DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

Air Quality Control Commission

REGULATION NO. 4

CONCERNING THE SALE AND INSTALLATION OF WOOD-BURNING APPLIANCES AND THE USE OF CERTAIN WOOD-BURNING APPLIANCES DURING HIGH POLLUTION DAYS

5 CCR 1001-6

I. DEFINITIONS

A. Unless otherwise required by the context, as used in this Regulation:

1. "Accredited Laboratory" means an independent testing laboratory that has obtained accreditation pursuant to the Federal Regulations 40 CFR Part 60 Subpart AAA (2004).

2. "Approved Masonry Heater" means a masonry heater as defined in Section I.A.12 that has complied with all requirements of Section IV.

3. "Approved Pellet Stove" means a pellet stove as defined in Section I.A.18, that has complied with all the requirements of Section III.

4. "Boiler" means a domestic solid wood-burning appliance used primarily for heating space where the appliance is located, by the distribution through pipes of a gas or fluid heated in the appliance. This appliance must be tested and listed as a boiler under accepted U.S. or Canadian safety testing codes.

5. "Burn down time" shall mean that period of time not to exceed three hours following the declaration of a high pollution day required for the cessation of combustion within any wood-burning stove, pellet stove, masonry heater or wood-burning fireplace pursuant to this Regulation.

6. REPEALED.

7. "Cookstove" means a domestic wood-burning appliance that is designed primarily for cooking food and that has the following characteristics:

   a. An oven, with a volume of 1 cubic foot or greater, and an oven rack:

   b. A device for measuring oven temperatures;

   c. A flame path that is routed around the oven;

   d. A shaker grate;

   e. An ash pan;

   f. An ash clean-out door below the oven; and

g. The absence of a fan or heat channels to dissipate heat from the appliance.

8. “Dealer” means a person who sells wood-burning stoves, pellet stoves, wood-burning fireplaces or masonry heaters on a regular basis.

8.5 “Exempt device” means a wood-burning device that does not meet the definition of a wood-burning stove by EPA standards (as contained in 40 CFR Part 40 Subpart AAA) and is not a fireplace, masonry heater, nor pellet stove as defined in this regulation.

9. “Furnace” means a domestic solid wood-burning appliance that is designed to be located outside of ordinary living areas and is used for heating spaces other than the space where the appliance is located by the distribution through ducts of air heated in the appliance. The appliance must be tested and listed as a furnace under accepted U.S. or Canadian safety testing codes.

10. “High pollution day” means those periods of time declared by Colorado Department of Public Health and Environment as provided for in Section 25-7-106.3(1), C.R.S.

11. “Manufacturer” means a person who constructs a wood-burning stove or pellet stove or is engaged in the business of designing and constructing masonry heaters or wood-burning fireplaces.

12. “Masonry Heater” means an appliance designed for or capable or burning wood, capable of and intended for domestic space heating or domestic water heating, that meets the following criteria:

a. A factory-built or site-built wood-burning appliance with a core constructed primarily of manufacturer-built, supplied or specified masonry materials (i.e., stone, cemented aggregate, clay, tile, or other non-combustible non-metallic solid materials) that weighs at least 800 kg;

b. The firebox effluent of the masonry heater travels horizontally and/or downward through one or more heat absorbing masonry duct(s) for a distance at least the length of the largest single internal firebox dimension before leaving the masonry heater;

For the purposes of this subparagraph:

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

ii. The largest single internal firebox dimension is defined as the longest of either the length or the width of the firebox hearth and the height of the

firebox, measured from the hearth to the top of the uppermost firebox door opening(s).

c. The appliance has one or more air-controlling door(s) for fuel-loading that are designed to be closed during the combustion of fuel loads, and that control the entry of combustion air (beyond simple spark arresting screen(s)) to one or more inlet(s) as prescribed by the masonry heater manufacturer;

d. The appliance is assembled in conformance with the underwriters' laboratories-listed and/or manufacturer's specifications for its assembly and, if the core is constructed with a substantial proportion of materials not supplied by the manufacturer, is certified by a representative of the manufacturer to be substantially in conformance with those specifications.

e. The appliance has a label permanently affixed to the appliance identifying its manufacturer and model.

13. “Method 5G” and “Method 5H” are test methods for determination of particulate emissions from wood-burning heaters from dilution tunnel sampling and stack locations as described in 40 CFR, Part 60, Subpart AAA, Appendix A (2004).

14. “Method 28” is a test method designed to establish certification test conditions and the particulate matter weighted emission values, as described in 40 CFR Part 60 Subpart AAA, Appendix A (2004).

15. “Method 28A” is a test method to measure air to fuel ratios and minimum achievable burn rates as described in 40 CFR, Part 60 Subpart AAA, Appendix A (2004).

16. “Model” means a group of wood stoves, pellet stoves, wood-burning fireplaces or masonry heaters that are identical to one another regarding design, emissions, and heating performance.

17. REPEALED

18. “Pellet Stove” means a heater which meets the following criteria: (1) the manufacturer makes no reference to burning cordwood in advertising or other literature, (2) the unit is safety listed for pellet fuel only, (3) the unit's operating and instruction manual must state the use of cordwood is prohibited by federal law, and (4) the unit must be manufactured and sold including a hopper and auger combination as integral parts.

19. “Phase III Certified wood-burning stove” means a wood-burning stove that meets the emission standards set forth in Section II.A.

20. “Primary source of heat” shall mean one or more residential wood-burning stoves, pellet stoves, masonry heaters or wood-burning fireplaces that provide more than half the annual heating demands for the residence.

21. “Standard method” means the applicable testing procedures and criteria set forth in the Federal Regulations 40 CFR Part 60 Subpart AAA, Appendix A.

21.5 “Wood-burning appliance” means any stove, fireplace, masonry heater, furnace, fire pit, fixture or device used, or intended for use, to burn only clean, dry, untreated wood.

22. "Wood burning fireplace" means an appliance with an open hearth (i.e. devoid of wood-burning inserts, gas logs, or electric devices), is not a masonry hearer, may or may not be equipped with air-controlling doors, is primarily constructed of masonry materials (brick, stone or ceramic) and is installed in a dwelling or building for purpose of burning wood.

23. "Wood burning stove" means an appliance, primarily constructed of metal, designed for or capable of burning wood, including a fireplace insert, capable of and intended for domestic space heating or domestic water heating that meets all of the following criteria:

    a. An air-to-fuel ratio in the combustion chamber averaging less than 35-to-1 as determined by EPA method 28A.

    b. A useable firebox volume of less than 20 cubic feet.

    c. A minimum burn rate of less than 5 Kilograms per hour.

    d. A maximum weight of 800 kilograms.

    e. The appliance has a label permanently affixed to the appliance identifying its manufacturer and model.

II. Limitation on the sale and installation of wood-burning stoves.

A. No person shall advertise to sell, offer to sell, sell, or install a wood-burning stove in Colorado unless it has been tested, certified, and labeled for emission performance in accordance with criteria and procedures specified in the Federal Regulations 40 CFR Part 60, Subpart AAA (2004) and meets the emission standards set forth in Subsection 60.532(b)(1) or (2).

B. The certification requirement shall apply to:

1. Advertisements for sale and offers for sale communicated by any means to any person in Colorado, including, but not limited to, offers to sell or advertisements for sale that are mailed to any person in Colorado.

2. Any sale occurring in Colorado, including, but not limited to, sales in which a new wood-burning stove is shipped, delivered, or transported to any person in Colorado by a person located either inside or outside Colorado and to both the initial sale and any subsequent resale of a new wood-burning stove.

C. Exemptions

1. Exempt Devices, as defined in section I.A.8.5 of this regulation.

2. Boilers

3. Furnaces

4. Cookstoves

D. On and after January 1, 1993 no person shall sell or install a used wood-burning device within those portions of the counties of Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson which are located in the AIR program area, as such area is defined in Section 42-4-304(20)(A), C.R.S., unless it meets the requirements set forth in Section II.A.

III. APPROVAL PROCEDURE FOR PELLET STOVES

A. No person shall advertise to sell, offer to sell, sell, or install a pellet stove unless it has been designated as an approved pellet stove in accordance with this Section III.

B. On or after August 1, 1992, a manufacturer of a pellet stove who wishes to have a particular model line designated as an approved pellet stove, shall submit to the Division for their review, the following information:

1. test results showing an air to fuel ratio of 35:1 or greater, using Method 28A.

2. test results using Method 5H, or Method 5G corrected to 5H, that have been conducted under minimum burn conditions, (category 1), Method 28.

3. a one-page letter signed by the laboratory president, verifying the information required in III.B.1. and 2.

C. All tests conducted under II.B shall be performed by an accredited laboratory.

D. Within twenty (20) working days after receipt of an application for approval, the Division shall notify the applicant if the application is complete. Within thirty (30) working days after receipt of a complete application, the Division shall notify the applicant whether the application satisfies all requirements for approval.

