

DRAFT

Regulation No. 4 Appendix A

Test Method Protocols for Measuring Wood-Burning Masonry Heater And Fireplace Emissions

Colorado Department of Public Health and
Environment
Air Pollution Control Division
Denver, Colorado

Table of Contents

1.0	SCOPE.....	10
2.0	DEFINITIONS.....	10
3.0	APPROVAL PROCEDURES	13
3.1	Requirements for Approval.....	13
3.1.1	Appliance Specifications	13
3.1.2	Test Report	14
3.2	Approval of Modifications Made to.....	14
3.2.1	Appliance Specifications	14
3.2.2	Documentation of Comparison to Previously Tested and Approved Model ..	14
3.2.2.1	Critical Dimensions.....	14
3.2.3	Construction Materials	15
3.2.4	Emissions Factor Margin.....	15
3.2.5	Test Report	15
3.2.6	Notarized Affidavit.....	15
3.3	Masonry Heater or Fireplace Quality Control	Error! Bookmark not defined.
3.3.1	Inspection.....	Error! Bookmark not defined.
3.3.1.1	Waiver of Inspection.....	Error! Bookmark not defined.
3.3.1.2	Inspection Report.....	Error! Bookmark not defined.
3.3.1.3	Re-testing.....	Error! Bookmark not defined.
3.4	Permanent Label, Temporary Label, and Owner's Manual.....	16
3.4.1	Labels and Owner's Manual.....	16
3.4.2	Closed-Door Operation Label.....	16
3.4.3	Fuel-Elevating Grate/Operation Label.....	16
3.4.4	Low Air-Supply Operations.....	16
3.5	Emissions Control Devices.....	17
3.5.1	Label Requirements.....	17
3.5.2	Lock Out Requirements	17
3.5.3	Non-Tested Models.....	17
3.5.3.1	Alternate Air-to-Fuel Ratio.....	17
3.6	List of Colorado APCD-Approved Masonry Heaters and Fireplaces	17
4.0	TEST LABORATORY ACCREDITATION	18
4.1	Laboratory Accreditation Requirements	Error! Bookmark not defined.
4.2	Application Requirements for Colorado APCD Laboratory Accreditation	Error! Bookmark not defined.
4.3	Colorado APCD Accredited Laboratory Updates..	Error! Bookmark not defined.
4.4	Colorado APCD Accreditation Revocation	Error! Bookmark not defined.
5.0	TESTING.....	18
5.1	Applicability and Principal.....	18

5.1.1	Alternative Sampling and Measurement Systems.....	18
5.2	Test Configurations	18
5.2.1	Minimum Required Masonry Heater Test Configurations.....	18
5.2.2	Minimum Required Fireplace Test Configurations	18
5.2.3	Test Configuration Not Required.....	18
5.2.4	Closed-Door(s) Testing	19
5.2.5	Additional Tests.....	19
5.3	Test Apparatus	19
5.3.1	Masonry Heater or Fireplace and Flue-Gas Temperature Sensors.....	19
5.3.2	Test Facility Temperature Sensor	19
5.3.3	Desiccator	19
5.3.4	Soxhlet Extractors	19
5.3.5	Scale	19
5.3.6	Analytical Balance.....	19
5.3.7	Wood-Fuel Moisture Meter.....	19
5.3.8	Anemometer.....	19
5.3.9	Barometer	19
5.3.10	Draft Gauge.....	19
5.3.11	Emissions Sampling System (ESS)	19
5.3.11.1	Flue-Gas Sample Probe.....	20
5.3.11.2	Heated Sampling Line	20
5.3.11.3	Flue-Gas Sampling Process.....	20
5.3.11.4	Sample Flow Control	20
5.3.11.5	Flue-Gas Sub-Sample Collection	20
5.3.11.6	Flow Meter	20
5.3.11.7	Condenser/Dryer	20
5.3.12	Linear-Measure Device	22
5.3.13	Vacuum Gages	22
5.3.14	Three-Way Valve	22
5.3.15	Gas Analyzers.....	22
5.3.15.1	Analyzer Calibration Error	22
5.3.15.2	Sampling System Bias	22
5.3.15.3	Zero Drift	22
5.3.15.4	Calibration Drift	22
5.3.15.5	Analytical Interference.....	22
5.3.15.6	CO2 Gas Analyzer Accuracy Limitation	22
5.4	Sampling Supplies and Reagents.....	22
5.4.1	Calibration Gases.....	22
5.4.2	Dichloromethane (Methylene Chloride).....	23
5.4.3	Methanol	23
5.4.4	Sample Filter.....	23

5.4.5	XAD-2 Sorbent Resin	23
5.4.6	Gas Sample Bags	23
5.4.6.1	Gas Sample-Bag Preparation	23
5.5	Test Fuel	23
5.5.1	Species	23
5.5.2	Fuel Piece Cross-Sectional Dimensions	23
5.5.2.1	Small Fireboxes	23
5.5.3	Fuel Moisture Content	24
5.5.4	Test-Fuel Cribs	24
5.5.5	Fuel Crib Dimensional Specifications	26
5.5.5.1	Fuel Crib Shape	26
5.5.5.2	Primary and Secondary Horizontal Hearth Dimension Designation	26
5.5.5.2.1	Line of Symmetry	26
5.5.5.2.2	Average PH_{hd}	26
5.5.5.2.3	Average SH_{hd}	26
5.5.5.3	Average Firebox Height (F_{bh})	26
5.5.5.3.1	Fireplace Firebox Height Limitation	26
5.5.5.4	Total Useable Hearth Area	26
5.5.5.5	Useable Firebox Volume (F_v)	26
5.5.5.6	Fuel-Crib Volume	26
5.5.5.6.1	Fuel-Elevating Grate	26
5.5.6	Fuel Piece Spacing	27
5.5.7	First Fuel-Crib Structure	27
5.5.7.1	Number of Fuel Pieces in the Bottom (First) Layer (n_{1_1})	27
5.5.7.2	Number of Fuel Pieces in Additional Layers (n_{1_i})	27
5.5.7.3	Number of Fuel Crib Layers (n_{fcl})	28
5.5.8	Second and Third Fuel-Crib Loads	28
5.5.9	Test-Fuel Crib Construction	28
5.5.10	Fuel-Crib Alignment For Testing	29
5.5.11	Fuel Crib Weight	29
5.5.12	Kindling	29
5.5.12.1	Kindling Preparation	29
5.5.12.1.1	First Layer	29
5.5.12.1.2	Second Layer	29
5.5.12.1.3	Newspaper	29
5.5.12.1.4	Third Layer	29
5.5.12.1.5	Fourth Layer	29
5.5.12.2	Small Firebox	30
5.5.12.3	Firebox with Fuel-Elevating Grate	30
5.5.12.4	Kindling Weight	30
5.6	Calibration and Audit Requirements	31

5.6.1	Scale	31
5.6.2	Temperature Measurement Devices	31
5.6.3	Fuel Moisture Meter	31
5.6.4	Anemometer.....	31
5.6.5	Barometer	31
5.6.6	Draft Gauge.....	31
5.6.7	Sample Gas Flow Meters	31
5.6.8	ESS Calibration.....	32
5.6.8.1	Oxygen Cell.....	32
5.6.9	Sample Flow Rates and System Response Times	32
5.6.9.1	Setting Sampling Flow Rate	32
5.6.9.2	Response Time Measurement	32
5.6.9.3	Response Time Limitation	32
5.7	Test Preparations	32
5.7.1	Masonry Heater or Fireplace Installation.....	32
5.7.2	Masonry Heater or Fireplace Description.....	32
5.7.3	Primary Flue-Gas Sampling and Temperature Measurement Location	33
5.7.3.1	Add-On Emission Control Equipment.....	33
5.7.3.1.1	Fueled Emissions Control Devices	33
5.7.4	Test Facility Ambient Temperature Probe.....	33
5.7.5	Heat-Aging, Curing, and Durability Confirmation.....	33
5.7.5.1	Catalyst And/Or Add-On Emissions Control Device-Equipped Masonry Heaters or Fireplaces	33
5.7.5.2	Flue-Gas Stratification Check.....	34
5.7.5.2.1	Stratification of Flue-gas Oxygen Concentrations.....	34
5.7.5.2.2	Stratification Remedy.....	34
5.7.6	Leak Check	34
5.7.6.1	Leak-Check Procedure.....	34
5.7.6.2	Leak Check Acceptance Criteria	34
5.7.7	ESS Pre-Test Set-Up	34
5.7.7.1	XAD-2 Cartridge	34
5.7.7.2	ESS Flow Rate	35
5.8	Masonry Heater and Fireplace Operation and Testing Protocols	35
5.8.1	Masonry Heater or Fireplace Cooling Period	35
5.8.2	Pre-Test Procedures	35
5.8.2.1	Room-Air Velocity.....	35
5.8.2.2	Barometric Pressure.....	35
5.8.2.3	Flue-Gas Temperature Determination.....	35
5.8.3	Test-Fuel Placement	35
5.8.4	Test-Burn Ignition.....	35
5.8.5	Test Period Initiation	35

5.8.6	Test-Time Sampling, Parameter Measurement, and Data Recording Requirements	36
5.8.7	ESS Component Temperatures	36
5.8.8	Test Facility Ambient Temperatures.....	36
5.8.9	ESS Flue-Gas Sub-Sample Bag Filling Rates.....	36
5.8.10	Test Fuel Additions	37
5.8.10.1	Alternative Fuel Addition Criteria.....	37
5.8.10.2	Inadequate Coal Bed.....	37
5.8.10.2.1	Additional Newspaper and/or Kindling	37
5.8.11	Test-Fuel Charge Adjustments	37
5.8.12	Combustion Air Supply Adjustment.....	37
5.8.13	Auxiliary Masonry Heater or Fireplace Equipment Operation	38
5.8.14	Test Completion.....	38
5.8.14.1	Alternative Test Completion Criteria	38
5.8.15	Post-Test Procedures.	38
5.8.15.1	Room-Air Velocities.....	38
5.8.15.2	Fuel Weight at Test Completion	38
5.8.15.3	Barometric Pressure at Test Completion.....	39
5.8.15.4	Leak Check	39
5.8.15.5	Critical-Orifice Flow Rate at Test Completion.....	39
5.8.16	ESS Particulate Emissions Sample Processing	39
5.8.16.1	Filter	39
5.8.16.2	XAD-2 Sorbent-Resin Cartridge	39
5.8.16.2.1	Blanks.....	39
5.8.16.3	ESS Hardware Clean-Up	39
5.8.16.3.1	Blanks	40
5.8.16.4	ESS Particulate Emissions Sample Preservation.....	40
5.8.16.5	Minimum ESS Particulate Emissions Sample Quantities	40
5.8.17	ESS Flue-Gas Sample Bag Processing.	40
5.8.17.1	Leak Checks	40
5.8.17.1.1	Leak-Check Procedure	40
5.8.17.1.2	Leak Check Acceptanc.....	40
5.8.17.2	Combustion-Gas Analyzer Calibrations.....	40
5.8.17.3	Flue-Gas Sample Bag Analysis.....	41
5.8.17.3.1	Flue-Gas Analysis Repeatability Requirements.....	41
5.8.17.3.2	Oxygen Concentration Requirements.....	41
5.8.17.4	Combustion Gas Analyzer Audit	41
5.8.17.5	Sampling Rate Constancy.....	41
6.0	CALCULATIONS	42
6.1	Total Test Period and Sampling Time	42
6.2	Test Period Burn Rate	42

6.3	Particulate Emissions	42
6.3.1	ESS Emissions Factor	42
6.3.2	EPA Method-5H Particulate Emissions Factor Equivalents	43
6.3.3	Carbon Monoxide (CO) Emissions.....	43
7.0	REPORTING REQUIREMENTS	43
7.1	Masonry Heater or Firep.....	43
7.2	Test Facility Information	43
7.3	Test Equipment Calibration and Audit Information	43
7.4	Pretest Information and Conditions	43
7.5	Particulate Emissions Data.....	44
7.6	Required Test Report Information and Suggested Format	44
7.6.1	Introduction.	44
7.6.1.1	Purpose of test	44
7.6.1.2	Masonry Heater or Fireplace Identification.....	44
7.6.1.3	Testing Laboratory	44
7.6.1.4	Test information	44
7.6.1.5	Test Method And/Or Masonry Heater or Fireplace Operating Protocol Deviations.....	44
7.6.2	Summary and Discussion of Results.....	44
7.6.2.1	Table of Results	44
7.6.2.2	Summary of Other Data	44
7.6.2.3	Discussion.....	44
7.6.3	Process Description.	44
7.6.3.1	Masonry Heater or Fireplace Dimensions	44
7.6.3.2	Firebox Internal Assembly Configuration.....	44
7.6.3.3	Add-On Emissions Control Equipment.....	45
7.6.3.4	Masonry Heater or Fireplace Operation Procedures.....	45
7.6.3.5	Test fuel	45
7.6.4	Sampling Locations.....	45
7.6.5	Sampling and Analytical Procedures.....	45
7.6.5.1	Analytical methods	45
7.6.6	Quality Control and Quality Assurance (QC/QA) Procedures and Results ...	47
7.6.6.1	Calibration Records.....	47
7.6.6.2	Test Method	47
7.6.7	Appendices	47
7.6.7.1	Example Calculations.....	47
7.6.7.2	Raw Data	47
7.6.7.3	Construction/Assembly Drawings.....	47
7.6.7.4	Sampling and Analytical Procedures.....	47
7.6.7.5	Calibration Records.....	47
7.6.7.6	Participants	47

7.6.7.7	Sampling and Operation Records	47
7.6.7.8	Additional Information.....	47
7.6.8	References Cited in the Report.....	47

Test Method Protocols for Measuring Wood-Burning Masonry Heater and Fireplace Emissions

1.0 SCOPE

These Test Method Protocols comprise the Colorado Department of Public Health, Air Pollution Control Division (Colorado APCD) wood-burning masonry heater and fireplace emissions performance requirements, masonry heater and fireplace approval and certification procedures, Colorado APCD test-laboratory accreditation requirements, masonry heater and fireplace manufacturer/builder record-keeping and reporting requirements, and test method protocols for measuring wood-burning masonry heater and fireplace particulate emissions.

2.0 DEFINITIONS

Terms as used in these Test Method Protocols are defined as follows:

Approved Fireplace — as defined as “approved wood-burning fireplace” in CAQCC Reg. 4.1.A

Approved Masonry Heater — as defined as “approved masonry heater” in CAQCC Reg. 4.1.A

Burn Rate — the average rate at which test-fuel is consumed in a masonry heater or fireplace during a test-burn period; measured in mass of dry wood burned per hour (kg/hour, lb/hour).

