



Standard Practice for Calculating Coal and Coke Analyses from As-Determined to Different Bases¹

This standard is issued under the fixed designation D 3180; 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 gives formulas to enable analytical data to be expressed on various different bases in common use. Such bases are: as received, dry, equilibrium moisture, dry ash free, and others.

1.2 *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 this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.3 The values stated in SI units are to be regarded as the standard.

2. Referenced Documents

2.1 ASTM Standards:

- D 388 Classification of Coals by Rank²
- D 1412 Test Method for Equilibrium Moisture of Coal at 96 to 97 Percent Relative Humidity and 30°C²
- D 2013 Method of Preparing Coal Samples for Analysis²
- D 3173 Test Method for Moisture in the Analysis Sample of Coal and Coke²
- D 3174 Test Method for Ash in the Analysis Sample of Coal and Coke from Coal²

3. Terminology

3.1 Definitions:

3.1.1 *as-determined basis*—analytical data obtained from the analysis sample of coal or coke after conditioning and preparation to No. 60 (250- μ m) sieve in accordance with Method D 2013. As-determined data represents the numerical values obtained at the particular moisture level in the sample at the time of analysis. These values are normally converted, according to formulae contained herein, to conventional reporting bases.

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 *Annual Book of ASTM Standards*, Vol 05.05.

3.1.2 *as-received basis*—analytical data calculated to the moisture condition of the sample as it arrived at the laboratory and before any processing or conditioning. If the sample has been maintained in a sealed state so that there has been no gain or loss, the as-received basis is equivalent to the moisture basis as sampled.

3.1.3 *dry basis*—data calculated to a theoretical base of no moisture associated with the sample. The numerical value as established by Test Method D 3173 is used for converting the as-determined data to a dry basis.

3.1.4 *dry, ash-free basis*—data calculated to a theoretical base of no moisture or ash associated with the sample. Numerical values as established by Test Method D 3173 and Test Method D 3174 are used for converting the as-determined data to a moisture- and ash-free basis.

3.1.5 *equilibrium moisture base*—data calculated to the moisture level established as the equilibrium moisture. Numerical values as established by Test Method D 1412 are used for the calculation.

4. Significance and Use

4.1 The calculations of analytical data for the coal and coke test parameters listed in Section 6, assume the analysis sample has been prepared according to Method D 2013.

4.2 This practice provides formulas, to enable calculations of data from the as-determined analysis sample to various moisture basis, in common use by the coal and coke industry.

5. Applicable Parameters and Symbols Used

5.1 The calculation procedures defined in 6.1.3 and 6.2.2 are applicable to the following analysis parameters when expressed as a weight percentage (except gross calorific value as Btu/lb):

- Ash
- Carbon
- Carbon dioxide
- Chlorine
- Calorific value (gross)
- Fixed carbon
- Nitrogen
- Sulfur
- Sulfur forms (namely, pyritic, sulfate, organic)
- Volatile matter

TABLE 1 Conversion Formula Chart

Given	Wanted			
	As-Determined (ad)	As-Received (ar)	Dry (d)	Dry Ash-free (daf)
As-Determined (ad)		$\frac{100 - M_{ar}}{100 - M_{ad}}$	$\frac{100}{100 - M_{ad}}$	$\frac{100}{100 - M_{ad} - A_{ad}}$
As-Received (ar)	$\frac{100 - M_{ad}}{100 - M_{ar}}$		$\frac{100}{100 - M_{ar}}$	$\frac{100}{100 - M_{ar} - A_{ar}}$
Dry (d)	$\frac{100 - M_{ad}}{100}$	$\frac{100 - M_{ar}}{100}$		$\frac{100}{100 - A_d}$
Dry Ash-free (daf)	$\frac{100 - M_{ad} - A_{ad}}{100}$	$\frac{100 - M_{ar} - A_{ar}}{100}$	$\frac{100 - A_d}{100}$	

5.2 The symbols used in this practice:

- A* = ash; weight %
- M* = moisture, weight %
- P* = any analysis parameter listed in 5.1, weight % (except gross calorific value is Btu/lb)
- ADL* = air-dry loss, weight % of as-received sample. See Method D 2013
- H* = hydrogen, weight %
- Ox* = oxygen, weight %

5.3 Subscripts used in this practice:

- ad = as-determined
- ar = as-received
- d = dry
- daf = dry, ash-free (equivalent to moisture and ash free, maf)

$$P_{ar} = P_{ad} \times \frac{100 - M_{ar}}{100 - M_{ad}} \quad (6)$$

NOTE 1—The equations in 6.1.2 and 6.1.3 may be applied to convert analysis values from the analysis sample moisture-containing basis to any other moisture-containing basis (such as equilibrium capacity moisture basis) by substituting the desired moisture value for *M_{ar}* in the equations.

