A Load Profile Test Method for Certification of Pellet or Chip Fuel-fired Automated Stove Emissions: Measurement of Particulate Matter (PM) using a TEOM, Carbon Monoxide (CO), and Heating Efficiency

June 18, 2024

Note: This method does not include all the specifications (e.g. equipment and supplies) and procedures (e.g., sample and analytical) essential to its performance. Some material is incorporated by reference from other methods. Therefore, to obtain reliable results, persons using this method shall have a thorough knowledge of at least the following EPA Test Methods

- Method 1 – Sample and Velocity Traverses for Stationary Sources
- Method 2– Determination of Stack Gas Velocity and Volumetric Flow Rate (Standard Pitot Tube)
- Method 3 – Gas Analysis for the Determination of Dry Molecular Weight
- Method 3A – Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources
- Method 4 – Determination of Moisture Content in Stack Gases
- Method 5G – Determination of Particulate Matter from Wood Heaters
- Method 10 – Carbon Monoxide - Instrumental Analyzer
- Method 28 – Certification and Auditing of Wood Heaters

1. Scope and Application

1.1. This test method specifies operation and fueling to certify and audit automatically fed solid-fuel-fired stoves and space heaters.

1.2. This test method measures particulate matter (PM) emissions, carbon monoxide (CO) emissions, and efficiency.

1.3. Particulate emissions are measured using the Tapered Element Oscillating Microbalance (TEOM) continuous PM method using procedures detailed in *NYSERDA Standard Operation Procedures for using a Thermo Scientific 1405-D TEOM™ in a dilution tunnel with wood-fired stoves, hydronic heaters, and furnaces*. Dilution tunnel configurations follow procedures specified in ASTM E2515-11 *Standard Test Method for Determination of Particulate Matter Emissions Collected in a Dilution Tunnel* with modifications as noted in this procedure.

1.4. Analyte. Particulate matter (PM), no CAS number assigned. Carbon monoxide (CO) CAS no. 630-08-0. Carbon dioxide (CO_2) CAS no. 124-38-9.

1.5. Carbon monoxide emissions are measured in the stack/flue per CSA B415.1 *Performance Testing of Solid-Fuel-Burning Heating Appliances.*

1.6. Carbon dioxide emissions are measured in the stack/flue per CSA B415.1 *Performance Testing of Solid-Fuel-Burning Heating Appliances.*

1.7. Distinguishing features of appliances covered by this standard include:

1.7.1. Fuel is automatically fed into the fire chamber in a pelletized or chip format.

1.7.2. Fuel tested can be any pelletized or chipped solid fuel including coal, corn, wood, or other biomass derived materials.

1.7.3. A chimney or vent, which exhausts combustion products from the appliance.

1.8. The values stated are to be regarded as the standard, whether in Inch-Pound or SI units. The values given in parentheses are for information only.

1.9. Data Quality Objectives.

1.9.1. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

1.9.2. Measurement of emissions and heating efficiency provides a uniform basis for comparison of product performance that is useful to the consumer. It is also required to relate emissions produced to useful heat production.

1.9.3. This laboratory method captures operating periods representative of actual field use without excessive test burden.

2. Referenced Methods

2.1. ASTM D1102 Test Method for Ash in Wood

2.2. ASTM 3176-15 Standard Practice for Ultimate Analysis of Coal and Coke

2.3. ASTM D4208-19 Standard Test Method for Total Chlorine in Coal by the Oxygen Vessel Combustion/Ion Selective Electrode Method

2.4. ASTM D4442 Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials

2.5. ASTM D5373-21 Standard Test Methods for Determination of Carbon, Hydrogen and Nitrogen in Analysis Samples of Coal and Carbon in Analysis Samples of Coal and Coke

2.6. ASTM E711-87 Standard Test Method for Gross Calorific Value of Refuse-Derived Fuel by the Bomb Calorimeter

2.7. ASTM E776-16 Standard Test Method for Determination of Forms of Chlorine in Refuse-Derived Fuel

2.8. ASTM E791-08 Standard Test Method for Calculating Refuse-Derived Fuel Analysis Data from As-Determined to Different Basis.

