Rafael A. Sanchez, Ph.D.

PROFESSIONAL OBJECTIVE

Senior Environmental Engineer with 25+ years of federal work experience seeking leadership opportunities in the environmental field.

SUMMARY

- 25+ years of federal work experience - with significant inspection, compliance, and enforcement responsibilities
- Recognized as senior subject matter expert for technical, compliance, and enforcement matters relating to wood heaters
- Expertise planning, executing, analyzing results, and reporting on inspection reports
- Track record of working with regulated entities to carry out enforcement actions and improve compliance
- Ph.D. in Environmental Science and Public Policy from George Mason University
- Bilingual - proficient in Spanish

FEDERAL WORK EXPERIENCE

Manager - Federal Wood Heater Program **04/2010 to Present**
US Environmental Protection Agency Office of Compliance

Manage compliance and enforcement of wood heater regulations while developing national policy and setting priorities. Plan, prepare and conduct wood heater inspections - writing reports and developing enforcement cases based on results. Initiate enforcement actions, negotiate compliance settlements, and assist manufacturers or retailers with coming back into compliance. Respond to residential complaints and inquiries from congressional, industry, state, and international sources. Publish wood heater data and maintain official EPA databases. Develop EPA guidance documents and publications. Write legally defensible environmental analyses and regulatory interpretations under Clean Air Act regulations.

- Serves as national authority and subject matter expert for federal wood heater residential program; participate in industry or stakeholder negotiations related to wood heaters and similar regulated appliances.
- As a lead inspector for federal wood heater inspections, develops and implements effective compliance strategies and advises senior managers on strategy.
- Reviews performance test data and recommends issuing certificates of compliance for new, existing, and modified wood heaters each year.
- Reviews and analyze sales data and compliance audit reports.
- Conducts field inspections of retailers and manufacturers each year.
- Developed EPA's Wood Heater Program database to track certification records.
- Reviews emerging wood heater technologies and issues multiple applicability determinations on regulations
- Oversees work of staff and interns.
- Won EPA Bronze Medal in 2017 for commendable service.

Acting Team Lead - Power Generation and Petroleum Refinery Sectors **01/1994 to 04/2010**
US Environmental Protection Agency Office of Compliance

Provided petroleum refining and power generation subject matter expertise and technical or compliance assistance to representatives from EPA regions, state and local agencies, tribes, and regulated entities. Participated in policy, rulemaking, and technical workgroup proceedings. Developed Clean Air Act enforcement cases and managed data in support of enforcement activities. Reviewed inspection data for several programs and prepared reports for review by senior leadership. Served as Acting Branch Chief during incumbent's absence to set priorities, allocate resources, mentor staff, and evaluate outcomes.

- Served as the primary point of contact for Environmental Leadership Program's Duke Power team - implemented voluntary compliance initiative that improved efficiency of Duke's environmental management system and developed new auditing/compliance programs that improved compliance while reducing environmental impact
- Developed EPA database to track training requirements and locate inspector expertise.
- Coordinated environmental justice training for 150 employees - developed agendas, produced training materials, scheduled speakers, and led presentations.
- Managed $50K contract to develop and implement a Work Assignment Management workshop for 1500 inspectors.
- Won EPA Bronze Medal in 1996 and 2005 for commendable service.

TEACHING EXPERIENCE

Graduate School Adjunct Associate Professor - University of Maryland University College	2009 to Present
Environmental Science Faculty - University of Phoenix	2006 to 2017

EDUCATION & TRAINING

Ph.D. in Environmental Science and Public Policy - George Mason University	2009
Master's in Technology Management - Environmental & Waste Management - University of Maryland	1997
Bachelor of Science in Chemical Engineering - University of Maryland	1990
Bachelor of Science in Chemistry - University of Maryland	1987

SKILLS & ABILITIES

Program Management, Project Management, Team Leadership, Supervisory Management, Environmental Science, Public Policy, Compliance Management, Inspections, Data Analysis, Enforcement Actions, Interagency Liaison, Budget Management, Team Building, Problem Solving, Conflict Resolution, Interpersonal Communication

PUBLICATIONS

"Institutional Pressures Affecting a Firm's Decision to Visit United States Environmental Protection Agency Compliance Assistance Websites: A Study of the Organic Chemical Industry." ProQuest. June 2010.

Robert J. Scinta, Jr., P.E.
Work E-mail: scinta.robert@epa.gov
Office: 202-564-7171

Work Experience:

U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington DC, **DC 20460**
Series: 0819
Pay Plan: GS
Grade: 15
Supervisor: Tony Miller, Acting Division Director (303-312-7161)
Supervisory Environmental Engineer/Branch Chief – OECA/OC/MAMPD/Air Branch
03/2019 - **Present**
Lead a highly skilled team of subject matter experts within the Air Branch of the Office of Enforcement and Compliance Assurance; Office of Compliance; Monitoring, Assistance, and Media Programs Division. Set vision for the Branch in alignment with Agency, Office, and Divisional missions. Conduct high level briefings, motivate staff and manage resources to achieve mission. Within the Branch, focus compliance assurance efforts on the Stationary Source Clean Air Act (CAA) programs [New Source Performance Standards (NSPS), National Emission Standards for Hazardous Air Pollutants (NESHAP), and 112(r) Prevention of Accidental Releases]. Work with regions, states, tribes, and local agencies to develop CAA strategies, initiatives, and emerging programs. Support the development of enforceable CAA regulations, provide comments on proposed legislation, participate on Agency workgroups, and coordinate with other Agency offices as appropriate. In addition, provide information and respond to questions on CAA programs and regulations through regulatory interpretations, applicability determinations, and alternative monitoring decisions, and provide a publicly accessible repository of all such decisions. The Branch develops and maintains a cadre of trained, credentialed inspectors to provide support to regions, states local agencies, tribes and headquarters offices. In addition, the Air Branch implements and manages the Federal Wood Heater NSPS Program.

U.S. DOC/NTIA/First Responder Network Authority (FirstNet)
12201 Sunrise Valley Drive
Reston, **VA 20192**
Series: 0560
Pay Plan: GS
Grade: 15
Temporary Detail
Supervisor: Jeffrey R. Underwood (571-665-6114)
Budget Analyst - Office of the Chief Financial Officer
09/2018 - **03/2019**
Duties included providing budgetary and resource allocation advice and assistance to the Chief Financial Officer of the First Responder Network Authority (FirstNet). Also supported FirstNet in the analysis and development of FirstNet fiscal policies, strategies, operating procedures and workplans.
<u>Additional Duties:</u>
• Managed multiple aspects of budget operations and ensured the efficient and effective achievement of management goals in compliance with FirstNet, National Telecommunications & Information Agency, the Department of Commerce, and Federal guidance and directives;
• Provided advice and assistance on fiscal matters related to FirstNet's development and management of Federal public safety wireless broadband communications, administrative planning, and project management activities;
• Performed a wide variety of managerial, administrative, and analytical duties connected with the formulation and execution of FirstNet's budget;

• Assigned tasks connected with the formulation and
execution of FirstNet's budget;
• Assigned staff to budgetary tasks and oversees staff work products for quality and consistency;
• Reviewed, analyzed, and interpreted existing and proposed Board resolutions, statutory language, executive orders, Office of Management and Budget and Department of Commerce guidance;
• Provided expert advice and recommendations for budgetary actions;
• Coordinated the formulation of budget and revenue estimates for multi-year projects;
• Developed financial management models and applications to inform budget processes;
• Developed cost-benefit analysis of proposed budgetary and program actions and advised Authority officials and project managers of most advantageous courses of actions; and
• Performed other duties as assigned.

U.S. DOC/NTIA/First Responder Network Authority (FirstNet)
12201 Sunrise Valley Drive
Reston, **VA 20192**
Series: 0819
Pay Plan: ZP
Grade: 15
Supervisor: Genevieve Walker (571-665-6134)
Environmental Engineer/Acting NEPA Coordinator - Office of the Chief Counsel
12/2015 - **08/2018**
FirstNet is responsible for developing and deploying a nationwide, interoperable public safety broadband network that will provide high speed wireless telecommunications services to more than 60,000 public safety organizations throughout the country, including fire fighters, police, emergency medical services, hospitals, ambulance services, and other public and private entities with emergency response responsibilities. I served as a member of the Environmental Compliance Team located in the Office of the Chief Counsel, FirstNet (OCC). I was responsible for providing advice and assistance to the Chief Counsel of FirstNet in the formulation, development, and implementation of policies and programs designed to stand-up and manage the environmental compliance program for the nationwide public safety broadband network (NPSBN). The NPSBN was administered with concerted effort to integrate the National Environmental Policy Act (NEPA) process (and other environmental laws and Executive Orders) with other planning at the earliest possible time to ensure that decisions reflected environmental values to avoid delays later in the process, and head-off potential conflicts.
<u>Duties:</u>
•Provided advice to FirstNet decision-makers so that they are aware of, and comply with, environmental and energy related laws, regulations, and Executive Orders and that they considered the environmental and energy impacts of their programs, projects, and policies.
•Worked collaboratively with the environmental team to identify the level of analysis, level of public involvement, and documentation required for the environmental and energy program.
•Assisted with, as appropriate, agreements with federal, state, and local regulatory and/or resource agencies, tribal governments concerning environmental compliance; and inter-bureau and inter-agency coordination and cooperation on environmentally related actions.
•Conducted technical sufficiency reviews of environmental documents and provided recommendations of sufficiency/adequacy to the signing official which also involved reviewing environmental documents to ensure a high-quality analysis is completed and that all applicable scheduling, scoping, consultation, circulation, and public involvement requirements was met.
•Led environmental activities related to the Endangered Species Act consultations and biological assessments, as appropriate.

U.S. Department of Commerce
Washington DC, **20230**
Candidate - U.S. Department of Commerce 2016 Executive Leadership Development Program
03/2015 - **12/2015**

The Executive Leadership Development Program (ELDP) was a 16-month program designed to provide a series of developmental experiences for high potential individuals so that they may compete for positions that require senior leadership responsibilities. These developmental experiences included formal training and seminars, a 90-day developmental assignment, mentoring, team action learning projects, field trips to other agencies or Capitol Hill, and other activities. ELDP concentrated on developing competencies in the following targeted areas: leading change; leading people; results driven; business acumen; building coalitions/communications.

U.S. Department of Commerce
Washington DC, **DC 20230**
Fellow - Partnership for Public Service Excellence in Government (EIG) Fellowship Program
10/2014 - **09/2015**
The Excellence in Government Fellows (EIG) program prepares leaders to be more than managers. Fellows are results driven innovators whose creativity in problem-solving stands up to the complexity of 21st century challenges. Through a proven combination of innovative coursework, best management practices benchmarking, challenging action learning projects, executive coaching and government-wide networking, the program meets the interagency training requirements for OPM-approved candidate development programs.

U.S. Department of Commerce
1401 Constitution Avenue, N.W.
Washington, **DC 20230**
Series: 0801
Pay Plan: ZP
Grade: 14
Supervisor: Mick Rusten (202-482-1340)
Chief, Space Management Division
08/2014 - **12/2015**
Led office providing space management services for the U.S. Department of Commerce's headquarters (Herbert C. Hoover Building), covering approximately two million square feet in office space and over 3,500 employees from ten Bureaus within the Department. Project goals were achieved through extensive project management utilized to plan, organize, motivate staff, and control project resources. Specific space management services included design, cost estimating, scheduling, space planning, construction, state of the art information technology infrastructure coordination, security coordination (when necessary), and procurement.
Clear, concise communication was required to brief customers (often senior level officials, including the Secretary of Commerce, Under Secretaries, and Directors), coordinate with contracting officers/acquisition staff, and direct vendors to complete work requests. All work aligned seamlessly with the eight phase, $1 billion renovation projecting being implemented at the headquarters building by the General Services Administration and Commerce’s Office of Building Renovation. When completed, the renovation project will have completely update the building office systems, utilities, and state of the art information technology infrastructure; including wireless access to all occupants. Supervisory duties included seven staff: two architects, four interior designers, and a space manager.

U.S. Department of Commerce
1401 Constitution Avenue, N.W.
Washington DC, **DC 20230**
Series: 0819
Pay Plan: ZP
Grade: 14
Supervisor: Rob Tomiak (202-564-7526)
Energy/Sustainability Program Manager
05/2009 - **08/2014**

As Energy/Sustainability Program Manager within the Office of Facilities and Environmental Quality for the U.S. Department of Commerce, I routinely demonstrated technical expertise, communication skills, and the ability to lead through a wide array of responsibilities. These responsibilities included analysis of Federal facility requirements, development of policy, and coordination with the Department's 12 Bureaus to provide guidance and to track progress towards Federal energy and sustainability mandates. Notable accomplishments in this position include the following:

Technical

• Served as technical expert on energy and sustainability matters, such as laws, regulations and Executive Orders. Provided executive briefs as necessary to inform and assist the Department in meeting requirements.
• Provided environmental support in review of Broadband Technology Opportunities Program (BTOP) projects intended to facilitate and integrate broadband and information technology infrastructure into underutilized local economies.
• Used my extensive experience with alternative financing to promote the implementation of energy efficiency upgrades and installation of renewable energy projects through performance-based contracting when traditional funding is unavailable, including numerous energy savings performance contracts (ESPCs) and Utility Energy Savings Contracts (UESCs);
• Developed a Departmental Energy and Environmental Administrative Order and 32 chapter management manual, setting policy for bureaus and operating units;
• Prepared, collected, assimilated, and submitted the Department's annual greenhouse gas inventory and sustainability data report (former annual energy report) to the Council on Environmental Quality (CEQ). I established a greenhouse gas inventory management plan for the Department that was posted on FedCenter.gov to be used as a template by other Federal agencies;
• Developed the Department's first ever five year sustainability action plan;
• Coordinated the semiannual submissions of the Department's Office of Management and Budget (OMB) sustainability/energy scorecard as well;
• Developed the Department's Strategic Sustainability Performance Plan (SSPP) requiring coordination with numerous offices including Real Property, Office of General Counsel, Office of the Chief Information Officer, Office of Budget, and Office of Acquisition Management. The SSPP establishes an integrated strategy towards sustainability within the Department and focuses on greenhouse gas emissions reduction, energy intensity reduction, increased use of renewable energy, fleet petroleum reduction, water conservation, pollution prevention, sustainable buildings, electronic stewardship, sustainable acquisitions, budget and climate change adaptation planning;
• Established interagency agreements as necessary to further Departmental programs; and,
• I served as an active member of numerous interagency working groups, including the Interagency Energy Management Task Force, Inter-Agency Forum on Climate Change Impacts and Adaptations, Greenhouse Gas Working Group, Water Working Group.

Communication

• Briefed senior Departmental staff, such as the Chief Financial Officer/Assistant Secretary for Administration, on Departmental sustainability efforts;
• Presented at various conferences including the GovEnergy Federal energy conference and the Marcus Evans Federal energy management conference;
• Provided responses to congressional inquiries, Government Accountability Office audits, and prepared senior staff for Federal News Radio interviews; and,
• Coordinated Earth Day and Energy Awareness month activities at Departmental headquarters.

Leadership

• Supervised and managed mixed workforces consisting of Federal and private sector staff,
• Have utilized limited resources to accomplish complex tasks;
• September 2015 Partnership for Public Service Excellence in Government Fellow;
• Currently enrolled the U.S. Department of Commerce Executive Leadership Development Program; and,
• Collaboratively coordinated with bureaus, Departmental offices, and outside agencies on a variety of projects.

Quality of Work

• I have performed under short deadlines to submit timely and accurate work; and,

• Provided quality customer service to both internal and external organizations.

U.S. DOJ/Federal Bureau of Prisons
320 1st Street, N.W.
Washington, **DC 20534**
Series: 0801
Pay Plan: GS
Grade: 13
Supervisor: Chuck Procaccini (202-514-6652)
Environmental Program Manager
12/2001 - **05/2009**
As Environmental Programs Manager, my responsibilities included the environmental aspects of all design, renovation, repair, construction, and operation of the over 100 Federal Bureau of Prison (FBOP) facilities nationwide. As the Bureau's subject matter expert on environmental matters, I researched and analyzed environmental and safety laws, regulations, and Executive Orders as well as provide staff with technical guidance on new requirements. This guidance was provided through direct communication with regional offices and facilities or through training programs for facility and safety managers. Information was collected through the use of environmental multimedia compliance surveys, via an audit agreement with the U.S. Environmental Protection Agency, as well as the ongoing development of an environmental management system (EMS) in accordance with Executive Order 13423. This information was used to continually evaluate and improve the FBOP's environmental and safety programs, as well as to assist in meeting Environmental Scorecard requirements for the U.S. Department of Justice (DOJ). Through new construction and renovation of facilities, I was able to review numerous NEPA evaluations and biological assessments including species such as vernal pool fairy shrimp (Atwater, California), the Indiana bat (Terra Haute, Indiana), and prairie dogs (Englewood Colorado). As acting Energy Programs Manager, my responsibilities included the continued improvement of FBOP's energy efficiency and reduction of natural resource usage, promoting the use of renewable energy and alternative fuels, and to assist in the integration of high performance and sustainable building standards into all new and existing assets in accordance with goals of Executive Order 13423 and Energy Scorecard requirements for the DOJ. These responsibilities are addressed through the use of energy savings performance contracts (ESPCs), utility energy savings contracts (UESCs), training programs, policy statements, and the implementation of FBOP's environmental management system. Through FBOP's energy program, I was involved in numerous NEPA evaluations including an environmental assessment to install a 0.75 MW wind turbine in Victorville, CA and biomass boilers in Petersburg, Virginia.

SCS Engineers
1126 Roger Bacon Dr.
Suite 300
Herndon, **VA 20190**
Supervisor: Eric Peterson (703-471-6150)
Project Engineer
07/1997 - **11/2001**
As a project engineer in the landfill gas group, I was able to experience a variety of both office and field work. I established relationships with clients, contractors, regulators, and fellow environmental professionals. Typical responsibilities included the development of design and review of engineering drawings, cost estimation, construction oversight, analytical review of laboratory reports, and general project management. Field work involved with this position allowed me to travel throughout the country and abroad. My most memorable experience was traveling to Israel for construction oversight of a landfill gas collection system. The system was to be used to transport landfill gas to a local Styrofoam manufacturing plant in order to heat its boilers. Development and implementation of health and safety plans were an integral part of daily job activities due to the explosiveness of landfill (methane) gas as well as the risk of oxygen depleted environments.

Northeastern University

Boston, **MA**
Supervisor: Prof. Irvine Wei (617-373-3308)
Teaching Assistant
01/1996 - **12/1996**
As a teaching assistant, I was responsible for the preparation of laboratory reagents and equipment, supervision of students during experimentation, and reorganization of the laboratory following experimentation. Hazardous chemicals were routinely used during experimentation. Personal protective equipment and implementation of lab safety procedures was essential.

Education:

Northeastern University
Boston, MA
Master's Degree - 06/1997
Major: Environmental Engineering
Master's Report: "The Love Canal: A New Beginning" This report was based on the Love Canal Hazardous Waste Site located in Niagara Falls, NY. The history of the canal was reviewed followed by a discussion on the remediation techniques used at the site. The report concludes by discussing revitalization efforts and the current condition of the area.

Clarkson University
Potsdam, NY
Bachelor's Degree - 05/1995
Major: Interdisciplinary Engineering and Management

Certifications/Awards:

Federal Security Clearance: Secret
Licensed Professional Engineer, Virginia (#0402 036308), June 2003 to present;
U.S. Department of Commerce Executive Leadership
Development Program (ELDP), March 2015;
Partnership for Public Service, Excellence in Government (EIG) Fellowship, September 2014;
2014 U.S. Department of Commerce Bronze Medal Award for Superior Performance;
Certified Energy Manager (CEM), Association of Energy Engineers, May 2010;
Renewable Energy Professional (REP), Association of Energy Engineers, July 2013;
U.S. Department of Commerce, Performance Excellence Award, February 2012;
LEED Green Associate, U.S. Green Building Council, February 2011;
DOC/OS/Office of Administrative Services Employee of the Quarter, July 2010 and September 2011;
FEMP 2009 Presidential Award for Leadership in Federal Energy Management;
2009 U.S. Department of Commerce Bronze Medal Award for Superior Performance;
GSA - Office of Real Property Management 2007 Sustainability Award - Greening Prisons;
Combined Federal Campaign (CFC) Keyworker – National Capitol Area, 2002, 2003, 2004, 2008.
Clarkson Merit Scholarship; 1997 Solid Waste Association of America (SWANA) Scholarship Award, Massachusetts Chapter.

Job Related Training:

Foundations of Security, Advanced Cyber Security Certificate
Program, University of Phoenix, Aug. 2018
Principles of Facility Management, George Mason University, Dec. 2010
International Facility Managers Association (IFMA) – Member 2010
MSTC, Facilities Management Training, March 2002;
FEMP Super ESPC Workshop, Charlotte, NC, July 2009;
ISO - 14001 Internal EMS Auditor Course, October 2008,
ISO 14001:2004 Lead Auditor Training, RAQSA - TPECS, December 2007, Georgia Institute of Technology;

U.S. EPA Workshop, Storage Tanks, May 2007;
Aarcher Institute of Environmental Training, Storage Tanks, April 2007;
Aarcher Institute of Environmental Training, Environmental Training Workshop, August 2006;
Aarcher Institute of Environmental Training, EMS Aspects and Impacts Workshop, April 2006;
U.S. EPA, Environmental Regulatory Training for Federal Correctional Facilities, February 2006;
Aarcher Institute of Environmental Training, Environmental Compliance Bootcamp, June 2005;
Duke University, Socioeconomic Impact Analysis Under NEPA, February 2004;
40-Hour OSHA Health and Safety Training for Hazardous Materials Site Workers, April 1999

References:

Robert Tomiak
Environmental Protection Agency
Office of Policy
Director, Office of Federal Activities
Phone Number: 202-564-5400
Email Address: tomiak.robert@epa.gov

John R, Bollinger
National Institute of Standards and Technology
Office of Facilities and Property Management
Facilities Team Lead, Capital Assets Management Group
Phone Number: 301-975-5014
Email Address: john.r.bollinger@nist.gov

Jennifer Brundage
Environmental Protection Agency Environmental Protection Specialist
Phone Number: 202-566-1265
Email Address: brundage.jennifer@epa.gov

Michael Rusten
U.S. Department of Interior
Director, Office of Facilities and Administrative Services
Phone Number: (202) 208-5617

Steffan M. Johnson

EPA Office of Air Quality Planning and Standards
Research Triangle Park, NC 27710

NATIONAL AIR EMISSIONS EXPERT

Program Development and Oversight | Air Emissions Measurement and Policy |Strategic Program Development
Key Personnel Training/Hiring/Retention | Staff Development and Motivation | Management Team Direction
Inter-Agency and Intra-Agency Relationship Development | Regulatory Program Advisor
Driver of Technology Innovation | Champion of Continuous Improvement

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Professional Profile

Group Leader GS-15: US EPA – OAQPS Air Quality Assessment Division/Measurement Technology Group

- Direct Stationary Source Air Pollution Test Method development, staff and budget
- Direct EPA Program Office response to EPA Regional air office air measurement concerns
- Direct US EPA relationships with state, and Local air agencies concerning air pollutant measurements
- Direct US EPA technical response to source pollutant enforcement issues
- Direct US EPA technical response to public comment regarding source measurement concerns
- Enact EPA Administrator authority for Alternate Test Method approval
- Lead EPA OAQPS Air Toxics Management and Mitigation Team
- Advise and inform US EPA Senior Administration on technical source measurement needs and direction
- Drive creative and collaborative approaches to incorporate new technologies into better practices
- Outreach interaction with industry trade groups and Non-Governmental Organizations
- Outreach with and provide technical expertise to foreign Environmental Agency representatives

Environmental Scientist GS-13: 04/11 – 08/15 US EPA – OAQPS SPPD/Measurement Policy Group

- Establish Regulatory Air Measurement Policy for Federal NSPS and NESHAP regulations
- Technical support and public response to comment for MATS, Industrial Boilers, RICE, Portland cement
- Technical support for establishment of NSPS and NESHAP air pollutant emissions limits
- Conduct technical research and create solutions in support of air measurement policy
- Interact with State and Federal regulatory groups in support of policy and enforcement resolution
- Outreach interaction with industry trade groups and Non-Governmental Organizations

Environmental Analyst IV: 11/2008 – 04/2011 Xcel Energy – Sherburne Co. Facility, Becker, Minnesota

- Federal and State reporting, records management of air monitoring for 2.3 GW-hr coal-fired power station
- CO_2 capture technology evaluation, review, and recommend emerging technologies to corporate office
- Annual EPCRA and TRI reporting to state environmental agency, assist EPCRA program
- Coordinate annual Part 75 and Part 60, and State permit required emissions testing
- Develop, update and deliver annual employee training on Emergency Action, SPPC, and Radiation Safety
- Hazardous waste tracking, shipping and facility status management
- PI system programming, P&ID updating of new equipment

Business Continuity: 11/2003 – 11/2008 Essentia Health, Duluth, Minnesota

- Conduct business impact analysis to Identify critical functions, interdependencies, and recovery strategies
- Manage enterprise BCP program development, training, and implementation
- Developed initial enterprise Business Continuity and Disaster Recovery plans

Operations Manager: 11/1993 – 06/2003 Horizon Engineering, Portland, Oregon

- Project management and field supervision of engineers and scientists measuring air emissions for industries in Oregon, Washington, California, Idaho, Nevada, Hawaii and Taiwan.
- Developed training program to standardize and streamline field practices
- Developed job material and labor cost estimates, test plans and technical reports
- Development of project protocols, selection of methodologies, scheduling of resources and personnel

Personal Profile

- Well honed writing skills
- Dedicated to a lifetime of learning
- Air pollution measurement, monitoring and policy expert
- Detailed knowledge of a wide variety of industrial sectors
- Science based, fact driven, environmental decision mindset
- Excellent verbal communicator and experienced public speaker
- Firm believer and champion of the continuous improvement model
- Open door management style, people first, work life balance promoter
- Highly motivated, reliable, and committed to solid professional standards
- Team inclusion oriented, consensus builder, respectful and objective listener
- Able to comprehend complex problems and direct focused actions toward resolution

Areas of Expertise

- **Pulp and Paper**
- **MACT Rules**
- **Source Measurement**
- **Compliance / Enforcement**
- **NAAQS compliance**
- **Residential Wood Heating**
- **Strategic planning**
- **Clean Water Act**
- **NSR/PSD Modeling**
- **Industrial Boilers**
- **Public speaking**
- **Criteria Pollutants**
- **NESHAP Rules**
- **Electric Utilities**
- **RICE Engines**
- **Air Pollutant modeling**
- **Portland Cement**
- **Budget management**
- **Regulatory Perspective**
- **NPDES Reporting**
- **Training development**
- **Team building**
- **GHG measurement**
- **Air Toxics**
- **Air Permitting**
- **SLAM networks**
- **Clean Air Act**
- **Public perspective**
- **Computer programming**
- **Oil and Gas**
- **Solution oriented**
- **LEAN Management**
- **Consensus building**

Education

B.S. Natural Science / Earth Science – Western Oregon University
Applied Information Technology Certification – Post Baccalaureate, Information Technology Institute

Professional Associations

Source Evaluation Society – Hall of Fame member - inducted 2019

- **Vice President - 2016 – 2018**
- **Board of Directors – 2 Terms: 2013-2015**
- **QSTI / QSTO Exam Development and Review Committee – 2007 to present**
- **Ethics, Rules and Constitution Committee Chair – 2013 to 2018**

Interests and Hobbies

Hiking and wilderness camping / canoeing, fishing, home-brewing, rock hounding, reading and computer programming

Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel[1]

This standard is issued under the fixed designation E2515; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method is applicable for the determination of particulate matter emissions from solid-fuel-burning appliances including woodstoves, pellet-burning appliances, factory-built fireplaces, masonry fireplaces, masonry heaters, indoor furnaces, and indoor and outdoor hydronic heaters within a laboratory environment.

1.2 Analytes will be a particulate matter (PM) with no CAS number assigned. For data quality objectives, see Appendix X1.

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

1.4 *This test method does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D2986 Practice for Evaluation of Air Assay Media by the Monodisperse DOP (Dioctyl Phthalate) Smoke Test (Withdrawn 2004)[3]

E2558 Test Method for Determining Particulate Matter Emissions from Fires in Wood-Burning Fireplaces

E2618 Test Method for Measurement of Particulate Emissions and Heating Efficiency of Solid Fuel-Fired Hydronic Heating Appliances

E2779 Test Method for Determining Particulate Matter Emissions from Pellet Heaters

E2780 Test Method for Determining Particulate Matter Emissions from Wood Heaters

E2817 Test Method for Test Fueling Masonry Heaters

2.2 *AISI Documents:*[4]

AISI 316 Stainless Steel

2.3 *NIST Documents:*[5]

NIST Monograph 175 Standard Limits of Error

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *laboratory environment*—the area or room that is used for the storage, weighing, assembly, disassembly, and desiccation of filters and related equipment (sample recovery and analysis).

3.1.2 *particulate matter (PM)*—all gas-borne matter resulting from combustion of solid fuel, as specified in the appliance operation test method, that is collected and retained by the specified filter and probe system under the conditions of the test.

3.1.3 *test facility*—the area in which the tested appliance is installed, operated, and sampled for emissions.

4. Summary of Test Method

4.1 The total flue-gas exhaust from a solid fuel burning appliance is collected along with ambient dilution air with a collection hood. Duplicate sampling trains are used to extract gas samples from the dilution tunnel for determination of particulate matter concentrations. Each sample train has two glass fiber filters in series. The samples are withdrawn at a consistently proportional rate from sampling points located at the centroid of a sampling tunnel. During sampling, the filters are maintained at a temperature less than 32°C (90°F). The mass of the sampled particulate matter is determined gravimetrically after the removal of uncombined water. The total particulate matter mass collected on the filters and in the probe

[1] This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.54 on Solid Fuel Burning Appliances.

Current edition approved Nov. 1, 2011. Published December 2011. Originally approved in 2007. Last previous edition approved in 2010 as E2515 – 10. DOI: 10.1520/E2515-11.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

[4] Available from American Iron and Steel Institute (AISI), 1140 Connecticut Ave., NW, Suite 705, Washington, DC 20036, http://www.steel.org.

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

and front filter housing are multiplied by the ratio of the dilution tunnel flow to sample flow to determine the total particulate emissions during a test.

4.2 The sampling system for this test method consists of duplicate dual-filter dry sampling trains. Both of the particulate sampling trains are operated simultaneously at a sample flow rate not to exceed 0.007 m^3/min (0.25 cfm/min). The total particulate results obtained from the two sampling trains are averaged to determine the particulate emissions and are compared as a quality control check on the data validity.

4.3 The particulate concentration results for each sampling train is adjusted by the particulate concentration result from a single room air sample blank collected and processed the same as the dilution tunnel particulate sampling trains described in 4.2, except that only one filter is used in the sampling train. A metering system as described in 6.1.1.4 shall be used to determine the volume of room air collected. The sample flow rate shall not exceed 0.007 m^3/min (0.25 cfm).

4.4 Appliances tested by this test method are to be fueled and operated as specified in appliance-specific test methods such as, but not limited to, Test Methods E2558, E2618, E2779, E2780, or E2817.

5. Safety

5.1 *Disclaimer*—This test method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to performing this test method.

6. Equipment and Supplies

6.1 *Sample Collection*—The following equipment is required for sample collection:

6.1.1 *Particulate Sampling Train*—Two separate, complete particulate sampling trains (also referred to as "sampling trains") are required for each test run. The filter face velocity shall not exceed 150 mm/sec (30 ft/min) during the test run. The dry gas meter shall be calibrated for the same flow rate range as encountered during the test runs. The sampling train configuration is shown in Fig. 1 and consists of the following components.

6.1.1.1 *Filter Holder Assembly*—The filter holder assembly is shown in Fig. 2 and consists of the following components:

(1) Filter Holders—The primary (front) filter holder shall be aluminum or PTFE.[6] The backup (rear) filter holder may be made of materials such as polycarbonate.[7] With such plastic materials, it is recommended not to use solvents when cleaning the filter holder parts. Mild soap and distilled water can be used for cleaning plastic filter holder parts. The two filter holders shall be placed in series with the backup filter holder located 25 to 100 mm (1 to 4 in.) downstream from the primary filter holder. The filter holders shall be capable of holding a filter with 47 mm diameter. The holder design shall provide a positive seal against leakage from the outside or around the filters. The use of a porous glass or ceramic frit to support the first (front) filter is not allowed. Any type of filter support is allowed for the second (rear) filter.

(2) Probe Assemblies—Probe assemblies shall consist of the following components assembled to provide a leak-tight seal:

(a) Front half of front filter holder as specified in 6.1.1.1(*1*).

[6] The Pall (Gelman) 1235 filter holder has been found suitable for this purpose. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[7] The Pall (Gelman) 1119 filter holder has been found suitable for this purpose. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

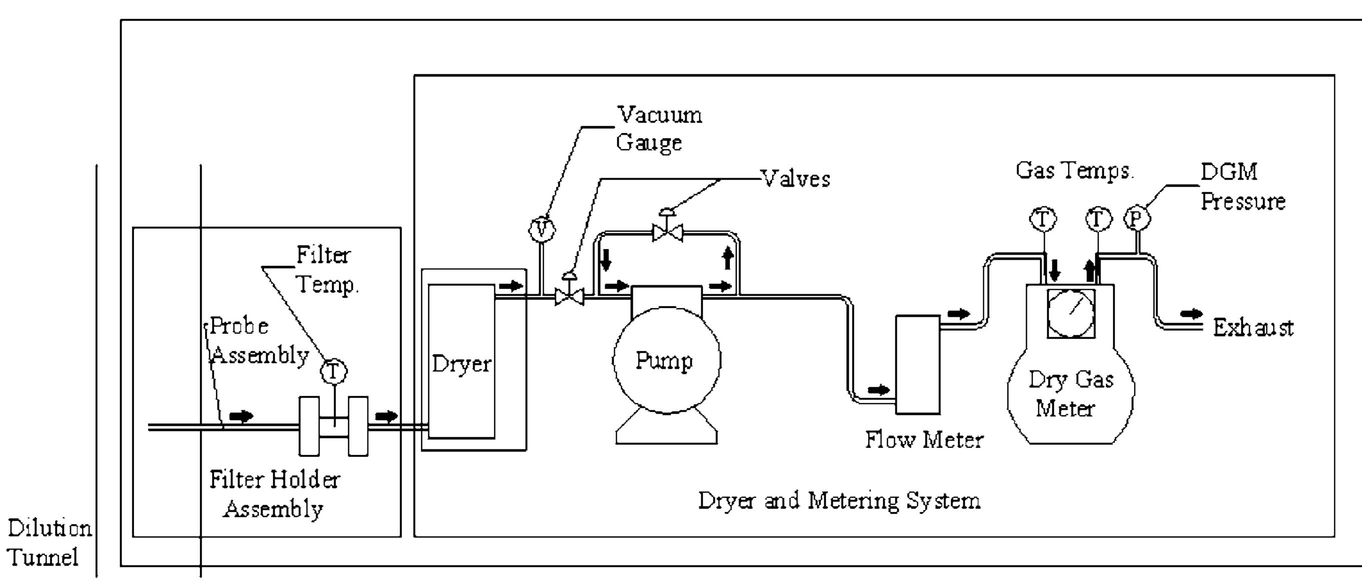

FIG. 1 Particulate Sampling Train

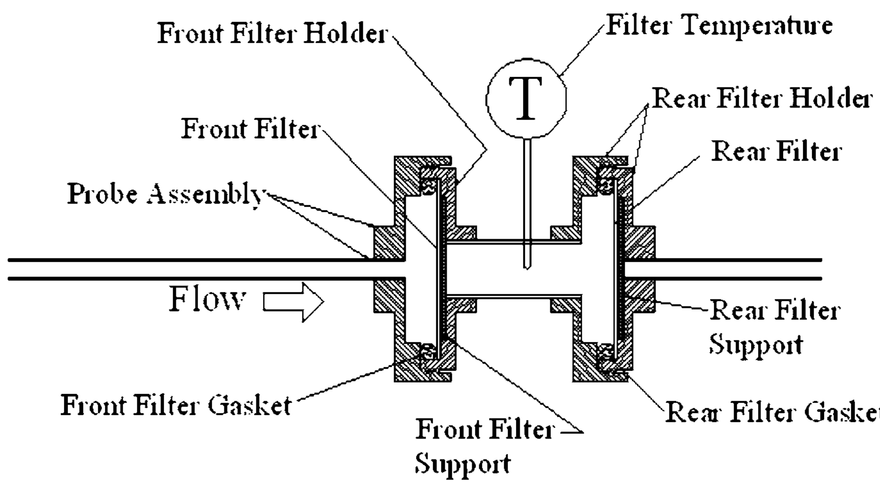

FIG. 2 Filter Holder Assembly

(b) Probe—The probe shall be constructed from seamless stainless steel (that is, AISI 316 or grade more corrosion resistant) 6.35 mm (¼ in.) outside diameter (O.D.) and 0.30 to 0.45 m (12 to 18 in.) in length, with a wall thickness such that the total weight of the probe and front filter housing can be weighed to an accuracy of 0.1 mg.

(3) Filters in accordance with 7.1.1.

(4) Filter Gaskets.

6.1.1.2 *Filter Temperature Monitoring System*—A temperature sensor capable of measuring with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, which ever is greater and meeting the calibration requirements specified in 8.2. The sensor shall be installed at the exit side of the front filter holder so that the sensing tip of the temperature sensor is in direct contact with the sample gas as shown in Fig. 2.

6.1.1.3 *Dryer*—Any system capable of removing water from the sample gas to less than 1.5 % moisture (volume percent) prior to the metering system. The system shall include a temperature sensor for demonstrating that sample gas temperature exiting the dryer is less than 27°C (80°F). See Fig. 1 for location of the dryer.

6.1.1.4 *Metering System*—The metering system shall include a vacuum gauge, leak-free pump, temperature sensors capable of measuring with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, which ever is greater and meeting the calibration requirements specified in 8.2, gas metering system capable of measuring the total volume sampled to within ± 2 % of the measured value, and related equipment, as shown in Fig. 1.

6.1.2 *Barometer*—Mercury, aneroid, or other barometer capable of measuring atmospheric pressure with an accuracy of ±2.5 mm Hg (0.1 in.). Must meet calibration requirements specified in 8.3.

NOTE 1—The barometric pressure reading may be obtained from a nearby National Weather Service station. In this case, the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and sampling point shall be made at a rate of minus 2.5 mm Hg (0.1 in.) per 30 m (100 ft) elevation increase or plus 2.5 mm Hg (0.1 in) per 30 m (100 ft) elevation decrease.

6.1.3 *Dilution Tunnel Gas Temperature Measurement*—A temperature sensor capable of measuring with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, which ever is greater and meeting the calibration requirements specified in 8.2.

6.1.4 *Pitot Tube*—A standard Pitot tube designed according to the criteria given in 6.1.4.1 shall be used to measure flow in the dilution tunnel. Pitot tubes will have an assumed Pitot coefficient of 0.99 and be designed according to these specifications:

6.1.4.1 Standard Pitot design (see Appendix X2 for an example);

6.1.4.2 Hemispherical, ellipsoidal, or conical tip;

6.1.4.3 A minimum of six diameters straight run (based upon D, the external diameter of the tube) between the tip and the static pressure holes;

6.1.4.4 A minimum of eight diameters straight run between the static pressure holes and the centerline of the external tube, following the 90° bend;

6.1.4.5 Static pressure holes of equal size (approximately 0.1 D), equally spaced in a piezometer ring configuration; and

6.1.4.6 90° bend, with curved or mitered junction.

6.1.5 *Differential Pressure Gauge*—An inclined manometer or equivalent shall be readable to the nearest 0.127 mm (0.005 in.) water for Δp values greater than 2.54 mm (0.10 in.) water, and to the nearest 0.025 mm (0.001 in.) water for Δp values less than 2.54 mm (0.10 in.) water.

6.1.6 *Dilution Tunnel*—The dilution tunnel apparatus is shown in Fig. 3 and Fig. 4 and consists of the following components:

6.1.6.1 *Hood*—Constructed of steel. Hood shall be large enough to capture all of the flue-gas flow exiting the top of the appliance chimney. The dilution tunnel hood shall be conical with a minimum diameter at the entrance of at least four times the tunnel diameter. The height of the conical section shall be at least three tunnel diameters. A skirt can be used around the inlet to the conical section to insure capture of the flue-gas exhaust as shown in 9.2.4 as long as the requirements of 9.2.3

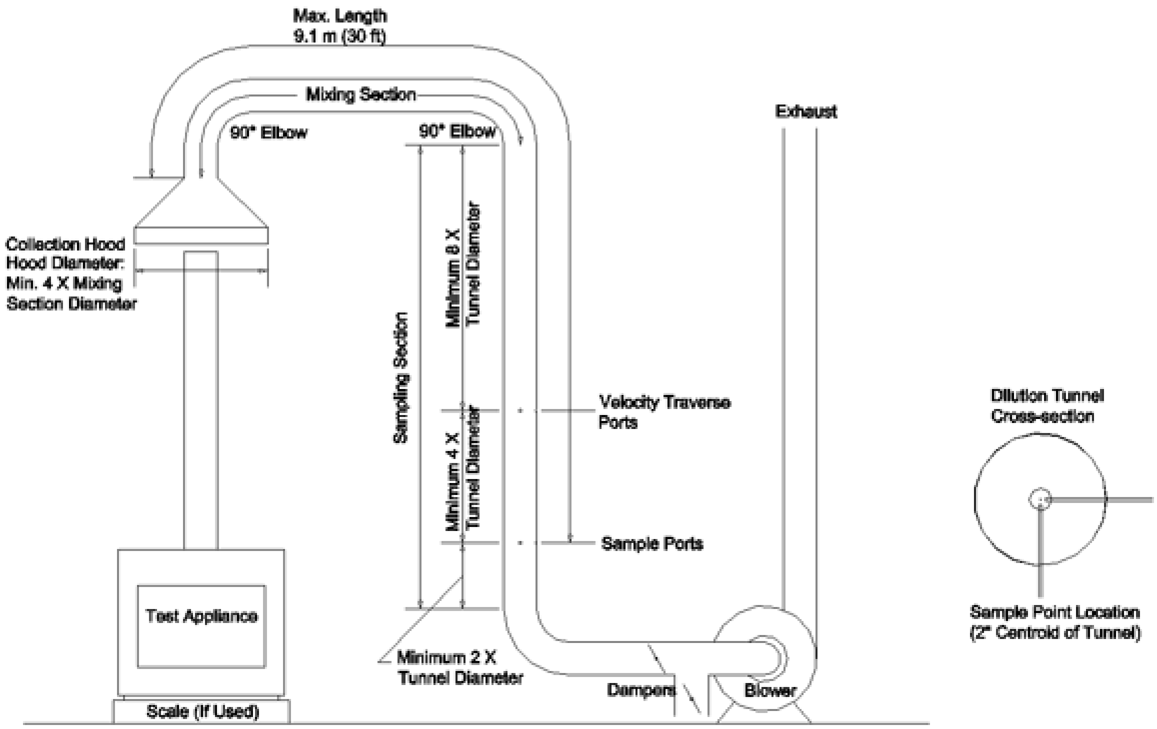

FIG. 3 Steel-Constructed Dilution Tunnel Apparatus

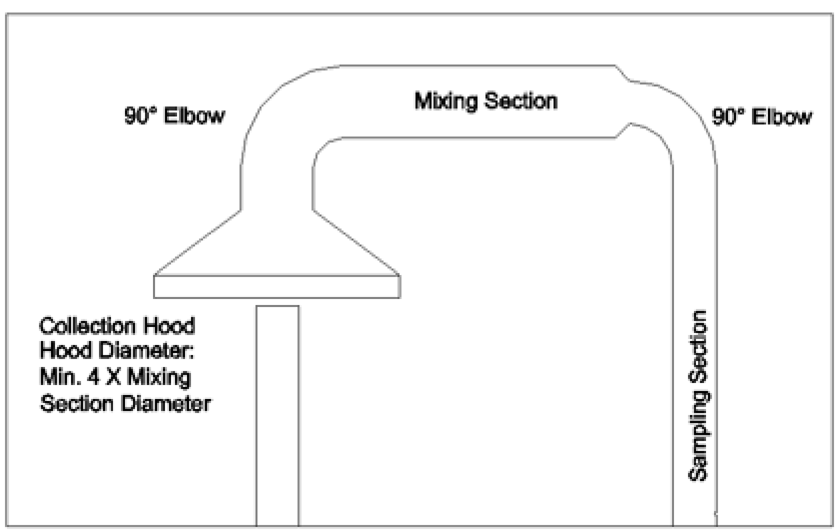

FIG. 4 Mixing Section and Sampling Section with Different Diameters

are met. The outlet of the conical section shall be sized to mate with the mixing section of the dilution tunnel. (See Fig. 3 and Fig. 4.)