Calibration Drift — the difference in an 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.

Calibration Error — the difference between the gas concentration displayed by a gas analyzer and the known concentration of the calibration gas when the calibration gas is introduced directly to the analyzer.

Calibration Gas — a known concentration of carbon dioxide (CO₂), carbon monoxide (CO), and/or oxygen (O₂) in nitrogen (N₂).

Certification Test or Certification Audit Test — the completion of at least one, three-fuel-load test-burn in accordance with the masonry heater and fireplace operating protocols and the measurement and analysis procedures specified by these Test Method Protocols.

Effective Flue-Gas Duct Diameter (ED) — for a round flue-gas duct the actual diameter. For a rectangular flue-gas duct it is determined using Equation 2.1 as follows:

$$ED = (2 \times (L \times W)) / (L + W) \qquad \text{Equation 2.1}$$

Where: L = Flue rectangular length.

W = Flue rectangular width.

Emissions Factor Margin — the difference between the emissions factor result for a masonry heater or fireplace measured using the procedures and specifications of this standard and 4.5 g/kg (i.e., 75% of the 6.0 g/kg Regulation 4 masonry heater emissions standard).

Firebox — the chamber in the masonry heater or fireplace within which fuel charges are placed and burned.

Fireplaces — as defined as “wood-burning fireplace” in CAQCC Reg. 4.1.A

Flue-Gas Exhaust Duct — the connector pipe, chimney, or other duct form that conveys exhaust gases from the masonry heater or fireplace firebox to the outdoor atmosphere. 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 fuel loading door (See definition for "Firebox Height" under “Usable Firebox Volume”).

Fuel-Elevating Grate — a non-combustible structure capable of elevating a fuel load above the hearth of a masonry heater or fireplace while offering no, or very little impedance to the passage of combustion air supplies to the bottom of the fuel load and up through the fuel load.

Fuel-Elevating Grate Height — is the fuel elevation height above the hearth; the distance between the hearth and a horizontal plane at the bottom of an elevated fuel load.

Fuel Total Weight — the total weight of the fuel pieces to be used in each fuel-load crib plus spacer and kindling weight.

Hearth Dimensions

Primary Horizontal Hearth Dimension (PH_{hd}) — for all hearth shapes, the length of a line drawn within the hearth perimeter that is: 1. either a line of hearth plan-view symmetry or the longest line that can be drawn within the hearth perimeter perpendicular to a plan-view line of symmetry and 2. the axis parallel to which fuel-piece lengths are oriented for testing. The masonry heater or fireplace manufacturer or builder shall designate the PH_{hd} , choosing either a line of symmetry or the longest line that can be drawn perpendicular to a line of symmetry, whichever is to be the axis line along which fuel piece lengths are oriented in parallel for burning.

Non-symmetrical hearth shapes — the PH_{hd} shall be designated by the Colorado APCD in accordance with the objective of making fuel piece orientation reflect the basic length and width orientation of the hearth within the space intended for fuel placement and burning.

Secondary Horizontal Hearth Dimension (SH_{hd}) — for all hearth area shapes the length of the longest line that can be drawn within the hearth perimeter perpendicular to the designated PH_{hd} .

Multiple Lines of Symmetry — Hearth shapes may have more than one line of symmetry to choose from. The SH_{hd} associated with one PH_{hd} and line of symmetry may not be used for calculating fuel crib dimensions with a PH_{hd} based on a different line of symmetry.

Note: For square and full-circle hearth shapes, the PH_{hd} and SH_{hd} are of equal length.

Horizontal Flue-Gas Pathway — the total net horizontal-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 (See definition for "Firebox Height" under “Usable Firebox Volume”) to the point where the centerline of the exhaust duct exit to the atmosphere intersects the horizontal plane at the total vertical extent (i.e., height) of the exhaust duct at the flue-gas exit to the atmosphere. For the purpose,

horizontal shall mean any amount of duct centerline traverse that is created by any angle which is either more or less than 90° or 270° from vertical.

Internal Assembly — the core construction and firebox design factors that may affect a masonry heater or fireplace's combustion function or particulate emissions factor.

Masonry Heaters — as defined as “masonry heater” in CAQCC Reg. 4.1.A

Masonry Heater or Fireplace Design — the construction and/or fabrication specifications including all dimensions and materials required for manufacturing or building a masonry heater or fireplace.

Masonry Heater or Fireplace Model Line — as defined as “model” in CAQCC Reg. 4.1.A

Maximum Flue-Gas Carbon Dioxide Plus Carbon Monoxide Peak — the difference between the baseline air-supply CO₂+CO concentration (normally 0) and the highest 5-minute average data point CO₂+CO concentration measured and recorded during the burning of a test fuel charge.

Maximum Flue-Gas Oxygen Depression — the difference between the baseline air supply oxygen concentration (i.e., 20.9%) and the lowest 5-minute average data point oxygen concentration measured and recorded during the burning of a test-fuel charge.

Pre-Test Flue-Gas Temperature — the temperature measured at the flue-gas sampling and temperature measurement location within 15 minutes before a test is initiated and at least one hour after the masonry heater or fireplace was closed in accordance with Section 5.8.2.3.

Response Time — the amount of time required for a gas measurement system to respond and display 90 percent of a step change in the analyte gas concentration.

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.

Span — the upper limit of the gas concentration measurement range. (Typically 25 percent for CO₂, O₂ and 5 percent for CO.)

Test-Burn or Test Period — the time from when flue-gas temperatures rise above 25°F over the pretest flue-gas temperature after initiation of a test burn to the time flue-gas oxygen concentrations have recovered 95% to 97% of the way back toward ambient oxygen concentrations after the burning of the last of three fuel load charges with the consumption of at least 90% of the mass of the three consecutively-burned test-fuel charges.

Test Facility — the building enclosure in which the masonry heater or fireplace is installed, operated, and sampled for emissions.

Test-Fuel Charge — one of three test-fuel cribs burned during a test period.

Test-Fuel Loading Factor — the ratio between test-fuel crib volume including inter-fuel-piece spacing, and the usable firebox volume.

Usable Firebox Volume (F_v) — the product of the useable hearth area and the average useable height. Useable means the volumetric space within the fire chamber of a masonry heater or fireplace into which fuel can be, or is intended to be, placed for firing. Usable firebox volume is calculated using the following dimensional definitions:

Firebox Length — average length of at least 9 equally spaced lines running parallel

to the greater of 1. the PH_{hd} , or 2. the SH_{hd} .

Firebox Width or Depth — average length of at least 9 equally spaced lines running perpendicular to the lines used for determining firebox length.

Firebox Floor Versus Hearth Area — If a masonry heater or fireplace has a larger floor area within the fire chamber than the area upon which it is intended that fuel be placed and burned, the useable hearth area shall be calculated as the sum of standard geometric areas or sub-areas of the area intended for fuel placement and burning.

Firebox Height (F_{bh}) — the vertical dimension measured from the hearth of a masonry heater or fireplace or the top of a fuel-elevating grate to the horizontal plane that intersects and is perpendicular to the top edge of the fuel loading door opening.

Fuel-Elevating Grates — For masonry heaters or fireplaces with grates that elevate fuel charges above the hearth, 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 most grate projections. Useable hearth areas calculated using fuel-elevating grate dimensions shall be multiplied by a factor of 1.5 for determining fuel load charge volumes. The volume of test-fuel charges calculated using fuel-elevating grate areas shall not exceed the volume of test-fuel charges determined for the masonry heater or fireplace hearth area.

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 (See definition for "Firebox Height" under "Usable Firebox Volume") to the point where the centerline of the exhaust duct exit to the atmosphere intersects the horizontal plane at the total vertical extent (i.e., height) of the exhaust duct at the flue-gas exit to the atmosphere. For the purpose of these protocols, horizontal shall mean any amount of duct centerline traverse that is created by any angle that is either more or less than 90° or 270° 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 direction) 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.

Zero Drift — the difference between the initial calibration response at the zero concentration level and the calibration response at the zero concentration level after a stated period of instrument operation during which no maintenance, repair, or adjustment took place.

3.0 APPROVAL PROCEDURES

3.1 Requirements for Approval.

On or after January X, 200Y, a manufacturer or builder of a masonry heater or fireplace who wishes to have a masonry heater or fireplace model, model line, or masonry heater or fireplace design designated as a Colorado APCD-approved masonry heater or fireplace, shall submit to the Colorado APCD for its review the following information:

3.1.1 Appliance Specifications. The masonry heater or fireplace manufacturer's name, street address, masonry heater or fireplace model, model line, or design

identification, all masonry heater or fireplace construction specifications, drawings of the masonry heater or fireplace firebox and internal assembly, and all specifications for required chimney systems and emission control devices, and

3.1.2 Test Report. A test report prepared in accordance with these Test Method Protocols showing that the arithmetically-averaged particulate emissions factor for all operating configurations tested on the candidate masonry heater or fireplace does not exceed 6.0 grams of particulate emissions per kilogram (g/kg) of fuel burned; test-method-adjusted to be equivalent to results obtained by using the U.S. Environmental Protection Agency (EPA) Method-5H sampling system (Code of Federal Regulations Title 40, Part 60, SubPart AAA).

3.2 Approval of Modifications Made to Tested and Approved Models. On or after Month Day, 2005, the Colorado APCD may grant approval for internal assembly modifications to a masonry heater or fireplace model, model line, or design that has been previously tested and Colorado APCD-approved upon submission of the following information by the applicant:

3.2.1 Appliance Specifications. The previously tested and APCD-approved masonry heater or fireplace manufacturer's name, street address, model, model line, or design identification, all construction specifications, drawings of the masonry heater or fireplace firebox and internal assembly system, and all specifications required for chimney systems and emission control devices.

3.2.2 Documentation of Comparison to Previously Tested and Approved Model. Documentation from a Colorado APCD-accredited laboratory that the candidate modified masonry heater or fireplace is a masonry heater or fireplace within the definition of Colorado APCD Regulation 4, has substantially the same internal assembly as a masonry heater or fireplace already tested by a Colorado APCD-accredited laboratory, and is substantially similar to a Colorado APCD-approved masonry heater or fireplace model, model line, or design in combustion function, and probable emissions performance as required by these Test Method Protocols. A modified masonry heater or fireplace model, model line, or design shall be deemed to have the same "internal assembly" and be "substantially similar" to a tested and Colorado APCD-approved masonry heater or fireplace model, model line, or design in combustion function, and probable emissions performance as required by Colorado APCD Regulation 4, if the modified masonry heater or fireplace model, model line, or design meets all of the following acceptance criteria when compared to a previously tested and Colorado APCD-approved masonry heater or fireplace model, model line, or design:

3.2.2.1 Critical Dimensions. Table 3.2.2.1.1 presents a list of 'critical' fireplace and masonry heater dimensions. Measurements of these Critical Dimensions from a previously-tested and Colorado APCD-approved fireplace or masonry heater shall be compared to the Critical Dimension measurements of a masonry heater or fireplace being submitted to the Colorado APCD for a modification approval. To qualify for Colorado APCD approval of a modification to a previously tested and Colorado APCD-approved masonry heater or fireplace, each Critical Dimension measurement from the masonry heater or fireplace being submitted for approval shall not be less than 80% of the

previously-tested and Colorado APCD-approved masonry heater or fireplace **and** shall not be more than 110% of the previously-tested and Colorado-APCD-approved fireplace or masonry heater. In addition, no single linear Critical-Dimension measurement may be more than 5 percentage points different from the average of all the other Critical Dimension measurement differences; no measured area (i.e., square) shall be more than 10 percentage points different from the corresponding area measurement; and no measured volume (i.e., cubic) shall be more than 15 percentage points different from the corresponding volume measurement.

Table 3.2.2.1.1 Critical Masonry Heater and Fireplace Dimensions	
Critical Dimensions	Allowed Differences¹ (%)
Average Firebox Width or Depth	5
Average Firebox Length	5
Hearth Area	10
Average Grate Width or Depth	5
Average Grate Length	5
Grate Area	10
Average Firebox Height	5
Firebox Volume	15
Downward "vertical" distance of the flue-gas pathway	5
Horizontal distance of the flue-gas pathway	5
Flue-gas exhaust cross-sectional area	10

Note 1: Between a previously tested and Colorado APCD-approved masonry heater or fireplace and a masonry heater or fireplace being submitted for a Colorado APCD modification approval.

3.2.3 Construction Materials. Materials used for fabricating or building all of the internal assembly components of a modified masonry heater or fireplace shall be identical in all respects to the materials used to fabricate or build the Colorado APCD-approved masonry heater or fireplace.

3.2.4 Emissions Factor Margin. The emissions factor margin of the Colorado APCD-approved masonry heater or fireplace shall be greater than 3.0 g/kg (i.e., the emissions rate margin is defined in Section 2.0).

3.2.5 Test Report. A copy of, or appropriate reference information for, the original test report for the already-tested and already Colorado APCD-approved internal assembly system.

3.2.6 Notarized Affidavit. A notarized affidavit of ownership shall be provided for the previously-tested and Colorado APCD-approved masonry heater or fireplace submitted as the basis of comparison in an application for Colorado APCD approval of a modified masonry heater or fireplace model, model line or design. Alternatively, an owner of a tested and Colorado APCD-approved masonry heater or fireplace 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 Colorado

APCD-approved masonry heater or fireplace as the basis of comparison in an application for Colorado APCD approval of a specified non-owned, modified masonry heater or fireplace.

3.3 OMITTED

3.4 Permanent Label, Temporary Label, and Owner's Manual

3.4.1 Labels and Owner's Manual. Permanent and temporary labels and an owner's manual shall be prepared and included with all Colorado APCD-approved "For Sale" masonry heaters or fireplaces as specified for wood heaters in Title 40 of the Code of Federal Regulations (CFR) Part 60, 60.536. Information that shall be presented on all labels includes:

- manufacturer's or builder's name, address, and phone number;
- masonry heater or fireplace model, model line, or design number and/or name;
- month and year of manufacture or construction, if site-built;
- on all Colorado APCD-approved masonry heater or fireplaces, the label shall state: "This appliance has been tested and has demonstrated compliance with Colorado APCD, January X, 200Y requirements; and
- the name, city and state address, and the registered service mark (i.e., U.S. Patent and Trademark Office, Washington, DC) of the Colorado APCD-accredited laboratory that conducted the test procedures, used for Colorado APCD approval.

