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Standard Test Method for Test Fueling Masonry Heaters[1]

This standard is issued under the fixed designation E2817; 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 solid fuel biomass (cordwood or other densified, binder free biomass fuels) fires in masonry heaters. It may also be used to test other similar appliances (see 3.2.20).

1.2 This test method is applicable to the operation and fueling of masonry heaters during particulate emissions measurement test periods. The prescribed methods and procedures of these protocols are performed on masonry heaters installed and operated in accordance with the builder or manufacturer's specifications.

1.3 In conjunction with Test Method E2515, this test method provides a protocol for laboratory emissions testing of masonry heaters that is intended to simulate actual use in residential homes and other consumer applications. Since such actual use involves almost solely cordwood fueling, Annex A1, Cordwood Fuel, provides as close a simulation as is currently possible of consumer use, and is recommended for predicting actual consumer emissions performance. For regulatory and other potential uses in comparing relative emissions of various masonry heater products and designs, Annex A2, Cribwood Fueling, and Annex A3, Cribwood Fuel, Top-Down Burn, provide optional additional fueling protocols that substitute dimensional lumber cribs for the cordwood fuel. Data that establish the relationships between the emissions results generated by Annex A2 and Annex A3 and the emissions results generated by Annex A1 are not currently available.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.5 *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.*

1.6 *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

E1602 Guide for Construction of Solid Fuel Burning Masonry Heaters

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

2.2 *Other Standards:*

EN 15250 Slow Heat Release Appliances Fired By Solid Fuel-Requirements And Test Methods[3]

EN 15544 One Off Kachelgrundfen/Putzgrundfen (Tiled/Mortared Stoves): Calculation Method[3]

NIST Monograph 175 Standard Limits of Error[4]

US EPA Title 40 Code of Federal Regulations[5]

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 *ashpit loss, n*—the incomplete burned residue (charcoal) left with the ash after a test run is completed.

3.2.2 *burn rate, n*—the average rate at which test-fuel is consumed in a masonry heater during a test run. The burn rate excludes the inorganic salts and minerals (that is, "ash") and

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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 Deutsches Institut für Normung e.V.(DIN), Am DIN-Platz, Burggrafenstrasse 6, 10787 Berlin, Germany, http://www.din.de.

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

[5] Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460, http://www.epa.gov.

incompletely burned residues (charcoal) remaining at the end of a test run; measured in mass of dry wood burned per hour (kg/hour, lb/hour).

3.2.3 *calibration error, n*—the difference between the gas concentration displayed by a gas analyzer and the known concentration of the calibration gas when the calibration gas is introduced directly to the analyzer.

3.2.4 *calibration (span) drift, n*—the difference between the expected instrument's response and the actual instrument's response when a calibration (span) gas is introduced to the analyzer after a stated period of time has elapsed during which no maintenance, repair or adjustment has taken place:

$$\text{calibration (span) drift} = \left(\frac{(\text{actual response} - \text{expected response})}{\text{expected response}} \right) \times 100$$

3.2.5 *calibration (span) gas, n*—a known concentration of carbon dioxide (CO_2), carbon monoxide (CO), or oxygen (O_2) in nitrogen (N_2), or a combination thereof.

3.2.6 *combustion period emissions rate (ER_{CP}), n*—the particulate emissions rate during the masonry heater combustion period only (cf. *heating cycle emissions rate*).

3.2.7 *Douglas fir, n*—for crib fueling protocols; untreated, standard, or better grade Douglas fir lumber with agency grade stamp: D. Fir or Douglas Fir.

3.2.8 *firebox, n*—the chamber within the masonry heater where the fuel is placed and combusted.

3.2.9 *firebox length, n*—the longest horizontal fire chamber dimension where fuel pieces might reasonably be expected to be placed in accordance with the manufacturer's written instructions that is parallel to a wall of the chamber (in non orthogonal fireboxes the fuel load will be placed according to the builder or manufacturer's instructions or at the best judgment of the testing lab).

3.2.10 *firebox width, n*—the shortest horizontal fire chamber dimension where fuel pieces might reasonably be expected to be placed in accordance with the manufacturer's written instructions that is parallel to a wall of the chamber (in non orthogonal fireboxes the fuel load will be placed according to the builder or manufacturer's instructions or at the best judgment of the testing lab).