E. If the Division denies approval, the Division shall notify the applicant in writing of the opportunity for a hearing before the Commission pursuant to Section 24-4-104(9), C.R.S.

F. The Division shall grant approval if all information required by Section III A. is submitted and the test results in Section III.B.2. demonstrate particulate emissions do not exceed 4.1 grams per hour.

IV. Limitations on the installation and sale of masonry heaters – Approval procedures

A. No person shall advertise to sell, offer to sell, sell, or install a masonry heater in Colorado unless it has been designated as an approved masonry heater in accordance with this Section IV.

B. A manufacturer or builder of a masonry heater who wishes to have a model or design designated as an approved masonry heater shall submit an application and test results that comply with the requirements of Appendix A.

C. Tests performed on masonry heaters shall comply with the particulates emission testing protocol set out in Appendix A and shall be performed by an accredited laboratory. The application shall include a letter signed by the laboratory president verifying: (1) the information required in Appendix A, and (2) that the methods used were conducted according to procedures contained in Appendix A.

D. Within twenty (20) working days after receipt of an application for approval, the Division shall notify the applicant if the application is complete. Within thirty (30) working days after receipt of a complete application, the Division shall notify the applicant whether the application satisfies all requirements for approval.

E. If the Division denies approval, the Division shall notify the applicant in writing of the opportunity for a hearing before the Commission pursuant to Section 24-4-104(9) C.R.S.

F. The Division shall grant approval if all information required by Section IV and Appendix A is submitted, and the tested appliance:

1. is a masonry heater, and

2. test results do not exceed 6.0 grams of particulate emissions per kilogram of fuel.

G. The Division may grant approval for a masonry heater model that has not been tested if the untested model has substantially the same core construction as an approved model, and is substantially similar to the approved model in firebox and duct design, combustion function and probable emissions performance. The applicant must demonstrate that the untested model complies with the criteria and parameters set out in Appendix A for evaluating such similarity. The application must include all information required by Appendix A.

H. Approved masonry heaters shall be labeled and equipped as provided in Appendix A.

V. ENFORCEMENT

A. The Division may enter and inspect the property or premises of any manufacturer, or dealer, for the purpose of investigating any actual, suspected, or potential violation of this regulation; and may, at reasonable times, have access to and copy any document, inspect any wood-burning stove, wood-burning stove component, pellet stove, masonry heater, wood-burning fireplace or testing equipment, or test the emissions of any wood-burning stove, wood-burning fireplace, pellet stove or masonry heater possessed by any manufacturer, or dealer, for the purpose of ascertaining compliance or noncompliance with this regulation.

B. The Division shall also enforce the provisions of this regulation through all means authorized by Part 1 Title 25, C.R.S.

VI. LIST OF APPROVED WOOD-BURNING APPLIANCES

The Division shall request each dealer to make available to consumers a list of Phase II certified wood-burning stoves, exempt devices, approved pellet stoves and approved masonry heaters to be compiled by the Division.

VII. HIGH POLLUTION DAYS

A. Applicability

Limitations on the use of wood burning appliances shall be applicable only in those portions of the counties of Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson that are located in the AIR program area, as such area is defined in Section 42-4-304(20)(A), C.R.S. but not including those areas above seven thousand feet elevation.

B. Provisions of this section may be enforced by the appropriate local agency. Local agencies are encouraged to develop suitable enforcement programs and enter into an agreement with the State to promote more effective enforcement of this regulation. Approval of a wood-burning stove, pellet stove or masonry heater model pursuant to this regulation does not constitute authorization not to comply with requirements of any local ordinance or resolution relating to the installation or use of any wood-burning appliance.

C. This section shall not apply within any municipality that had an ordinance mandating restricted use of wood-burning stoves, pellet stoves, masonry heaters and wood-burning fireplaces on high pollution days in effect on January 1, 1990.

1. All such exempt areas shall be required to submit a yearly report to the commission no later than June 30, providing information concerning the enforcement actions pursuant to their ordinance for the previous heating season.

D. Prohibitions of use

No person shall operate a wood-burning appliance during a high pollution day unless the appliance is exempt pursuant to section VII.E. A burn-down time shall be allowed for the burn-down of existing fires prior to the initiation of enforcement action. The use of any fuel other than clean, dry, untreated wood in any wood-burning appliance shall not constitute grounds for allowing its usage on a high pollution day.

E. Exemptions

1. Persons utilizing their wood-burning stove, pellet stove, masonry heater or wood-burning fireplace as a primary source of heat.

2. Persons operating a Phase II certified wood-burning stove or EPA Phase II wood-burning fireplace insert.

3. Persons operating an approved pellet stove or approved pellet-burning fireplace insert.

4. Persons operating an approved masonry heater.

VIII. REQUIREMENTS FOR INSTALLATION OF FIREPLACES

A. On and after the effective date of this regulation no person shall install any fireplace in any dwelling in the area defined in Section VIII.A. unless it is one of the following:

1. a gas appliance.

2. an electric device.

3. a fireplace insert that meets the requirements set forth in Section II.A.

4. an approved pellet burning fireplace insert.

5. any other clean burning device approved by the Commission that meets the emission standard set forth in Section II.A.

B. This section shall not apply to any municipality or a county, which has a provision in effect on January 1, 1993, which is substantially equivalent of this section as determined by the Commission.

IX. IMPLEMENTATION OF LOCAL CONTROL STRATEGIES

The local jurisdictions listed below shall implement and enforce the indicated ordinances and resolutions, as they exist on January 1, 1993. This ordinance limits wood-burning on high pollution days as determined by the Colorado Department of Public Health and Environment. In addition, each shall implement and enforce any ordinance adopted in accordance with this regulation. The indicated ordinances or resolutions may be amended in the sole discretion of the respective governing body, provided that they shall be submitted immediately to the Colorado Air Quality Control Commission and the United States Environmental Protection Agency as revisions to the State Implementation Plan. The listed ordinances and resolutions shall remain in full force

and effect until such time as the jurisdiction obtains full approval of a State Implementation Plan revision.

Community	HPD Ordinance Number	Date Enacted	Construction Ordinance	Date Enacted
Arvada	2451	11/87		
Aurora	87-118	4/86	92/47	5/92
Boulder	5007	10/86	5445	4/92
Broomfield	794	11/88		
Denver	Chapter 4.24	10/86	Chapter 4.24	5/90
Douglas County			R-991-128	11/91
Englewood	31	9/92	39	10/92
Federal Heights	565	1/88		
Glendale	2	1/88	15	10/92
Greenwood Village	17	6/88	9	3/92
Jefferson County	R-CC89-873	12/89	R-CC90-617	1/91
Lafayette	24	11/88		7/93
Lakewood	113	12/86	61	10/92
Littleton	17	12/88	26	8/92
Longmont	1	1/89		
Mountain View	5	1/91		
Sheridan	22	11/88	1	1/93
Thornton	2120	10/91	2194	10/92
Westminster	6/14	11/87	20	12/92

X. REFERENCES

Written statements of the basis and purpose of this regulation and revisions as well as all other material referenced in this Regulation is hereby incorporated by reference by the Air Quality Control Commission and made a part of the Colorado Air Quality Control Commission

Regulations. Materials incorporated by reference are those referenced and do not include later amendments. The material incorporated by reference is available for public inspection during regular business hours at the Office of the Commission, located at 4300 Cherry Creek Drive South, Denver, Colorado 80222, or may be examined at any state publications depository library. Parties wishing to inspect these materials should contact the Technical Secretary of the Commission, located at the Office of the Commission.

Regulation No. 4 - Adoption Chronology

To set a standard test methodology, an emission standard developed, establishes a certification fee, and develops an emission label -

Adopted: June 27, 1985

Effective: July 30, 1985

Revised to raise the certification fee -

Adopted: September 18, 1986

Effective: October 30, 1986

Revised to establish a definition for new woodstoves and exemptions from the woodstove certification program -

Adopted: May 19, 1988

Effective: June 30, 1988

Revised to establish a woodstove certification program -

Adopted: May 17, 1990

Effective: June 30, 1990

Revised to make locally adopted ordinances state enforceable -

Adopted: June 24, 1993

Effective: August 30, 1993

Revised to include provisions for pellet stoves -

Adopted: August 20, 1992

Effective: September 30, 1992

Revised to include provisions for masonry heaters -

Adopted: April 21, 1994

Effective: June 30, 1994

Revised Section X to meet requirements for incorporation by reference -

Adopted: February 16, 1995

Effective: April 30, 1995

APPENDIX A

Test Method Protocols for Measuring Wood-Burning Masonry Heater Emissions

Revision/Update: May 16, 2006

1.0 SCOPE

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

2.0 DEFINITIONS

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

Approved Masonry Heater — a masonry heater that has been certified by the Colorado APCD as meeting the requirements of Colorado APCD Regulation 4 and these Test Method Protocols.