3.4.2 Closed-Door Operation Label. If a masonry heater or fireplace was not tested in an open-door configuration and is not Colorado APCD-approved 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 Masonry Heater Or Fireplace Must Remain Closed At All Times."

3.4.3 Fuel-Elevating Grate/Operation Label. If a masonry heater or fireplace or masonry heater or fireplace was not tested in one of the fuel-elevating grate configurations (i.e., with or without) and is not Colorado APCD-approved for use by consumer users in the modified configuration, 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: "This Masonry Heater Or Fireplace Is Not Colorado APCD-Approved For Operation With/Without (Use Appropriate Term) A Hearth Fuel-Elevating Grate."

3.4.4 Low Air-Supply Operations. For masonry heaters or fireplaces with air supply controls, or if a masonry heater or fireplace cannot or is not intended to operate at its lowest air supply setting, a permanent instruction label shall be prominently affixed to the masonry heater or fireplace 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."

3.5 Emissions Control Devices

3.5.1 Label Requirements. If a masonry heater or fireplace is tested and Colorado APCD-approved with a non-integral emissions control device, the label shall state that "It is illegal to sell, install, or use this masonry heater or fireplace in Colorado without (insert the name of the specified emissions control device here) installed and operating."

3.5.2 Lock Out Requirements. Additionally, masonry heater and fireplace models approved by the Colorado APCD with non-integral emissions control devices, shall have "lock out" master control systems to prevent masonry heater or fireplace use without the emissions control device operating in a manner equivalent to its operation during the certification tests conducted in accordance with this standard.

3.5.3 Non-Tested Models. Qualifying emissions control devices may be approved by the Colorado APCD for use on various additional non-emissions-tested masonry heater or fireplace models. To qualify for Colorado APCD approval for use on a non-emissions-tested masonry heater or fireplace model, an emissions control device shall first be tested on a masonry heater or fireplace in accordance with this standard and the resulting emissions factor shall be less than 1.0 g/kg. An emissions control device meeting this requirement may then be approved for use on non-emissions-tested masonry heaters or fireplaces that demonstrate, using the fueling and flue-gas measurement protocols of this standard, a test-fuel burn period maximum air-to-fuel ratio less than the maximum air-to-fuel ratio measured during the qualifying Colorado-APCD-approval masonry heater or fireplace test period(s) but not less than 9:1; and an average flue-gas flow rate less (ft³/min, m³/min) than the average flue-gas flow rate measured during the qualifying Colorado-APCD-approved masonry heater or fireplace test periods. Air-to-fuel ratio (A/F) for this determination shall be calculated using Equation 3.5.3.1 as follows:

$$A/F_{O_2} = \frac{\{[42.5 / (0.21 - O_2)] \times [0.44 \times (0.21 - O_2) + (0.32 \times O_2) + 0.22]\} - 5.1}{10}$$

Equation 3.5.3.1

Where: A/F = air-to-fuel ratio expressed as unit mass of air per unit mass of dry wood fuel: lb/lb (kg/kg)
O₂ = mole fraction of oxygen in flue gas (%O₂ / 100)

3.5.3.1 Alternate Air-to-Fuel Ratio. If the alternative CO₂+CO flue-gas concentration recovery is used as the criteria for required fuel charging and test completion times instead of oxygen recovery, see Sections 5.8.10.1 and 5.8.14.1, A/F may be calculated using Equation 3.5.3.1.1 as follows:

$$A/F_{CO_2+CO} = \frac{\{[42.5 / (CO_2 + CO) \times [(0.44 \times CO_2) + (0.32 \times O_2) + 0.28 \times (N_2 + CO)]]\} - 5.1}{10}$$

Equation 3.5.3.1.1

3.6 List of Colorado APCD-Approved Masonry Heaters and Fireplaces. The Colorado APCD shall maintain a list of Colorado APCD-approved masonry heater or fireplace models, model lines, and designs at its Denver, Colorado offices, and that list shall be available to the public.

4.0 TEST LABORATORY ACCREDITATION

An EPA-accredited testing laboratory shall conduct all testing, test reporting, and inspection requirements.

5.0 TESTING

5.1 Applicability and Principal

The methods and protocols described in this section are applicable to the Colorado APCD approval of wood-burning masonry heaters or fireplaces and the auditing of particulate emissions factors and carbon monoxide emissions factors. Emissions measurements for this Test Standard are performed on a masonry heater or fireplace installed and operated in accordance with the following specific protocols: Emissions are sampled from masonry heater or fireplace flue gases using an emissions sampling system (ESS) described in Section 5.3.11. Flue gases are drawn through a stainless-steel sample probe, a heated sample line, a fiberglass filter, and a cooled sorbent resin for determining non-volatile as well as semi-volatile particulate emissions. Sampled combustion gases are also analyzed for oxygen (O₂), carbon dioxide (CO₂), and carbon monoxide (CO) concentrations which are used for calculating flue-gas flow rates and emissions factors.

5.1.1 Alternative Sampling and Measurement Systems. Upon approval by the Colorado APCD, qualified alternative emissions sampling methods may be used as equivalent methods to those prescribed. To qualify as equivalent, a candidate alternative method(s) shall be performed by a Colorado APCD-accredited laboratory in accordance with the U.S. EPA Method 301 Field Validation Procedure (Federal Register, December 12, 1992; Volume 57, Number 250, page 11,998). In order to qualify for alternative sampling system approval, the results of the qualifying EPA Method 301 tests shall comply with the U.S. EPA Field Validation acceptance criteria.

5.2 Test Configurations. All masonry heaters and fireplaces shall be tested in any and all of the configurations listed in Sections 5.2.1 and 5.2.2 for which the manufacturer or builder seeks Colorado APCD approval.

5.2.1 Minimum Required Masonry Heater Test Configurations. One, three-fuel-charge test-period shall be conducted for whichever of the following operating configurations is applicable:

- door(s) closed, with fuel-elevating grate; and
- door(s) closed, without fuel-elevating grate (optional).

5.2.2 Minimum Required Fireplace Test Configurations. One, three-fuel-charge test-period shall be conducted for each of the first two **or** each of the second two of the following operating configurations:

- door(s) closed, with fuel-elevating grate; and
- door(s) open, with fuel-elevating grate; or
- door(s) closed, without fuel-elevating grate (optional); and
- door(s) open, without fuel-elevating grate (optional).

5.2.3 Test Configuration Not Required. No test-burn shall be required for any configuration the appliance design cannot or is not intended to accommodate. If a possible configuration is not tested, the reason(s) must be submitted with the test

report and the permanent appliance label must state that the masonry heater or fireplace may not be used in that non-tested configuration by consumer.

5.2.4 Closed-Door(s) Testing. For all closed-door test configurations, the fuel loading door(s) shall be closed within 10 minutes after the addition of the first test-fuel piece of each test-fuel charge in a test-burn. During a test-burn period, the fuel loading door(s) shall not be re-opened except during test-fuel reload and adjustment as provided for in Section 5.8.10.

5.2.5 Additional Tests. The testing laboratory may conduct more than one test for each of the applicable configurations specified in Section 5.2. In the event 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 in calculating the arithmetic average emission factor for that configuration. The measurement data and results of all tests conducted shall be reported regardless of which values are used in calculating the average emission factor for that configuration.

5.3 Test Apparatus. The following test equipment is required for the performance of the emissions sampling procedures contained in this Test Standard.

5.3.1 Masonry Heater or Fireplace and Flue-Gas Temperature Sensors. Device(s) capable of measuring flue-gas temperature to within 1.0 percent of expected absolute temperature values.

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) in diameter that is open at both ends and capable of measuring air temperature to within 1.0 percent of expected absolute temperature values.

5.3.3 Desiccator. A desiccator for maintaining all particulate sample residues at constant room temperature and the relative humidity levels required in 40 CFR Part 60 Appendix A, U.S. EPA Method 5.

5.3.4 Soxhlet Extractors. Soxhlet extractors for extracting semi-volatile particulate emissions residues from the XAD-2 sorbent-resin.

5.3.5 Scale. Electronic strain-gauge scale capable of accurately weighing 220-pound (100-kg) test-fuel charge(s) to within 0.1 pound (0.05 kg).

5.3.6 Analytical Balance. An analytical balance capable of weighing sample filters, and sorbent-resin and equipment-rinse particulate residues to the nearest 0.1 mg.

5.3.7 Wood-Fuel Moisture Meter. Calibrated Delmhorst[®] or equivalent electrical resistance meter for measuring test-fuel moisture at a depth of 1 inch to within 1 percent moisture content (dry basis).

5.3.8 Anemometer. Device capable of measuring air velocities of 20 feet/minute (0.10 m/second), for measuring air velocities near the masonry heater or fireplace being tested.

5.3.9 Barometer. A barometer capable of measuring atmospheric pressure to within 0.02 inches (0.50 mm) of mercury.

5.3.10 Draft Gauge. Electro-manometer or inclined liquid manometer for the determination of flue/chimney draft (i.e., static pressure) readable to within 0.02 inches of water column (1.0 Pa).

5.3.11 Emissions Sampling System (ESS). Figure 5.3.11.1 shows a schematic

diagram of an ESS used for sampling wood-fired masonry heater or fireplace emissions. The ESS shall consist of the following component specifications.

5.3.11.1 Flue-Gas Sample Probe. A stainless-steel probe with $\frac{3}{8}$ -inch (10 mm) O.D. and at least long enough to reach the center of the flue/chimney at the flue-gas sampling and temperature measurement location as specified in Section 5.7.3. The stainless-steel probe shall be fitted with a stainless-steel $\frac{3}{8}$ -inch (10-mm) diameter leading edge button-hook nozzle to provide a 90° turn of the sampling probe into the direction from which the flue-gas stream flows.

5.3.11.2 Heated Sampling Line. A heated $\frac{3}{8}$ -inch (10 mm) O.D. Teflon® sampling line, not to exceed 18 feet (5.5 meters), shall be used to make the connection between the stainless-steel sampling probe and the ESS. Non-heated $\frac{3}{8}$ -inch (10 mm) O.D. Teflon® tubing shall be used to make all of the other necessary ESS connections upstream from the XAD-2 cartridge as shown in Figure 5.3.11.1.

5.3.11.3 Flue-Gas Sampling Process. Upon entering the ESS, the flue-gas sample stream shall travel through a heated U.S. EPA Method 5-type glass-fiber filter (40 CFR Part 60 Appendix A) for collection of particulate matter. The filter shall be followed by a cooled, in-line flow-through cartridge containing 20 to 25 grams of XAD-2 sorbent resin for collecting semi-volatile hydrocarbon compounds. Water vapor shall then be removed from the sampled flue-gases by a cooled condensate trap with a volume of no more than 100 ml. Sampled flue-gas oxygen concentrations shall be measured within the ESS system by an electrochemical cell meeting the performance specifications presented in Section 5.3.15.

5.3.11.4 Sample Flow Control. The ESS shall use a critical orifice to maintain a nominal but constant flue-gas sampling rate in the range of 0.035 cubic feet (1.0 liter) per minute to 0.106 cubic feet (3.0 liters) per minute, $\pm 10\%$. The critical orifice shall be calibrated through an operating temperature range of 50-200°F (10-95°C). The resulting calibration curve shall be used to correct the sampling rates taking place during each test period.

5.3.11.5 Flue-Gas Sub-Sample Collection. A consistently proportional sub-sample of the flue-gas sample stream exiting the ESS flue-gas sample processing system shall be directed into a 4 cubic-foot (100-liter) gas sampling bag for the measurement of the average carbon dioxide and carbon monoxide and confirmation of average ESS-measured oxygen concentrations for the test period.

5.3.11.6 Flow Meter. Rotameter with flow-control valve in the 0 to 1.0 cubic-foot per hour (0 to 500 ml per minute) range.

5.3.11.7 Condenser/Dryer. Low-volume (i.e., less than 100 ml total volume) Midget glass impinger(s).

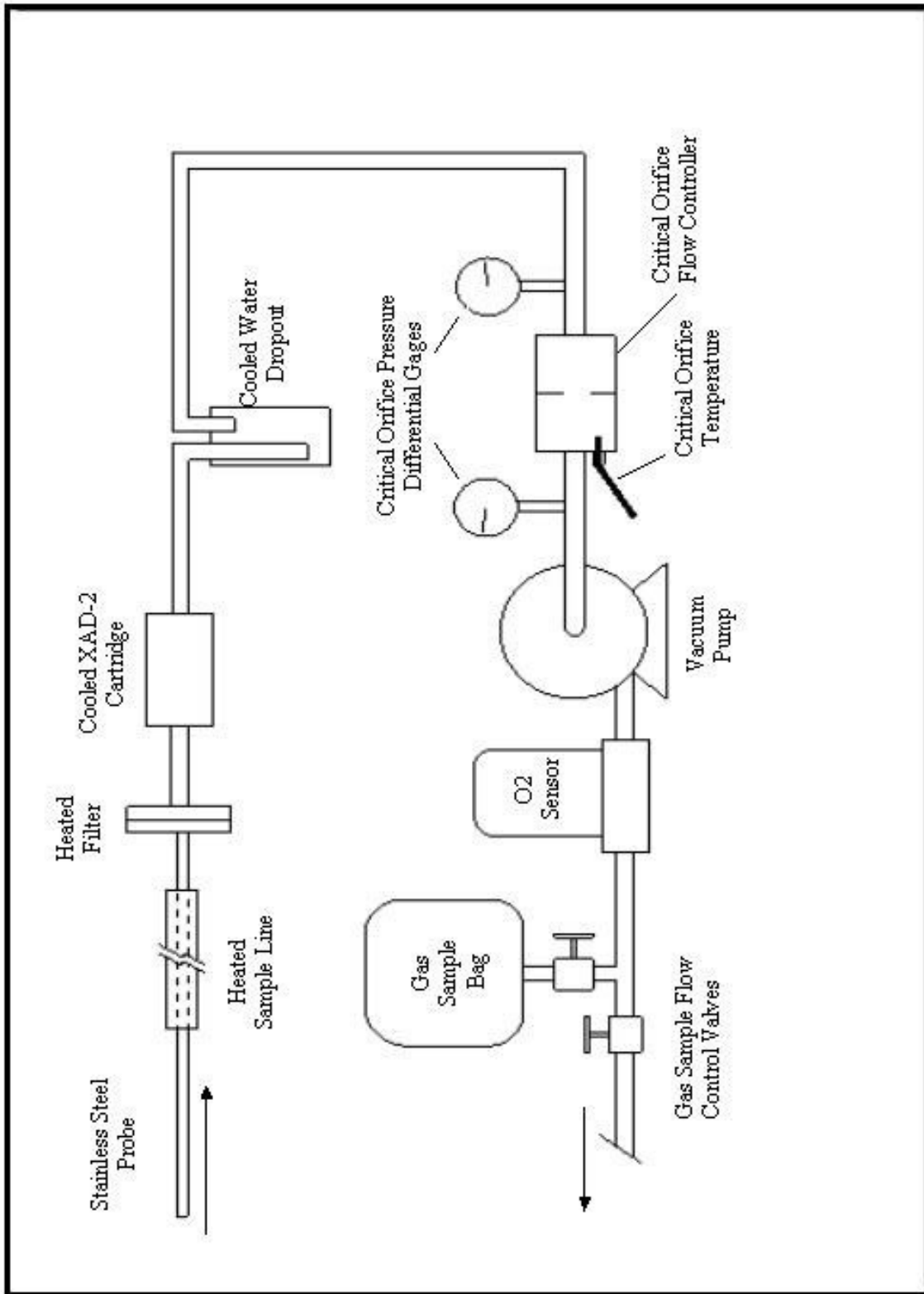


Figure 5.3.11.1 Schematic Diagram of Emissions Sampling System (ESS)

5.3.11.8 Filter. An in-line filter to remove solids and condensable materials from the sampled flue-gas stream. The filter can be fiberglass or glass wool. Disposable filter cartridges may also be used.

