Wood-Fired Fireplace, Heating Fireplace, and Masonry Heater Thermal Performance Testing and Classification Standard

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PART I

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WOOD-FIRED FIREPLACE, HEATING FIREPLACE, and MASONRY HEATER THERMAL PERFORMANCE TESTING and CLASSIFICATION STANDARD

1.0 SCOPE. This Standard contains operating protocols and measurement procedures for testing wood-fired fireplace, heating fireplace and masonry heater thermal performance. Thermal performance results are then used to classify tested appliances as “non-heating fireplaces” (or just fireplaces), “heating fireplaces”, or “masonry heaters”. Administrative requirements of this Standard include specifications for manufacturing quality assurance (QA), labeling, tester qualifications, non-tested appliance classifications, and the record keeping fireplace, heating fireplace, and masonry heater manufacturers and builders must comply with for maintaining new appliance classifications.

2.0 DEFINITIONS. For the purpose of this Standard, the following definitions will apply as indicated:

2.1 Analyzer Calibration Error. The difference between the gas concentration exhibited by the gas analyzer and the known concentration of the calibration gas when the calibration gas is introduced directly to the analyzer.

2.2 Burn Rate. The average rate at which test-fuel is consumed in a fireplace, heating fireplace, or masonry heater during a test-burn period prescribed by this Standard measured in kilograms of wood (dry basis) burned per hour (kg/hour).

2.3 Calibration Drift. The difference in the analyzer reading from the initial calibration response at a mid-range calibration value after a stated period of operation during which no maintenance, repair, or adjustment took place.

2.4 Calibration Gas. A known concentration of oxygen (O_2) in nitrogen (N_2).

2.5 Certification or Certification Audit Test. The completion of at least one, three-fuel-load test-burn or test period in accordance with the operating and sampling procedures of this Standard.

2.6 Effective Flue-Gas Duct/Chimney Diameter. The effective chimney diameter of a circular flue-gas duct is the actual diameter. The effective diameter (ED) of a rectangular flue-gas duct is determined using the following equation:

$$ED = 2 \times (L \times W) / (L + W)$$

Where: L = Flue rectangular length.

W = Flue rectangular width.

2.7 Firebox. The chamber in a fireplace, heating fireplace, or masonry heater in which test-fuel charges are placed and burned.

2.8 Firebox Height. The vertical dimension measured from the firebox floor or hearth to the horizontal plane that intersects and is perpendicular to the top edge of the firebox opening through which fuel is loaded.

2.9 Firebox Volume. The multiplication product of the firebox length (as defined in Section 2.28.1), the firebox width or depth (as defined in Section 2.28.2) and the firebox height (as defined in Section 2.8).

2.10 Fireplaces, Heating Fireplaces, and Masonry Heaters. These units will be referred to as to be classified appliances throughout this Standard.

- Are exempt from Title 40 of the U.S. Code of Federal Regulations (CFR) Part 60, Subpart AAA,
- Have useable firebox volumes (as defined in 40CFR60, Subpart AAA) of less than 20 cubic feet (6.2 m^3), and
- Are not cook stoves, boilers, furnaces, or pellet stoves as defined in 40CFR60, Subpart AAA.

2.11 Appliance Design. The construction and/or fabrication specifications including all dimensions and materials required for manufacturing or building a classified appliance.

2.12 Hearth. The firebox floor area, within the firebox of an appliance upon which a fire may be, or is intended to be built (see Section 2.28).

2.13 Model Line. A series of appliance models having the same internal assembly, including flue-gas exhaust ducting and grate height above hearth. Each model in a model line can have different facade designs and external decorative features.

2.14 Flue-Gas Exhaust Duct. The connector pipe, chimney, or other duct form that conveys exhaust gases from the firebox to the atmosphere. For purposes of model line classification, the flue-gas exhaust duct is considered to be a component of a model line configuration. Flue-gas exhaust duct cross-sectional area is calculated using duct dimensions measured at the narrowest point downstream from the horizontal plane which intersects the top-most edge of the firebox.

2.15 Grate Height Above Hearth. A measure of the vertical distance between the hearth floor and the bottom of a grate. It is the space under which and through which combustion air can pass into the fuel load being supported by the grate. For purposes of model line classification, the grate height above the hearth is considered to be a component of a model, model line, or design configuration.

2.16 Hearth Grate. A non-combustible structure capable of elevating and supporting a fuel load above the hearth of an appliance while offering no impedance to the passage of combustion air up to and through the fuel load.

2.17 Horizontal Flue-Gas Pathway. The total net horizontal-duct centerline distance measured from the point where the vertical centerline of the flue-gas exhaust duct from the firebox intersects the horizontal plane of the firebox height (i.e., See Section 2.8) to the point where the centerline of the exhaust duct exit to the atmosphere intersects the horizontal plane at the termination or vertical extent (i.e., height) of the exhaust duct (i.e., the point at which flue-gases exit to the atmosphere). For the purposes of this Standard, horizontal shall mean any amount of duct centerline traverse that is created by any angle which is either more or less than 90 degrees vertical.

2.18 Internal Assembly. The core construction and firebox design which produce the same combustion function and overall thermal efficiency of an appliance model line.

2.19 Minimum Flue-Gas Oxygen Concentration. The lowest recorded concentration of oxygen below the baseline ambient air supply oxygen concentration (i.e., 20.9% for this Standard) that occurs during the burning of a test-fuel load.

2.20 Pretest Flue-Gas Temperature. The temperature measured at the primary flue-gas sampling and measurement location one hour after a test appliance is closed in accordance with Section 5.8.2.

2.21 Response Time. The amount of time required for a gas sampling and measurement system to respond and display 90 percent of a step change in gas concentration.

2.22 Sampling System Bias. 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 gas of known concentration is introduced directly to the analyzer.

2.23 Span. The upper limit of the gas concentration measurement range (see Section 5.3.7).

2.24 Test-Burn or Test Period. The time required to consume at least 90 percent of the mass of three consecutively burned test-fuel loads.

2.25 Test Facility. The building enclosure in which the appliance is installed, operated, and sampled for emissions.

2.26 Test-Fuel Loading Factor. The factor is 7.0 wet-weight pounds of test fuel per square foot (0.30 kg/m^2) of usable appliance hearth area.

2.27 Thermal Efficiency.

2.27.1 Combustion Efficiency. A measure of the completeness of the chemical oxidizing and reducing reactions taking place within the fuel and between the fuel and oxygen during combustion. Combustion efficiency is expressed as the percentage of the total heat potential of the fuel which is actually converted to heat energy**.** For the purpose of this Standard combustion efficiency shall be 97%.

2.27.2 Heat Transfer Efficiency. A measure of how much of the heat produced by the chemical combustion reaction processes is transferred from a firebox into the mass of the appliance and/or into the room in which the appliance is located. Heat transfer efficiency is expressed as a percentage of the heat produced in the firebox and transferred into the mass of the appliance and/or the room in which the appliance is located.

2.27.3 Overall Thermal Efficiency. A measure of how much of the heat potential of fuel is absorbed into the mass of the appliance and/or reaches the room in which the appliance is located. It is expressed as that percentage of the total heat potential of the fuel absorbed into the mass of the appliance and/or reaches the room in which the appliance is located. Overall thermal efficiency is calculated as the multiplication product of the combustion efficiency and the heat transfer efficiency of an appliance.

2.28 Usable Firebox or Hearth Area. The firebox floor (or hearth) area, within the fire chamber of an appliance upon which a fire may be, or is intended to be built. Usable firebox area is calculated using the following definitions:

2.28.1 Length. The longest horizontal fire chamber dimension along the floor of the firebox that is parallel to a wall of the fire chamber.

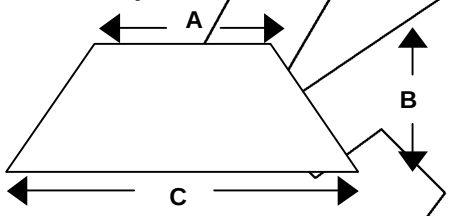
2.28.2 Width or Depth. The shortest horizontal fire chamber dimension along the floor of the firebox that is parallel to a wall of the fire chamber.

2.28.3 Angled/Curved Firebox Walls/Sides. For angled or curved firebox walls and/or sides, the effective usable firebox area shall be determined by calculating the sum of standard geometric areas or sub-areas of the firebox floor capable of supporting fuel load mass.

2.28.4 Floor Versus Hearth Area. If an appliance has a larger floor area within the fire chamber than the area upon which it is intended that fuel be placed and burned, the usable firebox area shall be calculated as the sum of standard geometric areas or sub-areas of the area intended for fuel placement and burning.

2.28.5 Grates. For grates which elevate the fuel above the firebox floor, the useable firebox area includes all geometric sub-areas within the total grate area or "foot print circumscribed by the connection of all of the outer edges of the most outer grate projections. Usable firebox hearth areas determined in this manner shall be multiplied by a factor of 1.5. The weight of test-fuel charges for grate-based useable-firebox-area tests shall not exceed the weight of test-fuel charges determined for the entire available appliance floor/hearth area.