Burn Rate — the average rate at which test-fuel is consumed in a masonry heater 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 (CO_2), carbon monoxide (CO), and/or oxygen (O_2) in nitrogen (N_2).

Certification Test or Certification Audit Test — the completion of at least one, three-fuel-load test-burn in accordance with the masonry heater 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 x (L x W)) / (L + W) **Equation 2.1**

Where: **L** = Flue rectangular length.

W = Flue rectangular width.

Emissions Factor Margin — the difference between a passing emissions factor result for a masonry heater tested in accordance with these Test Method Protocols and the Colorado APCD Regulation 4 masonry heater emissions factor standard (See 3.1.2).

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

Flue-Gas Exhaust Duct — the connector pipe, chimney, or other duct form that conveys exhaust gases from the masonry heater 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 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 — 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 all fuel pieces in each fuel-load crib including the weight of all fuel-piece spacers. Total Test-Period Fuel Weight is the weight of all three fuel-load cribs plus the weight of the kindling used during the test.

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 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 that is either more or less than 90º or 270º from vertical.

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

Masonry Heaters — wood-burning devices which are exempt from Title 40 of the Code of Federal Regulations (CFR) Part 60, Subpart AAA, are not cookstoves, boilers, furnaces, or pellet stoves as defined in 40 CFR Part 60, Subpart AAA, follow the guidelines of E1602-03 Standard Guide for Construction of Solid Fuel Burning Masonry Heaters, and are distinguished from fireplaces by Colorado APCD Regulation 4. Masonry heaters are designed for operation only in a closed combustion chamber configuration.

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

Masonry Heater Model Line — a series of masonry heater models which all have the same internal assembly. Each model in a model line may have different facade designs and external decorative features but must have the same internal assemblies. A masonry heater is deemed to have the same internal assembly if all internal assembly dimensions meet the criteria outlined in Section 3.2.2.1 are within 3.0% of the Colorado APCD-approved masonry heater.

Maximum Flue-Gas Carbon Dioxide Plus Carbon Monoxide Peak — the difference between the baseline air-supply CO_2+CO concentration (normally 0) and the highest 5-minute average data point CO_2+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 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% 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 a gas concentration measurement range. (Typically 25% for CO_2, O_2 and 5% for CO.)

Test-Burn or Test Period — the time from when flue-gas temperatures rise above 25ºF over the pretest flue-gas temperature after ignition of the test fuel to the time flue-gas oxygen concentrations have recovered to 95% but not more than 97% of the maximum flue-gas oxygen

depression caused by the last fuel charge of the required three consecutively-burned test fuel charges and the consumption of at least 90% of the total mass of the three consecutively-burned test-fuel charges.

Test Facility — the building enclosure in which the masonry heater 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. For this Standard, the test-fuel loading factor for masonry heaters is 0.30 (i.e., 30%).

Usable Firebox Volume **(F_v)** — the product of the useable hearth area and the average useable firebox height. Useable means the volumetric space within the fire chamber of a masonry heater 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 nine 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 nine equally spaced lines running perpendicular to the lines used for determining firebox length.
>
> ***Firebox Floor Versus Hearth Area*** — If a masonry heater has a larger floor area within the fire chamber than the area intended for fuel placement and burning, 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 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 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 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 90º or 270º 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 June 1, 2006, a manufacturer or builder of a masonry heater who wishes to have a masonry heater model, model line, or masonry heater design designated as a Colorado APCD-approved masonry heater under Colorado Regulation 4, shall submit to the Colorado APCD for its review the following information:

3.1.1 Appliance Specifications. The masonry heater manufacturer's name, street address, masonry heater model, model line, or design identification, all masonry heater construction specifications, drawings of the masonry heater 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 does not exceed 6.0 grams of particulate emissions per kilogram (g/kg dry weight) of fuel burned; test-method-adjusted for equivalency to U.S. Environmental Protection Agency (EPA) Method-5H sampling system (Code of Federal Regulations Title 40, Part 60, Subpart AAA) results.

3.2 Approval of Modifications Made to Tested and Approved Models. The Colorado APCD may grant approval for masonry heater internal assembly modifications that have 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 manufacturer's name, street address, model, model line, or design identification, all construction specifications, drawings of the masonry heater firebox and internal assembly, and all specifications required for chimney systems and emission control devices.

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

3.2.2.1 Critical Dimensions. Table 3.2.2.1.1 presents a list of 'critical' masonry heater dimensions. Measurements of these critical dimensions from a previously tested and Colorado APCD-approved masonry heater shall be compared to the critical dimension measurements of a masonry heater 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, each critical dimension measurement from the masonry heater being submitted for approval shall not exceed the tested-to-non-tested percentage differences presented in Table 3.2.2.1.1. In addition, no single linear critical-dimension measurement difference shall be more than 5 percentage points different from any of the other linear critical dimension measurement differences; no measured critical dimension area difference shall be more than 10 percentage points different from any of the other corresponding area measurement differences; and no critical dimension volume measurement difference shall be more than 15 percentage points different from any of the corresponding volume measurement differences.

Table 3.2.2.1.1 Critical Masonry Heater Dimensions

Critical Dimensions	Allowed ± Differences[1] (%)
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: Allowed difference between a previously tested and Colorado APCD-approved masonry heater and a masonry heater being submitted for a Colorado APCD modification approval.

3.2.3 Construction Materials. Without specific Colorado APCD approval, materials used for fabricating or building all of the internal assembly components of a modified masonry heater shall be identical, in all respects, to the materials used to fabricate or build the Colorado APCD-approved masonry heater.

3.2.4 Emissions Factor Margin. The emissions factor margin of the tested Colorado APCD-approved masonry heater shall be greater than 50% of the Colorado APCD masonry heater emissions factor standard (note, the emissions factor margin is defined in Section 2.0).

3.2.5 Test Report. A copy of, or appropriate reference information from, 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 submitted as the basis of comparison in an application for Colorado APCD approval of a modified masonry heater model, model line or design. Alternatively, an owner of a tested and Colorado APCD-approved masonry heater 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 as the basis of comparison in an application for Colorado APCD approval of a specified non-owned, modified masonry heater.

3.3 Re-Testing. A masonry heater shall be re-tested in accordance with the specifications of this Standard if it is determined during inspection that a design change has been incorporated into the Colorado APCD-approved masonry heater's internal assembly which may adversely affect its emissions factor. Any and all internal assembly design changes shall cause the subject masonry heater to be considered as "affecting its emissions factor" and shall be deemed a "modified" appliance. In order to qualify for continued Colorado APCD approval without re-testing, the previously Colorado APCD-approved and modified masonry heater shall comply with all of the dimensional, proportionality, and construction material comparison and emissions margin criteria contained in Section 3.2.2.

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 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 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 heaters, the label shall state: "This appliance has been tested and has demonstrated compliance with Colorado APCD, Regulation 4 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 testing for Colorado APCD approval.

3.4.2 Closed-Door Operation Label. A 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 Must Remain Closed At All Times."

3.4.3 Fuel-Elevating Grate/Operation Label. If a masonry heater was not tested with and without a fuel-elevating grate, 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 or, as an alternative, an addition to the "closed-door operation" label specified in Section 3.4.3 shall be made. This label or label addition shall state: "This Masonry Heater Is Not Colorado APCD-Approved For Operation With *(or Without; use the appropriate term)* A Hearth Fuel-Elevating Grate."

3.4.4 Low Air-Supply Operations. For masonry heaters with air supply controls, or if a masonry heater 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 air supply control mechanism. The label shall be affixed so that it is readily visible and readable to any person operating the control. This instruction label shall state: "This air supply control must be set to the "Normal" position during all firing periods." The builder's/manufacturer's owner's manual shall define "Normal" as the air supply position that has been tested and shown to be the optimum position for obtaining the lowest emissions and highest thermal efficiency.

3.5 Emissions Control Devices.

3.5.1 Label Requirements. If a masonry heater 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 in Colorado without *(insert the model name and manufacturer of the specified emissions control device here)* installed and operating."

