Designation: E2618 – 13 (Reapproved 2019)

Standard Test Method for Measurement of Particulate Emissions and Heating Efficiency of Solid Fuel-Fired Hydronic Heating Appliances[1]

This standard is issued under the fixed designation E2618; 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 applies to wood-fired or automatically fed biomass burning hydronic heating appliances. These appliances transfer heat to the indoor environment through circulation of a liquid heat exchange media such as water or a water-antifreeze mixture.

1.2 The test method simulates hand loading of seasoned cordwood or fueling with a specified biomass fuel and measures particulate emissions and delivered heating efficiency at specified heat output rates based on the appliance's rated heating capacity.

1.3 Particulate emissions are measured by the dilution tunnel method as specified in Test Method E2515. Delivered efficiency is determined by measurement of the usable heat output (determined through measurement of the flow rate and temperature change of water circulated through a heat exchanger external to the appliance) and the heat input (determined from the mass of dry fuel burned and its higher heating value). Delivered efficiency does not attempt to account for pipeline loss.

1.4 Products covered by this test method include both pressurized and non-pressurized heating appliances intended to be fired with wood or automatically fed biomass fuels. These products are hydronic heating appliances which the manufacturer specifies for outdoor or indoor installation. They are often connected to a heat exchanger by insulated pipes and normally include a pump to circulate heated liquid. They are used to heat structures such as homes, barns, and greenhouses and can heat domestic hot water, spas, or swimming pools.

1.4.1 Hydronic heating systems that incorporate a high mass heat storage system that is capable of storing the entire heat output of a standard fuel load are tested by the procedure specified in Annex A1. Systems that incorporate high mass heat storage capable of storing a portion of the output from a standard fuel load are tested by the procedure specified in Annex A2.

1.5 Distinguishing features of products covered by this standard include:

1.5.1 Manufacturers specify indoor or outdoor installation.

1.5.2 A firebox with an access door for hand loading of fuel or a hopper and automated feed system for delivery of particulate fuel such as wood pellets or solid biomass fuel to a burn pot or combustion chamber.

1.5.3 Typically a thermostatic control device that controls combustion air supply or fuel delivery, or both, to maintain the liquid in the appliance within a predetermined temperature range provided sufficient fuel is available in the firebox or hopper.

1.5.4 A chimney or vent that exhausts combustion products from the appliance.

1.6 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.

1.6.1 *Exception*—Metric units are used in 13.1, 13.4.3, Tables 4-6, and A1.11.6.

1.7 *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.*

1.8 *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.*

[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. Referenced Documents

2.1 *ASTM Standards:*[2]

D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials

E631 Terminology of Building Constructions

E711 Test Method for Gross Calorific Value of Refuse-Derived Fuel by the Bomb Calorimeter (Withdrawn 2011)[3]

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

2.2 *Other Standards:*

CAN/CSA-B415.1-2010 Performance Testing of Solid-Fuel-Burning Heating Appliances[4]

ASME Pressure Vessel Code[5]

EN303–5 Pressure Vessel Code[6]

NIST Traceable Methods[7]

2.3 *Other Document:*[7]

Monograph 175 Temperature-Electromotive Force Reference Functions and Tables for the Letter-Designated Thermocouple Types Based on the ITS-90

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology E631, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *burn rate*—the rate at which test fuel is consumed in an appliance measured in kilograms or pounds of fuel (dry basis) per hour.

3.2.2 *delivered efficiency*—the percentage of heat available in a test fuel charge that is delivered to a simulated heating load as specified in this test method. This test does not account for jacket losses or for transfer line losses which will vary with actual application.

3.2.3 *firebox*—the chamber in the appliance in which the test fuel charge is placed and combusted.

3.2.4 *hydronic heating*—a heating system in which a heat source supplies energy to a liquid heat exchange media such as water that is circulated to a heating load and returned to the heat source through pipes.

