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Generic Verification Protocol for Determination of Emissions from Outdoor Wood-Fired Hydronic Heaters

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Abbreviations and Acronyms

ANSI	American National Standards Institute
APCT Center	Air Pollution Control Technology Verification Center
ASQ	American Society for Quality (formerly ASQC – American Society for Quality Control)
CBI	confidential business information
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ETV	environmental technology verification
GVP	generic verification protocol
ISO	International Organization for Standardization
OAQPS	EPA Office of Air Quality Planning and Standards
ORD	EPA Office of Research and Development
OWHH	outdoor wood hydronic heater
PM	particulate matter
QA	quality assurance
QC	quality control
QMP	quality management plan
RTI	RTI International
SOP	standard operating procedure

1. INTRODUCTION

This protocol describes the Environmental Technology Verification (ETV) Program's considerations and requirements for verification of emissions reduction provided by outdoor wood-fired hydronic heaters (OWHHs). Outdoor wood-burning units provide heat and hot water for homes and other buildings. Outdoor wood-fired hydronic heaters also are called outdoor wood boilers, outdoor wood furnaces, or outdoor wood-fired heaters. The basis of the verification will be the emissions and performance of these heaters under standardized test conditions.

ETV provides verified emissions data for OWHH technologies. These data may be used as part of an overall process that leads to a product's qualification in the U.S. Environmental Protection Agency's (EPA) voluntary OWHH program. This protocol describes the ETV portions of that process in detail. **Table 1** provides an overview of OWHH ETV and its interface with the EPA voluntary OWHH program. These data may also be used for state programs.

Table 1. Overview of OWHH ETV Process and Participants' Responsibilities

Step in Process	Applicant	ETV		EPA-OAQPS	EPA-ORD
		APCT Center	Testing Org.		
Preparation of preliminary application (without ETV data)	Primary	None	None	Advise	Access
Preliminary test dialog	Participate	Organize & participate	Participate	Participate	Access
Test/quality assurance (QA) plan	Review	Shared preparation, APCT Center approve		Review	Review & approve
Acceptance of ETV test-QA plan, and terms and payment	Primary	Advise	Advise	Access	Access
Conduct ETV test	Access	Audit	Primary	Access	Audit
Prepare test report	Access	Review	Primary	Access	Access
Publish ETV report & statement	Review	Primary	Review	Access	Review & approve

1.1 Environmental Technology Verification

EPA through its Office of Research and Development (ORD) has instituted the ETV Program to verify the performance of innovative and improved technical solutions to problems that threaten human health or the environment. EPA created the ETV Program to accelerate the entrance of new and improved environmental technologies into the marketplace. It is a voluntary, nonregulatory program. Its goal is to verify the environmental performance characteristics of commercially available technologies through the evaluation of objective and quality-assured data so that potential purchasers and permittees are provided with an independent and credible assessment of what they are buying and permitting.

The ETV Program does not conduct technology research or development. ETV test results are always publicly available, and the applicants are strongly encouraged to ensure that they are satisfied with the performance of their technologies prior to beginning an ETV test. Within the ETV Program, this state of development is characterized as “commercially available” (i.e., the technology will be available for sale as tested).

The provision of high-quality performance data on a commercially available technology encourages more rapid implementation of that technology and consequent protection of the environment with better and less expensive approaches. The ETV Program is conducted by multiple ETV centers that span the breadth of environmental technologies.

1.2 Air Pollution Control Technology Verification Center

EPA’s partner in the Air Pollution Control Technology Verification Center (APCT Center) is RTI International,¹ a nonprofit contract research organization with headquarters in Research Triangle Park, NC. The APCT Center verifies the performance of commercially available technologies used to control air pollutant emissions. The emphasis of the APCT Center is currently on technologies for controlling particulate matter (PM), volatile organic compounds, nitrogen oxides, and hazardous air pollutants from both mobile and stationary sources. The activities of the APCT Center are conducted with the assistance of stakeholders from various interested parties. Overall, APCT Center guidance is provided by the Stakeholders Advisory Committee, whereas the detailed development of individual technology ETV protocols is conducted with input from stakeholders focused on each technology area.