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

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 models. To qualify for Colorado APCD approval for use on a non-emissions-tested masonry heater model, an emissions control device shall first be tested on a masonry heater 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 that demonstrate, using the fueling and flue-gas measurement protocols of this standard, a burn-period maximum air-to-fuel ratio of less than the maximum air-to-fuel ratio measured during the qualifying Colorado-APCD-approval masonry heater test period(s) but not less than 9:1; and an average flue-gas flow rate less (ft^3/min, m^3/min) than the average flue-gas flow rate measured during the qualifying Colorado-APCD-approved masonry heater test periods. Air-to-fuel ratio (A/F) for this determination shall be calculated using Equation 3.5.3.1 as follows:

$$A/F_{O2}=\frac{\{[42.5/(0.21-O_2)]x[0.44x(0.21-O_2)+(0.32xO_2)+0.22]\}}{}-5.1 \qquad \textbf{Equation 3.5.3.1}$$

Where: **A/F** = air-to-fuel ratio expressed as unit mass of air per unit mass of dry wood fuel: lb/lb (kg/kg)

O_2 = mole fraction of oxygen in flue gas (%O_2 / 100)

3.5.3.1 Alternate Air-to-Fuel Ratio. If the alternative CO_2+CO flue-gas concentration recovery is used as the criteria for required fuel charging and test completion times instead of oxygen recovery, see Sections 5.8.8.1 and 5.8.12.1, A/F may be calculated using Equation 3.5.3.1.1 as follows:

$$A/F_{CO2+CO}=\{[42.5/(CO_2+CO)x[(0.44xCO_2)+(0.32xO_2)+0.28x(N_2+CO)]\}-5.1 \qquad \text{Equation 3.5.3.1.1}$$

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

4.0 TEST LABORATORY ACCREDITATION

A Colorado APCD-accredited testing laboratory shall conduct all of the testing, test reporting, and inspection requirements.

4.1 Laboratory Accreditation Requirements. In order to qualify for Colorado APCD accreditation, the test laboratory shall be accredited:

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

•by the American National Standards Institute (ANSI) to the International Standards Organization (ISO) Standard ISO/IEC Guide 65 *General Requirements for Bodies Operating Product Certification Systems* ; **and**

•by a nationally recognized accreditation body to ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories.* The nationally recognized accrediting body shall operate under ISO Guide 58 (*Calibration and Testing Laboratory Accreditation Systems – General Requirements for Operation and Recognition).*

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 and the determination of particulate emissions factors. Emissions measurements for this Test Standard are performed on a masonry heater installed and operated in accordance with the following protocol components:

Emissions are sampled from masonry heater 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 analyzed for oxygen (O_2), carbon dioxide (CO_2), and carbon monoxide (CO) concentrations which are subsequently used for calculating fuel loading time criteria, 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 shall be tested in any and all of the configurations listed in Section 5.2.1 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 a fuel-elevating grate; and

•door(s) closed, without a fuel-elevating grate.

5.2.2 Test Configurations 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 label, as specified in Section 3.4, must state that the masonry heater may not be used in that non-tested configuration by a consumer.

5.2.3 Closed-Door(s) Testing. For all 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 5.8.9.

5.2.4 Additional Tests. The testing laboratory may conduct more than one test for each of the applicable configurations specified in Section 5.2.1. 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 and Flue-Gas Temperature Sensors. Device(s) capable of measuring flue-gas temperature to within 1.0% 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% 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% 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 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 emissions. The ESS shall consist of the following component specifications.

5.3.11.1 Flue-Gas Sample Probe. A stainless-steel probe with $^3/_8$ 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 $^3/_8$ inch (10 mm) diameter leading edge button-hook nozzle to provide a 90º turn of the sampling probe into the direction from which the flue-gas stream flows.

5.3.11.2 Sampling Line. If the sampling line length from the probe to the ESS filter inlet is less than 8 feet (2.4 m), $^3/_8$ inch (10 mm) I.D. Teflon® tubing may be used. However, if the distance is greater than 8 feet (2.4 m) a heated $^3/_8$ inch (10 mm) I.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 $^3/_8$ inch (10 mm) I.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 flue-gas sampling system or by a separate flue-gas sampling system with an electrochemical (or paramagnetic) sensor cell meeting the performance specifications presented in Section 5.3.14.

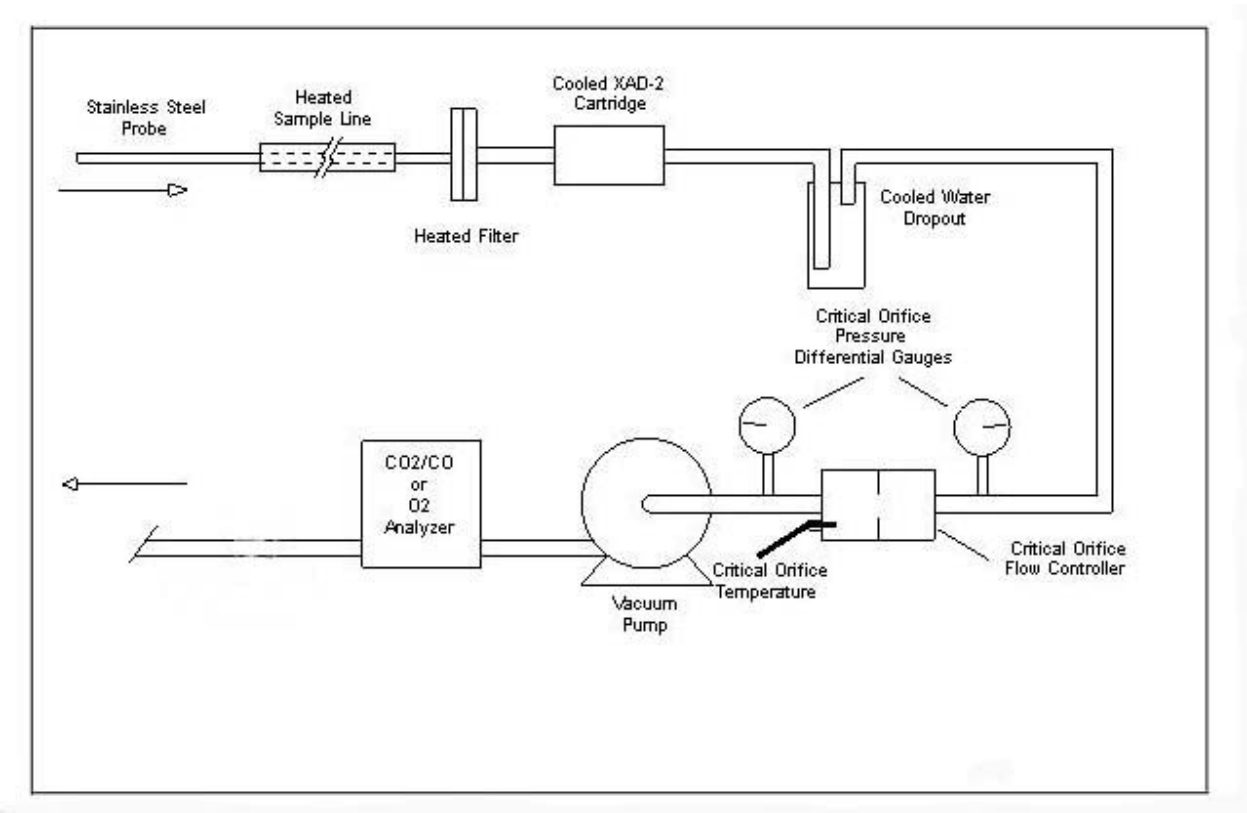
5.3.11.4 Sample Flow Control. The ESS shall use a critical orifice to maintain a nominal but constant flue-gas sampling rate in the range of 0.035 cubic feet (1.0 liter) per minute to 0.106 cubic feet (3.0 liters) per minute, less than or equal to 10%. The critical orifice shall be calibrated through an operating temperature

range of 50-200ºF (10-95ºC). The resulting calibration curve shall be used to correct the sampling rates taking place during each test period.

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

5.3.11.6 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)



5.3.11.7 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 Gas Analyzers. Gas analyzers with capabilities for measuring carbon dioxide (CO_2) in the range of 0.0 to 20.0%, carbon monoxide (CO) in the range of 0.00 to 5.00%, and oxygen (O_2) in the range of 0.0 to 25.0% 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:

5.3.14.1 Analyzer Calibration Error. The error shall be ≤ 2 percent of the span value for the high-range calibration gas used.

5.3.14.2 Sampling System Bias. The bias shall be ≤ 3 percent of the span value for the high-range calibration gas used.

5.3.14.3 Zero Drift. The drift shall be ≤ 2 percent of the high-range span value for the high-range calibration gas used.

5.3.14.4 Calibration Drift. The drift shall be ≤ 2 percent of the high-range span value for the high-range calibration gas used.

5.3.14.5 Analytical Interference. The interference of CO measurements caused by the presence of CO_2 in flue-gases shall be determined by the sampling of high-range CO_2 calibration gas through the carbon monoxide analyzer system. A calibration gas in the range of 10% to 12% CO_2 and 0.00% CO by volume shall not cause the CO analyzer to indicate a measurement of more than 0.20% CO.

5.3.14.6 CO_2 Gas Analyzer Accuracy Limitation. If the average test-period flue-gas CO_2 plus CO is not greater than 3.0%, the CO_2 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 Calibration Gas Concentrations[1]

Range:	Oxygen	Carbon Dioxide	Carbon Monoxide
High	19 – 21%	17 – 21%	1.0 – 2.5%
Mid	8 - 12%	8 – 12%	0.60 – 1.0%
Low	0 – 4%	0 – 4%	0 – 0.50%

Note 1: All calibration gas mixtures shall be certified by the calibration gas supplier or a laboratory meeting the requirements of Section 4.1 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 0.3 microns 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.