3.2.11 *firing interval (Θ_{FI}), n*—the period of time during which the stored heat energy is released prior to the next firing, as specified by the builder or manufacturer.

3.2.12 *flue-gas temperature, n*—the temperature measured at the primary flue-gas sampling and temperature measurement location: Pre-Test flue-gas temperature is measured at the Primary Flue-Gas Sampling and Temperature Measurement Location within 15 minutes before a test is initiated and at least 1 hour after the masonry heater was closed in accordance with 9.5.2.

3.2.13 *fuel crib, n*—the fuel load placed in the firebox prior to the test start. The fuel crib includes all of the kindling pieces, fuel pieces and spacers needed to assemble a fuel crib. Specific fuel crib configurations are described in Annex A2, Cribwood Fueling, or Annex A3, Cribwood Fuel, Top-Down Burn.

3.2.14 *fuel piece, n*—(*1*) *cordwood fuel*: triangularly split solid wood fuel: each piece shall be able to pass through a 152-mm (6-in.) hole while not passing through a 76-mm (3-in.) hole. Other cordwood cross sections shall be allowed if specified in the builder or manufacturer's instructions. (*2*) *crib fuel*: "2 × 2," "2 × 4," or "4 × 4" wood pieces used to construct fuel cribs: "2 × 2," "2 × 4," and "4 × 4" referring to the nominal width and depth dimensions for commonly available dimensional lumber. The actual dimensions are 38 mm × 38 mm (1½ in. × 1½ in.), 38 mm × 89 mm (1½ in. × 3½ in.) and 89 mm × 89 mm (3½ in. × 3½ in.).

3.2.15 *fuel weight, total, n*—(*1*) *cordwood*: the total weight of the kindling and fuel pieces used in a test run (the test load can be added as multiple fuel loadings if the builder or manufacturer indicates this in the operating instructions; no such individual fuel loading shall be less than 20 % of the total fuel weight). (*2*) *crib fuel*: the total weight of the kindling and fuel pieces and spacers.

3.2.16 *grate, n*—for the purposes of masonry heater testing and operation, any grate included with the masonry heater or specified by the masonry heater builder or manufacturer for the purpose of supplying combustion air, elevating the fuel load above the hearth, preventing fuel pieces from falling outside the intended burning area, or all of the above. The volume below a fuel-elevating grate shall not be considered part of the usable firebox volume.

3.2.17 *heating cycle emissions rate (ER_{HC}), n*—the effective particulate emissions over the heating cycle of the masonry heater. It is calculated based on the builder or manufacturer's specified period of time between firings in which the heat stored in the masonry heater radiates useful heat to the heated space (cf. *combustion period emissions rate*).

3.2.18 *internal assembly, n*—the core construction and firebox design factors that may affect combustion function or particulate emissions factor of a masonry heater.

3.2.19 *kindling brand, n*—the fuel comprised of fuel strips separated by air spaces and placed above or contiguous to crumpled newspaper to initiate combustion in the tested masonry heater (see Annex A2, Cribwood Fueling, or Annex A3, Cribwood Fuel, Top-Down Burn).

3.2.20 *masonry heater, n*—solid-fuel biomass burning appliance or unit as described in Guide E1602. This method may also be used in testing other appliances conforming to EN 15250 or EN 15544, or both, but not necessarily conforming to the Guide E1602 masonry heater definition.

3.2.21 *maximum flue-gas oxygen depression, n*—the difference between the baseline air supply oxygen concentration (that is, 20.9 %) and the lowest oxygen concentration measured and recorded during the test run or, alternatively, the difference between the base line air supply oxygen concentration (20.9 %) and the lowest oxygen measured and recorded during the test run determined by subtracting the maximum flue gas carbon dioxide (CO_2) and carbon monoxide (CO) values from 20.9 %:

$$\text{maximum } O_2 \text{ depression} = 20.9\,\% - \left[\%\,CO_2 + \left(\%\,\frac{CO}{2} \right) \right]$$

3.2.22 *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.

3.2.23 *primary flue-gas sampling and temperature measurement location, n*—area within the center 33 % of the cross-sectional area of the flue-gas exhaust duct at the point 30 cm (12 in.) downstream from the beginning of the flue collar or chimney system anchor plate or other connector used to connect the chimney to the masonry heater.

