



Designation: E2558 – 13 (Reapproved 2021)

Standard Test Method for Determining Particulate Matter Emissions from Fires in Wood-Burning Fireplaces¹

This standard is issued under the fixed designation E2558; 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 fueling and operating protocol for determining particulate matter emissions from wood fires in low mass wood-burning fireplaces. The fueling and operating protocol for determining particulate matter emissions from masonry or other high mass fireplaces is covered in **Annex A1** of this test method.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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

E631 Terminology of Building Constructions

E2515 Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel

2.2 *NIST Document:*³

Monograph 175 Temperature-Electromotive Force Reference Functions and Tables for the Letter-Designated

¹ This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.54 on Solid Fuel Burning Appliances.

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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.

³ Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.

Thermocouple Types Based on the ITS-90

3. Terminology

3.1 *Definitions*—Terms used in this test method are defined in Terminology **E631**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *base of fireplace, n*—the lowest part of the fireplace assembly that would normally be in contact with the floor of the dwelling or structure in which it is installed.

3.2.2 *Douglas fir, n*—untreated, standard, or better grade Douglas fir lumber with agency grade stamp: D. Fir or Douglas Fir.

3.2.3 *firebox, n*—the volume within the fireplace where logs are burned.

3.2.4 *first fuel crib, n*—the first fuel load (including fuel pieces and spacers to create air spaces) placed on the residual fuel from the kindling brands. The specific configuration is described in **9.3.5.1**.

3.2.5 *fuel piece, n*— 2×4 or 4×4 wood pieces used to construct fuel cribs and referring to the nominal width and depth dimensions for commonly available dimensional lumber. The actual dimensions are $1\frac{1}{2}$ in. \times $3\frac{1}{2}$ in. (38 mm \times 89 mm) and $3\frac{1}{2}$ in. \times $3\frac{1}{2}$ in. (89 mm \times 89 mm).

3.2.6 *grate, n*—any device included with the fireplace or specified by the fireplace manufacturer for the purpose of elevating the fuel load above the hearth or for constraining fuel pieces from falling outside the intended burning area, or both. This includes basket grates and andirons.

3.2.7 *hearth, n*—the footprint of the fireplace firebox.

3.2.8 *kindling brands, n*—the initial fuel load or loads placed above crumpled newspaper to initiate combustion in the fireplace and to establish a charcoal bed that will become the ignition source for subsequent fuel loads. These are comprised of fuel strips separated by air spaces. The specific configuration is described in **9.3.4**.

3.2.9 *low mass fireplace, n*—any fireplace and attached chimney that can be weighed (including the weight of the test fuel) on a platform scale that meets the requirements as specified in **7.3** and **8.2**.

3.2.10 *nominal fuel length, n*—the Nominal Fuel Length (NFL) is one of five incremental nominal fuel piece lengths that simulates real-world firewood five piece lengths. These lengths are 16 in. (406 mm), 18 in. (457 mm), 20 in. (508 mm), 22 in. (559 mm), and 24 in. (610 mm). The NFL is used for both the kindling brands and fuel cribs.

3.2.11 *particulate matter (PM), n*—all gas-borne matter resulting from combustion of solid fuel, as specified in this test method, which is collected in accordance with Test Method E2515.

3.2.12 *second fuel crib, n*—the second fuel load (including fuel pieces and spacers to create air spaces) placed on the residual fuel from the first fuel crib. The specific configuration is described in 9.3.5.2.

3.2.13 *spacers, n*—wood pieces used to hold individual fuel pieces together when constructing the three fuel cribs. Their function is to provide reproducible fuel crib geometry and air spaces between fuel pieces, as well as to hold the fuel cribs together (with nails).

3.2.14 *standardized fuel retainer, n*—any fireplace that doesn't include or specify a grate as defined in 3.2.6 shall use a standardized fuel retainer during testing. These retainers shall include vertical fuel retainer bars that are made from 0.75 in. × 0.75 in. (19 mm × 19 mm) steel square bar or 0.75 in. (19 mm) diameter round steel bar and shall be 8 in. ± 2 in. (200 mm ± 50 mm) high. They shall be attached to a steel plate that projects toward the front of the fireplace and shall not interfere with any fireplace function. They shall be spaced so they are 12 in. ± ½ in. (300 mm ± 13 mm) apart. Their purpose is to prevent fuel from rolling or falling forward during testing, thus helping to prevent an aborted test. (See Fig. 1.)