5.5 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 1.5- by 3.5-inch (38- 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). Adjusted fuel piece and spacer height shall be calculated using Equation 5.5.2.1.1 as follows:

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

Where: $\mathbf{FP_{ah}}$ = Adjusted fuel piece height

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

$\mathbf{AF_h}$ = 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. Fuel moisture content is the average of 1-inch deep moisture measurements made at three locations on each fuel piece; one each not closer than 2.0 inches (51 mm) from each end and one near the middle of the fuel piece length. The average fuel moisture of each fuel 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 measurement type.

5.5.4 Test-Fuel Cribs. Test fuel loads shall be constructed into multi-layered structures referred to herein as “fuel cribs” or “fuel charges”. The overall length, width, and height of fuel cribs are equally proportional to the average length, width, and height of the firebox being tested. Three separate fuel cribs shall be prepared for each test period. The first layer (i.e., the bottom layer) of the first fuel crib shall be made up of 1.5- by 3.5-inch (38- by 89-mm) fuel pieces. The second and higher layers of the first fuel crib and the entire second and the third fuel cribs are made only of 3.5- by 3.5-inch (89- by 89-mm) fuel pieces. See Figures 5.5.4.1 and 5.5.4.2.

5.5.4.1 Spacers. To provide equal spacing between all fuel pieces in a fuel crib, wood spacers with cross-sectional dimensions of 0.625- by 1.5-inch (16- by 38 mm) shall be placed laterally-centered between and on all fuel-piece sides facing other fuel-piece sides. No spacers are to be placed on the outward-facing fuel-crib sides. See Figure 5.5.4.1.1

Figure 5.5.4.1: First Fuel-Crib Load Details

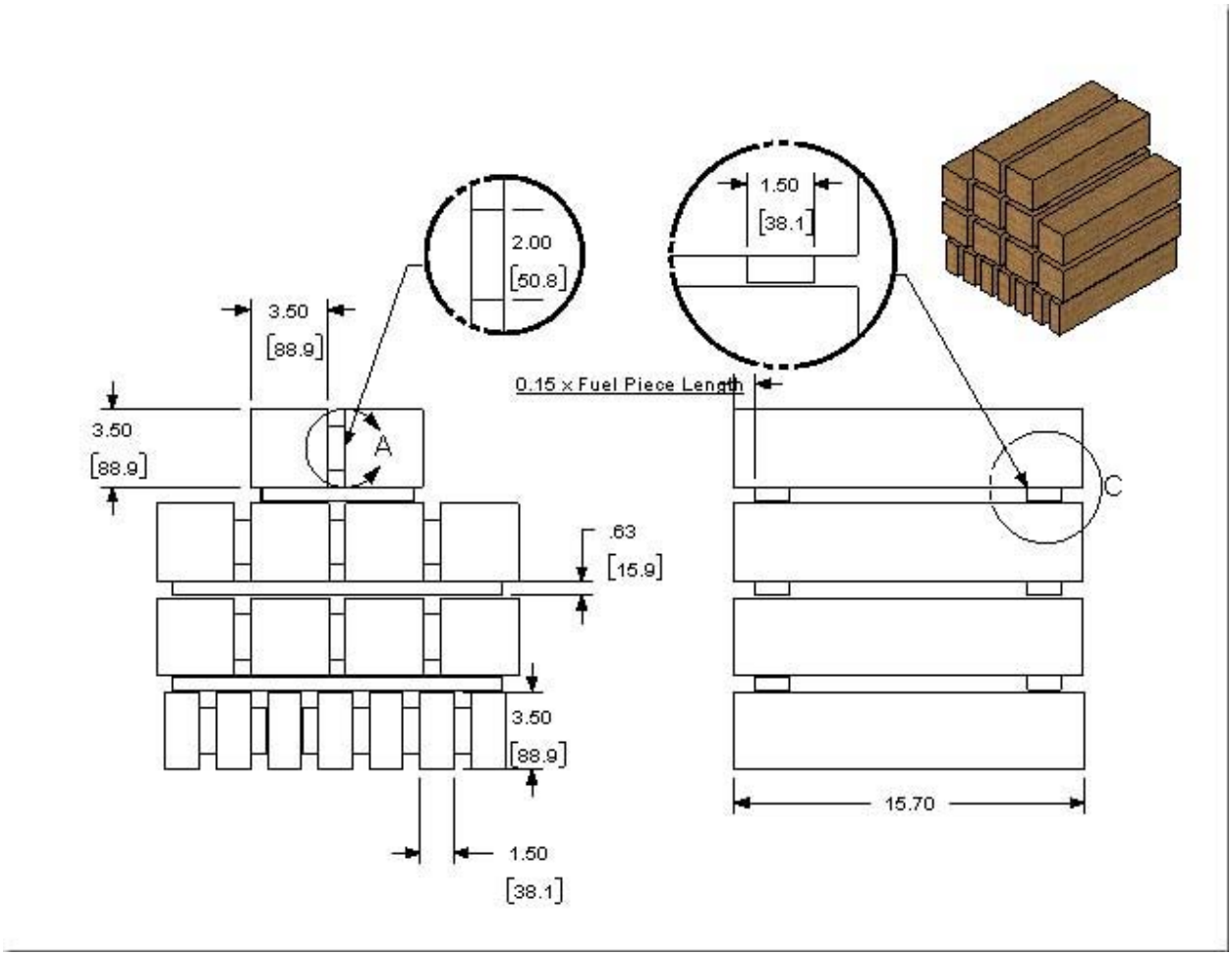


Figure 5.5.4.2: Second and Third Fuel Crib Details

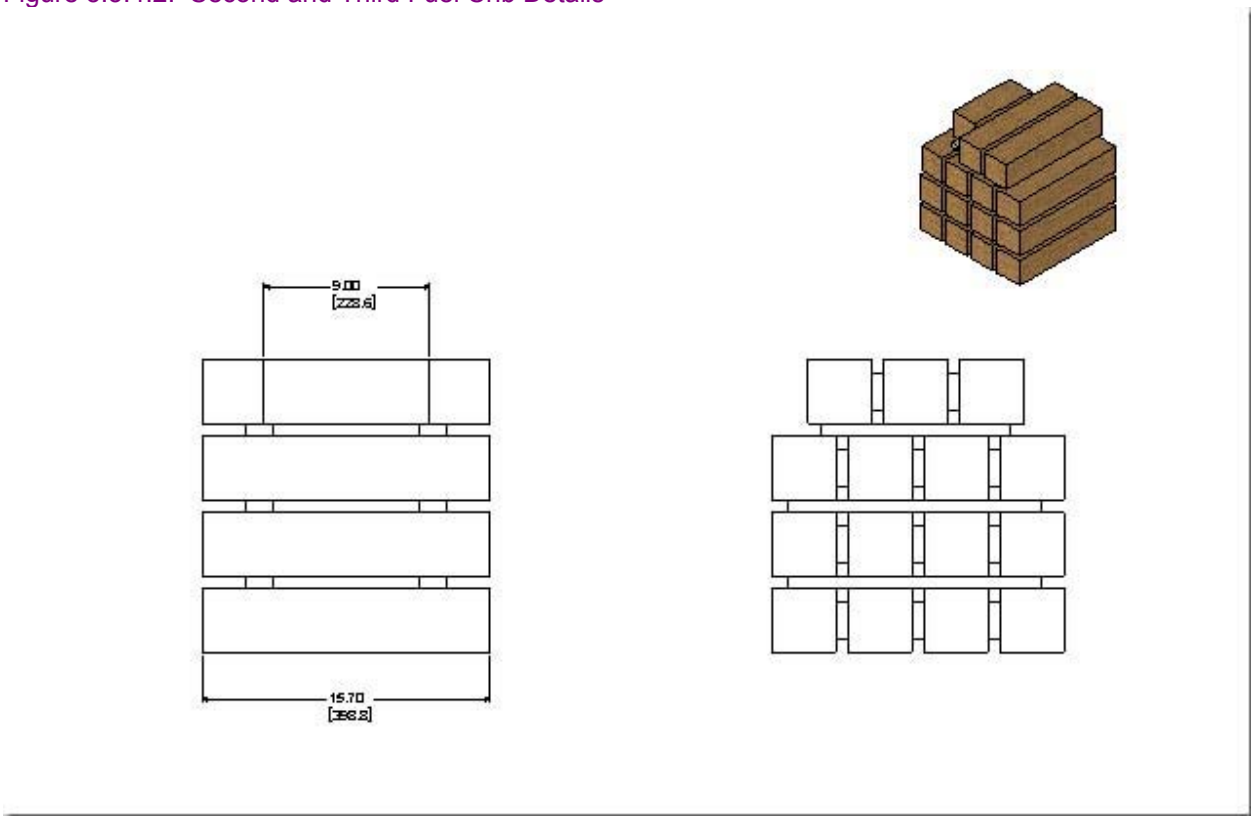
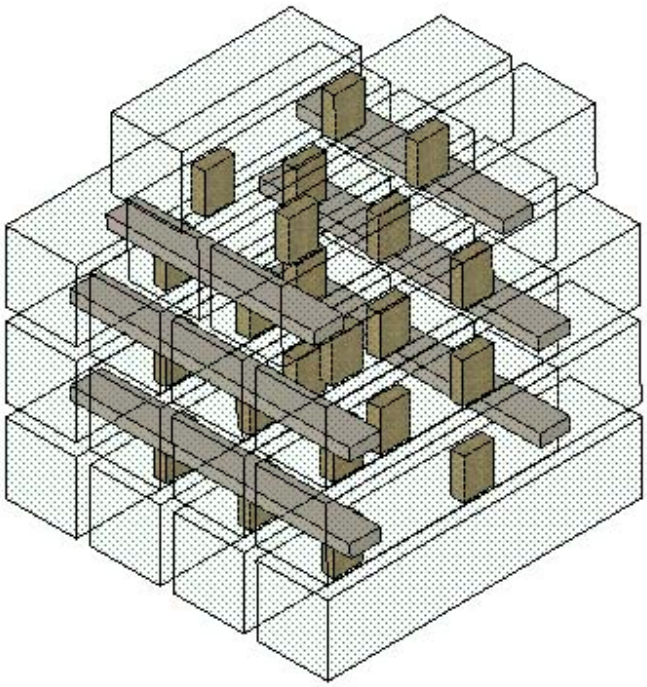