6.1.6.2 *90° Elbows*—Steel 90° elbows should be used for connecting mixing section, the sampling section, and the optional damper assembly. There shall be at least two 90° elbows upstream of the sampling section. (See Fig. 3 and Fig. 4.) The last elbow before the sampling section begins shall be of the same diameter as the sampling section straight ducting.

6.1.6.3 *Straight Duct*—Straight sections of steel ducting shall be used to construct both the mixing section and sampling section of the dilution tunnel apparatus. The mixing section is considered to be the ducting that is upstream of the last elbow before the sampling section begins. The mixing section and sampling section may be different diameters, but the sampling section shall have a consistent diameter over the its full length. (See Fig. 4.) Two velocity traverse ports shall be located at least eight tunnel diameters downstream of the last flow disturbance (for example, a 90° elbow) and positioned at 90° to each other in the dilution tunnel sampling section. These velocity traverse points shall be of sufficient size to allow entry of the standard Pitot tube but shall not exceed 12.7 mm (0.5 in.) diameter. Two particulate sample extraction ports shall be located at least four tunnel diameters downstream of the velocity traverse ports and at least two tunnel diameters upstream from the next downstream flow disturbance. These sample extraction ports shall be of sufficient size to allow entry of the sampling probes. The total length of duct from the center of the outlet of the hood to the sampling ports shall not exceed 9.1 m (30 ft). (See Fig. 3.)

6.1.6.4 *Blower*—Squirrel cage or other type of fan capable of gathering and moving all flue-gases and entrained dilution air from the dilution tunnel extraction hood to the dilution tunnel exhaust having sufficient flow to maintain dilution rate specifications in Section 9. (See 9.2.)

6.1.7 *Test Facility Temperature Monitor*—A thermocouple capable of measuring with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, which ever is greater, located centrally in a vertically oriented 150 mm (6 in.) long, 50 mm (2 in.) diameter pipe shield that is open at both ends. Must meet the calibration requirements specified in 8.2.

6.1.8 *Anemometer*—Device capable of detecting air velocities less than 0.10 m/sec (20 ft/min) and used for measuring air velocities in the test facility near the test appliance.

6.2 *Sample Analysis*—The following items are required for sample analysis:

6.2.1 *Desiccator*—Any airtight cabinet or other container containing desiccant to remove moisture from the probes, front filter housings, filters, and filter gaskets prior to and after testing;

6.2.2 *Analytical Balance*—With a resolution 0.1 mg or better. Must meet the calibration requirements specified in 8.4;

6.2.3 *Hygrometer or Sling Psychrometer*—To measure the relative humidity of the laboratory environment with a resolution of 2 % RH or better; and

6.2.4 *Temperature Sensor*—To measure the temperature of the laboratory environment with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, which ever is greater. and meeting the calibration requirements specified in 8.2.

7. Reagents and Standards

7.1 *Sample Collection*—The following reagents are required for sample collection:

7.1.1 *Filters*—Glass fiber filters with a diameter of 47 mm without organic binder, exhibiting at least 99.95 % efficiency (<0.05 % penetration) on 0.3-micron dioctyl phthalate smoke particles in accordance with Practice D2986. Manufacturer's quality control test data are sufficient for validation of efficiency.[8]

7.2 *Sample Analysis*—One reagent is required for the sample analysis:

7.2.1 *Desiccant*—Desiccant shall be capable of drying air to a moisture content of 0.005 g/L or less. Calcium sulfate ($CaSO_4$) and molecular sieve desiccants are suitable.

7.3 *Probe Assembly Cleaning*—Acetone is used to clean and remove moisture from the probe assembly before pretest desiccation and to remove particulate material that has accumulated on the outside of the probe during the test run prior to post-test desiccation.

8. Calibration and Standardization

NOTE 2—Maintain a laboratory record of all calibrations.

8.1 *Volume Metering System:*

8.1.1 Sampling system volume metering equipment shall be calibrated before initial use and at least semi-annually thereafter. Calibration shall be traceable to NIST and demonstrate a maximum uncertainty of ±1.0 % of measured volume at the operating conditions (flow rate and total volume) used in the test.

8.2 *Temperature Sensors*—Temperature measuring equipment shall be calibrated before initial use and at least semiannually thereafter. Calibrations shall be in compliance with NIST Monograph 175.

8.3 *Barometer*—Calibrate against a mercury barometer before the first certification test and at least semi-annually, thereafter. If a mercury barometer is used, no calibration is necessary. Follow the manufacturer's instructions for operation. Barometers shall have an uncertainty of ±1.27 mm (0.05 in.) of mercury or better.

8.4 *Analytical Balance*—Perform a multipoint NIST traceable calibration (at least five points spanning the operational range) of the analytical balance before the first test and semiannually, thereafter. Before each test, audit the balance by weighing at least one calibration weight that corresponds to 50 to 150 % of the weight of one filter. If the scale cannot reproduce the value of the calibration weight to within 0.1 mg, conduct the multipoint calibration before use.

9. Procedures

9.1 *Dilution Tunnel Assembly and Cleaning*—A schematic of a dilution tunnel is shown in Fig. 3. The dilution tunnel requirements and other features are described in 6.1.6. Assemble the dilution tunnel, sealing joints, and seams to prevent air leakage. Clean the dilution tunnel with an appropriately sized wire chimney brush before each test run.

9.2 *Dilution Tunnel:*

9.2.1 *Size*—The dilution tunnel diameter shall be sized such that the flow velocity as measured as shown in 9.3 and as established in 9.2.2 shall result in a minimum of 4.1 m/sec (800 ft/min) when the velocity pressure is measured to an accuracy of ±0.025 mm (0.001 in.) water or a minimum of 7.6 m/sec (1500 ft/min) when the velocity pressure is measured to an accuracy of ±0.127 mm (0.005 in.) water.

9.2.2 *Flow Rate*—The dilution tunnel flow rate shall be selected to provide sufficient flow to collect and fully entrain all flue products during the test and provide sufficient velocity for accurate flow measurement. For closed combustion appliances tunnel flow rates in the range of 0.07 to 0.24 scm/sec (150 to 500 SCFM) have been found to be acceptable. For open combustion appliances, such as fireplaces, tunnel flow rates in the range of 0.24 to 0.71 scm/sec (500 to 1500 SCFM) have been found to be acceptable. The maximum tunnel flow rate shall not exceed five times the minimum flow rate determined as shown in 9.2.4.

[8] Gelman A/E 61631 and Whatman 1841-047 filters have been found acceptable for this purpose. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

NOTE 3—Optimum accuracy is achieved when the dilution tunnel flow rate is set so that the ratio of sample flow to tunnel flow is maximized.

9.2.3 *Induced Draft Determination*—Prepare the test appliance in accordance with appropriate test method. Locate the dilution tunnel collection hood over the appliance chimney exhaust. Operate the dilution tunnel blower at the flow rate to be used during the test run. Measure the static pressure imposed on the appliance by the dilution tunnel (that is, the difference in static pressure measured with and without the dilution tunnel operating) at a location no greater than 0.3 m (1 ft) above the flue connector. Adjust the distance between the top of the test appliance chimney and the dilution tunnel hood so that the dilution tunnel induced static pressure is less than 1.25 Pa (0.005 in. water). Have no fire in the appliance, open and close any doors, and open fully the flue damper if applicable during this check and adjustment.

9.2.4 *Smoke Capture*—Prior to any test run, burn the appliance at a high burn rate using a kindling fuel load and specified test load, operate the dilution tunnel, and visually monitor the appliance chimney exhaust. Determine the minimum dilution tunnel flow rate needed to insure that 100 % of the chimney effluent is collected by the dilution tunnel collection hood. If the appliance has doors, operate the appliance with the doors in all positions specified in the appliance owner's manual. It may be necessary to artificially inject smoke (using smoke pellets or smoke generator) into the area around dilution tunnel collection hood to provide a better visual check that no exhaust gases are escaping. If less than 100 % of the chimney effluent is collected, adjust the distance between the test appliance chimney outlet and the dilution tunnel hood or increase the dilution tunnel flow rate just to the point where no visible effluent is escaping, or both. With the Pitot tube located at the center of the dilution tunnel, record this dilution tunnel velocity head (D_p), temperature and static pressure.

9.3 *Velocity Measurements*—Prior to ignition, conduct a velocity traverse in the dilution tunnel to determine the Pitot Factor (F_p). The Pitot tube shall be placed at the center of the tunnel during the test run.

9.3.1 *Velocity Traverse*—Measure the diameter of the dilution tunnel at the velocity traverse port location through both ports. Calculate the dilution tunnel area using the average of the two diameters. Place the standard Pitot tube at the center of the dilution tunnel in either of the velocity traverse ports. Seal any gap between the velocity traverse port in the dilution tunnel and the Pitot tube and seal the unused velocity traverse port to prevent any air leakage into the dilution tunnel. Adjust the damper or similar device on the blower inlet until the velocity indicated by the Pitot tube indicates that a dilution tunnel flow rate within the allowable range as shown in 9.2 has been achieved. Continue to read the velocity head (D_p) and temperature until the velocity has remained constant (less than 5 % change) for 1 min. Once a constant velocity is obtained at the center of the dilution tunnel, perform a velocity traverse as specified in 9.3.2. Seal any gap between the velocity traverse port in the dilution tunnel and the Pitot tube and seal the unused velocity traverse port to prevent any air leakage into the dilution tunnel.

9.3.1.1 Ensure that the proper differential pressure gauge is being used for the range of Δp values encountered (see Section 6.1.5). If it is necessary to change to a more sensitive gauge, do so, and re-measure the Δp and temperature readings at each traverse point. Conduct a post-test leak-check (mandatory), as described in 9.6.5, to validate the traverse. Measure the Δp and tunnel temperature at each traverse point and record the readings.

9.3.1.2 Calculate the total gas flow rate using calculations contained in Section 11, using the velocity traverse points in accordance with 9.3.2, excluding the center readings. Verify that the flow rate is equal to the target flow; if not, readjust the damper, and repeat the velocity traverse.

9.3.2 *Velocity Traverse Measurements*—Measure and record the velocity head and temperature at the traverse points specified as follows:

9.3.2.1 For dilution tunnel diameters equal to or greater than 0.3 m (12 in.) locate the traverse points on two perpendicular diameters according to the table in and the example shown in Fig. 5. For dilution tunnel diameters less than 0.3 m (12 in.) locate the traverse points on two perpendicular diameters according to the table and example shown in Fig. 6.

9.3.2.2 For dilution tunnel diameters equal to or less than 0.61 m (24 in.), no traverse points shall be located within 1.3 cm (0.50 in.) of the tunnel walls.

9.4 *Pretest Preparation*—The sampling equipment should be maintained according to good laboratory practices and manufacturer's instructions where applicable.

9.4.1 Check filters visually against light for irregularities, flaws, or pinhole leaks. Label the filters on the back side near the edge using numbering machine ink.

9.4.2 Rinse the probe assemblies with acetone to clean and remove moisture before desiccating.

9.4.3 Mark the probe assemblies in such a way that each can be identified during use.

9.4.4 Desiccate the filters, filter gaskets, and the probe assemblies at 20 ± 5.6°C (68 ± 10°F) and ambient pressure for at least 24 h. Weigh each component at intervals of not less than 6 h until a constant weight is achieved. Record results to the nearest 0.1 mg. During each weighing, the period for which the components are exposed to the laboratory environment shall be less than 2 min. The filter gaskets can be weighed in sets to be used in each filter holder and kept in an identified container at all times except during sampling and weighing. The filter holder assembly after the front filter need not be desiccated or weighed.

NOTE 4—For the purposes of this section, the term constant weight means a difference of no more than 0.2 mg between two consecutive weighings, with not less than 6 h of desiccation time between weighings.

9.5 *Preparation of the Filter Holder Assemblies*—During preparation and assembly of the filter holder assemblies, keep all openings where contamination can occur covered until just prior to assembly or until sampling is about to begin.

9.5.1 *Assemble the Filter Holder Assemblies*—Using tweezers or clean disposable surgical gloves, place one labeled and weighed filter in each of the front and back filter holders. Be sure that each filter is properly centered and that the identified filter gasket is properly placed so as to prevent the sample gas

Taverse Point	% of Diameter
1	4.4
2	14.6
3	29.6
Center	50.0
4	70.4
5	85.4
6	95.6

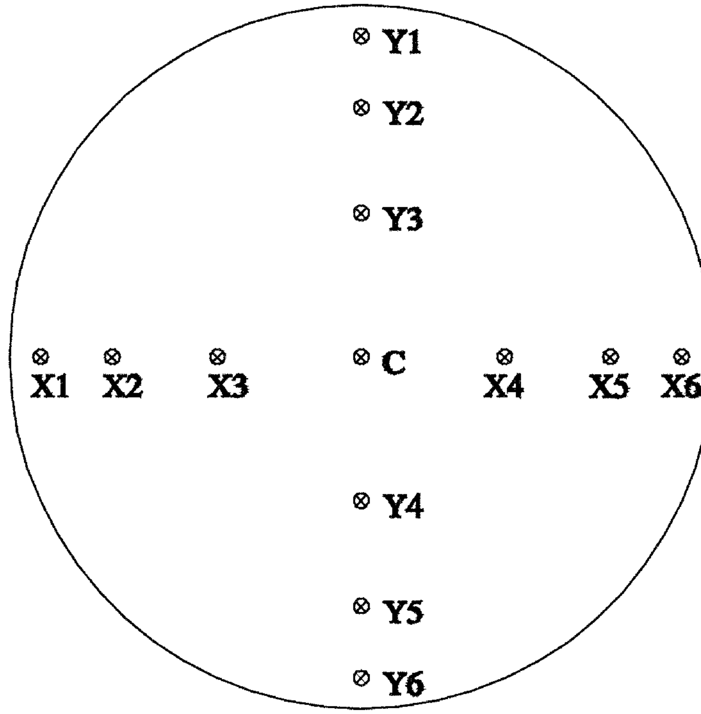

FIG. 5 Dilution Tunnel Diameter Equal To or Greater Than 0.3 m (12 in.) Traverse Point Table

Taverse Point	% of Diameter
1	6.7 *
2	25.0
Center	50.0
3	75.0
4	93.3 *

* No closer than 12.7 mm (0.50 in.) to tunnel wall.

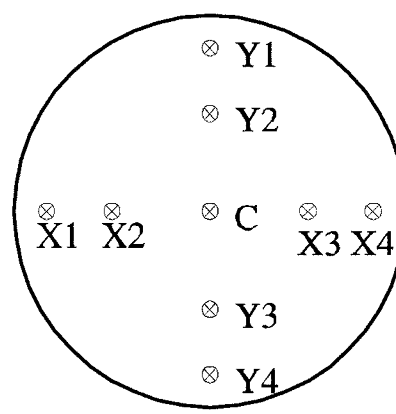

FIG. 6 Dilution Tunnel Diameter Less Than 0.3 m (12 in.) Traverse Point Table

stream from circumventing the filter. Mark the probes by a method that will not affect the tare weight to denote the proper distance for insertion into the tunnel. Set up the filter holder assemblies as shown in Fig. 2 and the sampling trains as shown in Fig. 1.

9.5.2 *Assemble the Room Air Blank Filter Holder Assembly*—Using tweezers or clean disposable surgical gloves, place one labeled and weighed filter in the single filter holder. Be sure that the filter is properly centered and that the identified filter gasket is properly placed so as to prevent the sample gas stream from circumventing the filter. Set up the room air blank filter holder assembly as shown in Fig. 7 and the dryer and metering system as shown in Fig. 1. The inlet to the room air blank filter holder assembly shall be located in the same space within the test facility as the test appliance and shall be within 3.1 m (10 ft) of the dilution tunnel hood entrance.

9.6 *Leak-Check Procedures:*

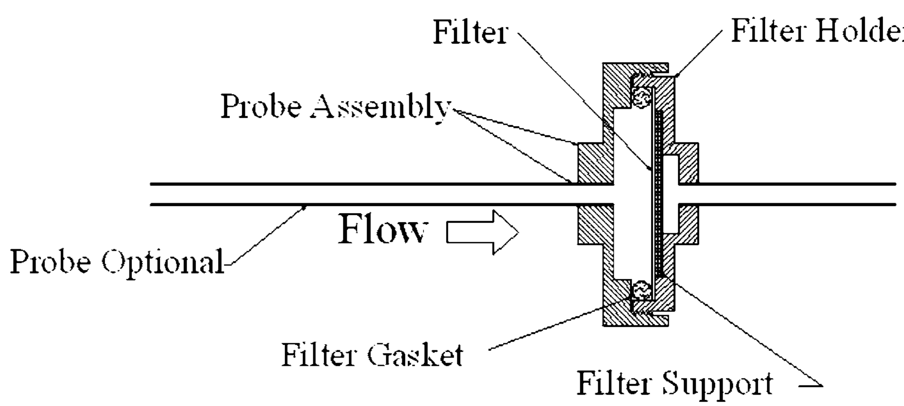

FIG. 7 Room Air Blank Filter Holder Assembly

9.6.1 *Leak-Check of Metering System Shown in Fig. 1*—That portion of the sampling train from the pump to the dry gas meter outlet (or orifice meter, if used) shall be leak-checked prior to initial use and at least semi-annually thereafter. Leakage after the pump will result in less volume being recorded than is actually sampled. The following procedure is suggested (see Fig. 1): Close the main valve before the pump. Attach a rubber tube to the dry gas meter outlet piping, downstream of the dry gas meter pressure gauge. Pressurize the system to 13 to 18 cm (5 to 7 in.) water column by blowing into the rubber tubing. Read the pressure on the dry gas meter pressure gauge. Pinch off the tubing, and observe the pressure gauge for 1 min.

9.6.2 If using an orifice meter, insert a one-hole rubber stopper with rubber tubing attached into the orifice exhaust pipe. Disconnect and vent the low side of the orifice manometer. Close off the low side orifice tap. Pressurize the system to 13 to 18 cm (5 to 7 in.) water column by blowing into the rubber tubing. Read the pressure on the orifice manometer. Pinch off the tubing, and observe the manometer for 1 min.

9.6.3 A loss of pressure on the dry gas meter pressure gauge or orifice manometer indicates a leak in the metering system; leaks, if present, must be corrected.

9.6.4 *Pretest Leak-Check:*

9.6.4.1 *Particulate Sampling Trains*—Pretest leak-checks of the sampling trains are required. Leakage in the sampling train results in less tunnel gas sample passing through the filters than is indicated by the metering system. The procedures outlined below should be used.

(1) After each sampling train has been assembled, plug the probe inlet and check for leaks by pulling a 380 mm (15 in.) Hg vacuum.

(2) Leakage rates in excess of 4 % of the average sampling rate or 0.0003 m^3/min (0.01 cfm), whichever is less, are unacceptable.

NOTE 5—A lower vacuum may be used, provided that it is not exceeded during the test. Start the pump with the bypass valve fully open and the coarse adjust valve completely closed. Partially open the coarse adjust valve, and slowly close the bypass valve until the desired vacuum is reached. If the desired vacuum is exceeded, either leak-check at this higher vacuum, or end the leak check and start over.

NOTE 6—If the leakage rate is above acceptable limit, find and repair the leakage source and leak test again. Repeat until the leakage rate is acceptable. When the leak check is completed, first slowly remove the plug from the inlet to the probe, and immediately turn off the vacuum pump.

9.6.4.2 *Pitot Tube Lines:*

(1) A pretest leak-check of Pitot lines using the following procedure is recommended: (*a*) blow through the Pitot impact opening until at least 7.6 cm (3.0 in.) water velocity head registers on the manometer; then, close off the impact opening. The pressure shall remain stable for at least 15 seconds; (*b*) do the same for the static pressure side, except using suction to obtain the minimum of 7.6 cm (3.0 in.) water.

9.6.5 *Post-Test Leak Checks:*

9.6.5.1 *Sampling Train*—A leak check of the sampling train is mandatory at the conclusion of each sampling run before sample recovery. The leak check shall be performed in accordance with the procedures outlined in 9.6.4.1, except that it shall be conducted at a vacuum equal to or greater than the maximum value reached during the sampling run. If the leakage rate is found to be no greater than 0.0003 m_3/min (0.01 cfm) or 4 % of the average sampling rate (whichever is less), the results are acceptable. If, however, a higher leakage rate is obtained, the test shall be considered void unless the total emissions measured by the dual sampling trains agree within the allowable limit as shown in 11.7 and one of the sampling trains is within the specified maximum post-test leakage limit.

9.6.5.2 *Pitot Tube Lines*—A leak test of the Pitot tube lines is mandatory at the conclusion of each sampling run before sample recovery. The leak test shall be conducted in accordance with the procedure outlined in 9.6.4.2. The lines must pass this leak-check in order to validate the velocity head data. The test run is invalid if this leak test is failed.

9.7 *Test Facility*—The test facility shall meet the following requirements during testing:

9.7.1 The test facility temperature shall be maintained between 13 and 32°C (55 and 90°F) during each test run. Locate the test facility temperature monitor on the horizontal plane that includes the primary air intake opening for the test appliance. Locate the temperature monitor 1 to 2 m (3.3 to 6.6 ft) from the front of the test appliance in the 90° sector in front of the test appliance (See Fig. 8.)

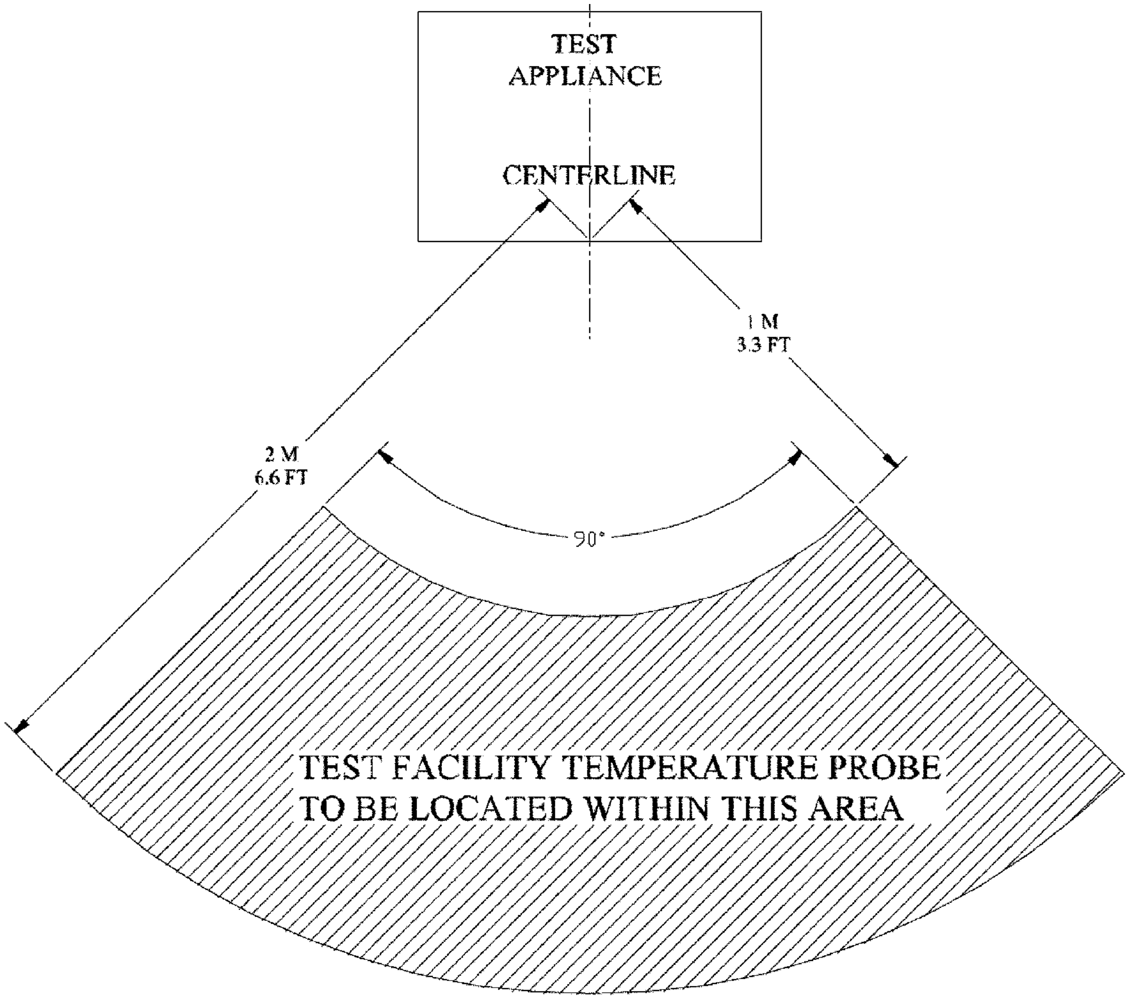

FIG. 8 Test Facility Temperature Monitor

9.7.2 Air velocities within 0.6 m (2 ft) of the test appliance shall be less than 0.25 m/sec (50 ft/min) without fire in the unit. Use an anemometer to measure the air velocity. Measure and record the room air velocity before starting a fire in the test appliance and once immediately following the test run completion.

9.7.3 Measure and record the test facility's ambient relative humidity, barometric pressure, and temperature before and after each test run.

9.8 *Sampling Train Operation*—Locate the probe inlets within the 50 mm (2 in.) diameter centroidal area of the dilution tunnel (see Fig. 3), no closer than 25 mm (1 in.) apart, and block off the openings around the probes to prevent unrepresentative dilution of the gas stream. Be careful not to bump the probes into the stack wall when removing or inserting the probe through the porthole; this minimizes the chance of extracting deposited material.

9.8.1 Begin sampling at the start of the test run as defined in the applicable test method. During the test run, maintain the sample flow rates for both tunnel particulate sampling trains proportional to the dilution tunnel flow rate (within 10 % of the initial proportionality ratio) and a filter holder temperature of no greater than 32°C (90°F). Begin room air sampling (background) at the same time as the tunnel particulate trains and maintain the room air sample flow rate with 20 % of the initial room air sample flow rate.

9.8.2 For each test run, record the required data. Be sure to record the starting dry gas meter readings for both tunnel particulate sampling trains and for the room air sampling train. Refer to Fig. 1 for a graphic description of the sampling trains. Record the dry gas meter readings for both tunnel particulate sampling trains at the beginning and end of each sampling time increment. It is not necessary to record dry gas meter readings for each sampling time increment for the room air sampling train. Recording flow meter readings is acceptable for the room air sampling train. Record the dry gas meter readings for both tunnel particulate sampling trains and the room air sampling train when sampling is halted. Take other needed readings at least once each 10 min during the test run. Since the manometer level and zero may drift because of vibrations and temperature changes, make periodic checks during the test run. Record tunnel gas static pressure at the beginning and end of each test run.

9.8.3 For the purposes of proportional sampling rate determinations, data from calibrated flow rate devices, such as glass rotameters, may be used in lieu of incremental dry gas meter readings. Proportional rate calculation procedures must be revised, but acceptability limits remain the same.

9.8.4 During the test run, make periodic adjustments to keep the temperature between the filters at the proper level. The probes may be cooled to help maintain filter temperature. Do not change sampling trains during the test run.

9.8.5 At the end of the test run as defined in the applicable test method, stop tunnel particulate sampling using the following procedure. Turn off both tunnel sampling train coarse adjust valves, remove the probe and filter assemblies from the dilution tunnel, turn off the sampling pumps, record the final dry gas meter readings, and conduct post-test leak-checks, as outlined in 9.6.5. Turn off the room air (background) sampling system at the same time as the tunnel particulate sampling trains. Record the final dry gas meter reading and conduct a post-test leak check as outlined in 9.6.5.

9.9 *Calculation of Proportional Sampling Rate*—Calculate percent proportionality (see Section 11) to determine whether the run was valid or another test run should be made.

9.10 *Sample Recovery*—After post test leak checking, disconnect the filter holder assembly from the dryer and metering system and carefully clean the outside of the probe with acetone, cap the ends of the filter holder assembly, identify (label) it, and transfer to the laboratory sample recovery area. Carefully disassemble the filter holder and remove the filters and the filter gaskets from the filter holders, and place them in identified containers. Use a pair of tweezers or clean disposable surgical gloves, or both, to handle the filters and filter gaskets. Reassemble the empty filter holder assemblies, cap the ends, identify (label), and transfer all the samples to the laboratory weighing area. Disassemble the filter holder assembly and remove the cap from the probe inlet. The probe assembly shall be weighed without sample recovery (use no solvents) in order to determine the sample weight gain. Requirements for filter holder reassembly, capping, and transport of sample containers are not applicable if sample recovery and weighing occur in the same laboratory environment.

10. Analytical Procedure

10.1 *Record the Data Required*—Use the same analytical balance for determining tare weights and final sample weights.

10.2 *Sample Weight Determination:*

10.2.1 Desiccate the filters and filter gaskets at 20 ± 5.6°C (68 ± 10°F) and ambient pressure for at least 24 h. Weigh each component at intervals of at least 6 h until a constant weight is achieved. Report the results to the nearest 0.1 mg. Filters and filter gaskets may be weighed directly without a Petri dish. They may be weighed in pairs (front and back filters and front and back filter gaskets from same filter train) to reduce handling and weighing errors. During each weighing, the components shall not be exposed to the laboratory atmosphere for longer than 2 min. For the room air background sample filter and filter gasket, treat negative particulate catch weights as "zero" when determining total room air particulate weight in accordance with 10.2.

10.2.2 Remove the probe assemblies from the filter holder assemblies and uncap the probe assemblies. Desiccate the probe assemblies at 20 ± 5.6°C (68 ± 10°F) and ambient pressure for at least 24 h. Weigh each probe assembly at intervals of at least 6 h until a constant weight is achieved. Report the results to the nearest 0.1 mg. During each weighing, the components shall not be exposed to the laboratory atmosphere for longer than 2 min. If the probe assemblies have reached constant weight and result in a negative particulate catch weight in the probe assembly:

10.2.2.1 Treat the negative sample probe catch as "zero" when determining total particulate catch weight in accordance with 10.2 if the negative value is equal to or less than 5 % of the total particulate catch (excluding the probe).

10.2.2.2 Treat the test run as invalid if the negative value is greater than 5 % of the total particulate catch weight (excluding the probe).

10.2.2.3 For the room air sample probe assembly, treat negative particulate catch weights as "zero" when determining total room air particulate weight in accordance with 10.2.

NOTE 7—For the purposes of 10.2, the term constant weight means a difference of no more than 0.2 mg or 1 % of total weight less tare weight (particulate catch), whichever is greater, between two consecutive weighings, with intervals of not less than 6 h of desiccation time between weighings.

11. Data Analysis and Calculations

11.1 Carry out calculations, retaining at least one extra significant figure beyond that of the acquired data. Round off figures after the final calculation. Other forms of the equations may be used as long as they give equivalent results.

11.2 *Nomenclature:*

A = Cross-sectional area of tunnel m^2 (ft^2).

B_{ws} = Water vapor in the gas stream, proportion by volume (assumed to be 0.02 (2.0 %)).

C_p = Pitot tube coefficient, dimensionless (assigned a value of 0.99).

c_r = Concentration of particulate matter room air, dry basis, corrected to standard conditions, g/dscm (gr/dscf) (mg/dscf).

c_s = Concentration of particulate matter in tunnel gas, dry basis, corrected to standard conditions, g/dscm (gr/dscf) (mg/dscf).

E_T = Total particulate emissions, g.

F_p = Adjustment factor for center of tunnel pitot tube placement.

$$F_p = \frac{V_{strav}}{V_{scent}} \quad (1)$$

$$K_p = \text{Pitot Tube Constant, } 34.97\,\frac{\text{m}}{\text{sec}}\left[\frac{(\text{g/g•mole})(\text{mm Hg})}{(\text{K})\,(\text{mm water})}\right]^{\frac{1}{2}} \quad (2)$$

or

$$K_p = \text{Pitot Tube Constant, } 85.49\,\frac{\text{ft}}{\text{sec}}\left[\frac{(\text{lb/lb}-\text{mole})(\text{in. Hg})}{(\text{R})(\text{in. H}_2 0)}\right]^{\frac{1}{2}}$$

L_a = Maximum acceptable leakage rate for either a pretest or post-test leak- check, equal to 0.0003 m^3/min (0.010 cfm) or 4 % of the average sampling rate, whichever is less.

L_p = Leakage rate observed during the post-test leak-check, m^3/min (cfm).
m_p = mass of particulate from probe, mg.
m_f = mass of particulate from filters, mg.
m_g = mass of particulate from filter gaskets, mg.
m_r = mass of particulate from the filter, filter gasket, and probe assembly from the room air blank filter holder assembly, mg.
m_n = Total amount of particulate matter collected, mg.
M_s = the dilution tunnel dry gas molecular weight (may be assumed to be 29 g/g mole (lb/lb mole).
P_{bar} = Barometric pressure at the sampling site, mm Hg (in. Hg).
P_g = Static Pressure in the tunnel (in. water).
PR = Percent of proportional sampling rate.
P_s = Absolute average gas static pressure in dilution tunnel, mm Hg (in. Hg).
P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).
Q_{std} = Average gas flow rate in dilution tunnel.

$$Q_{std} = 60\,(1 - B_{ws})\, v_s\, A \left[\frac{T_{std}\, P_s}{T_s\, P_{std}}\right] \tag{3}$$

dscm/min (dscf/min).

T_m = Absolute average dry gas meter temperature, K (R).
T_{mi} = Absolute average dry gas meter temperature during each 10-min interval, *i*, of the test run.

$$T_{mi} = \frac{(T_{mi(b)} + T_{mi(e)})}{2} \tag{4}$$

K (R).

where:

$T_{mi(b)}$ = Absolute dry gas meter temperature at the beginning of each 10-min test interval, *i*, of the test run, K (R), and
$T_{mi(e)}$ = Absolute dry gas meter temperature at the end of each 10-min test interval, *i*, of the test run, K (R).

T_s = Absolute average gas temperature in the dilution tunnel, K (R).
T_{si} = Absolute average gas temperature in the dilution tunnel during each 10-min interval, *i*, of the test run, K (R).

$$T_{si} = \frac{(T_{si(b)} + T_{m=si(e)})}{2} \tag{5}$$

K (R).

where:

$T_{si(b)}$ = Absolute gas temperature in the dilution tunnel at the beginning of each 10-min test interval, *i*, of the test run, K (R), and
$T_{si(e)}$ = Absolute gas temperature in the dilution tunnel at the end of each 10-min test interval, *i*, of the test run, K (R).

T_{std} = Standard absolute temperature, 293K (528R).
V_m = Volume of gas sample as measured by dry gas meter, dcm (dcf).
V_{mc} = Volume of gas sampled corrected for the post test leak rate, dcm (dcf).
V_{mi} = Volume of gas sample as measured by dry gas meter during each 10-min interval, *i*, of the test run, dcm.
$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions.

$$V_{m(std)} = K_1\, V_m\, Y\, \frac{P_{bar} + \left(\frac{\Delta H}{13.6}\right)}{T_m} \tag{6}$$

dscm (dscf).

where:

K_1 = 0.3855 K/mm Hg for SI units and = 17.64 R/in. Hg for inch-pound units.

NOTE 8—Eq 6 can be used as written unless the leakage rate observed during the mandatory post test leak check exceeds L_a. If L_p exceeds L_a but the other requirements in accordance with 9.6.5.1 are met, Eq 6 must be modified as follows:

$$V_{m(std)} = K_1\, V_{mc}\, Y\, \frac{P_{bar} + \left(\frac{\Delta H}{13.6}\right)}{T_m} \tag{7}$$

where:

V_{mc} = $V_m - (L_p - L_a)\theta$
V_{mr} = Volume of room air sample as measured by dry gas meter, dcm (dcf), and
$V_{mr(std)}$ = Volume of room air sample measured by the dry gas meter, corrected to standard conditions.

$$V_{mr(std)} = K_1\, V_{mr}\, Y\, \frac{P_{bar} + \left(\frac{\Delta H}{13.6}\right)}{T_m} \tag{8}$$

dscm (dscf).

where:

K_1 = 0.3855 K/mm Hg for SI units and = 17.64 R/in. Hg for inch-pound units, and
V_s = Average gas velocity in the dilution tunnel.

$$v_s = F_p K_p\, C_p \sqrt{\Delta p_{avg}} \sqrt{\frac{T_s}{P_s M_s}} \tag{9}$$

m/sec (ft/sec).

V_{si} = Average gas velocity in dilution tunnel during each 10-min interval, *i*, of the test run.

$$v_{si} = F_p K_p\, C_p \sqrt{\Delta p_i} \sqrt{\frac{T_{si}}{P_s M_s}} \tag{10}$$

m/sec (ft/sec).

V_{scent} = Average gas velocity at the center of the dilution tunnel calculated after the Pitot tube traverse.
V_{strav} = Average gas velocity calculated after the multi-point Pitot traverse.
Y = Dry gas meter calibration factor.
ΔH = Average pressure at the outlet of the dry gas meter or the average differential pressure across the orifice meter, if used, mm water (in. water).

Δp_{avg} = Average velocity pressure in the dilution tunnel, mm water (in. water).

Δp_i = Velocity pressure in the dilution tunnel as measured with the Pitot tube during each 10-min interval, *i*, of the test run.

$$\Delta p_i = \frac{(\Delta p_{i(b)} + \Delta p_{i(e)})}{2} \quad (11)$$

mm water (in. water).

where:

$\Delta p_{i(b)}$ = Velocity pressure in the dilution tunnel as measured with the Pitot tube at the beginning of each 10-min interval, *i*, of the test run, mm water (in. water), and

$\Delta p_{i(e)}$ = Velocity pressure in the dilution tunnel as measured with the Pitot tube at the end of each 10-min interval, i, of the test run, mm water (in. water).

θ = Total sampling time, min.
10 = ten min, length of first sampling period.
13.6 = Specific gravity of mercury.
100 = Conversion to percent.

11.3 *Total Particulate Weight*—Determine the total particulate catch, mn, from the sum of the catches obtained from the filters, probe and filter housing and filter gaskets (O-rings).

$$m_n = m_p + m_f + m_g \quad (12)$$

grams.

11.4 *Particulate Concentration:*

11.4.1 *Particulate Concentration-Sample:*

$$c_s = K_2 \frac{m_n}{V_{m(std)}} \quad (13)$$

g/dscm (g/dscf).

where:

K_2 = 0.001 g/mg.

11.4.2 *Particulate Concentration-Room Air:*

$$c_r = K_2 \frac{m_r}{Vm_{r(std)}} \quad (14)$$

g/dscm (g/dscf).

where:

K_2 = 0.001 g/mg.

11.5 *Total Particulate Emissions:*

$$E_T = (c_s - c_r)\, Qstd\, \theta \quad (15)$$

(total emissions in grams.)

NOTE 9—See specific appliance operation and test procedures for appropriate emissions rate or factor for calculations for the appliance type. This involves dividing the total emissions determined by this test method by operational parameters such as total fuel load weight, heat output rate, test duration, or other factors.

11.6 *Proportional Rate Variation*—Calculate PR for each 10-min interval, *i*, of the test run.

reported as percentage.

11.6.1 Alternate calculation procedures for proportional rate variation may be used if other sample flow rate data (for example, orifice flow meters or rotameters) are monitored to maintain proportional sampling rates. The proportional rate variations shall be calculated for each 10-min interval by comparing the dilution tunnel to sample probe nozzle velocity ratio for each 10-min interval to the average dilution tunnel to sample probe nozzle velocity ratio for the entire test run. Proportional rate variation may be calculated for intervals shorter than 10 min with appropriate revisions to Eq 16. The results are acceptable if 90 % of the PR values calculated for all the sampling intervals are between 90 % and 110 % and if no PR value falls outside the range of 80 % to 120 %. If the PR values for the test run are determined to be unacceptable, repeat the test run.

11.7 *Dual Train Comparison*—Calculate the total emissions from each sampling train as shown in 11.5 separately and determine the average total emissions from the two values. Calculate the emissions factors for each sample train by dividing the total emissions by the weight of dry fuel burned. The total emissions values calculated for each sampling train shall not differ by more than 7.5 % from the average total emissions value or the difference between the emissions factors for the two trains shall not be greater than 0.5 grams per kilogram of dry fuel. If this specification is not met, the results are unacceptable.

12. Precision and Bias

12.1 *Precision*—It is not possible to specify the precision of the procedure in this test method for measuring solid fuel burning appliance emissions because the appliance operation and fueling protocols and the appliances themselves produce variable amounts of emissions and therefore the results cannot be used to determine reproducibility or repeatability of this measurement method.

12.2 *Bias*—No information can be presented on the bias of the procedure in this test method for measuring solid fuel burning appliance emissions because no material having an accepted reference value is available.

APPENDIXES

(Nonmandatory Information)

X1. MEASUREMENT UNCERTAINTY

X1.1 Total Emissions Measurement Uncertainty

X1.2 *Introduction* —Solid fuel burning appliance particulate emissions measured by this test method are subject to both measurement uncertainty and variation due to uncontrolled random factors. The combustion process with wood fuels in particular results in variation in emissions measurements due to a large number of variables that cannot be precisely controlled. Fuel density, moisture content, piece size and placement, turbulent combustion air flow patterns and a number of other variables are known to have some effect on the total particulate emissions produced. There is insufficient data to determine just how significant the variation in results might be for particular appliances or appliance types. However, it is the consensus of experienced testers that these factors alone can account for variation in apparently identical test runs of at least ±10 % in total particulate emissions.