3.2.24 *response time, n*—the amount of time required for a gas measurement system to respond and display a 95 % step change in a gas concentration.

3.2.25 *sampling system bias, n*—the difference between the gas concentrations displayed by an analyzer when a gas of known concentration is introduced at the inlet of the sampling probe and the gas concentration displayed when the same gas is introduced directly to the analyzer.

3.2.26 *spacers, n*—wood pieces used to hold individual fuel pieces together when constructing 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).

3.2.27 *span (or span value), n*—the upper limit of a gas analyzer's measurement range. (Typically 25 % for CO_2 and O_2, and 5 % or 10 % for CO.)

3.2.28 *test facility, n*—the area in which the masonry heater is installed, operated, and sampled for emissions; may include commercial and residential structures.

3.2.29 *test-fuel loading factor, n*—the ratio between test-fuel crib volume, including kindling pieces and inter-fuel-piece spacing, and the usable firebox volume. For these protocols, the test-fuel loading factor for masonry heaters is 0.30 (that is, 30 %) unless otherwise specified.

3.2.30 *test run, n*—the time from the start of a test at ignition until the time flue-gas oxygen concentration has recovered to at least 95 % of the ambient oxygen concentration. A valid test must consume at least 90 % of the test fuel weight (see 9.5.8.2).

3.2.31 *test series, n*—a group of test runs at a lab on the same masonry heater.

3.2.32 *total sampling time (Θ), n*—the time that elapses between the start of the test as described in 9.5.3 and the end of the test as described in 9.5.7 (in minutes).

3.2.33 *usable firebox height, n*—the height within the firebox at or below which fuel is placed. The usable firebox height is to be specified by the builder or manufacturer. In the absence of a builder or manufacturer specification, the usable firebox height is the height of the top of the loading door.

3.2.34 *usable firebox volume (F_v), n*—the volumetric space within the firebox of a masonry heater into which fuel is intended to be placed.

3.2.35 *zero drift, n*—The difference between the expected instruments response and the actual instruments response when a zero gas is introduced to the analyzer after a stated period of time has elapsed during which no maintenance repair or adjustment has taken place:

$$\text{zero drift} = \left(\frac{(\text{actual response} - \text{expected response})}{\text{span}\ (\text{span value})}\right) \times 100$$

3.2.36 *zero gas, n*—a gas with no detectable (measurable) amounts of CO_2, CO, or O_2 (usually N_2), or a combination thereof.

4. Summary of Test Method

4.1 This test method is to be used in conjunction with Test Method E2515. The test masonry heater is constructed, fueled, and fired according to the builder or manufacturer's installation and operating instructions. In the absence of such written instructions, this test method provides defaults for the testing laboratory or other users to determine needed testing values.

4.2 The builder or manufacturer of the masonry heater being evaluated shall provide the following, as furnished to consumers or other end users:

4.2.1 Minimum and maximum designed heating capacity in kilowatts (BTU/hr),

4.2.2 Firing interval (hours),

4.2.3 Minimum and Maximum fuel load in kilograms (pounds),

4.2.4 Usable firebox dimensions in centimetres (inches) and volume in cubic centimetres (cubic inches),

4.2.5 Fuel piece length in centimetres (inches), and

4.2.6 A copy of the operating manual as furnished to consumers or other end users.

5. Significance and Use

5.1 This test method is used for determining emission factors and emission rates for cordwood or other densified, binder free biomass fuel burning masonry heaters.

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 masonry heaters, but must be used with caution as use patterns must be factored into any prediction of atmospheric particulate matter impacts from masonry heaters based on results from this method.

5.2 The reporting units are grams of particulate per kilogram of dry fuel (emissions factor), grams of particulate per hour of heating cycle (heating cycle emissions rate, based on the builder or manufacturer's specified firing interval), and grams of particulate per hour of test run (combustion period emissions rate, based on the tested combustion period).

5.3 **Warning—**Use of masonry heater emissions rate reporting numbers (grams per hour) for comparative purposes with other solid fuel burning appliances will require careful study of each of the appliance's comparative operating characteristics in the given application. Intermittently fired appliances such as masonry heaters and continuously fired appliances such as wood and pellet stoves are not accurately compared by their respective emissions rates.