2.9. ASTM E871 Standard Test Method for Moisture Analysis of Particulate Wood Fuels

2.10. ASTM E873 Standard Test Method for Bulk Density of Densified Particulate Biomass Fuels.

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

2.12. CAN/CSA-B415.1-10 Performance Testing of Solid-Fuel-Burning or the latest approved EPA version.

2.13. NIST Monograph 175 Standard Limits of Error.

2.14. "NYSERDA Standard Operation Procedures for using a Thermo Scientific 1405-D TEOM™ in a dilution tunnel with wood-fired stoves, hydronic heaters, and furnaces" using the most recent TEOM SOP and data template in the EPA docket at https://www.regulations.gov/docket/EPA-HQ-OAR-2016-0130

2.15. US EPA TID-024 Performance Test Calculation Guidelines on Rounding and Significant Figures (1990) at https://www.epa.gov/emc/technical-information-document-024-memo-rounding-and-significant-figures

3. Summary of Method

3.1. *Carbon Dioxide*. CO_2 concentrations as measured in the stack and used to calculate efficiency.

3.2. *Carbon Monoxide*. CO concentrations as measured in the stack and used to calculate efficiency and emissions.

3.3. Efficiency. Efficiency is measured by using a total carbon combustion method.

3.4. Dilution Tunnel. PM Emissions are determined using the "dilution tunnel" method specified in ASTM E2515-11 *Standard Test Method for Determination of Particulate Matter Emissions Collected in a Dilution Tunnel* (reapproved September 1, 2017) with exceptions as defined in Sections 10.1 and 10.2 of this test method. The flow in the dilution tunnel is maintained at a constant rate throughout the test cycle to improve measurement accuracy.

3.5. *Operation*. Appliance operation is conducted on a cold-to-hot test cycle, meaning that the appliance starts the first test run at room temperature and ends with the appliance in a fully heated state. A test run consists of eight phases and four operational conditions representing start-up emissions, high heat demand, low heat demand, and restarting. To complete the certification test, the appliance shall complete three valid runs averaged to determine the test results.

3.6. *Particulate Matter*. Real-time PM Measurements are made with a TEOM, Thermo model 1405-D TEOM, operated using the specifications detailed in the document titled*, "NYSERDA Standard Operating Procedures for Using TEOM 1405-D in a Dilution Tunnel with wood-fired stoves, hydronic heaters, or furnaces"* following the most recent TEOM SOP in the EPA docket at https://www.regulations.gov/docket/EPA-HQ-OAR-2016-0130

3.7. *Repeatability.* A series of three valid replicate test runs. The test run consists of eight phases in four different heat demands phases conducted for certification or audit purposes. Each run must follow the same protocol. The first test run the stove must start at room temperature. The second and third test runs may start at a slightly warmer temperature if the appliance is designed to retain the heat from the first run.

4. Definitions

4.1. *Appliance.* A wood heater capable of and intended for space heating as defined in the applicable regulation. The appliance includes a combustion chamber, combustion air settings, operating controls, thermostat, if specified, and any other accessory required for standard operation, such as a barometric damper.

4.2. *Auto-feed space heater.* An appliance used for heating a space that burns pellets, chips, or other standardized fuel made of wood or other organic matter where the fuel is placed in a hopper and fed into the fire via an auger and is controlled by mechanical means such as a thermostat or proportional controllers, or manually via controls.

4.3. *Buffer tank.* A container which contains a medium that can store heat and is separate from the appliance.

4.4. *Burn pot.* Serves as the receptacle for combustion. It is the location where air and fuel are introduced for combustion.

4.5. *Dry Burn rate*. The rate at which test fuel is consumed in the wood heater corrected for moisture content. (kg/hr or lb/hr db).