X1.2.1 One component of the variability in results is the Measurement Uncertainty (MU) of the actual particulate emissions measurement. This component of variability can be analyzed and estimated by standard MU analysis techniques. The purpose of Appendix X1 is to provide an outline of the process for determining MU with an example of the needed calculations for its application. However, performing this calculation is not a requirement of the test method.

X1.2.2 For the purposes of this appendix, uncertainties will be stated at a 95 % confidence level meaning that there is a 5 % or less probability that any measurement would deviate from the true value by more than the stated MU. To simplify the analysis it will be assumed that all uncertainties of individual measurements have the same distribution and coverage factor so that standard uncertainties do not need to be derived or stated.

X1.3 Measurement Uncertainty Analysis

X1.3.1 Every numerical physical measurement process is subject to a quantifiable level of uncertainty. This uncertainty is determined in the process of calibrating the measurement instrument. Therefore, the measurement uncertainty for each direct measurement required in a test method can be determined. When multiple measurements of specific quantities are combined into a final numerical measurement result, the combined uncertainty can be calculated by application of well defined and accepted procedures. These procedures are outlined fully in ISO "Guide to the Expression of Uncertainty in Measurement."

X1.3.2 Analysis of the MU for the total particulate emissions in this test method requires combining the uncertainty of the following individual measurements.

X1.3.2.1 Dilution tunnel volumetric flow rate.

X1.3.2.2 Sampling system volumetric flow rate.

X1.3.2.3 Filter and sample probe particulate gravimetric catch.

X1.3.2.4 Ambient particulate background concentration.

X1.3.3 *Component Measurement Uncertainties:*

X1.3.3.1 *Dilution Tunnel Flow Rate*—The dilution tunnel flow is measured by a standard Pitot tube and a differential pressure gauge. The direct measurement is of flow velocity at the operating temperature and pressure. Pitot tube measurements are considered a primary reference method and therefore the primary component of uncertainty in the velocity measurement is that of the differential pressure gauge. Conversion of the velocity measurement to flow rate at standard temperature and pressure conditions requires additional measurements of the tunnel cross sectional area, the temperature and the absolute pressure. An analysis of the overall uncertainty of the tunnel flow rate indicates that the measurements of tunnel cross sectional area, temperature and pressure have a relatively minor affect. The procedure in this standard has been specified such that the overall uncertainty of this parameter is about ±2 % of the flow rate.

X1.3.3.2 *Sampling Volumetric Flow Rate*—The equipment available to measure the sample flow rate has a high precision and can be calibrated such that the measurement uncertainty is ±1 % or better of the actual flow rate. For the purposes of this appendix a ±1 % uncertainty will be assumed. However, laboratories should use the actual MU of the metering equipment they use to estimate the MU of their test results.

X1.3.3.3 *Filter and Probe Particulate Catch*—The analytical balance specified has a measurement uncertainty of ±0.0001g (0.1 mg). A total of 4 to 6 weighings may be needed to determine the net catch depending on whether filters, o-rings and probes are weighed together or separately. Since each weighing is subject to the same uncertainty, the overall uncertainty of the weighing is:

$$MU_{weighing} = \sqrt{0.1^2 \bullet X} \quad (X1.1)$$

where:

X = The total number of weight values actually used to calculate emissions. This does not include weighings during pretest or post-test drying.
= For a process that involves three pretest and three post-test weighings, this uncertainty is ±0.245 mg.

An additional component of the filter catch weight uncertainty is the potential for incomplete recovery of the filter material. There is no objective data to determine the magnitude of this factor, but laboratories familiar with the procedures report that they believe it to be less than 0.1 mg. Combining an additional ±0.1 mg with the weighing uncertainty results in an overall weighing uncertainty of ±0.27 mg.

X1.3.3.4 *Ambient Particulate Background Concentration* —This measurement uses the same measurement equipment and procedures as the sample system and is subject to a similar measurement uncertainty.

X1.3.4 *Combined Measurement Uncertainty*—This section shows an example calculation.

X1.3.4.1 Combined uncertainties are calculated by taking the square root of the sum of squares of the component uncertainties multiplied by a "sensitivity coefficient". The sensitivity coefficient is the partial derivative of the function used to calculate the result with respect to the specific measurement parameter. The general formula (law of propagation of uncertainty) is:

$$uY = \sqrt{((\delta Y/\delta x_1) \times u_1)^2 + \ldots + ((\delta Y/x_n) \times u_n)^2} \quad (X1.2)$$

where:

$\delta Y/\delta x_i$ = Partial derivative of the combining formula with respect to individual measurement x_i, and

u_i = is the uncertainty associated with that measurement.

The formula to calculate total particulate emissions is:

$$E_T = (c_s - c_r)\, Q_{std}\, \theta \quad (X1.3)$$

where:

c_s = sample filter catch/(sample flow rate x test duration), g/dscf,

c_r = room background filter catch/(sample flow x sampling time), g/dscf,

Q_{std} = average dilution tunnel flow rate, dscf/min, and

θ = sampling time, minutes.

X1.3.4.2 For the sake of example the following values will be used in an MU analysis of E_T.

Measurement	Measured Value	MU	Units
Sample Filter Catch (F_c)	0.025	±0.00027	g
Sample Flow Rate (Q_{sample})	0.25	±0.0025	dscfm
Sampling Duration (θ)	180	±0.1	minutes
Background Filter Catch (BG_c)	0.002	±0.00027	g
Background Filter Flow Rate (Q_{BG})	0.15	±0.0015	dscfm
Tunnel Flow Rate (Q_{std})	150	±3.0	dscfm

(1) Calculate the MU of c_s:

$$c_s = F_c/(Q_{sample}\, x\, \theta) = 0.025/(0.25 \times 180) = 0.0005555 \quad (X1.4)$$

$$\frac{\delta c_s}{\delta F_c} = \frac{1}{Q_{sample} \bullet \Theta} = \frac{1}{0.25 \bullet 180} = 0.0222 \quad (X1.5)$$

$$\frac{\delta c_s}{\delta Q_{sample}} = \frac{-F_c}{Q^2_{sample} \bullet \Theta} = \frac{-0.025}{0.25^2 \bullet 180} = -0.00222 \quad (X1.6)$$

$$\frac{\delta c_s}{\delta \Theta} = \frac{-F_c}{Q_{sample} \bullet \Theta^2} = \frac{-0.025}{0.25 \bullet 180^2} = -0.000003 \quad (X1.7)$$

$$MUc_s = \sqrt{(0.00027 \bullet 0.0222)^2 + (0.0025 \bullet -0.00222)^2} \quad (X1.8)$$

$$\sqrt{+(0.1 \bullet -0.000003)^2} = 0.0000081g$$

Thus, c_s would be 0.555 mg/dscf ± 0.0081 mg/dscf at 95 % confidence level.

(2) Calculate the MU of c_r:

$$c_r = BGc/(QBG \times \theta) = 0.002/(0.15 \times 180) = 0.000074 \quad (X1.9)$$

$$\frac{\delta c_r}{\delta BG_c} = \frac{1}{Q_{BG} \bullet \Theta} = \frac{1}{0.15 \bullet 180} = 0.03704 \quad (X1.10)$$

$$\frac{\delta c_r}{\delta Q_{BG}} = \frac{-BG_c}{Q^2_{BG} \bullet \Theta} = \frac{-0.002}{0.15^2 \bullet 180} = -0.0004938 \quad (X1.11)$$

$$\frac{\delta c_r}{\delta \Theta} = \frac{-BG_c}{Q_{BG} \bullet \Theta^2} = \frac{-0.002}{0.15 \bullet 180^2} = -0.0000004 \quad (X1.12)$$

$$MUc_r = \sqrt{(0.00027 \bullet 0.03704)^2 + (0.0015 \bullet -0.0004938)^2} \quad (X1.13)$$

$$\sqrt{+(0.1 \bullet -0.0000004)^2} = 0.00001g$$

Thus, c_r would be 0.074 mg/dscf ± 0.01 mg/dscf at 95 % confidence level.

(3) Calculate E_T and MU_{ET}

$$E_T = (c_s - c_r)\, Q_{sd}\, \theta = (0.000555 - 0.000074) \times 150 \times 180 = 13.00\, g \quad (X1.14)$$

$$\frac{\delta E_T}{\delta c_s} = Q_{std} \bullet \Theta = 150 \bullet 180 = 27{,}000 \quad (X1.15)$$

$$\frac{\delta E_T}{\delta c_r} = Q_{std} \bullet \Theta = 150 \bullet 180 = 27{,}000 \quad (X1.16)$$

$$\frac{\delta E_T}{\delta Q_{std}} = c_s \bullet \Theta - c_r \bullet \Theta = 0.000555 \bullet 180 - 0.000074 \bullet 180 = 0.08667 \quad (X1.17)$$

$$\frac{\delta E_T}{\delta \Theta} = c_s \bullet Q_{std} - c_r \bullet Q_{std} = 0.000555 \bullet 150 - 0.000074 \bullet 150 = 0.07222 \quad (X1.18)$$

$$MU_{ET} = \sqrt{(27{,}000 \bullet 0.0000081)^2 + (27{,}000 \bullet 0.00001)^2\, (0.08667 \bullet 3)^2} \quad (X1.19)$$

$$\sqrt{+(0.07222 \bullet 0.1)^2} = 0.436$$

Thus the result in this example would be:
ET = 13.00 g ± 0.44 g at a 95 % confidence level.

X1.3.5 *Conclusion*—This example, which is representative of the measurement method as it is currently applied to woodstoves under the EPA NSPS, indicates that the uncertainty related to the dilution tunnel flow rate measurement and filter catch weights are the primary components of the overall uncertainty of the result. Tunnel flow rates may be much higher than necessary to capture all emissions. This can influence the uncertainty of the test method. For example, increasing the tunnel flow rate from 150 to 600 scfm in the above example increases the MU of the result to ±1.3 g or about ±10 % of the measured emissions. Therefore, keeping tunnel flow rates near the minimum necessary to reliably capture the exhaust stream, while keeping the tunnel velocity at a level that can be accurately measured during tests will minimize the uncertainty of the measurement.

X2. STANDARD PITOT TUBE

X2.1 See Fig. X2.1.

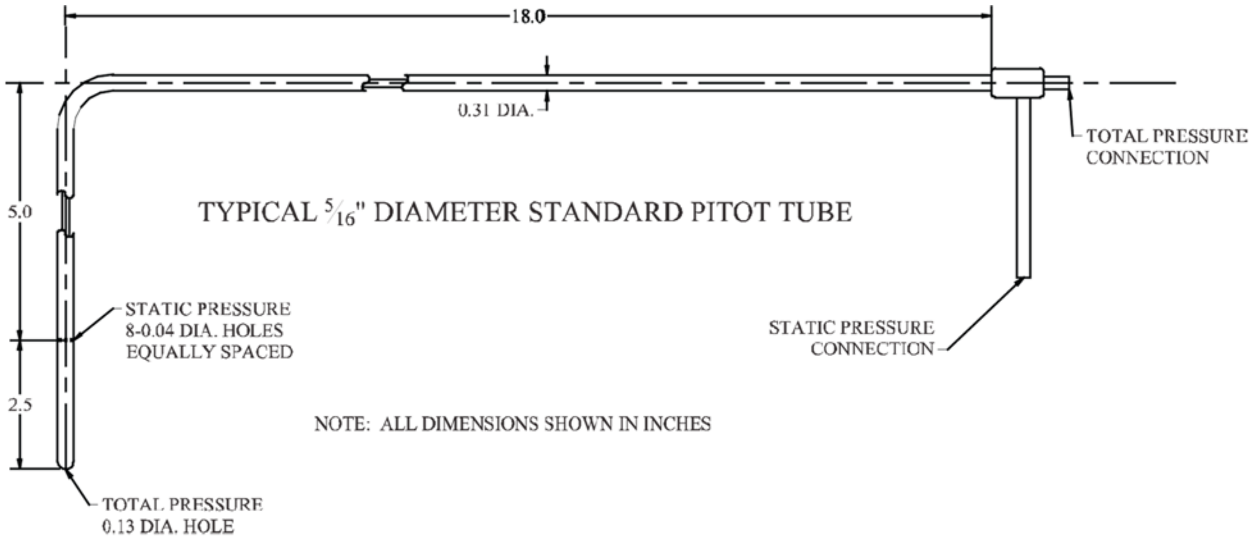

FIG. X2.1 Standard Pitot Tube

Designation: E2780 – 10

Standard Test Method for Determining Particulate Matter Emissions from Wood Heaters[1]

This standard is issued under the fixed designation E2780; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the fueling and operating protocol for determining particulate matter emissions from wood fires in wood-burning room heaters and fireplace inserts as well as determining heat output and efficiency.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E631 Terminology of Building Constructions

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

2.2 *Other Standards:*

ANSI/UL-103 Standard for Chimneys, Factory-Built, Residential Type and Building Heating Appliance

CSA B415.1 Performance Testing of Solid-Fuel-Burning Heating Appliances

3. Terminology

3.1 *Definitions*—Terms used in this test method are defined in Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *burn rate, n*—the rate at which test fuel is consumed in a wood heater. Measured in kilograms (lb) (dry basis) per hour.

3.2.2 *combustion air control, n*—an air control device that regulates air to the wood heater that is primarily intended promote pyrolysis of the fuel load.

3.2.3 *Douglas fir, n*—untreated, standard, or better grade Douglas fir lumber with agency grade stamp: D. Fir or Douglas Fir.

3.2.4 *firebox, n*—the chamber in the wood heater in which the test fuel charge is placed and combusted.

3.2.5 *fuel piece, n*—2 × 4 or 4 × 4 wood pieces used to construct test fuel cribs and referring to the nominal width and depth dimensions for commonly available dimensional lumber. The actual dimensions are 38 × 89 mm (1½ × 3½ in.) and 89 × 89 mm (3½ × 3½ in.).

3.2.6 *fuel piece length, n*—the length of fuel pieces used to construct the test fuel crib measured in mm (in.).

3.2.7 *firebox height, n*—unless otherwise specified in the manufacturer's written instructions included with the heater, firebox height is the vertical distance extending above the loading door, if fuel could reasonably occupy that space, but not more than 2 inches above the top (peak height) of the loading door, to the floor of the firebox (i.e., below a permanent grate) if the grate allows a 1-inch diameter piece of wood to pass through the grate, or, if not, to the top of the grate. Firebox height is not necessarily uniform but must account for variations caused by internal baffles, air channels, or other permanent obstructions. A visible indicator or landmark within the firebox that will provide a clear indication to the heater user of the maximum height that fuel should be loaded, and is specifically referenced in the manufacturer's written instructions, may be used to determine firebox height for the purposes of calculating usable firebox volume.

3.2.8 *firebox length, n*—the longest horizontal fire chamber dimension where fuel pieces might reasonably be expected to be placed in accordance with the manufacturer's written instructions that is parallel to a wall of the chamber.

3.2.9 *firebox width, n*—the shortest horizontal fire chamber dimension where fuel pieces might reasonably be expected to be placed in accordance with the manufacturer's written instructions that is parallel to a wall of the chamber.

[1] This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.54 on Solid Fuel Burning Appliances.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.10 *kindling, n*—wood pieces used to initiate combustion of the pre-burn fuel. Kindling may be ignited using crumpled newspaper.

3.2.11 *manufacturer's written instructions, n*—specific information regarding the fueling and operation procedures recommended by the heater manufacturer and included with the heater. These instructions must be consistent with information provided to the heater end-user in the owner's manual or equivalent.

3.2.12 *owner's manual, n*—written information provided to the heater end-user regarding the installation and recommended fueling and operating procedures that will help the heater user to achieve the best heater performance. It is also referred as the installation and operation guide or other equivalent title.

3.2.13 *particulate matter (PM), n*—all gas-borne matter resulting from combustion of solid fuel, as specified in this test method, which is collected in accordance with Test Method E2515.

3.2.14 *pre-burn fuel, n*—wood pieces used to pre-heat the wood heater and establish a charcoal bed prior to the test run.

3.2.15 *secondary combustion air control, n*—an air control device that regulates air to the wood heater that is primarily intended to provide the additional oxygen needed to promote secondary combustion of the combustible materials released during pyrolysis of the fuel load.

3.2.16 *test facility, n*—the area in which the wood heater is installed, operated, and sampled for emissions.

3.2.17 *test fuel crib, n*—the arrangement of the test fuel pieces and test fuel spacers.

3.2.18 *test fuel density, n*—the dry basis density of the test fuel pieces that comprise the test fuel crib.

3.2.19 *test fuel loading density, n*—the weight of the as-fired test fuel crib per unit volume of usable firebox.

3.2.20 *test fuel pieces, n*—the individual fuel pieces (nominal 2 × 4 and 4 × 4 dimensional lumber) that comprise the test fuel crib.

3.2.21 *test fuel spacers, n*—wood pieces used to space fuel pieces apart in the test fuel crib. Their function is to provide reproducible fuel crib geometry and air spaces between fuel pieces.

3.2.22 *test run, n*—an individual emission test which encompasses the time required to consume the mass of the test fuel crib.

3.2.23 *test series, n*—a group of test runs on the same wood heater.

3.2.24 *usable firebox volume, n*—the volume of the firebox determined using its height, length, and width as defined in this section.

3.2.25 *wood heater, n*—an enclosed, wood burning appliance capable of and intended for space heating and/or domestic water heating.

4. Summary of Test Method

4.1 This test method is used in conjunction with Test Method E2515. The wood heater under evaluation is fueled with kindling, pre-burn fuel and a test fuel load. Each test run is a hot-to-hot cycle. Individual test runs are conducted at burn rates ranging from low to maximum burn rates. The fuel load configuration is determined based on the usable firebox volume of the heater plus the firebox dimensions and geometry. Kindling and crumpled newspaper are used to ignite a pre-burn fuel load(s) that is burned to heat the wood heater to normal operating temperature and to establish a charcoal bed. The test fuel load is placed on the charcoal bed and given time to ignite before the air control(s) is (are) set to the test run condition. When the full weight of the test fuel load has been burned, the test run is terminated. Burn rate is determined based on the weight of the test fuel load divided by the length of test run and corrected to a dry fuel basis. Particulate sampling begins before the test fuel load is added and stops when the test run terminates. The total particulate emissions are determined over the test run length. The particulate emissions rate is then determined from the total particulate emissions divided by the length of the test run and is reported in grams of particulate per hour. The particulate emission factor may also be determined from the total particulate emissions divided by the dry basis weight of the test fuel load and is reported in grams of particulate per dry kilogram of fuel. This test method may also be used in conjunction with CSA B415.1 for determining heat output and efficiency. If heat output is determined, particulate emissions per unit of heat delivered may also be calculated and is reported in grams of particulate per megajoule.

5. Significance and Use

5.1 This test method is used for determining emission rates and emission factors for wood heaters.

5.1.1 The emission factor is useful for determining emission performance during product development.

5.1.2 The emission factor is useful for the air quality regulatory community for determining compliance with emission performance limits.

5.1.3 The emission rate may be useful for the air quality regulatory community for determining impacts on air quality from wood heaters.

5.2 The reporting units are grams of particulate per hour, grams of particulate per kilogram of dry fuel and grams of particulate per megajoule of heat output.

5.2.1 Appropriate reporting units for comparing emissions from all types of solid fuel fired appliances: g/kg.

5.2.2 Appropriate reporting units for predicting atmospheric emission impacts: g/h or g/MJ.

5.3 The fuel load specified in this test method is a lumber crib of uniform dimensions, identical to that specified in EPA Method 28. Cribs were specified in EPA Method 28 to provide a reproducible and repeatable test method. In normal operation the majority of fuel used by consumers is cordwood with irregular shapes and dimensions. Very little data exists to indicate whether or not the fuel cribs specified in this standard yield results that are predictive of performance using cordwood fuel. This standard, therefore, includes Annex A1 which provides a fueling procedure using cordwood. It is provided so that those interested in measuring emissions performance with cordwood will have a consistent method to follow. A comparative database using the two fueling procedures will provide data to determine whether test results using crib fuel correlate to test results using cordwood fuel.

6. Safety

6.1 *Disclaimer*—This test method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to performing this test method.

7. Equipment and Supplies

7.1 *Wood Moisture Meter*—Calibrated electrical resistance meter capable of measuring test fuel moisture to within 1 % moisture content. Must meet the calibration requirements specified in 8.1.

7.2 *Test Fuel Scale*—A scale capable of weighing test fuel to within 0.005 kg (0.01 lb). Must meet the calibration requirements specified in 8.3.

7.3 *Platform Scale*—A scale capable of weighing the test wood heater and attached chimney, including the weight of the test fuel, to within 0.05 kg (0.1 lb). Must meet the calibration requirements specified in 8.2.

7.4 *Wood heater Flue Gas Temperature Measurement Device*—A 3.2 mm (0.125 in.) diameter sheathed, non-isolated junction Type K thermocouple capable of measuring flue gas temperature with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, whichever is greater. Must meet calibration requirements specified in 8.4.

7.5 *Wood Heater Surface Temperature Measuring Device*—A temperature sensor capable of measuring surface temperatures with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, whichever is greater. Must meet calibration requirements specified in 8.4.

7.6 *Catalytic Combustor Exit Temperature Measuring Device*—A temperature sensor capable of measuring the temperature of the gases exiting the catalytic combustor in a catalyst equipped heater with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, whichever is greater. Must meet calibration requirements specified in 8.4.

7.7 *Insulated Solid Pack Chimney*—Chimney used for installation of wood heater in the test facility. Solid pack insulated chimneys shall have a minimum of 2.5 cm (1 in.) solid pack insulating material surrounding the entire flue and possess a label demonstrating conformance to ANSI/UL-103, Standard for Chimneys, Factory-Built, Residential Type and Building Heating Appliance.

8. Calibration and Standardization

8.1 *Wood Moisture Meter*—Calibrate as in accordance with the manufacturer's instructions before each certification test.

8.2 *Platform Scale*—Perform a multipoint calibration (at least five points spanning the operational range) of the platform scale before its initial use. The scale manufacturer's calibration results are sufficient for this purpose. Before each certification test, audit the scale with the test wood heater in place by weighing at least one calibration weight (ASTM Class F) that corresponds to between 20 and 80 % of the expected test fuel charge weight. If the scale cannot reproduce the value of the calibration weight within 0.05 kg (0.1 lb) or 1 % of the expected test fuel charge weight, whichever is greater, recalibrate the scale before use with at least five calibration weights spanning the operational range of the scale.

8.3 *Test Fuel Scale*—Perform a multipoint calibration (at least five points spanning the operational range) of the test fuel scale before its initial use. The scale manufacturer's calibration results are sufficient for this purpose. Before each certification test, audit the scale with the wood heater in place by weighing at least one calibration weight (ASTM Class F) that corresponds to between 20 and 80 % of the expected test fuel charge weight. If the scale cannot reproduce the value of the calibration weight within 0.005 kg (0.01 lb) or 1 % of the expected test fuel charge weight, whichever is greater, recalibrate the scale before use with at least five calibration weights spanning the operational range of the scale.

8.4 *Temperature Sensors*—Temperature measuring equipment shall be calibrated before initial use and at least semi-annually thereafter. Calibrations shall be in compliance with National Institute of Standards and Technology (NIST) Monograph 175, Standard Limits of Error.

9. Procedure

9.1 *Pre-conditioning of the Wood Heater*—The wood heater must be pre-conditioned before a test series begins.

9.1.1 Set up the wood heater in accordance with instructions provided by the manufacturer. The total height of chimney when measured from the floor or top of the platform scale shall be 4.6 ± 0.3 m (15 ± 1 ft).

9.1.2 Install a flue-gas temperature measurement device at the center of the flue, 2.6 ± 0.15 m (8.5 ± 0.5 ft) above the floor or top of the platform scale. For catalyst-equipped heaters, install a catalytic combustor exit temperature measurement device at the centroid of the catalytic combustor exit face and within 25 mm (1 in.) downstream of the catalytic combustor exit face.

9.1.3 Operate the wood heater for at least 48 hours at a medium burn rate as defined in 9.5.1 using fuel meeting the specifications in 9.4 or with any type of untreated wood with a moisture content between 15 and 25 % wet basis. The hours of operation do not need to be continuous.

9.1.4 Record the time and weight for all fuel added.

9.1.5 Record the flue-gas temperature at least once during each hour of operation.

9.1.6 For catalyst-equipped wood heaters, record the hourly catalytic combustor exit temperature.

9.1.7 Allow the wood heater to cool to room temperature and remove all unburned wood, charcoal, ash, or other debris from the firebox.

9.1.8 Clean the chimney using a standard chimney brush appropriately sized for the chimney.

9.2 Install the wood heater in the test facility.

9.2.1 Set up the wood heater in accordance with instructions provided by the manufacturer. Place the wood heater centrally on the platform scale. The venting shall consist of single wall pipe extending to 2.4 ± 0.1 m (8 ± 0.3 ft) above the top of the platform scale, and above this level, insulated solid pack type chimney extending to 4.6 ± 0.3 m (15 ± 1 ft) above the platform scale, and of the size specified by the wood heater manufacturer. This applies to both freestanding and fireplace insert type wood heaters. Do not install a chimney cap.

9.2.1.1 Other chimney types (e.g., solid pack insulated pipe) may be used in place of the steel flue pipe if the wood heater manufacturer's written appliance specifications require such chimney for home installation.

NOTE 1—The chimney that is used for testing should be documented in the test data and test report.

9.2.2 Locate wood heater surface temperature measuring devices at five locations on the wood heater firebox exterior surface. Position the temperature monitors centrally on the top surface, on two sidewall surfaces, and on the bottom and back surfaces. Position the monitor sensing tip on the firebox exterior surface inside of any heat shield, air circulation walls, or other wall or shield separated from the firebox exterior surface.

9.2.3 Center the flue outlet (chimney) under the dilution tunnel hood. Refer to Test Method E2515 for specific requirements including positioning the flue outlet to meet induced draft and smoke capture requirements.

9.2.4 Install a flue-gas temperature measurement device at the center of the flue, 2.6 ± 0.15 m (8.5 ± 0.5 ft) above the top of the platform scale.

9.3 *Usable Firebox Volume Determination:*

9.3.1 Determine the firebox volume using the definitions for firebox height, width, and length in Section 3. Follow the manufacturer's written instructions that are included with the wood heater for specific recommendations to consumers for where fuel should or should not be placed in the firebox when determining usable firebox volume.

9.3.1.1 In the absence of specific written instructions regarding the placement of fuel in the firebox, take into account reasonable consumer loading practices. Guidelines for usable firebox volume adjustments due to the presence of firebrick and other permanent fixtures are as follows:

(1) Adjust width and length dimensions to extend to the metal wall of the wood heater above the firebrick or permanent obstruction if the firebrick or obstruction extending the length of the side(s) or back wall extends less than one third of the usable firebox height. Use the width or length dimensions inside the firebrick if the firebrick extends more than one third of the usable firebox height.

(2) If a log retainer or grate is a permanent fixture and the manufacturer recommends that no fuel be placed outside the retainer, the area outside of the retainer is excluded from the firebox volume calculations.

(3) Include areas adjacent to and above a baffle (up to two inches above the fuel loading opening) if four inches or more horizontal space exist between the edge of the baffle and a vertical obstruction (e.g., sidewalls or air channels).

9.4 *Fuel:*

9.4.1 *Fuel Properties:*

9.4.1.1 *Fuel Species*—The fuel is untreated, standard, or better grade certified Douglas fir lumber.

9.4.1.2 *Fuel Moisture*—The fuel moisture shall be measured using a fuel moisture meter as specified in 7.1. Moisture shall not be added to previously dried fuel pieces except by storage under high humidity conditions and temperature up to 100ºF. Fuel moisture shall be measured within four hours of using the fuel for a test.

NOTE 2—It has been found that to maintain fuel within the allowable moisture content range storage at a relative humidity of 95 % or higher and temperature of 90 to 100ºF is necessary. In addition, storage at these conditions for a period of several weeks results in relatively uniform moisture content throughout the fuel pieces and thus improves the accuracy of the moisture content measurement.

(1) Test Fuel Piece Moisture—The average fuel moisture for each test fuel piece used to construct the test fuel cribs (excluding test fuel spacers) shall be between 19 and 25 % dry basis. Kiln-dried lumber is not permitted. Determine the fuel moisture for each test fuel piece used for the test fuel crib by averaging at least three fuel moisture meter readings, one from each of three sides, measured parallel to the wood grain. If an electrical resistance type fuel moisture meter is used, penetration of insulated electrodes shall be ¼ the thickness of the fuel piece or 19 mm (¾ in.), whichever is greater.

(2) Test Fuel Spacer Moisture—Determine fuel moisture for each test fuel spacer. One moisture meter reading from each spacer, measured parallel to the wood grain is sufficient. If an electrical resistance type fuel moisture meter is used, penetration of insulated electrodes shall be ¼ the thickness of the spacers. Average all the readings for all the test fuel spacers to determine the average test fuel spacer moisture.

9.4.1.3 *Test Fuel Density*—The average test fuel density, dry basis, shall be in the range of 401 to 578 kg/m^3 (25 to 36 lb/ft^3) for the test fuel cribs. Nails and test fuel spacers are excluded from the density determinations. Determine the total volume of the fuel pieces that comprise the test fuel crib. Use the wet basis weight and the arithmetically averaged dry basis moisture content to determine the dry basis weight for the individual fuel pieces. Determine dry basis weight for the test fuel pieces that comprise the test fuel crib (excluding nails and spacers) by summing the dry basis weight of the individual fuel pieces that comprise the crib. Divide the dry basis weight by the volume to determine the density.

9.4.1.4 *Fuel Temperature*—The test fuel temperature shall be within the allowable test facility temperature range as in accordance with Test Method E2515. The fuel temperature may be determined by measuring the temperature of the room where the test fuel has been stored for at least 24 hours prior to the fuel moisture determination.

9.4.1.5 The test fuel crib loading density shall be 112 ± 11.2 kg/m^3 (7 ± 0.7 lb/ft^3) of usable firebox volume on a wet basis.

9.4.1.6 *Fuel Dimensions*—The cross-sectional dimensions of each test fuel piece shall conform to the nominal measurements of 2 × 4 and 4 × 4 lumber. Each test fuel piece (not including spacers) shall be of equal length, except as provided in 9.4.1.10, and shall closely approximate ⅚ the dimensions of the firebox length. Alternatively, the shape of the test fuel crib may be geometrically similar to the shape of the firebox volume without resorting to special angular or round cuts on the individual fuel pieces.

(1) The fuel piece composition of the test fuel crib shall be determined in relation to the appliance's firebox volume according to guidelines listed below:

(a) If the usable firebox volume is less than or equal to 0.043 m^3 (1.5 ft^3), use only 2 × 4 lumber.

(b) If the usable firebox volume is greater than 0.043 m^3 (1.5 ft^3) and less than or equal to 0.085 m^3 (3.0 ft^3), use 2 × 4 and 4 × 4 lumber. From 35 to 65 % of the weight of the test fuel crib including spacers shall be 2 × 4 lumber and the remainder shall be 4 × 4 lumber.

(c) If the usable firebox volume is greater than 0.085 m^3 (3.0 ft^3), use only 4 × 4 lumber.

(2) Test Fuel Spacer—The test fuel spacers shall be 130 × 40 × 20 mm (5 × 1.5 × 0.75 in.).

9.4.1.7 *Nails*—Use uncoated, un-galvanized nails for assembling the attaching test fuel spacers to the test fuel pieces. The number of nails used should be limited to the minimum number necessary to hold the test fuel spacers to the test fuel pieces.

9.4.1.8 *Test Fuel Crib Weight (dry basis)*—Determine the total dry basis fuel weight by summing the dry basis weight of the individual test fuel pieces and combined dry basis weight of the test fuel spacers that comprise the test fuel crib (without nails).

9.4.1.9 Attach the test fuel spacers to the test fuel pieces with nails in accordance with 9.4.1.7 as illustrated in Fig. 1. Attachment of test fuel spacers to the top of the test fuel piece(s) that comprise the top layer of the test fuel crib is optional.

9.4.1.10 To avoid stacking difficulties, or when a whole number of test fuel pieces does not result, all piece lengths shall be adjusted uniformly to remain within the specified loading density.

9.4.1.11 *Test Fuel Crib Weight (wet basis)*—Record the total weight (wet basis) of the test fuel crib after it is assembled (including nails and spacers) using the test fuel scale specified in 8.3. The weighed test fuel crib must be used within 3 h of being weighed.

9.5 *Burn Rates:*

9.5.1 *Burn Rate Categories*—One emission test run is required in each of the following burn rate categories:

TABLE 1 Burn Rate Categories

Average kg/h (lb/h), Dry Basis		
Low	Medium	Maximum
0.60^A to 1.15 (1.32^A to 2.54)	1.16 to 1.75 (2.55 to 3.86)	Maximum burn rate

[A] Burn rates < 0.6 kg/h (1.32 lb/h) are allowed but not required.

TABLE 2 Alternative Burn Rate Categories

% of Maximum Burn Rate		
Low	Medium	Maximum
18^A to 35	36 to 53	100

[A] Burn rates < 18 % of maximum are allowed but not required.

9.5.1.1 *Maximum Burn Rate*—For the Maximum Category, the wood heater shall be operated with the combustion air control(s) set to achieve the maximum possible burn rate during the entire test run (or, if thermostatically controlled, the thermostat shall be set at maximum heat output setting at the start of the test run and shall be allowed to operate normally during the test run).

9.5.1.2 *Other Burn Rate Categories:*

(1) For burn rates in the low category, the combustion air control(s) or other mechanical control device shall be set at the minimum operating setting(s) other than fully off. The minimum operating setting(s) is the lowest possible operating

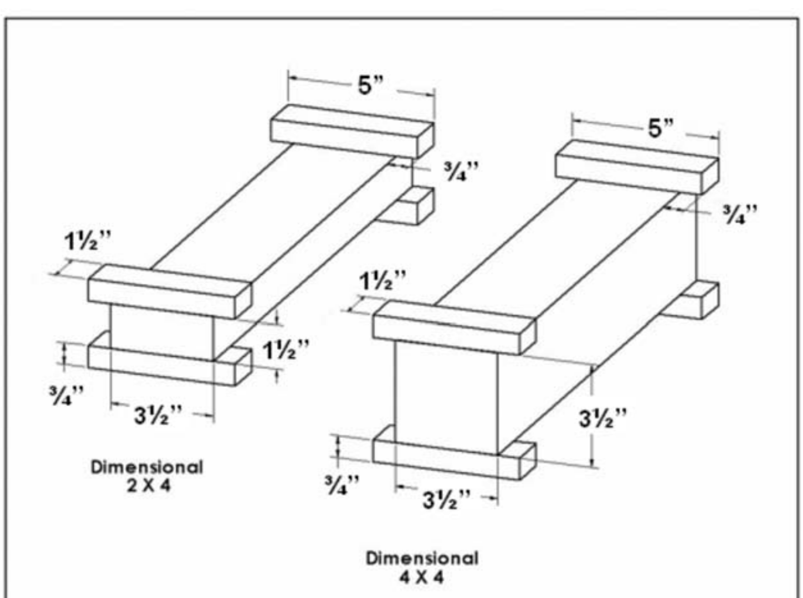

FIG. 1 Test Fuel Spacer Attachment

position(s) or at the combustion air control stop, whichever is applicable. If the resultant burn rate is less than 0.6 kg/h (1.32 lb/h) when using Table 1 or less than 18 % of the maximum burn rate when using Table 2, the test run may be replaced with a test run with a burn rate that is less than or equal to 0.8 kg/h (1.76 lb/h) when using Table 1 or less than 24 % of the maximum burn rate when using Table 2. Results from any test run conducted at a burn rate below the minimum burn rate range as defined in Table 1 or Table 2, as applicable, shall be reported or but need not be included in the test run weighted average provided that such results are replaced with results from a test run meeting the criteria above.

(2) For test runs in the medium category, the wood heater shall be operated with the combustion air control(s), or other mechanical control device, set at a predetermined position necessary to obtain the average burn rate required for the category.

(3) For heaters with automatic controls, the controls may be allowed to function in a manner consistent with the owner's manual and with normal operation in a home as long as the required burn rate categories in accordance with 9.5.1 are achieved. The test laboratory shall document the procedures used to achieve the burn rates.

(4) The results from test runs that fall above the definition of the medium burn rate category in accordance with Table 1 or Table 2 shall be included with the medium category test results when determining the average emissions in accordance with Section 10.

9.5.1.3 If a wood heater tested using Table 1 cannot be operated at a burn rate below 1.15 kg/h (2.54 lb/h), the flue shall be dampered in order to achieve one average burn rate test run at or below 1.15 kg/h. Additionally, if flue dampering must be used to achieve a burn rate below 1.15 kg/h, results from any test run conducted at a burn rate below 1.00 kg/h need not be reported or included in the test run weighted average provided that such results are replaced with results from a test run meeting the criteria above.

(1) Evidence that a wood heater cannot be operated at a burn rate less than 1.15 kg/h shall include documentation of two or more test runs demonstrating that the burn rates were above 1.15 kg/h when the combustion air control(s) were adjusted to the lowest operating setting(s) in accordance with 9.5.1.2*(1)*.

9.5.1.4 If a wood heater tested using Table 2, cannot be operated at a burn rate below 35 % of the maximum burn rate, the flue shall be dampered in order to achieve one average burn rate test run at or below 35 % of the maximum burn rate. Additionally, if flue dampering must be used to achieve burn rates below 35 % of the maximum burn rate results from any test run conducted at a burn rate below 25 % of the maximum burn rate need not be reported or included in the test run weighted average provided that such results are replaced with results from a test run meeting the criteria above.

(1) Evidence that a wood heater cannot be operated at a burn rate less than 35 % of the maximum burn rate shall include documentation of two or more test runs demonstrating that the burn rates were above 35 % of the maximum burn when the combustion air control(s) were adjusted to the lowest possible operating setting(s) in accordance with 9.5.1.2*(1)*.

9.5.2 *Pre-burn Ignition*—Build a fire in the wood heater in accordance with the manufacturer's written instructions.

9.5.2.1 *Pre-burn Fuel Charge*—Crumpled newspaper and kindling may be used to help ignite the pre-burn fuel. The pre-burn fuel, used to sustain the fire and establish the pre-test run charcoal bed, shall meet the same fuel requirements prescribed in 9.4.

9.5.3 *Wood Heater Operation and Adjustments*—Set the combustion air control(s) at any position that will maintain combustion of the pre-burn fuel load. At least one hour before the start of the test run, set the combustion air control(s) at the approximate positions necessary to achieve the burn rate desired for the test run. Adjustment of the combustion air control(s), fuel addition or subtractions, and coal bed raking shall be kept to a minimum but are allowed up to 15 minutes prior to the start of the test run. For the purposes of this method, coal bed raking is the use of a metal tool (poker) to stir coals, break burning fuel pieces into smaller pieces, dislodge fuel pieces from positions of poor combustion, and check for the condition of uniform charcoalization. Record all adjustments made to the combustion air control(s), adjustments to and additions or subtractions of fuel, and any other changes to wood heater operations that occur during pre-burn ignition period. Record fuel weight data and wood heater temperature measurements at 10 minute intervals during the hour of the pre-burn ignition period preceding the start of the test run. During the 15-minute period prior to the start of the test run, the wood heater loading door shall not be open more than a total of 1 minute. Coal bed raking is the only adjustment allowed during this period.

NOTE 3—One purpose of the pre-burn ignition period is to achieve uniform charcoalization of the test fuel bed prior to loading the test fuel crib. Uniform charcoalization is a general condition of the test fuel bed evidenced by an absence of large pieces of burning wood in the coal bed and the remaining fuel pieces being brittle enough to be broken into smaller charcoal pieces with a metal poker. Manipulations to the fuel bed prior to the start of the test run should be done to achieve uniform charcoalization while maintaining the desired burn rate. In addition, some wood heaters (e.g., high mass units) may require extended pre-burn burn time and fuel additions to reach an initial average surface temperature sufficient to meet the thermal equilibrium criteria in 9.5.10.

9.5.4 The weight of pre-burn fuel remaining at the start of the test run is determined as the difference between the weight of the wood heater with the remaining pre-burn fuel and the tare weight of the cleaned, dry wood heater with or without dry ash or sand added consistent with the manufacturer's instructions and the owner's manual. The tare weight of the wood heater must be determined with the wood heater (and ash, if added) in a dry condition.

9.5.5 *Test Run Start:*

9.5.5.1 When the kindling and pretest fuel have been consumed to leave a pre-test charcoal bed weight between 20 and 25 % of the weight of the test fuel crib (wet basis), record the weight of the fuel remaining and start the test run. Record all wood heater individual surface temperatures, catalyst temperature if applicable, any initial sampling method measurement values, and begin the particulate emission sampling in accordance with Test Method E2515. Within 1 minute following the start of the test run, open the wood heater door, load the test fuel crib, and record the test fuel crib weight. Recording of the average, rather than individual, surface temperatures is acceptable.

9.5.5.2 Unless a different fuel loading orientation is recommended in the manufacturer's written instructions, position the fuel crib so that the spacers are parallel to the floor of the firebox, with the spacer edges abutting each other. If loading difficulties result, some fuel pieces may be placed on edge. If the usable firebox volume is between 0.043 and 0.085 m^3 (1.5 and 3.0 ft^3), alternate the piece sizes in vertical stacking layers to the extent possible. For example, place 2 × 4's on the bottom layer in direct contact with the coal bed and 4 × 4's on the next layer, etc. (see Fig. 1). Position the fuel pieces parallel to each other and parallel to the longest wall of the firebox to the extent possible within the specifications in 9.4.

9.5.5.3 Load the test fuel crib in appliances having unusual or unconventional firebox design maintaining air space intervals between the test fuel pieces and in conformance with the manufacturer's written instructions. For any appliance that will not accommodate the loading arrangement specified in the paragraph above, document the test fuel crib arrangement used including the rationale for the fuel piece placement.

9.5.5.4 *Load Time*—The maximum allowable time for loading the test fuel into the wood heater is equal to 1060 s/m^3 (30 s/ft^3) of usable firebox volume as determined in accordance with 9.3.

9.5.5.5 *Start-up Time*—The wood heater door may remain open and the combustion air control(s) adjusted for up to 5 minutes after the maximum load time in accordance with 9.5.5.4 has lapsed in order to make adjustments to the test fuel crib and to ensure ignition of the test fuel crib has occurred. Within the 5 minute start-up time, close the wood heater door(s) and adjust the combustion air control(s) to the position determined to produce the desired burn rate. No other adjustments to the combustion air control(s) or the test fuel crib are allowed (except as specified in 9.5.7 and 9.5.8) after the five minutes of start-up time has elapsed. Record the length of time the wood heater door remains open, the adjustments to the combustion air control(s), and any other operational adjustments.