2.28.6 Example Calculation for Trapezoidal Hearth/Grate. The area of a trapezoidal hearth or grate is determined using the following equation:



$$\text{Area} = (A \times B) + \left(\frac{(C-A)*B}{2}\right)$$

2.29 Vertical Flue-Gas Pathway. The total vertical duct centerline distance measured from the point where the vertical centerline of the flue-gas exit duct from the firebox intersects the horizontal plane of the firebox height (i.e., See Section 2.8) to the point where the centerline of the exhaust duct exit to the atmosphere intersects the horizontal plane located at the total vertical extent (i.e., height) of the exhaust duct at the flue-gas exit to the atmosphere. For the purpose of this Standard, horizontal shall mean any amount of duct centerline traverse that is created by any angle either more or less than 90^{o} or 270^{o} from vertical. The length of a downward vertical flue-gas pathway is the total sum of all vertical flue-gas pathway distances (upward and downward flow directions) minus the total vertical distance measured from the horizontal plane of the firebox height to the total vertical extent of the flue-gas exit duct to the atmosphere.

2.30 Zero Drift. The difference between the initial gas analyzer calibration response at a zero concentration level and the calibration response at the zero concentration level after a 4-hour period of instrument operation during which no maintenance, repair, or adjustment took place.

3.0 Appliance Classification Requirements.

3.1 Wood-Burning Fireplace, Heating Fireplace, and Masonry Heater Classifications.

3.1.1 Masonry Heaters. A wood-burning appliance meeting the specifications contained in Section 2.10 and tested in accordance with the protocols of this Standard shall have a measured overall thermal efficiency equal to or greater than 50.0%

3.1.2 Heating Fireplaces. A wood-burning appliance meeting the specifications contained in Section 2.10 and tested in accordance with the protocols of this Standard shall have a measured overall thermal efficiency equal to or greater than 25.0% and less than 50.0%.

3.1.3 Fireplaces. A wood-burning appliance meeting the specification contained in Section 2.10 and tested in accordance with the protocols of this Standard shall have a measured overall thermal efficiency of less than 25.0% but no less than 0.0%.

3.2 Tester Requirements. In order to "certify" the results obtained by performance of the requirements of this Standard the tester shall be accredited or certified in at least one of the following categories:

3.2.1 U.S. EPA. By the U.S. Environmental Protection Agency (EPA) for testing wood-burning residential space heaters in accordance with *40 CFR Part 60, Subpart AAA, Section 60.535*, **or**

3.2.2 ISO. By an Accrediting Body Evaluation Program (ABEP)-approved accreditation organization to the International Standards Organization (ISO) Guide 25 standard for *General Requirements for The Competence of Calibration and Testing Laboratories: 1990(E)*. The ABEP-approved accreditation organization shall meet the requirements of the ISO Guide 58 standard for *General Requirements for Accreditation Organizations*. (Note: ABEP is a program of the U.S. National Institute of Standards and Technology (NIST)), **or**

3.2.3 Chimney Safety Institute of America. By the Chimney Safety Institute of America as a CSIA Certified Chimney Sweep with a specific endorsement for competence in conducting the requirements of this Standard.

3.3 Classification Termination.

3.3.1 Five-Year Renewal. All appliance model, model line and design classifications shall terminate five years from the classification date. Previously classified appliance models, model lines, and/or designs may be granted re-approval upon review by an accredited tester (see Section 3.2). The review shall determine whether the previously classified appliance model, model line, or design meets all applicable regulations in effect at the time of the application model, model line, or design for re-approval. No testing shall be required for appliance model, model line or design re-approvals unless the accredited tester determines that:

- Design changes have been incorporated into the appliance model, model line, or design that exceed the acceptance criteria for Non-Tested Appliances contained in Section 4.2,
- The testing requirements of this Standard have been changed, or

3.3.2 Noncompliance. The accredited tester may revoke the classification of an appliance model, model line and/or design if it is determined that a appliance model, model line, or design being produced does not comply with the requirements of this Standard. Such a determination shall be based on all available evidence, including but not limited to:

3.3.2.1 Retest Data. Test data from retesting (i.e., an "audit" test) of the original unit on which the certification test was conducted or a sample unit from the current model, model line, or design.

3.3.2.2 Invalid Test. A finding that the certification test upon which the tester relied for classifying an appliance model, model line and/or design was not valid.

3.3.2.3 Labeling. A finding that the labeling of the appliance model, model line, or design does not comply with the requirements in Section 3.5.

3.3.2.4 Reporting and Record Keeping Requirements. Failure by the appliance manufacturer or builder to comply with reporting and record keeping requirements under Sections 3.4 and 8.0.

3.3.2.5 Physical Examination. Results of a physical examination shows that a significant percentage of inspected appliances are not similar in all material respects to the appliance submitted for certification testing (i.e., meets the requirements of Section 4.2.

3.3.2.6 Quality Assurance. Failure of the manufacturer or builder to conduct a quality assurance program in conformance with Section 3.4.

3.3.3 Notification. Revocation of classification under this section shall not take effect until the appliance manufacturer or builder concerned has been given written notice by the accredited tester setting forth the basis for revocation. The appliance manufacturer or builder concerned shall have 30 calendar days from the written-notice date to request a hearing to appeal the revocation.

3.4 Appliance Quality Control.

3.4.1 Inspections. Within 30 days of each annual anniversary of the initial classification of an appliance model, model line, or design, an authorized representative of the accredited tester that tested the appliance model, model line, or design shall inspect a sample of the most recently produced appliance at its manufacturing location (or site, if site-built) to document adherence to the classified appliance design within the allowed deviation specifications contained in Section 4.2 and the labeling specifications of Section 3.5.

3.4.1.1 No Production. If no appliances of a classified model, model line or design were produced or built during the previous 12-month period, no inspection is required. However, an affidavit documenting that no appliances of the classified model, model line or design were produced during the previous 12-month period must be signed by an authorized representative of the appliance manufacturer or builder (if site-built).

3.4.1.2 Inspection Report. An inspection report for each classified appliance model, model line and/or design must be documented within 30 days after the inspection date. The inspection report shall include, as a minimum, the model identification and serial number of the appliance inspected, the location where the model was inspected, the names of the manufacturer's and/or builder's representatives present, the date of inspection, and a description of any changes made to the classified appliance model, model line or design since the last inspection. The accredited tester which conducts the annual quality control

inspection is responsible for auditing the content and format of all labels to be applied to classified appliances as stipulated in Section 3.5.

3.4.1.3 Re-testing. An appliance shall be re-tested in accordance with this Standard if it is determined during inspection that a design change has been incorporated into the classified appliance's internal assembly which may adversely affect its overall thermal efficiency. Any and all appliance design changes shall cause the subject appliance to be considered as "affecting its thermal efficiency and shall be deemed a "non-tested" appliance. In order to qualify for continued classification without re-testing, the previously classified, non-tested appliance, shall comply with all of the dimensional, proportionality, and construction material comparison criteria contained in Section 4.2.

3.5 Permanent Label and Owner's Manual.

3.5.1 Labels and Owner's Manual. A permanent label and an owner's manual shall be prepared and installed in all classified "For Sale" fireplaces, heating fireplaces, or masonry heaters as specified in Section 7.0.

4.0 Classification of Non-Tested Appliances. This Standard can be used to classify a model, model line, or design (as defined in Sections 2.11 and 2.13) that has not been tested pursuant to this Standard when compared to a tested model, model line, or design. A report shall be developed with the following information:

4.1 Appliance Specifications. The candidate non-tested appliance manufacturer's name, street address, model identification, all construction specifications, drawings of the firebox and internal assembly system, and all specifications required for chimney systems and emission control devices.

4.2 Tester Documentation. Documentation from an accredited tester (see Section 3.2) that the candidate non-tested model, model line, or design is a fireplace, heating fireplace or masonry heater within the definition of this Standard, has the same internal assembly as a model, model line, or design already tested by an accredited tester, and is substantially similar to a tested model, model line, or design in combustion function, and probable thermal efficiency as required by this Standard. A non-tested model, model line, or design shall be deemed to have the same "internal assembly" and be "substantially similar" to a tested and classified model, model line, or design in combustion function, and probable efficiency as required by this Standard if the non-tested model, model line, or design meets all of the following acceptance criteria when compared to a tested model, model line, or design (see Appendix A for an example):

4.2.1 Hearth Area. The proportionality between the hearth area (as defined in Section 2.28) of the non-tested model, model line, or design and the hearth area of the tested model, model line, or design shall be more than 64% and less than 121% of the tested model's, model line's, or design's hearth area.

4.2.2 Firebox Volume. The proportionality between the firebox volume of the non-tested model, model line, or design and the hearth area of the tested model, model line, or design shall be more than 51% and less than 133% of the tested model's, model line's, or design's firebox volume.