4.6. *Calibration curve.* The relationship between an analyzer's output and a range of calibration gases concentrations.

4.7. *Calibration gas.* The gas mixture containing a known concentration of a subject gas and produced and certified in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards," September 1997, as amended August 25, 1999, EPA-600/R-97/121 or more recent updates. The tests for analyzer calibration error, drift, and system bias require using calibration gas prepared according to this protocol. If a zero gas is used for the low-level gas, it must meet the requirements under the definition for "zero air material" in 40 CFR 72.2 in place of being prepared by the traceability protocol.

4.8. *Calibration span*. The upper limit of the analyzer's range, set by the choice of the high-level calibration gas. No valid run average concentration may exceed the calibration span. To the extent practicable, the measured concentrations should be between 20 to 100 percent of the instrument calibration span.

4.9. *Centroidal Area.* The central area of the stack or duct, 2 in. diameter.

4.10. *Certification or audit test.* A series of at least three test runs conducted for certification or audit purposes that meets the specifications detailed in this protocol.

4.11. *Combustion efficiency.* The fraction of a fuel's chemical energy that is converted to heat. It measures combustion completeness.

4.12. *Heat Output.* Energy delivered to the heated space from the appliance.

4.13. *Drift*. Difference between pre- and post-run calibration system bias (or system calibration error) checks at a specific calibration concentration level.

4.14. *Emission factor.* The emission of a pollutant expressed in mass per unit of heat output from the appliance (lb/MMBtu) or mass of a pollutant per unit of fuel consumed (g/kg) on a dry basis.

4.15. *Emission rate.* The emission of a pollutant expressed in mass per unit of time from the appliance (g/hr).

4.16. *Flue gas measurement system.* All the equipment used to determine the flue gas measured concentration. This system comprises five major subsystems: sample acquisition, sample transport, sample conditioning, gas analyzer, and data recorder.

4.17. *Fuel feed system.* The system that moves the fuel from the fuel hopper to the burn pot.

4.18. *Fuel hopper.* The place where fuel is stored and mechanically fed via the fuel feed system to the burn pot.

4.19. *Gas analyzer* – Instrument that measures gas concentration and transmits an electronic signal output that is proportional to a measured gas concentration.

4.20. *Heat Output rate, Total* – Rate of total energy including the change in energy of the appliance, change in energy of the buffer tank or tanks, and the sum of the energy transfer from the system to the cooling water through the cooling heat exchanger (MJ/hr).

4.21. *High-level gas* – Calibration gas with a concentration that is at the upper range of the instrument's full-scale range.

4.22. *High Phase* - air supply and fuel feed rates controls adjusted to the highest possible position or settings.

4.23. *Incomplete Test Run* – Any test run that does not successfully complete all eight test phases continuously due to stopped fuel combustion or other appliance issues, as detailed in Section 11.9.

4.24. *Invalid Test Run* – Any complete or partial test that does not meet the specifications detailed in this test method as the fault of the system operation.

4.25.*Low Phase* - air supply and fuel feed rates controls adjusted to the lowest possible, non-off position or settings.

4.26. *Mid-level gas* – Calibration gas with a concentration in the middle range of the expected measurement range of the gas analyzer.

4.27. *Medium Phase* - air supply and fuel feed rates controls adjusted to provide a heat output that is the within 10% of the mid-point of the heat outputs from the low phase and the high phase. *NIST* – National Institute of Standards and Technology.

4.28. *Off Phase* – fuel feed mechanism is placed in the off position.

4.29. *Phase* – A distinct period in the test run with its own operational procedures and conditions.

4.30. *Primary air supply* – air supply that introduces air to the wood heater in the combustion chamber. The wood heater manufacturer or test facility can document this through design drawings.

4.31. *Rated heat output capacity* – the maximum heat that an appliance can deliver, as verified by testing (Btu/hr).

4.32. *Stack Loss Method (SLM) efficiency* - based on input energy minus all flue gas loss (sensible, latent, and chemical). It does not include energy lost from a boiler or furnace jacket to the surrounding environment.

