



## Standard Test Method for Total Moisture in a Refuse-Derived Fuel Laboratory Sample<sup>1</sup>

This standard is issued under the fixed designation E 949; 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 approval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the measurement of the total moisture in RDF as it exists at the time it is sampled. Because of its empirical nature, strict adherence to test procedures are required for valid results. The standard is available to producers, vendors, and consumers as a total, two-stage moisture method.

1.2 Since RDF can vary from extremely wet (water saturated) to relatively dry, special emphasis must be placed on sampling, sample preparation, and the method of determination.

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.* For hazard statement, see Section 7.

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>2</sup>

D 3173 Test Method for Moisture in the Analysis Sample of Coal and Coke

E 790 Test Method for Residual Moisture in Refuse-Derived Fuel Analysis Sample

E 829 Practice for Preparing Refuse-Derived Fuel (RDF) Laboratory Samples for Analysis

### 3. Terminology Definitions

3.1 *air drying*—a process of partial drying of RDF to bring its moisture content near to equilibrium with the atmosphere in which further reduction, division, and characterization of the sample are to take place. In order to bring about the equilibrium, the RDF is usually subjected to drying under controlled temperature conditions ranging from 30 to 40°C.

3.2 *analysis sample*—the final subsample prepared from the air-dried laboratory sample but reduced by passing through a mill with a 0.5 mm (0.02 in.) size or smaller final screen.

3.3 *bias*—a systematic error that is consistently negative or consistently positive. The mean of errors resulting from a series of observations that does not tend towards zero.

3.4 *gross sample*—a sample representing one lot and composed of a number of increments on which neither reduction nor division has been performed.

3.5 *laboratory sample*—a representative portion of the gross sample received by the laboratory for analysis.

3.6 *lot*—a large designated quantity (greater than the quantity of the final sample) of RDF which can be represented by a properly selected gross sample.

3.7 *precision*—a term used to indicate the capability of a person, an instrument, or a method to obtain reproducible results; specifically, a measure of the random error as expressed by the variance, the standard error, or a multiple of the standard error.

#### 3.8 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.

3.9 *representative sample*—a sample collected in such a manner that it has characteristics equivalent to the lot sampled.

3.10 *sample division*—the process of extracting a smaller sample from a sample so that the representative properties of the larger sample are retained. During this process it is assumed that no change in particle size or other characteristics occurs.

3.11 *sample preparation*—the process that includes drying, size reduction, division, and mixing of a laboratory sample for the purpose of obtaining an unbiased analysis sample.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.12 *sample reduction*—the process whereby sample particle size is reduced without change in sample weight.

3.13 *significant loss*—any loss that introduces a bias in final results that is of appreciable importance to concerned parties.

#### 4. Summary of Test Method

4.1 This test method is based on the loss in weight of RDF in an air atmosphere under controlled conditions of temperature, time, and air flow.

4.2 The laboratory sample is air-dried to near equilibrium with the atmosphere in the area where division and reduction will take place. The residual moisture determination is made in a heated, forced-circulation oven, under rigidly defined conditions.

4.3 The total moisture is calculated from losses in air-drying and the residual moisture as shown in 11.

#### 5. Significance and Use

5.1 The collection and treatment of the sample as specified herein is intended for the specific purpose of determining the total moisture in a laboratory sample of RDF.

5.2 This test method is available as the method for the determination of total moisture unless alternative techniques or modifications have been agreed upon by involved parties.

#### 6. Apparatus

##### 6.1 *Air Dry Moisture:*

6.1.1 *Drying Oven*—A large chamber mechanical draft oven capable of maintaining a controlled temperature in the range of 25 to 40°C. Air changes should be at the rate of 1 to 4 changes per minute. Air flow should be baffled to prevent samples from being blown out of the sample containers.

6.1.2 *Drying Pan*—A non-corroding pan or mesh basket to be used for holding the sample during air drying operations.

6.1.3 *Balance (Laboratory Sample)*—A balance of sufficient capacity to weigh the sample and container with a sensitivity of 0.5 g.