4.2.3 Grate Area. The proportionality between the grate area (as defined in Section 2.28.5) of the non-tested model, model line, or design and the grate area of the tested model, model line, or design shall be more than 64% and less than 121% of the tested model's, model line's, or design's grate area.

4.2.4 Grate Height Above the Hearth. The proportionality between the grate height above the hearth (as defined in Section 2.15) of the non-tested model, model line, or design and the grate height above the hearth of the tested model, model line, or design shall be more than 80% and less than 110% of the tested model's, model line's, or design's grate height above the hearth.

4.2.5 Downward (Vertical) Distance Of Flue-Gas Pathway. The proportionality between the downward "vertical" distance of the flue-gas pathway (as defined in Section 2.29) of the non-tested model, model line, or design and the downward vertical distance of the flue-gas pathway of the tested model, model line, or design shall be more than 80% and less than 115% of the tested model's, model line's, or design's downward vertical distance of the flue-gas pathway.

4.2.6 Horizontal Distance Of Flue-Gas Pathway. The proportionality between the horizontal distance of the flue-gas pathway (as defined in Section 2.17) of the model, model line, or design and the horizontal distance of the flue-gas pathway of the tested model, model line, or design shall be more than 80% and less than 110% of the tested model's, model line's, or design's horizontal distance of the flue-gas pathway.

4.2.7 Flue-Gas Exhaust Duct Location. The location of the flue-gas exhaust duct of the non-tested model, model line, or design must be in the same location as the tested model, model line, or design (e.g., top-center, rear-center).

4.2.8 Cross-Sectional Area Of Flue-Gas Exhaust Duct. The proportionality between the cross-sectional area of the flue-gas exhaust duct (as defined in Section 2.14) of the non-tested model, model line, or design and the cross-sectional area of the flue-gas exhaust duct at the exit from the firebox of the tested model, model line, or design shall be more than 51% and less than 133% of the tested model's, model line's, or design's cross-sectional area of the flue-gas exhaust duct at the exit from the firebox.

4.2.9 Ratio Of Total Grate Area To Total Hearth Area. The proportionality between the ratio of the total grate area to total hearth area of the non-tested model, model line, or design and the ratio of the total grate area to the total hearth area of the tested model, model line, or design shall be more than 80% and less than 110% of the tested model's, model line's, or design's ratio of total grate area to total hearth area.

4.2.10 Firebox Volume Proportionality And Hearth Area Proportionality. As a percentage of the firebox volume proportionality, the ratio between the firebox volume proportionality and the hearth area proportionality of the tested and non-tested models, model lines, or designs shall be more than 80% and less than 110% of the tested model's, model line's, or design's firebox volume proportionality.

4.2.11 Firebox Volume Proportionality And Downward Flue-Gas Pathway Proportionality. As a percentage of the firebox volume proportionality, the ratio between the firebox volume proportionality and the downward flue-gas pathway proportionality of the tested and non-tested models, model lines, or designs shall be more than 80% and less than 110% of the tested model's, model line's, or design's firebox volume proportionality.

4.2.12 Firebox Volume Proportionality And Horizontal Flue-Gas Pathway Proportionality. As a percentage of the firebox volume proportionality, the ratio between the firebox volume proportionality and the horizontal flue-gas pathway proportionality of the tested and non-tested models, model lines, or designs shall be more than 80% and less than 110% of the tested model's, model line's, or design's firebox volume proportionality.

4.2.13 Firebox Volume Proportionality And Flue-Gas Exhaust Cross-Sectional Area Proportionality. As a percentage of the firebox volume proportionality, the ratio between the firebox volume proportionality and the flue-gas exhaust cross-sectional area proportionality of the tested and non-tested models, model lines, or designs shall be more than 80% and less than 110% of the tested model's, model line's, or design's firebox volume proportionality.

4.2.14 Firebox Grate Proportionality And Flue-Gas Exhaust Cross-Sectional Area Proportionality. As a percentage of the firebox grate proportionality, the ratio between the firebox grate proportionality and the flue-gas exhaust cross-sectional area proportionality of the tested and non-tested models, model lines, or designs shall be more than 80% and less than 110% of the tested model's, model line's, or design's firebox grate proportionality.

4.2.15 Firebox Front/Back, Front/Depth, and Front/Height Ratios. The standard deviation of the firebox front/back, front/depth, and front/height ratio proportionalities (expressed as a percentages of the tested model's, model line's, or design's respective dimensions) shall be less than 10% of the average of the firebox front/back, front/depth and front/height ratio proportionalities.

4.2.16 Construction Materials. Construction materials for fabricating or building all of the internal assembly components of a non-tested model, model line, or design shall be identical in all respects to the materials used to fabricate or build the tested model, model line, or design.

4.3 Tested Appliance Test Report. A copy of, or appropriate reference information for, the original test report for the -tested internal assembly system.

4.4 Notarized Affidavit of Ownership. A notarized affidavit of ownership shall be provided for the already-tested model, model line, or design used as the basis of comparison to a non-tested model, model line or design. Alternatively, an owner of a tested model, model line, or design shall submit a notarized affidavit of ownership along with an additional notarized affidavit stating the owner's approval for allowing the use of his or her tested model, model line, or design as the basis of comparison to a specified non-owned, non-tested model, model line, or design.

5.0 TESTING.

5.1 Applicability. The methods described in this section are applicable for establishing thermal efficiency for fireplaces, heating fireplaces, and masonry heaters.

5.2 Principle. Thermal performance is a measure of the amount of total fuel heat potential converted to useful heating of the room(s) in which an appliance is installed. Thermal performance measurements are made on an appliance installed and operated in accordance with the specific methods of this Standard. Overall thermal efficiency is the

arithmetic product of chemical combustion efficiency and heat transfer efficiency. For this test Standard, a default chemical heat loss value of 3.0% of the total fuel heat potential is assigned (i.e., a chemical or combustion efficiency of 97.0%). The default chemical heat loss value of 3.0% includes the higher heating values of flue-gas carbon monoxide and incompletely burned volatile, semi-volatile, and solid carbonaceous materials. Total sensible and latent heat losses are determined from measured flue-gas oxygen concentrations and temperatures, the measured fuel burn rate, and calculated flue-gas moisture concentrations.

5.3 Test Apparatus. The following test apparatus is required for performing the thermal efficiency measurement procedures contained in this Standard:

5.3.1 Appliance Temperature Sensors. Device(s) capable of measuring flue-gas temperature to within 1.0 percent of expected absolute temperature values. These monitors are to be sited in accordance with Sections 5.6.2.

5.3.2 Test Facility Temperature Sensor. A device located centrally in a vertically oriented pipe-shield 6 inches (150 mm) long and 2 inches (50 mm) inside diameter that is open at both ends and capable of measuring air temperature to within 1.0 percent of expected absolute temperature values. These monitors are to be sited in accordance with Section 5.8.7.

5.3.3 Wood-Fuel Moisture Meter. Calibrated electrical resistance meter for measuring test-fuel moisture to within 1 percent moisture content (dry basis).

5.3.4 Anemometer. Device capable of detecting air velocities of less than 20 feet/minute (0.10 meters/second), for measuring air velocities near the appliance being tested.

5.3.5 Barometer. Barometer, capable of measuring atmospheric pressure to within 0.1-inch (2.5 mm) of mercury.

5.3.6 Draft Gauge. Electro-manometer or inclined liquid manometer for the determination of flue draft (i.e., static pressure) readable to within 0.01 inches of water column (0.50 Pa).

5.3.7 Flue-Gas Oxygen Analyzer. A combustion gas analyzer for measuring oxygen (O_2) in the range of 0.0 to 25.0% shall be used for conducting the gas analysis requirements. The gas analyzer must meet the following measurement system performance specifications:

5.3.7.1 Analyzer Calibration Error. Shall be less than ±2% of the span value for the zero, low-range, mid-range and high-range calibration gases.

5.3.7.2 Sampling System Bias. Shall be less than ±3% of the span value for the zero, low-range, mid-range and high-range calibration gases.

5.3.7.3 Zero Drift. Shall be less than ±2% of the span value over the time of each test period.

5.3.7.4 Calibration Drift. Shall be less than ±2% of the span value over the time of each test period

5.3.7.5 Response Time. Shall be less than 1.5 minutes.

5.4 Sampling Supplies and Reagents.

5.4.1 Calibration Gases. Oxygen calibration gas shall have concentrations at each of the nominal levels indicated in Table 5.4.1.

Table 5.4.1	
Flue-Gas Oxygen Analyzer Calibration Level	**O_2 Concentration (Approximate Volume Percent)**
High-Level	20%
Mid-Level	14%
Zero	0%

Note 1: All calibration gas mixtures shall be certified by the calibration gas supplier.

5.5 Calibration and Test Instrument Audit Requirements.

5.5.1 Scale. Within 3 hours before a test period, the scale used for weighing test-fuel charges shall be audited by weighing at least one calibration weight (Class F) that is in the range of 20 percent to 80 percent of the expected test-fuel charge weight. If the scale cannot reproduce the value of the calibration weight within 0.1 pound (0.05 kg) or 1 percent of the expected test-fuel charge weight, whichever is greater, re-calibrate the scale before use with at least five calibration weights spanning the operational range of the scale.