9.5.6 *Data Recording*—Record all data at intervals no greater than 10 minutes, including fuel weight data, wood heater individual surface and catalyst temperature measurements, other wood heater operational data (e.g., draft), test facility temperature and Test Method E2515 data.

9.5.7 *Test Fuel Crib Adjustment*—The test fuel crib pieces may be adjusted (i.e., repositioned) once during a test run if more than 60 % of the initial test fuel crib weight has been consumed and more than 10 minutes have elapsed without a measurable (< 0.05 kg (0.1 lb) or 1.0 %, whichever is greater) weight change. The time used to make this adjustment shall be less than 15 seconds.

9.5.8 *Air Control(s) Adjustment*—Secondary combustion air control(s) may be adjusted once during the test run following the manufacturer's written instructions. No other air control(s) adjustments are allowed during the test run.

9.5.9 *Test Run Completion*—The test run is completed when the remaining weight of the test fuel charge is 0.00 kg (0.0 lb). End the test run when the scale has indicated a test fuel charge weight of 0.00 kg (0.0 lb) or less for 30 seconds. At the end of the test run, stop the particulate sampling, and record the final fuel weight, the run time, and all final measurement values.

9.5.10 *Wood Heater Thermal Equilibrium*—The average of the wood heater surface temperatures at the end of the test run shall agree with the average surface temperature at the start of the test run to within 70°C (126°F) or the test run is invalid. Alternatively, the wood heater thermal equilibrium criteria in 10.3 may be used to determine test validity.

9.5.11 *Auxiliary Wood Heater Equipment Operation*—Heat exchange blowers sold with the wood heater shall be operated during the test run following the manufacturer's written instructions. In the absence of manufacturer's written instructions, operate the heat exchange blower in the "high" position. (Automatically operated blowers shall be operated as designed.) Shaker grates, by pass controls, or other auxiliary equipment may be adjusted only one time during the test run following the manufacturer's written instructions. Record all adjustments on a wood heater operational written record.

NOTE 4—If the wood heater is sold with a heat exchange blower as an option, test the wood heater with the heat exchange blower operating as described in 9.5.1 through 9.5.10 and report the results. As an alternative to repeating all test runs without the heat exchange blower operating, one additional test run shall be conducted without the blower operating as described in 9.5.9 at a burn rate in the Medium Category (see 9.5.1). If the emission rate resulting from this test run without the blower operating is equal to or less than the emission rate plus 1.0 g/h (0.0022 lb/h) for the test run in the Medium burn rate Category with the blower operating, the wood heater may be considered to have the same average emission rate with or without the blower operating. Additional test runs without the blower operating are unnecessary.

9.5.12 *Consecutive Test Runs*—Test runs on a wood heater may be conducted consecutively provided that a minimum one hour interval occurs between test runs.

9.5.13 *Additional Test Runs*—The testing laboratory may conduct more than one test run in each of the burn rate categories specified in 9.5.1. If more than one test run is conducted at a specified burn rate, the results from at least two thirds of the test runs in that burn rate category shall be used in calculating the weighted average emission rate (see 10.2). The measurement data and results of all test runs shall be reported regardless of which values are used in calculating the weighted average emission rate.

10. Data Analysis and Calculations

10.1 Carry out calculations, retaining at least one extra significant figure beyond that of the acquired data. Round off figures after the final calculation. Other forms of the equations may be used as long as they give equivalent results.

10.2 *Nomenclature:*

$$M_{Sdb} = (M_{Swb})\,(100/(100+FM_S)) \tag{1}$$

where:

FM_S = average fuel moisture of all test fuel spacers, % dry basis,

M_{Swb} = weight of all test fuel spacers, wet basis, kg (lb), and
M_{Sdb} = weight of all test fuel spacers, dry basis, kg (lb).

$$M_{Cdb} = \sum (M_{CPnwb}) \, (100/(100+FM_{CPn})) \quad (2)$$

where:
M_{CPnwb} = weight of each test fuel piece n in fuel crib, excluding nails and spacers, wet basis, kg (lb),
M_{Cdb} = weight of fuel crib, excluding nails and spacers, dry basis, kg (lb),
FM_{CPn} = average fuel moisture of test fuel piece n in fuel crib, % dry basis, and
n = individual test fuel pieces that comprise the test fuel crib, as applicable.

$$D_{Cdb} = M_{Cdb}/V_C \quad (3)$$

where:
D_{Cdb} = density of fuel crib, excluding spacers and nails, dry basis, kg/m^3 (lb/ft^3), and
V_C = volume of fuel crib, m^3 (ft^3).

$$M_{FTAdb} = M_{Sdb} + M_{Cdb} \quad (4)$$

where:
M_{FTAdb} = total weight of fuel crib excluding nails, dry basis, kg (lb).

$$BR = \frac{60 \, M_{FTAdb}}{\theta} \quad (5)$$

where:
BR = dry burn rate, kg/h (lb/h), and
θ = total length of test run, min.

$$PM_R = 60(E_T/\theta) \quad (6)$$

where:
E_T = total particulate emissions for test run from Test Method E2515, g (lb),
θ = total length of test run, min, and
PM_R = particulate emission rate for test run, g/h.

$$PM_F = E_T/M_{FTAdb} \quad (7)$$

where:
PM_F = particulate emission factor for test run, g/dry kg of fuel burned.

$$PM_H = E_T/E_O \quad (8)$$

where:
E_O = average measured overall heat output over the test run from Annex A2, MJ (MMBtu), and
PM_H = average particulate emissions per unit of average heat output over the test run, g/MJ (lb/MMBtu).

$$PM_{Rw} = 0.4(PM_{RLAve}) + 0.4(PM_{RMAve}) + 0.2(PM_{RHAve}) \quad (9)$$

where:
PM_{RLAve} = arithmetic average emission rate for all test runs (except in accordance with 9.5.13) that are included in the Low Burn Rate Category, g/h (lb/h),
PM_{RMAve} = arithmetic average emission rate for all test runs (except in accordance with 9.5.13) that are included in the Medium Burn Rate Category, g/h (lb/h),
PM_{RHAve} = arithmetic average emission rate for all test runs (except in accordance with 9.5.13) are included in the High Burn Rate Category, g/h (lb/h), and
PM_{Rw} = weighted average emission rate, g/h (lb/h).

$$PM_{Hw} = 0.4(PM_{HLAve}) + 0.4(PM_{HMAve}) + 0.2(PM_{HHAve}) \quad (10)$$

where:
PM_{HLAve} = arithmetic average emissions per heat output unit for all test runs (except in accordance with 9.5.13) that are included in the Low Burn Rate Category, g/MJ (lb/MMBtu),
PM_{HMAve} = arithmetic average emissions per heat output unit for all test runs (except in accordance with 9.5.13) that are included in the Medium Burn Rate Category, g/MJ (lb/MMBtu),
PM_{HHAve} = arithmetic average emissions per heat output unit for all test runs (except in accordance with 9.5.13) that are included in the High Burn Rate Category, g/MJ (lb/MMBtu), and
PM_{Hw} = weighted average emissions per heat output unit, g/MJ (lb/MMBtu).

$$\eta_{Ow} = 0.4(\eta_{OLAve}) + 0.4(\eta_{OMAve}) + 0.2(\eta_{OHAve}) \quad (11)$$

where:
η_{OLAve} = arithmetic average overall efficiency for all test runs (except in accordance with 9.5.13) that are included in the Low Burn Rate Category as determined in accordance with Annex A2, %,
η_{OMAve} = arithmetic average overall efficiency for all test runs (except in accordance with 9.5.13) that are included in the Medium Burn Rate Category as determined in accordance with Annex A2, %,
η_{OHAve} = arithmetic average overall efficiency for all test runs (except in accordance with 9.5.13) that are included in the High Burn Rate Category as determined in accordance with Annex A2, %, and
η_{Ow} = weighted average overall efficiency, %.

10.3 *Wood Heater Thermal Equilibrium:*

10.3.1 If the difference between the amount of heat stored in the mass of the test heater at the end of the test run versus the beginning of the test run (ΔQH) is greater than 8.5 % of the dry basis heat content of the test fuel crib (QFC), the test run shall be invalid. If $|\Delta Q_H| > 0.085(Q_{FC})$, the test run is invalid

$$\Delta Q_H = (0.5M_{Hm} + 0.83M_{Hr}) \, (\Delta T_H) \quad (12)$$

where:
M_{Hm} = weight of the metallic portion of the heater assembly, kg,
M_{Hr} = weight of the refractory portion of the heater assembly, kg, and
ΔT_H = the difference in the average heater surface temperature from the start of the test run to the end of the test run, °C, and

ΔQ_H = the difference between the amount of heat stored in the mass of the test heater at the end of the test run versus the beginning of the test run, KJ.

$$\Delta Q_H = (0.1M_{Hm} + 0.2M_{Hr})(\Delta T_H) \quad (13)$$

where:

M_{Hm} = weight of the metallic portion of the heater assembly, lb,

M_{Hr} = weight of the refractory portion of the heater assembly, lb, and

ΔT_H = the difference in the average heater surface temperature from the start of the test run to the end of the test run, °F, and,

ΔQ_H = the difference between the amount of heat stored in the mass of the test heater at the end of the test run versus the beginning of the test run, BTU.

$$Q_{FC} = (M_{FTAdb})(H_{FC}), \quad (14)$$

where:

H_{FC} = heating value of fuel crib, dry basis, (BTU/lb) (refer to Annex A2 in this test method for additional information about heating value), and

Q_{FC} = the dry basis heat content of the test fuel crib KJ (BTU).

11. Precision and Bias

11.1 *Precision*—It is not possible to specify the precision of the procedure in this test method for measuring wood heater emissions because the appliance operation and fueling protocols and the appliances themselves produce variable amounts of emissions and, therefore, the results cannot be used to determine reproducibility or repeatability of this measurement method.

11.2 *Bias*—No information can be presented on the bias of the procedure in this test method for measuring woo heater emissions because no material having an accepted reference value is available.

12. Keywords

12.1 emissions; particulate; particulate matter; wood-burning; wood heater; wood stove

ANNEXES

(Mandatory Information)

A1. CORDWOOD FUELING AND OPERATION

A1.1 Scope

A1.1.1 This annex to the test method covers fueling and operating protocol for determining particulate matter emissions from wood heaters using cordwood test fuel. The annex provides substitute requirements for cordwood operation. This annex is used in conjunction with all other applicable requirements of the test method. This annex may also be used in conjunction with Annex A2 when determining wood heater efficiency.

A1.2 Terminology

A1.2.1 *Definitions of Terms Specific to this Annex:*

A1.2.1.1 *cordwood test fuel, n*—conventional firewood, often referred to as "round wood," although, in practice, it is usually round wood 300 to 600 mm (11.8 to 23.6 in.) long that has been split into segments. There is no equivalent SI term to the imperial volumetric measure of cord (4 ft × 4 ft × 8 ft = 128 ft^3), as piled, including air space; the SI conversion factor is 3.624 556 m^3/cord.

A1.2.1.2 *test run, n*—an individual emission test which encompasses the time required to consume the mass of the cordwood test fuel load.

A1.3 Equipment and Supplies A1.3 (Same as Test Method)

A1.4 Calibration and Standardization A1.4 (Same as Test Method)

A1.5 Cordwood Test Fuel

A1.5.1 *Fuel Properties:*

A1.5.1.1 *Fuel Species and Properties*—Test fuel charge fuel shall be species of cordwood with a specific gravity range of 0.60 to 0.73 (see Table A1.1 for examples of some fuel species that typically meet the specific gravity requirement. Other fuel

TABLE A1.1 Specific Gravity of Commercially Important Species of Wood Based on Oven-Dry Weight and Oven-Dry Volume

Species	Specific Gravity
Ash, white	0.63
Beech	0.67
Birch, sweet	0.71
Birch, yellow	0.65
Elm, rock	0.67
Maple, hard (black)	0.60
Maple, hard (sugar)	0.67
Oak, red	0.66
Oak, white	0.71
Pine, Southern, longleaf	0.64

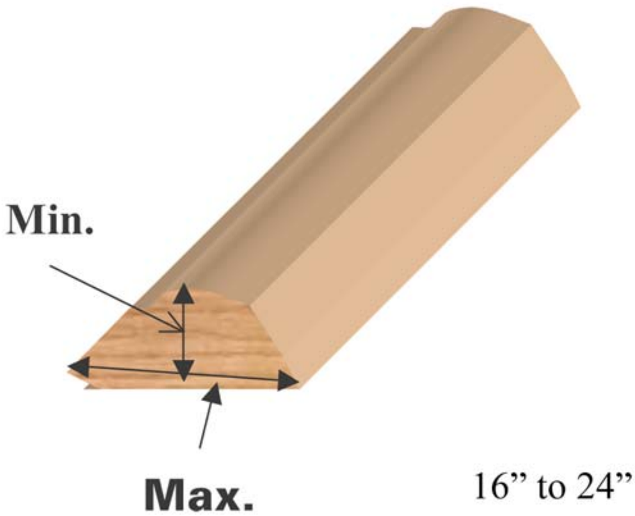

FIG. A1.1 Dimensions of Test Fuel Pieces

species may be used if they meet the specific gravity requirement). Only cordwood pieces that are free of decay, fungus and loose bark shall be used.

A1.5.1.2 *Cordwood Test Fuel Moisture*—The average cordwood test fuel piece moisture content shall be in the range of 18 to 28 % on a dry basis when tested in accordance with the following procedure.

NOTE A1.1—Once split cordwood pieces have dried to an average moisture content that is near the top of the allowable moisture content range, it has been found that to maintain the fuel pieces within the allowable moisture content range, storage at a relative humidity of 95 % or higher and temperature of 90 to 100ºF is necessary. In addition, storage at these conditions for a period of several months helps achieve a more uniform moisture content throughout the fuel pieces and thus improves the accuracy of the moisture content measurement.

(1) Using a fuel moisture meter as specified in 7.1 of the test method, determine the fuel moisture for each cordwood test fuel piece used for the cordwood test fuel load by averaging at least three fuel moisture meter readings, one from each of three sides, measured parallel to the wood grain. Penetration of the moisture meter insulated electrodes shall be ¼ the thickness of the fuel piece or 19 mm (¾ in.), whichever is greater. Moisture shall not be added to previously dried fuel pieces except by storage under high humidity conditions and temperature up to 100 ºF. Fuel moisture shall be measured within four hours of using the fuel for a test.

A1.5.1.3 *Cordwood Test Fuel Piece Length*—Piece length shall be 508 ± 102 mm (20 ± 4 in) (see Fig. A1.1).

A1.5.2 *Cordwood Test Fuel Loads*—Test fuel loads shall be determined by multiplying the firebox volume by 4.54 kg (10 lb), or a higher load density as recommended by the manufacturers printed operating instructions, of wood (as used wet weight) per cubic foot. Test fuel loads shall be made up of fuel pieces as specified in Table A1.2. Select the number of pieces of fuel that most nearly match this target weight. When the manufacturer's written instructions specify fuel loading to a specific level, the firebox shall be loaded with fuel as specified in A1.5.5 to the level indicated and the weight of the fuel load recorded. This weight shall then be divided by the firebox volume as determined in 9.3 in the Test Method and the resulting loading density shall be reported. If this loading density is less than 162 kg/m^3 (10 lb/ft^3), all tests shall be run with fuel load densities of 162 kg/m^3 (10 lb/ft^3) even though this could require loading to a level higher than indicated in the manufacturer's instructions.

A1.5.3 *Pre-burn Fuel*—The pre-burn fuel pieces shall be cordwood in approximately the same weight ratio as used for the test fuel load. Crumpled newspaper and kindling may be used to help ignite the pre-burn fuel.

A1.5.4 When the kindling and pre-burn fuel have been consumed to leave a pre-test fuel weight between 10 and 25 % of the weight of the test fuel load, record the weight of the fuel remaining and start the test run. Record all required data at the start of the test run. Load time and start-up time are as defined in 9.5.5.4 and 9.5.5.5 in the test method. Refer to other requirements in the test method as applicable and to the requirements of Test Method E2515.

A1.5.5 *Test Fuel Piece Placement*—Pieces are to be placed in the firebox parallel to the longest firebox dimension or in the direction specified in the manufacturer's printed operating instructions. When loading test fuel loads, no effort shall be made to stack fuel pieces either tightly or loosely with respect to one another.

TABLE A1.2 Correlation of Cordwood Wood Pieces with Appliance Firebox Volume[A]

Firebox Volume m^3 (ft^3)	Cross Section Min/Max mm (in.)	Piece Min Weight kg (lb)	Piece Max Weight kg (lb)	80% Piece Weight Range kg (lb)	Number of Pieces
<0.113 (4.0)	51 (2.0) / 152 (6.0)	1 (2.2)	6 (13.2)	1.5 (3.3) – 5 (11.0)	4 – 7
0.113 (4.0) – 0.283 (10.0)	64 (2.5) / 203 (8.0)	2 (4.4)	8 (17.6)	3 (6.6) – 7 (15.5)	5 – 10
0.283 (10.0) – 0.566 (20.0)	76 (3.0) / 254 (10.0)	3 (6.6)	10 (22.0)	4 (8.8) – 9 (19.8)	8 – 15
>0.566 (20.0)	76 (3.0) / 305 (12.0)	4 (8.8)	12 (26.4)	4 (8.8) – 10 (22.0)	>12

[A] Source: Wood Structural Design Data—National Forest Products Association

A2. WOOD HEATER THERMAL EFFICIENCY AND HEAT OUTPUT DETERMINATION

A2.1 Scope

A2.1.1 This annex to the test method covers the determination of overall efficiency and heat output for wood heaters.

A2.2 Referenced Documents

A2.2.1 *Other Documents:*

CSA B415.1 Performance Testing of Solid-Fuel-Burning Heating Appliances

An Atlas of Thermal Data for Biomass and Other Fuels (NREL/TP-433-7965)

The Energy Research Center of the Netherlands "PHYLLIS" database

A2.3 Summary of Test Method

A2.3.1 The procedures in this annex may be used in conjunction with the test method to allow determination of the overall thermal efficiency and the heat output for each test run. Literature values, rather than measured values are used for the calorific value and ultimate analysis for the fuel species used for testing. This annex may be used with crib test fuel or cordwood test fuel. Additionally, in conjunction with the test method, the results determined by the procedures in the annex may be used to determine the integrated average particulate emissions per delivered heat output for each test run, expressed in g/MJ (lb/MMBtu).

A2.4 Significance and Use

A2.4.1 This annex is used for determining the average thermal efficiency and heat output for wood heaters.

A2.4.2 This annex is used to determine the particulate emission rate per unit of heat delivered. This is useful when comparing different types of heating equipment.

A2.4.3 Due to the variability from piece to piece within a given test fuel load, the uncertainty in whether fuel properties determined using ASTM sampling and test methods are actually representative of the average fuel properties of the entire test fuel load has resulted in the use of literature values for the properties (other than moisture content) of the fuel in the calculation of overall efficiency and heat output. The literature values are based on average values reported in scientific literature and in international data bases. Table A2.1 provides this data for some common fuel wood species. This data is taken from "An Atlas of Thermal Data for Biomass and Other Fuels" (NREL/TP-433-7965) and the Energy Research Center of the Netherlands "PHYLLIS" database. If species not listed in Table A2.1 are used for testing, average values for the fuel properties (other than moisture content) reported in scientific literature or in international databases should be used.

A2.5 Procedure

A2.5.1 The procedures used in the annex shall be in accordance with Clauses 6.2.1, 6.2.2, 6.3, 10.4.3 (a), 10.4.3(f-j), and 13.7 of CSA B415.1, 3rd Edition, 2010.

A2.5.1.1 Measure and record the test room air temperature in accordance with the requirements of CSA B415.1, Clauses 6.2.1 and 10.4.3 (g).

TABLE A2.1 Fuel Properties by Fuel Species

Species	%C	%H	%O	%Ash	HHV MJ/kg	HHV Btu/lb
Ash, white	49.7	6.9	43	0.3	20.75	8927
Beech	48.7	5.8	44.7	0.6	18.8	8088
Birch	49.8	6.5	43.4	0.3	20.12	8656
Elm, rock	50.4	6.6	42.3	0.7	20.49	8815
Maple, hard (black)	50.64	6.02	41.74	1.35	19.96	8587
Maple, hard (sugar)	50.64	6.02	41.74	1.35	19.96	8587
Oak, red	49.5	6.62	43.7	0.2	20.2	8690
Oak, white	50.4	6.59	42.7	0.2	20.5	8819
Pine, Southern, longleaf	52.6	7.02	40.1	1.3	22.3	9594
Douglas Fir	48.73	6.87	43.9	0.5	19.81	8522

A2.5.1.2 Measure and record the flue gas temperature in accordance with the requirements of CSA B415.1, Clauses 6.2.2 and 10.4.3 (f).

A2.5.1.3 Determine and record the Carbon Monoxide (CO) and Carbon Dioxide (CO_2) concentrations in the flue gas in accordance with CSA B415.1, Clauses 6.3 and 10.4.3 (i) and (j).

A2.5.1.4 Measure and record the test fuel weight in accordance with the requirements of CSA B415.1, Clause 10.4.3 (h).

A2.5.1.5 Record the test run time in accordance with the requirements of CSA B415.1, Clause 10.4.3 (a).

A2.6 Data Analysis and Calculations

A2.6.1 *Thermal Efficiency and Heat Output:*

A2.6.1.1 For determination of the average thermal efficiency and average heat output for the test run, use the data collected over the full test run and the calculations in accordance with CSA B415.1, Clause 13.7 except for 13.7.2 (d), (e), (f), and (g), use the fuel properties in accordance with Table A2.1 for the fuel species used for testing.

A2.6.2 *Nomenclature:*

E_O = average measured overall heat output over the test run, MJ (MMBtu/h), and

ηr = overall efficiency for the test run, %.

APPENDIX

(Nonmandatory Information)

X1. SINGLE BURN RATE APPLIANCE FUELING AND OPERATION

X1.1 Scope

X1.1.1 This annex to the test method covers fueling and operating protocol for determining particulate matter emissions from wood heaters that have non-adjustable combustion air control(s). This annex is used in conjunction with all other applicable requirements of the test method. This annex may also be used in conjunction with Annex A2 when determining wood heater efficiency.

X1.2 Terminology

X1.2.1 *Definitions of Terms Specific to this Annex:*

X1.2.1.1 *single burn rate appliance, n*—a wood heater with combustion air control(s) that is not adjustable by the heater user and that meets the requirements of X1.4.2.

X1.3 Summary of the Test Method

X1.3.1 The procedures in this annex allow the determination of performance for single burn rate appliances by addressing the differences in operation between heaters with adjustable combustion air controls and those with non-adjustable combustion air control(s). The difference in the procedure for testing single burn rate appliances involves how the heater is operated, the number of test runs required and the determination of average emissions.

X1.4 Procedure

X1.4.1 Other than the requirements for testing at low, medium and maximum burn rates in 9.5.1 in the test method, all other test method test procedure requirements must be met.

X1.4.2 Conduct at least two test runs following the manufacturer's written instructions for operation of the heater. The heater shall be considered to have a single burn rate if the burn rate for any individual test run is within 10 % of the average burn rate for all test runs.

X1.4.3 For heaters with automatic controls, the controls may be allowed to function in a manner consistent with the owner's manual and with normal operation in a home as long as the requirements of X1.4.2 are met.

X1.5 Data Analysis and Calculations

X1.5.1 *Nomenclature:*

$$PM_{RA} = (PM_{R1} + PM_{R2} + \ldots PM_{Rn})/n \quad (X1.1)$$

where:

PM_{RA} = the average emission rate, g/h (lb/h),
PM_{R1} = the emission rate for test run 1, g/h (lb/h),
PM_{R2} = the emission rate for test run 2, g/h (lb/h),
PM_{Rn} = the emission rate for each additional valid test run, g/h (lb/h), and
n = number of valid test runs.

$$PM_{FA} = (PM_{F1} + PM_{F2} + \ldots PM_{Fn})/n \quad (X1.2)$$

where:

PM_{FA} = the average emission factor, g/kg (lb/ton),
PM_{F1} = the emission factor for test run 1, g/kg (lb/ton),
PM_{F2} = the emission factor for test run 2, g/kg (lb/ton),
PM_{Fn} = the emission factor for each additional valid test run, g/kg (lb/ton), and
n = number of valid test runs.

$$PM_{AH} = (PM_{1H} + PM_{2H} + \ldots PM_{nH})/n \quad (X1.3)$$

where heat output is determined in accordance with Annex A2:

PM_{AH} = arithmetic average emissions per heat output unit for all test runs, g/MJ (lb/MMBtu),
PM_{1H} = average emissions per heat output unit for test run 1, g/MJ (lb/MMBtu),
PM_{2H} = average emissions per heat output unit for test run 2, g/MJ (lb/MMBtu), and
PM_{nH} = average emissions per heat output unit for each additional test run n, g/MJ (lb/MMBtu).

$$\eta_A = (\eta_1 + \eta_2 + \dots \eta_n)/n \quad (X1.4)$$

where:

η_A = arithmetic average overall efficiency for all test runs, %,

η_1 = average overall efficiency for test run 1 as determined in accordance with Annex A2, %,

η_2 = average overall efficiency for test run 2 as determined in accordance with Annex A2, %, and

η_n = average overall efficiency for each additional test run n as determined in accordance with Annex A2, %.

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METHOD 28 - CERTIFICATION AND AUDITING OF WOOD HEATERS

Note: This method does not include all of the specifications (*e.g.,* equipment and supplies) and procedures (*e.g.,* sampling and analytical) essential to its performance. Some material is incorporated by reference from other methods in this part. Therefore, to obtain reliable results, persons using this method should have a thorough knowledge of at least the following additional test methods: Method 1, Method 2, Method 3, Method 4, Method 5, Method 5G, Method 5H, Method 6, Method 6C, and Method 16A.

1.0 Scope and Application

1.1 Analyte. Particulate matter (PM). No CAS number assigned.

1.2 Applicability. This method is applicable for the certification and auditing of wood heaters, including pellet burning wood heaters.

1.3 Data Quality Objectives. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

2.0 Summary of Method

2.1 Particulate matter emissions are measured from a wood heater burning a prepared test fuel crib in a test facility maintained at a set of prescribed conditions. Procedures for determining burn rates and particulate emission rates and for reducing data are provided.

3.0 Definitions

3.1 *2 × 4 or 4 × 4* means two inches by four inches or four inches by four inches (50 mm by 100 mm or 100 mm by 100 mm), as nominal dimensions for lumber.

3.2 *Burn rate* means the rate at which test fuel is consumed in a wood heater. Measured in kilograms or lbs of wood (dry basis) per hour (kg/hr or lb/hr).

3.3 *Certification or audit test* means a series of at least four test runs conducted for certification or audit purposes that meets the burn rate specifications in Section 8.4.

3.4 *Firebox* means the chamber in the wood heater in which the test fuel charge is placed and combusted.

3.5 *Height* means the vertical distance extending above the loading door, if fuel could reasonably occupy that space, but not more than 2 inches above the top (peak height) of the loading door, to the floor of the firebox (*i.e.,* below a permanent grate) if the grate allows a 1-inch diameter piece of wood to pass through the grate, or, if not, to the top of the grate. Firebox height is not necessarily uniform but must account for variations caused by internal baffles, air channels, or other permanent obstructions.

3.6 *Length* means the longest horizontal fire chamber dimension that is parallel to a wall of the chamber.

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

3.8 *Secondary air supply* means an air supply that introduces air to the wood heater such that the burn rate is not altered by more than 25 percent when the secondary air supply is adjusted during the test run. The wood heater manufacturer can document this through design drawings that show the secondary air is introduced only into a mixing chamber or secondary chamber outside the firebox.

3.9 *Test facility* means the area in which the wood heater is installed, operated, and sampled for emissions.

3.10 *Test fuel charge* means the collection of test fuel pieces placed in the wood heater at the start of the emission test run.

3.11 *Test fuel crib* means the arrangement of the test fuel charge with the proper spacing requirements between adjacent fuel pieces.

3.12 *Test fuel loading density* means the weight of the as-fired test fuel charge per unit volume of usable firebox.

3.13 *Test fuel piece* means the 2 × 4 or 4 × 4 wood piece cut to the length required for the test fuel charge and used to construct the test fuel crib.

3.14 *Test run* means an individual emission test which encompasses the time required to consume the mass of the test fuel charge.

3.15 *Usable firebox volume* means the volume of the firebox determined using its height, length, and width as defined in this section.

3.16 *Width* means the shortest horizontal fire chamber dimension that is parallel to a wall of the chamber.

3.17 *Wood heater* means an enclosed, wood burning appliance capable of and intended for space heating or domestic water heating, as defined in the applicable regulation.

4.0 Interferences[Reserved]

5.0 Safety

5.1 Disclaimer. This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to performing this test method.

6.0 Equipment and Supplies

Same as Section 6.0 of either Method 5G or Method 5H, with the addition of the following:

6.1 Insulated Solid Pack Chimney. For installation of wood heaters. Solid pack insulated chimneys shall have a minimum of 2.5 cm (1 in.) solid pack insulating material surrounding the entire flue and possess a label demonstrating conformance to U.L. 103 (incorporated by reference—see §60.17).

6.2 Platform Scale and Monitor. For monitoring of fuel load weight change. The scale shall be capable of measuring weight to within 0.05 kg (0.1 lb) or 1 percent of the initial test fuel charge weight, whichever is greater.

6.3 Wood Heater Temperature Monitors. Seven, each capable of measuring temperature to within 1.5 percent of expected absolute temperatures.

6.4 Test Facility Temperature Monitor. A thermocouple located centrally in a vertically oriented 150 mm (6 in.) long, 50 mm (2 in.) diameter pipe shield that is open at both ends, capable of measuring temperature to within 1.5 percent of expected temperatures.

6.5 Balance (optional). Balance capable of weighing the test fuel charge to within 0.05 kg (0.1 lb).

6.6 Moisture Meter. Calibrated electrical resistance meter for measuring test fuel moisture to within 1 percent moisture content.

6.7 Anemometer. Device capable of detecting air velocities less than 0.10 m/sec (20 ft/min), for measuring air velocities near the test appliance.

6.8 Barometer. Mercury, aneroid or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg).

6.9 Draft Gauge. Electromanometer or other device for the determination of flue draft or static pressure readable to within 0.50 Pa (0.002 in. H_2O).

6.10 Humidity Gauge. Psychrometer or hygrometer for measuring room humidity.

6.11 Wood Heater Flue.

6.11.1 Steel flue pipe extending to 2.6 ±0.15 m (8.5 ±0.5 ft) above the top of the platform scale, and above this level, insulated solid pack type chimney extending to 4.6 ±0.3 m (15 ±1 ft) above the platform scale, and of the size specified by the wood heater manufacturer. This applies to both freestanding and insert type wood heaters.

6.11.2 Other chimney types (*e.g.,* solid pack insulated pipe) may be used in place of the steel flue pipe if the wood heater manufacturer's written appliance specifications require such chimney for home installation (*e.g.,* zero clearance wood heater inserts). Such alternative chimney or flue pipe must remain and be sealed with the wood heater following the certification test.

6.12 Test Facility. The test facility shall meet the following requirements during testing:

6.12.1 The test facility temperature shall be maintained between 18 and 32°C (65 and 90°F) during each test run.

6.12.2 Air velocities within 0.6 m (2 ft) of the test appliance and exhaust system shall be less than 0.25 m/sec (50 ft/min) without fire in the unit.

6.12.3 The flue shall discharge into the same space or into a space freely communicating with the test facility. Any hood or similar device used to vent combustion products shall not induce a draft greater than 1.25 Pa (0.005 in. H_2O) on the wood heater measured when the wood heater is not operating.

6.12.4 For test facilities with artificially induced barometric pressures (*e.g.*, pressurized chambers), the barometric pressure in the test facility shall not exceed 775 mm Hg (30.5 in. Hg) during any test run.

7.0 Reagents and Standards

Same as Section 6.0 of either Method 5G or Method 5H, with the addition of the following:

7.1 Test Fuel. The test fuel shall conform to the following requirements:

7.1.1 Fuel Species. Untreated, air-dried, Douglas fir lumber. Kiln-dried lumber is not permitted. The lumber shall be certified C grade (standard) or better Douglas fir by a lumber grader at the mill of origin as specified in the West Coast Lumber Inspection Bureau Standard No. 16 (incorporated by reference—see §60.17).

7.1.2 Fuel Moisture. The test fuel shall have a moisture content range between 16 to 20 percent on a wet basis (19 to 25 percent dry basis). Addition of moisture to previously dried wood is not allowed. It is recommended that the test fuel be stored in a temperature and humidity-controlled room.

7.1.3 Fuel Temperature. The test fuel shall be at the test facility temperature of 18 to 32°C (65 to 90°F).

7.1.4 Fuel Dimensions. The dimensions of each test fuel piece shall conform to the nominal measurements of 2×4 and 4×4 lumber. Each piece of test fuel (not including spacers) shall be of equal length, except as necessary to meet requirements in Section 8.8, and shall closely approximate 5/6 the dimensions of the length of the usable firebox. The fuel piece dimensions shall be determined in relation to the appliance's firebox volume according to guidelines listed below:

7.1.4.1 If the usable firebox volume is less than or equal to 0.043 m^3 (1.5 ft^3), use 2×4 lumber.

7.1.4.2 If the usable firebox volume is greater than 0.043 m^3 (1.5 ft^3) and less than or equal to 0.085 m^3 (3.0 ft^3), use 2×4 and 4×4 lumber. About half the weight of the test fuel charge shall be 2×4 lumber, and the remainder shall be 4×4 lumber.

7.1.4.3 If the usable firebox volume is greater than 0.085 m^3 (3.0 ft^3), use 4×4 lumber.

7.2 Test Fuel Spacers. Air-dried, Douglas fir lumber meeting the requirements outlined in Sections 7.1.1 through 7.1.3. The spacers shall be 130×40×20 mm (5×1.5×0.75 in.).

8.0 Sample Collection, Preservation, Storage, and Transport

8.1 Test Run Requirements.

8.1.1 Burn Rate Categories. One emission test run is required in each of the following burn rate categories:

Burn Rate Categories

[Average kg/hr (lb/hr), dry basis]

Category 1	Category 2	Category 3	Category 4
<0.80	0.80 to 1.25	1.25 to 1.90	Maximum.
(<1.76)	(1.76 to 2.76)	(2.76 to 4.19)	burn rate.

8.1.1.1 Maximum Burn Rate. For Category 4, the wood heater shall be operated with the primary air supply inlet controls fully open (or, if thermostatically controlled, the thermostat shall be set at maximum heat output) during the entire test run, or the maximum burn rate setting specified by the manufacturer's written instructions.

8.1.1.2 Other Burn Rate Categories. For burn rates in Categories 1 through 3, the wood heater shall be operated with the primary air supply inlet control, or other mechanical control device, set at a predetermined position necessary to obtain the average burn rate required for the category.

8.1.1.3 Alternative Burn Rates for Burn Rate Categories 1 and 2.

8.1.1.3.1 If a wood heater cannot be operated at a burn rate below 0.80 kg/hr (1.76 lb/hr), two test runs shall be conducted with burn rates within Category 2. If a wood heater cannot be operated at a burn rate below 1.25 kg/hr (2.76 lb/hr), the flue shall be dampered or the air supply otherwise controlled in order to achieve two test runs within Category 2.

8.1.1.3.2 Evidence that a wood heater cannot be operated at a burn rate less than 0.80 kg/hr shall include documentation of two or more attempts to operate the wood heater in burn rate Category 1 and fuel combustion has stopped, or results of two or more test runs demonstrating that the burn rates were greater than 0.80 kg/hr when the air supply controls were adjusted to the lowest possible position or settings. Stopped fuel combustion is evidenced when an elapsed time of 30 minutes or more has occurred without a measurable (< 0.05 kg (0.1 lb) or 1.0 percent, whichever is greater) weight change in the test fuel charge. See also Section 8.8.3. Report the evidence and the reasoning used to determine that a test in burn rate Category 1 cannot be achieved; for example, two unsuccessful attempts to operate at a burn rate of 0.4 kg/hr are not sufficient evidence that burn rate Category 1 cannot be achieved.

Note: After July 1, 1990, if a wood heater cannot be operated at a burn rate less than 0.80 kg/hr, at least one test run with an average burn rate of 1.00 kg/hr or less shall be conducted. Additionally, if flue dampering must be used to achieve burn rates below 1.25 kg/hr (or 1.0 kg/hr), results from a test run conducted at burn rates below 0.90 kg/hr need not be reported or included in the test run average provided that such results are replaced with results from a test run meeting the criteria above.

8.2 Catalytic Combustor and Wood Heater Aging. The catalyst-equipped wood heater or a wood heater of any type shall be aged before the certification test begins. The aging procedure shall be conducted and documented by a testing laboratory accredited according to procedures in §60.535 of 40 CFR part 60.

8.2.1 Catalyst-equipped Wood Heater. Operate the catalyst-equipped wood heater using fuel meeting the specifications outlined in Sections 7.1.1 through 7.1.3, or cordwood with a moisture content between 15 and 25 percent on a wet basis. Operate the wood heater at a medium burn rate (Category 2 or 3) with a new catalytic combustor in place and in operation for at least 50 hours. Record and report hourly catalyst exit temperature data (Section 8.6.2) and the hours of operation.

8.2.2 Non-Catalyst Wood Heater. Operate the wood heater using the fuel described in Section 8.4.1 at a medium burn rate for at least 10 hours. Record and report the hours of operation.

8.3 Pretest Recordkeeping. Record the test fuel charge dimensions and weights, and wood heater and catalyst descriptions as shown in the example in Figure 28–1.

8.4 Wood Heater Installation. Assemble the wood heater appliance and parts in conformance with the manufacturer's written installation instructions. Place the wood heater centrally on the platform scale and connect the wood heater to the flue described in Section 6.11. Clean the flue with an appropriately sized, wire chimney brush before each certification test.

8.5 Wood Heater Temperature Monitors.

8.5.1 For catalyst-equipped wood heaters, locate a temperature monitor (optional) about 25 mm (1 in.) upstream of the catalyst at the centroid of the catalyst face area, and locate a temperature monitor (mandatory) that will indicate the catalyst exhaust temperature. This temperature monitor is centrally located within 25 mm (1 in.) downstream at the centroid of catalyst face area. Record these locations.

8.5.2 Locate wood heater surface temperature monitors at five locations on the wood heater firebox exterior surface. Position the temperature monitors centrally on the top surface, on two sidewall surfaces, and on the bottom and back surfaces. Position the monitor sensing tip on the firebox exterior surface inside of any heat shield, air circulation walls, or other wall or shield separated from the firebox exterior surface. Surface temperature locations for unusual design shapes (*e.g.*, spherical, etc.) shall be positioned so that there are four surface temperature monitors in both the vertical and horizontal planes passing at right angles through the centroid of the firebox, not including the fuel loading door (total of five temperature monitors).

8.6 Test Facility Conditions.

8.6.1 Locate the test facility temperature monitor on the horizontal plane that includes the primary air intake opening for the wood heater. Locate the temperature monitor 1 to 2 m (3 to 6 ft) from the front of the wood heater in the 90° sector in front of the wood heater.

8.6.2 Use an anemometer to measure the air velocity. Measure and record the room air velocity before the pretest ignition period (Section 8.7) and once immediately following the test run completion.

8.6.3 Measure and record the test facility's ambient relative humidity, barometric pressure, and temperature before and after each test run.

8.6.4 Measure and record the flue draft or static pressure in the flue at a location no greater than 0.3 m (1 ft) above the flue connector at the wood heater exhaust during the test run at the recording intervals (Section 8.8.2).

8.7 Wood Heater Firebox Volume.

8.7.1 Determine the firebox volume using the definitions for height, width, and length in Section 3. Volume adjustments due to presence of firebrick and other permanent fixtures may be necessary. Adjust width and length dimensions to extend to the metal wall of the wood heater above the firebrick or permanent obstruction if the firebrick or obstruction extending the length of the side(s) or back wall extends less than one-third of the usable firebox height. Use the width or length dimensions inside the firebrick if the firebrick extends more than one-third of the usable firebox height. If a log retainer or grate is a permanent fixture and the manufacturer recommends that no fuel be placed outside the retainer, the area outside of the retainer is excluded from the firebox volume calculations.

8.7.2 In general, exclude the area above the ash lip if that area is less than 10 percent of the usable firebox volume. Otherwise, take into account consumer loading practices. For instance, if fuel is to be loaded front-to-back, an ash lip may be considered usable firebox volume.

8.7.3 Include areas adjacent to and above a baffle (up to two inches above the fuel loading opening) if four inches or more horizontal space exist between the edge of the baffle and a vertical obstruction (*e.g.*, sidewalls or air channels).

8.8 Test Fuel Charge.

8.8.1 Prepare the test fuel pieces in accordance with the specifications outlined in Sections 7.1 and 7.2. Determine the test fuel moisture content with a calibrated electrical resistance meter or other equivalent performance meter. If necessary, convert fuel moisture content values from dry basis ($\%M_d$) to wet basis ($\%M_w$) in Section 12.2 using Equation 28–1. Determine fuel moisture for each fuel piece (not including spacers) by averaging at least three moisture meter readings, one from each of three sides, measured parallel to the wood grain. Average all the readings for all the fuel pieces in the test fuel charge. If an electrical resistance type meter is used, penetration of insulated electrodes shall be one-fourth the thickness of the test fuel piece or 19 mm (0.75 in.), whichever is greater. Measure the moisture content within a 4-hour period prior to the test run. Determine the fuel temperature by measuring the temperature of the room where the wood has been stored for at least 24 hours prior to the moisture determination.

8.8.2 Attach the spacers to the test fuel pieces with uncoated, ungalvanized nails or staples as illustrated in Figure 28–2. Attachment of spacers to the top of the test fuel piece(s) on top of the test fuel charge is optional.

8.8.3 To avoid stacking difficulties, or when a whole number of test fuel pieces does not result, all piece lengths shall be adjusted uniformly to remain within the specified loading density. The shape of the test fuel crib shall be geometrically similar to the shape of the firebox volume without resorting to special angular or round cuts on the individual fuel pieces.

8.8.4 The test fuel loading density shall be 112 ±11.2 kg/m^3 (7 ±0.7 lb/ft3) of usable firebox volume on a wet basis.

8.9 Sampling Equipment. Prepare the sampling equipment as defined by the selected method (*i.e.*, either Method 5G or Method 5H). Collect one particulate emission sample for each test run.

8.10 Secondary Air Adjustment Validation.

8.10.1 If design drawings do not show the introduction of secondary air into a chamber outside the firebox (see "secondary air supply" under Section 3.0, Definitions), conduct a separate test of the wood heater's secondary air supply. Operate the wood heater at a burn rate in Category 1 (Section 8.1.1) with the secondary air supply operated following the manufacturer's written instructions. Start the secondary air validation test run as described in Section 8.8.1, except no emission sampling is necessary and burn rate data shall be recorded at 5-minute intervals.