4.33. *Standby/Idle* – A control state where the appliance is not feeding fuel into the firebox chamber, the burner is inactive, and there is no call for heat. This assumes that the unit does not need to be turned off to turn off the fuel feed.

4.34. *Test data* – the data for all test runs conducted on the wood heater, including any data collected during incomplete, failed, and/or invalid runs, and includes records of preparation of standards, identification of equipment used and all personnel present, records of calibrations, raw data sheets, raw data sheets for laboratory analyses, chain-of-custody documentation, and example calculations for reported results.

4.35. *Test facility* – the laboratory area where the wood heater is installed, operated, and sampled for emissions.

4.36. *Test fuel load* – the weight of fuel used during certification testing.

4.37. *Test run* – an individual emission test that includes the eight phases and four heat demands/operational conditions.

4.38. *Test series* – The complete data set for all test runs conducted on the systems to include all runs completed, including, but not limited to, valid runs, incomplete runs, preliminary runs, and invalid runs.

4.39. *Thermostatic control* – a mechanism that opens, closes, or modulates the fuel feed rate or air in response to a change in the control setting that modulates heat delivery.

4.40. *Zero gas*. Calibration gas with a zero concentration of CO and CO2, typically referred to as "Zero Air."

5. Interferences

5.1. *CO* - Reserved.

5.2. *PM* - Reserved.

5.3. CO2 - Reserved.

6. Significance and Use

6.1. IDC protocols provide an assessment of variable conditions commonly observed in homeowner operation to provide a lab test that provides a more representative assessment of how the appliance will operate in the field. The method also requires three replicates, which provides a gauge appliance performance variability.

6.2. Measuring particulate matter emission rates provides an important metric widely used in air pollution control.

6.2.1. These measurements, when approved by state or federal agencies, are often required to determine compliance with regulations and statutes.

6.2.2. The measurements made before and after design modifications are necessary to demonstrate the effectiveness of design changes in reducing emissions and make this standard an important tool in manufacturers' research and development programs.

6.3. Heating efficiency measures provide a uniform basis for comparing product performance useful to the consumer. It is also required to relate emissions produced to useful heat production.

7. Safety

7.1. Disclaimer. This method may involve hazardous materials, operations, and equipment. This test method may not address all 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.

7.2. These tests involve the combustion of pelletized wood fuel or wood chips, which release substantial amounts of heat and combustion products. Appropriate precautions must be taken to protect personnel from burn hazards and the respiration of combustion products. Exposure of personnel to unsafe levels of carbon monoxide must be avoided, and the use of continuous ambient carbon monoxide monitoring or a CO alarm system is strongly recommended.

7.3. Refer to section 5.0 of EPA Method 10 for additional safety considerations.

*8. **Equipment and Supplies.*** The following items are required for sample collection:

8.1. *Anemometer.* A device capable of detecting air velocities less than 0.10 m/sec (20 ft/min) for measuring air velocities within 2 ft. (0.6 m) of the appliance.

8.2. Appliance Flue.

8.2.1. Steel flue pipe extending to 8.5 ±0.5 ft. (2.6 ±0.15 m) above the top of the platform scale. The flue pipe vents directly into an insulated solid pack-type chimney extending to 15 ±1 ft. (4.6 ±0.3 m) above the platform scale. This applies to both freestanding and inserts-type appliances.

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

8.2.3. Solid-pack insulated chimneys shall have a minimum of 2.5 cm (1.0 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).

8.3. Appliance Platform Scale and Monitor. For monitoring of fuel load weight change. The scale shall be capable of measuring weight to within 0.01 kg (0.02 lb) and calibrated to NIST traceable standards at least annually.

8.4. Barometer. Aneroid or another equivalent barometer capable of measuring atmospheric pressure to within 0.10 in. Hg (2.5 mm Hg) with an uncertainty of +/- 0.050 in Hg (+/- 1.27 mm Hg).