5.5.2 Temperature Monitor. Calibrate the temperature monitor before the first test period and semiannually thereafter.

5.5.3 Fuel Moisture Meter. Calibrate the fuel moisture meter in accordance with the manufacturer's instructions within 1 hour before measuring fuel moisture.

5.5.4 Anemometer. Calibrate the anemometer in accordance with the manufacturer's instructions before the first test period and semiannually thereafter.

5.5.5 Barometer. Calibrate the barometer against a mercury barometer before the first test period and semiannually thereafter.

5.5.6 Draft Gauge. Calibrate the draft gauge in accordance with the manufacturer's instructions before the first test period and semiannually thereafter.

Note: An inclined liquid manometer does not require calibration but must be checked for level (zero tilt) before each test period.

5.5.7 Sample Gas Flow Meters. Sample gas flow meters shall be calibrated once before the first test period and semiannually thereafter or once after every 10 tests whichever occurs first.

5.6 Test Appliance Preparations.

5.6.1 Appliance Installation. The appliance being tested must be constructed, on site, in accordance with the designer's/manufacturer's written instructions. The chimney shall have a total vertical height above the hearth of not less than 15 feet (4.6 m). The appliance flue/chimney exit to the atmosphere must be freely communicating with the appliance combustion makeup-air source. There shall be no artificial atmospheric pressure differential imposed between the chimney exit to the atmosphere and the

appliance make-up air inlet. The flue/chimney configuration and grate height above hearth shall be noted for purposes of model, model line, or design identification.

5.6.2 Thermal Efficiency Temperature Measurement Location. A thermal efficiency temperature probe is to be located at the 8-foot (2.44m) level of the appliance in order to obtain data which is representative of where the last possible thermal donation would occur in a standard 8-foot (2.44m) high room. This shall be referred to as the thermal efficiency temperature probe. It is conceivable and allowable that the primary temperature probe could be substituted for the thermal efficiency temperature probe when the primary sampling location is within one equivalent flue/chimney diameter of the 8-foot (2.44m) level in the flue exhaust duct.

5.6.2.1 Secondary Temperature Measurement Location. A secondary temperature probe shall be required if the appliance is equipped with an emissions control device located in the flue, downstream from the appliance firebox. This probe shall be positioned one equivalent flue/chimney diameter upstream from the flue-gas inlet to the emission control device. This location shall be referred to as the secondary sampling location and these measurements shall be referred to as secondary temperature readings.

5.6.3 Heat-Aging and Curing. An appliance of any type shall be aged before certification testing begins. The aging procedure shall be conducted and documented by the accredited tester.

5.6.3.1 Catalyst- And/Or Add-On Emissions Control Device-Equipped Appliance. Operate a catalyst- and/or add-on emissions control-equipped appliance using fuel described in Section 5.7 for at least 50 hours prior to conducting testing. Record and report the hours of operation, hourly catalyst exit temperatures, add-on emissions control equipment operating parameters, flue-gas temperatures, and the weight of all fuel burned during the heat-aging and curing period.

5.6.3.2 Non-Catalyst- And/Or Non-Add-On Emissions Control- Equipped Appliance. Operate the appliance using the fuel described in Section 5.7 for at least 10 hours. Record and report the hours of operation, flue-gas temperatures and weight of all fuel burned during the aging and curing period.

5.6.4 Flue-Gas Stratification Check. During the last five hours of the aging and curing period specified in Section 5.6.3, use the flue-gas oxygen analyzer and sampling system specified in Section 5.3.7 to determine whether flue gases become stratified in the flue/chimney cross-section at the sampling location.

5.6.4.1 Flue-Gas Stratification Procedure. Stratification of flue-gas oxygen concentrations shall be determined by first sampling at the center of the flue duct for at least one minute and then moving the sampling probe to within 1 inch (25.4mm) of the flue duct wall for an additional minute. This procedure is to be repeated on at least two traverses of the flue duct that are 90^{o} from each other. Flue-gas oxygen concentration changes of more than 15% (i.e., 15% of the oxygen concentration measured) when the sample probe is moved from the center of the flue duct to within 1 inch (25.4 mm) of the flue duct wall shall be considered stratified.

5.6.4.2 Flue-Gas Stratification Remedies. The presence of a stratified flue-gas at the flue/chimney sampling location shall be remedied by either changing the flue/chimney duct design, changing the flue-gas sampling location, or changing the flue-gas sampling probe to equally and simultaneously sample the flue-gases in the center of at least 4 separate and equal areas of the flue/chimney cross-section.

5.7 Test Fuel. Test fuel pieces shall consist of air-dried Douglas fir 3½ x 3½inch (89 x 89-mm) and 3½ x 2-inch (89 x 51-mm) actual-dimensioned lumber. Fuel pieces shall not be less than ½ or more than $^5/_6$ of the length of the average fire chamber width or not more than 1.5 times the average grate width if a grate is used in the firebox. The moisture content of each piece of fuel, as measured at a depth of one inch (25 mm), shall be in the range of 16 to 20 percent wet basis (19 to 25 percent dry basis).

5.7.1 Test-Fuel Charges. The total wet weight of each test-fuel load shall be calculated by multiplying the useable firebox floor or hearth area (see definition in Section 2.28), in square feet, by 7.0 pounds per square foot (square meters of hearth area x 0.30 kg/m^2). Three equal (± 5%) test-fuel crib loads shall be prepared for each test-burn.

5.7.2 Test-Fuel Cribs. The test-fuel pieces specified in Section 5.7.1 shall be constructed into fuel-load "cribs" utilizing ¾ x 1½inch (19 x 38-mm) Douglas fir spacers. Spacer moisture content is not specified. Test-fuel cribs shall consist of at least two layers of fuel pieces with ¾inch (19-mm) spacing between all fuel pieces. The bottom fuel-crib layer shall consist entirely of 3½ x 2-inch (89 x 51 mm) fuel pieces nailed parallel to each other with ¾inch (19-mm) spacing between them and with their 3½inch (89-mm) sides positioned vertically. The second, third, and higher fuel crib layers shall consist entirely of 3½ x 3½inch (89 x 89-mm) fuel pieces nailed together with the same spacers as specified for the first crib layer.

5.7.3 Test-Fuel Crib Spacer Attachment. The ¾inch (19-mm) spacing between the parallel pieces shall be made by nailing, with 18 gauge x 1¼inch finishing brads, ¾ x 1½ x 3½inch (19 x 38 x 89-mm) spacers flush with each end and on alternating facing sides of each fuel piece. No spacers are to be attached to fuel piece faces located on the outer faces of the fuel crib. Spacing between fuel crib layers shall also be accomplished by nailing, with 18 gauge x 1¼inch finishing brads, one crib-depth (front-to-back) length of the ¾ x 1½inch (19 x 38-mm) spacer wood flush with each end and on the bottom of each of the next highest crib layers.

5.7.4 Kindling. Fifty percent of the kindling-fuel weight shall consist of Douglas fir ¾ x 1½inch (19 x 38-mm) and 50% of Douglas fir ¾ x ¾inch (19 x 19-mm) dimensional lumber. The moisture content of the kindling fuel is not specified. The initial fuel load of each three fuel-load test-burn period shall be started by using a kindling-fuel load which is 25% ± 5% of the first test-fuel load weight. The first kindling-fuel load weight is not part of the initial test-fuel load weight but is in addition to it and is used in calculating total fuel used for the test period.

5.8 Pretest Preparations.

5.8.1 Cooling Period. No fuel shall be burned in the test appliance and no other means for heating the appliance may be used within 12 hours preceding the start of a test period.

5.8.2 Pre-Test Flue-Gas Temperature Determination. At least one hour before initiating a test period (i.e., ignition of a fire in the appliance), close all air supply controls appliance door(s). If the appliance is not equipped with a door(s), use other means for closing the open face area of the appliance. After one hour of closure and within 10.0 minutes of opening the appliance for test-fire ignition, measure and record the pre-test flue-gas temperature at the thermal efficiency temperature location or the secondary sampling location whichever is closer to the hearth floor.

5.8.3 Appliance Description. Record appliance and, if equipped, catalyst and/or add-on emissions control device descriptions. The appliance description shall include photographs showing all externally observable features and drawings showing all internal and external dimensions needed for fabrication and/or construction. The drawings must be verified as representing the appliance being tested and signed by an authorized representative of the testing laboratory.

5.8.4 Test Fuel Description. Record test-fuel charge dimensions, moisture content, and weights.

5.8.5 Leak Checks. A pre-analysis leak check of the oxygen analyzer train is recommended to be performed within 2.0 hours before each test period initiation. A post-analysis leak check is mandatory at the conclusion of the sample analysis.