8.10.2 After the start of the test run, operate the wood heater with the secondary air supply set as per the manufacturer's instructions, but with no adjustments to this setting. After 25 percent of the test fuel has been consumed, adjust the secondary air supply controls to another setting, as per the manufacturer's instructions. Record the burn rate data (5-minute intervals) for 20 minutes following the air supply adjustment.

8.10.3 Adjust the air supply control(s) to the original position(s), operate at this condition for at least 20 minutes, and repeat the air supply adjustment procedure above. Repeat the procedure three times at equal intervals over the entire burn period as defined in Section 8.8. If the secondary air adjustment results in a burn rate change of more than an average of 25 percent between the 20-minute periods before and after the secondary adjustments, the secondary air supply shall be considered a primary air supply, and no adjustment to this air supply is allowed during the test run.

8.10.4 The example sequence below describes a typical secondary air adjustment validation check. The first cycle begins after at least 25 percent of the test fuel charge has been consumed.

Cycle 1

Part 1, sec air adjusted to final position—20 min

Part 2, sec air adjusted to final position—20 min

Part 3, sec air adjusted to final position—20 min

Cycle 2

Part 1, sec air adjusted to final position—20 min

Part 2, sec air adjusted to final position—20 min

Part 3, sec air adjusted to final position—20 min

Cycle 3

Part 1, sec air adjusted to final position—20 min

Part 2, sec air adjusted to final position—20 min

Part 3, sec air adjusted to final position—20 min

Note that the cycles may overlap; that is, Part 3 of Cycle 1 may coincide in part or in total with Part 1 of Cycle 2. The calculation of the secondary air percent effect for this example is as follows:

$$\%BR_{sec} = \frac{\left|\overline{BR_{1,3}} - \overline{BR_2}\right|}{\overline{BR_{1,3}}} \times 100 \qquad \text{Eq. 28-1}$$

8.11 Pretest Ignition. Build a fire in the wood heater in accordance with the manufacturer's written instructions.

8.11.1 Pretest Fuel Charge. Crumpled newspaper loaded with kindling may be used to help ignite the pretest fuel. The pretest fuel, used to sustain the fire, shall meet the same fuel requirements prescribed in Section 7.1. The pretest fuel charge shall consist of whole 2×4's that are no less than 1/3 the length of the test fuel pieces. Pieces of 4×4 lumber in approximately the same weight ratio as for the test fuel charge may be added to the pretest fuel charge.

8.11.2 Wood Heater Operation and Adjustments. Set the air inlet supply controls at any position that will maintain combustion of the pretest fuel load. At least one hour before the start of the test run, set the air supply controls at the approximate positions necessary to achieve the burn rate desired for the test run. Adjustment of the air supply controls, fuel addition or subtractions, and coalbed raking shall be kept to a minimum but are allowed up to 15 minutes prior to the start of the test run. For the purposes of this method, coalbed raking is the use of a metal tool (poker) to stir coals, break burning fuel into smaller pieces, dislodge fuel pieces from positions of poor combustion, and check for the condition of uniform charcoalization. Record all adjustments made to the air supply controls, adjustments to and additions or subtractions of fuel, and any other changes to wood heater operations that occur during pretest ignition period. Record fuel weight data and wood heater temperature measurements at 10-minute intervals during the hour of the pretest ignition period preceding the start of the test run. During the 15-minute period prior to the start of the test run, the wood heater loading door shall not be open more than a total of 1 minute. Coalbed raking is the only adjustment allowed during this period.

Note: One purpose of the pretest ignition period is to achieve uniform charcoalization of the test fuel bed prior to loading the test fuel charge. Uniform charcoalization is a general condition of the test fuel bed evidenced by an absence of large pieces of burning wood in the coal bed and the remaining fuel pieces being brittle enough to be broken into smaller charcoal pieces with a metal poker. Manipulations to the fuel bed prior to the start of the test run should be done to achieve uniform charcoalization while maintaining the desired burn rate. In addition, some wood heaters (*e.g.*, high mass units) may require extended pretest burn time and fuel additions to reach an initial average surface temperature sufficient to meet the thermal equilibrium criteria in Section 8.3.

8.11.3 The weight of pretest fuel remaining at the start of the test run is determined as the difference between the weight of the wood heater with the remaining pretest fuel and the tare weight of the cleaned, dry wood heater with or without dry ash or sand added consistent with the manufacturer's instructions and the owner's manual. The tare weight of the wood heater must be determined with the wood heater (and ash, if added) in a dry condition.

8.12 Test Run. Complete a test run in each burn rate category, as follows:

8.12.1 Test Run Start.

8.12.1.1 When the kindling and pretest fuel have been consumed to leave a fuel weight between 20 and 25 percent of the weight of the test fuel charge, record the weight of the fuel remaining and start the test run. Record and report any other criteria, in addition to those specified in this section, used to determine the moment of the test run start (*e.g.*, firebox or catalyst temperature), whether such criteria are specified by the wood heater manufacturer or the testing laboratory. Record all wood heater individual surface temperatures, catalyst temperatures, any initial sampling method measurement values, and begin the particulate emission sampling. Within 1 minute following the start of the test run, open the wood heater door, load the test fuel charge, and record the test fuel charge weight. Recording of average, rather than individual, surface temperatures is acceptable for tests conducted in accordance with §60.533(o)(3)(i) of 40 CFR part 60.

8.12.1.2 Position the fuel charge so that the spacers are parallel to the floor of the firebox, with the spacer edges abutting each other. If loading difficulties result, some fuel pieces may be placed on edge. If the usable firebox volume is between 0.043 and 0.085 m^3 (1.5 and 3.0 ft^3), alternate the piece sizes in vertical stacking layers to the extent possible. For example, place 2 × 4's on the bottom layer in direct contact with the coal bed and 4 × 4's on the next layer, etc. (See Figure 28–3). Position the fuel pieces parallel to each other and parallel to the longest wall of the firebox to the extent possible within the specifications in Section 8.8.

8.12.1.3 Load the test fuel in appliances having unusual or unconventional firebox design maintaining air space intervals between the test fuel pieces and in conformance with the manufacturer's written instructions. For any appliance that will not accommodate the loading arrangement specified in the paragraph above, the test facility personnel shall contact the Administrator for an alternative loading arrangement.

8.12.1.4 The wood heater door may remain open and the air supply controls adjusted up to five minutes after the start of the test run in order to make adjustments to the test fuel charge and to ensure ignition of the test fuel charge has occurred. Within the five minutes after the start of the test run, close the wood heater door and adjust the air supply controls to the position determined to produce the desired burn rate. No other adjustments to the air supply controls or the test fuel charge are allowed (except as specified in Sections 8.12.3 and 8.12.4) after the first five minutes of the test run. Record the length of time the wood heater door remains open, the adjustments to the air supply controls, and any other operational adjustments.

8.12.2 Data Recording. Record on a data sheet similar to that shown in Figure 28–4, at intervals no greater than 10 minutes, fuel weight data, wood heater individual surface and catalyst temperature measurements, other wood heater operational data (*e.g.*, draft), test facility temperature and sampling method data.

8.12.3 Test Fuel Charge Adjustment. The test fuel charge may be adjusted (*i.e.*, repositioned) once during a test run if more than 60 percent of the initial test fuel charge weight has been consumed and more than 10 minutes have elapsed without a measurable (<0.05 kg (0.1 lb) or 1.0 percent, whichever is greater) weight change. The time used to make this adjustment shall be less than 15 seconds.

8.12.4 Air Supply Adjustment. Secondary air supply controls may be adjusted once during the test run following the manufacturer's written instructions (see Section 8.10). No other air supply adjustments are allowed during the test run. Recording of wood heater flue draft during the test run is optional for tests conducted in accordance with §60.533(o)(3)(i) of 40 CFR part 60.

8.12.5 Auxiliary Wood Heater Equipment Operation. Heat exchange blowers sold with the wood heater shall be operated during the test run following the manufacturer's written instructions. If no manufacturer's written instructions are available, operate the heat exchange blower in the “high” position. (Automatically operated blowers shall be operated as designed.) Shaker grates, by-pass controls, or other auxiliary equipment may be adjusted only one time during the test run following the manufacturer's written instructions.

Record all adjustments on a wood heater operational written record.

Note: If the wood heater is sold with a heat exchange blower as an option, test the wood heater with the heat exchange blower operating as described in Sections 8.1 through 8.12 and report the results. As an alternative to repeating all test runs without the heat exchange blower operating, one additional test run may be without the blower operating as described in Section 8.12.5 at a burn rate in Category 2 (Section 8.1.1). If the emission rate resulting from this test run without the blower operating is equal to or less than the emission rate plus 1.0 g/hr (0.0022 lb/hr) for the test run in burn rate Category 2 with the blower operating, the wood heater may be considered to have the same average emission rate with or without the blower operating. Additional test runs without the blower operating are unnecessary.

8.13 Test Run Completion. Continue emission sampling and wood heater operation for 2 hours. The test run is completed when the remaining weight of the test fuel charge is 0.00 kg (0.0 lb). End the test run when the scale has indicated a test fuel charge weight of 0.00 kg (0.0 lb) or less for 30 seconds. At the end of the test run, stop the particulate sampling, and record the final fuel weight, the run time, and all final measurement values.

8.14 Wood Heater Thermal Equilibrium. The average of the wood heater surface temperatures at the end of the test run shall agree with the average surface temperature at the start of the test run to within 70 C (126 °F).

8.15 Consecutive Test Runs. Test runs on a wood heater may be conducted consecutively provided that a minimum one-hour interval occurs between test runs.

8.16 Additional Test Runs. The testing laboratory may conduct more than one test run in each of the burn rate categories specified in Section 8.1.1. If more than one test run is conducted at a specified burn rate, the results from at least two-thirds of the test runs in that burn rate category shall be used in calculating the weighted average emission rate (see Section 12.2). The measurement data and results of all test runs shall be reported regardless of which values are used in calculating the weighted average emission rate (see Note in Section 8.1).

9.0 Quality Control

Same as Section 9.0 of either Method 5G or Method 5H.

10.0 Calibration and Standardizations

Same as Section 10.0 of either Method 5G or Method 5H, with the addition of the following:

10.1 Platform Scale. Perform a multi-point calibration (at least five points spanning the operational range) of the platform scale before its initial use. The scale manufacturer's calibration results are sufficient for this purpose. Before each certification test, audit the scale with the wood heater in place by weighing at least one calibration weight (Class F) that corresponds to between 20 percent and 80 percent of the expected test fuel charge weight. If the scale cannot reproduce the value of the calibration weight within 0.05 kg (0.1 lb) or 1 percent of the expected test fuel charge weight, whichever is greater, recalibrate the scale before use with at least five calibration weights spanning the operational range of the scale.

10.2 Balance (optional). Calibrate as described in Section 10.1.

10.3 Temperature Monitor. Calibrate as in Method 2, Section 4.3, before the first certification test and semiannually thereafter.

10.4 Moisture Meter. Calibrate as per the manufacturer's instructions before each certification test.

10.5 Anemometer. Calibrate the anemometer as specified by the manufacturer's instructions before the first certification test and semiannually thereafter.

10.6 Barometer. Calibrate against a mercury barometer before the first certification test and semiannually thereafter.

10.7 Draft Gauge. Calibrate as per the manufacturer's instructions; a liquid manometer does not require calibration.

10.8 Humidity Gauge. Calibrate as per the manufacturer's instructions before the first certification test and semiannually thereafter.

11.0 Analytical Procedures

Same as Section 11.0 of either Method 5G or Method 5H.

12.0 Data Analysis and Calculations

Same as Section 12.0 of either Method 5G or Method 5H, with the addition of the following:

12.1 Nomenclature.

BR = Dry wood burn rate, kg/hr (lb/hr)

E_i = Emission rate for test run, i, from Method 5G or 5H, g/hr (lb/hr)

E_w = Weighted average emission rate, g/hr (lb/hr)

k_i = Test run weighting factor=Pi+1− P_{i-1}

$\%M_d$ = Fuel moisture content, dry basis, percent.

$\%M_w$ = Average moisture in test fuel charge, wet basis, percent.

N = Total number of test runs.

P_i = Probability for burn rate during test run, i, obtained from Table 28–1. Use linear interpolation to determine probability values for burn rates between those listed on the table.

W_{wd} = Total mass of wood burned during the test run, kg (lb).

12.2 Wet Basis Fuel Moisture Content.

$$\%M_w = \frac{100(\%M_d)}{100 + \%M_d} \qquad \text{Eq. 28-2}$$

12.3 Weighted Average Emission Rate. Calculate the weighted average emission rate (E_w) using Equation 28–1:

$$E_w = \frac{\sum_{i-1}^{n}(K_i E_i)}{\sum_{i-1}^{n} K_i} \qquad \text{Eq. 28-3}$$

Note: P_o always equals 0, P(n+1)always equals 1, P_1corresponds to the probability of the lowest recorded burn rate, P_2corresponds to the probability of the next lowest burn rate, etc. An example calculation is in Section 12.3.1.

12.3.1 Example Calculation of Weighted Average Emission Rate.

Burn rate category	Test No.	Burn rate (Dry-kg/hr)	Emissions (g/hr)
1	1	0.65	5.0
2[1]	2	0.85	6.7
2	3	0.90	4.7
2	4	1.00	5.3
3	5	1.45	3.8
4	6	2.00	5.1

[1]As permitted in Section 6.6, this test run may be omitted from the calculation of the weighted average emission rate because three runs were conducted for this burn rate category.

Test No.	Burn rate	P_i	E_i	K_i
0		0.000		
1	0.65	0.121	5.0	0.300
2	0.90	0.300	4.7	0.259
3	1.00	0.380	5.3	0.422
4	1.45	0.722	3.8	0.532
5	2.00	0.912	5.1	0.278
6		1.000		

$K_1 = P_2 - P_0 = 0.300 - 0 = 0.300$

$K_2 = P_3 - P_1 = 0.381 - 0.121 = 0.259$

$K_3 = P_4 - P_2 = 0.722 - 0.300 = 0.422$

$K_4 = P_5 - P_3 = 0.912 - 0.380 = 0.532$

$K_5 = P_6 - P_4 = 1.000 - 0.722 = 0.278$

Weighted Average Emission Rate, E_w, Calculation

$$E_w = \frac{\sum (K_i E_i)}{\sum K_i}$$

$$= \frac{(0.3)(5.0) + (0.259)(4.7) + (0.422)(5.3) + (0.532)(3.8) + (0.278)(5.1)}{1.791}$$

$$= 4.69\, g/hr$$

12.4 Average Wood Heater Surface Temperatures. Calculate the average of the wood heater surface temperatures for the start of the test run (Section 8.12.1) and for the test run completion (Section 8.13). If the two average temperatures do not agree within 70°C (125°F), report the test run results, but do not include the test run results in the test average. Replace such test run results with results from another test run in the same burn rate category.

12.5 Burn Rate. Calculate the burn rate (BR) using Equation 28–3:

$$BR = \frac{60 W_{wd}}{\theta} \times \frac{100 - \%M_w}{100} \qquad \text{Eq. 28-3}$$

12.6 Reporting Criteria. Submit both raw and reduced test data for wood heater tests.

12.6.1 Suggested Test Report Format.

12.6.1.1 Introduction.

12.6.1.1.1 Purpose of test-certification, audit, efficiency, research and development.

12.6.1.1.2 Wood heater identification-manufacturer, model number, catalytic/noncatalytic, options.

12.6.1.1.3 Laboratory-name, location (altitude), participants.

12.6.1.1.4 Test information-date wood heater received, date of tests, sampling methods used, number of test runs.

12.6.1.2 Summary and Discussion of Results

12.6.1.2.1 Table of results (in order of increasing burn rate)-test run number, burn rate, particulate emission rate, efficiency (if determined), averages (indicate which test runs are used).

12.6.1.2.2 Summary of other data-test facility conditions, surface temperature averages, catalyst temperature averages, pretest fuel weights, test fuel charge weights, run times.

12.6.1.2.3 Discussion-Burn rate categories achieved, test run result selection, specific test run problems and solutions.

12.6.1.3 Process Description.

12.6.1.3.1 Wood heater dimensions-volume, height, width, lengths (or other linear dimensions), weight, volume adjustments.

12.6.1.3.2 Firebox configuration-air supply locations and operation, air supply introduction location, refractory location and dimensions, catalyst location, baffle and by-pass location and operation (include line drawings or photographs).

12.6.1.3.3 Process operation during test-air supply settings and adjustments, fuel bed adjustments, draft.

12.6.1.3.4 Test fuel-test fuel properties (moisture and temperature), test fuel crib description (include line drawing or photograph), test fuel loading density.

12.6.1.4 Sampling Locations.

12.6.1.4.1 Describe sampling location relative to wood heater. Include drawing or photograph.

12.6.1.5 Sampling and Analytical Procedures

12.6.1.5.1 Sampling methods-brief reference to operational and sampling procedures and optional and alternative procedures used.

12.6.1.5.2 Analytical methods-brief description of sample recovery and analysis procedures.

12.6.1.6 Quality Control and Assurance Procedures and Results

12.6.1.6.1 Calibration procedures and results-certification procedures, sampling and analysis procedures.

12.6.1.6.2 Test method quality control procedures-leak-checks, volume meter checks, stratification (velocity) checks, proportionality results.

12.6.1.7 Appendices

12.6.1.7.1 Results and Example Calculations. Complete summary tables and accompanying examples of all calculations.

12.6.1.7.2 Raw Data. Copies of all uncorrected data sheets for sampling measurements, temperature records and sample recovery data. Copies of all pretest burn rate and wood heater temperature data.

12.6.1.7.3 Sampling and Analytical Procedures. Detailed description of procedures followed by laboratory personnel in conducting the certification test, emphasizing particular parts of the procedures differing from the methods (*e.g.*, approved alternatives).

12.6.1.7.4 Calibration Results. Summary of all calibrations, checks, and audits pertinent to certification test results with dates.

12.6.1.7.5 Participants. Test personnel, manufacturer representatives, and regulatory observers.

12.6.1.7.6 Sampling and Operation Records. Copies of uncorrected records of activities not included on raw data sheets (*e.g.*, wood heater door open times and durations).

12.6.1.7.7 Additional Information. Wood heater manufacturer's written instructions for operation during the certification test.

12.6.2.1 Wood Heater Identification. Report wood heater identification information. An example data form is shown in Figure 28–4.

12.6.2.2 Test Facility Information. Report test facility temperature, air velocity, and humidity information. An example data form is shown on Figure 28–4.

12.6.2.3 Test Equipment Calibration and Audit Information. Report calibration and audit results for the platform scale, test fuel balance, test fuel moisture meter, and sampling equipment including volume metering systems and gaseous analyzers.

12.6.2.4 Pretest Procedure Description. Report all pretest procedures including pretest fuel weight, burn rates, wood heater temperatures, and air supply settings. An example data form is shown on Figure 28–4.

12.6.2.5 Particulate Emission Data. Report a summary of test results for all test runs and the weighted average emission rate. Submit copies of all data sheets and other records collected during the testing. Submit examples of all calculations.

13.0 Method Performance[Reserved]

14.0 Pollution Prevention[Reserved]

15.0 Waste Management[Reserved]

16.0 Alternative Procedures

16.1 Pellet Burning Heaters. Certification testing requirements and procedures for pellet burning wood heaters are identical to those for other wood heaters, with the following exceptions:

16.1.1 Test Fuel Properties. The test fuel shall be all wood pellets with a moisture content no greater than 20 percent on a wet basis (25 percent on a dry basis). Determine the wood moisture content with either ASTM D 2016–74 or 83, (Method A), ASTM D 4444–92, or ASTM D 4442–84 or 92 (all noted ASTM standards are incorporated by reference—see §60.17).

16.1.2 Test Fuel Charge Specifications. The test fuel charge size shall be as per the manufacturer's written instructions for maintaining the desired burn rate.

16.1.3 Wood Heater Firebox Volume. The firebox volume need not be measured or determined for establishing the test fuel charge size. The firebox dimensions and other heater specifications needed to identify the heater for certification purposes shall be reported.

16.1.4 Heater Installation. Arrange the heater with the fuel supply hopper on the platform scale as described in Section 8.6.1.

16.1.5 Pretest Ignition. Start a fire in the heater as directed by the manufacturer's written instructions, and adjust the heater controls to achieve the desired burn rate. Operate the heater at the desired burn rate for at least 1 hour before the start of the test run.

16.1.6 Test Run. Complete a test run in each burn rate category as follows:

16.1.6.1 Test Run Start. When the wood heater has operated for at least 1 hour at the desired burn rate, add fuel to the supply hopper as necessary to complete the test run, record the weight of the fuel in the supply hopper (the wood heater weight), and start the test run. Add no additional fuel to the hopper during the test run.

Record all the wood heater surface temperatures, the initial sampling method measurement values, the time at the start of the test, and begin the emission sampling. Make no adjustments to the wood heater air supply or wood supply rate during the test run.

16.1.6.2 Data Recording. Record the fuel (wood heater) weight data, wood heater temperature and operational data, and emission sampling data as described in Section 8.12.2.

16.1.6.3 Test Run Completion. Continue emission sampling and wood heater operation for 2 hours. At the end of the test run, stop the particulate sampling, and record the final fuel weight, the run time, and all final measurement values, including all wood heater individual surface temperatures.

16.1.7 Calculations. Determine the burn rate using the difference between the initial and final fuel (wood heater) weights and the procedures described in Section 12.4. Complete the other calculations as described in Section 12.0.

17.0 References

Same as Method 5G, with the addition of the following:

1. Radian Corporation. OMNI Environmental Services, Inc., Cumulative Probability for a Given Burn Rate Based on Data Generated in the CONEG and BPA Studies. Package of materials submitted to the Fifth Session of the Regulatory Negotiation Committee, July 16–17, 1986.

18.0 Tables, Diagrams, Flowcharts, and Validation Data

Table 28–1—Burn Rate Weighted Probabilities for Calculating Weighted Average Emission Rates

Burn rate (kg/hr-dry)	Cumulative probability (P)	Burn rate (kg/hr-dry)	Cumulative probability (P)	Burn rate (kg/hr-dry)	Cumulative probability (P)
0.00	0.000	1.70	0.840	3.40	0.989
0.05	0.002	1.75	0.857	3.45	0.989
0.10	0.007	1.80	0.875	3.50	0.990
0.15	0.012	1.85	0.882	3.55	0.991
0.20	0.016	1.90	0.895	3.60	0.991
0.25	0.021	1.95	0.906	3.65	0.992
0.30	0.028	2.00	0.912	3.70	0.992
0.35	0.033	2.05	0.920	3.75	0.992
0.40	0.041	2.10	0.925	3.80	0.993
0.45	0.054	2.15	0.932	3.85	0.994
0.50	0.065	2.20	0.936	3.90	0.994
0.55	0.086	2.25	0.940	3.95	0.994
0.60	0.100	2.30	0.945	4.00	0.994
0.65	0.121	2.35	0.951	4.05	0.995
0.70	0.150	2.40	0.956	4.10	0.995
0.75	0.185	2.45	0.959	4.15	0.995
0.80	0.220	2.50	0.964	4.20	0.995
0.85	0.254	2.55	0.968	4.25	0.995
0.90	0.300	2.60	0.972	4.30	0.996
0.95	0.328	2.65	0.975	4.35	0.996
1.00	0.380	2.70	0.977	4.40	0.996
1.05	0.407	2.75	0.979	4.45	0.996
1.10	0.460	2.80	0.980	4.50	0.996
1.15	0.490	2.85	0.981	4.55	0.996
1.20	0.550	2.90	0.982	4.60	0.996
1.25	0.572	2.95	0.984	4.65	0.996
1.30	0.620	3.00	0.984	4.70	0.996
1.35	0.654	3.05	0.985	4.75	0.997
1.40	0.695	3.10	0.986	4.80	0.997
1.45	0.722	3.15	0.987	4.85	0.997
1.50	0.750	3.20	0.987	4.90	0.997
1.55	0.779	3.25	0.988	4.95	0.997
1.60	0.800	3.30	0.988	≥5.00	1.000
1.65	0.825	3.35	0.989		

Appliance Identification

Appliance Manufacturer ______________________ Address ______________________

______________________ Agent and phone number ______________________

______________________ Name and Model number ______________________

______________________ Weight ______________________

______________________ Serial number ______________________

Design: Catalytic ____________ Noncatalytic ____________

Insert ____________ Freestanding ____________

Woodheater Description: (Attach figure showing air supplies and firebox configuration)

Materials of construction: ______________________

Air Introduction System: ______________________

Combustion Control Mechanisms: ______________________

Internal Baffles: ______________________

Other Features: ______________________

Catalyst Specifications

Manufacturer ______________________

Serial Number ______________________

Age ______________________(Hours)

Dimensions ______________________(in.)

Firebox Dimensions

Volume ______________________(ft^3)

Length ______________________(in.)

Width ______________________(in.)

Height ______________________(in.)

Adjustments (Describe) ________(in.)

Test Fuel Information

(for each Test Run)

Weight of Test Change ____________(lb)

Number of 2 × 4's ____________

Number of 4 × 4's ____________

Length of test pieces ________(in.)

Fuel Grade (Certification) ____________Fuel

Moisture Content ____________(%)

Diagram or Photograph of Test Fuel Crib

Figure 28-1. Wood Heater and Test Fuel Information.

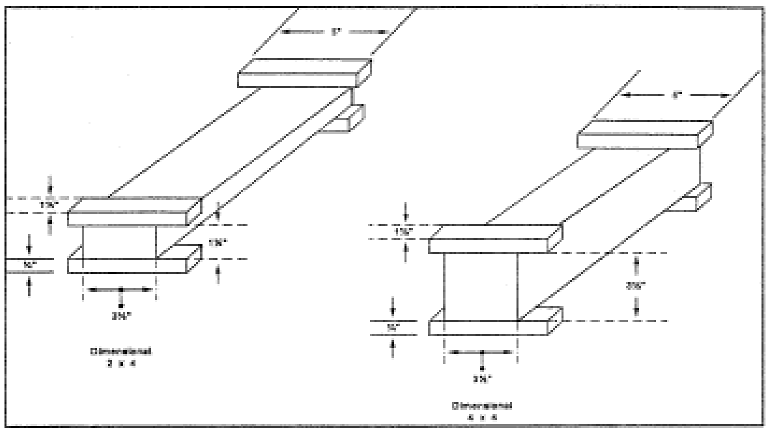


Figure 28-2. Test Fuel Spacer Dimensions.

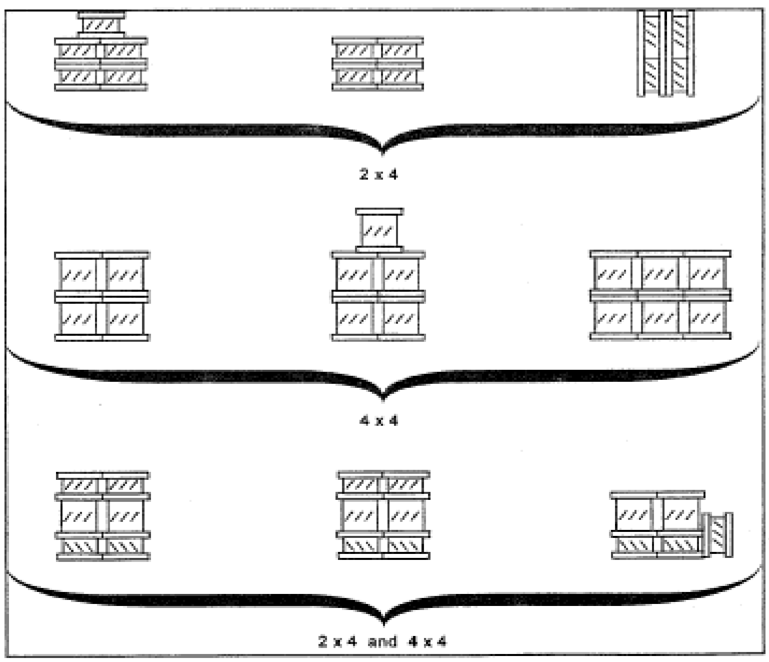


Figure 28-3. Test Fuel Crib Arrangements.

Sheet ________ of ________

Date ____________________

Operator ____________________

Sampling Method ____________________

Wood Heater Information

Manufacturer ____________________

Model ____________________

Primary Air Setting ____________________

Secondary Air Setting ____________________

Thermostat Setting ____________________

Other Settings ____________________

Test Run Information

Test Run No. ____________________

Burn Rate ____________________

Room Temperature before/after ____/____

Barometric Pressure before/after ____/____

Relative Humidity before/after ____/____

Room Air Velocity before/after ____/____

Surface Temp Average Pretest ______ end ______

Test Run Time (minutes)	Test Fuel Scale Reading (lb)	Surface Temperature					Catalyst Temperature		Flue Draft (in. H_2O)
							Inlet (°F)	Outlet (°F)	
(Pretest Period)									
(Test Run Start)									

Figure 28-4. Test Run Wood Heater Operation Data Sheet.

Test Method 28R for Certification and Auditing of Wood Heaters

1.0 Scope and Application

1.1 This test method applies to certification and auditing of wood-fired room heaters and fireplace inserts.

1.2 The test method covers the fueling and operating protocol for measuring particulate emissions, as well as determining burn rates, heat output and efficiency.

1.3 Particulate emissions are measured by the dilution tunnel method as specified in ASTM E2515-11 *Standard Test Method for Determination of Particulate Matter Emissions Collected in a Dilution Tunnel*. (IBR, see § 60.17) Upon request, four-inch filters may be used. Upon request, Teflon-coated glass fiber filters may be used.

2.0 Procedures

2.1 This method incorporates the provisions of ASTM E2780-10 (IBR, see § 60.17) except as follows:

2.1.1 The burn rate categories, low burn rate requirement, and weightings in Method 28 shall be used.

2.1.2 The startup procedures shall be the same as in Method 28.

2.1.3 Manufacturers shall not specify a smaller volume of the firebox for testing than the full usable firebox.

2.1.4 Prior to testing, the heater must be operated for a minimum of 50 hours using a medium burn rate. The conditioning may be at the manufacturer's facility prior to the certification test. If the conditioning is at the certification test laboratory, the pre-burn for the first test can be included as part of the conditioning requirement.

2.2 Manufacturers may use ASTM E871-82 (reapproved 2013) (IBR, see § 60.17) as an alternative to the procedures in Method 5H or Method 28 for determining total weight basis moisture in the analysis sample of particulate wood fuel.

ENGLAND STOVE WORKS. INC.
TEST REPORT

SCOPE OF WORK
EPA EMISSIONS TESTING FOR MODEL 15-SSW01

REPORT NUMBER
103758222MID-001

TEST DATE(S)
01/24/19 THROUGH 2/05/19

ISSUE DATE **[REVISED DATE]**
11/18/19

PAGES
19

DOCUMENT CONTROL NUMBER
GFT-OP-10c (05/10/17)

REPORT ISSUED TO

ENGLAND STOVE WORKS, INC.
589 South Five Forks Road
Monroe, VA 24574-2821

SECTION 1
SCOPE

Intertek Building & Construction (B&C) was contracted by England Stove Works, 589 South Five Forks Road, Monroe, VA 24574-2821 to perform testing in accordance with, ASTM E2515-2011 "Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel", ASTM E2780-2010 "Standard Test Method for Determining Particulate Matter Emissions from Wood Heaters" on their Model 15-SSW01, Wood Fuel Room Heater. Results obtained are tested values and were secured by using the designated test method(s). Testing was conducted at Intertek test facility in Middleton, WI.

This report does not constitute certification of this product nor an opinion or endorsement by this laboratory.

SECTION 2
SUMMARY OF TEST RESULTS

The appliance tests resulted in the following performance:

Particulate Emissions: 1.956 g/hr
Carbon Monoxide: 1.659 g/min
Heating Efficiency: 73.77% (Higher Heating Value Basis)

For INTERTEK B&C:

COMPLETED BY:	Ken Slater	**REVIEWED BY:**	Brian Ziegler
TITLE:	Associate Engineer – Hearth	**TITLE:**	Technical Team Leader - Hearth
SIGNATURE:	Ken Slater	**SIGNATURE:**	
DATE:	02/21/19	**DATE:**	02/21/19

SECTION 3
TEST METHOD(S)

The specimen was evaluated in accordance with the following:

ASTM E2515-2011 - Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel

ASTM E2780-2010 – Standard Test Method for Determining Particulate Matter Emissions from Wood Heaters

SECTION 4
MATERIAL SOURCE

A sample was submitted to Intertek directly from the client. The sample was not independently selected for testing. The test unit was received at Intertek in Middleton, WI on 01/18/19 and was shipped via the client. The unit was assigned sample ID # MID1901181005-001. The unit was inspected upon receipt and found to be in good condition. The unit was set up following the manufacturer's instructions without difficulty.

Following assembly, the unit was placed on the test stand. Prior to beginning the emissions tests, the manufacturer operated the unit for a minimum of 50 hours at high-to-medium burn rates to break in the stove. This break-in period was witnessed by England Stove Works, Inc. staff.

The unit's chimney system and laboratory dilution tunnels were cleaned using standard wire brush chimney cleaning equipment. On 01/24/19 the unit was set-up for testing.

SECTION 5
EQUIPMENT

Equipment	INV Number	Calibration Due	MU
Platform Scale	008	4/10/19	± 27g
Balance	713	4/10/19	± 0.47mg
Data Logger	986	4/10/19	± 0.33°F
Scale	1134	4/10/19	± 27g

Timer	1212	4/4/19	±0.3 sec
Timer	1213	4/4/19	±0.3 sec
Flow Meter	1413	7/18/19	± 17mL/min
Flow Meter	1414	7/18/19	± 17mL/min
Barometer	1420	4/12/19	± 0.24°F,1.7%RH, 0.011 in Hg
Dry Gas Meter	1210	6/27/19	± 0.00284 cfm

SECTION 6
LIST OF OFFICIAL OBSERVERS

NAME	COMPANY
Ken Slater	Intertek B&C
John Wray	England Stove Works, Inc.

SECTION 7
TEST PROCEDURE

From 01/24/19 to 02/05/19, the unit was tested for emissions. The tests were conducted in accordance with ASTM E2780-10. The fuel used for the test run was Douglas Fir.

TEST SET-UP DESCRIPTON

A 6” diameter vertical single wall pipe and insulated chimney system was installed to 15’ above floor level. The single wall pipe extended to 8 feet above the floor and uninsulated chimney extended the remaining height.

AIR SUPPLY SYSTEM

Combustion air enters the rear of the unit, which is directed to the firebox. All gasses exit through the 6” flue located at the top of the heater

TEST FUEL PROPERTIES

Wood used for the testing is nominal 4” x 4” Douglas Fir Cribs. Douglas Fir has a default heating value of 8523 Btu/hr (19810 kJ/kg) and a moisture content between 19% and 25% on a dry basis.

SAMPLING LOCATIONS

Particulate samples are collected from the dilution tunnel at a point 20 feet from the tunnel entrance. The tunnel has two elbows and two mixing baffles in the system ahead of the sampling section. (See Figure 3.) The sampling section is a continuous 13 foot section of 6 inch diameter pipe straight over its entire length. Tunnel velocity pressure is determined by a standard Pitot tube located 60 inches from the beginning of the sampling section. The dry bulb thermocouple is located six inches downstream from the Pitot tube. Tunnel samplers are located 60 inches downstream of the Pitot tube and 36 inches upstream from the end of this section. (See Figure 1.)

Stack gas samples are collected from the steel chimney section 8 feet ± 6 inches above the scale platform. (See Figure 2.)

FIGURE 1 – DILUTION TUNNEL

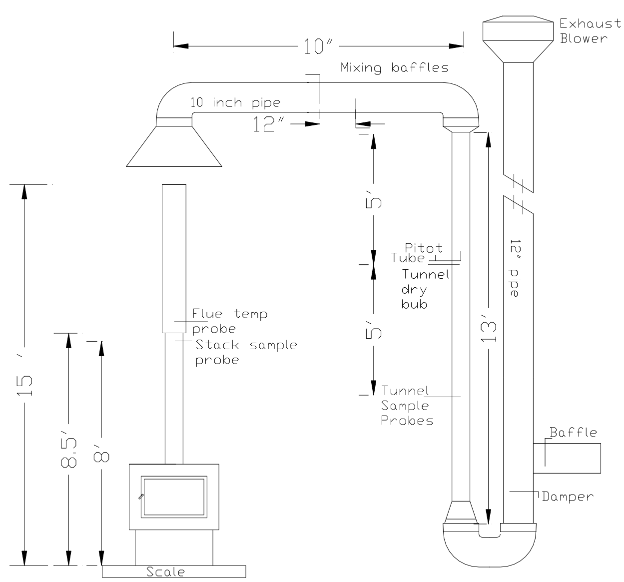
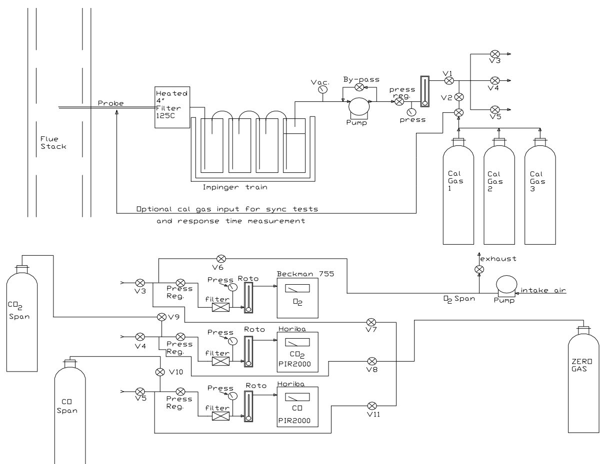


FIGURE 1

FIGURE 2 – STACK GAS SAMPLE TRAIN



ITS FLUE GAS SAMPLE TRAIN

FIGURE 2

FIGURE 3 – DILUTION TUNNEL SAMPLE SYSTEMS

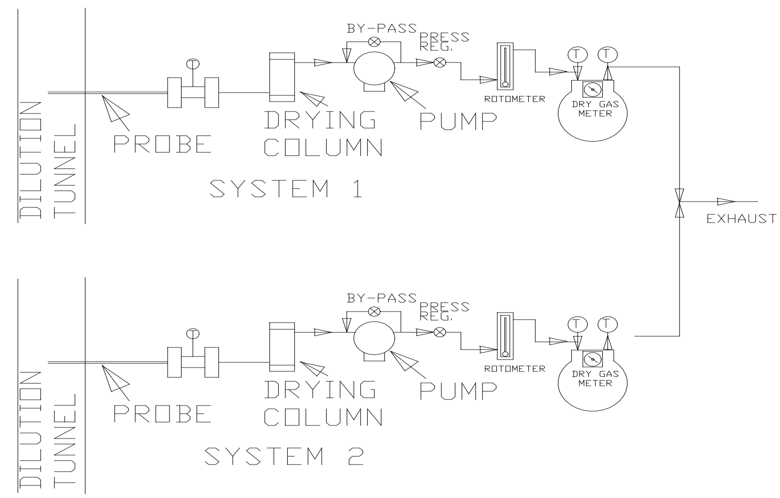


Figure 3

SAMPLING METHODS

PARTICULATE SAMPLING

Particulates were sampled in strict accordance with ASTM E2515-2011. This method uses two identical sampling systems with Gelman A/E 61631 binder free, 47-mm diameter filters. The dryers used in the sample systems are filled with "Drierite" before each test run. In order to measure first-hour emissions rates the a third filter set is prepared at one hour into the test run, the filter sets are changed in one of the two sample trains. The two filter sets used for this train are analyzed individually to determine the first hour and total emissions rate.

INSTRUMENT CALIBRATION

DRY GAS METERS

At the conclusion of each test program the dry gas meters are checked against our standard dry gas meter. Three runs are made on each dry gas meter used during the test program. The average calibration factors obtained are then compared with the six-month calibration factor and, if within 5%, the six-month factor is used to calculate standard volumes. Results of this calibration are contained in Appendix D.

An integral part of the post test calibration procedure is a leak check of the pressure side by plugging the system exhaust and pressurizing the system to 10” W.C. The system is judged to be leak free if it retains the pressure for at least 10 minutes.

The standard dry gas meter is calibrated every 6 months using a Spirometer designed by the EPA Emissions Measurement Branch. The process involves sampling the train operation for 1 cubic foot of volume. With readings made to .001 ft^3, the resolution is .1%, giving an accuracy higher than the ±2% required by the standard.

STACK SAMPLE ROTAMETER

The stack sample rotometer is checked by running three tests at each flow rate used during the test program. The flow rate is checked by running the rotometer in series with one of the dry gas meters for 10 minutes with the rotometer at a constant setting. The dry gas meter volume measured is then corrected to standard temperature and pressure conditions. The flow rate determined is then used to calculate actual sampled volumes.

GAS ANALYZERS

The continuous analyzers are zeroed and spanned before each test with appropriate gases. A mid-scale multi-component calibration gas is then analyzed (values are recorded). At the conclusion of a test, the instruments are checked again with zero, span and calibration gases (values are recorded only). The drift in each meter is then calculated and must not exceed 5% of the scale used for the test.

At the conclusion of each unit test program, a three-point calibration check is made. This calibration check must meet accuracy requirements of the applicable standards. Consistent deviations between analyzer readings and calibration gas concentrations are used to correct data before computer processing. Data is also corrected for interferences as prescribed by the instrument manufacturer’s instructions.

TEST METHOD PROCEDURES

LEAK CHECK PROCEDURES

Before and after each test, each sample train is tested for leaks. Leakage rates are measured and must not exceed 0.02 CFM or 4% of the sampling rate. Leak checks are performed checking the entire sampling train, not just the dry gas meters. Pre-test and post-test leak checks are conducted with a vacuum of 10 inches of mercury. Vacuum is monitored during each test and the highest vacuum reached is then used for the post test vacuum value. If leakage limits are not met, the test run is rejected. During, these tests the vacuum was typically less than 2 inches of mercury. Thus, leakage rates reported are expected to be much higher than actual leakage during the tests.

TUNNEL VELOCITY/FLOW MEASUREMENT

The tunnel velocity is calculated from a center point Pitot tube signal multiplied by an adjustment factor. This factor is determined by a traverse of the tunnel as prescribed in EPA Method 1. Final tunnel velocities and flow rates are calculated from EPA Method 2, Equation 6.9 and 6.10. (Tunnel cross sectional area is the average from both lines of traverse.)

Pitot tubes are cleaned before each test and leak checks are conducted after each test.

PM SAMPLING PROPORTIONALITY

Proportionality was calculated in accordance with ASTM E2515-11. The data and results are included in Appendix C.

DEVIATIONS FROM STANDARD METHOD:

SECTION 8
TEST CALCULATIONS

NOMENCLATURE FOR ASTM E2515:

A = Cross-sectional area of tunnel m2 (ft2).

B_{ws} = Water vapor in the gas stream, proportion by volume (assumed to be 0.02 (2.0 %)).

C_p = Pitot tube coefficient, dimensionless (assigned a value of 0.99).

c_r = Concentration of particulate matter room air, dry basis, corrected to standard conditions, g/dscm (gr/ dscf) (mg/dscf).

c_s = Concentration of particulate matter in tunnel gas, dry basis, corrected to standard conditions, g/dscm (gr/dscf) (mg/dscf).