The APCT Center develops generic verification protocols and specific test/quality assurance (QA) plans, conducts independent testing of technologies, and prepares ETV test reports and statements for broad dissemination. Testing costs are ultimately borne by the technology applicants.

This generic verification protocol (GVP) provides the requirements for APCT Center’s verification of the emissions performance of OWHH. The APCT Center reserves the right to evaluate each technology submitted for verification and to determine the applicability of this protocol to that specific technology. The critical data quality objectives (DQOs) in this document were based on emissions measurements necessary to support the vendor’s application for OAQPS voluntary program and to provide data of interest to state programs. Regulatory authorities, including EPA through its Office of Air Quality Planning and Standards (OAQPS) and state agencies, may have additional requirements.

This protocol was developed and based on input from EPA and a broad group of stakeholders who have expertise in OWHH and come from the vendor, user, and regulatory spheres.

The tests will be conducted at an independent, third-party testing organization that has been qualified and audited by the APCT Center. The data quality requirements of this GVP will be applied at approved testing organizations through the preparation of a laboratory-specific test-QA plan. Other application- or technology-specific information may also need to be addressed in

¹RTI International is a trade name of Research Triangle Institute.

the test-QA plan, which is described in Section 10.0. Test results will be presented as ETV reports and statements.

This generic protocol will be revised as necessary. Changes to the protocol will not affect products that already have been verified. However, such changes will be reflected in test-QA plans not yet finalized regardless of the applicant's application status. Test-QA plans that are being carried out when a protocol change is enacted will be examined by the APCT Center to determine whether any modifications must be made.

1.3 Quality Management

Management and testing in the APCT Center program are performed in accordance with procedures and protocols defined by the following:

- U.S. EPA. 2008. Environmental Technology Verification Program Quality Management Plan, EPA/600/R-08/009, U.S. EPA, Cincinnati, OH;
- RTI (Research Triangle Institute). 2005. Quality Management Plan for Verification Testing of Air Pollution Control Technology, Revision 2.2, Research Triangle Park, NC;
- *Generic Verification Protocol for Determination of Emissions from Outdoor Wood-fired Hydronic Heaters (this document)*;
- Test-QA plan prepared for each test organization; and
- Test-QA plan addendum prepared for each OWHH model.

EPA's ETV Quality Management Plan (QMP) lays out the definitions, procedures, processes, inter-organizational relationships, and outputs that ensure the quality of both the data and the programmatic elements of the ETV Program. Part A of the ETV QMP contains the specifications and guidelines that are applicable to common or routine quality management functions and activities necessary to support the ETV Program. Part B of the ETV QMP contains the specifications and guidelines that apply to test-specific environmental activities involving the generation, collection, analysis, evaluation, and reporting of test data.

The APCT Center QMP describes the quality systems in place for the overall APCT Center. It was prepared by RTI and approved by EPA. Among other quality management items, it defines what must be covered in the GVPs and test-QA plans for technologies undergoing ETV testing. Generic verification protocols are prepared to describe the general procedures to be used for testing a type of technology and to define the critical DQOs.

A test-QA plan is prepared by each test organization. The test-QA plan describes, in detail, how the testing organization will implement and meet the requirements of the GVP. The test-QA plan also sets DQOs for any planned measurements that were not set in the GVP for a particular technology. The test-QA plan addresses issues such as the testing organization's management structure, the test schedule, test procedures and documentation, analytical methods, recordkeeping requirements, and instrument calibration and traceability. It also specifies the QA and quality control (QC) requirements for obtaining ETV data of sufficient quantity and quality

to satisfy the DQOs of the GVP. Testing organizations will be audited by the APCT Center against the approved GVP and test-QA plan they are expected to follow. Section 10 of this GVP addresses requirements for the test-QA plan.

2. OBJECTIVE AND SCOPE

2.1 Objective

The objective of this GVP is to establish the parameters within which OWHH will be tested to verify their emissions control performance with uniform and consistent methods.

2.2 Scope

This protocol describes the considerations and requirements for ETV of emissions from OWHH. Before an OWHH technology can be accepted for verification, several criteria must be met:

- The controlling interests in each technology must be in agreement to pursue ETV;
- The applicant must be a single organization with authority to pay for the applicant's cost; and
- The applicant must show that the technology has a credible impact on emissions.