5.8.5.1 Leak-Check Procedure. Seal the sample inlet probe nozzle for each sampling system or train. Use the sample pump controls to create a vacuum greater than either twice the maximum vacuum encountered during test period sampling, or 5 inches (125 mm) of mercury, whichever is greater. Record the resulting sample flow rate indicated by the instrument flow meter when the required vacuum is achieved, corrected for system pressure, if applicable.

5.8.5.2 Leak Check Acceptance Criteria. If the vacuum leakage rate is found to be in excess of 2% of the average test-period sampling rate the test results shall be invalid.

5.8.6 Room-Air Velocity. Using an anemometer, measure and record the room-air velocity within 2 feet (0.6 meters) of the test appliance within 1 hour before test initiation. Air velocity within 2 feet (0.6 meters) of the test appliance shall be less than 50 feet/minute (250 mm/second). No external means shall be used to affect air velocities within 2 feet (0.6 meters) of the test appliance during a test period.

5.8.7 Test Facility Ambient Temperature Probe. Locate the test-facility ambient temperature probe on the horizontal plane that includes the primary air intake opening for the appliance. Locate the temperature monitor probe at a distance of 3 to 6 feet (1.0 to 2.0 meters) from the front of the appliance and in a 90º sector which is defined by lines drawn at ±45º from a perpendicular line to centerline of the appliance face.

5.8.8 Barometric Pressure. Measure and record the barometric pressure within 1 hour before test period initiation.

5.9 Appliance Operation and Testing Protocols.

5.9.1 Required Test Configurations. One, three fuel-load test period shall be conducted for each of the following operating configurations:

- Door(s) closed, with hearth grate;

- Door(s) open, with hearth grate;

5.9.1.1 Closed-Door(s) Testing. For all closed-door test configurations, the fuel loading door(s) shall be closed within 5.0 minutes after the addition of the first test-fuel crib in a test period. During a test period, the fuel loading door(s) shall not be re-opened except during test-fuel reloading and adjustment as specified in Sections 5.9.7 and 5.9.8 of these protocols.

5.9.1.2 Additional Tests. The testing manager may conduct more than one test for each of the applicable configurations specified in Section 5.9.1. If more than one test is conducted for a specified configuration, the results from at least two thirds of the tests for that configuration shall be used for calculating the average emissions for that configuration. The measurement data and results of all tests conducted shall be reported regardless of which values are used in calculating the emissions for that configuration.

5.9.2 Test-Fuel Placement. All appliances shall be tested using a conventional fuel-load stacking configuration. For the purposes of this Standard, "conventional" shall be defined as the long axes of the fuel pieces/cribs having horizontal or approximately horizontal placement parallel to the hearth floor and the long axis of the hearth area. The fuel loads are described in Section 5.7.2.

5.9.2.1 Non-Conventional Fuel Placement Configuration. If a manufacturer's or builder's written operating instructions specify the stacking or placement of fuel in a non-conventional configuration, the manufacturer or builder shall perform an additional set of tests using the proposed "non-conventional" fuel loading configuration for each applicable appliance configuration required in Section 5.9.1 of this Standard. In any case, the first fuel load weight shall consist of 50% 3½ x 2-inch (89 x 51-mm) and 50% 3½ x 3½inch (89 x 89-mm) fuel pieces and the second and third fuel loads shall consist entirely of 3½ x 3½inch (89 x 89-mm) fuel pieces. Results of the tests preformed with conventional fuel-load positioning and tests performed with the manufacturer's or builder's specified fuel placement configuration shall be averaged for the final results.

5.9.3 Test-Burn Ignition. The test burn shall be started only with matches (i.e., no charcoal-lighter torches or other high temperature devices), with or without paper, and/or with or without kindling. If used, the weight of the starting paper shall not be included in test-fuel charge weight. The entire first test-fuel charge must be added within 5.0 minutes after test initiation as described in Section 5.9.4.

Note: Prior to fuel charge ignition in a masonry heater type of appliance, it may be necessary to first establish an operational flue draft so that combustion gases exit properly through the convoluted venting path and out the chimney exit. Otherwise, initial firebox combustion gases might vent out the fuel-loading door or extinguish test fuel combustion. Establish sufficient operating draft by first heating the venting path with burning paper and/or kindling, so that flue draft is at least 0.02 inches of water column (5 Pa) measured at the 8-foot (2.44 meter) sampling level. The weight of paper used to initiate a draft for nominal appliance operation are not considered part of the fuel load charges and are not included in total fuel weight determinations.

5.9.4 Sampling Period Initiation. Flue-gas oxygen sampling is initiated after the kindling has been ignited and within 15 seconds of when flue-gas temperature at the center of the flue at the primary flue-gas sampling and measurement location, or the upstream flue-gas measurement location of an emissions control device reaches 25°F

(14°C) greater than the pre-test flue-gas temperature. Once all test sampling and measurements have been initiated, all test sampling and measurements shall continue without interruption until the test is terminated in accordance with Section 5.9.11.

5.9.5 Test-Period Sampling, Parameter Measurements, and Data Recording Requirements. The following information shall be recorded for each test:

Test-period starting time
Test-period ending time
Date
Total length of sampling periods
Fuel load data:
Time
Weight
Moisture

Once all test sampling and measurements have begun at test initiation in accordance with Section 5.8.4 (i.e., zero time), all test sampling, parameter measurement, and data recording requirements shall be conducted at each 10-minute interval and shall continue without interruption until the test is terminated in accordance with Section 5.9.11. Test-period sampling and measurement parameters shall include:

Oxygen (O_2)
Temperatures:
Ambient Air
Flue-Gas
Before Emission Control Device
After Emission Control Device, and
Draft Pressure at the Primary Sampling and Measurement Location

5.9.6 Test Facility Ambient Temperatures. Test facility ambient temperatures shall be maintained between 65 and 95° F (18 and 32° C) during all test periods.

5.9.7 Test Fuel Additions. The second and third test-fuel loads for a test-burn period shall be placed and burned in the fire chamber only after flue-gas oxygen concentrations have increased by at least 80% but not more than 82% from the minimum flue-gas oxygen concentration resulting from combustion of the previous test-fuel load. 20.9% shall be used as the baseline ambient air-supply oxygen concentration. As an example, if the minimum flue-gas oxygen concentration resulting from the burning of a precedent fuel load was 17.50%, the next fuel load may only be loaded after the measured flue-gas oxygen concentration has returned to values equal to or between 20.2% [i.e., ((0.80 x (20.9-17.5)) + 17.5) = 20.22%] and 20.3% [i.e., ((0.82 x (20.9-17.5) + 17.5) = 20.3%].

5.9.7.1 Inadequate Coal Bed. If the coal bed remaining after the flue-gas oxygen concentration has increased 80% from the minimum flue-gas oxygen generated by combustion of the precedent fuel load, is not adequate for restarting the next test-fuel load within 5.0 minutes after loading the test-fuel charge, newspaper and/or kindling may be added and the test-fuel load re-positioned in order to facilitate “reasonable” ignition of the added test-fuel load.

The addition of all newspaper and/or kindling and the entire test-fuel charge including any additional newspaper and/or fuel added shall be completed within 5.0 minutes from the time the first piece of the test-fuel charge is loaded into the firebox.

The weight of newspaper and/or kindling added shall be weighed to the nearest 0.1 lb (0.05 kg) and recorded. The weight of the newspaper and/or additional kindling added shall NOT be included in the total test-fuel weight for the test period.

5.9.8 Test-Fuel Charge Adjustments. Test-fuel charges may be adjusted (i.e., repositioned) once during the burning of each test-fuel charge. The time used to make this adjustment shall not exceed 15 seconds.

5.9.9 Combustion Air Supply Adjustment. Any means for controlling combustion air supplies may only be adjusted during the first 5.0 minutes after the addition of each test-fuel load. After the first 5.0 minutes, after the addition of each test-fuel charge, all air supply control settings must be set to the lowest level and shall remain at the lowest setting throughout the remaining burning time for each test-fuel load.

5.9.10 Auxiliary Appliance Equipment Operation. Only auxiliary appliance equipment permanently installed and integrated into the design and construction of a appliance may be used during a test period. Where provided, heat exchange blowers shall be operated during all test burns following the manufacturer's written instructions. If no manufacturer's written instructions are available, operate heat exchange blowers in their "high" or maximum position. (Automatically operated blowers shall be operated as designed.) Shaker grates, catalyst, afterburner, or emissions control equipment by-pass mechanisms, or any other auxiliary equipment allowed under this section may be adjusted only once during the entire test period and the adjustment shall be in accordance with the manufacturer's written instructions. All operational adjustments made on an appliance or the auxiliary equipment associated with the appliance during the test period shall be recorded.

Note: The total energy losses used to calculate thermal efficiency shall be increased by the amount of natural or propane gas energy or electrical energy used by heat exchange blowers, afterburners, or emissions control equipment used during the test period. Use standard engineering handbooks or local suppliers for energy content of natural and propane gases and use 3419 Btu per KW-hour of electrical energy.