E_T = Total particulate emissions, g.

F_p = Adjustment factor for center of tunnel pitot tube placement.

$F_p = V_{strav}/V_{scent}$

K_P = Pitot Tube Constant, $34.97 \frac{m}{\sec}\left[\frac{\left(\frac{g}{g}\blacksquare mole\right)(mm\ Hg)}{(K)(mm\ water)}\right]^{\frac{1}{2}}$

or

= Pitot Tube Constant, $85.49 \frac{ft}{\sec}\left[\frac{\left(\frac{lb}{lb}-mole\right)(in\ Hg)}{(R)(in\ water)}\right]^{\frac{1}{2}}$

L_a = Maximum acceptable leakage rate for either a pretest or post-test leak- check, equal to 0.0003 m3/min (0.010 cfm) or 4 % of the average sampling rate, whichever is less.

L_p = Leakage rate observed during the post-test leak-check, m3/min (cfm).

m_p = mass of particulate from probe, mg.

m_f = mass of particulate from filters, mg.

m_g = mass of particulate from filter gaskets, mg.

m_r = mass of particulate from the filter, filter gasket, and probe assembly from the room air blank filter holder assembly, mg.

m_n = Total amount of particulate matter collected, mg.

M_s = the dilution tunnel dry gas molecular weight (may be assumed to be 29 g/g mole (lb/lb mole).

P_{bar} = Barometric pressure at the sampling site, mm Hg (in. Hg).

P_g = Static Pressure in the tunnel (in. water).

P_R = Percent of proportional sampling rate.

P_s = Absolute average gas static pressure in dilution tunnel, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

Q_{std} = Average gas flow rate in dilution tunnel.

$Q_{std} = 60 (1 - B_{ws}) V_s A [T_{std} P_s/T_s P_{std}]$

dscm/min (dscf/min).

T_m = Absolute average dry gas meter temperature, K (R).

T_{mi} = Absolute average dry gas meter temperature during each 10-min interval, *i*, of the test run.

$$T_{mi} = (T_{mi(b)} + T_{mi(e)})/2$$

where:

$T_{mi(b)}$ = Absolute dry gas meter temperature at the beginning of each 10-min test interval, i, of the test run, K (R), and

$T_{mi(e)}$ = Absolute dry gas meter temperature at the end of each 10-min test interval, i, of the test run, K (R).

Ts = Absolute average gas temperature in the dilution tunnel, K (R).

Tsi = Absolute average gas temperature in the dilution tunnel during each 10-min interval, i, of the test run, K (R).

$$T_{si} = (T_{si(b)} + T_{m=si(e)})/2$$

where:

$T_{si(b)}$ = Absolute gas temperature in the dilution tunnel at the beginning of each 10-min test interval, i, of the test run, K (R), and

$T_{si(e)}$ = Absolute gas temperature in the dilution tunnel at the end of each 10-min test interval, i, of the test run, K (R).

V_m = Volume of gas sample as measured by dry gas meter, dcm (dcf).

V_{mc} = Volume of gas sampled corrected for the post test leak rate, dcm (dcf).

V_{mi} = Volume of gas sample as measured by dry gas meter during each 10-min interval, i, of the test run, dcm.

$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions.

$$V_{m(std)} = K_1 V_m Y [(P_{bar} + (\Delta H/13.6))/T_m]$$

where:

K_1 = 0.3855 K/mm Hg for SI units and = 17.64 R/in. Hg for inch-pound units.

$$V_{m(std)} = K_1 V_{mc} Y [(P_{bar} + (\Delta H/13.6))/T_m]$$

where:

V_{mc} = Vm– (Lp– La)u

V_{mr} = Volume of room air sample as measured by dry gas meter, dcm (dcf), and

$V_{mr(std)}$ = Volume of room air sample measured by the dry gas meter, corrected to standard conditions.

$$V_{m(std)} = K_1 V_{mr} Y [(P_{bar} + (\Delta H/13.6))/T_m]$$

Where:

K_1 = 0.3855 K/mm Hg for SI units and = 17.64 R/in. Hg for inch-pound units, and

V_s = Average gas velocity in the dilution tunnel.

$$V_s = F_p K_p C_p (\sqrt{\Delta P_{avg}})(\sqrt{(T_s/P_s M_s)})$$

V_{si} = Average gas velocity in dilution tunnel during each 10-min interval, i, of the test run.

$$V_{si} = F_p K_p C_p (\sqrt{\Delta P_i})(\sqrt{(T_{si}/P_s M_s)})$$

V_{scent} = Average gas velocity at the center of the dilution tunnel calculated after the Pitot tube traverse.

V_{strav} = Average gas velocity calculated after the multipoint Pitot traverse.

Y = Dry gas meter calibration factor.

ΔH = Average pressure at the outlet of the dry gas meter or the average differential pressure across the orifice meter, if used, mm water (in. water).

ΔP_{avg} = Average velocity pressure in the dilution tunnel, mm water (in. water).

ΔP_i = Velocity pressure in the dilution tunnel as measured with the Pitot tube during each 10-min interval, i, of the test run.

$$\Delta P_i = (\Delta P_{i(b)} + \Delta P_{i(e)})/2$$

where:

$\Delta P_{i(b)}$ = Velocity pressure in the dilution tunnel as measured with the Pitot tube at the beginning of each 10-min interval, i, of the test run, mm water (in. water), and

$\Delta P_{i(e)}$ = Velocity pressure in the dilution tunnel as measured with the Pitot tube at the end of each 10-min interval, i, of the test run, mm water (in. water).

θ = Total sampling time, min.

10 = ten min, length of first sampling period.

13.6 = Specific gravity of mercury.

100 = Conversion to percent.

TOTAL PARTICULATE WEIGHT – ASTM E2515

$$M_n = m_p + m_f + m_g$$

PARTICULATE CONCENTRATION – ASTM E2515

$$C_s = K_2(m_n/V_{m(std)})\ \text{g/dscm (g/dscf)}$$

where:

K_2 = 0.001 g/mg

TOTAL PARTICULATE EMISSIONS (g) – ASTM E2515

$$E_T = (C_s - C_r)Q_{std}\theta$$

PROPORTIONAL RATE VARIATION (%) – ASTM E2515

$$PR = [\theta(V_{mi}\ V_s\ T_m\ T_{si})/(10(V_m\ V_{si}\ T_s\ T_{mi})] \times 100$$

MEASUREMENT OF UNCERTAINTY – ASTM E2515

$$MU_{weighing} = \surd 0.1^2 \bullet X$$

GENERAL FORMULA – ASTM E2515

$$uY = \surd((\delta Y/\delta x_1) \times u_1)^2 + \ldots + ((\delta Y/\delta x_n) \times u_n)^2$$

Where:

$\delta Y/\delta x_i$ = Partial derivative of the combining formula with respect to individual measurement xi,

u_i = is the uncertainty associated with that measurement.

TOTAL PARTICULATE EMISSIONS – ASTM E2515

$$E_T = (c_s - c_r)\ Q_{std}\ \theta$$

where:

c_s = sample filter catch/(sample flow rate x test duration), g/dscf,

c_r = room background filter catch/(sample flow x sampling time), g/dscf,

Q_{std} = average dilution tunnel flow rate, dscf/min, and

θ = sampling time, minutes.

MU OF c_s

$c_s = F_c/(Q_{sample} \times \theta) = 0.025/(0.25 \times 180) = 0.0005555$

$\delta c_s/\delta F_c = 1/Q_{sample} \bullet \Theta = 1/0.25 \bullet 180 = 0.0222$

$\delta c_s/\delta Q_{sample} = -F_c/Q^2_{sample} \bullet \Theta = -0.025/0.25^2 \bullet 180 = -0.00222$

$\delta c_s/\delta \Theta = -F_c/Q_{sample} \bullet \Theta^2 = -0.025/0.25 \bullet 180^2 = -0.000003$

$MUc_s = \surd(0.00027 \bullet 0.0222)^2 + (0.0025 \bullet -0.00222)^2$

$\surd + (0.1 \bullet -0.000003)^2 = 0.0000091g$

Thus, c_s would be 0.555 mg/dscf ± 0.0081 mg/dscf at 95% confidence level.

MU OF c_r

$c_r = BG_c/(QBG \times \theta) = 0.002/(0.15 \times 180) = 0.000074$
$\delta c_r/\delta BG_c = 1/Q_{BG} \bullet \Theta = 1/0.15 \bullet 180 = 0.03704$
$\delta c_r/\delta Q_{BG} = -BG_c/Q^2_{BG} \bullet \Theta = -0.002/0.15^2 \bullet 180 = -0.0004938$
$\delta c_r/\delta \Theta = -BG_c/Q_{BG} \bullet \Theta^2 = -0.002/0.15 \bullet 180^2 = -0.0000004$
$MUc_r = \sqrt{}(0.00027 \bullet 0.03704)^2 + (0.0015 \bullet - 0.0004938)^2$
$\sqrt{} + (0.1 \bullet - 0.0000004)^2 = 0.00001g$
Thus, c_r would be 0.074 mg/dscf ± 0.01 mg/dscf at 95% confidence level.

E_T AND MU_{ET}

$E_T = (c_s – c_r)\ Q_{sd}\ \theta = (0.000555 - 0.000074) \times 150 \times 180 = 13.00g$
$\delta E_T/\delta c_s = Q_{std} \bullet \Theta = 150 \bullet 180 = 27{,}000$
$\delta E_T/\delta c_r = Q_{std} \bullet \Theta = 150 \bullet 180 = 27{,}000$
$\delta E_T/\delta Q_{std} = c_s \bullet \Theta – c_r \bullet \Theta = 0.000555 \bullet 180 – 0.000074 \bullet 180 = 0.08667$
$\delta E_T/\delta \Theta = c_s \bullet Q_{std} – c_r \bullet Q_{std} = 0.000555 \bullet 180 – 0.000074 \bullet 180 = 0.07222$
$MU_{ET} = \sqrt{}(27{,}000 \bullet 0.0000081)^2 + (27{,}000 \bullet 0.00001)^2\ (0.08667 \bullet 3)^2$
$\sqrt{} + (0.07222 \bullet 0.1)^2 = 0.436$
Thus the result in this example would be:
ET = 13.00g ± 0.44 g at a 95% confidence level.

EFFICIENCY – CSA B415.1

The change in enthalpy of the circulating air shall be calculated using the moisture content and temperature rise of the circulating air, as follows:

$$\Delta h = \Delta t\ (1.006 + 1.84x)$$

Where:
Δh = change in enthalpy, kJ/kg
Δt = temperature rise, °C
1.006 = specific heat of air, kJ/kg °C
1.84 = specific heat of water vapor, kJ/kg °C
x = humidity ratio, kg/kg

The equivalent duct diameter shall be calculated as follows:

$$ED = 2HW/H+W$$

Where:
ED = equivalent duct diameter
H = duct height, m
W = duct width, m

The air flow velocity shall be calculated as follows:

$$V = F_p \times C_p \times 34.97 \times \sqrt{T/28.56(P_{baro} + P_s)}$$

where

V = velocity, m/s

F_P = Pitot tube calibration factor determined from vane anemometer measurements

C_P = Pitot factor

= 0.99 for a standard Pitot tube or as determined by calibration for a Type S Pitot tube

34.97 = Pitot tube constant

Note: The Pitot tube constant is determined on the basis of the following units: $m/s[g/g\ mole\ (mm\ Hg)/(K)(mm\ H_2O)]^{0.5}$

ΔP = velocity pressure, mm H2O

T = temperature, K

28.56 = molecular weight of air

P_{Baro} = barometric pressure, mm Hg

P_s = duct static pressure, mm Hg

The mass flow rate shall be calculated as follows:

$$m = 3600VAp$$

where:

m = mass flow rate, kg/h

V = air flow velocity, m/s

3600 = number of seconds per hour

A = duct cross-sectional area, m2

p = density of air at standard temperature and pressure (use 1.204 kg/m3)

The rate of heat release into the circulating air shall be calculated using the air flow and change in enthalpy, as follows:

$$\Delta e = \Delta h \times m$$

Where:

Δe = rate of heat release into the circulating air, kJ/h

Δh = change in enthalpy of the circulating air, kJ/kg

m = mass air flow rate, kg/h

The heat output over any time interval shall be calculated as the sum of the heat released over each measurement time interval, as follows:

$$E_t = \sum(\Delta e \times i) \text{ for } i = t_1 \text{ to } t_2$$

Where:

Et = delivered heat output over any time interval t_2–t_1, kJ
i = time interval for each measurement, h

The average heat output rate over any time interval shall be calculated as follows:

$$e_t = E_t / t$$

where
e_t = average heat output, kJ/h
t = time interval over which the average output is desired, h

The total heat output during the burn shall be calculated as the sum of all the heat outputs over each time interval, as follows:

$$E_d = \sum(E_t) \text{ for } t = t_0 \text{ to } t_{final}$$

Where:
E_d = heat output over a burn, kJ/h (Btu/h)
E_t = heat output during each time interval, kJ/h (Btu/h)

The efficiency shall be calculated as the total heat output divided by the total energy input, expressed as a percentage as follows:

$$\text{Efficiency, \%} = 100 \times E_d/I$$

Where:
E_d = total heat output of the appliance over the test period, kJ/kg
I = input energy (fuel calorific value as-fired times weight of fuel charge), kJ/kg (Btu/lb)

SECTION 9

TEST SPECIMEN DESCRIPTION

The model 15-SSW01 Wood Fuel Room Heater is constructed of sheet steel. The outer dimensions are 35.75-inches high, 22-inches wide, and 27-inches deep. The unit has a door located on the front with a viewing glass.

SECTION 10

TEST RESULTS

DESCRIPTION OF TEST RUNS:

RUN #1 (01/24/19): Air control set for a category 1 burn rate with a burn time of 292 minutes. The test was loaded in 60 seconds with the door remaining open for 5 minutes after the fuel was added. Air shutter was fully closed. The fan was set to low position. The results of the test ended as a category 3 burn rate of 1.283 kg/hr. This test was not used.

RUN #2 (01/25/1): Air control set for a category 1 burn rate with a burn time of 167 minutes. The test was loaded in 60 seconds with the door remaining open for 3.5 minutes after the fuel was added. The fan was set to low position. The bi-metal spring did not activate as required and the test resulted in a category 4 with a burn rate of 2.208 kg/hr. This test was not used

RUN #3 (01/28/19): Air control set for a category 1 burn rate with a burn time of 340 minutes. The test was loaded in 60 seconds with the door remaining open for 4.5 minutes after the fuel was added. Air shutter fully closed. The fan was set to low position. The results of the test ended as a category 2 burn rate of 1.155 kg/hr. This test was not used.

RUN #4 (01/29/19): Air control set for a category 2 burn rate with a burn time of 312 minutes. The test was loaded in 60 seconds with the door remaining open for 1 minute after the fuel was added. Air shutter fully closed. The fan was set to low position. The results of the test ended as a category 2 burn rate of 1.217 kg/hr.

RUN #5 (01/31/19): Air control set for a category 4 burn rate with a burn time of 70 minutes. The test was loaded in 60 seconds with the door remaining open for 3 minutes after the fuel was added. Air shutter full open. The fan was set to low position. The filters began to plug after 30 minutes of testing and became completely plugged at 70 minutes, Test was discontinued. This test was not used.

RUN #6 (01/31/19): Air control set for a category 4 burn rate with a burn time of 182 minutes. The test was loaded in 60 seconds with the door remaining open for 5 minutes after the fuel was added. Air shutter full open. The fan was set to high position. The results of the test ended as a category 4 burn rate of 2.021 kg/hr.

RUN #7 (02/01/19): Air control set for a category 3 burn rate with a burn time of 187 minutes. The test was loaded in 60 seconds with the door remaining open for 1 minute after the fuel was added. Air shutter set at 1/8" from fully closed. The fan was set to high position. The results of the test ended as a category 4 burn rate of 2.005 kg/hr. This test was not used.

RUN #8 (02/04/19): Air control set for a category 3 burn rate with a burn time of 260 minutes. The test was loaded in 60 seconds with the door remaining open for 1.75 minutes after the fuel was added. Air shutter set at 1/6" from fully closed. The fan was set to high position. The results of the test ended as a category 3 burn rate of 1.466 kg/hr.

RUN #9 (02/05/19): Air control set for a category 1 burn rate with a burn time of 387 minutes. The test was loaded in 60 seconds with the door remaining open for 5 minutes after the fuel was added. Air shutter fully closed. The fan was set to low position. The results of the test ended as a category 1 burn rate of 0.923 kg/hr.

TABLE 1 – EMISSIONS

RUN#	TEST DATE	BURN RATES (kg/hr)(Dry)	PARTICULATE EMISSION RATE (g/hr)	1st HOUR EMISSIONS (g)	CO EMISSIONS (g/min)	HEATING EFFICIENCY (%HHV)
4	01/29/19	1.217	2.228	11.62	1.62	73.9
6	01/31/19	2.021	2.562	7.137	1.97	73.1
8	02/04/19	1.446	0.858	3.042	1.56	74.4
9	02/05/19	0.923	2.166	9.934	1.49	73.6

TABLE 2 – WEIGHTED AVERAGE CALCULATION

RUN #	BURN RATE	(E) AVERAGE EMISSION RATE g/hr	(CO) AVERAGE EMISSION RATE g/hr	(OHE)	HEAT OUTPUT (Btu/hr)	PROBABILITY	(K) WEIGHTING FACTOR	(KxE)	(KxOHE)
9	0.923	2.166	89.26	73.60	11129.72	0.3129	0.5575	1.2075	41.03
4	1.217	2.228	97.16	73.90	14674.83	0.5575	0.4181	0.9315	30.90
8	1.466	0.858	93.54	74.40	17677.32	0.7310	0.3579	0.3071	26.63
6	2.021	2.562	118.36	73.10	24369.62	0.9154	0.2690	0.6893	19.67
						Totals	1.60248	3.1353	118.22
							Weighted Average Emissions (g/hr)		1.96
							Weighted Average Overall Efficiency (%)		73.77

TABLE 3 – TEST FACILITY CONDITIONS

RUN #	ROOM TEMP BEFORE (°F)	ROOM TEMP AFTER (°F)	BARO PRES BEFORE (in/Hg)	BARO PRES AFTER (in/Hg)	R. H. BEFORE (%)	R. H. AFTER (%)	AIR VEL BEFORE (ft/min)	AIR VEL AFTER (ft/min)
4	69	70	28.82	28.83	14.0	13.0	0	0
6	68	72	29.29	29.26	11.0	11.0	0	0
8	72	71	28.57	28.69	31.0	28.0	0	0
9	70	68	29.10	29.03	24.0	19.0	0	0

TABLE 4 – DILUTION TUNNEL FLOW RATE MEASUREMENTS AND SAMPLING DATA

RUN #	BURN TIME (min)	VELOCITY (ft/sec)	VOLUMETRIC FLOW RATE (dscf/min)	AVG TEMP (°R)	SAMPLE VOLUME (dscf)		PARTICULATE CATCH (mg)	
					1	2	1	2
4	312	18.77	201.70	546.31	73.93	73.82	14.30	12.90
6	182	17.68	186.44	565.30	43.94	43.84	10.50	9.60
8	260	19.60	207.01	551.99	59.37	59.30	4.60	3.60
9	387	22.72	248.89	540.19	90.71	90.58	14.10	12.20

TABLE 5 - DILUTION TUNNEL DUAL TRAIN PRECISION

RUN #	SAMPLE RATIOS		TOTAL EMISSIONS (g)		DEVIATION (%)	DEVIATION (g/kg)
	TRAIN 1	TRAIN 2	TRAIN 1	TRAIN 2		
4	851.22	852.54	12.17	11.00	5.07	0.186
6	772.32	774.01	8.11	7.43	4.37	0.111
8	906.62	907.67	4.17	3.27	12.14	0.142
9	1061.85	1063.42	14.97	12.97	7.15	0.336

TABLE 6 - GENERAL SUMMARY OF RESULTS

RUN #	BURN RATE (kg/hr)(dry) (OVERALL)	INITIAL DRAFT (in/H_2O)	RUN TIME (min)	AVERAGE DRAFT (in/H_2O)
4	1.217	0.033	312	0.026
6	2.021	0.028	182	0.035
8	1.466	0.046	260	0.029
9	0.923	0.036	387	0.021

TABLE 7 - CSA B415.1 RESULTS

BURN RATE (kg/hr)(dry)	CO EMISSIONS (g/min)	HEATING EFFICIENCY (% HHV)	HEAT OUTPUT (Btu/hr)
Run #4 – 1.20	1.62	73.9	16,622
Run #6 – 2.01	1.97	73.1	27,546
Run #8 – 1.44	1.56	74.4	20,162
Run #9 – 0.91	1.49	73.6	12,617

SECTION 11
CONCLUSION

This test demonstrates that this unit is an affected facility under the definition given in the regulation. The emission rate of 1.956 g/hr meets the EPA requirements for the Step 2 limits.

Model 15-SSW01 is a representative for similar models 50-SHSSW01 and 50-TRSSW01. All models have the same internal design, electrical components, and controls. The only differences are external cosmetic designs.

SECTION 12
PHOTGRAPHS

Photo No. 1

Final security wrap

SECTION 13
REVISION LOG

REVISION #	DATE	PAGES	REVISION
0	11/18/19	N/A	Original Report Issue

Intertek

Date 1-29-19
Tech [signature] Ken Slater

Manufacturer: England Stoves Model : 15-SSW01
Job #_G103758222 Run #4 CAT C

PRETEST DILUTION TUNNEL TRAVERSE RUN

Barometric pressure (P_{bar}) 28.82 (inches Hg.) Static pressure (P_q) .336 (inches w.c.)

Inside diameter: Port A ____in Port B ____in Tunnel cross sectional area: ____Ft^2

Pitot tube type: Standard

Traverse Point	Position (inches)	Velocity Head Δ_p (inches H_2O)	Tunnel Temperature (°F)	$\sqrt{\Delta p}$
A-Centroid	3.00	.103		
B-Centroid	3.00	.104		
A-1	0.50	.090		
A-2	1.50	.098		
A-3	4.50	.101		
A-4	5.50	.094		
B-1	0.50	.090		
B-2	1.50	.100		
B-3	4.50	.095		
B-4	5.50	.089		
		AVERAGE		

Adjustment factor application

Pitot correction 9647

Where,
C_p = Pitot tube coefficient = 0.99 for standard pitot
Δ_p = manometer reading (inches H_2O)
T_s = average absolute dilution tunnel temperature (°F + 460)
P_s = absolute dilution tunnel gas pressure or Pbar + P_g

P_g = static pressure $\frac{inches H_2O}{13.6}$

M_s = 28.56, wet molecular weight of stack gas (alternatively, it may be measured)

Adjustment factor for alternative Pitot tube placement:

$$V_s = K_p C_p F_p \left(\sqrt{\Delta_p}\right) AVG \sqrt{\frac{T_s}{P_s M_s}} \qquad V_s = K_p C_p \left(\sqrt{\Delta_p}\right) avg. \sqrt{\frac{T_s}{P_s M_s}} \qquad F_p = \frac{\left(\sqrt{\Delta_p}\right) avg}{\left(\sqrt{\Delta_p}\right) centroid}$$

K_p = 85.49 Pitot tube constant, (conversion factor for English units)

$\left(\sqrt{\Delta_p}\right) avg.$ = Average of the square roots of the velocity heads ($)_p$) measured at each traverse point.

$\left(\sqrt{\Delta_p}\right) centroid$ = Average of the square roots of the velocity heads measured at the tunnel centroid (inches of H_2O)

Intertek

Manufacturer: England Stoves Model : 15-SSW01 Run #4 CAT Z

Job #_G103758222

Date 1-29-19

Tech [signature] Ken Slater

Pre/Post Checks

	Pre-Test	Post-Test
Facility Conditions:		
Air Velocity	✓ fpm	✓ fpm
Smoke Capture Check	Ø	Ø
Wood Heater Conditions:		
Date Wood Heater Stack Cleaned	1-21-19	
Date Dilution Tunnel Cleaned	1-21-19	
Induced Draft Check	✓	✓
Tunnel Velocity	.112	.109
Pitot Leak Check:		
Side A	✓	✓
Side B	✓	✓

Temperature System:

Ambient (65°- 90°F)	°F

Proportional Checks:

CO Analyzer Drift Check	✓
CO_2 Analyzer Check	✓
O_2 Analyzer Check	✓
Thermocouple check	

Sampling Train ID Numbers:

	Train 1	Train 2	Train 3
Probe	I	J	1
Filter Front	37	39	1
Filter Back	38	40	2
Filter Thermocouple	19	22	
Filter 5G-3 (<90°F)			

mn

Intertek

Manufacturer: England Stoves ___ ________ Model : 15-SSW01 _______ Date 1-29-19
Job # G103758222 ________ Run #4 CAT 2 _______ Tech [signature] Ken Slater

Pre-Test Scale Audit

Scale Type	Audit Weight	Measured Weight
Platform	2500 lbs., Class F	25.00 lbs.
Wood	10.00 lbs., Class F	10.00 lbs.
Analytical	100.000 mg, Class S	100.000 mg.

LIMITS OF WEIGHT RANGES

ANALYTICAL SCALE:.. 50%-150% of dry filter weight, ± 0.1 mg
PLATFORM SCALE..20%-80% of ideal test load weight, ± 0.1 lbs. or 1%
WOOD SCALE..20%-80% of ideal test load weight, ± 0.1 lbs. or 1%

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Manufacturer: England Stoves___ _______________ Model : 15-SSW01____________
Job #_G103758222______________________ Run #4 CAT 2

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Date 1-29-'9
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SAMPLING EQUIPMENT CHECK OUT

Leakage Checks Tunnel Samplers

Leakage Checks Tunnel Samplers

	SAMPLE 1		SAMPLE 2		SAMPLE 3	
Unplugged Flow Rate = .25cfm	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-test	Post Test
Vacuum (inches Hg.)	10"	10"	10"	10"	10"	10"
Final 1 minute DGM (ft^3)	Ø	Ø	Ø	0	426.086	435.879
Initial 1 minute DGM (ft^3)	Ø	Ø	Ø	0	426.086	435.879
Change (C) (ft^3)	Ø	Ø	Ø	0	Ø	Ø
Allowable leakage .04 x Sample rate or .02cfm	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
Check OK	✓	✓	✓	✓	✓	✓

Leakage Checks Flue Gas Sampler

Plugged Probe	Pre Test	Post Test
Vacuum (inches Hg.)	10"	10"
Rotometer Reading (mm)	Ø	Ø
Flow Rate (CFM)	Ø	Ø
Allowable (.04 x Sample Rate)		
Check OK	✓	✓

Intertek

Manufacturer: England Stoves
Job # G103758222
Model : 15-SSW01
Run #4 CAT 2
Date 1-29-19
Tech [signature] Ken Slater

CONTINUOUS ANALYZERS

Pre-Test (Adjust and Record)

	ZERO		SPAN		CAL. (Record Only)	
CO_2	Ø	Ø	24.88	24.88	11.95	11.99
CO	Ø	Ø	8.976	8.976	4.06	4.001
O_2	Ø	Ø	20.95	20.95	9.99	10.01
	Actual	Should Be	Actual	Should Be	Actual	Should Be

Post Test (Record Only)

	Zero	Span	Cal.	Zero Drift	Span Drift	Cal. Drift	OK?	Not OK*
CO_2	0.01	24.75	11.87	.01	.13	.12	✓	
CO	-0.09	8.52	3.80	.09	.45	.26	✓	
O_2	0.02	20.89	9.95	.02	.06	.04	✓	

* Greater than ± 5% of the range used.

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Manufacturer: England Stoves___ ________________ Model : 15-SSW01____________
Job #_G103758222______________________ Run #4 ~~CAT~~ 2

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Date 1-29-19
Tech Ken Slater

TEST DATA LOG

RAW DRY GAS METER READINGS

	System 1	System 2	System 3
Final (ft^3)	77.31	77.29	435.859
Initial (ft^3)	0	0	426.086

AMBIENT CONDITIONS

	Start	End
Barometer. (inches Hg)	72.5	70.8
Temperature (°F)	14	13
Humidity (%)	28.82	28.83

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Manufacturer: England Stoves___ _______________ Model : 15-SSW01____________
Job #_G103758222____________________ Run #4 CAT 2

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Date 1-29-14
Tech [signature]
Ken Slater

READING #	REAL TIME	ELAPSED TIME	DGM 1	ROTOMETER 1	DGM 2	ROTOMETER 2	DGM 3	ROTOMETER 3	DRAFT	MAX DGM PRESSURE
0	9:07	0					426.086			
1		10					427.660			
2		20					429.300			
3		30					430.930			
4		40					432.560			
5		50					434.290			
6		60					435.859			
7		70								
8		80								
9		90								
10		100								
11		110								
12		120								
13		130								
14		140								
15		150								
16		160								
17		170								
18		180								
19		190								
20		200								
21		210								
22		220								
23		230								
24		240								
25		250								
26		260								
27		270								
28		280								
29		290								
30		300								
31		310								
32		320								
33		330								
34		340								
35		350								
36		360								

Intertek

Manufacturer: England Stoves___ ________________ Model : 15-SSW01____________
Job #_G103758222______________________ Run_#4 CAT2

Page 8 of 10
Date 1-29-19
Tech [signature]
Ken Slater

COMMENTS

7:13 AM - PRETEST STARTED

907 AM TEST STARTED
DOOR REMAINED open for 1 MINUTE
Air shutter fully closed
SHUTTER ACTIVATED @ 4 MINUTES

Intertek

Date 1-29-19
Tech Ken Slater

Manufacturer: England Stoves
Job #_G103758222
Model : 15-SSW01
Run #4 CAT 2

FUEL DATA

PRE-TEST LOAD

FUEL DESCRIPTION:

Kindling weight: 4.6 lbs. Consisting of: Scrap and paper Fire lit Time:

Pre-test load weight: 16.15 lbs. Consisting of: 2X4X________inches Time loaded:

Pre-test moisture content: Uncorrected:________% Corrected Dry:________% Wet:________%

Test Air Control Settings:________________________________Time:

Test Unit Fan Settings:________________________________Time:

TEST LOAD

	Lower Limit	Ideal	Upper Limit
Test Load Weight:	15.12 Lbs.	16.80 lbs.	18.48 Lbs.

Fire Box Volume:	2.4 Ft.^{3}	Ideal Length:	Inches
Load Volume:	Ft.^{3}	Loading Density:	lbs/ft^3
Spacer weight	2.81 Lbs	Load Density:	lbs/ft^3

Piece Size	Weight	Meter Moisture Content (% dry)*		
2 x 4 x 15 in.	1.53 lbs.	19.7 %	20 %	21 %
2 x 4 x 15 in	1.38 lbs.	19.9 %	18.1 %	22.1 %
2 x 4 x 15 in	1.20 lbs.	19.3 %	20.2 %	19.7 %
2 x 4 x 15 in	1.33 lbs.	19.2 %	19.4 %	19.9 %
2 x 4 x 15 in	1.21 lbs.	20.7 %	18.4 %	19.7 %
4 x 4 x 15 in	3.60 lbs.	18.5 %	18 %	18.6 %
4 x 4 x 15 in	3.65 lbs.	20.5 %	20.8 %	20.8 %
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%

TEST LOAD WEIGHT: 16.71 lbs. **DRY WEIGHT:** 6.33 kg.

AVERAGE MOISTURE CONTENT:

(DRY) 19.73 % CORRECTED TO TWO PIN: (DRY) 19.73 % (WET) 16.48 %

COAL BED RANGE:

3.4 lbs. to 4.1 lbs. (10% to 15% of test load)

________lbs. to ________lbs. (20% to 25% of test load)

TEST CHARGE:

Time loaded: 9:07 Coal bed weight: 3.7 lbs. Coal bed weight = ________% of test load weight

CHARCOALIZATION: good |--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--| poor

Intertek

Manufacturer : ENGLAND STOVES
Job # G103758222

Model: 15-SSW01
Run #4 CAT 2

Page 10 of 10
Date 1-29-19
Tech K. Slater

DILUTION TUNNEL PARTICULATE SAMPLER DATA

FILTER TYPE: Gelman 47mm A/E

Pre-test Weight Record		SYSTEM 1 Probe & Housing Number	SYSTEM 1 Front Filter + gasket Number	SYSTEM 1 Back Filter + gasket Number	SYSTEM 2 Probe & Housing Number	SYSTEM 2 Front Filter + gasket Number	SYSTEM 2 Back Filter + gasket Number	SYSTEM 3 Probe & Housing Number	SYSTEM 3 Front Filter + gasket Number	SYSTEM 3 Back Filter + gasket Number	Temp	Humidity
Date	Time	I	37	38	J	39	40	1	1	2	°F	%
1-22-19	10:00 A	89.6811	1.8610	1.8347	92.0499	3.2763	3.3407	91.3675	1.8449	1.7892	61.9	19
1-29-19	7:00 A	89.6909	1.8608	1.8346	92.0497	3.2761	3.3406	91.3673	1.8447	1.7891	64.4	14
		Total:	3.6954		Total:	6.6167		Total:	3.6338			

Post-test Weight Record		SYSTEM 1 Probe & Housing Number	SYSTEM 1 Combined Filter/gasket Number	SYSTEM 2 Probe & Housing Number	SYSTEM 2 Combined Filter/gasket Number	SYSTEM 3 Probe & Housing Number	SYSTEM 3 Combined Filter/gasket Number	Temp	Humidity
Date	Time	I	37+38	J	39+40	1	1+2	°F	%
1-29-19	2:28	89.6823	3.7111	92.0504	6.6302	91.3682	3.6444	71.8	13
1-31-19	7:47	89.6809	3.7097	92.0497	6.6296	91.3673	3.6428	56.9	11
2-1-19	8:18	—	3.7097	—	6.6296	—	3.6428	64.5	13
2-4-19	7:02	—	3.7097	—	6.6295	—	3.6428	68.9	31

Dry Down Weight

Date	Time	P1	F1	P2	F2	P3	F3	Gr/hr	Lb/MMbtu
1-29-19	2:28	1.4	15.7	.7	13.5	.9	10.6	2.564	1.217
1-31-19	7:47	0	14.3	0	12.9	0	9.0	2.228	
2-1-19	8:18	0	14.3	0	12.9	0	9.0		
2-4-19	7:02	0	14.3	0	12.8	0	9.0		

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Page 1 of 10
Date 7-31-19
Tech Ken Slater

Manufacturer: England Stoves___ ________________ Model : 15-SSW01____________
Job #_G103758222______________________ Run # 6 CAT 4

PRETEST DILUTION TUNNEL TRAVERSE RUN

Barometric pressure (P_{bar}) 29.29 (inches Hg.) Static pressure (P_q) .313 (inches w.c.)
Inside diameter: Port A _____in Port B ___in Tunnel cross sectional area: ____Ft^2
Pitot tube type: Standard

Traverse Point	Position (inches)	Velocity Head Δ_p (inches H_2O)	Tunnel Temperature (°F)	$\sqrt{\Delta p}$
A-Centroid	3.00	.102		
B-Centroid	3.00	.103		
A-1	0.50	.089		
A-2	1.50	.097		
A-3	4.50	.100		
A-4	5.50	.095		
B-1	0.50	.089		
B-2	1.50	.099		
B-3	4.50	.095		
B-4	5.50	.088		
		AVERAGE		

Adjustment factor application

Pitot correction .9659

Where,
C_p = Pitot tube coefficient = 0.99 for standard pitot
Δ_p = manometer reading (inches H_2O)
T_s = average absolute dilution tunnel temperature (°F + 460)
P_s = absolute dilution tunnel gas pressure or Pbar + P_g

P_g = static pressure $\frac{inchesH_2O}{13.6}$

M_s = 28.56, wet molecular weight of stack gas (alternatively, it may be measured)

Adjustment factor for alternative Pitot tube placement:

$$V_s = K_p C_p F_p\left(\sqrt{\Delta_p}\right)AVG\sqrt{\frac{T_s}{P_s M_s}}$$

$$V_s = K_p C_p\left(\sqrt{\Delta_p}\right)avg.\sqrt{\frac{T_s}{P_s M_s}}$$

$$F_p = \frac{\left(\sqrt{\Delta_p}\right)avg}{\left(\sqrt{\Delta_p}\right)centroid}$$

K_p = 85.49 Pitot tube constant, (conversion factor for English units)

$\left(\sqrt{\Delta_p}\right)avg.$ = Average of the square roots of the velocity heads ($)_p$) measured at each traverse point.

$\left(\sqrt{\Delta_p}\right)centroid$ = Average of the square roots of the velocity heads measured at the tunnel centroid (inches of H_2O)

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Date 1-31-19
Tech [signature] Ken Slater

Manufacturer: England Stoves
Model : 15-SSW01
Job # G103758222
Run #6 CAT 4

Pre/Post Checks

	Pre-Test	Post-Test
Facility Conditions:		
Air Velocity	✓ fpm	✓ fpm
Smoke Capture Check	0	0
Wood Heater Conditions:		
Date Wood Heater Stack Cleaned	1-21-19	
Date Dilution Tunnel Cleaned	1-21-19	
Induced Draft Check	✓	✓
Tunnel Velocity	.101	.099
Pitot Leak Check:		
Side A	✓	✓
Side B	✓	✓
Temperature System:		
Ambient (65°- 90°F)		✓ °F
Proportional Checks:		
CO Analyzer Drift Check		✓
CO_2 Analyzer Check		✓
O_2 Analyzer Check		✓
Thermocouple check		

Sampling Train ID Numbers:	Train 1	Train 2	
Probe	5	6	7
Filter Front	9	11	13
Filter Back	10	12	14
Filter Thermocouple	19	22	
Filter 5G-3 (<90°F)			

mn

Manufacturer: England Stoves
Job # G103758222

Model : 15-SSW01
Run 6 QAT 4

Page 3 of 10
Date 1-31-19
Tech [signature] Ken Slater

Pre-Test Scale Audit

Scale Type	Audit Weight	Measured Weight
Platform	25.00 lbs., Class F	25.00 lbs.
Wood	10.00 lbs., Class F	10.00 lbs.
Analytical	100.000 mg, Class S	100.000 mg.

LIMITS OF WEIGHT RANGES

ANALYTICAL SCALE: .... 50%-150% of dry filter weight, ± 0.1 mg
PLATFORM SCALE .... 20%-80% of ideal test load weight, ± 0.1 lbs. or 1%
WOOD SCALE .... 20%-80% of ideal test load weight, ± 0.1 lbs. or 1%

Intertek

Manufacturer: England Stoves___ ________________ Model : 15-SSW01____________
Job #_G103758222______________________ Run_#6 CAT 4

Page 4 of 10
Date 1-31-19
Tech [signature]
Ken Slater

SAMPLING EQUIPMENT CHECK OUT

Leakage Checks Tunnel Samplers
Leakage Checks Tunnel Samplers

	SAMPLE 1		SAMPLE 2		SAMPLE 3	
Unplugged Flow Rate = .25cfm	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-test	Post Test
Vacuum (inches Hg.)	10"	10"	10	10	10	10
Final 1 minute DGM (ft^3)	0	0	0	0	443.635	453.416
Initial 1 minute DGM (ft^3)	0	0	0	0	443.635	453.416
Change (C) (ft^3)	0	0	0	0	0	0
Allowable leakage .04 x Sample rate or .02cfm	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
Check OK	✓	✓	✓	✓	✓	✓

Leakage Checks Flue Gas Sampler

Plugged Probe	Pre Test	Post Test
Vacuum (inches Hg.)	10	10"
Rotometer Reading (mm)	0	0
Flow Rate (CFM)	0	0
Allowable (.04 x Sample Rate)		
Check OK	✓	✓

Intertek

Manufacturer: England Stoves___ ________________ Model : 15-SSW01____________
Job #_G103758222______________________ Run #6 CAT 4

Page 5 of 10
Date 1-31-19
Tech [signature]
Ken Slater

CONTINUOUS ANALYZERS

Pre-Test (Adjust and Record)

	ZERO		SPAN		CAL. (Record Only)	
CO_2	0	0	24.88	24.88	11.97	11.99
CO	0	0	8.976	8.976	4.03	4.001
O_2	0	0	20.95	20.95	10.00	10.01
	Actual	Should Be	Actual	Should Be	Actual	Should Be

Post Test (Record Only)

	Zero	Span	Cal.	Zero Drift	Span Drift	Cal. Drift	OK?	Not OK*
CO_2	-0.05	24.83	11.89	.05	.05	.08	✓	
CO	-0.07	8.71	3.87	.07	.26	.16	✓	
O_2	0.02	20.95	9.97	.02	0	.03	✓	

* Greater than ± 5% of the range used.

Intertek

Manufacturer: England Stoves
Job #_G103758222
Model : 15-SSW01
Run #6 CAT 4
Date 1-31-19
Tech [signature] Ken Slater

TEST DATA LOG

RAW DRY GAS METER READINGS

	System 1	System 2	System 3
Final (ft^3)	45.75	45.33	453.495
Initial (ft^3)	0	0	443.635

AMBIENT CONDITIONS

	Start	End
Barometer. (inches Hg)	29.29	29.26
Temperature (°F)	71.0	73.4
Humidity (%)	11	11

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Date 1-31-19
Tech [signature] Ken Slater

Manufacturer: England Stoves
Job #_G103758222
Model : 15-SSW01
Run# 6 CAT 4

READING #	REAL TIME	ELAPSED TIME	DGM 1	ROTOMETER 1	DGM 2	ROTOMETER 2	DGM 3	ROTOMETER 3	DRAFT	MAX DGM PRESSURE
0	12:25	0					443.635			
1		10					445.215			
2		20					446.850			
3		30					448.585			
4		40					450.110			
5		50					451.730			
6		60					453.495			
7		70								
8		80								
9		90								
10		100								
11		110								
12		120								
13		130								
14		140								
15		150								
16		160								
17		170								
18		180								
19		190								
20		200								
21		210								
22		220								
23		230								
24		240								
25		250								
26		260								
27		270								
28		280								
29		290								
30		300								
31		310								
32		320								
33		330								
34		340								
35		350								
36		360								

Intertek

Manufacturer: England Stoves___ ______________ Model : 15-SSW01___________ Date 1-31-19

Job #_G103758222_____________________ Run #6 CAT 4 Tech [signature] Ken Slater

FUEL DATA

PRE-TEST LOAD

FUEL DESCRIPTION:

Kindling weight: 4.5 lbs. Consisting of: Scrap and paper Fire lit Time:

Pre-test load weight: 16.03 lbs. Consisting of: 2X4X________inches Time loaded:

Pre-test moisture content: Uncorrected:________% Corrected Dry:_________% Wet:_________%

Test Air Control Settings:____Time:

Test Unit Fan Settings:____Time:

TEST LOAD

	Lower Limit	Ideal	Upper Limit
Test Load Weight:	15.12 Lbs.	16.80 lbs.	18.48 Lbs.