Figure 5.5.4.1.1: Fuel Piece Spacer Placement



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 three 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 (PH_{hd} and SH_{hd}). 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 nine 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 nine 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 nine closely-equal and square hearth sub-areas, none of which exceeds 16 square inches (100 square centimeters).

5.5.5.4 Total Useable Hearth Area (H_{ua}). 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 (F_{cv}). Calculate the fuel-crib volume (F_{cv}) as 30.0% of the F_v.

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.

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

Where: **X** = 30.0% for masonry heaters and bake ovens,

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 following equations:

$$FC_l = PH_{hd} \times FC_{dsf} \qquad \textbf{Equation 5.5.5.8.1}$$

$$FC_{tw} = SH_{hd} \times FC_{dsf} \qquad \textbf{Equation 5.5.5.8.2}$$

$$FC_{th} = FB_h \times FC_{dsf} \qquad \textbf{Equation 5.5.5.8.3}$$

5.5.6 Fuel Piece Spacing. The 0.625 inch (16 mm) vertical and horizontal spacing between parallel fuel pieces shall be made by nailing, with 18 gage by 1¼ inch (32 mm) finishing brads, 0.625- by 1.5- by 2.0-inch (16- by 38- 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- by 2.0-inch (38- by 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-piece side to which it is being attached. To maintain 0.625 inch (16 mm) spacing between all 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 0.625 inches (16 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 Equation 5.5.7.1.1 as follows:

$n1_1 = (FC_{tw} + 0.625 \text{ inches}) / 2.125 \text{ inches}$ Equation 5.5.7.1.1 (in/lb)

$n1_1 = (FC_{tw} + 1.59 \text{ cm}) / 5.40 \text{ cm}$ Equation 5.5.7.1.2 (SI)

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

0.625 inches (1.59 cm) = Place holder for last spacer in each layer

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 ($n1_i$) of the first fuel crib and all layers of additional cribs, is the closest whole number result from the equation as follows:

$n1_i = (FC_{tw} + 0.625 + 0.69) / 4.125 \text{ inches}$ Equation 5.5.7.2.1 (in/lb)

$n1_i = (FC_{tw} + 1.59 + 1.74) / 10.48 \text{ cm}$ Equation 5.5.7.2.2 (SI)

Where: $n1_i$ = Number of fuel pieces in the ith layer when 'i' is greater than 1

0.625 inches (1.59 cm) = Place holder for last spacer in each layer

0.69 inches (1.74 cm) = Factor for forcing an additional fuel piece in the event a partial piece of less than 0.333 is calculated.

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

5.5.7.3 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:

$n_{fcl} = (FC_{th} + 0.625 + 0.69) / (FP_h + 0.625)$ **Equation 5.5.7.3.1 (in/lb)**

$n_{fcl} = (FC_{th} + 1.59 + 1.74) / (FP_h + 1.59)$ **Equation 5.5.7.3.2 (SI)**

Where: $n1_{fcl}$ = Number of fuel crib layers

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

0.625 inches (1.59 cm) = Place holder for last spacer in each layer

0.69 inches (1.74 cm) = Factor for forcing an additional fuel crib layer in the event a partial layer of less than 0.333 is calculated.

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

5.5.8 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 0.625 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 gage 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, then 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.

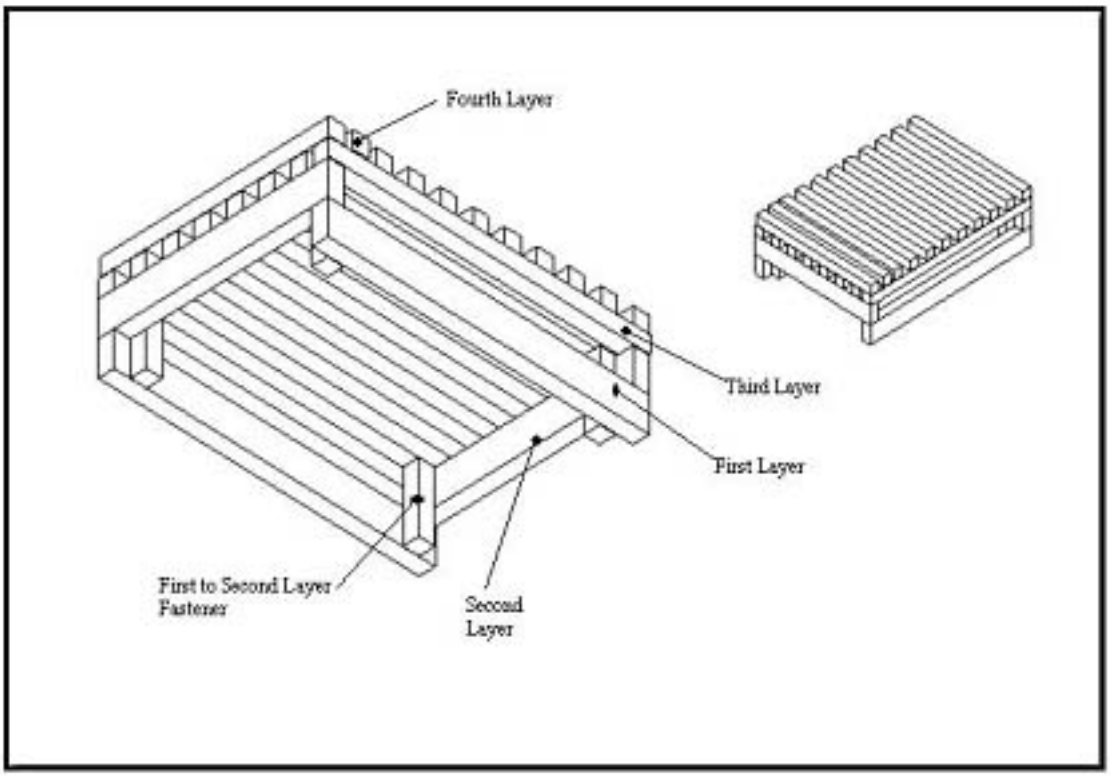
5.5.12.1 Kindling Preparation. For each test, a kindling bed or kindling stack shall be prepared for initiating test fire burning periods. Kindling fuel shall consist of 0.75- by 0.75-inch (19- by 19-mm), 0.75- by 1.5-inch (19- by 38-mm), and 1.5- by 1.5-inch (38- by 38-mm) dimensioned lumber. Kindling 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 two equal-length pieces of the ¾- by 1½-inch (19- by 38-mm) lumber cut to the length dimension of the fuel crib. These two pieces are placed on their ¾ 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 two equal-length pieces of the ¾- by 1½-inch (19- by 38-mm) lumber cut to the fuel crib width dimension, placed on their ¾ 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 (73 mm) length of ¾- by ¾-inch (19- by 19-mm) kindling fuel into the inside of each corner using 18 gage by 1¼ inch (32 mm) brads.

Figure 5.5.12.1.1: Kindling Stack Details.



