Designation: E791 – 08 (Reapproved 2016)

Standard Test Method for Calculating Refuse-Derived Fuel Analysis Data from As-Determined to Different Bases[1]

This standard is issued under the fixed designation E791; 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 test method gives equations to enable analytical data from the application of RDF analyses procedures to be expressed on various different bases in common use. Such bases are: as-received; dry; dry, ash-free; and others.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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]

D5681 Terminology for Waste and Waste Management

3. Terminology

3.1 For definitions of terms used in this test method, refer to Terminology D5681.

3.2 *Symbols:*

3.2.1 The symbols used in this test method are as follows:

M = moisture, weight %,
M_{ar} = moisture as-received (total moisture), weight %,
M_{ad} = moisture as-determined (residual moisture), weight %,
ADL = air-dry loss, weight %,
P = any analysis parameter listed in 5.1, weight % (except gross calorific value in Btu/lb),
H = hydroxygen, weight %,
O = oxygen, weight %, and
A = ash, weight %.

3.2.2 Subscripts used in this test method are as follows:

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

4. Significance and Use

4.1 This test method is available to producers and users of RDF to use in converting laboratory data from one basis to another.

5. Applicable Parameters

5.1 The calculation procedures defined in 7.1.3, 7.2.2, and 7.3.2 are applicable to the following analysis parameters when expressed as a weight percent (except gross calorific value as Btu/lb).

5.1.1 Ash,
5.1.2 Carbon,
5.1.3 Chloride, water-soluble,
5.1.4 Chlorine, total,
5.1.5 Calorific value (gross),
5.1.6 Fixed carbon,
5.1.7 Nitrogen,
5.1.8 Sulfur, and
5.1.9 Volatile matter.

6. Sampling

6.1 Sampling techniques are not directly applicable to this test method. However, sampling procedures are identified in the respective methods of analyses.

7. Methods for Calculating Data

7.1 Converting from the as-determined analysis sample basis to the as-received basis:

7.1.1 *Moisture:*

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

[1] This test method is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.03 on Treatment, Recovery and Reuse.

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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.

7.1.2 *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, alternate conversion procedures are defined as follows:

7.1.2.1 Hydrogen and oxygen reported include hydrogen and oxygen in water:

$$H_{ar} = \left[(H_{ad} - 0.1119\, M_{ad}) \times \frac{100 - M_{ar}}{100 - M_{ad}} \right] + 0.119\, M_{ar} \quad (2)$$

$$O_{ar} = \left[(O_{ad} - 0.8881\, M_{ad}) \times \frac{100 - M_{ar}}{100 - M_{ar}} \right] + 0.881\, M_{ar} \quad (3)$$

where:

0.1119 = ratio of the weight of hydrogen in water to the molecular weight of water, and

0.8881 = ratio of the weight of oxygen in water to the molecular weight of water.

7.1.2.2 Hydrogen and oxygen reported do not include hydrogen and oxygen in water:

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

$$O_{ar} = (O_{ad} - 0.881\, M_{ad}) \times \frac{100 - M_{ar}}{100 - M_{ad}} \quad (5)$$

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

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

7.2 Converting from the as-determined analysis sample basis to the dry basis:

7.2.1 *Hydrogen and Oxygen:*

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

$$O_{d} = (O_{ad} - 0.881\, M_{ad}) \times \frac{100}{100 - M_{ad}} \quad (8)$$

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

$$P_{d} = P_{ad} \times 100/(100 - M_{ad}) \quad (9)$$

7.3 Converting from the as-determined analysis sample basis to the dry, ash-free basis (see Note 1).

7.3.1 *Hydrogen and Oxygen:*

$$H_{daf} = (H_{ad} - 0.1119\, M_{ad}) \times \frac{100}{100 - M_{ad} - A_{ad}} \quad (10)$$

$$O_{daf} = (O_{ad} - 0.8881\, M_{ad}) \times \frac{100}{100 - M_{ad} - A_{ad}} \quad (11)$$

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

$$P_{daf} = P_{ad} \times \frac{100}{100 - M_{ad} - A_{ad}} \quad (12)$$

NOTE 1—It may not always be practical to report some parameters on a dry, ash-free basis due to oxidation of constituents as well as some elements being retained in the ash. The data calculated are to a theoretical base of no moisture or ash present in the sample.

8. Conversion Chart

8.1 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 column in Table 1.

8.2 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 not containing the hydrogen and oxygen in water (moisture) reported on that basis. Conversion procedures are shown in Table 2.

9. Sample Calculations

9.1 An example of analysis data tabulated for a hypothetical RDF on various bases is shown in Table 3.

10. Reporting of Results

10.1 Report the results of the proximate and ultimate analysis based on the example shown in Table 3.

10.2 To avoid ambiguity and to provide a means for conversion of data to other than the reported basis, it is essential that an appropriate moisture and ash content be given in the data report.