##### 6.2 *Sample Reduction:*

6.2.1 *Mill*—A mill operating on the principle of cutting or shearing action shall be used for sample particle size reduction. It shall have the capability to regulate the particle size of the final product by means of either interchangeable screens or mill adjustments. The mill shall be enclosed and should generate a minimum amount of heat during the milling process to minimize the potential for loss of moisture. The final product shall pass through a 0.5 mm or smaller screen into a receiver integral with the mill. Access should be provided so that the mill can be cleaned quickly and easily between samples.

##### 6.3 *Residual Moisture:*

##### 6.3.1 *Drying Oven:*

6.3.1.1 *Referee Type*—The oven shall be so constructed as to have a uniform temperature within the specimen chamber, have a minimum excess air volume, and be capable of constant temperature regulation at  $107 \pm 3^\circ\text{C}$ . Provision shall be made for renewing the preheated air in the oven at the rate of two to four times a minute, with the intake air dried by passing it through a desiccant. An oven similar to the one illustrated in Fig. 1, Moisture Oven, of Test Method D 3173 is suitable.

6.3.1.2 *Routine Type*—A drying oven of either the mechanical or natural circulation type which is capable of constant uniform temperature within the specimen chamber regulated at  $107 \pm 3^\circ\text{C}$ .

NOTE 1—Either type of oven may be used for routine determinations. However, the referee-type oven shall be used to resolve differences between determinations.

6.3.2 *Containers*—A convenient form that allows the ash determination to be made on the same sample is a porcelain capsule 22 mm in depth and 44 mm in diameter or a fused silica capsule of similar shape. This shall be used with a well-fitting flat aluminum cover. Platinum crucibles or glass capsules with ground glass caps may also be used. They should be as shallow as possible consistent with convenient handleability.

6.3.3 *Analytical Balance*, with 0.1 mg sensitivity.

6.3.4 *Analysis Sample Containers*—Heavy (minimum 4 mil), vapor-impervious bags, properly sealed; or noncorroding cans, glass jars, or plastic bottles with air-tight sealing covers to store RDF samples for analysis. Containers shall be checked for suitability by measuring weight loss or gain of the sample and container stored for 1 week under ambient laboratory conditions. The weight loss or gain should be less than 0.5 % of the sample weight stored in container.

#### 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 the samples. Recommended hygienic practices include use of gloves when handling RDF; wearing dust masks (NIOSH-approved type), especially when shredding RDF samples; conducting tests under negative pressure hood when possible; and when washing hands before eating or smoking.

7.2 Laboratory sample handling shall be performed by trained personnel. All operations shall be done as rapidly as possible to avoid sample moisture changes due to atmospheric exposure.

7.3 At all times RDF samples should be protected from moisture change due to exposure to rain, snow and sun, or contact with absorbent materials.

7.4 Since heavy fine particles tend to segregate rapidly in the RDF analysis sample, the analyst should exercise care to assure that the analysis sample is well mixed prior to performing the residual moisture determination.

7.5 When the residual moisture is to be used for the determination of total moisture, special care shall be taken to avoid any change in sample moisture between the completion of air drying and analysis for residual moisture. It is recommended that the delay between sample preparation and the determination of residual moisture be a maximum of 72 h.

7.6 Samples should be transported to the laboratory and analyzed as soon as possible. If any sample handling step involves an extended time period, the sample and container should be weighed before and after the process to determine any weight gain or loss. This weight gain or loss shall be included in the calculation of moisture content.

7.7 Force-feeding of the sample through the mill can overload the motor. An overload can cause rapid heating of the rotor and mill chamber with possible loss of residual moisture.

## 8. Sampling (Note 2)

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

8.2 The sampling method for this procedure should be based on agreement between the involved parties.

8.3 For this procedure the laboratory sample size will normally not exceed 2 kg with some variation possible depending on the laboratory equipment available.

8.3.1 Due to the heterogeneous nature of RDF, dividing a laboratory sample to a very small size analysis sample may result in non-representative results. Since milling operations mix the sample as well as reduce particle size, laboratory samples should not be divided before the initial preparation steps have been completed.

NOTE 2—ASTM Subcommittee E38.01 is currently in the process of developing a procedure for sampling RDF. The chairman of E38.01 should be contacted for details.