5.5.12.1.3 Newspaper. Crumple one full, double-tabloid-width (approximately 650 square inches (4200 cm^2)) of newspaper for every 50 square inches (323 cm^2) 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 ¾- by ¾-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 1½ 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 1½- by 1½-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:

$$\mathbf{KP_{ah} = KP_{sh} \times AF_h / 12\ inches\ (305\ mm)} \qquad \textbf{Equation 5.5.12.2.1}$$

Where: $\mathbf{KP_{ah}}$ = Adjusted kindling piece height

$\mathbf{KP_{sh}}$ = Standard kindling piece height: ¾ inches or 1.5 inches (19 mm or 38 mm)

$\mathbf{AF_h}$ = 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 2.0-inch (50 mm) 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 above the hearth of 3.0 inches (76 mm) shall have: 3 / 2 (76 mm / 50 mm) = 1.5 additional layers of 1½- by 1½-inch (38- by 38-mm) kindling. The 0.5 partial layer shall have 0.5 of the volume of a whole 1½- by 1½-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 before test initiation, the total weight of all kindling pieces shall be measured to with in 0.1 lb (45 g) and recorded.

5.6 Calibration and Audit Requirements.

5.6.1 Scale. Within three 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 to 80% 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 one 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 ten tests whichever occurs first.

5.6.8 Sample Flow Rates and System Response Times. ESS flue-gas sample and any other alternative flue-gas sampling system flow rate shall be set in accordance with Section 5.6.8.1 within two 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.

5.6.8.1 Response Time Measurement. The response time for all flue-gas sampling systems shall be determined by 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 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.

5.6.8.2 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 Installation. The masonry heater being tested must be constructed, if site-built, or, if manufactured, installed in accordance with the designer's/manufacturer's written instructions. These shall be the same instructions provided by the manufacturer or builder to the homeowner/consumer. 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 chimney exit to the atmosphere must be freely communicating with the masonry heater combustion makeup-air source. There shall be no artificial atmospheric pressure differential imposed between the chimney exit to the atmosphere and the masonry heater make-up air inlet.

5.7.2 Masonry Heater Description. Record masonry heater and, if equipped, catalyst and/or add-on emissions control device descriptions. The recorded masonry heater 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 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 firebox hearth. 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 is equipped with an emissions control device located in the flue/chimney duct, downstream from the masonry heater 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 is equipped with an emissions control device that requires additional energy provided by the combustion of any fuel input, a real-time flue-gas oxygen analyzer 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 and test period air-to-fuel ratios.

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. Locate the temperature monitor probe at a distance of 3 to 6 feet (1 to 2 meters)

from the front of the masonry heater and in a 90º sector defined by lines drawn at ± 45º from a perpendicular line to centerline of the masonry heater face.

5.7.5 Heat-Aging, Curing, and Durability Confirmation. A masonry heater of any type shall be operated at under "normal" conditions before certification testing begins. Operate the masonry heater using the fuel described in Section 5.5 for at least ten 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. Operate a catalyst and/or add-on emissions control-equipped masonry heater 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 heat-aging and curing period specified in Section 5.7.5, use the oxygen analyzer and sampling system specified in Section 5.3.14 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 flue-gas sampling and temperature measurement location for at least 15 seconds but not more than one minute and then moving the sampling probe to within 1 inch (25.4 mm) of the flue chimney wall for at least 15 seconds but not more than one 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 highest 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 four 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 two 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% 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 5.8.14.2 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 Operation and Testing Protocols.

5.8.1 Masonry Heater Cooling Period. No fuel shall be burned in the test masonry heater and no other means for heating the masonry heater 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 air supply duct intake or fuel loading door within one hour before test initiation. Air velocity at the specified locations shall be less than 200 feet/minute (61 m/minute). During a test period, no external means shall be used to affect air velocities within 2 feet (0.6 meters) of the masonry heater being tested.

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), close all air supply controls and the masonry heater door(s). After one hour of masonry heater 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 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 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 and any manufacturer-/builder-prescribed start-up procedures shall be within 10 minutes after test initiation as described in Section 5.8.4.

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" H_2O 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 25ºF 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.

5.8.4 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 25ºF (14ºC) greater than the pre-test flue-gas temperature as measured in Section 5.8.2.3.

5.8.5 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 5.8.4 (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 5.8.12. Test-time sampling and temperature measurement parameters shall include:

ESS Oxygen (O_2) (alternatively, real-time CO_2+CO may be measured instead of O_2; see Sections 5.8.8.1 and 5.8.12.1).

Temperatures:

Flue-Gas

Heated Sample Line (if used)

Heated ESS Filter

Cooled XAD-2 Cartridge

ESS Moisture Condensate Trap

ESS Critical Orifice

All Flue-Gas Sample Train/System Sampling Rates

Vacuum Across ESS Critical Orifice

Draft Pressure at the Primary Sampling and Temperature Measurement Location

5.8.6 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 250ºF (95 to 121ºC) during all sampling periods,

•The glass-fiber filter and its holder shall be maintained in a temperature range from 200 to 250ºF (95 to 121ºC) during all sampling periods, and

•The XAD-2 cartridge and the moisture condensate trap shall be maintained in a temperature range from 35 to 40ºF (1.7 and 4.4ºC) during all sampling periods.

5.8.7 Test Facility Ambient Temperatures. Test facility ambient temperatures shall be maintained between 65 and 100ºF (18 and 38ºC) during all test periods.

5.8.8 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 have recovered (i.e., increased) to at least 70% but not more than 80% of the maximum flue-gas oxygen depression value resulting from combustion of the immediately previous kindling or test-fuel charge. 20.9% shall be used as the baseline ambient air supply oxygen concentration. An example calculation for test fuel additions; 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%** (i.e., 20.9% – 12.5% = 8.4%) the next fuel charge may only be loaded after the flue-gas oxygen concentration has recovered to at least 17.2% (i.e., (0.70 x 12.5%) + 8.4% = 17.2%)oxygen but not more than 18.4% oxygen (i.e., (0.8 x 12.5%) + 8.4% = 18.4%).

5.8.8.1 Alternative Fuel Addition Criteria. The recovery of the peak sum of real time flue-gas carbon dioxide and carbon monoxide (CO_2+CO) concentrations back to ambient CO_2+CO concentrations may be used as an alternative to the flue-gas oxygen concentration recovery fuel load addition/loading criteria. When using CO_2+CO concentrations, test fuel additions shall be placed and burned in the fire chamber only after flue-gas CO_2+CO concentrations have recovered (i.e., decreased) back to at least 30% of the maximum flue-gas CO_2+CO value resulting from combustion of the immediately previous test-fuel charge.

5.8.8.2 Inadequate Coal Bed. If the coal bed remaining after flue-gas oxygen concentration has recovered (i.e., increased) to at least 70% 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.

5.8.8.2.1 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 5.8.8.1 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.

5.8.9 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.

5.8.10 Combustion Air Supply Adjustment. Any and all means for controlling masonry heater combustion air supplies may only be adjusted during each of the 10-minute test-fuel charging periods. For masonry heaters with air supply controls, or if a masonry heater cannot or is not intended to operate at its lowest air supply setting, a permanent instruction label as described in Section 3.4.4 shall be prominently affixed to the masonry heater air supply control mechanism.

5.8.11 Auxiliary Masonry Heater Equipment Operation. Heat exchange blowers (standard or optional) sold with the masonry heater 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 equipment during the test period.

5.8.12 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 5.6.8.1, for each sampling train.

5.8.12.1 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 (CO_2+CO) concentrations back toward ambient CO_2+CO concentrations may be used as an alternative to the flue-gas oxygen concentration recovery for test completion criteria: When using CO_2+CO concentrations, test completion shall occur only after flue-gas CO_2+CO concentrations have recovered (i.e., decreased) back down to at least 3% but not more than 5% of the maximum flue-gas CO_2+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 5.6.8.1, for each sampling train.

5.8.13 Post-Test Procedures.

5.8.13.1 Room-Air Velocities. Using a low-velocity-range anemometer within 10 minutes after test completion, measure and record the room-air velocity within 2 feet (0.6 meters) of the test masonry heater. Air velocity within 2 feet (0.6 meters) of the test masonry heater shall not be more than 50 feet/minute (15 m/min) without the masonry heater operating.

5.8.13.2 Fuel Weight at Test Completion. Within 5 minutes after test completion, as defined in Section 5.8.12, 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% of the weight of the total test-fuel charges plus the kindling weight has been consumed in the masonry heater firebox.

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

5.8.13.4 Leak Check. The ESS shall be leak checked at the maximum test-period vacuum level within one 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.

5.8.13.5 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.

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

5.8.14.1 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).

5.8.14.2 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.

5.8.14.2.1 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 5.8.14.2.

5.8.14.3 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% dichloromethane and 50% methanol. The resulting dissolved emissions residues and cleaning solvent solutions shall be placed in tarred glass beakers, evaporated in an ambient-air dryer, desiccated to constant weight (i.e., less than 0.5 mg change within a two hour period), and weighed to the nearest 0.1 mg.