3.2.5 *manufacturer's rated heat output capacity*—the value in Btu/h (MJ/h) that the manufacturer specifies a particular model of hydronic heating appliance is capable of supplying at its design capacity as verified by testing, in accordance with Section 12.

3.2.6 *overall efficiency, also known as stack loss efficiency*—The efficiency for each test run as determined using the CSA B415.1-2010 Stack Loss Method (SLM)

3.2.7 *test fuel charge*—a full load of fuel as specified in Section 12 placed in the appliance at the start of the emission test run or the mass of fuel consumed by automatically fed appliance during a test run.

3.2.8 *test run*—an individual emission test which encompasses the time required to consume the mass of the test fuel charge.

3.2.9 *thermostatic control*—a control device that opens, closes or modulates a circuit to control the rate of fuel consumption in response to the temperature of the heating media in the heating appliance.

4. Summary of Test Method

4.1 *Dilution Tunnel*—Emissions are determined using the "dilution tunnel" method specified in Test Method E2515. The flow rate in the dilution tunnel is maintained at a constant level throughout the test cycle and accurately measured. Samples of the dilution tunnel flow stream are extracted at a constant flow rate and drawn through high efficiency filters. The filters are dried and weighed before and after the test to determine the particulate emissions catch and this value is multiplied by the ratio of tunnel flow to filter flow to determine the total emissions produced in the test cycle.

4.2 *Efficiency:*

4.2.1 *Delivered Efficiency*—The efficiency test procedure takes advantage of the fact that this type of appliance delivers heat through circulation of the heated liquid (water) from the appliance to a remote heat exchanger and back to the appliance. Measurements of the water temperature difference as it enters and exits the heat exchanger along with the measured flow rate allow for an accurate determination of the useful heat output of the appliance. The input is determined by weight of the test fuel charge, adjusted for moisture content, multiplied by the higher heating value. Additional measurements of the appliance weight and temperature at the beginning and end of a test cycle are used to correct for heat stored in the appliance.

4.2.2 *Overall Efficiency*—Overall Efficiency (SLM) is determined using the CSA B415.1-2010 Stack Loss Method for data quality assurance purposes.

4.3 *Operation*—Appliance operation is conducted on a hot-to-hot test cycle meaning that the appliance is brought to operating temperature and a coal bed is established prior to the addition of the test fuel charge and measurements are made for each test fuel charge cycle. The measurements are made under constant heat draw conditions within predetermined ranges. No attempt is made to modulate the heat demand to simulate an indoor thermostat cycling on and off in response to changes in the indoor environment. Four test categories are used. These are:

4.3.1 *Category I*—A heat output of 15 % or less of Manufacturer's Rated Heat Output Capacity.

4.3.2 *Category II*—A heat output of 16 to 24 % of Manufacturer's Rated Heat Output Capacity.

[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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, http://www.csagroup.org.

[5] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

[6] Available from European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.

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

4.3.3 *Category III*—A heat output of 25 to 50 % of Manufacturer's Rated Heat Output Capacity.

4.3.4 *Category IV*—Manufacturer's Rated Heat Output Capacity.

5. Significance and Use

5.1 The measurement of particulate matter emission rates is an important test method widely used in the practice of air pollution control.

5.1.1 These measurements, when approved by federal or state agencies, are often required for the purpose of determining compliance with regulations and statutes.

5.1.2 The measurements made before and after design modifications are necessary to demonstrate the effectiveness of design changes in reducing emissions and make this standard an important tool in manufacturer's research and development programs.

5.2 Measurement of heating efficiency provides a uniform basis for comparison of product performance that is useful to the consumer. It is also required to relate emissions produced to the useful heat production.

5.3 This is a laboratory method and is not intended to be fully representative of all actual field use. It is recognized that users of hand-fired wood burning equipment have a great deal of influence over the performance of any wood-burning appliance. Some compromises in realism have been made in the interest of providing a reliable and repeatable test method.