5.3.12 Linear-Measure Device. A standard-verified meter stick or tape measure capable of measuring increments of 0.1 inch (2 mm).

5.3.13 Vacuum Gages. Vacuum gage with a range of 0 to 30 inches of mercury.

5.3.14 Three-Way Valve. For purging and evacuating gas sample bags, for isolating the sample bag once evacuated, and for permitting withdrawal of sample from the bag for analysis.

5.3.15 Gas Analyzers. Gas analyzers with capabilities for measuring carbon dioxide (CO₂) in the range of 0.0 to 20.0 percent, carbon monoxide (CO) in the range of 0.00 to 5.00 percent, and oxygen (O₂) in the range of 0.0 to 25.0 percent in flue-gas samples shall be used for conducting the gas analysis requirements of these Test Method Protocols. Each gas analyzer shall meet the following measurement system performance specifications:

5.3.15.1 Analyzer Calibration Error. The error shall be less than $\sqrt{2}$ percent of the span value for the high-range calibration gas used.

5.3.15.2 Sampling System Bias. The bias shall be less than $\sqrt{3}$ percent of the span value for the high-range calibration gas used.

5.3.15.3 Zero Drift. The drift shall be less than $\sqrt{2}$ percent of the high-range span value for the high-range calibration gas used.

5.3.15.4 Calibration Drift. The drift shall be less than $\sqrt{2}$ percent of the high-range span value for the high-range calibration gas used.

5.3.15.5 Analytical Interference. The interference of CO measurements caused by the presence of CO₂ in flue-gases shall be determined by the sampling of high-range CO₂ calibration gas through the carbon monoxide analyzer system. A calibration gas in the range of 10% to 12% CO₂ and 0.00% CO by volume shall not cause the CO analyzer to indicate a measurement of more than 0.20% CO.

5.3.15.6 CO₂ Gas Analyzer Accuracy Limitation. If average test-period flue-gas CO₂ plus CO is not greater than 2.0%, the CO₂ analyzer shall have a resolution of at least 100 parts per million (0.01 %)

5.4 Sampling Supplies and Reagents.

5.4.1 Calibration Gases. Calibration gases for each flue-gas constituent to be measured shall have concentrations at each of the nominal ranges indicated in Table 5.4.1.1. Mixtures or combinations of calibration gases may be used in place of separate cylinders for each calibration constituent.

Table 5.4.1.1 Nominal Analyte Calibration Gas Concentrations

	Oxygen		Carbon Dioxide		Carbon Monoxide	
	Fireplaces	Masonry Heaters	Fireplaces	Masonry Heaters	Fireplaces	Masonry Heaters
High	19 – 21%	19 – 21%	8 – 12%	17 – 21%	0.70– 1.1%	1.0 – 2.5%
Mid	11 – 15%	8 - 12%	4 – 8%	8 - 12%	0.20 - 0.70%	0.60 – 1.0%
Low	4 – 7%	0 – 4%	0 – 2%	0 – 4%	0 – 0.30%	0 – 0.50%

Note 1: All calibration gas mixtures shall be certified by the calibration gas supplier or the Colorado APCD-approved test laboratory using the reference methods contained in Title 40 Code of Federal Regulations, Part 60, Appendix A: Methods 3 and 10.

5.4.2 Dichloromethane (Methylene Chloride). Reagent grade or better. (Report blanks for each supply batch.)

5.4.3 Methanol. Reagent Grade or better. (Report blanks for each supply batch.)

5.4.4 Sample Filter. Type A/E glass-fiber filters rated at 99.9% removal of particulate matter $\geq 0.3\mu\text{m}$ aerodynamic diameter: 102 mm diameter.

5.4.5 XAD-2 Sorbent Resin. The XAD-2 sorbent resin shall be Amberlite® or equivalent and shall not produce blank residues of 2.0 mg per 25 grams of XAD-2 when extracted in dichloromethane for 24 hours.

5.4.6 Gas Sample Bags. Gas sample bags shall be Tedlar® or equivalent and shall hold a volume adequate to provide at least 3 minutes of sample extraction and analysis by the gas analysis instrumentation systems being utilized.

5.4.6.1 Gas Sample-Bag Preparation. Fill each flue-gas sample bag with zero-air or nitrogen and then evacuate with a vacuum pump. If necessary, tightly roll the bag up toward the inlet/outlet port-valve fitting to complete the evacuation.

5.5 Test Fuel

5.5.1 Species. Test fuel shall be Douglas fir.

5.5.2 Fuel Piece Cross-Sectional Dimensions. For average firebox heights of more than 12.0 inches (305 mm), test fuel pieces shall consist of air-dried 2.0- by 3.5-inch 51- by 89-mm) and 3.5- by 3.5-inch (89- by 89-mm) actual-dimension lumber.

5.5.2.1 Small Fireboxes. For average firebox heights equal to or less than 12.0 inches (305 mm) (e.g., bake ovens), the height of each fuel piece and all vertically positioned fuel crib spacers shall be reduced proportionally to the amount the firebox height is less than 12.0 inches (305 mm). Adjust fuel piece and spacer height shall be calculated using Equation 5.5.2.1.1 as follows:

$$FP_{ah} = FP_{sh} \times AF_h / 12 \text{ inches (305 mm)} \quad \text{Equation 5.5.2.1.1}$$

Where: FP_{ah} = Adjusted fuel piece height

FP_{sh} = Standard fuel piece height: 3.5 inches (89 mm)

AF_h = Actual firebox height

FP_{ah} shall be used in the equations in Section 5.5.7.3 for calculating the number of fuel piece layers in each fuel crib.

5.5.3 Fuel Moisture Content. For each fuel piece fuel moisture content is the average of 1-inch deep moisture measurements made at three locations on each piece; one each not closer than 2.0 inches (51 mm) from each end and one near the middle of the length. The average fuel moisture of each piece shall be in the range of 19 to 25% dry basis (16 to 20% wet basis).

Note: Most wood moisture meters measure in dry-basis percent. Verify the moisture meter specifications to confirm its moisture basis output measurement type.

5.5.4 Test-Fuel Cribs. Except as specified in Section 5.5.5.3.1, fuel load cribs shall be constructed so that their length, width, and height are equally proportional to the average length, width, and height of the firebox being tested. Three separate fuel-load cribs shall be prepared. The first layer of the first fuel crib load shall be made up of 1.5- x 3.5-inch (38- x 89-mm) fuel pieces. The second and higher layers of the first fuel crib load and the second and third fuel crib loads are made entirely of 3.5- x 3.5-inch (89- x 89-mm) fuel pieces. Wood spaces shall be laterally centered between and on all fuel-piece sides facing another fuel piece side. No spacers are placed on any outward-facing fuel crib piece sides. See Figures 5.5.4.1, 5.5.4.2, and 5.5.4.3.

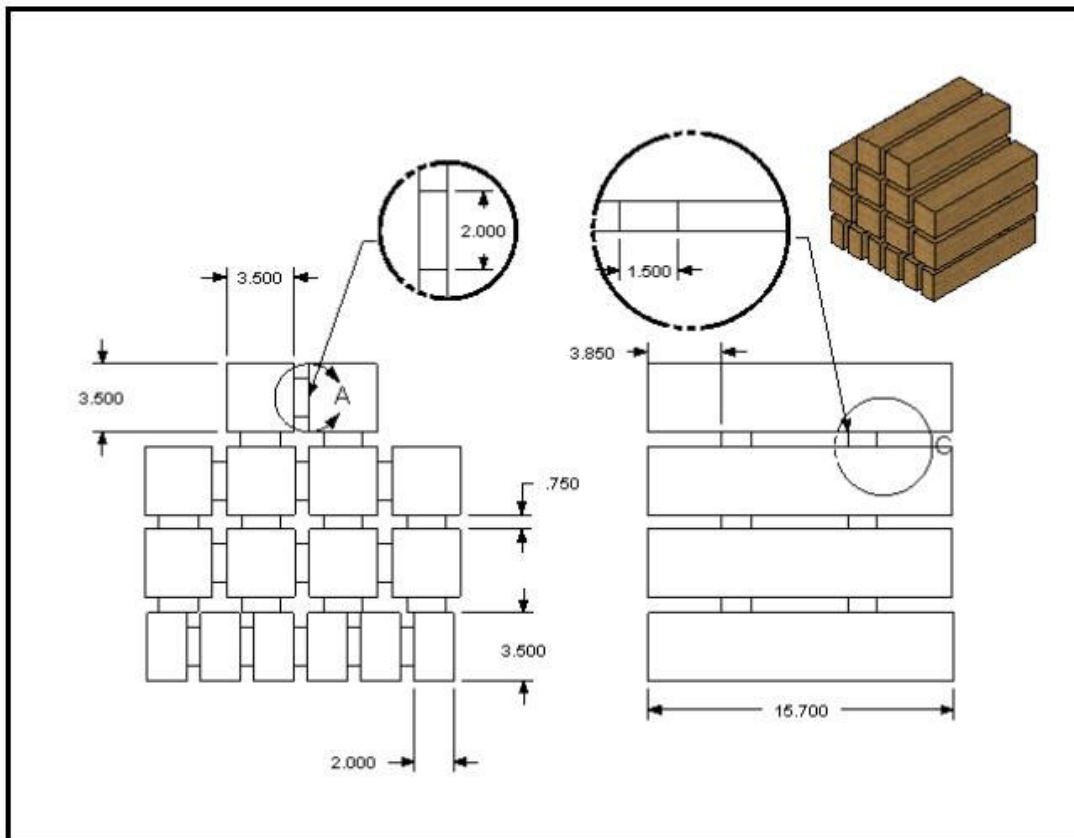


Figure 5.5.4.1: First Fuel-Crib Load Details.

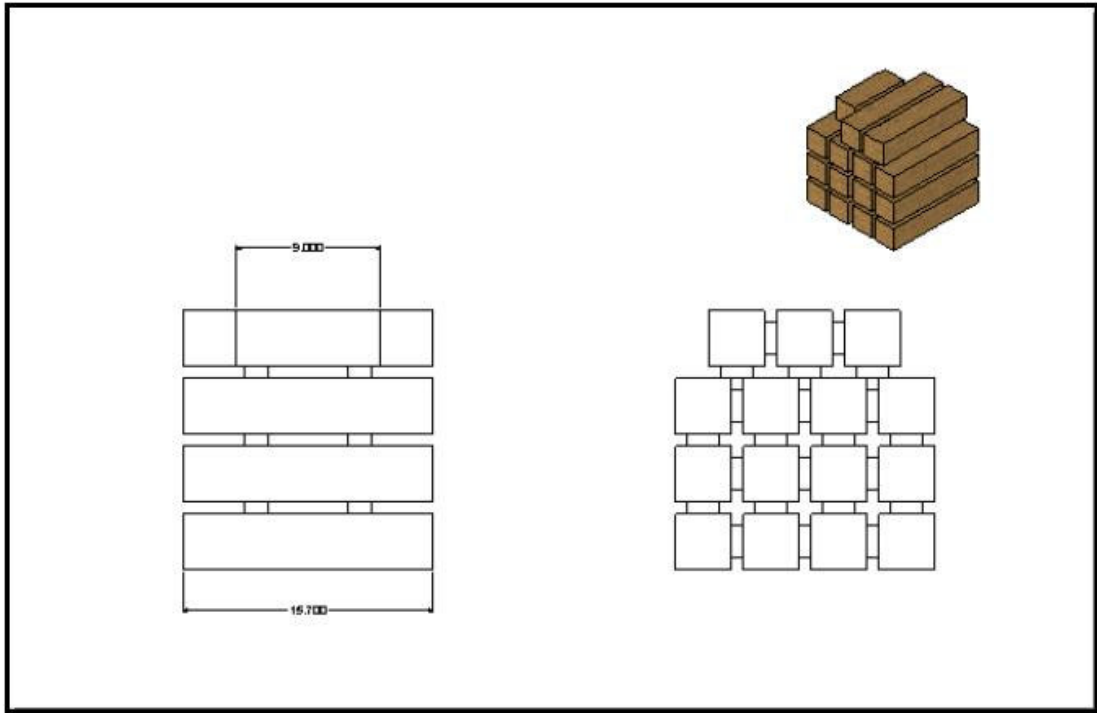


Figure 5.5.4.2: Second and Third Fuel Crib Details.