Emissions testing under this protocol is based on EPA Test Method 28 OWHH for Measurement of Particulate Emissions and Heating Efficiency of Outdoor Wood-Fired Hydronic Heating Appliances and American Society for Testing Materials International Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel (E2515-07). EPA Test Method 28 OWHH also includes energy efficiency. Additional testing may be specified in the Test-QA plan addendum to match data needs of state or other agencies.

2.3 Relationship of ETV Program to EPA-OAQPS Voluntary OWHH Program

EPA-OAQPS has initiated a voluntary program for OWHH. The test results EPA-OAQPS will use to evaluate a technology should be generated following the ETV process, with the ETV report and verification statement submitted by the vendor as the data package to EPA-OAQPS. The Voluntary OWHH Program is described and appropriate contacts are identified at <http://www.epa.gov/woodheaters>.

2.4 Data Quality Objectives

The data of primary interest for verification of OWHH technologies are the emissions of particulate matter. The DQOs of this GVP are the QC requirements of the test methods referenced in Section 2.2. The test-QA plan will address the DQOs.

3. ETV RESPONSIBILITIES

Table 1 (see page 1) provides an overview of OWHH ETV and its interface with the EPA voluntary OWHH program and lists primary responsibilities for each organization involved in the OWHH ETV verification program.

The technology applicant provides the complete product for ETV testing, and logistical and technical support, as required, during the ETV testing. The applicant's responsibilities are defined by a contract with the APCT Center. The preliminary application (Table 1, Row 1) provides relevant background data and technology information to facilitate test-QA plan development. The applicant must pay the verification cost required at the time its contractual relationship with the APCT Center begins.

In addition to the items in Table 1, the APCT Center prepares the GVP (this document); qualifies, approves, and audits the testing organization; approves test-QA plans; prepares the ETV reports and statements from the laboratory test reports; and, jointly with EPA-ORD, reviews and approves the ETV reports and statements. Qualified testing organizations prepare the test-QA plan for their organization and conduct ETV verifications under contract to the APCT Center. The order of activities in Table 1 is mandatory, with the test-QA plan being prepared and approved before testing. The testing organization also conducts internal QA on test results and reports.

4. APPLICATION AND TECHNOLOGY DESCRIPTION

The ETV applicant is the basic source of information regarding its technology, information which is provided to the APCT Center. This information is used by the testing organization and APCT Center to prepare and review a test-QA plan addendum that meets the requirements of the applicant. An applicant may conduct privately sponsored tests at a testing organization for development purposes prior to conducting verification tests. Such pre-testing is understood to be common and important to ensure the technology is properly adjusted and tuned to the application.

4.1 Arranging Testing

Manufacturers wishing to have their products tested under this protocol will notify the APCT Center and contact one of the approved testing laboratories to arrange for testing. All participating test laboratories that have met the requirements of Section 11.0 will be eligible to perform the testing. On request, the APCT Center will provide the names of testing laboratories that meet the requirements given in Section 11.0 and that are participating in the ETV program.

4.2 Identification and Acquisition of OWHH

OWHH will be selected by the manufacturers and shipped to a testing facility that has been qualified and audited by the APCT Center. The OWHH unit will be supplied directly from the manufacturer with a letter signed by the manufacturer's chief executive officer, president, or other responsible corporate representative, attesting that the heater is representative of what will be available to the commercial market. Included in the signed letter will be the full name and description of the product and a description of how the unit was selected.

Information describing the product must include the following.

- The model name and number, serial number, date of manufacture and the thermal output rating, in Btu/h;

- Four color photographs of the unit showing the front, back and both sides;
- A copy of the operation and maintenance instructions; and
- Engineering drawings and specifications for each of the following components:
 - firebox, including a secondary combustion chamber,
 - air induction systems,
 - baffles,
 - refractory and insulation materials,
 - catalysts,
 - flue gas exit,
 - door and catalyst bypass gaskets,
 - outer shielding and coverings,
 - fuel feed system, and
 - blower motors and fan blade size.