6. Apparatus

6.1 *Scale*—A platform scale capable of weighing the appliance under test and associated parts and accessories when completely filled with water to an accuracy of ±1.0 lb (±0.5 kg).

6.2 *Heat Exchanger*—A water-to-water heat exchanger capable of dissipating the expected heat output from the system under test.

6.3 *Water Temperature Difference Measurement*—A Type -T "special limits" thermopile with a minimum of five pairs of junctions shall be used to measure the temperature difference in water entering and leaving the heat exchanger. The temperature difference measurement uncertainty of this type of thermopile is equal to or less than ±0.50 °F (±0.25 °C). Other temperature measurement methods may be used if the temperature difference measurement uncertainty is equal to or less than ±0.50 °F (±0.25 °C).

6.4 *Load Side Water Flow Meter*—A water flow meter shall be installed in the inlet to the load side of the heat exchanger. The flow meter shall have an accuracy of ±1 % of measured flow.

6.4.1 *Optional Appliance Side Water Flow Meter*—A water flow meter with an accuracy of ±1 % of the flow rate is recommended but not required to monitor appliance side water flow rate to the heat exchanger.

6.5 *Recirculation Pump*—Optional circulating pump used during test to prevent stratification of liquid being heated.

6.6 *Water Temperature Measurement*—Thermocouples or other temperature sensors to measure the water temperature at the inlet and outlet of the load side of the heat exchanger. Must meet the calibration requirements specified in 10.1.

6.7 *Wood Moisture Meter*—Calibrated electrical resistance meter capable of measuring test fuel moisture to within 2 % moisture content. Must meet the calibration requirements specified in 10.4.

6.8 *Flue Gas Temperature Measurement*—Must meet the requirements of CSA B415.1-2010, Clause 6.2.2.

6.9 *Test Room Temperature Measurement*—Must meet the requirements of CSA B415.1-2010, Clause 6.2.1.

6.10 *Flue Gas Composition Measurement*—Must meet the requirements of CSA B415.1-2010, Clauses 6.3.1 through 6.3.3.

7. Hazards

7.1 These tests involve combustion of solid fuel and substantial release of heat and products of combustion. The heating system also produces large quantities of very hot water and the potential for steam production and system pressurization. Pressurized (closed system) appliances must include an appropriately rated American Society of Mechanical Engineers (ASME) pressure relief device and a pressure vessel that complies with the ASME Pressure Vessel Code or EN303-5 pressure vessel code. Alternatively, a pressure vessel may be installed open to the atmosphere with a stand pipe if allowed by the manufacturer's installation instructions. Appropriate precautions must be taken to protect personnel from burn hazards and respiration of products of combustion.

8. Sampling, Test Specimens, and Test Appliances

8.1 Test specimens shall be supplied as complete appliances including all controls and accessories necessary for installation in the test facility. A full set of specifications and design and assembly drawings shall be provided when the product is to be placed under certification of a third-party agency. The manufacturer's written installation and operating instructions are to be used as a guide in the set up and testing of the appliance.

9. Preparation of Apparatus

9.1 The appliance is to be placed on a scale capable of weighing the appliance fully loaded with a resolution of ±1.0 lb (±0.5 kg).

9.2 The appliance shall be fitted with the type of chimney recommended or provided by the manufacture and extending to 15 ± 0.5 ft (4.6 ± 0.15 m) from the upper surface of the scale. If no flue or chimney system is recommended or provided connect the appliance to a flue of a diameter equal to the flue outlet of the appliance and extending 15 ± 0.5 ft (4.6 ± 0.15 m) from the top of the scale. For flue systems not provided by the manufacturer, the flue section from the appliance flue collar to 8 ± 0.5 ft (2.44 ± 0.15 m) above the scale shall be single wall stove pipe and the remainder of the flue shall be double wall insulated Class A chimney.