Fire Box Volume:	24 Ft.^{3}	Ideal Length:	Inches
Load Volume:	Ft.^{3}	Loading Density:	lbs/ft^3
Spacer weight	2.96 Lbs	Load Density:	lbs/ft^3

Piece Size	Weight	Meter Moisture Content (% dry)*		
4 x 4 x 15 in.	3.43 lbs.	22.7 %	22.1 %	22.2 %
4 x 4 x 15 in	3.48 lbs.	22.7 %	22.3 %	22.5 %
2 x 4 x 15 in	1.36 lbs.	18.0 %	18.1 %	18.3 %
2 x 4 x 15 in	1.29 lbs.	21.8 %	21.0 %	22.5 %
2 x 4 x 15 in	1.2 lbs.	21.2 %	21.4 %	22.2 %
2 x 4 x 15 in	1.42 lbs.	19.1 %	18.6 %	18.9 %
2 x 4 x 15 in	1.22 lbs.	21.1 %	20.8 %	22.8 %
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%

TEST LOAD WEIGHT: 16.35 lbs. **DRY WEIGHT:** 6.13 kg.

AVERAGE MOISTURE CONTENT:

(DRY) 20.97% CORRECTED TO TWO PIN: (DRY) 20.97% (WET) 17.33%

COAL BED RANGE:

3.3 lbs. to 4.0 lbs. (10% to 15% of test load)

__________lbs. to __________lbs. (20% to 25% of test load)

TEST CHARGE:

Time loaded: 12:25 Coal bed weight: 3.9 lbs. Coal bed weight = ________% of test load weight

CHARCOALIZATION: good |--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--| poor

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Date 7-31-19
Tech [signature]
Ken Slater

Manufacturer: England Stoves
Job # G103758222

Model : 15-SSW01
Run # 6 CAT 4

COMMENTS

10:32 AM PRETEST STARTED

12:25 TEST ~~[illegible]~~ STARTED
DOOR REMAINED open for 5 MINUTES
Shutter full open.

Intertek

Manufacturer : England Stoves
Job # G103758222

Model: 15-SSW01
Run #6 CAT 4

Page 10 of 10
Date 1-31-19
Tech Ken Slaton

DILUTION TUNNEL PARTICULATE SAMPLER DATA

FILTER TYPE: Gelman 47mm A/E

Pre-test Weight Record		SYSTEM 1 Probe & Housing Number	SYSTEM 1 Front Filter + gasket Number	SYSTEM 1 Back Filter + gasket Number	SYSTEM 2 Probe & Housing Number	SYSTEM 2 Front Filter + gasket Number	SYSTEM 2 Back Filter + gasket Number	SYSTEM 3 Probe & Housing Number	SYSTEM 3 Front Filter + gasket Number	SYSTEM 3 Back Filter + gasket Number	Temp	Humidity
Date	Time	5	9	10	6	11	12	7	13	14	°F	%
1-29-19	10:00A	91.6659	1.8394	1.8210	91.5349	1.8402	1.8460	90.9218	1.8233	3.3003		
1-31-19	12:00P	91.0058	1.8392	1.8209	91.5349	1.8401	1.8460	90.9217	1.8231	3.3000	71.1	11
		Total:	3.6601		Total:	3.6861		Total:	5.1231			

Post-test Weight Record		SYSTEM 1 Probe & Housing Number	SYSTEM 1 Combined Filter/gasket Number	SYSTEM 2 Probe & Housing Number	SYSTEM 2 Combined Filter/gasket Number	SYSTEM 3 Probe & Housing Number	SYSTEM 3 Combined Filter/gasket Number	Temp	Humidity
Date	Time	5	9+10	6	11+12	7	13+14	°F	%
1-31-19	3:17	91.0058	3.6716	91.5349	3.6965	90.9217	5.1302	73.2	12%
2-1-19		—	3.6706	—	3.6957	—	5.1292	64.5	12
2-4-19	7:02	—	3.6706	—	3.6957	—	5.1292	68.5	31
2-5-19	6:24	—	3.6706	—	3.6957	—	5.1292	66.9	22

Dry Down Weight

Date	Time	P1	F1	P2	F2	P3	F3	Gr/hr	Lb/MMbtu
1-31-19		0	11.5	0	10.4	0	7.1	2.791	2.021
2-1-19		0	10.5	0	9.6	0	6.1	2.562	
2-4-19	7:02	0	10.5	0	9.6	0	6.1	2.562	
2-5-19		0	10.5	0	9.6	0	6.1	2.562	

Intertek

Manufacturer: England Stoves___ _______________ Model : 15-SSW01____________ Page 1 of 10
Job #_G103758222____________________ Run #9 CAT 1 Date 2-5-19
Tech [signature] Ken Slater

PRETEST DILUTION TUNNEL TRAVERSE RUN

Barometric pressure (P_{bar}) 29.10 (inches Hg.) Static pressure (P_q) .343 (inches w.c.)
Inside diameter: Port A _____in Port B ___in Tunnel cross sectional area: ____Ft^2
Pitot tube type: Standard

Traverse Point	Position (inches)	Velocity Head Δ_p (inches H_2O)	Tunnel Temperature (°F)	$\sqrt{\Delta p}$
A-Centroid	3.00	.105		
B-Centroid	3.00	.108		
A-1	0.50	.086		
A-2	1.50	.101		
A-3	4.50	.101		
A-4	5.50	.090		
B-1	0.50	.080		
B-2	1.50	.104		
B-3	4.50	.105		
B-4	5.50	.088		
		AVERAGE		

Adjustment factor application

Pitot correction .9575

Where,
C_p = Pitot tube coefficient = 0.99 for standard pitot
Δ_p = manometer reading (inches H_2O)
T_s = average absolute dilution tunnel temperature (°F + 460)
P_s = absolute dilution tunnel gas pressure or Pbar + P_g

P_g = static pressure $\frac{inches H_2O}{13.6}$

M_s = 28.56, wet molecular weight of stack gas (alternatively, it may be measured)

Adjustment factor for alternative Pitot tube placement:

$$V_s = K_p C_p F_p \left(\sqrt{\Delta_p}\right) AVG \sqrt{\frac{T_s}{P_s M_s}} \qquad V_s = K_p C_p \left(\sqrt{\Delta_p}\right) avg. \sqrt{\frac{T_s}{P_s M_s}} \qquad F_p = \frac{\left(\sqrt{\Delta_p}\right) avg}{\left(\sqrt{\Delta_p}\right) centroid}$$

K_p = 85.49 Pitot tube constant, (conversion factor for English units)

$\left(\sqrt{\Delta_p}\right) avg.$ = Average of the square roots of the velocity heads $()_p$) measured at each traverse point.

$\left(\sqrt{\Delta_p}\right) centroid$ = Average of the square roots of the velocity heads measured at the tunnel centroid (inches of H_2O)

Intertek

Manufacturer: England Stoves___ ________________ Model : 15-SSW01____________
Job #_G103758222_____________________ Run #9 CAT 1

Page 2 of 10
Date 2-5-19
Tech [signature]
Ken Slater

Pre/Post Checks

	Pre-Test	Post-Test
Facility Conditions:		
Air Velocity	✓ fpm	✓ fpm
Smoke Capture Check	0	0
Wood Heater Conditions:		
Date Wood Heater Stack Cleaned	1-21-19	
Date Dilution Tunnel Cleaned	1-21-19	
Induced Draft Check	✓	✓
Tunnel Velocity	.105	.145
Pitot Leak Check:		
Side A	✓	✓
Side B	✓	✓

Temperature System:

Ambient (65°- 90°F)	°F

Proportional Checks:

CO Analyzer Drift Check	✓
CO_2 Analyzer Check	✓
O_2 Analyzer Check	✓
Thermocouple check	✓

Sampling Train ID Numbers:

	Train 1	Train 2	TRAIN 3
Probe	D	E	F
Filter Front	27	29	31
Filter Back	28	30	32
Filter Thermocouple	19	22	
Filter 5G-3 (<90°F)			

mn

Intertek

Manufacturer: England Stoves___ _______________ Model : 15-SSW01____________
Job #_G103758222______________________ Run #9 CAT 1

Date 2-5-19
Tech [signature] Ken Slater

Pre-Test Scale Audit

Scale Type	Audit Weight	Measured Weight
Platform	25.00 lbs., Class F	25.00 lbs.
Wood	10.00 lbs., Class F	10.00 lbs.
Analytical	100.000 mg, Class S	100.000 mg.

LIMITS OF WEIGHT RANGES

ANALYTICAL SCALE:.. 50%-150% of dry filter weight, ± 0.1 mg
PLATFORM SCALE...20%-80% of ideal test load weight, ± 0.1 lbs. or 1%
WOOD SCALE ....20%-80% of ideal test load weight, ± 0.1 lbs. or 1%

Intertek

Manufacturer: England Stoves___ _______________ Model : 15-SSW01____________
Job #_G103758222____________________ Run #9 CAT 1

Date 2-5-19
Tech [signature]
Ken Slater

SAMPLING EQUIPMENT CHECK OUT

Leakage Checks Tunnel Samplers

Leakage Checks Tunnel Samplers

	SAMPLE 1		SAMPLE 2		SAMPLE 3	
Unplugged Flow Rate = .25cfm	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-test	Post Test
Vacuum (inches Hg.)	10"	10"	10"	10"	10"	10"
Final 1 minute DGM (ft^3)	0	0	0	0	473.310	483.274
Initial 1 minute DGM (ft^3)	0	0	0	0	473.310	483.274
Change (C) (ft^3)	0	0	0	0	0	0
Allowable leakage .04 x Sample rate or .02cfm	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
Check OK	✓	✓	✓	✓	✓	✓

Leakage Checks Flue Gas Sampler

Plugged Probe	Pre Test	Post Test
Vacuum (inches Hg.)	10"	10"
Rotometer Reading (mm)	0	0
Flow Rate (CFM)	0	0
Allowable (.04 x Sample Rate)		
Check OK	✓	✓

Intertek

Manufacturer: England Stoves
Job #_G103758222

Model : 15-SSW01
Run #9 CAT 1

Date 2-5-19
Tech [signature] Ken Slater

CONTINUOUS ANALYZERS

Pre-Test (Adjust and Record)

	ZERO		SPAN		CAL. (Record Only)	
CO_2	0	0	24.88	24.88	11.88	11.99
CO	0	0	8.97	8.976	4.00	4.001
O_2	0	0	20.95	20.95	9.94	10.01
	Actual	Should Be	Actual	Should Be	Actual	Should Be

Post Test (Record Only)

	Zero	Span	Cal.	Zero Drift	Span Drift	Cal. Drift	OK?	Not OK*
CO_2	-.07	24.78	11.89	.07	.10	.01	✓	
CO	-0.10	8.68	3.88	.10	.29	.12	✓	
O_2	-0.03	20.86	9.93	.03	.09	.01	✓	

* Greater than ± 5% of the range used.

TEST DATA LOG

RAW DRY GAS METER READINGS

	System 1	System 2	System 3
Final (ft^3)	94.15	94.15	483.275
Initial (ft^3)	0	0	473.310

AMBIENT CONDITIONS

	Start	End
Barometer. (inches Hg)	29.10	29.03
Temperature (°F)	69.3	72.6
Humidity (%)	24	19

Intertek

Manufacturer: England Stoves___ ________________ Model : 15-SSW01____________
Job #_G103758222______________________ Run #9 CAT 1

Page 7 of 10
Date 2-5-19
Tech [signature]
Ken Slater

READING #	REAL TIME	ELAPSED TIME	DGM 1	ROTOMETER 1	DGM 2	ROTOMETER 2	DGM 3	ROTOMETER 3	DRAFT	MAX DGM PRESSURE
0	9:28	0					473.310			
1		10					474.900			
2		20					476.570			
3		30					478.235			
4		40					479.900			
5		50					481.565			
6		60					483.275			
7		70								
8		80								
9		90								
10		100								
11		110								
12		120								
13		130								
14		140								
15		150								
16		160								
17		170								
18		180								
19		190								
20		200								
21		210								
22		220								
23		230								
24		240								
25		250								
26		260								
27		270								
28		280								
29		290								
30		300								
31		310								
32		320								
33		330								
34		340								
35		350								
36		360								

Intertek

Manufacturer: England Stoves

Job #_G103758222

Model : 15-SSW01

Run #9 CAT 1

Date 2-5-19

Tech Ken Slater

COMMENTS

7:13 AM Pretest Started

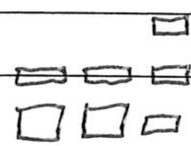
9:28 Test Started

Door Remains open for 5 minutes

Shutter Set @ Fully Closed

~~Set~~ Trigger Activated @ 31 minutes

Room Fan Set to Low



Intertek

Manufacturer: England Stoves___ _______________ Model : 15-SSW01____________ Page 9 of 10
Job #_G103758222______________________ Run #9 CAT 1 Date 2-5-19
Tech [signature] Ken Slater

FUEL DATA

PRE-TEST LOAD

FUEL DESCRIPTION:
Kindling weight: 4.5 lbs. Consisting of: Scrap and paper Fire lit Time:
Pre-test load weight: 16.32 lbs. Consisting of: 2X4X________inches Time loaded:
Pre-test moisture content: Uncorrected:_________% Corrected Dry:_________% Wet:_________%

Test Air Control Settings:______________________________________Time:
Test Unit Fan Settings:______________________________________Time:

TEST LOAD

	Lower Limit	Ideal	Upper Limit
Test Load Weight:	15.12 Lbs.	16.80 lbs.	18.48 Lbs.

Fire Box Volume:	2.4 Ft.^{3}	Ideal Length:	Inches
Load Volume:	Ft.^{3}	Loading Density:	lbs/ft^3
Spacer weight	2.46 Lbs	Load Density:	lbs/ft^3

Piece Size	Weight	Meter Moisture Content (% dry)*		
2 x 4 x 15 in.	1.59 lbs.	19.2 %	19.5 %	19.6 %
2 x 4 x 15 in	1.53 lbs.	18.5 %	18.7 %	18.2 %
2 x 4 x 15 in	1.26 lbs.	18.2 %	18 %	18.7 %
2 x 4 x 15 in	1.40 lbs.	18.5 %	18.1 %	19.1 %
2 x 4 x 15 in	1.54 lbs.	18.0 %	20.8 %	20.5 %
4 x 4 x 15 in	2.93 lbs.	20.5 %	20.3 %	19.7 %
4 x 4 x 15 in	2.90 lbs.	18.0 %	18.2 %	18.0 %
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%
x x in	lbs.	%	%	%

TEST LOAD WEIGHT: 15.60 lbs. **DRY WEIGHT:**__________________kg.
AVERAGE MOISTURE CONTENT:
(DRY) 18.97 % CORRECTED TO TWO PIN: (DRY) 18.97 % (WET) 15.94 %
COAL BED RANGE:
3.2 lbs. to 3.9 lbs. (10% to 15% of test load)
__________lbs. to __________lbs. (20% to 25% of test load)
TEST CHARGE:
Time loaded: 9:28 Coal bed weight: 3.9 lbs. Coal bed weight = ________% of test load weight

CHARCOALIZATION: good |--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--| poor

Intertek

Page 10 of 10
Date 2-5-19
Tech K. SLATER

Manufacturer : ENGLAND STOVES
Job # G103758222

Model: 15-SSWO1
Run #9 OAT 1

DILUTION TUNNEL PARTICULATE SAMPLER DATA

FILTER TYPE: Gelman 47mm A/E

Pre-test Weight Record		SYSTEM 1			SYSTEM 2			SYSTEM 3				
		Probe & Housing Number	Front Filter + gasket Number	Back Filter + gasket Number	Probe & Housing Number	Front Filter + gasket Number	Back Filter + gasket Number	Probe & Housing Number	Front Filter + gasket Number	Back Filter + gasket Number	Temp	Humidity
Date	Time	D	27	28	E	29	30	F	31	32	°F	%
2-4-19	7:30A	180.9107	3.2968	3.2371	92.5991	3.2595	3.2984	90.9604	3.3007	3.3406	67.7	33
2-5-19	6:32A	180.9106	3.2968	3.2370	92.5990	3.2594	3.2984	90.9603	3.3006	3.3406	65.8	23
		Total:	6.5338		Total:	6.5578		Total:	6.6412			

Post-test Weight Record		SYSTEM 1		SYSTEM 2		SYSTEM 3			
		Probe & Housing Number	Combined Filter/gasket Number	Probe & Housing Number	Combined Filter/gasket Number	Probe & Housing Number	Combined Filter/gasket Number	Temp	Humidity
Date	Time	D	27+28	E	29+30	F	31+32	°F	%
2-5-19	3:48	180.9141	6.5490	92.6009	6.5712	90.9615	6.6494	72.9	19
2-6-19	6:52	180.9110	6.5483	92.5996	6.5703	90.9603	6.6483	68.0	22
2-7-19	7:30A	180.9110	6.5480	92.5995	6.5701	—	6.6480	66.7	18
2-8-19	7:30A	180.9106	6.5479	92.5990	6.5700	—	6.6480	65.7	13

Dry Down Weight

Date	Time	P1	F1	P2	F2	P3	F3	Gr/hr	Lb/MMbtu
2-5-19	3:48	3.5	15.2	1.9	13.4	1.2	8.2	2.801	~~.940~~ .923
2-6-19	6:52	.4	14.5	.6	12.5	0	7.1	2.304	
2-7-19	7:30	.4	14.2	.5	12.3	0	6.8	2.257	
2-8-19	7:30A	0	14.1	0	12.2	0	6.8	2.166	

intertek Total Quality. Assured.	CLIENT:	England Stoves		PERFORMED BY:	Ken Slater
	PROJECT #:	G103758222		REVIEWED BY:	
	PRODUCT:	Wood Fuel Room Heater		MODEL:	15SSW01
SAMPLE ID #:	MID1901181005-001			DATE:	1/29/2019
STANDARD(S):	See List on emissions tab	VERSION YEAR:		LOCATION:	Middleton
EQUIPMENT					
ASSET # - DESCRIPTION:	See below			CALIBRATION DUE:	See below
CONDITIONING					
SAMPLE CONDITIONING (IF APPLICABLE):	NA				
AMBIENT TEMPERATURE (°F):	69.39				
RESULTS					
PASS		FAIL		NO PASS/FAIL	X

Table of Test Equiment Used				
Item	Description	Asset #	Calibration Due	MU
1	Platform Scale	8	4/10/2019	(+/-) 27 grams
2	Balance	713	4/10/2019	(+/-) 0.47 mg
3	Data Logger	986	4/10/2019	(+/-) 0.33°F
4	Scale	1134	4/10/2019	(+/-) 27 grams
5	Timer	1212	4/4/2019	(+/-) 0.3 sec
6	Timer	1213	4/4/2019	(+/-) 0.3 sec
7	Flow Meter	1413	7/18/2019	(+/-) 17ml/min
8	Flow Meter	1414	7/18/2019	(+/-) 17ml/min
9	Barometer	1420	4/12/2019	(+/-) 0.24°F, 1.7%RH 0.011 in Hg
10	Dry Gas Meter	2110	6/27/2019	(+/-) 0.00284 cfm
11				
12				
13				
14				
15				
16				
17				
18				
19				

Time 10.0	Flue Temp 1	Room Temp 2	Tunnel Dry Bulb 3	DGM 1 In 13	DGM 1 Out 14	Filter 1 15	DGM 2 In 16	DGM 2 Out 17	Filter 2 18	DGM 3 In 19	Filter 3 20	Meter #1 21	Meter #2 22	Draft 23	Tunnel 24	CO % 25	CO2 % 25	O2 % 27	scale Lbs 28	0 Corrected Scale	Meter #1 Cu Ft	Meter #2 Cu Ft	Draft	Calculated Tunnel
0.0	319.49	69.11	123.33	70.70	69.01	69.83	70.99	70.36	69.09	69.88	69.11	0.02	0.02	1.13	1.32	0.29	8.04	12.19	16.42	16.42	0.00	0.00	0.033387	0.07953
10.0	339.08	70.00	96.04	70.26	72.24	74.66	70.02	73.38	73.75	70.02	72.44	6.86	6.76	1.14	1.33	0.92	5.42	14.50	14.82	14.82	2.42	2.39	0.035411	0.08179
20.0	329.57	69.96	94.19	71.61	72.49	76.85	71.70	73.49	75.77	70.29	74.25	6.85	6.82	1.13	1.33	0.49	7.64	12.57	13.53	13.53	2.42	2.41	0.032838	0.08301
30.0	404.64	70.01	98.78	72.02	72.62	79.27	72.37	73.36	77.88	70.71	75.53	6.74	6.82	1.15	1.32	0.41	13.75	6.99	12.10	12.10	2.38	2.41	0.038727	0.07977
40.0	446.84	70.33	103.83	72.30	72.73	81.03	72.80	73.48	79.73	70.87	76.98	6.75	6.75	1.16	1.33	0.69	15.93	4.83	10.49	10.49	2.38	2.38	0.04123	0.08137
50.0	454.74	71.25	101.44	72.27	72.52	79.94	72.83	73.51	79.82	71.15	77.82	6.56	6.67	1.17	1.33	1.69	15.95	4.10	8.69	8.69	2.32	2.36	0.042927	0.08321
60.0	388.54	70.91	96.06	71.79	72.83	80.48	72.43	73.50	80.13	71.05	77.47	6.80	6.79	1.15	1.30	0.08	10.89	9.54	7.70	7.70	2.40	2.40	0.038066	0.07437
70.0	358.88	70.10	91.31	70.71	72.63	79.74	71.60	73.41	79.23	70.81	126.78	6.83	6.83	1.14	1.32	0.12	10.83	9.57	6.89	6.89	2.41	2.41	0.035319	0.08039
80.0	348.18	69.45	92.12	71.55	72.56	79.33	72.29	73.49	79.04	70.51	126.29	6.88	6.84	1.14	1.31	0.19	10.88	9.40	6.09	6.09	2.43	2.41	0.034185	0.07775
90.0	333.54	69.60	90.29	71.85	72.86	79.27	72.42	73.66	78.64	70.46	127.90	6.87	6.85	1.13	1.31	0.10	10.43	9.87	5.40	5.40	2.42	2.42	0.032174	0.0786
100.0	320.28	69.30	87.84	71.69	72.76	78.77	72.15	73.70	78.03	70.54	128.02	6.85	6.86	1.12	1.32	0.13	9.93	10.26	4.79	4.79	2.42	2.42	0.031238	0.0807
110.0	313.78	68.79	88.33	71.84	73.13	78.59	72.46	73.95	77.69	70.63	129.29	6.82	6.85	1.12	1.33	0.16	9.94	10.21	4.19	4.19	2.41	2.42	0.029888	0.08223
120.0	305.08	68.73	88.57	71.89	72.94	78.57	72.61	73.99	77.73	71.12	128.24	6.91	6.85	1.12	1.33	0.21	9.37	10.36	3.78	3.78	2.44	2.42	0.029501	0.08233
130.0	296.14	68.85	88.08	72.18	73.30	78.48	72.67	74.12	77.86	70.79	128.52	6.87	6.85	1.11	1.35	0.21	9.35	10.50	3.28	3.28	2.43	2.42	0.027337	0.08649
140.0	280.58	69.06	87.01	72.23	73.18	78.10	73.00	74.11	77.69	71.04	130.81	6.81	6.81	1.11	1.33	0.36	8.43	11.16	3.00	3.00	2.41	2.40	0.026401	0.08151
150.0	258.10	69.32	85.60	72.46	73.55	78.00	72.93	74.07	77.16	71.14	131.90	6.87	6.82	1.09	1.32	0.55	7.44	12.09	2.78	2.78	2.42	2.41	0.023642	0.07999
160.0	244.50	70.19	82.65	71.37	73.46	77.57	72.22	74.17	76.87	71.02	130.02	6.83	6.84	1.09	1.31	0.61	7.25	12.34	2.59	2.59	2.41	2.41	0.022682	0.07651
170.0	238.03	69.54	81.44	71.15	73.36	76.97	72.13	74.07	76.08	70.97	131.88	6.87	6.89	1.09	1.34	0.66	7.30	12.31	2.27	2.27	2.42	2.43	0.021768	0.08414
180.0	231.68	68.12	79.50	70.01	72.99	76.36	71.48	73.87	74.97	70.93	127.07	6.88	6.91	1.09	1.30	0.83	6.77	12.80	2.08	2.08	2.43	2.44	0.021655	0.0761
190.0	226.46	68.72	79.66	70.74	73.10	75.74	71.29	73.92	74.61	70.72	128.64	6.90	6.93	1.08	1.32	0.81	6.89	12.72	1.88	1.88	2.44	2.45	0.020445	0.07883
200.0	222.89	69.00	78.90	70.43	73.21	75.26	71.26	73.89	74.27	70.59	127.10	6.87	6.88	1.08	1.32	0.88	6.70	12.92	1.67	1.67	2.42	2.43	0.02011	0.08113
210.0	219.55	69.29	79.16	70.56	73.19	75.27	71.38	73.81	74.24	70.62	127.65	6.88	6.89	1.08	1.31	1.00	6.44	13.16	1.58	1.58	2.43	2.43	0.019927	0.07734
220.0	217.78	69.34	78.91	70.44	73.01	74.79	71.34	73.79	73.94	70.50	127.90	6.90	6.90	1.08	1.32	1.13	6.43	13.10	1.38	1.38	2.44	2.44	0.019369	0.07945
230.0	215.64	69.17	78.23	70.52	72.98	74.66	71.20	73.50	73.78	70.53	127.80	6.92	6.91	1.08	1.28	1.18	6.09	13.45	1.19	1.19	2.44	2.44	0.019451	0.07052
240.0	209.70	69.22	77.91	70.32	72.99	74.49	71.27	73.57	73.42	70.53	129.95	6.94	6.92	1.07	1.31	1.36	5.30	14.18	1.08	1.08	2.45	2.44	0.018735	0.07813
250.0	207.36	68.75	77.84	70.21	72.92	74.23	71.05	73.59	73.20	70.52	129.66	6.83	6.84	1.07	1.34	1.15	5.55	14.04	0.89	0.89	2.41	2.41	0.018165	0.08558
260.0	203.65	69.02	77.91	69.98	72.74	74.02	70.90	73.34	73.02	70.37	128.36	6.77	6.84	1.07	1.32	1.24	5.51	14.04	0.69	0.69	2.39	2.42	0.018208	0.08107
270.0	201.51	68.65	77.51	70.19	72.85	74.10	70.89	73.66	73.01	70.45	129.59	6.88	6.85	1.07	1.32	1.45	5.24	14.21	0.59	0.59	2.43	2.42	0.017443	0.07928
280.0	196.14	68.67	77.75	70.28	72.66	73.76	70.70	73.25	72.66	70.09	125.89	6.90	6.86	1.07	1.33	1.43	4.77	14.72	0.48	0.48	2.43	2.42	0.017339	0.08166
290.0	191.32	69.08	77.14	70.08	72.79	73.75	70.94	73.44	72.66	70.28	128.66	6.91	6.87	1.07	1.32	1.48	4.56	14.95	0.29	0.29	2.44	2.42	0.016735	0.08066
300.0	187.41	68.96	76.98	70.28	72.69	73.57	70.79	73.26	72.39	70.19	128.33	6.86	6.87	1.06	1.34	1.54	4.31	15.18	0.19	0.19	2.42	2.43	0.016053	0.0844
310.0	183.60	69.04	76.50	70.36	72.54	73.60	70.71	73.14	72.11	70.14	126.18	6.86	6.88	1.06	1.32	1.57	4.08	15.38	0.08	0.08	2.42	2.43	0.015452	0.08105
320.0	183.61	70.27	77.44	70.92	73.90	74.40	71.84	74.45	73.32	71.11	131.57	6.75	6.71	1.06	1.34	1.52	4.20	15.34	0.00	0.00	2.38	2.37	0.015529	0.08428
																				0.00				
																				0.00				
																				0.00				
																				0.00				

Probe Sample Train 2:			0
Room Particulate Correction			
Mr	0	Milligram Catch (mg)	
Vmr	40.32288	Total Volume Sampled (dscf)	
		Rotometer (glass) at 100	
		flow rate is 0.12924 cfm	
missions			

	Room Temp		Bar Pressure		Relative Humidity		Air Velocity	
	Before	After	Before	After	Before	After	Before	After
	69	70	28.82	28.83	14.0	13.0	0	0

Average Dilution Tunnel Measurements						Sample Data		
Burn	Velocity	Flow Rate	Temp	Total Sample		Particulate Catch		
Time	(Ft/sec)	(dscf/min)	(R)	1	2	1	2	
312	18.77	201.70	546.31	73.93	73.82	14.30	12.90	

	Dilution Tunnel Dual Train Precision				
	Sample Ratios		Total Emissions (g)		
	Train 1	Train 2	Train 1	Train 2	Deviation (%)
	851.22	852.54	12.17	11.00	5.07%

Burn				Initial		Run	Average
Rate		Surface		Draft		Time	Draft
1.217		0.000		0.033		312.000	0.026

Run	Date	Burn Rate	Emission
4	1/29/2019	1.217	2.228

E&E Boiler Tunnel Traverse Worksheet

Static Pressure: **0.336**

Barometer: 28.82

	TUNNEL VELOCITY	TUNNEL TEMP	SQUARE ROOT
A CENTER	0.103		0.3209
B CENTER	0.104		0.3225
A1	0.09		0.3000
A2	0.098		0.3130
A3	0.101		0.3178
A4	0.094		0.3066
B1	0.09		0.3000
B2	0.1		0.3162
B3	0.095		0.3082
B4	0.089		0.2983
AVERAGE		#DIV/0!	0.3104

PITOT CONSTANT= 0.9647

E&E FUEL LOAD DATA SHEET

			Test Load Weight:		
			Lower	Ideal	Upper
Firebox Volume:	2.4	cu. ft	15.12	16.80	18.48
Load Volume:	0.5187	cu. ft	Loading Density:	6.963	lbs./ft3
Number of Spacers:	24		Load Density:	32.217	lbs./ft3

Piece Size: Thick	x Wide	x Length	Weight lbs	Meter Moisture Content Dry Uncorrected %			
4	4	15	3.65	19.70	20.00	21.00	183.75
4	4	15	3.60	19.90	18.10	22.10	183.75
2	4	15	1.21	19.30	20.12	19.70	78.75
2	4	15	1.33	19.20	19.40	19.90	78.75
2	4	15	1.20	20.70	18.40	19.70	78.75
2	4	15	1.38	18.50	18.00	18.60	78.75
2	4	15	1.53	20.50	20.80	20.80	78.75
			2.81				0.00
							0.00

Test Load Weigh 16.71 lbs. **Dry Weig** 6.33 kg.

Average Moisture Content: %

Dry 19.73 | 19.73 | Wet: 16.48

Pre-test moisture content: %

#DIV/0! | #DIV/0! | Wet: #DIV/0!

Coal Bed Range 3.4 lbs. to 4.1 lbs. 20% to 25% of test load

E&E FUEL LOAD DATA SHEET

			Test Load Weight:		
			Lower	Ideal	Upper
Firebox Volume:	2.4	cu. ft	15.12	16.80	18.48
Load Volume:	0.0182	cu. ft	Loading Density:	6.729	lbs./ft3
Number of Spacers:			Load Density:	885.943	lbs./ft3

Piece Size: Thick	x Wide	x Length	Weight lbs	Meter Moisture Content Dry Uncorrected %			
2	4	6	16.15	19.30	23.30	17.20	31.50
				17.90	16.70	17.30	0.00
							0.00
							0.00
							0.00
							0.00
							0.00
							0.00
							0.00

Test Load Weigh 16.15 lbs. **Dry Weig** 5.34 kg.

Average Pretest Moisture Content: %

Dry 37.23 two pin: (dry) 37.23 Wet: 27.13

intertek Total Quality. Assured.	CLIENT:	England Stoves		PERFORMED BY:	Ken Slater
	PROJECT #:	G103758222		REVIEWED BY:	
	PRODUCT:	Wood Fuel Room Heater		MODEL:	15SSW01
SAMPLE ID #:	MID1901181005-001			DATE:	1/31/2019
STANDARD(S):	See List on emissions tab	VERSION YEAR:		LOCATION:	Middleton
EQUIPMENT					
ASSET # - DESCRIPTION:	See below			CALIBRATION DUE:	See below
CONDITIONING					
SAMPLE CONDITIONING (IF APPLICABLE):	NA				
AMBIENT TEMPERATURE (°F):	70.98				
RESULTS					
PASS		FAIL		NO PASS/FAIL	X

Table of Test Equiment Used				
Item	Description	Asset #	Calibration Due	MU
1	Platform Scale	8	4/10/2019	(+/-) 27 grams
2	Balance	713	4/10/2019	(+/-) 0.47 mg
3	Data Logger	986	4/10/2019	(+/-) 0.33°F
4	Scale	1134	4/10/2019	(+/-) 27 grams
5	Timer	1212	4/4/2019	(+/-) 0.3 sec
6	Timer	1213	4/4/2019	(+/-) 0.3 sec
7	Flow Meter	1413	7/18/2019	(+/-) 17ml/min
8	Flow Meter	1414	7/18/2019	(+/-) 17ml/min
9	Barometer	1420	4/12/2019	(+/-) 0.24°F, 1.7%RH 0.011 in Hg
10	Dry Gas Meter	1210	6/27/2019	(+/-) 0.00284 cfm
11				
12				
13				
14				
15				
16				
17				
18				
19				

																CO	CO2	O2	scale	-0.003658	Meter	Meter		
Time	Flue	Room	Tunnel	DGM 1	DGM 1	Filter 1	DGM 2	DGM 2	Filter 2	DGM 3	Filter 3	Meter #1	Meter #2	Draft	Tunnel	%	%	%	Lbs	Corrected	#1	#2	Draft	Calculated
10.0	Temp 1	Temp 2	Dry Bulb 3	In 13	Out 14	15	In 16	Out 17	18	In 19	20	21	22	23	24	25	25	27	28	Scale	Cu Ft	Cu Ft		Tunnel
0.0	241.93	68.40	117.46	72.34	70.79	72.23	72.89	72.56	70.87	71.86	70.80	0.02	0.02	1.11	1.28	0.50	1.02	19.29	16.21	16.22	0.00	0.00	0.028358	0.06966
10.0	504.39	68.41	120.94	71.18	73.75	78.85	71.26	74.44	77.48	71.25	76.95	6.81	6.85	1.19	1.29	0.65	13.76	6.42	13.91	13.92	2.41	2.42	0.047689	0.07201
20.0	552.43	68.66	125.72	71.17	73.53	79.36	71.32	74.31	77.56	71.08	77.42	6.85	6.84	1.20	1.28	0.64	16.41	4.21	11.22	11.22	2.42	2.41	0.050215	0.06947
30.0	567.88	70.07	128.24	71.75	73.53	79.27	71.80	74.50	77.42	71.20	78.15	6.74	6.78	1.20	1.29	1.45	17.38	3.03	8.69	8.69	2.38	2.39	0.050843	0.07185
40.0	537.42	71.47	123.97	71.96	73.56	78.68	72.03	74.42	77.42	71.59	77.70	6.82	6.77	1.19	1.27	0.83	16.01	4.19	6.50	6.50	2.41	2.39	0.047621	0.06805
50.0	476.43	72.46	117.46	72.11	73.77	78.24	72.21	74.60	76.79	71.84	77.13	6.79	6.74	1.17	1.26	0.02	12.23	8.12	5.20	5.20	2.40	2.38	0.042601	0.06529
60.0	434.05	72.61	112.31	73.35	74.02	81.84	74.12	75.02	79.70	72.29	79.57	6.75	6.71	1.16	1.30	0.03	10.48	9.99	4.20	4.20	2.38	2.37	0.040111	0.07486
70.0	404.86	71.99	107.78	73.21	74.19	83.23	74.42	75.21	81.48	72.42	139.74	6.74	6.74	1.16	1.27	0.05	9.32	11.04	3.48	3.48	2.38	2.38	0.038852	0.06865
80.0	383.68	71.85	104.79	72.79	74.54	83.93	74.02	75.21	82.31	72.37	120.71	6.75	6.75	1.15	1.28	0.16	8.96	11.30	2.89	2.89	2.38	2.38	0.036481	0.0709
90.0	363.58	71.45	101.60	72.45	74.46	83.89	73.95	75.25	82.08	72.20	148.67	6.74	6.75	1.14	1.27	0.43	8.12	11.91	2.40	2.40	2.38	2.38	0.034058	0.06713
100.0	339.01	70.98	98.85	72.27	74.50	83.48	73.70	75.04	81.98	72.10	125.23	6.74	6.75	1.13	1.27	0.70	7.08	12.67	2.09	2.09	2.38	2.38	0.032424	0.06814
110.0	328.51	70.57	97.18	72.28	74.71	83.05	73.76	75.11	81.60	71.93	144.94	6.74	6.75	1.12	1.27	0.74	6.91	12.87	1.80	1.80	2.38	2.38	0.030802	0.06812
120.0	314.78	71.01	95.95	72.05	74.63	82.89	73.55	75.31	81.23	72.00	118.00	6.72	6.75	1.12	1.28	0.72	6.79	13.08	1.49	1.49	2.37	2.38	0.029702	0.06949
130.0	306.95	71.41	94.67	72.19	74.66	82.38	73.67	75.25	80.97	71.90	115.86	6.72	6.75	1.12	1.29	0.87	6.43	13.49	1.19	1.19	2.37	2.38	0.029172	0.07351
140.0	301.62	70.86	94.14	72.49	74.50	82.18	73.81	75.17	80.62	71.98	125.33	6.72	6.75	1.11	1.29	0.92	6.39	13.53	0.99	0.99	2.37	2.38	0.028315	0.07162
150.0	297.63	71.06	93.89	72.39	74.63	81.76	73.81	75.28	80.46	71.84	127.49	6.77	6.75	1.11	1.28	0.96	6.22	13.71	0.80	0.80	2.39	2.38	0.027983	0.07008
160.0	293.52	71.14	93.07	72.11	74.42	81.63	73.75	75.39	80.17	72.21	150.98	6.77	6.75	1.11	1.28	0.96	5.96	13.99	0.49	0.49	2.39	2.38	0.027611	0.06893
170.0	287.99	71.39	92.80	72.38	74.61	81.61	73.91	75.41	80.13	72.24	125.73	6.77	6.75	1.11	1.26	0.99	5.58	14.37	0.29	0.29	2.39	2.38	0.026861	0.06411
180.0	278.22	71.39	92.06	72.37	74.70	81.25	73.84	75.28	79.85	72.01	125.64	6.77	6.74	1.10	1.29	1.03	4.99	14.94	0.09	0.09	2.39	2.38	0.025986	0.0728
190.0	279.02	72.38	93.17	73.33	75.38	82.31	74.88	75.91	80.81	72.67	138.26	6.76	6.74	1.10	1.29	1.03	4.99	14.95	0.00	0.00	2.39	2.38	0.026071	0.07164
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Probe Sample Train 2:			0
Room Particulate Correction			
Mr	0	Milligram Catch (mg)	
Vmr	23.52168	Total Volume Sampled (dscf)	
		Rotometer (glass) at 100	
		flow rate is 0.12924 cfm	
missions			

	Room Temp		Bar Pressure		Relative Humidity		Air Velocity	
	Before	After	Before	After	Before	After	Before	After
	68	72	29.29	29.26	11.0	11.0	0	0
Average Dilution Tunnel Measurements						Sample Data		
Burn	Velocity	Flow Rate	Temp	Total Sample		Particulate Catch		
Time	(Ft/sec)	(dscf/min)	(R)	1	2	1	2	
182	17.68	186.44	565.30	43.94	43.84	10.50	9.60	
	Dilution Tunnel Dual Train Precision							
	Sample Ratios		Total Emissions (g)					
	Train 1	Train 2	Train 1	Train 2	Deviation (%)			
	772.32	774.01	8.11	7.43	4.37%			
Burn				Initial		Run	Average	
Rate		Surface		Draft		Time	Draft	
2.021		0.000		0.028		182.000	0.035	
Run	Date	Burn Rate	Emission					
6	1/31/2019	2.021	2.562					

E&E Boiler Tunnel Traverse Worksheet

Static Pressure: **0.313**

Barometer: 29.29

	TUNNEL VELOCITY	TUNNEL TEMP	SQUARE ROOT
A CENTER	0.102		0.3194
B CENTER	0.103		0.3209
A1	0.089		0.2983
A2	0.097		0.3114
A3	0.1		0.3162
A4	0.095		0.3082
B1	0.089		0.2983
B2	0.099		0.3146
B3	0.095		0.3082
B4	0.088		0.2966
AVERAGE		#DIV/0!	0.3092

PITOT CONSTANT= 0.9659

E&E FUEL LOAD DATA SHEET

			Test Load Weight:			
			Lower	Ideal	Upper	
Firebox Volume:	2.4	cu. ft	15.12	16.80	18.48	
Load Volume:	0.5187	cu. ft	Loading Density:	6.813	lbs./ft3	
Number of Spacers:	24		Load Density:	31.527	lbs./ft3	

Piece Size: Thick	x Wide	x Length	Weight lbs	Meter Moisture Content Dry Uncorrected %			
4	4	15	3.43	22.70	22.10	22.20	183.75
4	4	15	3.48	22.70	22.30	22.50	183.75
2	4	15	1.36	18.00	18.10	18.30	78.75
2	4	15	1.29	21.80	21.00	22.50	78.75
2	4	15	1.20	21.20	21.40	22.20	78.75
2	4	15	1.41	19.10	18.60	18.90	78.75
2	4	15	1.22	21.10	20.80	22.80	78.75
			2.96				0.00
							0.00

Test Load Weigh 16.35 lbs. **Dry Weig** 6.13 kg.

Average Moisture Content: %

Dry 20.97 20.97 Wet: 17.33

Pre-test moisture content: %

#DIV/0! #DIV/0! Wet: #DIV/0!

Coal Bed Range 3.3 lbs. to 4.0 lbs. 20% to 25% of test load

E&E FUEL LOAD DATA SHEET

			Test Load Weight:		
			Lower	Ideal	Upper
Firebox Volume:	2.4	cu. ft	15.12	16.80	18.48
Load Volume:	0.0182	cu. ft	Loading Density:	6.729	lbs./ft3
Number of Spacers:			Load Density:	885.943	lbs./ft3

Piece Size: Thick	x Wide	x Length	Weight lbs	Meter Moisture Content Dry Uncorrected %			
2	4	6	16.15	19.30	23.30	17.20	31.50
				17.90	16.70	17.30	0.00
							0.00
							0.00
							0.00
							0.00
							0.00
							0.00
							0.00

Test Load Weigh 16.15 lbs. **Dry Weig** 5.34 kg.