For purposes of product identification (for example, by the test laboratory, auditors, end-users, and local inspectors), the manufacturer must attach information to the unit in a reasonably permanent manner to show the name of the manufacturer, all applicable model numbers, and date (year and month) of manufacture. If this information is not present, the test laboratory will reject the heater for testing. All products that the manufacturer claims to be covered by the ETV verification test report and statement must be consistent with this information or they are not covered by the verification test report and statement. Anytime a manufacturer changes a product (e.g., firebox dimensions, airflow rates, airflow direction, heat output, pressure differential through the OWHH) the ETV Verification Statement is no longer valid and a new verification test is required if verification of the product is desired.

4.3 Confidential Business Information

The ETV program is intended to provide independent and quality-assured performance data to potential users of technologies through a documented public process. ETV documents (protocol, test-QA plans, reports, and verification statements) are publicly available. When necessary to conduct verification, confidential business information (CBI) can be submitted to the APCT Center. CBI should be submitted under separate cover, not in the application form, to the APCT Center along with an explanation of why the applicant believes that the submission of CBI is required and why the information is confidential. The applicant can provide CBI design information directly to the test laboratory with written permission to forward the CBI to the APCT Center with the test results. The applicant should also provide written permission to share the CBI with the EPA or state OWHH programs as appropriate.

5. ETV TESTING

The test requirements for verification of OWHH are contained in two methods. They are:

- EPA Test Method 28 OWHH for Measurement of Particulate Emissions and Heating Efficiency of Outdoor Wood-Fired Hydronic Heating Appliances; and

- ASTM Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel (E2515-07).

The test laboratory will confirm that the tested unit conforms to descriptive and design information submitted by the applicant. Any deviation from these methods must be documented in the approved test-QA plan addendum. ETV verification reports must report all data collected and use all valid data as specified by the methods to calculate verification results.

6. REPORTING AND DOCUMENTATION

This section addresses reporting data in the verification report and verification statement. The specifics of what data must be included and the format in which the data must be included shall be covered in a test-QA plan for the test organization (e.g., QA/QC summary forms, raw data collected, and photographs/slides/video tapes). All data collected during ETV tests will be retained by the test organization and reported to the APCT Center, including invalid test results. All data that meet the QA requirements of the test-QA plan are considered valid and will be used to compute emissions reductions for ETV purposes. The emissions will be reported as specified in EPA Method 28 OWHH including units of lb/MM Btu heat input and output and g/hr.

The verification report for each technology will include near the beginning a verification statement that summarizes the verification test and its results. The verification report, including the verification statement, will be written by the APCT Center based on the test report submitted to the APCT Center by the testing organization. The verification report and verification statement will be reviewed by the APCT Center and the technology applicant before being submitted to the EPA for review and approval as specified in the ETV QMP.

6.1 Reports

Based on the test data and report from the laboratory, the APCT Center will prepare the draft verification report, which includes the following topics:

- Verification statement;
- Introduction;
- Description and identification of product tested;
- Procedures and methods used in testing;
- Documentation of test conditions;
- Summary and discussion of results as required to support the verification statement and explain and document necessary deviations from the test plan; and
- References

The verification statement will be signed and will include the following:

- Technology applicant's name and technology's descriptive information,
- Summary of ETV test program,
- Results of the ETV test,
- Any limitations related to the ETV results, and
- Brief QA statement.

The report will contain a statement that the test was performed according to EPA Method 28 OWHH. Review and approval of the draft ETV report and statement are described in Section 1.0, Table 1.

6.2 Data Reduction

Data from measurements made as part of the ETV test will be reported as specified in EPA Method 28 OWHH. Data reduction will be according to this method (or by reference, the ASTM PM test method) or will be documented in the test-QA plan for the test organization.

7. DISSEMINATION OF ETV REPORTS AND STATEMENTS

After an OWHH technology has been tested and the draft verification report and verification statement prepared by the APCT Center, the APCT Center will send a draft of both to the applicant for review. This gives the applicant the opportunity to review the results, test methodology, and report terminology while the drafts remain working documents. The applicant may submit comments and revisions on the draft statement and report to the APCT Center for consideration.