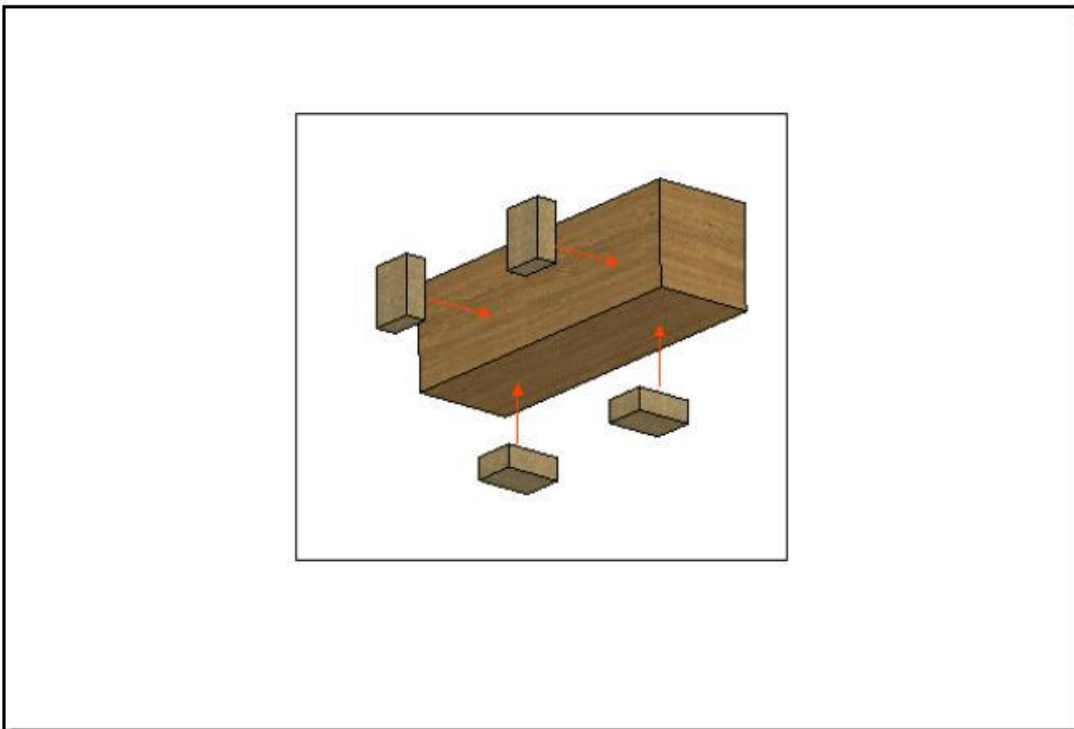


Figure 5.5.4.3: Fuel Piece Spacer Placement.

5.5.5 Fuel Crib Dimensional Specifications. This section describes the procedure by which fuel crib dimensional specifications are determined for hearth perimeters delineated by at least 3 straight-line walls/sides around the hearth and hearth perimeters having at least one horizontal line of symmetry across the hearth.

5.5.5.1 Fuel Crib Shape. All fuel cribs built to the specifications of this section will have rectilinear plan and length views.

5.5.5.2 Primary and Secondary Horizontal Hearth Dimension Designation. The manufacturer or builder shall designate either the line of symmetry or the longest line drawn perpendicular to the line of symmetry as the PH_{hd} along which the length of the fuel crib shall be oriented for burning. The longest line perpendicular to the PH_{hd} is designated as the Secondary Horizontal Hearth Dimension (SH_{hd}).

5.5.5.2.1 Line of Symmetry. A line of symmetry is obtained by drawing a straight line across a plan-view drawing of the hearth area, or, if present, the fuel elevating grate area so that the line bisects the hearth or fuel-elevating grate area into mirror images. For hearth or fuel-elevating grate areas that have more than one line of symmetry, only one shall be chosen as the PH_{hd} . This standard makes no preference or specification of which one is chosen.

5.5.5.2.2 Average PH_{hd} . Determine the average PH_{hd} from the lengths of at least 9 lines equally spaced and parallel to the PH_{hd} along the whole length of the SH_{hd} .

5.5.5.2.3 Average SH_{hd} . Determine the average SH_{hd} from the lengths of at least 9 lines equally spaced and parallel to the SH_{hd} along the whole length of the PH_{hd} .

5.5.5.3 Average Firebox Height (F_{bh}). If there are inwardly slanted or curved firebox walls or other downward physical projections, an average firebox height shall be determined using vertical dimensions measured from the hearth or top of a fuel-elevating grate to the horizontal plane that intersects and is perpendicular to the top of the fuel loading door opening or any lower projection directly above the centers of at least 9 closely-equal and square hearth sub-areas, none of which exceeds 16 square inches (100 square centimeters).

5.5.5.3.1 Fireplace Firebox Height Limitation. For fireplaces, the average- F_{bh} /average- SH_{hd} ratio shall not exceed 0.75. If the average- F_{bh} /average- SH_{hd} ratio is greater than 0.75, the average F_{bh} shall be reduced to 75% of the average- SH_{hd} . This adjusted average- F_{bh} (or if applicable, F_{bha}) shall be substituted for F_{bh} in all of the following fuel-crib calculations.

5.5.5.4 Total Useable Hearth Area. Determine the total usable hearth area (H_{ua}) or, if present, the total horizontal plan area of the fuel elevating grate.

5.5.5.5 Useable Firebox Volume (F_v). Calculate useable firebox volume by multiplying the average F_{bh} (or, if applicable, the F_{bha}) by H_{ua} .

5.5.5.6 Fuel-Crib Volume. Calculate the fuel-crib volume (F_{cv}) as 25.0% of the F_v for masonry heaters and 15% of the F_v for fireplaces.

5.5.5.6.1 Fuel-Elevating Grate. Fuel-crib volume calculated from a fuel-elevating-grate-based H_{ua} (see Fuel-Elevating Grate under the Firebox

Volume definition in Section 2.0) shall not be greater than the fuel-crib volume calculated using an H_{ua} derived from the whole useable hearth area.

5.5.5.7 Fuel-Crib Dimension Sizing Factor (FC_{dsf}). Determine the fuel-crib-dimension/firebox-dimension sizing factor as the cube root of the fuel-crib-volume/firebox-volume loading factor.

$$FC_{dsf} = \sqrt[3]{(X / 100)} \quad \text{Equation 5.5.5.7.1}$$

Where: $X = 25\%$ for masonry heaters or
 $X = 15\%$ for fireplaces

5.5.5.8 Fuel-Crib Length (FC_l) and Target Fuel Crib Width (FC_{tw}) and Height (FC_{th}). Determine FC_l , FC_{tw} , and FC_{th} using the equations as follows:

$$FC_l = PH_{hd} \times FC_{dsf} \quad \text{Equation 5.5.4.8.1}$$

$$FC_{tw} = SH_{hd} \times FC_{dsf} \quad \text{Equation 5.5.4.8.2}$$

$$FC_{th} = FB_h \times FC_{dsf} \quad \text{Equation 5.5.4.8.3}$$

5.5.6 Fuel Piece Spacing. The 0.75-inch (19-mm) vertical and horizontal spacing between parallel fuel pieces shall be made by nailing, with 18-gage by 1¼-inch (32-mm) finishing brads, 0.75-inch by 1.5-inch by 2.0-inch (19-mm by 38-mm by 51-mm) spacers positioned so their 1.5-inch (38-mm) longitudinal side centerline is 'X' inches from and parallel to the 3.5-inch (89 mm) end edge of the fuel piece to which it is being attached. Where: $X = 0.15 \times F_{pl}$. These fuel-piece spacers are further positioned so the latitudinal centerline of the 1.5- x 2.0-inch (38- x 51-mm) side of the spacer is perpendicular to the longitudinal spacer centerline and 1.75 inches (45 mm) from the longitudinal edge of the fuel pied side to which it is being attached. To maintain 0.75-inch (38-mm) spacing between fuel pieces, spacers should only be attached on alternating facing sides of each fuel piece. No spacers are to be attached to fuel-piece faces located on the outer-most faces of the fuel crib. Maximum spacing between all fuel pieces shall not exceed 0.75 inches (19 mm).

5.5.7 First Fuel-Crib Structure.

5.5.7.1 Number of Fuel Pieces in the Bottom (First) Layer ($n1_1$). The number of bottom/first layer pieces in the first fuel crib is the closest whole number result from the equation as follows:

$$n1_1 = (FC_{tw} + 0.75 \text{ inches}) / 2.25 \text{ inches} \quad \text{Equation 5.5.7.1.1 (in/lb)}$$

$$n1_1 = (FC_{tw} + 0.19 \text{ cm}) / 5.7 \text{ cm} \quad \text{Equation 5.5.7.1.2 (SI)}$$

Where: $n1_1$ = Number of fuel pieces in the first layer of the first fuel crib

Note: When the result is X.50, round up if the preceding integer, x, is even and down if the integer, x, is odd.

5.5.7.2 Number of Fuel Pieces in Additional Layers ($n1_i$). The number of 3.5- x 3.5-inch (89- x 89-mm) fuel pieces in each of the second, third, and higher layers ($n1_i$), is the closest whole number result from the equation as follows:

$$n1_i = (FC_{tw} + 0.71 + 0.75 \text{ inches}) / 4.25 \text{ inches} \quad \text{Equation 5.5.7.2.1 (in/lb)}$$

$$n1_i = (F_{tw} + 0.18 + .19 \text{ cm}) / 10.8 \text{ cm} \quad \text{Equation 5.5.7.2.2 (SI)}$$

Where: n_{1_i} = Number of fuel pieces in the i th layer when ' i ' is greater than 1
0.75 inches (0.19 cm) = Place holder for last spacer in each layer
0.71 inches (0.18 cm) = Factor for forcing an additional fuel piece in the event a partial piece of less than 0.333 is calculated.

Note: Round up for X.50 results when the X integer is even and down for X.5 results when the X integer is odd.

5.5.7.3 Number of Fuel Crib Layers (n_{fcl}). The number of fuel-crib layers for each and all fuel cribs shall be the closest whole number result from the equation as follows:

$$n_{fcl} = (FC_{th} + 0.71 + 0.75 \text{ inches}) / (FP_h + 0.75) \text{ inches} \quad \text{Equation 5.5.7.3.1}$$

$$n_{fcl} = (FC_{th} + 0.18 + 0.19 \text{ cm}) / (FP_h + 0.19) \text{ cm} \quad \text{Equation 5.5.7.3.2}$$

Where: $n_{1_{fcl}}$ = Number of fuel crib layers

$FP_h = FP_{sh}$ or FP_{ah} (see Section 5.5.2)

0.75 inches (0.19 cm) = Place holder for last spacer in each layer

0.71 inches (0.18 cm) = Factor for forcing an additional fuel crib layer in the event a partial layer of less than 0.333 is calculated.

5.5.8 Second and Third Fuel-Crib Loads. Except as specified in Section 5.5.2.1, the second and third fuel-crib loads shall consist entirely of 3.5- by 3.5-inch (89- by 89-mm) fuel pieces nailed and fastened parallel to each other with 0.75-inch (19-mm) spacing between them. The number of pieces in each second and third fuel crib layer shall be equal to the number of pieces in the second and higher layers of the first fuel-crib load and the number of layers in each second and third fuel-crib load shall be equal to the number of layers in the first fuel crib load.

5.5.9 Test-Fuel Crib Construction. All fuel pieces with attached spacers shall be positioned in place to form a rectilinear-shaped fuel crib. All the fuel pieces of the whole fuel crib are then secured in position by wrapping and twist-tying 12-gauge bailing wire around each end of the crib's longitudinal axis. If a fully constructed and bailing-wire-secured fuel crib cannot be safely loaded into the firebox or cannot fit through the test appliance's fuel-loading door, whole fuel-crib layers may be loaded separately starting with the lowest layer and placing subsequently higher layers on top of each other without inter-connecting bailing wire. Only in cases where whole fuel crib layers cannot be placed in the firebox safely or cannot fit through the test appliance's fuel loading door can fuel crib layers be separated into smaller groups of fuel pieces or individual fuel pieces for loading. In any case, the fuel piece spacing and fuel crib layer and stacking configurations prescribed in this section shall be maintained.

5.5.10 Fuel-Crib Alignment For Testing. Kindling loads and test-fuel-cribs shall be aligned for fuel charging and re-charging so that the lengths of the fuel pieces are parallel to the designated PH_{hd} .

5.5.11 Fuel Crib Weight. Within 30 minutes before testing is initiated, each fuel crib with all their fuel pieces and spacers shall be weighed to the nearest 0.1 lb (45 g) and recorded.

5.5.12 Kindling.

5.5.12.1 Kindling Preparation. For each test, a kindling bed or kindling stack shall be prepared for initiating test fire burning periods. Kindling fuel shall consist of 0.75- by 0.75-inch (19- by 19-mm), 0.75- by 1.5-inch (19- by 38- mm), and 1.5- by 1.5-inch (38- by 38 mm) dimensioned lumber. Kindling fuel species shall be Douglas fir with a moisture content of not more than 15% dry basis. The kindling-fuel load weight is not part of the initial fuel-crib load weight but is in addition to it and is used in calculating total fuel used during a test period. For fireboxes with no fuel-elevating grate, the kindling bed shall consist of four layers of the specified kindling fuel pieces constructed or positioned as follows. See Figure 5.5.12.1.1.

5.5.12.1.1 First Layer. The first (bottom) kindling layer shall consist of 2 equal-length pieces of the 19- by 38-mm ($\frac{3}{4}$ - by $1\frac{1}{2}$ -inch) lumber cut to the length dimension of the fuel crib. These two pieces are placed on their $\frac{3}{4}$ -inch (19-mm) edge on the hearth parallel to the PH_{hd} .

5.5.12.1.2 Second Layer. The second kindling layer shall consist of 2 equal-length pieces of the $\frac{3}{4}$ -by $1\frac{1}{2}$ -in (19- by 38-mm) lumber cut to the fuel crib width dimension, placed on their $\frac{3}{4}$ -inch (19-mm) edge on top of the two-piece first layer and perpendicular to the first layer pieces. The ends of the second layer, (i.e., top) two pieces shall be positioned so that the ends of all first- and second-layer pieces meet to form right-angled corners. All first and second layer pieces shall be fastened together at the corners by nailing a 3-inch length of $\frac{3}{4} \times \frac{3}{4}$ -inch (19- x 19-mm) kindling fuel into the inside of each corner using 18-gage by $1\frac{1}{4}$ -inch (32-mm) brads.

5.5.12.1.3 Newspaper. Crumple one full, double-tabloid-width (approximately 650 square inches (4200 cm^2)) of newspaper for every 100 square inches of horizontal fuel crib area and place them with even spacing and without excessive compression, within the space created by the first two kindling bed layers.

5.5.12.1.4 Third Layer. The third kindling layer shall consist of $\frac{3}{4}$ - by $\frac{3}{4}$ -inch (19- by 19-mm) lumber cut to equal lengths that are cut to the fuel crib length dimension. Enough of these pieces are prepared so that they can be placed at $1\frac{1}{2}$ -inch (38-mm) center-to-center intervals all the way across the top of, and perpendicular to the second layer pieces.

