INTERNATIONAL

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Standard Classification of Coals by Rank[1]

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1. Scope

1.1 This standard covers the classification of coals by rank, that is, according to their degree of metamorphism, or progressive alteration, in the natural series from lignite to anthracite.

1.2 This classification is applicable to coals that are composed mainly of vitrinite.

NOTE 1—Coals rich in inertinite or liptinite (exinite), or both, cannot be properly classified because, in those macerals, the properties that determine rank (calorific value, volatile matter, and agglomerating character) differ greatly from those of vitrinite in the same coal. Often such coals can be recognized by megascopic examination. In North America, these coals are mostly nonbanded varieties that contain only a small proportion of vitrain and consist mainly of attrital materials. The degree of metamorphism of nonbanded and other vitrinite-poor coals can be estimated by determining the classification properties of isolated or concentrated vitrinite fractions, or by determining the reflectance of the vitrinite (see Test Method D2798 and ~~Appendix~~Appendix X1 ~~X1~~ of this classification). However, in the use of these vitrinite-poor coals, some properties normally associated with rank, such as rheology, combustibility, hardness, and grindability (as well as the rank determining properties) may differ substantially from those of vitrinite-rich coals of the same degree of metamorphism.

The precision of the classification of impure coal may be impaired by the effect of large amounts of mineral matter on the determination of volatile matter and calorific value, and on their calculation to the mineral-matter-free basis.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard. The values given in parentheses are for information only.

1.3.1 *Exception*—The values stated in British thermal units per pound (Btu/lb) are to be regarded as the standard. The SI equivalents of Btu/lb are provided for information only and are not considered standard.

1.4 *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.*

1.5 *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
~~D720~~D720/D720M Test Method for Free-Swelling Index of Coal
~~D1412~~D1412/D1412M Test Method for Equilibrium Moisture of Coal at 96 to 97 Percent Relative Humidity and 30 °C
~~D2013~~D2013/D2013M Practice for Preparing Coal Samples for Analysis
D2234/D2234M Practice for Collection of a Gross Sample of Coal
D2798 Test Method for Microscopical Determination of the Vitrinite Reflectance of Coal
D3172 Practice for Proximate Analysis of Coal and Coke
~~D3173~~D3173/D3173M 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
D3175 Test Method for Volatile Matter in the Analysis Sample of Coal and Coke
~~D3302~~D3302/D3302M Test Method for Total Moisture in Coal

[1] This classification is under the jurisdiction of ASTM Committee D05 on Coal and Coke and is the direct responsibility of Subcommittee D05.18 on Classification of Coals.

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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.

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
D5016 Test Method for Total Sulfur in Coal and Coke Combustion Residues Using a High-Temperature Tube Furnace Combustion Method with Infrared Absorption
D5192 Practice for Collection of Coal Samples from Core
D5865 Test Method for Gross Calorific Value of Coal and Coke

3. Terminology

3.1 *Definitions:*

3.1.1 For additional definitions of terms used in this classification, refer to Terminology D121.

3.1.2 *agglomerating, adj*—as applied to coal, the property of softening when it is heated to above about 400 °C in a nonoxidizing atmosphere, and then appearing as a coherent mass after cooling to room temperature.

3.1.3 *apparent rank, n*—of coal, the rank designation obtained on samples other than channel samples or core samples with 100 % recovery, but otherwise conforming to procedures of Classification D388.

3.1.4 *coal seam, n*—the stratum, layer, or bed of coal that lies between two other rock layers whose compositions differ significantly from that of coal.

3.2 *Abbreviations:*

3.2.1 Where it is desired to abbreviate the designation of the ranks of coal, the following abbreviations shall be used:

ma—meta-anthracite
an—anthracite
sa—semianthracite
lvb—low volatile bituminous
mvb—medium volatile bituminous
hvAb—high volatile *A* bituminous
hvBb—high volatile *B* bituminous
hvCb—high volatile *C* bituminous
subA—subbituminous *A*
subB—subbituminous *B*
subC—subbituminous *C*
ligA—lignite *A*
ligB—lignite *B*

3.3 *Symbols:*

3.3.1 *Descriptive Symbols (symbols used for describing quantities, all in lowercase, roman)*

d—dry basis
f—free basis (e.g., mineral-matter-free and sulfur-trioxide-free)
im—inherent moisture basis

3.3.2 *Simple Quantity Symbols (calculated quantities with units, all in upper case, italicized)*

A—ash, %
FC—fixed carbon, %
FSI—free swelling index
GCV—gross calorific value, Btu/lb
IM—inherent moisture, %
MM—mineral matter, %
S—total sulfur, %
SO_3*:A*—sulfur trioxide in the ash, %
SO_3*:C*—sulfur trioxide in the ash, expressed as a percentage of the coal, %
VM—volatile matter, %