TABLE 1 Conversion Chart

NOTE 1—To convert any of analyses values for the parameters listed in 5.1 from one basis to another, multiply the given value by the value shown in the appropriate column.

To convert from / Multiply by	Conversion Factor			
	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)	$\frac{100 - (M_{ad} - A_{ad})}{100}$	$\frac{100 - (M_{ar} - A_{ar})}{100}$	$\frac{100 - A_{d}}{100}$	...

TABLE 2 Procedures for Converting As-Determined Values to Other Bases

Parameter	As-Determined	As Received		Dry Basis	Dry, Ash-Free Basis
		H_{ar} and O_{ar} include H and O in M_{ar}	H_{ar} and O_{ar} do not include H and O in M_{ar}		
P (ash, carbon, nitrogen, sulfur, chlorine)	no corrections (see standard method)	$P_{ar} = P_{ad} \times \left(\frac{100 - M_{ar}}{100 - M_{ad}}\right)$	...	$P_d = P_{ad} \times \left(\frac{100}{100 - M_{ad}}\right)$	$P_{daf} = P_{ad} \times \left(\frac{100}{100 - M_{ad} - A_{ad}}\right)$
H (hydrogen)	no corrections (see standard method)	$H_{ar} = \left[(H_{ad} - 0.1119\,M_{ad}) \times \left(\frac{100 - M_{ar}}{100 - M_{ad}}\right)\right] + 0.1119\,M_{ar}$	$H_{ar} = (H_{ad} - 0.1119\,M_{ad}) \times \left(\frac{100 - M_{ar}}{100 - M_{ad}}\right)$	$H_d = (H_{ad} - 0.1119\,M_{ad}) \times \left(\frac{100}{100 - M_{ad}}\right)$	$H_{daf} = (H_{ad} - 0.1119\,M_{ad}) \times \left(\frac{100}{100 - M_{ad} - A_{ad}}\right)$
O (oxygen)	$O_{ad} = 100 - (A_{ad} + C_{ad} + H_{ad} + N_{ad} + S_{ad} + Cl_{ad})$	$O_{ar} = \left[(O_{ad} - 0.8881\,M_{ad}) \times \left(\frac{100 - M_{ar}}{100 - M_{ad}}\right)\right] + 0.8881\,M_{ar}$	$O_{ar} = (O_{ad} - 0.8881\,M_{ad}) \times \left(\frac{100\ b - M_{ar}}{100 - M_{ad}}\right)$	$O_d = (O_{ad} - 0.8881\,M_{ad}) \times \left(\frac{100}{100 - M_{ad}}\right)$ or $O_d = 100 - (A_d + C_d + H_d + N_d + S_d + Cl_d)$	$O_{daf} = (O_{ad} - 0.8881\,M_{ad}) \times \left(\frac{100}{100 - M_{ad} - A_{ad}}\right)$

TABLE 3 Standard Reporting Form Analyses Data of RDF

	As-Determined	As-Received		Dry Basis	Dry, Ash-Free Basis
		H_{ar} and O_{ar} include H and O in sample M_{ar}	H_{ar} and O_{ar} do not include H and O in sample M_{ar}		
Air dry loss, %	18.69	...	...	...	...
Residual moisture (M_{ad}), %	2.15	...	...	...	...
Total moisture (M_{ar}), %	...	20.44	20.44	...	...
Ash, %	20.68	16.82	16.82	21.14	...
Volatile matter, %	62.29	50.65	50.65	63.66	80.73
Fixed carbon, %	14.88	12.09	12.09	15.20	19.27
Total, proximate	100.00	100.00	100.00	100.00	100.00
Total, moisture, %	...	...	20.44	...	...
Ash, %	20.68	16.82	16.82	21.14	...
Carbon, %	39.66	32.25	32.25	40.53	51.40
Hydrogen, %	5.12	6.25	3.97	4.99	6.32
Nitrogen, %0.60	0.60	0.49	0.49	0.61	0.78
Chlorine, %	0.30	0.24	0.24	0.31	0.39
Sulfur, %0.15	0.15	0.12	0.12	0.15	0.19
Oxygen, %	33.49	43.83	25.68	32.28	40.93
Total, ultimate	100.00	100.00	100.00	100.00	100.00
Gross heating value, Btu/lb	6868	5584	5584	7019	8900
Chloride, water soluble, %	0.19	0.15	0.15	0.19	0.25

10.3 If hydrogen or oxygen data, or both, are reported on an as-received basis (or any other moisture basis), a footnote or some other means shall be employed in the report to indicate whether the values reported do or do not include hydrogen and oxygen in the moisture associated with the sample.