8.5. CO Gas Analyzer. A nondispersive infrared (NDIR) analyzer which measures CO concentration in the flue gas stream. The use of a dual-range analyzer is acceptable. These analyzers are often equipped with automated range-switching capability so that when readings exceed the full scale of the low measurement range, they are recorded on the high range. As an alternative to using a dual-range analyzer, you may use two segments of a single, large measurement scale to serve as the low and high ranges. When two ranges are used, you must quality-assure both ranges using the proper sets of calibration gases. High-level not to exceed 10,000 ppm.

8.6. CO2 Gas Analyzer. A NDIR analyzer that measures the CO_2 concentration in the flue gas stream. The use of a dual-range analyzer is acceptable. These analyzers are often equipped with automated range-switching capability so that when readings exceed the full scale of the low measurement range, they are recorded on the high range. As an alternative to using a dual-range analyzer, you may use two segments of a single, large measurement scale to serve as the low and high ranges. When two ranges are used, you must quality-assure both ranges using the proper sets of calibration gases.

8.7. Dilution Tunnel must meet the requirements of ASTM E2515, clauses 6.1.6 and 9.2.

8.8. Dilution Tunnel temperature measurement. A sensor capable of measuring tunnel temperature to within 0.9 ˚F (0.5 ˚C)

8.9. Draft Gauge. Electro-manometer or other device for the determination of flue draft or static pressure readable to within 0.005 in. H_2O (1.25 Pa)

8.10. Flue Gas Temperature Measurement. A type K-thermocouple or equivalent located in the centroid of the stack located 8.0 +/- 0.5 ft (2.44 m +/- 150 mm) above the platform scale. Capable of measuring with an accuracy of 4.0 ˚F (2.2 ˚C) or 0.75% of reading, whichever is greater.

8.11. Flue Gas Composition Measurement. A sample probe and infrared analyzer capable of measuring span of carbon monoxide (CO) and carbon dioxide (CO_2) in the flue gas produced by the appliance tested. Analyzers (or equivalent) shall have maximum zero and span drift over a 24 hr period of 1% of full scale.

8.12. Fuel Scale. Balance capable of weighing the test fuel charge to within 0.02 kg (0.05 lb) and calibrated to NIST traceable standards at least annually.

8.13. Humidity Gauge. Psychrometer or hygrometer, or equivalent, for measuring room humidity to within +/- 4% from 25 to 95% RH.

8.14. Infrared Thermometer. For measuring internal stove temperature (firepot). Capable of measuring temperatures between 0˚C and 1000 ˚C within 1.5 percent of expected absolute temperatures with an accuracy of 2.7 ˚F (1.5 ˚C) or 0.75% of reading, whichever is greater.

8.15. Convection Air Temperatures. Capable of measuring temperature to within 1.5 percent of expected absolute temperatures with an accuracy of 4.0 ˚F (2.2 ˚C) or 0.75% of reading, whichever is greater.

8.16. Test Facility Temperature Monitor. A thermistor, RTD, Type T-Special thermocouple, or other equivalent device, 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 ˚F (0.6 ˚C) of expected temperatures.

8.17. Dilution tunnel TEOM – Thermo Scientific TEOM model 1405-D (Thermo part # 1405D-ANF, excluding models 1405, 1405-DF, or 1405-F) to measure and report continuous particulate matter (PM) measurements in an ASTM E2515 dilution tunnel or equivalent dilution method, and operated according to the *NYSERDA Standard Operation Procedures for use of a Thermo Scientific 1405-D TEOM™ in a dilution tunnel with wood-fired stoves, hydronic heaters, and furnaces.*

8.18. Laboratory air TEOM – Thermo Fisher Scientific TEOM model 1405 (Thermo part # 1405-ANF, excluding models 1405-D, 1405-DF, or 1405-F) to measure and report continuous particulate matter (PM) measurements in laboratory air, and operated according to the *NYSERDA Standard Operation Procedures for use of a Thermo Scientific 1405-D TEOM™ in a dilution tunnel with wood-fired stoves, hydronic heaters, and furnaces.*

9. Calibration and Standardizations

9.1. *Anemometer*. Calibrate the anemometer as specified by the manufacturer's instructions before the first certification test and annually thereafter.