3.3.3 *Complex Quantity Symbols (simple quantity symbols with roman subscripts)*

A_d—ash, dry basis (possibly sulfate-bearing), %
A_{im}—ash, inherent-moisture basis, %
A_{im,SO_3f}—ash, inherent-moisture basis, sulfur-trioxide-free basis, %
FC_d—fixed carbon, dry basis, %
$FC_{d,MMf}$—fixed carbon, dry basis, mineral-matter-free basis, %
FC_{im}—fixed carbon, inherent-moisture basis, %
FC_{im,SO_3f}—fixed carbon, inherent-moisture basis, sulfur-trioxide-free basis, %
GCV_d—gross calorific value, dry basis, Btu/lb
GCV_{im}—gross calorific value, inherent-moisture basis, Btu/lb
$GCV_{im,MMf}$—gross calorific value, inherent-moisture basis, mineral-matter-free basis, Btu/lb
MM_{d,SO_3f}—mineral matter, dry basis, sulfur-trioxide-free basis, %
MM_{im,SO_3f}—mineral matter, inherent-moisture basis, sulfur-trioxide-free basis, %

S_d—total sulfur, dry basis, %
S_{im}—total sulfur, inherent-moisture basis, %
SO_3: A_d—sulfur trioxide in the ash, dry basis, %
SO_3:C_{im}—sulfur trioxide in the ash, expressed as a percentage of the coal, inherent moisture basis, %
VM_d—volatile matter, dry basis, %
$VM_{d,MMf}$—volatile matter, dry basis, mineral-matter-free basis, %
VM_{im}—volatile matter, inherent moisture basis, %

4. Significance and Use

4.1 This classification establishes categories of coal based on gradational properties that depend principally on the degree of metamorphism to which the coal was subjected while buried. These categories indicate ranges of physical and chemical characteristics that are useful in making broad estimates of the behavior of coal in mining, preparation, and use.

5. Basis of Classification

5.1 Classification is according to fixed carbon and gross calorific value (expressed in British thermal units per pound, Btu/lb) calculated to the mineral-matter-free basis. The higher-rank coals are classified according to fixed carbon on the dry basis; the lower-rank coals are classified according to gross calorific value on the moist basis. Agglomerating character is used to differentiate between certain adjacent groups.

6. Classification by Rank

6.1 *Fixed Carbon and Gross Calorific Value*—Coals shall be classified by rank in accordance with Table 1. Classify coals having gross calorific values of 14 000 Btu/lb or more on the inherent-moisture, mineral-matter-free basis, and coals having fixed carbon of 69 % or more on the dry, mineral-matter-free basis, according to fixed carbon on the dry, mineral-matter-free basis. Classify

TABLE 1 Classification of Coals by Rank[A]

Class/Group	$FC_{d,MMf}$ Limits, %		$VM_{d,MMf}$ Limits, %		$GCV_{im,MMf}$ Limits[B]				Agglomerating Character
					Btu/lb		MJ/kg[C]		
	Equal or Greater Than	Less Than	Greater Than	Equal or Less Than	Equal or Greater Than	Less Than	Equal or Greater Than	Less Than	
Anthracitic:									
Meta-anthracite	98	. . .	. . .	2	. . .	. . .	. . .	. . .	non-agglomerating
Anthracite	92	98	2	8	. . .	. . .	. . .	. . .	
Semianthracite[D]	86	92	8	14	. . .	. . .	. . .	. . .	
Bituminous:									
Low volatile bituminous coal	78	86	14	22	. . .	. . .	. . .	. . .	commonly agglomerating[E]
Medium volatile bituminous coal	69	78	22	31	. . .	. . .	. . .	. . .	
High volatile *A* bituminous coal	. . .	69	31	. . .	14 000[F]	. . .	32.557	. . .	
High volatile *B* bituminous coal	. . .	. . .	. . .	. . .	13 000[F]	14 000	30.232	32.557	
High volatile *C* bituminous coal	. . .	. . .	. . .	. . .	11 500	13 000	26.743	30.232	
					10 500	11 500	24.418	26.743	agglomerating
Subbituminous:									
Subbituminous *A* coal	. . .	. . .	. . .	. . .	10 500	11 500	24.418	26.743	non-agglomerating
Subbituminous *B* coal	. . .	. . .	. . .	. . .	9 500	10 500	22.09	24.418	
Subbituminous *C* coal	. . .	. . .	. . .	. . .	8 300	9 500	19.30	22.09	
Lignitic:									
Lignite *A*	. . .	. . .	. . .	. . .	6 300	8 300	14.65	19.30	
Lignite *B*	. . .	. . .	. . .	. . .	. . .	6 300	. . .	14.65	

[A] This classification does not apply to certain coals, as discussed in Section 1.
[B] Refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.
[C] Megajoules per kilogram. To convert British thermal units per pound to megajoules per kilogram, multiply by 0.0023255.
[D] If agglomerating, classify in low volatile group of the bituminous class.
[E] It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and that there are notable exceptions in the high volatile *C* bituminous group.
[F] Coals having 69 % or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of gross calorific value.

coals having gross calorific values less than 14 000 Btu/lb on the inherent-moisture, mineral-matter-free basis according to gross calorific value on the inherent-moisture, mineral-matter-free basis, provided the fixed carbon on the dry, mineral-matter-free basis is less than 69 %.