After the APCT Center incorporates appropriate revisions, the draft final verification report and verification statement will be submitted to EPA for review and approval. When complete, four original verification statements with EPA and APCT Center signatures will be produced. One will be filed and retained by the APCT Center, two provided to EPA ETV staff, and one to the applicant. Further distribution of the ETV report, if desired, is at the applicant's and EPA's discretion and responsibility. However, approved verification statements and verification reports will be posted on the ETV web site (www.epa.gov/etv) site for public access without restriction. Full documentation of the verification test will not be posted on the web site, but will be publicly available from the APCT Center.

8. APPLICANT'S OPTIONS SHOULD A TECHNOLOGY PERFORM BELOW EXPECTATIONS

ETV is not a technology research and development program; technologies submitted to ETV are to be commercially available, with well-understood performance. Tests that meet the ETV data quality requirements are considered valid and suitable for publishing; however, a technology may fail to meet the applicant's expectations. In this case, the applicant may request that a verification statement not be issued. However, ETV reports are always in the public domain and will be posted on the ETV web site. Verification reports will be written and will be available from EPA for review by the public regardless of a request not to issue a verification statement. The applicant may improve the product and resubmit it under a new model identification for ETV testing. ETV reports and statements for acceptable tests of the new product will be issued as they are processed by the APCT Center and EPA.

9. LIMITATIONS ON TESTING AND REPORTING

To avoid having multiple ETV reports for the same product and to maintain the ETV testing as independent and a cooperative effort with the applicant, the following restrictions apply to ETV testing under this protocol:

- Applicants may submit only products they own or whose distribution they control. Applicants may not submit for ETV testing products whose use is not in their control, except with the written agreement of the manufacturer or vendor.
- Verifications are valid for a given product (e.g., brand, model, design) as tested. Only one ETV report and statement will be issued for any single application and verification test.
- Test organizations that generate data for verifications must be independent of the applicant.

10. REQUIREMENTS FOR TEST-QA PLAN

10.1 Quality Management

All testing organizations participating in this ETV Program must meet the QA/QC requirements defined below and have an adequate quality system to manage the quality of work performed. Documentation and records management must be performed according to the ETV and APCT Center QMPs or their superseding documents. Testing organizations must also perform assessments and allow audits by the APCT Center (headed by the APCT Center QA officer) and EPA corresponding to those in Section 11.

10.2 Requirements for Participating Laboratories

The APCT Center ETV Program is open to multiple test laboratories. All participating laboratories, domestic and international, must register their laboratories with the APCT Center, meet the ETV program's QA requirements, and accept on-site audits by the APCT Center, EPA, or its representatives. The audits may include technical system audits, performance evaluations, assessments of the test laboratory's quality system, and audits of data quality. In order to qualify, a test laboratory must take the following actions:

- Have American National Standards Institute / American Society for Quality Control (ANSI/ASQC) E4 or International Organization for Standardization (ISO) 9000 quality management systems in place;
- Possess the equipment and facilities required to perform the tests identified in Section 5.0 of this protocol;
- Be an independent organization (e.g., not be a manufacturer's or end user's in-house laboratory or subsidiary);
- Have an EPA-compliant QA system;
- Allow on-site audits by APCT Center staff, EPA, or their representatives;
- Have an EPA and APCT Center approved test-QA plan as described in Section 10.0 of this protocol;
- Provide written health and safety procedures for ETV testing; and

- Comply with APCT Center reporting requirements.

In addition, a test laboratory must be accredited for the woodstove new source performance standard (see 40 CFR 60.535) and have participated on at least one American Society for Testing and Materials technical subcommittee for residential wood heating appliances. Other independent laboratories with similar qualifications will be considered on a case-by-case basis.

10.3 Quality Assurance

All ETV testing will be done following an approved test-QA plan that meets *EPA Requirements for Quality Assurance Project Plans* (U.S. EPA, 2001c) and Part B, Section 2.2.2 of EPA's ETV QMP. These documents establish the requirements for test-QA plans and the common guidance document, *Guidance for Quality Assurance Project Plans*, provides guidance on how to meet these requirements. The APCT Center Quality Management Plan implements this guidance for the APCT Center.

The test-QA plan must describe in adequate detail how the test methods are implemented by the testing organization. Internal standard operating procedures (SOPs) may be referenced provided they are available for audit review. (SOPs need not be incorporated into the test-QA plan except by reference. If considered proprietary to the testing organization, they should be clearly marked.) Steps the testing organization will take to ensure acceptable data quality in the test results are also identified in the test-QA plan. Detailed reference to SOPs or other available documents is encouraged. Any needed SOPs will be developed in accordance with EPA's *Guidance for Preparing Standard Operating Procedures (SOPs)*.