5.9.11 Test Completion. A test (i.e., a three fuel-load test-burn period) is completed and all sampling and test-period measurements are stopped at the time the flue-gas oxygen concentration has increased by at least 95% but not more than 97% from the minimum flue-gas oxygen concentrations resulting from combustion of the third test-fuel load. All temperature measurements and recordings shall stop at test completion.

5.10 Post-Test Clean-Up and Sample Processing Procedures.

5.10.1 Room-Air Velocities. Using an anemometer, measure and record the room-air velocity within 2 feet (0.6 meters) of the test appliance within 10 minutes after test completion. Air velocity within 2 feet (0.6 meters) of the test appliance shall be less than 50 feet/minute (250 mm/second) without the appliance operating.

5.10.2 Fuel Weight at Test Completion. Within 5 minutes after the test-burn is completed and all measurements and sampling has stopped, the remaining coals

and/or unburned fuel, and ash shall be removed from the firebox and weighed to the nearest 0.1 pound (0.05 kg). (It is recommended that the coals first be extinguished with carbon dioxide.) The weight of these unburned materials and ash shall be subtracted from the total test-burn fuel weight when calculating the test period burn rate.

Note: A test-burn shall be invalid if less than 90% of the weight of the total test-fuel loads plus the kindling weight have been consumed during the test period.

5.10.3 Barometric Pressure at Test Completion. Measure and record the barometric pressure within 10 minutes after test period completion.

5.10.4 Leak Checks. Leak checks of the combustion gas analyzer systems shall be performed within 2.0 hours after test completion. Leak checks shall be performed as follows as described in Section 5.8.5.1.

5.10.4.1 Leak Check Acceptance Criteria. Unless the leakage rate under the required vacuum is less than 2 percent of the average sample processing (i.e., analyzer flow) rate, analysis results shall be invalid.

6.0 CALCULATIONS.

6.1 Operating Performance. After test completion, data sheets shall be reviewed for completeness and proper equipment operation. The data sheets, log books, and records maintained by field and laboratory staff shall be reviewed to ensure sample integrity. Test period data sheets shall be used in conjunction with flue-gas analyses to calculate the appliance operational parameters.

6.1.1 Total Test Period and Sampling Time.. The total test period (t_{tt}) in minutes is calculated using Equation 6.1.1.1 as follows:

Equation 6.1.1.1:

$$(t_{tt}) = (t_c \times N_{T>25^{o}F/CO2+CO>95\%})$$

WHERE:

$\mathbf{t_c}$ = The data-recording cycle (10.0 minutes for these protocols).

$\mathbf{N}_{T>25^{o}F/CO2+CO>95\%}$= The total number of whole 10-minute data-recording cycles that occurred between the time when the flue-gas temperature after test-burn ignition first exceeded 25°F (14°C) more than the pre-test flue-gas temperature (i.e., test period initiation as defined in Section 5.9.4) and the time when the flue-gas oxygen concentration recovery back to the ambient oxygen concentration from the third test-fuel charge exceeded 95% (i.e., test period completion as defined in Section 5.9.11).

6.1.2 Burn Rate. Multiplying the emission factor by the average burn rate yields the particulate emission rate. Burn rate (kg/hr) is calculated by Equation 6.1.2.1 as follows:

Equation 6.1.2.1

$$\text{Burn Rate} = \frac{\text{Total Fuel} \times 60}{t_{tt}}$$

WHERE:

Total Fuel = The dry weight of the total fuel, including kindling, added during the entire test-burn period minus the remaining unburned materials and ash at the end of the test-burn period (kilograms).

6.2 Thermal Efficiency. In the following calculations retain at least one extra decimal place beyond that of the acquired data. Round-off figures to significant digits after each final calculation. (Other forms of the following equations may be used as long as they provide equivalent results.)

6.2.1 Nomenclature For Thermal Efficiency Calculations.

C_{mf} = Mass fraction of carbon in dry (zero moisture content) fuel; Use 0.510 for Douglas fir fuel (i.e., derived from the carbon molar fraction of Douglas fuel used by the U.S. EPA (i.e., 0.0425 kg-mole/kg x 12 kg/kg-mole = 0.510): 40CFR Part 60 Appendix A Methods 5H and 28).

C_{FG} = Average specific heat of dry flue-gas: kilojoule/kg-°K (Btu/lb-°R).

C_{H2O} = Specific heat of water vapor: 1.9 kilojoule/kg-°K (0.45 Btu/lb-°R).

CO_{2DFG} = Volume percent of CO_2 in flue-gas sample: percent.

E_{LL} = Latent energy loss, assuming complete combustion: kilojoule (Btu).

E_{SL} = Sensible energy loss: kilojoule (Btu).

E_W = Fuel (wood) chemical energy: kilojoule (Btu).

EF_C = Combustion efficiency: percent (reported to nearest 0.1percent).

EF_{HT} = Heat transfer efficiency (uncorrected for appliance energy storage): percent (Reported to nearest 0.1%).

EF_{OA} = Overall thermal energy efficiency (uncorrected for appliance energy storage): percent (Reported to nearest 0.1%).

h = Enthalpy of water vaporization at room temperature: use 2442 kilojoule/kg (1050 Btu/lb).

H = Mass fraction of hydrogen in dry (zero moisture content) fuel; use 0.0583 for Douglas fir fuel (the Total Combustible Carbon Method for Determination of Energy Efficiency of Wood-Fired Heaters; Federal Register, Volume 55, Number 161, Monday, August 20, 1990, page 33925-33935).

HHV_W = Higher heating value of the dry (wood) fuel: use 19,810 kilojoule/kg (8,516 Btu/lb).

m_d = Mass of fuel load, dry basis: kg (lb); = m_W / (1 + MC_d).

m_{H2O} = Mass of water released and generated assuming wet fuel is completely oxidized: kg (lb).

m_{FG} = Total mass of dry flue-gas: kg (lb).

m_W = Mass of fuel load, wet (as-fired) basis: kg (lb).

M_d = Flue-gas molecular weight: g/g-mole (lb/lb-mole).

MC_d = Moisture content of fuel, dry basis: percent.

P = Average heat output rate (power): kW (kilojoule/hour or Btu/hr).

T_A = Average ambient temperature: °K (°R).

T_{FG} = Average flue-gas temperature: °K (°R). Note: If no emission control device is installed as described in Section 5.6.2.1, use the average flue-gas temperature measured at the 8-foot level above the hearth. If an emissions control device is installed as described in Section 5.6.2.1 use the average flue-gas temperature of whichever location (i.e., upstream from the emissions control device or downstream from the emission control device) has the highest average flue-gas temperature during the test-burn period.

6.2.2 Fuel and Combustion Moisture. Calculate the total theoretical mass of water vapor released from fuel moisture and generated by the combustion of wood-based hydrogen during the test period (m_{H2O}) (assuming complete combustion) using Equation 6.2.2.1 as follows:

Equation 6.2.2.1

$$m_{H2O} = m_d \times (9H + (\frac{MC_d}{100}))$$

6.2.3 Flue-Gas Molecular Weight. Calculate the test-period average molecular weight of the dry flue-gas (M_d) using Equation 6.2.3.1 as follows:

Equation 6.2.3.1

$$M_d = \frac{(44 \times (20.3 - O_2)) + (32 \times (O_{2_{FI}})) + (28 \times (100 - O_2 - O_{2_{FI}}))}{100}$$

6.2.4 Flue-Gas Specific Heat. Calculate the test-period average flue-gas specific heat (C_{FG}) in kj/kg °K using Equation 6.2.4.1 as follows:

Equation 6.2.4.1

$$C_{FG} = 1.003 + ((0.00345) \times (T_{FG} - T_A))$$

6.2.5 Mass of Dry Flue-Gas. Calculate the total mass of dry flue-gas (m_{FG}) generated during the test period using Equation 6.2.5.1 as follows:

Equation 6.2.5.1

$$M_{FG} = \frac{M_d \times C_{mf} \times m_d}{12 \times CO_{2_{FI}} / 100}$$

6.2.6 Wood-Fuel Energy Input. Calculate the total wood-fuel energy input during the test period (E_W) using Equation 6.2.6.1 as follows:

Equation 6.2.6.1

$$E_W = m_d \times HHV_W$$

6.2.7 Latent Heat Losses. Calculate the total latent heat losses during the test period (E_{LL}) using Equation 6.2.7.1 as follows:

Equation 6.2.7.1

$$E_{LL} = m_{H2O} \times h$$

6.2.8 Sensible Heat Losses. Calculate the total sensible heat losses during the test period (E_{SL}) using Equation 6.2.8.1 as follows:

Equation 6.2.8.1

$$E_{SL} = ((m_{FG} \times C_{FG}) + (m_{H2O} \times C_{H2O})) \times (T_{FG} - T_A)$$

6.2.9 Average Overall Thermal Efficiency. Calculate the average overall thermal efficiency for the test period (EF_{OA}) using Equation 6.2.9.1 as follows:

Equation 6.2.9.1

$$EF_{OA} = \frac{100 \times (1 - (E_{LL} + E_{SL} + 0.03))}{E_W}$$

6.2.10 Average Heat Output Rate. Calculate the average heat output rate for the test period in Btu/hour (kw) using Equation 6.2.10.1 as follows:

Equation 6.2.10.1

$$P = (\frac{EF_{OA}}{100}) \times (\frac{E_W \times 60}{t_{tt}})$$

7.0 Permanent Label and Owner's Manual. A permanent label and an owner's manual shall be prepared and installed in all classified "For Sale" fireplaces, heating fireplaces, or masonry heaters.