## 9. Sample Preparation

9.1 The principles, terms, organization and preparation procedures as established in Practice E 829 shall apply to the handling and preparation of RDF for determination of total moisture by the two-stage method.

9.2 This procedure provides for using an air-drying oven to equilibrate laboratory sample moisture prior to reduction in size or amount and a moisture oven for determination of residual moisture on the air-dried analysis sample.

9.3 The laboratory sample must be air dried and particle size reduced to pass a 0.5 mm screen as described in Practice E 829, for the residual moisture (second stage) of the total moisture determination.

## 10. Procedure

### 10.1 Air Drying Laboratory Sample:

10.1.1 Weigh the entire laboratory sample into a tared air-drying pan. Use more than one pan if necessary. If a very fine mesh type of drying pan is used, size the mesh such that the sample will not be lost through it. Sample depth in the drying pan shall be no greater than 10 cm (4 in) and any lumps of sample shall be broken up.

10.1.2 Air dry the sample at 10 to 15°C above ambient, but not greater than 40°C until the weight loss is less than 0.1 % of the sample weight per hour. Normally, allow the sample to air dry for a set time period such as overnight or 24 h. To speed the drying stage, stir the sample carefully while avoiding loss of sample (Note 3).

NOTE 3—The air discharge of the forced draft air drying oven should be filtered prior to discharge to minimize laboratory contamination by air entrained RDF dust.

10.1.3 At the end of the air drying period, cool the sample to room temperature and weigh. Protect the sample from contamination and loss during the cool-down process but do

not place in a desiccator. Calculate air dry moisture loss percent in accordance with Section 11.

10.1.4 Separate, weigh, and hold non-millables for further classification and use for analysis if necessary (Note 4). Mill the remainder of the sample in accordance with Practice E 829.

10.1.5 The calculation for the decimal percent of non-millables (*NM*) is:

$$NM = \frac{\text{Weight in grams of non-millables}}{\text{Weight in grams of air-dried sample}} \quad (1)$$

NOTE 4—Non-millables are those materials which will not pass through the milling screen, or may damage the milling apparatus, or both.

### 10.2 Residual Moisture on Air-Dried Analysis Sample:

10.2.1 Heat the empty containers and covers under the conditions at which the sample is to be dried, place the stopper or cover on the container, cool over a desiccant for about 15 to 20 min, and weigh. Mix the sample, if necessary, and dip out with a spoon or spatula from the sample bottle approximately 1 g of the sample. Put the sample quickly into the container, cover and weigh at once (Note 5).

NOTE 5—If weighing bottles with air-tight covers are used, it may not be necessary to preheat the moisture analysis container nor to desiccate it after drying.

10.2.2 Remove the cover and place in a desiccator. Quickly place the uncovered container into an oven preheated to  $107 \pm 3^\circ\text{C}$  through which is passed a current of dry air. Close the oven at once and heat for 1 h. Open the oven, remove, cover the container quickly, and cool in a desiccator over desiccant. Weigh the sample and container as soon as cooled to room temperature.

## 11. Calculation

11.1 The air dry moisture, *A*, is calculated as follows:

$$A = \frac{G - L}{G} \times 100 \quad (2)$$

where:

*A* = air dry moisture, %,

*G* = weight, in grams, of laboratory sample before air drying, and

*L* = weight, in grams, of laboratory sample after air drying.

11.2 Calculate the percent residual moisture, *R*, in the analysis sample as follows:

$$R = \frac{S - B}{S} \times 100 (1 - NM) \quad (3)$$

where:

*R* = residual moisture, %,

*S* = grams of analysis sample used,

*B* = grams of sample after heating at 107°C, and

*NM* = decimal percent of non-millables as determined in 10.1.5.

11.3 Calculate the percent total moisture, *M*, in the laboratory sample, as follows:

$$M = \frac{R(100 - A)}{100} + A \quad (4)$$

where:

*M* = total moisture, %,   
*R* = residual moisture, %, and   
*A* = air dry moisture, %

## **12. Precision and Bias**

12.1 Precision and bias has not been determined.

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