the resistivity and natural gamma can also be used, especially if caves or washouts have caused material to be lost during coring. Generally, the midpoint (the point at one half the deflection between the lithologic-density lines) on the log trace is used to determine bed boundaries. However, for certain geophysical tools it may be necessary to use other criteria, such as one-third deflection, initial deflection, and so forth. Geophysical tool manufacturers or service companies have specific instructions for the calibration and interpretation of their logs and should be consulted by the user.

8.3 Regardless of the method used to determine thickness, check the estimated thickness from the geophysical log(s) against measured coal-core sections for final determination. This is particularly critical in cases of gradational contacts or thin, dense partings for which thicknesses are commonly overexaggerated by the response of the geophysical tool. Generally, thicknesses can be determined from geophysical tools within ±30 mm [0.1 ft] or less depending on the type of tool used.

9. Sampling Procedures

9.1 Handle the section of coal core carefully as it is extracted from the borehole. Additional breakage should be prevented.

9.2 Transfer the core onto a core tray that has been constructed to receive the length and diameter of the core being drilled.

9.2.1 *Split-Tube Core Barrels*—Place the tube in the tray, remove one section of the tube, and roll the core into the tray.

9.2.2 *Solid-Tube Core Barrels*—Place the tube at a slight angle above the tray with one end in the tray, pull the tube lengthwise down the tray and push the core at the opposite end, thereby extruding the core onto the tray while at the same time moving the tube along the length of the tray. Match any broken contacts so that the lengths of the core can be measured.

9.3 Measure the lengths of the core for various lithologies and record the values.

NOTE 4—In steeply dipping coal seams, the measured coal-seam thickness can exceed the true seam thickness. In addition, improper arrangement of broken pieces of the core can also contribute to inaccuracies in determination of the true thickness of the seam.

9.3.1 *Splitting the Core Lengthwise by Sawing*—If necessary, the core can be sawn in the field or laboratory into approximately equal sections of intact core. This should be performed by keeping the core in the PVC pipe or by using a similar support to keep the core intact while sawing.

9.4 Remove all drill mud or cuttings from the core using clean water. Alternatively, if contaminating materials are not present and it is suspected that the only moisture in the core is the sought-after inherent moisture, apply the following field test:

9.4.1 Inspect the outside of the core for visible water. Break the core in several places and examine the fresh exposed surfaces. Visible water on either the exterior or interior of a core sample indicates that the moisture content is greater than inherent. If no visible water is present, perform the procedure shown in 9.4.2 to check for dried coal.

9.4.2 Apply a light coat of water by spraying or wiping the surface of the coal with a slightly wet cloth, and note the rate at which the liquid disappears from the sample. Rapid disappearance (typically within a few seconds) indicates absorption and demonstrates that the coal contains less than its full compliment of inherent moisture. Slower disappearance (taking a minute or more) is characteristic of evaporation and suggests that the pores are filled with (inherent) moisture. To account for variations in field conditions such as temperature, humidity, different absorption rates by different coals, and so forth, apply this test to a number of coal pieces throughout the sample collection process.

9.4.3 In the absence of visible water, together with the absence of rapid absorption of added water, the coal is considered to be at its inherent moisture level.