7.1 Labels. Each appliance classified as a fireplace, heating fireplace, or masonry heater in accordance with this Standard shall have a permanent label affixed to it that meets the requirements of this section. The permanent label may be combined with any other label, as long as the required information is displayed, and the integrity of the label is not compromised. The label must:

- Be affixed in a readily visible or accessible location,
- Be at least 3 inches (7.6 cm) wide by 2 inches (5.1 cm) high,
- Be made of material expected to last the lifetime of the appliance,
- Be affixed in such a manner that it cannot be removed from the appliance without damage to the label,
- Present the information required in Section 7.1.1 in a manner so that it is likely to remain legible for the lifetime of the appliance.

7.1.1 Label Contents. The permanent label shall use the Arial font type. The top line shall be in 16 point size and shall state, “Certified Classification: XXXX”. Where XXXX is the classification (fireplace, heating fireplace, or masonry heater) determined using the procedures of this Standard. All other required label information shall be in the 12 point font size. The label shall contain the following information.

- Manufacturer's or builder's name, address, and phone number,
- Appliance model, model line, or design number and/or name,

- Month and year of manufacture or construction, if site-built,
- Serial number,
- On all classified appliances the label shall state: "This appliance has been tested and has demonstrated compliance with the Wood-Fired Fireplace, Heating Fireplace and Masonry Heater Thermal Performance and Testing and Classification Standard."
- The name, address, and U.S. or Canadian registered service mark (or trademark) of the accredited tester which conducted the test procedures used for classification, and
- The name, city and state address, and the registered service mark (i.e., U.S. Patent and Trademark Office, Washington, DC) of the accredited tester which conducted the thermal performance and classification test procedures.

7.1.1.1 Emissions Control Devices. If an appliance was tested and classified with an emissions control device which is not an integral part of the appliance structure, the label shall state that "This fireplace, heating fireplace, or masonry heater was tested and classified with (insert the name of the specified emissions control device here) in place and operational."

7.1.1.2 Closed-Door-Operation Label. If an appliance was not tested in an open-door configuration and is not classified for open-door use by consumer users, an additional permanent label shall be secured in a location on or near the fuel-loading door handle(s) or fuel-loading opening so that it is readily and easily read by consumer users. This label shall state: "Except for Fuel Loading Operations, the Fuel-Loading Door(s) of this Fireplace, Heating Fireplace, or Masonry Heater Must Remain Closed at All Times."

7.1.1.3 Low Air-Supply Operations. If an appliance cannot or is not intended to operate at the lowest air supply settings, a permanent instruction label shall be prominently affixed to the appliance air supply control mechanism. The label shall be affixed so that it is readily visible and readable to any person operating the controls. This instruction label shall state: "This air supply control must be set to the fully open position during all firing periods."

7.2 Owner's Manual. Each appliance offered for sale must be accompanied by an owner's manual that shall contain the information listed in this Section. Such information shall be adequate to enable consumers to achieve optimal thermal performance. Such information shall be consistent with the operating instructions provided by the manufacturer to the tester for operating the appliance during thermal performance testing.

7.2.1 Installation Instructions. There shall be adequate information to install the appliance including requirements for achieving proper draft.

7.2.2 Operation and Maintenance Instructions. The owner's manual must contain the following information:

- Wood loading procedures, recommendations of wood selection, and warnings on what fuels not to use, such as treated wood, colored paper, cardboard, solvents, trash and garbage,

- Fire starting procedures,
- Proper use of air controls, if any,
- Ash removal procedures,
- Instructions on gasket or seal replacement, if any,
- For catalytic models, information on the catalytic combustor:
  - Procedures for achieving and maintaining catalyst activity,
  - Maintenance procedures,
  - Procedures for determining deterioration or failure,
  - Procedures for replacement, and
  - Information on how to exercise warranty rights, and
  - The following statement: "This fireplace, heating fireplace or masonry heater contains a catalytic combustor, which needs periodic inspection and replacement for proper operation."

8.0 REPORTING REQUIREMENTS. Include both raw and reduced data for all appliance tests. All test information and appliance drawings shall be verified by the tester who performed the tests. Specific reporting requirements are as follows:

8.1 Appliance Identification. Report appliance identification information including manufacturer or builder, model, model line, or design and serial number of the appliance tested. Also include the published installation and operating instructions as an appendix to the report.

8.2 Test Facility Information. Report test facility location, elevation, temperature, and air velocity information.

8.3 Test Equipment Calibration and Audit Information. Report calibration and audit results for the test-fuel scale, test-fuel moisture meter and flue-gas analyzer.

8.4 Pretest Information and Conditions. Report all pretest conditions including test-fuel charge weights, appliance temperatures, and air supply settings.

8.5 Required Test Report Information and Suggested Format. Test report information requirements are presented in the following recommended report format:

8.5.1 Introduction.

8.5.1.1 Appliance Identification. Manufacturer, model name or number, catalytic/non-catalytic, emissions control equipment, and any optional equipment. Include a copy of appliance installation and operation manuals.

8.5.1.2 The Tester That Performed The Testing. Name, address, and certifications and other qualifications.

8.5.1.3 Test Information. Date appliance was received, if factory-built, date construction was completed, if site-built, date that each test was conducted, a description of each configuration tested as required in Section 5.9.1, and the number of test burns conducted for each appliance configuration.

8.5.1.4 Test Method And/Or Appliance Operating Protocol Deviations. The report shall contain a complete description of any test method or operating protocol deviation conducted in the performance of the required test procedures prescribed in this test Standard. The report must provide detailed rationale explaining the necessity for the deviation and the possible effects the deviation(s) may have had on the results.

8.5.2 Summary and Discussion of Results.

8.5.2.1 Table of Results. Test-burn numbers, appliance configurations, burn rates, overall thermal efficiency, and averages (indicate which test-burns are included in the averages presented). An example test period summary table is presented in Figures 8.5.2.1a and 8.5.2.1b.

Figure 8.5.2.1a

Thermal Performance Test Determined Classification: _____

Manufacturer: Manufacturer
Test Conducted By: Tester
Test Run Number: #
Test Period Start Date/Time: xx/xx/xxxx, xx:xx:xx AM/PM
Test Period End Date/Time: xx/xx/xxxx, xx:xx:xx AM/PM
Model Tested: Model
Fireplace, Heating Fireplace or Masonry Heater Type: Catalytic/Non-Catalytic
Configuration: Door Open/Door Closed

Time

Total Test Period	xx.x	Hours
Test Data Recording Cycle	10.0	Minutes

Fuel

Total Fuel Used	xx.x	kg wet
Average Fuel Moisture	xx.x%	Dry Basis
Total Fuel Burned	xx.x	kg dry
Average Burn Rate During Operation	x.xx	kg/hour (dry)

Average Flue-Gas Concentrations

Oxygen	xx.x%

Average Thermal Performance

Combustion Efficiency	xx%
Heat Transfer Efficiency	xx%
Overall Thermal Efficiency	xx%

Average Temperatures

Flue-Gas Temperature (at 8 feet above hearth)	xxx	°F	xxx	°C
Test Facility Ambient Temperature	xxx	°F	xxx	°C

Test Notes:
Test Note Number 1: STP for this test is: 1.0 Atmosphere and 68°F (20°C)

Figure 8.5.2.1b

Run Number	Configuration	Burn Rate, kg/hour	Overall Thermal Efficiency, %
1	With Door Open	x.xx	xx
2	With Door Closed	x.xx	xx
	Averages	x.xx	xx

8.5.2.2 Summary of Other Data. Test facility conditions, surface temperature averages, catalyst temperature averages, test-fuel charge weights, and test-burn times.

8.5.2.3 Discussion. Include which appliance classification was determined from the test results, specific test-burn problems and solutions and rationale for, and for not testing specific configurations like an open-door configuration.

8.5.3 Description.

8.5.3.1 Appliance Dimensions. Firebox height, width, length (or any other pertinent dimensions), weight, and hearth area used for calculating fuel-charge weight. Include a complete set of accredited tester verified drawings of the appliance tested.

8.5.3.2 Firebox Internal Assembly Configuration. Including the laboratory-certified verification of the construction or assembly drawings, photographs showing air supply locations and operating mechanisms, combustion air supply pathway(s), refractory materials and dimensions, catalyst location, baffle and/or by-pass configurations and operating mechanisms.

8.5.3.3 Add-On Emissions Control Equipment. If the appliance being submitted for classification utilizes add-on emissions control equipment or a catalytic device for reducing appliance emissions, provide a complete description of each component including drawings, photographs, and materials used in its construction for production.