3.2.15 *test facility, n*—the area in which the tested fireplace is installed, operated, and sampled for emissions.

3.2.16 *third fuel crib, n*—the third and final fuel load (including fuel pieces and spacers to create air spaces) placed on the residual fuel from the second fuel crib. The specific configuration is described in 9.3.5.3.

4. Summary of Test Method

4.1 This test method is used in conjunction with Test Method E2515. The fireplace under evaluation is fueled with kindling and cribs in a way that simulates fireplace operation in

the home. An algorithm that uses the specific configuration of the test fireplace, including hearth and grate dimensions, is used to determine the kindling and fuel crib geometry and dimensions. Kindling brands are placed in the fireplace above crumpled newspaper and ignited. When the kindling brands have burned to a certain point, the first fuel crib is placed on the remains of the kindling. When the first crib is substantially burned, the remaining material is adjusted as needed to form a base for the second crib. This process is repeated again before addition of the third crib. The third crib is allowed to burn until all flaming from volatile material in the fuel ceases, at which point the test is terminated. Burn rate is determined based on the amount of fuel added less the amount remaining at the end of the test divided by the length of test and corrected to a dry fuel basis. Particulate sampling begins at the time of ignition of the newspaper and stops when the test terminates. The total particulate emissions are determined over the test period. The particulate emissions factor is then determined from the total emissions and the total amount of fuel burned and is reported in grams of particulate per dry kilogram of fuel or grams of particulate per hour.

4.2 If the test fireplace includes standard (or offers optional) components that affect particulate emission performance and that have more than one operating position or condition allowed in the owner's manual that accompanies the fireplace, separate emissions tests may be required for each of the various positions or conditions that are allowed in the manual. This might include things like door open and door closed operation, for example. (See 9.4.14 – 9.4.16.)

5. Significance and Use

5.1 This test method is used for determining emission factors and emission rates for low mass wood-burning fireplaces.

5.1.1 The emission factor is useful for determining emission performance during product development.

5.1.2 The emission factor is useful for the air quality regulatory community for determining compliance with emission performance limits.

5.1.3 The emission rate may be useful for the air quality regulatory community for determining impacts on air quality from fireplaces, but must be used with caution as use patterns

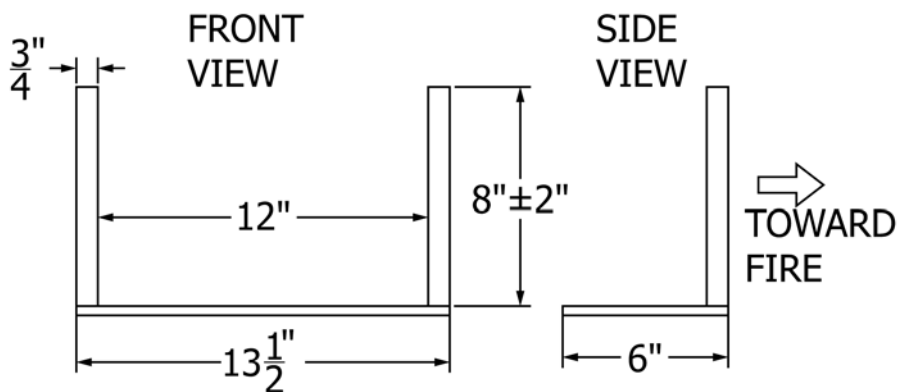


FIG. 1 Example, Standardized Fuel Retainer

must be factored into any prediction of atmospheric particulate matter impacts from fireplaces based on results from this method.

5.2 The reporting units are grams of particulate per kilogram of dry fuel and grams of particulate per hour.

5.2.1 Appropriate reporting units for comparing emissions from non-heating appliances: grams per kilogram.

5.2.2 Appropriate reporting units for predicting atmospheric emission impacts only if hours of fireplace use are factored in: grams per hour.

6. Safety

6.1 *Disclaimer*—This test method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety concerns associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to performing this test method.

7. Equipment and Supplies

7.1 *Wood Moisture Meter*—Calibrated electrical resistance meter capable of measuring test fuel moisture to within 1 % moisture content. Must meet the calibration requirements specified in 8.1.

