Standard Test Method for Thermal Characteristics of Refuse-Derived Fuel Macrosamples[1]

This standard is issued under the fixed designation E 955; 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 covers the determination of moisture, noncombustibles and combustibles, and the calculation of higher heating value content of a large mass of refuse-derived fuel-three (RDF).

1.2 This test method may be applicable to any waste material, including residues from combustion, from which a representative sample can be prepared.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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 and health practices and determine the applicability of regulatory limitations prior to use.* See Section 7 for additional hazard information.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

E 711 Test Method for Gross Calorific Value of Refuse-Derived Fuel by the Bomb Calorimeter

E 791 Test Method for Calculating Refuse-Derived Fuel Analysis Data from As-Determined to Different Bases

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *combustibles*—that portion of the RDF sample which is consumed upon ignition exclusive of the moisture present in the sample.

3.1.2 *macrosample*—a representative sample in the order of 1 kg mass is used to determine moisture, combustible, and noncombustible content without further processing or size reduction.

3.1.3 *noncombustibles*—that fraction of a macrosample remaining after moisture and combustibles are driven off by heat and combustion. It is composed of metallic and glass particles in addition to the residue from combustion of organic substances.

3.1.4 *forms of refuse-derived fuel (RDF): —*

RDF-1—Wastes used as a fuel in as-discarded form.

RDF-2—Wastes processed to coarse particle size with or without ferrous metal separation.

RDF-3—shredded fuel derived from municipal solid waste (MSW) that has been processed to remove metal, glass, and other inorganics. This material has a particle size such that 95 weight % passes through a 2-in. (50 mm) square mesh screen.

RDF-4—Combustible waste processed into powder form, 95 weight % passing 10-mesh screening.

RDF-5—Combustible waste densified (compressed) into the form of pellets, slugs, cubettes, or briquettes.

RDF-6—Combustible waste processed into liquid fuel.

RDF-7—Combustible waste processed into gaseous fuel.

4. Summary of Test Method

4.1 A macrosample of RDF is dried and ashed successively. The moisture, combustibles, and noncombustibles content are determined gravimetrically.

4.2 Heating value of a macrosample of RDF is calculated using an established moisture and noncombustible free heating value.

4.2.1 Normal practice is for contracting practices to rate RDF on a higher heating value basis.

4.2.2 If contracting parties choose to rate RDF on a lower heating value basis, provision is made using an established moisture and non-combustible free lower heating value.

5. Significance and Use

5.1 This test method is available to producers and users of RDF as a means of determining thermal characteristics of a large sample of RDF without extensive processing of the laboratory sample. It is intended that the results obtained be used to monitor changes in the fuel characteristics of RDF over a period of time.

---

[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.

Current edition approved March 25, 1988. Published May 1988. Originally published as E 955-83. Last previous edition E 955-83.

[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.

6. Apparatus

6.1 *Oven*—A large chamber mechanical draft oven (approximately 508 by 508 by 508 mm (20 by 20 by 20 in.) inside dimensions) capable of maintaining a controlled temperature between 100 and 500°C may be used. A minimum of one air change per minute is satisfactory. Air flow should be baffled to prevent any sample loss due to air currents.

NOTE 1—A home electric oven with self-cleaning mode of operation, modified with an air inlet has been found satisfactory.[3]

6.2 *Balance*, having a sensitivity of 0.5 g and a capacity of at least 2000 g.

6.3 *Sample Container*—A noncorroding pan (stainless steel or aluminum) approximately 15 dm^3(0.5 ft^3).

NOTE 2—Disposable aluminum roasting pans (381 × 508 × 82.6 mm) (12 by 20 by 3¼)) have been suitable for this purpose. (Two pans will probably be required for a 1 kg sample).[3]

7. Hazards

7.1 Due to the origins of RDF in municipal waste, common sense dictates that some precautions should be observed when conducting tests on samples. Recommended hygienic practices include use of gloves when handling RDF; wearing dust masks (NIOSH approved type); conducting tests under negative pressure hood; and washing hands before eating or smoking.

8. Sampling

8.1 RDF products are heterogeneous. For this reason, significant care should be exercised to obtain a representative laboratory sample from the RDF lot to be characterized.

8.2 The sampling method for this procedure should be based on agreements between both involved parties.[4]

9. Procedure

9.1 *Moisture Determination*:

9.1.1 Place a sample of approximately 1 kg into a tared container(s) weighed to the nearest 0.5 g. A maximum depth of 10 cm is recommended. Quickly weigh the container, and sample to the nearest 0.5 g.

9.1.2 Place the container and sample in the oven at 105°C (220°F) until the sample has attained constant weight. (Constant weight is reached when the loss in sample weight is less than 0.1 % per hour of the original sample weight).

NOTE 3—After several runs, a period of time can be established for the material to reach constant weight. Overnight drying has been found to be convenient and sufficient for some RDF products.[3]

9.1.3 After a sufficient drying time, remove the samples from the oven and immediately weigh while hot to the nearest 0.5 g.