5.8.14.3.1 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 5.8.14.3.

5.8.14.4 ESS Particulate Emissions Sample Preservation. If ESS samples cannot be processed within two 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 50ºF (10ºC), and transported to, or stored in, the laboratory for processing within 48 hours.

5.8.14.5 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 emissions simultaneously during each test-burn. If emissions factor results from the two ESSs are different by more than 10% 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% of the higher emissions factor amount.

5.8.14.6 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.

•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.

5.8.14.7 Sampling Rate Constancy. For the ESS and any alternative flue-gas sampling system, calculate the average sampling rate during the entire test period from the data recorded in accordance with Section 5.8.5. 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% and if no single deviation is larger than 10%.

6.0 CALCULATIONS

After test completion, data sheets shall be reviewed for completeness and proper equipment operation. The data sheets, log books, chain-of-custody, 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 flue-gas sample analyses to calculate the test-period burn rate and the particulate emissions factor.

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

$$t_{tt} = t_c \times N_{T>25^{o}F/\%>95<97} \qquad \textbf{Equation 6.1.1}$$

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

$N_{T>25^oF/\%>95<97}$ = 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 25°F (14°C) more than the pre-test flue-gas temperature (i.e., test period initiation as defined in Section 5.8.4) and the time when the flue-gas oxygen recovery from the third test-fuel charge was at least 95% but not more than 97% (i.e., test period completion as defined in Section 5.8.12).

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

Burn Rate (kg/hour) = (Fuel Total Weight x 60) / t_{tt} 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 Using Test Period Oxygen Concentrations. The equation for the ESS-particulate emissions factor (EF_{ESS}) presented below utilizes the average flue-gas oxygen concentrations measure during the test period. The calculation produces reporting units of grams of emissions per dry kilogram of fuel burned (g/kg):

$$EF_{ESS} = (P_m \times F_{mcc} \times M_{vs}) / (t_{tt} \times S_r \times [(19.3-O_2)/100]) \quad \text{Equation 6.3.1.1}$$

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.

O_2 = The test period average (i.e., percent O_2 in the flue gases).

19.3 = Sum of dry stoichiometric combustion products (as CO_2 and/or ½ CO).

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

6.3.1.1 Alternate ESS Emission Factor. The ESS Emissions Factor Using the Alternative CO_2+CO flue-gas measurements:

$$EF_{ESS} = (P_m \times F_{mcc} \times M_{vs}) / (t_{tt} \times S_r \times (Y_{CO2} + Y_{CO})) \quad \text{Equation 6.3.1.1.1}$$

Where: Y_{CO2} = 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 Equivalent. To 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}) use Equation 6.3.2.1 as follows:

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

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

7.0 REPORTING REQUIREMENTS

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

7.1 Masonry Heater Identification. Report masonry heater identification information including manufacturer, model, model line, or design and serial number of the masonry heater 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 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 Identification. Manufacturer, model name or number, catalytic/non-catalytic, emissions control equipment, and any optional equipment. Include a copy of masonry heater installation and operation manuals.

7.6.1.3 Testing Laboratory. The Colorado APCD approved laboratory name, street and mailing address information, telephone number(s), email and contact addresses for key personnel, web site address (if existing) and the names of all test personnel that performed the testing. A copy of each of the accreditation

certificates stipulated in Section 4.1 shall be located in an appendix of the test report.

7.6.1.4 Test Information. Date masonry heater 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 configuration tested as required in Section 5.2, and the number of test burns conducted for each masonry heater configuration.

7.6.1.5 Test Method And/Or Masonry Heater Operating Protocol Deviations. The report shall contain a complete description of any test method or masonry heater 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 identification number, masonry heater configuration, burn rate, particulate emission factor (in U.S. EPA Method 5H equivalents). An example test period summary table is presented in Figure 7.6.2.1.

7.6.2.2 Summary of Other Data. Test facility conditions, masonry heater surface temperature averages, catalyst temperature averages, test-fuel charge weights, the average draft pressure measured, and the test-burn durations.

7.6.2.3 Discussion. Include specific test-burn problems and solutions and rationale for, and for not, testing specific configurations like a fuel-elevating grate configuration.

Figure 7.6.2.1 An Example Test-Period Summary Table.

Example Masonry Heater Test Information Sheet							
Manufacturer/Builder: *Manufacturer Name*			Test Run Number: #				
Test Conducted By: *Laboratory Name* Technician: *Technician Name*			Test Period Start Date/Time: / / , AM/PM Test Period End Date/Time: / / , AM/PM				
Model Tested: *Model Name and/or Number*			Configuration: *With/Without Fuel Elevating Grate*				
Masonry Heater Type: *Catalytic/Non-Catalytic or With or Without an emissions control device*							
Time			**Average Temperatures**				
Total Test Period	xx.x	Hours	Flue-Gas Temperature	xxx	°F	xxx	°C
Test Data Recording Cycle	5.0	Minutes	Test Facility Ambient Temperature	xxx	°F	xxx	°C
Fuel			**Average Flue-Gas Concentrations**				
Total Fuel Used	xx.x	kg wet	Oxygen	xx.x%	%		
Average Fuel Moisture	xx.x%	Dry Basis	Carbon Dioxide	xx.x%	%		
Total Fuel Burned	xx.x	kg dry	Carbon Monoxide	xx.x	ppm		
Average Burn Rate During Operation	x.xx	kg/hour (dry)					
Emissions							
EPA 5H Equivalents	x.xx	g/kg					

7.6.3 Process Description.

7.6.3.1 Masonry Heater 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 being submitted for Colorado APCD approval utilizes add-on emissions control equipment or a catalytic device for reducing masonry heater emissions, provide a list of the brand names and/or sources for all masonry heater components and a complete description of each component including drawings, photographs, and materials used in their construction or production.

7.6.3.4 Masonry Heater Operation Procedures. Air supply settings and any air supply and/or fuel-bed/coal-bed adjustments made during the 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 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.

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 temperature data.

7.6.7.3 Construction/Assembly Drawings. Masonry heater 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 door-open times and durations).

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

7.6.7.9 Laboratory Accreditation Documentation. Copies of each of the accreditation certificates stipulated in Section 4.1.

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.

Statement of Basis, Specific Statutory Authority and Purpose Revisions to Colorado Air Quality Control Commission Regulation No. 4

January 19th, 2006

This Statement of Basis, Specific Statutory Authority and Purpose complies with the requirements of the Colorado Administrative Procedures Act, Section 24-4-103, C.R.S. and the Colorado Air Pollution Prevention and Control Act, Sections 25-7-110 and 110.5, C.R.S.

Basis

The proposed rule changes would establish a procedure for particulate emissions testing of masonry heaters, where one does not currently exist although an approval process for these devices is outlined in Section IV. Currently, Regulation No. 4 requires only that any manufacturer wishing to have a masonry heater approved by the state of Colorado submit required documentation verifying that "field test results" conducted by an "EPA-accredited laboratory" show no violation of the existing 6.0 g/kg particulates emission standard. Neither the methodology nor the procedures for developing the "field test results" are outlined in the current regulation. Such a testing requirement does not adequately inform an applicant of the testing criteria that a masonry heater must meet to demonstrate to the APCD that the unit would operate in compliance with the standard, nor does it provide for consistency in fairly evaluating all masonry heaters submitted for approved status.

Specific Statutory Authority

The Commission may promulgate the proposed amendments pursuant to section 25-7-105(1)(b), C.R.S. (authority to promulgate and modify emission control regulations); section 25-7-106(1), C.R.S. (authority to promulgate regulations desirable to carry out the air quality control program); section 25-7-106.3, C.R.S. (authority to promulgate regulations to restrict the use of wood burning stoves and fireplaces on high pollution days); section 25-7-109, C.R.S. (authority to promulgate and modify emission control regulations); section 25-7-110, C.R.S. (procedures for adopting or modifying rules and regulations);

section 25-7-401, C.R.S. (authority to promulgate rules and regulations relating to wood burning stoves); and pursuant to the procedural rules adopted by the Air Quality Control Commission.

Purpose

To revise Regulation No. 4 to allow for the incorporation into the already existing section for approved masonry heaters a particulate emissions testing protocol, and to make non-substantive corrections and clarifications in the rule language.

Findings

1. The Commission has considered, and has based it decision on, the reasonably available, validated, reviewed and sound scientific methods and technical information presented by the affected parties.

2. Evidence in the record supports the need for the inclusion of a particulate emissions testing protocol into the approval process for masonry heaters.

3. The rule amendments do not affect federal requirements and do not negatively impact persons, facilities, or activities currently controlled under Regulation No. 4.

COLORADO AIR QUALITY CONTROL COMMISSION

ADOPTED:_____