8.5.3.4 Appliance Operating Procedures Utilized During Each Test Period. Air supply settings and adjustments, fuel-bed/coal-bed adjustments, and draft.

8.5.3.5 Test Fuel. Test fuel properties (moisture and temperature), test-fuel description (include drawings or photograph), and the test-fuel charge loading factor.

8.5.4 Sampling Locations. Describe sampling location relative to appliance components. Include drawings and/or photographs.

8.5.5 Sampling Procedure.

8.5.5.1 Measurement Methods. A brief reference to operational and measurement procedures, and optional and alternative procedures used. Include details of any parts of the procedures differing from the prescribed methods. Include a copy of this Standard as an appendix to the report.

8.5.6 Quality Control and Quality Assurance (QC/QA) Procedures and Results.

8.5.6.1 Description of Calibration Procedures and Results.

8.5.6.2 Test Method Quality Control Procedures. This shall include leak-checks.

8.5.7 Appendices.

8.5.7.1 Raw Data Results and Example Calculations. Include complete data tables and accompanying examples of all calculations not performed in the format presented in Section 6.0.

8.5.7.2 Raw Data. Include copies of all original data sheets for sampling records, parameter measurements, and temperature records. Include copies of all burn-rate and appliance temperature data.

8.5.7.3 Construction/Assembly Drawings. Appliance construction or assembly drawings which clearly show all dimensions needed for completing the requirements of Section 4.2.

8.5.7.4 Sampling and Analytical Procedures. Include detailed description of procedures followed by laboratory personnel in conducting the certification tests being reported.

8.5.7.5 Calibration Results. Details of all calibrations, checks, and audits pertinent to the reported test results including dates.

8.5.7.6 Participants. Test personnel, manufacturer representatives, and regulatory observers present during testing.

8.5.7.7 Sampling and Operation Records. Copies of original records or logs of activities not included on raw data sheets (e.g., appliance door-open times and durations).

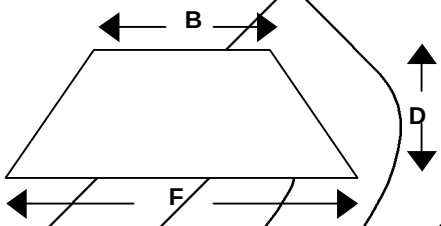
8.5.7.8 Additional Information. Appliance manufacturer's or builder's written instructions for operation of the appliance during the reported test periods and a copy of the production-ready (print-ready) permanent label required in Section 3.5.

Appendix A:

Non-Tested Fireplace, Heating Fireplace, or Masonry Heater Acceptance Worksheet

Fireplace/Heating Fireplace/Masonry Heater Manufacturer: _____
Tested Model, Model Line, or Design: _____
Candidate Non-Tested Model, Model Line or Design Name: _____

I. Hearth Dimensions



II. Firebox Comparisons

		Tested Model Model Name	Non-Tested Model Model Name		Acceptance Criteria	Determination (NA/Acceptable /Out-of-Limits)
1	Back (inches B)	xx.x	xx.x			
2	Depth (inches D)	xx.x	xx.x			
3	Front (inches F)	xx.x	xx.x			
4	Height (inches H)	xx.x	xx.x			
5	Average Hearth Length (inches)	0.0	0.0			
6	Hearth Area (square Feet)	0.00	0.00			
7	**Hearth Area Proportionality (% of Tested Appliance)**		**XX%**	→	**Greater Than 64% and Less Than 121%**	
8	**Ratio of Firebox Volume Proportionality (#17 below) to Hearth Area Proportionality (#7 above) (% of Firebox Volume Proportionality)**		**XX%**	→	**Greater Than 80% and Less Than 120%**	
9	Front/Back Ratio (See Note 2)	0.00	0.00			
10	**Front/Back Ratio Proportionality (% of Tested Appliance)**		**XX%**			
11	Front/Depth Ratio (See Note 2)	0.00	0.00			
12	**Front/Depth Ratio Proportionality (% of Tested Appliance)**		**XX%**			
13	Front/Height Ratio (See Note 2)	0.00	0.00			
14	**Front/Height Ratio Proportionality (% of Tested Appliance)**		**XX%**			
15	**Standard Deviation of Firebox Dimensional Ratios (% of Mean)**		**XX%**	→	**Less Than 10%**	
16	Firebox Volume (cubic feet)	0.00	0.00			
17	**Firebox Volume Proportionality (% of Tested Appliance**		XX%	→	**Greater Than 51% and Less Than 133%**	

III. Hearth Grate Comparisons

1	Back (inches B)	xx.x	xx.x			
2	Depth (inches D)	xx.x	xx.x			
3	Front (inches F)	xx.x	xx.x			
4	Hearth Area (square Feet)	0.00	0.00			
5	**Grate Area Proportionality (% of Tested Appliance)**		**XX%**	→	**Greater Than 64% and Less Than 121%**	
6	Ratio of Grate Area to Hearth Area	0.00	0.00			
7	**Ratio of Grate Area To Hearth Area Proportionality (% of Tested Appliance)**		**XX%**	→	**Greater Than 80% and Less Than 110%**	
8	Height of Grate Above Hearth (inches)	0.00	0.00			
9	**Proportionality of Grate Height Above Hearth (% of Tested Appliance)**		XX%	→	**Greater Than 80% and Less Than 110%**	

	IV. Horizontal and/or Downward Flue-Gas Pathway (See Note 3)	Tested Model Model Name	Non-Tested Model Model Name		Acceptance Criteria	Determination (NA/Acceptable /Out-of-Limits)
1	Distance of Downward Flue-Gas Pathway (inches)	0.00	0.00			
2	**Downward Distance Proportionality (% of Tested Appliance)**		**XX%**	→	**Greater Than 80% and Less Than 110%**	
3	**Ratio of Firebox Volume Proportionality to Downward Flue-Gas Pathway Proportionality (% of Downward Flue-Gas Pathway Proportionality)**		**XX%**	→	**Greater Than 80% and Less Than 110%**	
4	Distance of Horizontal Flue-Gas Pathway (inches)	0.00	0.00			
5	**Horizontal Distance Proportionality (% of Tested Appliance**		**XX%**	→	**Greater Than 80% and Less Than 110%**	
6	**Ratio of Firebox Volume Proportionality to Horizontal Flue-Gas Pathway Proportionality (% of Horizontal Flue-Gas Pathway Proportionality)**		**XX%**	→	**Greater Than 80% and Less Than 110%**	

	V. Chimney/Flue and Chimney/Flue Connector Comparisons					
1	Chimney/Flue Connector Location (see note 4)			→	**Same**	
2	Chimney/Flue Diameter (inches)	0	0			
3	Chimney/Flue Cross-Sectional Area (square inches)	0.0	0.0			
4	**Downward Distance Proportionality (% of Tested Appliance)**		**XX%**	→	**Greater Than 51% and Less Than 133%**	
5	**Ratio of Firebox Volume Proportionality to Chimney/Flue Cross-Sectional Area Proportionality (% of Chimney/Flue Cross-Section Area Proportionality)**		**XX%**	→	**Greater Than 80% and Less Than 110%**	
6	**Ratio of Grate Area Proportionality to Chimney/ Flue Cross-Sectional Area Proportionality (% of Chimney/Flue Cross-Sectional Area Proportionality)**		**XX%**	→	**Greater Than 80% and Less Than 110%**	

VI. Firebox Construction Materials			→	**Same**	
VII. Pass/Fail					

Note 1: This spreadsheet establishes the acceptance or non-acceptance of non-tested appliances based on whether the tested appliances has an acceptable margin of low emissions and an acceptable set of dimensional proportionalities between the tested and non-tested appliances. The criteria used in this spreadsheet define the "substantially the same core construction" and the "substantially similar to the classified model in internal assembly design, combustion function.

Note 2: Proportionality (%) = Measured Linear Dimension of Non-Tested Appliance x 100 / Measured Linear Dimension of Tested Appliance
where: D = Linear Depth of firebox F = Front Linear Dimension
H = Linear Height of firebox B = Back Linear Dimension

Note 3: Horizontal and/or downward flue-gas pathway is defined as the net horizontal and/or downward internal duct length, measured from the top of the uppermost firebox fuel loading door to the exit of the appliance as traveled by any effluent on a single pathway through duct channel(s) within the appliance (or average of net internal duct lengths for multiple pathways of different lengths, if applicable). Net internal duct length is measured from the center of the internal side or top surface of a duct, horizontally or vertically to the center of the opposite side or the bottom surface of the same duct, and summed for multiple ducts or directions on a single pathway, if applicable. For duct channel(s) traversing horizontal angles of less than ninety degrees from vertical, only the net actual horizontal distance traveled is included in the total duct length.

Note 4. Use descriptive notation: i.e., TopCenter, TopFront, or TopBack. Other, more appropriate flue exit location descriptors may be used. However, make sure that when the position descriptors for the tested and non-tested models are the same, the spelling and case are matched exactly.