NOTE 4—The practicality of this procedure step is demonstrated in Footnote 3.

9.2 *Noncombustible Determination*:

9.2.1 Place the container with the dried sample into a laboratory hood, and ignite the sample with a flame. Stirring is required to maintain the flame. Take care so no sample is lost when stirring.

NOTE 5—**Caution:** Because of the unknown nature of the material, use caution during ignition and stirring.

9.2.2 When a flame can no longer be maintained, place the container with the partially combusted sample into the oven at 500°C until constant weight is reached.

NOTE 6—It may be determined that constant weight can be routinely established by allowing samples to ash at the prescribed temperature for a set period of time. (Two hours have been found to be sufficient).

NOTE 7—A home electric oven in the self cleaning mode modified to permit air circulation has been found to achieve sufficient ashing during a 3 h clean cycle.[3]

9.2.3 Remove the container and noncombustibles from the oven. As soon as the container is cool enough to handle, weigh to the nearest 0.5 g.

10. Calculation

10.1 Calculate the percent moisture as follows:

$$A = \frac{B - C}{B} \times 100 \quad (1)$$

where:

A = mass percent moisture,
B = "as received" sample mass in grams, and
C = "dry" sample mass in grams.

Round value to nearest percent.

10.2 Calculate the percent non-combustibles as follows:

$$D = \frac{E}{B} \times 100 \quad (2)$$

where:

D = mass percent noncombustibles,
E = non-combustibles mass in grams, and
B = "as received" sample mass in grams.

Round value to nearest percent.

10.3 Calculate the percent combustibles as follows:

$$F = 100 - (A + D) \quad (3)$$

where:

F = mass percent combustibles,
A = mass percent moisture, and
D = mass percent non-combustibles.

10.4 Calculate the higher heating value as follows:

$$G = \frac{F \times H}{100} \text{ or } G = \frac{[100 - (A + D)]H}{100} \quad (4)$$

where:

G = higher heating value "as received,"
F = mass percent combustibles,
H = higher heating value, moisture and non-combustibles free, in MJ/kg (Btu/lb) established by the contracting parties,
A = mass percent moisture, and
D = mass percent non-combustibles free.

NOTE 8—Round robin testing sponsored by Committee E-38 on Resource Recovery has found that the mean moisture/ash free heating value

[3] Hecklinger, R. S., and Large, R. M., "Determination of the Fuel Characteristics of Refuse-Derived Fuels by Macroanalysis," *Proceedings of the Seventh Mineral Waste Utilization Symposium*, U.S. Bureau of Mines, 1980, pp. 84–90.

[4] ASTM Subcommittee E38.01 on Energy is currently in the process of developing procedures for sampling RDF-3.

on six different samples of RDF analyzed in replicate (4 times) by as many as twelve different laboratories is 21.92 MJ/kg (9423 Btu/lb) with a standard deviation of 772 kJ/kg (332 Btu/lb).[5] The relative constancy of RDF higher heating value, moisture and ash free, is corroborated by research conducted by the National Bureau of Standards.[6] Therefore, those using this method may agree to establish a higher heating value, moisture and ash free, of 22 MJ/kg (9400 Btu/lb). As an alternative, those using this test method may agree to establish or adjust the higher heating value, moisture and ash free, for a particular plant by means of Test Methods E 711 and E 791.

10.5 *Optional Calculation*—Calculate the lower heating value as follows:

$$I = \frac{[100 - (A + D)]J}{100} - (A \times 10.3) \quad (5)$$

where:

I = lower heating value "as received,"
A = mass percent moisture,
D = mass percent non-combustibles,
J = lower heating value moisture and non-combustibles, and free, in MJ/kg (Btu/lb) established by the contacting parties.

NOTE 9—The lower heating value of 20 MJ/kg (8600 Btu/lb) is equivalent to 22 MJ/kg (9400 Btu/lb) higher heating value from Note 8.

NOTE 10—If the analysis is performed on residue from combustion of municipal solid waste, the combustibles in the residue should be largely fixed carbon. If bomb calorimetry is not available to establish a moisture and ash free heating value, an estimated moisture and ash free heating value of 28 MJ/kg (12 000 Btu/lb) may be used for residue.

11. Report

11.1 The report shall include the following RDF Analysis" as received"

Moisture	*A* %
Combustibles	*F*
Noncombustibles	*D*
Total	100 %
Either	
Higher heating value—MJ/kg (Btu/lb)	
Or	
Lower heating value—MJ/kg (Btu/lb)	

12. Precision and Bias

12.1 The precision and bias of this test method has yet to be determined.

[5] Supporting data (Kieffer, John K., "An Approach for Determining the Heating Value of Municipal Waste From its Combustible Content") are available from ASTM Headquarters, 1916 Race St., Philadelphia, PA 19103. Request RR: E-38-1002.

[6] Kirklin, D. R., et al, "The Variability of Municipal Solid Waste and Its Relationship to the Determination of the Calorific Value of Refuse-Derived Fuels," *Resources and Conservation*, Vol 9, 1982, pp. 281–300.