5.5.12.1.5 Fourth Layer. The fourth kindling layer shall consist of the $1\frac{1}{2}$ - by $1\frac{1}{2}$ -inch (38- by 38-mm) lumber cut to equal lengths that are cut to the fuel crib width dimension. Enough of these pieces are prepared so that they can be placed at 2.5-inch (64-mm) center-to-center intervals all the way across the top of, and perpendicular to the third-layer pieces.

5.5.12.2 Small Firebox. If the average firebox height is less than 12 inches (305 mm), the height of each kindling piece shall be reduced in proportion to the amount the firebox height is less than 12 inches (305 mm). Kindling piece height shall be adjusted using the Equation 5.5.12.2.1 as follows:

$$KP_{ah} = KP_{sh} \times AF_h / 12 \text{ inches (305 mm)} \quad \text{Equation 5.5.12.2.1}$$

Where: KP_{ah} = Adjusted kindling piece height

KP_{sh} = Standard kindling piece height: $\frac{3}{4}$ inches or 1.5-inches (19 mm or 38 mm)

AF_h = Actual firebox height

5.5.12.3 Firebox with Fuel-Elevating Grate. For fireboxes with a fuel-elevating grate, one layer of 1.5- by 1.5-inch (38- by 38-mm) kindling fuel shall be added to the base 4-layer kindling bed for every 2.0 inches (51 mm) of fuel elevation above the hearth. Added layers shall be placed perpendicular to the length of the pieces making up the layer immediately below. In the event of a partial 50 mm (2.0 inch) fuel-elevating grate height increment, a partial kindling layer shall be prepared. The partial layer shall have a kindling fuel volume directly proportional to the partial height increment of the fuel-elevating grate. For example, a fuel-elevating grate height of 3.0 inches (76 mm) shall have: $3 / 2$ (76 mm / 50 mm) = 1.5 additional layers of $1\frac{1}{2}$ - x $1\frac{1}{2}$ -inch (38- by 38-mm) kindling. The 0.5 partial layer shall have 0.5 of the volume of a whole $1\frac{1}{2}$ - by $1\frac{1}{2}$ -inch (38- by 38-mm) fuel piece layer. Partial kindling-layer pieces shall be cut to the same length as full-layer pieces and placed at equal intervals onto the previous layer.

5.5.12.4 Kindling Weight. Within 30 minutes of test initiation, the total weight of all kindling pieces shall be measured to within 0.1 lb (45 g) and recorded.

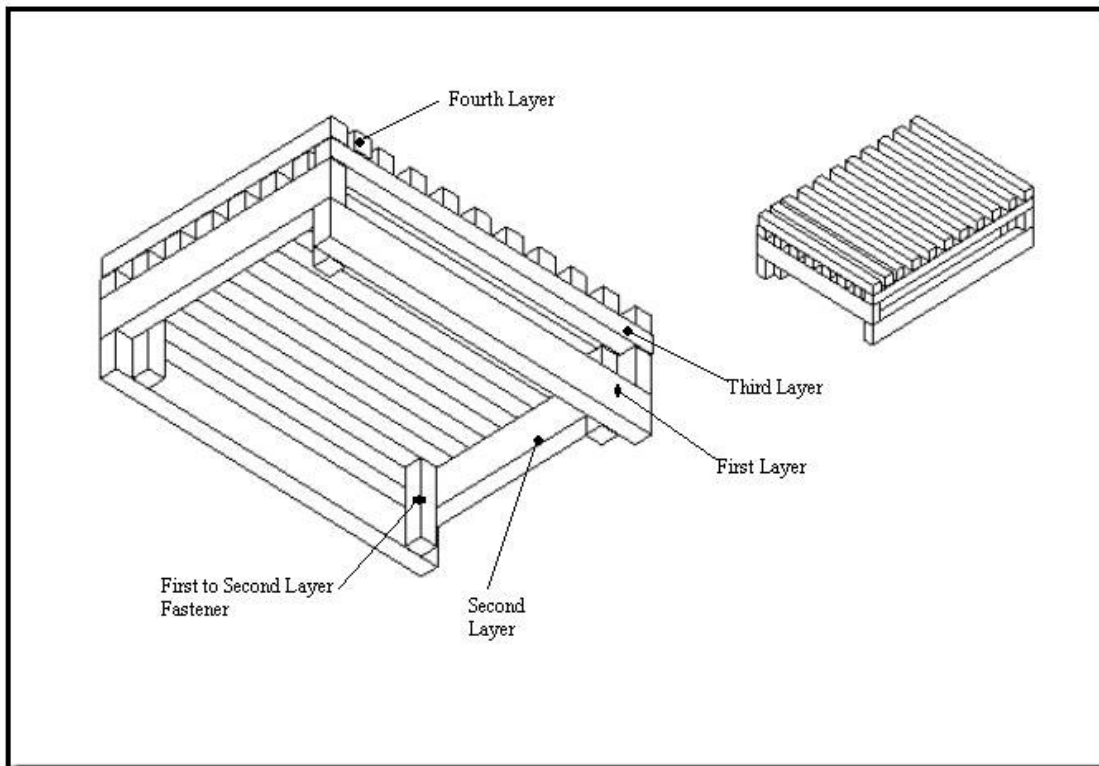


Figure 5.5.12.1.1: Kindling Stack Details.

5.6 Calibration and Audit Requirements.

5.6.1 Scale. Within 3 hours before the initiation of a test, 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), re-calibrate the scale before use with at least three calibration weights spanning the operational range of the scale.

5.6.2 Temperature Measurement Devices. Calibrate the temperature measurement devices before the first test period and semiannually thereafter.

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

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

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

5.6.6 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.

5.6.7 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.

5.6.8 ESS Calibration.

5.6.8.1 Oxygen Cell. The ESS oxygen cell shall be calibrated in accordance with the procedures specified in Section 5.8.17.2 within 2 hours of test period initiation.

5.6.9 Sample Flow Rates and System Response Times. ESS flue-gas sample-bag and any other alternative flue-gas sampling system flow rate shall be set in accordance with Section 5.6.9.1 within 2 hours before sampling system response time is measured. The determination of response time for the ESS or an alternative gas sampling system shall be conducted before the first test period initiation and semiannually thereafter or at any time sampling system flow control components are changed.

5.6.9.1 Setting Sampling Flow Rate. Adjust the flue-gas sample-bag flow rate so that enough sample gas is collected in the gas-sample bag over the entire test period to provide at least 3 minutes of post test period gas analyzer sampling operation without running out of sample. During the test period, the gas sampling bag shall not over-fill and become pressurized to the extent that the gas sample flow rate to the gas sample bag is affected.

5.6.9.2 Response Time Measurement. The response time for all flue-gas sampling systems shall be determined by a the measurement of a step change in analyte gas concentration. First, supply a low-range analyte calibration gas (see Table 5.4.1.1) into the sample probe inlet end until the certified calibration gas concentration is measured. After the low range analyte is measured, switch the probe to a high-range calibration gas and immediately start timing the system response time. Response time shall be measured starting at the time the a sample probe is switched from the low-range analyte calibration gas to high-range calibration gas and ending at the time the respective analyte analyzer reading is 90% of the difference in calibration gas concentrations utilized.

5.6.9.3 Response Time Limitation. Response time for all gas-sampling analyzers shall not exceed 1.0 minute for the ESS flue-gas sub-sample system.

5.7 Test Preparations

5.7.1 Masonry Heater or Fireplace Installation. The masonry heater or fireplace being tested must be constructed, if site-built, or installed, if manufactured, in accordance with the designer's/manufacture's written instructions. These shall be the same instructions provided by the manufacturer or builder to the homeowner/user. The chimney shall have a total vertical height above the hearth of not less than 15 feet (4.6 m) nor more than 18 feet (5.5 m). The masonry heater or fireplace chimney exit to the atmosphere must be freely communicating with the masonry heater or fireplace combustion makeup-air source. There shall be no artificial atmospheric pressure differential imposed between the chimney exit to the atmosphere and the masonry heater or fireplace make-up air inlet.

5.7.2 Masonry Heater or Fireplace Description. Record masonry heater or fireplace and, if equipped, catalyst and/or add-on emissions control device descriptions. The recorded masonry heater or fireplace 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 tested masonry heater or fireplace and signed by an authorized representative of the Colorado APCD-accredited testing laboratory.

5.7.3 Primary Flue-Gas Sampling and Temperature Measurement Location.

The Primary ESS sampling probe shall draw its flue-gas sample stream from near the center of the flue at a location which is at least 6.0 effective flue/chimney duct diameters (as calculated using Equation 2.1) upstream from the flue exit to the atmosphere or 8 feet (2.44 m) above the hearth whichever is the least flue-gas exhaust-duct center line distance from the hearth of the firebox. The flue-gas temperature probe shall also be positioned near the center of the flue/chimney duct at the flue-gas sampling location but shall not interfere in any way with the ESS sample probe inlet.

5.7.3.1 Add-On Emission Control Equipment. If a masonry heater or fireplace is equipped with an emissions control device located in the flue/chimney duct, downstream from the masonry heater or fireplace firebox, the primary ESS flue-gas sampling and temperature measurement locations shall be re-positioned immediately downstream from the emissions control device but not less than 6.0 effective flue diameters upstream from the flue exit to the atmosphere. An ESS flue-gas sampling and temperature measurement location positioned immediately downstream from an emissions control device shall meet the flue-gas stratification requirements of Section 5.7.5.2.

5.7.3.1.1 Fueled Emissions Control Devices. If a masonry heater or fireplace is equipped with an emissions control device that requires additional energy input, except for electricity, an real-time flue-gas oxygen analyzer and a second integrated test period flue-gas sample collection system (with a gas sample bag) shall be located at the original primary ESS flue-gas sampling and temperature measurement location specified in Section 5.7.3. Test period real-time oxygen concentrations indicated by this analyzer, upstream from the emissions control device, shall be used for determining fuel recharge and test completion times.

5.7.4 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 masonry heater or fireplace. Locate the temperature monitor probe at a distance of 3 to 6 feet (1.0 to 2.0 meters) from the front of the masonry heater or fireplace and in a 90° sector defined by lines drawn at +/- 45° from a perpendicular line to centerline of the masonry heater or fireplace face.

5.7.5 Heat-Aging, Curing, and Durability Confirmation. A masonry heater or fireplace of any type shall be operated at under "normal" conditions before certification testing begins. Operate the masonry heater or fireplace using the fuel described in Section 5.5 for at least 10 hours. Record and report the hours of operation and weight of all fuel burned during the aging, curing and durability confirmation period.

5.7.5.1 Catalyst And/Or Add-On Emissions Control Device-Equipped

Masonry Heaters or Fireplaces. Operate a catalyst and/or add-on emissions control-equipped masonry heater or fireplace using fuel described in Section 5.5 for at least 50 hours prior to conducting a test. Record and report hourly catalyst temperatures and add-on emissions control equipment operating parameters during the hours of operation and the weight of all fuel burned during the heat-aging, curing, and durability confirmation period.

5.7.5.2 Flue-Gas Stratification Check. During the masonry heater or fireplace heat-aging and curing period specified in Section 5.7.5, use the oxygen analyzer and sampling system specified in Section 5.3.15 to determine whether flue gases become stratified in the flue/chimney cross-section at the primary emissions sampling and temperature measurement location specified in Section 5.7.3.

5.7.5.2.1 Stratification of Flue-gas Oxygen Concentrations. The stratification of flue-gas oxygen concentrations shall be determined by first sampling at the center of the flue/chimney at the ESS flue-gas sampling and temperature measurement location for at least one minute and then moving the sampling probe to within 1 inch (25.4 mm) of the flue chimney wall for an additional minute. This procedure is to be repeated on at least two horizontal and perpendicular traverses of the flue/chimney cross-section. Flue-gas oxygen concentration differences of more than 15% of the oxygen concentration measured at any of the other three cross-section sample points shall be considered stratified.

5.7.5.2.2 Stratification Remedy. The presence of a stratified flue-gas flow regime at the emissions sampling location shall be remedied by either changing the flue/chimney duct design or changing the flue-gas sampling and temperature measurement probes to ones that equally and simultaneously sample the flue-gases and temperatures in the center of at least 4 separate and equal areas of the flue/chimney cross-section.

5.7.6 Leak Check. A leak check of the ESS and any other alternative flue-gas sampling system shall be performed within 2.0 hours before each test period initiation. Leak checks shall be performed as follows.

5.7.6.1 Leak-Check Procedure. Seal the sample inlet probe-nozzles 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.

5.7.6.2 Leak Check Acceptance Criteria. Unless the leakage rate under the required vacuum is less than 2 percent of the average sample flow rate, analysis results shall be invalid.

5.7.7 ESS Pre-Test Set-Up.

5.7.7.1 XAD-2 Cartridge. Within 72 hours before each test period, the XAD-2 cartridge shall be processed as described in Section 5.8.16.2 for the determination of an XAD-2 resin blank. No XAD-2 resin blank that exceeds 2 mg per 25 gram batch of XAD-2 resin shall be used for any test.

5.7.7.2 ESS Flow Rate. Within 72 hours before each test-burn, the ESS flow rate shall be confirmed to within 0.0007 cubic feet (0.02 liters) per minute using the temperature-corrected critical orifice flow calibration curve and a standardized volumetric bubble-type flow meter.

5.8 Masonry Heater and Fireplace Operation and Testing Protocols

5.8.1 Masonry Heater or Fireplace Cooling Period. No fuel shall be burned in the test masonry heater or fireplace and no other means for heating the masonry heater or fireplace shall be used within the 12-hour period preceding test period initiation.

5.8.2 Pre-Test Procedures

5.8.2.1 Room-Air Velocity. Using an anemometer, measure and record the room-air velocity within 2 feet (0.6 meters) of the test masonry heater or fireplace air supply duct intake or fuel loading door within 1 hour before test initiation. Air velocity at the specified locations shall be less than 200 feet/minute (61 m/minute). No external means shall be used to affect air velocities within 2 feet (0.6 meters) of the test masonry heater or fireplace during a test period.

5.8.2.2 Barometric Pressure. Measure and record the barometric pressure within one hour before test period initiation.

5.8.2.3 Flue-Gas Temperature Determination. At least one hour before initiating a test period (i.e., ignition of a fire in the masonry heater or fireplace), close all air supply controls and the masonry heater or fireplace door(s), or if the fireplace is not equipped with a door(s), use other means for closing the open face area of the fireplace. After one hour of masonry heater or fireplace air-supply and open-face-area closure and within 5.0 minutes before opening the door(s) or the other means for closing the open face area of the masonry heater or fireplace to initiate test-fire ignition, measure and record the pre-test flue-gas temperature at the flue-gas sampling and temperature measurement location or at the upstream temperature measurement location of an emission control device, as provided in Section 5.7.3.