Average Pretest Moisture Content: %

Dry 37.23 two pin: (dry) 37.23 Wet: 27.13

intertek Total Quality. Assured.	CLIENT:	England Stoves		PERFORMED BY:	Ken Slater
	PROJECT #:	G103758222		REVIEWED BY:	
	PRODUCT:	Wood Fuel Room Heater		MODEL:	15SSW01
SAMPLE ID #:	MID1901181005-001			DATE:	2/5/2019
STANDARD(S):	See List on emissions tab	VERSION YEAR:		LOCATION:	Middleton
EQUIPMENT					
ASSET # - DESCRIPTION:	See below			CALIBRATION DUE:	See below
CONDITIONING					
SAMPLE CONDITIONING (IF APPLICABLE):	NA				
AMBIENT TEMPERATURE (°F):	69.79				
RESULTS					
PASS		FAIL		NO PASS/FAIL	X

Table of Test Equiment Used				
Item	Description	Asset #	Calibration Due	MU
1	Platform Scale	8	4/10/2019	(+/-) 27 grams
2	Balance	713	4/10/2019	(+/-) 0.47 mg
3	Data Logger	986	4/10/2019	(+/-) 0.33°F
4	Scale	1134	4/10/2019	(+/-) 27 grams
5	Timer	1212	4/4/2019	(+/-) 0.3 sec
6	Timer	1213	4/4/2019	(+/-) 0.3 sec
7	Flow Meter	1413	7/18/2019	(+/-) 17ml/min
8	Flow Meter	1414	7/18/2019	(+/-) 17ml/min
9	Barometer	1420	4/12/2019	(+/-) 0.24°F, 1.7%RH 0.011 in Hg
10	Dry Gas Meter	1210	6/27/2019	(+/-) 0.00284 cfm
11				
12				
13				
14				
15				
16				
17				
18				
19				

Time 10.0	Flue Temp 1	Room Temp 2	Tunnel Dry Bulb 3	DGM 1 In 13	DGM 1 Out 14	Filter 1 15	DGM 2 In 16	DGM 2 Out 17	Filter 2 18	DGM 3 In 19	Filter 3 20	Meter #1 21
0.0	271.42	70.32	113.75	72.32	70.65	71.38	72.85	73.04	70.23	70.80	70.46	0.02
10.0	433.50	70.35	96.53	71.21	73.65	77.81	71.85	74.79	76.80	70.41	76.44	6.82
20.0	417.61	70.23	94.93	70.97	73.52	78.56	71.79	74.40	77.49	70.19	76.85	6.83
30.0	483.31	70.22	101.42	71.06	73.46	79.48	72.14	74.23	78.64	70.29	77.56	6.84
40.0	340.04	70.66	90.38	71.50	73.23	79.25	72.25	74.12	78.09	70.63	76.99	6.86
50.0	320.29	71.67	86.07	71.51	73.51	78.38	72.44	74.23	77.30	70.64	76.11	6.87
60.0	381.31	71.14	86.21	71.12	73.11	77.80	72.01	74.03	76.91	70.38	76.00	6.85
70.0	332.71	71.04	84.92	71.04	73.41	77.44	71.94	74.09	76.48	70.43	73.85	6.85
80.0	307.96	70.84	84.13	70.97	73.19	77.16	71.68	74.15	75.82	70.32	73.28	6.86
90.0	295.54	70.92	82.64	70.78	73.12	76.73	71.64	73.98	75.27	70.67	72.83	6.86
100.0	294.44	70.37	82.20	70.89	73.18	76.24	71.77	74.06	75.11	70.48	72.39	6.85
110.0	286.83	70.00	81.23	70.89	73.25	75.84	71.80	73.97	74.74	70.18	71.72	6.85
120.0	266.67	70.09	82.51	71.15	73.36	76.04	72.25	74.22	75.01	70.65	71.87	6.86
130.0	247.48	69.91	82.13	71.47	73.36	75.87	72.34	74.13	75.01	70.79	71.68	6.85
140.0	223.13	71.07	79.95	71.32	73.61	75.50	72.57	74.43	74.69	70.85	71.61	6.85
150.0	206.96	70.20	78.43	71.18	73.43	75.02	71.97	74.30	73.94	70.70	71.14	6.84
160.0	196.99	70.02	77.56	70.75	73.31	74.48	72.01	74.16	73.55	70.81	71.19	6.84
170.0	191.24	69.41	76.59	70.53	73.31	74.26	71.52	73.93	73.08	70.62	71.44	6.86
180.0	187.36	69.82	75.61	70.80	73.47	73.88	71.73	73.88	72.83	70.70	71.30	6.85
190.0	185.17	69.54	75.19	70.27	73.13	73.33	71.71	74.00	72.49	70.51	71.05	6.85
200.0	183.48	70.34	77.23	70.90	73.39	73.59	71.87	74.08	72.67	70.46	70.83	6.85
210.0	182.07	70.04	77.58	71.09	73.51	73.68	71.93	74.10	72.96	70.74	70.86	6.85
220.0	180.13	70.55	76.41	71.25	73.15	73.38	71.90	73.94	72.57	70.68	70.72	6.84
230.0	176.87	70.31	75.86	71.28	73.52	73.64	72.16	74.16	72.24	70.51	70.55	6.84
240.0	173.49	69.80	74.92	71.69	73.45	73.03	72.49	74.26	72.47	70.71	70.49	6.84
250.0	171.55	69.65	74.54	71.72	73.64	73.10	72.60	74.36	72.26	70.78	70.74	6.83
260.0	170.35	69.21	74.41	71.59	73.44	72.92	72.55	74.33	72.12	70.76	70.54	6.82
270.0	168.10	68.93	73.77	71.55	73.49	72.81	72.42	74.37	72.01	70.93	70.97	6.82
280.0	166.67	69.01	74.69	71.71	73.44	72.69	72.68	74.50	72.06	70.81	70.92	6.81
290.0	163.71	68.73	75.28	71.94	73.73	73.21	72.85	74.65	72.48	71.14	71.07	6.80
300.0	161.94	68.54	75.44	71.55	73.49	73.17	72.74	74.37	72.52	71.32	71.16	6.81
310.0	159.96	68.76	75.95	71.78	73.66	73.44	72.95	74.69	72.73	71.27	71.21	6.84
320.0	159.00	69.18	75.00	71.96	73.79	73.33	72.85	74.63	72.71	71.45	71.28	6.83
330.0	158.33	69.09	74.29	71.66	73.72	73.20	72.92	74.68	72.51	71.28	71.45	6.83
340.0	158.41	69.00	73.49	71.42	73.71	73.18	72.61	74.52	72.29	71.28	71.38	6.83
350.0	155.89	68.49	73.24	71.28	73.81	72.89	72.51	74.75	72.27	71.30	71.51	6.83
360.0	156.21	68.28	72.93	71.63	73.63	72.80	72.89	74.57	71.98	71.41	71.73	6.83
370.0	154.9	68.3	72.8	71.3	73.5	72.7	72.6	74.6	71.9	71.3	71.4	6.8
380.0	153.6	68.1	72.4	71.4	73.7	72.5	72.6	74.6	71.8	71.2	71.5	6.8
390.0	153.1	69.4	74.9	72.8	74.6	73.3	73.5	75.2	72.7	72.3	72.1	6.8

Time 10.0	Meter #2 22	Draft 23	Tunnel 24	CO % 25	CO2 % 25	O2 % 27	scale Lbs 28	-0.004877 Corrected Scale	Meter #1 Cu Ft	Meter #2 Cu Ft	Draft	Calculated Tunnel
0.0	0.02	1.14	1.42	0.34	2.14	18.26	15.43	15.43	0.00	0.00	0.035766	0.10599
10.0	6.82	1.16	1.41	0.45	9.84	10.15	13.32	13.32	2.41	2.41	0.04106	0.10325
20.0	6.81	1.16	1.42	0.44	8.78	11.38	12.01	12.02	2.41	2.40	0.040374	0.10581
30.0	6.84	1.18	1.42	0.22	12.86	7.88	10.61	10.62	2.42	2.41	0.044038	0.10551
40.0	6.83	1.13	1.44	0.60	9.30	10.97	9.51	9.51	2.42	2.41	0.033419	0.11013
50.0	6.84	1.13	1.41	1.02	10.58	9.86	8.70	8.70	2.42	2.41	0.031858	0.10364
60.0	6.91	1.14	1.49	0.74	15.12	5.63	7.49	7.50	2.42	2.44	0.035854	0.1232
70.0	6.87	1.13	1.47	0.64	11.05	9.36	6.70	6.71	2.42	2.43	0.032248	0.1179
80.0	6.87	1.12	1.52	0.63	10.28	10.01	6.00	6.00	2.42	2.43	0.029511	0.13104
90.0	6.88	1.11	1.48	0.84	9.84	9.99	5.50	5.50	2.42	2.43	0.028176	0.11971
100.0	6.87	1.11	1.53	0.48	10.76	9.31	4.90	4.91	2.42	2.42	0.028319	0.13272
110.0	6.88	1.11	1.47	0.48	10.62	9.36	4.38	4.39	2.42	2.43	0.026347	0.11807
120.0	6.82	1.11	1.49	0.95	9.31	10.44	3.98	3.99	2.42	2.41	0.026347	0.12145
130.0	6.82	1.08	1.52	1.25	8.68	10.80	3.60	3.61	2.42	2.41	0.020879	0.13034
140.0	6.82	1.08	1.50	1.63	7.67	11.35	3.29	3.29	2.42	2.41	0.019849	0.12611
150.0	6.86	1.07	1.49	1.42	7.56	11.50	3.10	3.10	2.42	2.42	0.017675	0.12327
160.0	6.86	1.06	1.51	1.52	7.27	11.72	2.89	2.89	2.42	2.42	0.015679	0.12769
170.0	6.87	1.07	1.51	1.56	7.18	11.84	2.78	2.79	2.42	2.42	0.016276	0.12794
180.0	6.87	1.06	1.52	1.69	7.11	11.89	2.59	2.60	2.42	2.43	0.015441	0.1293
190.0	6.88	1.06	1.49	1.32	7.43	11.89	2.49	2.50	2.42	2.43	0.014597	0.12275
200.0	6.79	1.06	1.47	1.45	7.31	11.96	2.28	2.28	2.42	2.40	0.013819	0.11692
210.0	6.82	1.05	1.51	1.31	7.34	11.95	2.18	2.18	2.42	2.41	0.013521	0.12707
220.0	6.82	1.05	1.49	1.50	6.93	12.23	2.08	2.09	2.42	2.41	0.013518	0.12202
230.0	6.81	1.05	1.51	1.65	6.63	12.42	1.89	1.90	2.41	2.41	0.013502	0.12699
240.0	6.86	1.05	1.51	1.76	6.46	12.60	1.79	1.80	2.41	2.42	0.013332	0.12822
250.0	6.85	1.05	1.50	1.66	6.70	12.49	1.68	1.68	2.41	2.42	0.013213	0.12471
260.0	6.84	1.05	1.49	1.66	6.60	12.55	1.49	1.49	2.41	2.41	0.012902	0.12275
270.0	6.84	1.05	1.52	1.58	6.28	12.95	1.39	1.39	2.41	2.41	0.013125	0.12901
280.0	6.84	1.05	1.47	1.80	6.03	13.03	1.29	1.30	2.40	2.41	0.012506	0.11844
290.0	6.83	1.05	1.50	1.94	5.84	13.11	1.19	1.20	2.40	2.41	0.012302	0.12413
300.0	6.83	1.05	1.49	1.81	5.99	13.23	0.98	0.99	2.40	2.41	0.0116	0.12374
310.0	6.82	1.05	1.50	1.93	5.66	13.31	0.89	0.89	2.42	2.41	0.011506	0.12464
320.0	6.81	1.05	1.51	1.94	5.62	13.36	0.79	0.80	2.41	2.40	0.011692	0.1279
330.0	6.81	1.05	1.50	1.54	5.80	13.52	0.69	0.69	2.41	2.40	0.011789	0.12481
340.0	6.81	1.05	1.47	1.45	5.87	13.46	0.59	0.60	2.41	2.40	0.011972	0.11845
350.0	6.82	1.05	1.51	1.49	5.74	13.62	0.48	0.49	2.41	2.41	0.011573	0.12822
360.0	6.82	1.05	1.49	1.46	5.78	13.59	0.28	0.29	2.41	2.41	0.011671	0.12171
370.0	6.8	1.0	1.5	1.46	5.78	13.59	0.28	0.29	2.41	2.41	0.011613	0.1367
380.0	6.8	1.0	1.5	1.46	5.78	13.59	0.28	0.29	2.41	2.41	0.011701	0.12125
390.0	6.8	1.0	1.5	1.40399	5.42839	14.0839	0.00	0.00	2.41	2.41	0.010996	0.12636

Probe Sample Train 2:			0
Room Particulate Correction			
Mr	0	Milligram Catch (mg)	
Vmr	50.01588	Total Volume Sampled (dscf)	
		Rotometer (glass) at 100	
		flow rate is 0.12924 cfm	
missions			

	Room Temp		Bar Pressure		Relative Humidity		Air Velocity	
	Before	After	Before	After	Before	After	Before	After
	70	68	29.10	29.03	24.0	19.0	0	0
Average Dilution Tunnel Measurements						Sample Data		
Burn	Velocity	Flow Rate	Temp	Total Sample		Particulate Catch		
Time	(Ft/sec)	(dscf/min)	(R)	1	2	1	2	
387	22.72	248.89	540.19	90.71	90.58	14.10	12.20	
	Dilution Tunnel Dual Train Precision							
	Sample Ratios		Total Emissions (g)					
	Train 1	Train 2	Train 1	Train 2	Deviation (%)			
	1061.85	1063.42	14.97	12.97	7.15%			
Burn				Initial		Run	Average	
Rate		Surface		Draft		Time	Draft	
0.923		0.000		0.036		387.000	0.021	
Run	Date	Burn Rate	Emission					
9	2/5/2019	0.923	2.166					

E&E Boiler Tunnel Traverse Worksheet

Static Pressure: **0.343**

Barometer: 29.1

	TUNNEL VELOCITY	TUNNEL TEMP	SQUARE ROOT
A CENTER	0.105		0.3240
B CENTER	0.108		0.3286
A1	0.086		0.2933
A2	0.101		0.3178
A3	0.101		0.3178
A4	0.09		0.3000
B1	0.09		0.3000
B2	0.104		0.3225
B3	0.105		0.3240
B4	0.088		0.2966
AVERAGE		#DIV/0!	0.3125

PITOT CONSTANT= 0.9575

E&E FUEL LOAD DATA SHEET

				Test Load Weight:	
			Lower	Ideal	Upper
Firebox Volume:	2.4	cu. ft	15.12	16.80	18.48

Load Volume: 0.5187 cu. ft — Loading Density: 6.504 lbs./ft3

Number of Spacers: 24 — Load Density: 30.097 lbs./ft3

Piece Size: Thick	x Wide	x Length	Weight lbs	Meter Moisture Content Dry Uncorrected %			
4	4	15	2.90	19.20	19.50	19.60	183.75
4	4	15	2.93	18.50	18.70	18.20	183.75
2	4	15	1.54	18.20	18.00	18.70	78.75
2	4	15	1.40	18.50	18.10	19.10	78.75
2	4	15	1.26	18.00	20.80	20.50	78.75
2	4	15	1.53	20.50	20.30	19.70	78.75
2	4	15	1.59	18.00	18.20	18.00	78.75
			2.46				0.00
							0.00

Test Load Weigh 15.61 lbs. **Dry Weig** 5.95 kg.

Average Moisture Content: %

Dry 18.97 — 18.97 — Wet: 15.94

Pre-test moisture content: %

#DIV/0! — #DIV/0! — Wet: #DIV/0!

Coal Bed Range 3.2 lbs. to 3.9 lbs. 20% to 25% of test load

E&E FUEL LOAD DATA SHEET

			Test Load Weight:		
			Lower	Ideal	Upper
Firebox Volume:	2.4	cu. ft	15.12	16.80	18.48
Load Volume:	0.0182	cu. ft	Loading Density:	6.800	lbs./ft3
Number of Spacers:			Load Density:	895.269	lbs./ft3

Piece Size: Thick	x Wide	x Length	Weight lbs	Meter Moisture Content Dry Uncorrected %			
2	4	6	16.32	19.30	23.30	17.20	31.50
				17.90	16.70	17.30	0.00
							0.00
							0.00
							0.00
							0.00
							0.00
							0.00
							0.00

Test Load Weigh 16.32 lbs.

Dry Weig 5.39 kg.

Average Pretest Moisture Content: %

Dry: 37.23

two pin: (dry) 37.23

Wet: 27.13

Measurement Technology Group

Test Report Review Template – ASTM E3053 & ASTM E2515

Date___4/7/2021___________

Appliance Model ___England Stoves 15 SSW01___________________________

Test Lab___Intertek Labs___________________________

Date of Compliance Test___01/23/2020__________________

Test Report ID___ 103758222MID-001R1_______________________

Findings: (highlight one) Acceptable Deficient Invalid

List of major issues found:

Issue	Applicable Method/Rule Section	Note
No conditioning information found in the report. Just states that 50 hours were completed by manufacturer.	M28R (2.1.4) ASTM E2780 (9.1.3), (9.1.4), (9.1.5), (9.1.6) 40 CFR 60.533(b)(5)	No data found in report.
Missing PM Test Data, Runs 1, 2, 3, 5 and 7	40 CFR 60.533(b)(5) 40 CFR 60.534(a)(1)	No PM or run data found for these test
Runs 5 not proportional sampling (filter plugging)	ASTM E2515 (9.8.1)	In order to maintain proportional sampling, the test lab must change the filter and continue testing without aborting the test.
Usable Firebox dimensions and calculations missing.	ASTM E2780 (9.3) 40 CFR 60.533(b)(3) 40 CFR 60.533(b)(5)	Calculations missing from report. No dimension criteria to support volume determination.
Test fuel density not reported	ASTM E2780 Section (9.4.1.3)	This information is missing from the report.
Test fuel moisture content too low	ASTM E2780 Section (9.4.1.2(1))	Several fuel pieces fell below the allowable range of 19-25% moisture.

Report doesn't demonstrate that the low burn rate was achieved.	M28 (8.1.1) via M28R (2.1.1) 40 CFR 60.537(a)(2)	The report does not demonstrate that the test with the 0.923 kg/hr was the lowest achievable by the unit, nor does the report state why a category 1 test could not be conducted. Documentation of a failed test effort to achieve a category 1 test is needed, or clear evidence that the two category 2 tests were conducted at the lowest achievable heat output rate.
Data missing for determining dual train comparison. Discussion on run 7 and 8 which had greater than 7.5% deviation is missing in the summary section.	ASTM E2515 (11.7) 40 CFR 60.533(b)(5)	This discussion should be included in the report. calculations demonstrating that the 0.5 g/kg criteria were met must also be included in the test report.
Should have averaged multiple category tests per the method requirement.	ASTM E2780 (9.5.13)	Where multiple tests were done in a category you must average at least 2 of the tests. If only two were done they must both be included in the average. If 3 were done you can exclude 1 test run.
Manufacturer's instructions to lab missing.	40 CFR 60.534(h) 40 CFR 60.536(g)(1)	Must be provided in the report.

Additional Notes:

The report does not include data for a category 1 test. The report does not clarify why a category 1 could not be met.

The report does include two category 2 tests, however, the data presented does not demonstrate on their own that the lowest burn rate was done. The report needs a discussion on why a category 1 test could not be conducted and the report must clearly demonstrate that the lowest output test is the lowest that could be achieved in normal home use.

8.1.1 Burn Rate Categories. One emission test run is required in each of the following burn rate categories:

Burn Rate Categories

[Average kg/hr (lb/hr), dry basis]

Category 1	Category 2	Category 3	Category 4
<0.80	0.80 to 1.25	1.25 to 1.90	Maximum.
(<1.76)	(1.76 to 2.76)	(2.76 to 4.19)	burn rate.

RUN #4 (01/29/19): Air control set for a category 2 burn rate with a burn time of 312 minutes. The test was loaded in 60 seconds with the door remaining open for 1 minute after the fuel was added. Air shutter fully closed. The fan was set to low position. The results of the test ended as a category 2 burn rate of 1.217 kg/hr.

RUN #9 (02/05/19): Air control set for a category 1 burn rate with a burn time of 387 minutes. The test was loaded in 60 seconds with the door remaining open for 5 minutes after the fuel was added. Air shutter fully closed. The fan was set to low position. The results of the test ended as a category 1 burn rate of 0.923 kg/hr.

Meisenbach, Caitlin

From:	WoodHeaterReports
Sent:	Monday, August 2, 2021 5:15 PM
To:	'John Wray'
Cc:	Chris Terrell; Carroll Hudson (chudson@englanderstoves.com); Scinta, Robert; Ayres, Sara; Johnson, Steffan; Miller, Anthony; Werner, Jacqueline; Porter, Amy; Wayland, Richard; Jordan, Scott; Vizard, Elizabeth; Duffy, Rick; Brian Ziegler Intertek; Brian Brunson Intertek
Subject:	England's Stove Works, Inc., Problems/Irregularities in Certification Test Report for Wood Heater Models 15-SSW01, 50-SHSSW01, 50-TRSSW01, 15-W03, 50-SHW03, and 50-TRW03; Certificate of Compliance Number 193-19
Attachments:	Deficiency Letter England's Stove 15-SSW01_ (002).pdf
Importance:	High

Dear Mr. Wray,

Please find attached a letter concerning the above-referenced wood heater models. We kindly ask for an initial response within **ten (10) calendar days** from receipt of the attached letter.

Please acknowledge receipt of this email. If you have any questions, please let me know.

Rafael Sanchez, Ph.D.
Wood Heater Program Lead
Air Branch
Monitoring, Assistance, and Media Programs Division
Office of Compliance
U.S. Environmental Protection Agency (EPA)
Room 7149-D
1200 Pennsylvania Ave., NW
MS:2227A
Washington, DC 20460
202-564-7028
202-564-0050 fax
Teleworking on Mondays, Wednesdays, and Fridays (571-236-1927)

Questions about Wood Heaters or Certifications? Send them to WoodHeaterReports@epa.gov

Are you looking for a wood heater or central heater? Please try our fully searchable EPA Certified Wood Heater Database (https://www.epa.gov/compliance/epa-certified-wood-heater-database).

CX 16

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF
ENFORCEMENT AND COMPLIANCE
ASSURANCE

August 2, 2021

Mr. John Wray
Lab Technician
England's Stove Works, Inc.
589 South Five Forks Road
Monroe, Virginia 24574

Re: England's Stove Works, Inc., Wood Heater Models 15-SSW01, 50-SHSSW01, 50-TRSSW01, 15-W03, 50-SHW03, and 50-TRW03; Certificate of Compliance Number 193-19

Dear Mr. Wray:

The United States Environmental Protection Agency (EPA or Agency) has completed a post-certification review of England's Stove Works, Inc. (England's), Certification of Conformity, and November 18, 2019 certification test report, submitted to EPA for the above-referenced wood heater models. As discussed below, this review found that the certification test was not conducted in accordance with the 2015 Wood Heater Rule and applicable test method. As a result, England's Certification of Conformity and certification test are both invalid, serving as the basis upon which EPA may revoke the Certificate of Compliance Number 193-19 (Subject Certificate) for the wood heater models 15-SSW01, 50-SHSSW01, 50-TRSSW01, 15-W03, 50-SHW03, and 50-TRW03 (Subject WH Models). *See* 2015 Wood Heater Rule at 40 C.F.R. § 60.533(l)(1)(ii) and (vii).

This is not a final Agency action. Before initiating the process to revoke the Subject Certificate, EPA is providing you the opportunity to conduct a valid certification test in accordance with the applicable test method. If you intend to take the opportunity to retest, you must confirm that you intend to retest as described below. Furthermore, you must also confirm that you will cease the advertisement and sale of the Subject WH Models and confirm that you will notify any distributors and retailers of the need to cease the advertisement and sale of the Subject WH Models. The Subject WH Models may not be sold until EPA reviews the resubmitted information and determines that you have submitted a valid certification test and Certification of Conformity demonstrating compliance with the applicable emission standard. If you decline to retest, EPA will formally initiate the revocation process, and you will have the opportunity for a hearing, pursuant to 40 C.F.R. § 60.539.

Identified Problems/Irregularities in Certification Test Report and Applicable Regulatory Basis and/or Test Method

Pursuant to the 2015 Wood Heater Rule, manufacturers must conduct a valid certification test using the prescribed test methods and procedures for each wood heater model. *See* 40 C.F.R. § 60.534.

Primary Identified Problem or Irregularity
Our review of England's November 18, 2019 certification test report found that the certification test was invalid because it was not conducted in accordance with the 2015 Wood Heater Rule and applicable test method. Specifically, the certification test did not use test fuel pieces within the allowable moisture range. The American Society for Testing and Materials (ASTM) Test Method E2780, Section 9.4.1.2(1), states that the average fuel moisture content for each test fuel piece used to construct the test fuel cribs (excluding test fuel spacers) must be between 19 and 25 percent dry basis. However, the Subject WH Models' certification test was conducted using five test fuel pieces with moisture contents between 18.07 and 18.47 percent (Runs 4, 6, and 9). Moisture content outside the specified range can make a significant difference in emissions and efficiency. Therefore, because the certification test did not use test fuel pieces within the allowable moisture content range, EPA has determined that the certification test is invalid.

Additional Problems or Irregularities
EPA's review also found the following issues in the test report, which should be addressed in subsequent reports submitted to EPA.

Test Report Problems or Irregularities	Regulatory Citation and/or Test Method	Information Needed to Address Problems or Irregularities
Missing Information – Conditioning Data.	EPA M28R Section 2.1.4, ASTM E2780 Sections 9.1.3, 9.1.4, 9.1.5, and 9.1.6.	Conditioning data must be included in the test report demonstrating the device was conditioned at a minimum of 50 hours using a medium burn rate.
Missing Information in the Non-Confidential Business Information (Non-CBI) Test Report – Usable Firebox Dimensions and Volume Calculation Data.	40 C.F.R. § 60.533(b)(5), 40 C.F.R. § 60.537(f), ASTM E2780 Section 9.3.	The test report must include firebox dimensions and volume calculation data.
Missing Information – Particulate Matter (PM) Test Data.	40 C.F.R. § 60.533(b)(5), 40 C.F.R. § 60.534(a)(1).	Valid PM test data must be included for Runs 1, 2, 3, 5, and 7.
Sampling Train Operation - Not Proportional Sampling (Filter Plugging).	ASTM E2515 Section 9.8.1.	The test report did not demonstrate the test laboratory changed the filter and continued testing without aborting the test (Run 5).
Missing Information – Test Fuel Density.	ASTM E2780 Section 9.4.1.3.	The test report must include the average test fuel density, dry basis. Test fuel density shall be in the range of 25 to 36 lb/ft^3.
Compliance Determination Cannot be Made - Failure to Demonstrate and Document Lowest Achievable Burn Rate.	EPA M28 Section 8.1.1 via M28R Section 2.1.1, 40 C.F.R. § 60.537(a)(2).	The test report must include documentation that the Category 1 test at 0.923 kg/hr represents the lowest achievable output rate accessible to a home user and the lowest burn rate for which the test

Test Report Problems or Irregularities	Regulatory Citation and/or Test Method	Information Needed to Address Problems or Irregularities
		was conducted. Documentation of a failed test effort to achieve a Category 1 test is needed, or clear evidence that the two Category 2 tests were conducted at the lowest achievable heat output rate.
Missing Information – Dual Train Comparison.	ASTM E2515 Section 11.7, 40 C.F.R. § 60.533(b)(5).	The test report (summary section) must include a discussion on Runs 7 and 8 regarding dual train deviation. Both runs had a deviation greater than 7.5 percent. Discussion should include calculations demonstrating the 0.5 g/kg criteria was met.
Missing Information – Instructions from the Manufacturer to the Laboratory on the Operation of the Device.	40 C.F.R. § 60.534(h), 40 C.F.R. § 60.536(g)(1).	The test report must document all communication with the laboratory regarding the operation of the device. Any communication or instructions must be consistent with instructions provided in the Owner's Manual.
Burn Rates – Failure to Average Additional Test Runs.	ASTM E2780 Section 9.5.13.	The test report shows multiple test runs within the same Category. In the event of multiple test runs within the same Category, the test lab must average at least two of the tests. For example, if only two were done, they must both be included in the average. If three were done, you may exclude one test run.

<u>Re-Test Information</u>

If you choose to retest, you must submit a written statement, signed by a responsible official of the manufacturer or authorized representative, within ten calendar days of receiving this letter. The signed statement must include the following: (1) your intent to retest the Subject WH Models; (2) confirmation that you will cease advertisement and sales of the Subject WH Models within 21 calendar days of receipt of this letter, and (3) that you will notify any distributors and retailers of the need to cease sales of the Subject WH Models within 21 calendar days of receipt of this letter. The signed statement must be submitted to WoodHeaterReports@epa.gov. The subject line of your email should contain "Wood Heater Proposed Certification Re-Test" and the model name.

If you choose to retest, you must notify EPA of the date that certification testing is scheduled to begin. This notice must be received by EPA at least 30 calendar days before the start of testing. The notification of testing must include:

1. Manufacturer's name and responsible official and physical and email addresses,
2. Approved test laboratory's name and physical and email addresses,
3. Third-party certifier name, and
4. Dates and location of testing.

Once testing is completed, you must submit new CBI and non-CBI versions of the certification test report along with a Certification of Conformity and all other required documentation. EPA will review the new certification test report to determine if a valid certification test was completed. If EPA determines that the new certification test is valid, you will be notified, and you may resume advertisement and sale of the model line. Please submit the notification of testing, new test reports, and Certification of Conformity to WoodHeaterReports@epa.gov. The subject line of your email(s) should contain "Wood Heater Certification Re-Test Information."

Failure to Notify EPA or Retest the Subject WH Models

If you decline to retest, or if we do not hear from you within the identified timeframe, EPA will formally initiate the revocation process and notify you of our intent to revoke the Subject Certificate for the above-referenced Subject WH Models. You will have the opportunity for a hearing pursuant to 40 C.F.R. § 60.539.

If you have any further information EPA should consider with respect to our determination that the certification test for the Subject WH Models is invalid, EPA is extending you, by this letter, an opportunity to advise the Agency, in person, via a conference call, or in writing, of any such information. To request such an opportunity to confer, please contact Bob Scinta of my staff within five (5) calendar days of receipt of this letter at Scinta.robert@epa.gov or 202-564-7171.

This request has been coordinated with EPA's Office of Air Quality Planning and Standards and the Office of General Counsel. If you have any other questions regarding this letter, please contact Rafael Sanchez of my staff at 202-564-7028 or via email at WoodHeaterReports@epa.gov.

Sincerely,

Vizard,
Elizabeth

Digitally signed by Vizard, Elizabeth
Date: 2021.08.02 14:46:30 -04'00'

for Anthony J. Miller
Acting Director
Monitoring, Assistance, and Media Programs Division
Office of Compliance
Office of Enforcement and Compliance Assurance

cc:

Richard A. Wayland, OAQPS/AQAD
Steffan M. Johnson, OAQPS/MTG
Jacqueline Robles Werner, OECA/OC
Amy Porter, OECA/OC
Robert Scinta, OECA/OC/MAMPD/Air Branch
Scott Jordan, OGC
Brian Ziegler, Intertek Building & Construction

Meisenbach, Caitlin

From:	WoodHeaterReports
Sent:	Thursday, September 30, 2021 2:35 PM
To:	John Wray
Cc:	Carroll Hudson (chudson@englanderstoves.com); Scinta, Robert; Johnson, Steffan; Brashear, Angelina; Ayres, Sara; Malave, Maria; Wayland, Richard; Vizard, Elizabeth; Werner, Jacqueline; Jordan, Scott; Miller, Anthony; Duffy, Rick
Subject:	Re: Notice of Proposed Determination to Revoke Certificate of Compliance Number 193-19 for the 15-SSW01, 50-SHSSW01, 50-TRSSW01, 15-W03, 50-SHW03, and 50-TRW03 Wood Heater Models
Attachments:	Certification Revocation England's Stove Works, Inc., Wood Heater Models 15-SSW01 .pdf
Importance:	High
Sensitivity:	Personal

Dear Mr. Wray:

I am attaching a letter concerning the above-referenced wood heater models.

Would you please acknowledge receipt of this email? If you have any questions, please let me know. Thank you.

Rafael Sanchez, Ph.D.
Wood Heater Program Manager
Air Branch
Monitoring, Assistance, and Media Programs Division
Office of Compliance
U.S. Environmental Protection Agency (EPA)
Room 7149-D
1200 Pennsylvania Ave., NW
MS:2227A
Washington, DC 20460
Ph. 202-564-7028
Teleworking on Mondays, Wednesdays, and Fridays, ph. 202-844-6993

Questions about Wood Heaters or Certifications? Please send them to WoodHeaterReports@epa.gov

Are you looking for a wood heater or central heater? Please try our fully searchable EPA Certified Wood Heater Database (https://www.epa.gov/compliance/epa-certified-wood-heater-database).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

September 30, 2021

Mr. John Wray
Lab Technician
England's Stove Works, Inc.
589 South Five Forks Road
Monroe, Virginia 24574

Re: Notice of Proposed Determination to Revoke Certificate of Compliance Number 193-19 for the 15-SSW01, 50-SHSSW01, 50-TRSSW01, 15-W03, 50-SHW03, and 50-TRW03 Wood Heater Models

Dear Mr. Wray:

The United States Environmental Protection Agency (EPA or Agency) is providing England's Stove Works, Inc. (England's) notice of our proposed determination to revoke the above-referenced Certificate of Compliance. Pursuant to the 2015 Wood Heater Rule, the revocation will not take place until England's has an opportunity to request a hearing. To request a hearing, you must submit a written request within 30 calendar days following receipt of this notice, as required under 40 CFR 60.539(a)(1)(iii). Revocation of the above-referenced Certificate of Compliance will become effective if England's does not request a hearing within 30 calendar days. The basis for the proposed determination to revoke certification is discussed below.

In a letter dated August 2, 2021, EPA notified England's that a post-certification review found the certification test submitted for the above-referenced models was not conducted in accordance with the 2015 Wood Heater Rule and the applicable test method. Specifically, the Agency found the following problems/irregularities in the certification test report:

Primary Identified Problem or Irregularity

- The certification test did not use test fuel pieces within the allowable moisture range. The American Society for Testing and Materials (ASTM) Test Method E2780, Section 9.4.1.2(1), states that the average fuel moisture content for each test fuel piece used to construct the test fuel cribs (excluding test fuel spacers) must be between 19 and 25 percent dry basis. However, the certification test was conducted using five test fuel pieces with moisture contents between 18.07 and 18.47 percent (Runs 4, 6, and 9).

Additional Problems or Irregularities

- Missing Information – Conditioning Data.
- Missing Information in the Non-Confidential Business Information (Non-CBI) Test Report – Usable Firebox Dimensions and Volume Calculation Data.
- Missing Information – Particulate Matter (PM) Test Data.
- Missing Information – Test Fuel Density.
- Missing Information – Dual Train Comparison.
- Missing Information –Instructions from the Manufacturer to the Laboratory on the Operation of the Device.
- Failure to Demonstrate and Document Lowest Achievable Burn Rate.
- Failure to Average Additional Test Runs.
- Sampling Train Operation - Not Proportional Sampling (Filter Plugging).

As a result of the above-identified problems/irregularities, EPA found both the certification test and the Certification of Conformity to be invalid. This finding is the basis for the proposed determination to revoke the Certificate of Compliance. In our August 2, 2021 letter, we had provided you with the opportunity to conduct a valid certification test in accordance with the applicable test method. In addition, our August 2 letter provided you with an opportunity to confer with the Agency. As a result, subsequent conference calls were held with my staff on August 6 and August 25. During this period of conferring with EPA, we paused the 10-day timeframe by when you needed to provide notice of your intent to retest and stop the advertisement and sales of the above-referenced wood heater models. Therefore, as we have not received notification of your intention to retest and stop sales since the August 25 call and the time by which you were required to provide such notice has passed, we are now formally notifying England's of our proposed determination and initiating the revocation of the above-referenced Certificate of Compliance. *See* 2015 Wood Heater Rule at 40 C.F.R. § 60.533(l)(1)(ii) and (vii).

As stated above, you may request a hearing within 30 calendar days of receipt of this letter notifying England's of EPA's proposed determination to revoke the Certificate of Compliance. The hearing request must be in writing, must be signed by an authorized representative of England's, and must include a statement setting forth with particularity your objection to the proposed determination. 40 C.F.R. § 60.539(b). The hearing request should be sent to WoodHeaterReports@epa.gov. The subject line of your email should contain "Wood Heater Hearing Request" and the model names. If a hearing is not requested within the required timeframe, revocation of the Certificate of Compliance will become effective 30 calendar days following receipt of this letter.

This response has been coordinated with the Office of Air Quality Planning and Standards and the Office of General Counsel. If you have any questions regarding this letter, please contact Rafael Sanchez of my staff at 202-564-7028 or via email at WoodHeaterReports@epa.gov.

Sincerely,

ELIZABETH VIZARD

Digitally signed by ELIZABETH VIZARD
Date: 2021.09.30 13:35:53 -04'00'

For Anthony J. Miller
Acting Director
Monitoring, Assistance, and Media Programs Division
Office of Compliance
Office of Enforcement and Compliance Assurance

cc:

Richard A. Wayland, OAQPS/AQAD
Steffan M. Johnson, OAQPS/MTG
Jacqueline Robles Werner, OC
Robert Scinta, OC/MAMPD
Scott Jordan, OGC

MANUFACTURER AND GENERAL INFORMATION					
Date of review completion:	**1/21/2021**		**Certification Number, if applicable:**		
Manufacturer Name:					
Model Name/Number:					
Heater Type Check one):	☐Adjustable Burn Rate Wood Stove	☐Pellet Stove	☐Single Burn Rate Wood Stove	☐Hydronic Heater	☐Forced-Air Furnace (FAF)
Hydronic Heater Type (Check one):	☐Full Storage	☐Partial Storage	☐Indoor	☐Outdoor	
Fuel Tested:	☐Crib	☐Pellet	☐Cordwood: ________	☐Wood Chips	☐ Other
Date of WH application submission to EPA:	**7/6/2020**	**Date of Test Report**	12/9/2020		
Revised? ☐**Yes** ☐**No, If yes, date:**	12/9/2020	Performance test data submitted within 60 days? _ Yes _No, if no, explain.			
Certification test dates:					
Was the WH application complete, including manufacturer's statements and signed, when submitted to the EPA?*	☒**Yes** ☐**No**	**If no, date of completion:**	Click or tap to enter a date.		
EPA/ASTM Test Method(s):	**EXAMPLES: ASTM E2515-2011** - Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel **ASTM E2618-2013** - Standard Test Method for Measurement of Particulate Emissions and Heating Efficiency of Wood-Fired Hydronic Heating Appliances **CSA B415.1-2010** - Performance Testing of Solid-Fuel-Burning Heating Appliances				
Was this heater tested using an Alternative Test Method (ATM)?	☐**Yes** ☐**No**	**Is this heater equipped with a catalytic combustor?**	☐**Yes** ☒**No**		
Name of EPA-Approved Test Laboratory		**Name of EPA-Approved Third-Party Certifier:**			

OAQPS REVIEW SUMMARY (IF APPLICABLE)				
	Date of Review Request by OC:		**Date of Review Completed by OAQPS:**	

	Findings: __ **Acceptable** __ **Deficient** __ **Invalid**	**See Test Report Review Summary**	
	Revised Test Report date:		
SUMMARY OF EMISSIONS, EFFICIENCY and CO			
	WH **2020** weighted average of **2.0 g/hr** (0.0044 lb/hr). **2020** cord wood alternative compliance option weighted average of **2.5 g/hr** (0.0055 lb/hr)	Particulate Emissions	
		Carbon Monoxide Emissions	
		Higher Heating Value Basis – CSA B415.1 Stack Loss	
	HH **2020** - **0.10 lb/mmBtu** (0.026 g/MJ) heat output per individual burn rate **2020 cord wood** alternative compliance option for particulate matter emission limit: **0.15 lb/mmBtu** (0.026 g/MJ) heat output per individual burn rate	Particulate Emissions	
		Carbon Monoxide Emissions	
		Higher Heating Value Basis – CSA B415.1 Stack Loss	
	FAF **2020** forced-air furnace particulate matter emission limit: **0.15 lb/mmBtu** (0.026 g/MJ) heat output per individual burn rate	Particulate Emissions	
		Carbon Monoxide Emissions	
		Higher Heating Value Basis – CSA B415.1 Stack Loss	

Comprehensive Certification Test Review Checklist - Part B (New Certifications and ADEC)							
Manufacturer							
Model				Type:			
Determination	Approved			Date: 9/1/2020			
Testing Information	***Determination***						***Notes***
Test report date		***Revision date(s)***					
Test method	Not reported						
Test Lab							
Certificate of Conformity							
QA plan?							
Test Report Elements	***Determination***						***Notes***
Wght Avg PM emissions (g/hr)		1-hr (g/hr)?					
Wght Avg HHV Efficiency (%)							
Wght Avg CO (g/hr)		Wght Avg CO (g/min)					
Max heat output (Btu/hr)							
Manufacturers Instructions to lab							
Firebox vol. test report							
Firebox dimensions		Longest dim. (in)					
Firebox calculations							
Efficiency calculations							
Burn rate calculations							
Raw data sheets							
Pre-burn completed by (M28 Only)							
Pre-burn data/Conditioning data							
Lab technician notes							
Doc. of run appropriateness							
Doc. of run validity							
Doc. of run anomolies							
Doc. of run burn rates							
Engineering diagrams?							
Temperature sensor If catalytic							
Photos of the fuel loaded							
Test Run Data	***Determination***						***Notes***

Run #								
Run Category								
Burn rate (kg/hr)								
PM emissions by run (g/hr)								
PM 1-hr filter pull (g/hr)								
Filter data								
Train precision (%)								
Negative weights								
Discussion Negs handled appropriately								
Heat output by run (Btu/hr)								
CO by run (g/hr)								
HHV efficiency (%)								
Lowest burn rate tested								
All run data								
Appliance Fueling (Cordwood)	***Determination***							***Notes***
Fuel species								
Log length (in)								
Direction of longest dimension								
Log direction for testing								
Squared (Must not have fungus)								
Debarked (ASTM test only)								
Load density (lb/ft3)								
Fuel moisture content load (%wb)								
Fuel piece configuration								
Appliance Fueling (Pellets)	***Determination***							***Notes***
Pellet species/type	Reported							
Pellet fuel certification	Reported							
Source of the pellet specification	Reported							
Owners Manual Req.	***Determination***							***Notes***
Stack height								
Location recommendation								
Guidance on proper draft								
Fuel loading & reloading								
Fuel selection recomm.								

Improper fuels warnings		
Fire starting procedures		
Proper use of air controls		
Proper operation low		
Ash removal procedures		
Replacement parts		
Federal warning (C or NC)		
Warranty rights		
Catalytst operation		
Cat maintenance procedures		
smoke detectors and carbon monoxide r		
EPA compliance status		
Determining catalyst det. or failure		
Reporting	***Determination***	***Notes***
Summary tables complete		
All run data submitted		
Description and Pictures of heater?		
If coordwood, if ATM included?		
Test report complete		
Full CBI and non-CBI test report?		
Owner manual complete		
Test dates		

WH

Category 1	**< 0.80 (< 1.76)**
Category 2	**0.80 to 1.25 (1.76 to 2.76)**
Category 3	**1.25 to 1.90 (2.76 to 4.19)**
Category 4	**Maximum burn rate**