6.2 *Agglomerating Character*—Classify coals having 86 % or more fixed carbon on the dry, mineral-matter-free basis, if agglomerating, in the low volatile group of the bituminous class. Classify coals having gross calorific values in the range from 10 500 to 11 500 Btu/lb on the inherent-moisture, mineral-matter-free basis according to their agglomerating character (Table 1).

6.3 *Supplemental Information*—A correlation of the ranking property, volatile matter (100–fixed carbon), with the mean-maximum reflectance of the vitrinite group macerals in coals tested in one laboratory over a period of several years is shown in Appendix X1.

7. Sampling

7.1 *Samples*—Classify a coal seam, or part of a coal seam, in any locality based on the average analysis and gross calorific value (and agglomerating character where required) of not less than three and preferably five or more whole seam samples, either face channels or cores, taken in different and uniformly distributed localities, either within the same mine or closely adjacent mines representing a continuous and compact area not greater than approximately 10 km^2 (4 square miles) in regions of geological uniformity. In regions in which conditions indicate that the coal probably varies rapidly in short distances, the spacing of sampling points and grouping of analyses to provide average values shall not be such that coals of obviously different rank will be used in calculating average values.

7.1.1 Take channel samples by excluding mineral partings more than 1 cm (⅜ in.) and lenses or concretions (such as sulfur balls) more than 1.25 cm (½ in.) thick and 5 cm (2 in.) wide, as specified in Practice D4596.

7.1.2 A drill core sample may be used provided it was collected as specified in Practice D5192 and meets the following provisions: core recovery is 100 % of the seam, the major mineral partings and concretions are excluded as specified in 7.1.1, and drilling mud is removed from the core (see also 7.1.6).

7.1.3 Place all samples in metal or plastic cans with airtight lids, or heavy vapor impervious bags, properly sealed to preserve inherent moisture.

7.1.4 Analyses of samples from outcrops or from weathered or oxidized coal shall not be used for classification by rank.

7.1.5 In case the coal is likely to be classified on the *moist* basis, that is, inclusive of its natural complement of inherent moisture, take samples in a manner most likely to preserve inherent moisture for purposes of analysis. Because some of the moisture in a freshly collected sample condenses on the inside of the sample container, weigh both the container and the coal before and after air drying, and report the total loss in mass as air-drying loss.

7.1.6 ~~If the sample is a core or if it is impossible to sample the coal~~ It is often difficult to obtain samples without including visible surface moisture, ~~or if there may be other reasons to question the accuracy of inherent moisture content determinable from the sample,~~ such as in typical coring situations where injected water or drilling mud is used or when the coal seam is an aquifer. When the as-received basis moisture in samples is questionable in terms of representing inherent moisture, and the coal is likely to be classified on the *moist* basis, the sampler shall include the following statement in the description: *Moisture questionable*. Samples so marked shall not be used for classification on a moist basis unless brought to a standard condition of moisture equilibrium as specified in Test Method ~~D1412~~D1412/D1412M. Analyses of such samples that have been treated in this manner shall be designated as *samples equilibrated per Test Method ~~D1412~~D1412/D1412M*.

7.1.7 Equilibrium moisture results for suspected lignite and subbituminous coals shall be adjusted utilizing the procedure outlined in Test Method D1412/D1412M, Appendix X1 to estimate inherent moisture content.

7.2 *Other Types of Samples*—A standard rank determination cannot be made unless samples have been obtained in accordance with 7.1. However, the relation to standard determinations may be usefully given for other types of samples taken under unspecified conditions, providing the same standards of analysis and computation are followed. Designate these comparative indications as *apparent rank*, which indicates the correct relative position for the sample analyzed but does not imply any standards of sampling. Whenever apparent rank is stated, give additional information as to the nature of the sample.

7.2.1 The apparent rank of the coal product from a mine shall be based on representative samples taken in accordance with the Organization and Planning of Sampling Operations section (Section 7) of Practice D2234/D2234M.

7.2.2 In case the coal is likely to be classed on the *moist* basis, take samples at the tipple or preparation plant and seal the sample to prevent loss of moisture.

8. Methods of Analysis and Testing

8.1 *Laboratory Sampling and Analysis*—Prepare coal in accordance with Test Method ~~D2013~~D2013/D2013M and analyze it in accordance with Test Methods ~~D3173~~D3173/D3173M, D3174, D3175, D4239, ~~D3302~~D3302/D3302M, and Practice D3172. Determine its gross calorific value in accordance with Test Method D5865. Determine the sulfur trioxide (SO_3) retained in the ash in accordance with Test Method D5016 and express the result on a dry basis. Inherent moisture is reported as as-received (AR) moisture if the sample was collected according to 7.1.1 or as equilibrium moisture if 7.1.6 (Test Method ~~D1412~~D1412/D1412M) applies.