5.8.3 OMITTED

5.8.4 Test-Burn Ignition. The test burn may be started only with a match (i.e., no charcoal-lighter torches or other devices), with or without paper, and/or with or without kindling. Completion of test-fuel charging shall be within 10 minutes after test initiation as described in Section 5.8.5.

Note: Prior to fuel charge ignition in a masonry heater, 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 the fire might extinguish. Establish sufficient operating draft by first heating the venting path by burning paper and/or kindling, so that flue draft is at least 0.02" H₂O measured at the 8-foot (2.44 meter) sampling level. Test measurements and sampling shall be initiated within 15 seconds of when flue-gas temperatures reach 25°F above pre-test flue-gas temperature as specified in Section 5.8.2.3. The weight of paper and/or kindling used to initiate a draft for nominal masonry heater operation are not considered part of the fuel load charges and are not included in total fuel weight determinations.

5.8.5 Test Period Initiation. Flue-gas sampling is initiated after the kindling and

fuel have been ignited and within 15 seconds of when flue-gas temperatures at the center of the flue/chimney at the flue-gas sampling and temperature measurement location, or the upstream flue-gas sampling and temperature measurement location of an emissions control device as provided in Section 5.7.3, reaches 25°F (14°C) greater than the pre-test flue-gas temperature as measured in Section 5.8.2.3.

5.8.6 Test-Time Sampling, Parameter Measurement, and Data Recording Requirements. Once all test sampling and temperature measurements have begun at test initiation in accordance with Section 5.8.5 (i.e., zero time), all test sampling, parameter measurement, and data recording requirements shall be conducted at each 5-minute interval and shall continue without interruption until the test is terminated in accordance with Section 5.8.14. Test-time sampling and temperature measurement parameters shall include:

ESS Oxygen (O₂) (alternatively, real-time CO₂ + CO may be measured instead of oxygen; see Sections 5.8.10.1 and 5.8.14.1).

Temperatures:

Flue-Gas

Heated Sample Line

Heated ESS Filter

Cooled XAD-2 Cartridge

ESS Moisture Condensate Trap

ESS Critical Orifice

Sample Train/System Bag Filling Rates:

ESS Sub-Sample Gas Bag

Sample Train Vacuum:

Across ESS Critical Orifice

Draft Pressure at the Primary Sampling and Temperature Measurement Location

5.8.7 ESS Component Temperatures. During all test periods, the temperature of the following ESS components shall be controlled to the following specifications:

- The heated sample line shall be maintained in a temperature range from 200 to 250°F (95 to 121°C) during all sampling periods,
- The glass-fiber filter and its holder shall be maintained in a temperature range from 200 to 250°F (95 to 121°C) during all sampling periods, and
- The XAD-2 cartridge and the moisture condensate trap shall be maintained in a temperature range from 35 to 40°F (1.7 and 4.4°C) during all sampling periods.

5.8.8 Test Facility Ambient Temperatures. Test facility ambient temperatures shall be maintained between 65 and 100°F (18 and 38°C) during all test periods.

5.8.9 ESS Flue-Gas Sub-Sample Bag Filling Rates. The sampling rate into all gas-sample bags shall be constant throughout the test period to within ∇ 10% of the test-period average. From the beginning of a test period to the end, gas sampling rates shall be high enough to ensure that the total volume of each collected sample is greater than 3.0 cubic feet (82 liters). In the event that the resulting sample flow

rate is more than the desired bag-filling rate, starting at the test period initiation, vent excess sample to the atmosphere.

5.8.10 Test Fuel Additions. Test-fuel crib charges for a test-burn period shall be placed and burned in the fire chamber only after flue-gas oxygen concentrations, as measured by the ESS oxygen sensor, have recovered (i.e., increased) to at least 80% of the maximum flue-gas oxygen depression value resulting from combustion of the immediately previous kindling or test-fuel charge. 20.9 percent shall be used as the baseline ambient air supply oxygen concentration. For example, if the maximum flue-gas oxygen depression from the burning of a preceding fuel charge was 12.5% (i.e., the minimum flue-gas oxygen concentration during burning of the fuel load was 8.4%: $20.9 - 12.5 = 8.4\%$) the next fuel charge may only be loaded after the flue-gas oxygen concentration has returned to 18.40% or greater: i.e., $(0.8 \times 12.5) + 8.4 = 18.4\%$.

5.8.10.1 Alternative Fuel Addition Criteria. The recovery of the peak sum of real time flue-gas carbon dioxide and carbon monoxide ($\text{CO}_2 + \text{CO}$) concentrations back to ambient $\text{CO}_2 + \text{CO}$ concentrations may be used as an alternative to the flue-gas oxygen concentration recovery fuel load addition/loading criteria. When using $\text{CO}_2 + \text{CO}$ concentrations, test fuel additions shall be placed and burned in the fire chamber only after flue-gas $\text{CO}_2 + \text{CO}$ concentrations have recovered (i.e., decreased) back to at least 20% of the maximum flue-gas $\text{CO}_2 + \text{CO}$ value resulting from combustion of the immediately previous test-fuel charge.

5.8.10.2 Inadequate Coal Bed. If the coal bed remaining after flue-gas oxygen concentration has recovered (i.e., increased) to at least 80% of the preceding maximum flue-gas oxygen depression value does not appear to be sufficient or adequate for restarting the next test-fuel charge within the allowed 10.0-minute fuel-loading period, newspaper and/or kindling may be added and the test-fuel charge re-positioned in order to facilitate reasonable ignition of the added test-fuel charge.

5.8.10.2.1 Additional Newspaper and/or Kindling. The addition of all newspaper and/or kindling and the entire test-fuel charge including any additional newspaper and/or fuel added under Section 5.8.10.1 shall be completed within 10.0 minutes from the time the first piece of the test-fuel charge is loaded into the firebox. The weight of all newspaper and/or kindling shall be weighed to the nearest 0.1 lb (0.05 kg), recorded, and added to the total test-fuel weight.

5.8.11 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 20 seconds.

5.8.12 Combustion Air Supply Adjustment. Any and all means for controlling masonry heater or fireplace combustion air supplies may only be adjusted during each of the 10-minute post test-fuel charging periods. At the end of each 10-minute fuel charging period, after the addition of each test-fuel charge, all air supply control settings must be set to the lowest setting and shall remain at the lowest setting throughout the remaining burn time for each test-fuel charge.

Note: If a masonry heater or fireplace cannot or is not intended to operate at the lowest air supply setting, a permanent instruction label shall be prominently affixed to the masonry heater or fireplace 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 (*or alternatively, to the test-specified*) position during all firing periods."

5.8.13 Auxiliary Masonry Heater or Fireplace Equipment Operation. Heat exchange blowers (standard or optional) sold with the masonry heater or fireplace shall be operated during all test burns following the manufacturer's or builder's written consumer instruction manual instructions. If no manufacturer's written consumer instruction manual is available, operate the heat exchange blower in the "high" or maximum position. (Automatically operated blowers shall be operated as designed.) Shaker grates, by-pass controls, afterburners, or other auxiliary equipment may be adjusted only once during the period that each test-fuel charge burns and the adjustment shall be in accordance with the manufacturer's or builder's written instructions. Record and report all adjustments made to auxiliary masonry heater or fireplace equipment during the test period.

5.8.14 Test Completion. A test period (i.e., a three fuel-crib test-burn period) is completed and all sampling and test-period temperature measurements are stopped at the end of the first five-minute interval after which the flue-gas oxygen concentrations, as measured by the ESS oxygen sensor, have recovered (i.e., increased) to at least 95% but not more than 97% of the maximum flue-gas oxygen depression value which resulted from combustion of the third test-fuel charge. The ESS and any alternative flue-gas sampling systems shall continue operation after test completion for a period of time equal to the respective response time, as determined in Section 5.6.9.2, for each sampling train.

5.8.14.1 Alternative Test Completion Criteria. As with fuel load additions, the recovery of the peak sum of real-time flue-gas carbon dioxide and carbon monoxide ($\text{CO}_2 + \text{CO}$) concentrations back toward ambient $\text{CO}_2 + \text{CO}$ concentrations may be used as an alternative to the flue-gas oxygen concentration recovery for test completion criteria: When using $\text{CO}_2 + \text{CO}$ concentrations, test completion shall occur only after flue-gas $\text{CO}_2 + \text{CO}$ concentrations have recovered (i.e., decreased) back down to between 3% and 5% of the maximum flue-gas $\text{CO}_2 + \text{CO}$ value resulting from combustion of the immediately previous kindling or test-fuel charge. The ESS and any alternative flue-gas sampling systems shall continue operation after test completion for a period of time equal to the respective response time, as determined in Section 5.6.10.2, for each sampling train.

5.8.15 Post-Test Procedures.

5.8.15.1 Room-Air Velocities. Using a low-velocity-range anemometer, measure and record the room-air velocity within 2 feet (0.6 meters) of the test masonry heater or fireplace within 10 minutes after test completion. Air velocity within 2 feet (0.6 meters) of the test masonry heater or fireplace shall not be more than 50 feet/minute (250 mm/second) without the masonry heater or fireplace operating.

5.8.15.2 Fuel Weight at Test Completion. Within 5 minutes after test

completion, as defined in Section 5.8.14, the remaining coals and/or unburned fuel and/or ash shall be carefully removed from the firebox and weighed to the nearest 0.1 pounds (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. A test-burn shall be invalid if less than 90 percent of the weight of the total test-fuel charges plus the kindling weight has been consumed in the masonry heater or fireplace firebox.

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

5.8.15.4 Leak Check. The ESS shall be leak checked at the maximum test-period vacuum level within 1 hour of sampling completion. Under maximum test-period vacuum, the ESS sampling system shall not have a leak rate of more than 2 liters per hour.

5.8.15.5 Critical-Orifice Flow Rate at Test Completion. Post-test critical-orifice flow-rate determinations shall be performed before the ESS is dismantled for sample recovery and clean up. Pre-test and post-test critical-orifice flow rate measurements shall be within 0.0007 cubic feet (0.02 liters) per minute of each other or the test-burn emissions results shall be invalid.

5.8.16 ESS Particulate Emissions Sample Processing. Each component of the ESS shall be processed as follows:

5.8.16.1 Filter. The glass-fiber filter (4 inches (102 mm) in diameter) shall be removed from the ESS filter housing and placed in a petri dish for desiccation and gravimetric analysis. ESS filters shall be processed in accordance with U.S. Environmental Protection Agency (EPA) Method 5 protocols (Title 40 Code of Federal Regulations, Part 60, Appendix A).

5.8.16.2 XAD-2 Sorbent-Resin Cartridge. The contents of the XAD-2 sorbent-resin cartridge shall be extracted in a Soxhlet extractor with dichloromethane (methylene chloride) for 24 hours. The extraction solution shall be transferred to a clean tared glass beaker and evaporated in a filtered-air dryer at ambient laboratory conditions. The beaker, with dried residue, shall then be desiccated to constant weight (i.e., less than ∇ 0.5 mg change within a 2-hour period). The dry dichloromethane-extractable residues shall then be weighed to the nearest 0.1 mg. EPA Method 5 procedures (Title 40 Code of Federal Regulations, Part 60, Appendix A) for desiccation and weighing-time intervals shall be followed for processing the ESS XAD-2 emissions residues.

5.8.16.2.1 Blanks. Blank values shall be determined for the amount of dichloromethane solvent used for extracting the ESS emissions residues and these blank values shall be subtracted from the total measured emissions residues determined in Section 5.8.16.2.

5.8.16.3 ESS Hardware Clean-Up. All hardware components which are in the flue-gas sample stream (i.e., the stainless-steel probe, the heated sampling line, the filter holder, and all other Teflon[®] and stainless-steel fittings) through the top of the sorbent-resin cartridge, shall be cleaned with a solvent mixture of 50 percent dichloromethane and 50 percent methanol. The resulting dissolved

emissions residues and cleaning solvent solutions shall be placed in tared glass beakers, evaporated in an ambient-air dryer, desiccated to constant weight (i.e., less than ∇ 0.5 mg change within a 2-hour period), and weighed to the nearest 0.1 mg.

5.8.16.3.1 Blanks. Blank values shall be determined for the amount of each solvent used for cleaning ESS components and these blank values shall be subtracted from the total measured emissions residues determined in Section 5.8.16.3.

5.8.16.4 ESS Particulate Emissions Sample Preservation. If ESS samples cannot be processed within 2 hours after test completion, the stainless-steel sampling probe, the heated sampling line, the filter holder, and the XAD-2 sorbent-resin cartridge(s) shall be removed from the ESS, placed in a container capable of maintaining temperatures of less than 50°F (10°C), and transported to, or stored in, the laboratory for processing within 48 hours.

5.8.16.5 Minimum ESS Particulate Emissions Sample Quantities. For each complete test period, the ESS must catch a minimum total particulate material mass of at least 5 mg. Alternatively, the ESS must sample a minimum of 10 cubic feet (275 liters) of flue gases during each test-burn period. If this volume cannot be sampled in the test-burn time period, two ESS samplers must be utilized to sample masonry heater or fireplace emissions simultaneously during each test-burn. If emissions factor results from the two ESSs are different by more than 10 percent of the higher emissions-factor result, the test-burn results shall be invalid. An arithmetic average is calculated for test-burn results when two ESSs are utilized in this manner and have emissions factor results within 10 percent of the higher emissions factor amount.

5.8.17 ESS Flue-Gas Sample Bag Processing.

5.8.17.1 Leak Checks. Leak checks of the combustion gas analyzer systems shall be performed within 2.0 hours before gas-bag analyses are performed. Leak checks shall be performed as follows:

5.8.17.1.1 Leak-Check Procedure. Seal the sample inlet probe-nozzles of each analyzer system. Use the analyzer pump controls to create a vacuum greater than either twice the maximum vacuum encountered during sample processing, 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.

5.8.17.1.2 Leak Check Acceptance Criteria. If the leakage rate at the required vacuum is greater than 5 percent of the average sample processing (i.e., analyzer flow) rate, the analysis results shall be invalid.