6.2 Converting from the analysis sample basis to the dry basis (Note 2):

6.2.1 *Hydrogen and Oxygen*:

$$H_d = (H_{ad} - 0.1119M_{ad}) \times \frac{100}{100 - M_{ad}} \quad (7)$$

$$Ox_d = (Ox_{ad} - 0.8881M_{ad}) \times \frac{100}{100 - M_{ad}} \quad (8)$$

6.2.2 *Other Parameters*—The equation below is applicable to all parameters, *P*, listed in 5.1:

$$P_d = P_{ad} \times \frac{100}{100 - M_{ad}} \quad (9)$$

NOTE 2—The equations in 6.2.1 and 6.2.2 may be applied to convert analysis values from any moisture-containing basis to the dry basis by substituting the appropriate moisture value for *M_{ad}* in the equations. If *H* and *Ox* values reported on the moisture-containing basis do not include *H* and *Ox* in the moisture, the equation in 6.2.2 is applicable.

6.3 For converting data from the as-determined basis to the dry, mineral-matter-free basis, see procedures in Classification D 388.

6. Methods for Calculating Data

6.1 Converting from the analysis sample basis to the as-received basis (Note 1):

6.1.1 *Moisture*:

$$M_{ar} = \left[M_{ad} \times \frac{100 - ADL}{100} \right] + ADL \quad (1)$$

6.1.2 *Hydrogen and Oxygen*—Inasmuch as hydrogen and oxygen values may be reported on the basis of containing or not containing the hydrogen and oxygen in water (moisture) associated with the sample, alternative conversion procedures are defined as follows:

6.1.2.1 *H* and *Ox* reported include *H* and *Ox* in water:

$$H_{ar} = \left[(H_{ad} - 0.1119M_{ad}) \times \frac{100 - M_{ar}}{100 - M_{ad}} \right] + 0.1119M_{ar} \quad (2)$$

$$Ox_{ar} = \left[(Ox_{ad} - 0.8881M_{ad}) \times \frac{100 - M_{ar}}{100 - M_{ad}} \right] + 0.8881M_{ar} \quad (3)$$

6.1.2.2 *H* and *Ox* reported do not include *H* and *Ox* in water:

$$H_{ar} = (H_{ad} - 0.1119M_{ad}) \times \frac{100 - M_{ar}}{100 - M_{ad}} \quad (4)$$

$$Ox_{ar} = (Ox_{ad} - 0.8881M_{ad}) \times \frac{100 - M_{ar}}{100 - M_{ad}} \quad (5)$$

6.1.3 *Other Parameters*—The equation below is applicable to all parameters, *P*, listed in 5.1:

7. Conversion Formula Chart

7.1 To convert any of the analysis values for the parameters listed in 5.1 from one basis to another, multiply the given value by the value shown in the appropriate wanted column in Table 1.

7.2 The chart is applicable to conversion of hydrogen and oxygen values only when the given values do not include the

TABLE 2 Proximate Analysis

Sample Coal Analysis	Air-Dried Basis	Dry Basis	As Received Basis
Moisture, %	8.23	...	23.24
Ash, %	4.46	4.86	3.73
Volatile, %	40.05	43.64	33.50
Fixed carbon, %	47.26	51.50	39.53
Total	100.00	100.00	100.00

(Air-Dry Loss in accordance with Method D 2013 = 16.36 %)

hydrogen and oxygen in the associated moisture. If the given hydrogen and oxygen values include the hydrogen and oxygen in associated water, refer to 6.1.2.1 or 6.2.1.

8. Sample Calculations

8.1 An example of a proximate analysis reported on three different bases is shown in Table 2.

8.2 An example of ultimate analysis data tabulated for a hypothetical coal on various bases is shown in Table 3.

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

TABLE 3 Ultimate Analysis Data

Test Parameter	As-Determined		As-Received Basis	
	Hydrogen and oxygen include <i>H</i> and <i>Ox</i> in sample moisture (M_{ad})	Dry Basis	Hydrogen and oxygen include <i>H</i> and <i>Ox</i> in sample moisture (M_{ar})	Hydrogen and oxygen do not include <i>H</i> and <i>Ox</i> in sample moisture (M_{ar})
Carbon, weight %	60.08	66.02	46.86	46.86
Hydrogen, weight %	5.44	4.87	6.70	3.46
Nitrogen, weight %	0.88	0.97	0.69	0.69
Sulfur, weight %	0.73	0.80	0.57	0.57
Ash, weight %	7.86	8.64	6.13	6.13
Oxygen, weight % (by difference)	25.01	18.70	39.05	13.27
Total %	100.00	100.00	100.00	70.98
Total moisture, weight % (as-received)	...		(29.02)	29.02
Moisture weight % (sample as-determined)	9.00			Total % 100.00

(Air-Dry Loss in accordance with Method D 2013 = 22.00 %)

9. Report

9.1 To avoid ambiguity and to provide a means for conversion of data to 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.

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