The testing organization must prepare a test-QA plan and submit it for approval by the APCT Center. The test-QA plan must also be approved by EPA before the testing organization can begin ETV testing. A test-QA plan contains the 24 elements listed below, the contents of which may be stand-alone or include references to widely distributed and publicly available sources.

Group A Elements: Project Management

- A1 Title and Approval Sheet
- A2 Table of Contents
- A3 Distribution List
- A4 Project/Task Organization
- A5 Problem Definition/Background
- A6 Project/Task Description
- A7 Quality Objectives and Criteria
- A8 Special Training/Certifications
- A9 Documentation and Records

Group B Elements: Data Generation and Acquisition

- B1 Sampling Process Design (Experimental Design)
- B2 Sampling Methods
- B3 Sample Handling and Custody

- B4 Analytical Methods
- B5 Quality Control
- B6 Instrument/Equipment Testing, Inspection, and Maintenance
- B7 Instrument/Equipment Calibration and Frequency
- B8 Inspection/Acceptance of Supplies and Consumables
- B9 Non-direct Measurements
- B10 Data Management

Group C Elements: Assessment and Oversight

- C1 Assessments and Response Actions
- C2 Reports to Management

Group D Elements: Data Validation and Usability

- D1 Data Review, Verification, and Validation
- D2 Verification and Validation Methods
- D3 Reconciliation with User Requirements

11. ASSESSMENT AND RESPONSE

Each independent testing organization must conduct internal assessments of its quality and technical systems and must allow external assessments of these systems by APCT Center QA personnel and by EPA QA personnel. After an assessment, the testing organization will be responsible for developing and implementing corrective actions in response to the assessment's findings.

As appropriate, the APCT Center, EPA, or both will conduct assessments to determine the testing organization's compliance with its test-QA plan. The requirement to conduct assessments is specified in EPA's ETV QMP, and in RTI's APCT Center QMP. EPA will assess RTI's compliance with APCT Center's test-QA plans. The APCT Center will assess the compliance of other organizations with their test-QA plans. The assessments will be conducted according to EPA's *Guidance on Technical Audits and Related Assessments for Environmental Data Operations* and *Guidance on Assessing Quality Systems*.

11.1 Assessment Types

Quality system assessment—Qualitative assessment of a particular quality system to establish whether the prevailing quality management structure, policies, practices, and procedures meet EPA requirements and are adequate for ensuring that the type and quality of measurements needed are obtained.

Technical systems audit—Qualitative on-site audit of the physical setup of the test. The auditors determine the compliance of testing personnel with the test-QA plan.

Performance evaluation audit—Quantitative audit in which measurement data are independently obtained and compared with routinely obtained data to evaluate the accuracy (bias and precision) of a measurement system.

Audit of data quality—Qualitative and quantitative audit in which data and data handling are reviewed and data quality and data usability are assessed.

11.2 Assessment Frequency

Activities performed during verification testing that affect the quality of the data will be assessed regularly and the findings reported to management to ensure that the requirements stated in the generic verification protocols and the test-QA plans are being implemented as prescribed. The types and minimum frequency of assessments for the ETV Program are listed in Part A Section 9.0 of EPA's ETV QMP.

11.3 Response to Assessment

When needed, appropriate corrective actions shall be taken and their adequacy verified and documented in response to the findings of the assessments. The impact and the action taken shall be documented. Assessments are conducted according to procedures contained in the APCT Center QMP. Findings are provided in audit reports. Responses by the testing organization to adverse findings are required within 10 working days of receiving the audit report. Follow-up by the auditors and documentation of responses are required.

12. SAFETY MEASURES

12.1 Safety Responsibilities

The testing organization's project leader is responsible for ensuring compliance with all applicable occupational health and safety requirements. Each individual staff member is expected to follow the requirements and identify personnel who deviate from them and report such action to their supervisor.

12.2 Safety Program

The testing organization must maintain a comprehensive safety program and ensure that all test personnel are familiar with and follow it.