5.8.17.2 Combustion-Gas Analyzer Calibrations. To correct analytical accuracy and drift errors, combustion gas analyzers shall be calibrated using the following three-point calibration procedures before and after the analysis of samples for each test period. If at any time during the analysis procedures, a single-point audit fails (i.e., Section 5.8.17.4), the following multi-point calibration procedure shall be re-performed:

- allow the instrument to operate for a sufficient time to stabilize, as

- recommended by the manufacturer's recommended operating procedures;
- introduce zero gas into the inlet at a "normal" sample flow rate, and zero the analyzer output. Then introduce the high-range calibration gas and span the analyzer output;
- introduce consecutively, in the same manner as described above, the zero and mid-range calibration gases, and record the instrument response to each when no further change in the analyzer response can be detected; and
- calculate and plot a linear least-squares calibration curve, forcing, if necessary, the curve to pass through the origin.

5.8.17.3 Flue-Gas Sample Bag Analysis. Measure the CO₂, CO, and O₂ concentrations in the gas sample bag at least twice each. After preparation of the combustion gas analyzer as described in Section 5.8.17.2, analyze the contents of the flue-gas sample bag within 10 minutes. Next, re-zero the analyzer and re-analyze the gas-sample bag a second time.

5.8.17.3.1 Flue-Gas Analysis Repeatability Requirements. If the two measurements for each analyzed gas constituent agrees to within 2.0% of the paired-average values, the analyses are complete. If any pair of flue-gas constituent analyses do not satisfy the acceptance criteria, re-zero the analyzer and re-analyze the sample bag a third time using the same procedure. If one pair of the three analyses for a constituent satisfies the acceptance criterion, the analysis for that constituent is acceptable. However, if no pair out of the three analyses for any of the constituents analyzed do not meet the acceptance criterion, the whole analysis set is unacceptable. For example, a paired set of direct flue-gas CO₂ analyses which result in measurements of 9.9 and 10.1 mole-percent passes, and a paired set which results in measurements of 9.9 and 10.2 mole-percent, fails.

5.8.17.3.2 Oxygen Concentration Requirements. An average ESS flue-gas O₂ concentration for the entire test period shall be calculated and compared to the flue-gas sample bag O₂ concentration analysis performed in Section 5.8.17.3. In the event the difference between the ESS oxygen-cell test-period average O₂ concentration and the flue-gas sample bag oxygen concentration is more than 5.0 percent of the average of the combined ESS oxygen cell and flue-gas sample bag analysis results, the test shall be invalid.

5.8.17.4 Combustion Gas Analyzer Audit. Within 15 minutes after analyzing the flue-gas sample bag from a test period, zero and span the CO₂, CO, and O₂ analyzers with the zero- and high-range calibration gases. Then introduce the mid-range calibration gas. Using the most recent calibration curve for each analyzer, compare the measured concentration of each mid-range calibration gas to its actual concentration. If the values do not agree to within 5 percent of the average of their respective calibration gas values, re-calibrate the analyzer, and conduct the analyzer audit procedure over again. If the values do not agree within 5 percent on the second analysis, the test data are invalid.

5.8.17.5 Sampling Rate Constancy. For the ESS and any alternative flue-gas sample-bag sampling system, calculate the average sampling rate during the

entire test period from the data recorded in accordance with Section 5.8.6. Then calculate the percentage deviation of each recorded sampling rate from its test period average. The sampling rate is adequately constant and valid if the average magnitude of the deviations is less than 5 percent and if no single deviation is larger than 10 percent.

6.0 CALCULATIONS

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 ESS particulate samples and gas sample-bag analyses to calculate the emissions factor, emissions rate, and masonry heater or fireplace operational parameters.

6.1 Total Test Period and Sampling Time. The total test period sampling time (t_{tt}) in minutes is calculated as follows:

$$t_{tt} = t_c \times N_{T>25^{\circ}F / \%>95} \quad \text{Equation 6.1.1}$$

Where: t_c = The data-recording cycle (5.0 minutes for this Test Standard).

$N_{T>25^{\circ}F / \%>95}$ = The total number of whole 5.0-minute data-recording cycles that occurred between the time when the flue-gas temperature after test-burn ignition first exceeded 25EF (14EC) more than the pre-test flue-gas temperature (i.e., test period initiation as defined in Section 5.8.5) and the time when the flue-gas oxygen recovery from the third test-fuel charge exceeded 95% (i.e., test period completion as defined in Section 5.8.14).

6.2 Test Period Burn Rate. Burn rate is calculated as follows:

$$\text{Burn Rate (kg/hour)} = (\text{Fuel Total Weight} \times 60) / t_{tt} \quad \text{Equation 6.2.1}$$

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

6.3 Particulate Emissions.

6.3.1 ESS Emissions Factor. The equation for the total ESS-particulate emission factor (EF_{ESS}) presented below produces reporting units of grams of emissions per dry kilogram of fuel burned (g/kg):

$$EF_{ESS} = (P_m \times F_{mcc} \times M_{vs}) / (t_{tt} \times S_r \times (Y_{CO_2} + Y_{CO})) \quad \text{Equation 6.3.1.1}$$

Where: P_m = The total mass of particulate material from the filter, the XAD-2 resin cartridge; the probe, and ESS hardware clean-up and rinse solutions (grams).

S_r = The ESS-sampling rate. The actual, verified, and documented critical orifice sampling rate determined in Section 5.7.7.2 (liters per minute).

F_{mcc} = The molar carbon content of the fuel (i.e., 42.5 gram moles of carbon per dry kilogram of fuel derived from the 51.0% carbon content of Douglas fir).

M_{vs} = Molar volume of ideal gases at standard conditions (i.e., 24.06 cubic meters per kilogram-mole).

Y_{CO_2} = The test period average of the molar fraction of carbon dioxide in the flue gases (i.e., percent CO_2 in the flue gases divided by 100).

Y_{CO} = The test period average of the molar fraction of carbon monoxide in the flue gases (i.e., percent CO in the flue gas divided by 100).

Note: Multiplying the emission factor by the average burn rate yields the particulate emissions rate in grams/hour.

6.3.2 EPA Method-5H Particulate Emissions Factor Equivalents. Convert the ESS Particulate Emissions Factor (EF_{ESS}) results from Section 6.3.1 above, to a final Colorado EPA-Method-5H-Equivalent Emissions Factor (CEF_{M-5}) as follows:

$$CEF_{M-5} = (0.247 + (0.232 \times EF_{ESS}) + (0.00491 \times EF_{ESS}^2)) \quad \text{Equation 6.3.2.1}$$

Where: EF_{ESS} = The ESS Particulate Emissions Factor (gram/kilogram) from Section 6.3.1.

6.3.3 Carbon Monoxide (CO) Emissions. The CO emission-factor is calculated as follows:

$$CO_{\text{emissions factor}} = CO_f \times F_{f-g} \times 1.1637 \quad \text{Equation 6.3.3.1}$$

Where: CO_f = The molar fraction of CO measured in the flue-gas sample bag.

Note: Percent CO divided by 100 gives the molar fraction of CO_f .

F_{f-g} = The flue-gas "F" factor calculated as follows:

$$F_{f-g} = (F_{mcc} \times M_{vs}) / Y_{CO_2}$$

1.1637 = kg of CO per cubic meter of CO = The gram molecular weight of carbon monoxide (i.e., 28) divided by the standard molar volume of 24.06 cubic meters per kilogram-mole of ideal gas at STP.

7.0 REPORTING REQUIREMENTS

Submit both raw and reduced data for all masonry heater or fireplace tests conducted for Colorado APCD approval. All test information and masonry heater or fireplace drawings submitted for Colorado APCD-approval shall be verified and certified by the **EPA**-accredited laboratory, which performed the tests being submitted for Colorado APCD-approval. Specific reporting requirements are as follows:

7.1 Masonry Heater or Fireplace Identification. Report masonry heater or fireplace identification information including manufacturer, model, model line, or design and serial number of the masonry heater or fireplace tested. Also include the published installation and operating instructions.

7.2 Test Facility Information. Report test facility location and test period temperatures and air velocity information.

7.3 Test Equipment Calibration and Audit Information. Report calibration and audit results for the test-fuel scale, test-fuel moisture meter, analytical balance, and sampling equipment including volume metering systems and flue-gas analyzers.

7.4 Pretest Information and Conditions. Report all pretest conditions including test-fuel charge weights, masonry heater or fireplace temperatures, and air supply settings.

7.5 Particulate Emissions Data. Report a summary of test results for all test-burns conducted and the arithmetically averaged emission factor for the test-burns used for Colorado APCD approval. Submit copies of all data sheets and other records collected during the testing. Submit examples of all calculations performed if not performed in the format presented in Section 6.0.

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

7.6.1 Introduction.

7.6.1.1 Purpose of test. Colorado APCD-approval or audit.

7.6.1.2 Masonry Heater or Fireplace Identification. Manufacturer, model name or number, catalytic/non-catalytic, emissions control equipment, and any optional equipment. Include a copy of masonry heater or fireplace installation and operation manuals.

7.6.1.3 Testing Laboratory. The EPA-approved laboratory name, location, and test personnel that performed the testing.

7.6.1.4 Test information. Date masonry heater or fireplace was received, if factory-built, date construction was completed, if site-built, date that each test was conducted, sampling methods used, a description of each masonry heater or fireplace configuration tested as required in Section 5.2, and the number of test burns conducted for each masonry heater or fireplace configuration.

7.6.1.5 Test Method And/Or Masonry Heater or Fireplace Operating Protocol Deviations. The report shall contain a complete description of any test method or masonry heater or fireplace operating protocol deviation conducted in the performance of the required test procedures and protocols contained in this Test Standard. The report must provide detailed rationale explaining the necessity for the deviation(s) and a record of communications conducted for obtaining Colorado APCD approval for the deviation(s) undertaken.

7.6.2 Summary and Discussion of Results.

7.6.2.1 Table of Results. Test-burn number, masonry heater or fireplace configuration, burn rate, particulate emission factor (in U.S. EPA Method 5H equivalents). An example test period summary table is presented in Figures 7.6.2.1a and 7.6.2.1b.

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

7.6.2.3 Discussion. Include specific test-burn problems and solutions and rationale for, and for not testing specific configurations like an open-door configuration.

7.6.3 Process Description.

7.6.3.1 Masonry Heater or Fireplace Dimensions. Firebox height, width, length (or any other pertinent dimensions), weight, and hearth area used for calculating fuel-charge weight.

7.6.3.2 Firebox Internal Assembly Configuration. Include 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.

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

7.6.3.4 Masonry Heater or Fireplace Operation Procedures. Air supply settings and adjustments, fuel-bed/coal-bed adjustments, and draft utilized during each test period.

7.6.3.5 Test fuel. Test fuel properties including: the volume, weight, and average dry basis moisture content of each fuel load. Also, include photographs of the kindling crib and each fuel load crib.

7.6.4 Sampling Locations. Describe sampling location relative to masonry heater or fireplace components. Include drawings and/or photographs.

7.6.5 Sampling and Analytical Procedures. Include a brief reference to operational and sampling procedures, and optional and alternative procedures used, include details of any parts of the procedures differing from the prescribed methods (e.g., Colorado APCD-approved alternatives).

7.6.5.1 Analytical methods. A brief description of sample recovery and analysis procedures.

Manufacturer: Manufacturer				Test Run Number: #			
Test Conducted By: Laboratory				Test Period Start Date/Time: xx/xx/xxxx, xx:xx:xx AM/PM			
Technician: Technician Name				Test Period End Date/Time: xx/xx/xxxx, xx:xx:xx AM/PM			
Model Tested: Model				Configuration: Door Open/Door Closed			
Fireplace or Masonry Heater Type: Catalytic/Non-Catalytic							
Time							
Total Test Period	xx.x	Hours					
Test Data Recording Cycle	10.0	Minutes					
Fuel							
Total Fuel Used	xx.x	kg wet	Average Temperatures				
Average Fuel Moisture	xx.x%	Dry Basis	Flue-Gas Temperature (at 8 feet above hearth)	xxx	°F	xxx	°C
Total Fuel Burned	xx.x	kg dry	Test Facility Ambient Temperature	xxx	°F	xxx	°C
Average Burn Rate During Operation	x.xx	kg/hour (dry)					
Emissions							
ESS Emission Factor	x.xx	g/kg					
EPA 5H Equivalents	x.xx	g/kg					
Carbon Monoxide	x.xx	g/kg					
Average Flue-Gas Concentrations							
Oxygen	xx.x%	%					
Carbon Dioxide	xx.x%	%					
Carbon Monoxide	xx.x	Ppm					

Figures 7.6.2.1a. Page 1 of an Example Test Period Summary Table.

Run Number	Configuration	Burn Rate, kg/hour	Method 5H Equivalents
1	With Door Open	x.xx	x.xx
2	With Door Closed	x.xx	x.xx
Averages		x.xx	x.xx

Figures 7.6.2.1b. Page 2 of an Example Test Period Summary Table.

7.6.6 Quality Control and Quality Assurance (QC/QA) Procedures and Results

7.6.6.1 Calibration Records. Description of calibration procedures and results.

7.6.6.2 Test Method. Test method quality control procedures: leak-checks, volume-meter checks and sample-blank analyses.

7.6.7 Appendices

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

7.6.7.2 Raw Data. Include copies of all original data sheets for sampling records, parameter measurements, temperature records, and sample recovery. Include copies of all burn-rate and masonry heater or fireplace temperature data.

7.6.7.3 Construction/Assembly Drawings. Masonry heater or fireplace construction or assembly drawings which clearly show all dimensions needed for completing the requirements of Section 3.2.

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

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

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

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

7.6.7.8 Additional Information. Masonry heater or fireplace manufacturer's written instructions for operation of the masonry heater or fireplace during the reported test periods and copies of the production-ready (print-ready) temporary and permanent labels required in Section 3.4.

7.6.8 References Cited in the Report

Example Reference Citation Format:

1. Code of Federal Regulations, U.S. EPA Title 40, Part 60, Subpart AAA

and Appendix A.

2. Barnett, S. G. and P. G. Fields, 1991, "In-Home Performance of Exempt Pellet Stoves in Medford, Oregon," prepared for U.S. Department of Energy, Oregon Department of Energy, Tennessee Valley Authority, and Oregon Department of Environmental Quality, July 1991.
3. Barnett, S. G. and R. R. Roholt, 1990, "In-Home Performance of Certified Pellet Stoves in Medford and Klamath Falls, Oregon," prepared for the U.S. Department of Energy, 1990.
4. Barnett, S. G., 1990, "Field Performance of Advanced Technology Woodstoves in Glens Falls, New York, 1988-1989," for New York State Energy Research and Development Authority, U.S. EPA, Coalition of Northeastern Governors, Canadian Combustion Research Laboratory, and the Wood Heating Alliance, December 1989.