7.2 *Test Fuel Scale*—A scale capable of weighing test fuel to within 0.01 lb (0.005 kg). Must meet the calibration requirements specified in 8.3.

7.3 *Platform Scale*—A scale capable of weighing the test fireplace and attached chimney, including the weight of the test fuel, to within 0.1 lb (0.05 kg). Must meet the calibration requirements specified in 8.2.

7.4 *Fireplace Flue Gas Temperature Measurement Device*—A 0.125 in. (3.2 mm) diameter sheathed, non-isolated junction Type K thermocouple capable of measuring flue gas temperature with an accuracy of 4.0 °F (2.2 °C) or 0.75 % of the reading, whichever is greater and meeting the calibration requirements specified in 8.4.

7.5 *Fireplace Temperature Measuring Device*—A temperature sensor capable of measuring firebox surface temperatures with an accuracy of 4.0 °F (2.2 °C) or 0.75 % of the reading, whichever is greater and meeting the calibration requirements specified in 8.4.

8. Calibration and Standardization

8.1 *Wood Moisture Meter*—Calibrate as in accordance with the manufacturer's instructions before each certification test.

8.2 *Platform Scale*—Perform a multipoint calibration (at least five points spanning the operational range) of the platform scale before its initial use. The scale manufacturer's calibration results are sufficient for this purpose. Before each certification test, audit the scale with the test fireplace in place by weighing at least one calibration weight (ASTM Class F) that corresponds to between 20 % and 80 % of the expected test fuel charge weight. If the scale cannot reproduce the value of the calibration weight within 0.1 lb (0.05 kg) or 1 % of the

expected test fuel charge weight, whichever is greater, recalibrate the scale before use with at least five calibration weights spanning the operational range of the scale.

8.3 *Test Fuel Scale*—Perform a multipoint calibration (at least five points spanning the operational range) of the test fuel scale before its initial use. The scale manufacturer's calibration results are sufficient for this purpose. Before each certification test, audit the scale with the wood heater in place by weighing at least one calibration weight (ASTM Class F) that corresponds to between 20 % and 80 % of the expected test fuel charge weight. If the scale cannot reproduce the value of the calibration weight within 0.01 lb (0.005 kg) or 1 % of the expected test fuel charge weight, whichever is greater, recalibrate the scale before use with at least five calibration weights spanning the operational range of the scale.

8.4 *Temperature Sensors*—Temperature measuring equipment shall be calibrated before initial use and at least semi-annually thereafter. Calibrations shall be in compliance with National Institute of Standards and Technology (NIST) Monograph 175 Temperature-Electromotive Force Reference Functions and Tables for the Letter-Designated Thermocouple Types Based on the ITS-90.

9. Procedure

9.1 *Preconditioning of the Fireplace*—Prior to testing for emissions, the fireplace to be evaluated must be burned until the weight of the fireplace is stable to within ± 0.5 lb (± 0.25 kg) but for no less than 10 h for fireplaces without catalytic combustors or no less than 48 h for fireplaces with catalytic combustor(s). This may be done inside or outside the test facility.

9.1.1 Set up the fireplace in accordance with instructions provided by the manufacturer. The total height of chimney when measured from the base of the fireplace shall be 15 ft \pm 1 ft (4.6 m \pm 0.3 m).

9.1.2 Install a flue-gas temperature measurement device at the center of the flue, 8 ft \pm 0.3 ft (2.4 m \pm 0.1 m) above the base of the fireplace.

9.1.3 Record the start time, fireplace weight, and flue gas temperature.

9.1.4 Ignite a fire using newspaper and kindling and establish an actively burning fire. Add more fuel as needed to sustain the fire.

NOTE 1—Any type of untreated wood may be used for the preconditioning.

9.1.5 Record the time and weight for all fuel added.

9.1.6 Record the flue-gas temperature at least once during each 30 min of operation.

9.1.7 Periodically allow the fire to burn down completely. While the fireplace is still warm, shovel out all residual fuel, ash and other debris, lift the fireplace off the scale, re-zero the scale and return the fireplace to scale. Record the empty weight of the fireplace. Repeat this process of burning the fireplace and determining the empty weight until the weight becomes stable in accordance to the requirements of 9.1.

9.1.8 When the fireplace weight has stabilized or after at least 10 h of preconditioning fires for fireplaces without