9.2. *ASTM E2515-11.* Perform all calibrations required by Section 8 of ASTM E2515-11.

9.3. Barometer. Calibrate using a reference pressure monitor calibrator before the first certification test and semiannually after.

9.4. *Flow meters and temperature measurements.* Conduct all dilution tunnel checks and calibrations per ASTM E2515-11.

9.5. *Flue Gas Analyzers*. In accordance with CSA B415.1-2010, clause 6.8.

9.6. *Humidity Gauge for laboratory RH*. Calibrate as per the manufacturer's instructions before the first certification test and semi-annually thereafter.

9.7. *Moisture meters.* Calibrate per the manufacturer's instructions before the first certification test and semiannually thereafter.

9.8. *Scales*. Perform a multipoint calibration using NIST-traceable methods (at least five points spanning the operational range) of the platform scale before its initial use and semi-annually thereafter. Calibration results from an accredited laboratory are sufficient for this purpose.

Before and after each certification test run, audit the scale with the appliance in place by weighing at least one calibration weight (Class F or equivalent) that corresponds to between 20 percent and 80 percent of the expected change in fuel mass during a run. If the scale cannot reproduce the calibration weight value within 0.05 kg (0.11 lb) or 1 percent of the expected test fuel charge weight, whichever is greater, then recalibrate, or service scale.

9.9. *Temperature Sensors*. Temperature measuring equipment shall be calibrated before initial use and at least semi-annually thereafter. Calibrations shall follow NIST Monograph 175, Standard Limits of Error

9.10. Failed or expired calibration checks related to scales (fuel, filter, or appliance), sampling flow meter, gas analyzers, pressure transducer, TEOM, or thermocouples invalidate the test run.

10. Sampling, Test Specimens, and Test Appliances

10.1. Modifications to ASTM E2515 requirements.

10.1.1. When a filter train is disassembled, it must be inspected for the presence of any liquid water on the filter, filter holder, or other components of the sample train. The presence of any liquid water found during this inspection invalidates the test run. This inspection must be documented for each filter train set used during a test.

10.1.2. Dilution tunnel temperature must be measured and logged near the sample probe. The location and distance of this measurement to the sample probe must be documented. The probe must be placed more than one and less than three duct diameters downstream of the PM sampling probe in the centroid.

10.1.3. For a valid test run, the following conditions must not exceed any of the following conditions:

10.1.3.1. The dilution tunnel temperature at the particulate measurement point shall be no more than 115 ˚F (46.1 ˚C) for any rolling 10-minute average derived from 1-minute data.

10.1.3.2. A minimum tunnel flow of 600 SCFM is required. Higher tunnel flows may be required to meet the parameters of Section 10.1.3. The maximum tunnel flow shall not exceed 1300 SCFM.

10.1.3.3. All exceedances must be reported in the test anomalies section, including any deviations that are within test method tolerances.

10.1.4. *Particulate Matter Sampling.* TEOM PM data must be reported in 1-minute intervals. TEOM operation must follow the procedures listed in the most recent TEOM SOP found in the EPA docket at https://www.regulations.gov/docket/EPA-HQ-OAR-2016-0130

10.1.5. TEOM data must be reported in the TEOM data processing Excel spreadsheet following the minimum data reporting requirements.

10.2. Rounding requirements must conform to specifications and procedures detailed in US EPA TID-024.

10.3. *Flue Gas Measurements:* CO and CO_2 data shall be reported in 1-minute average intervals and gathered following the requirements as specified in this test method.

10.4. Sample Collection. Particulate Matter Sampling uses a 2-channel dichot TEOM to obtain real-time PM data. TEOM data shall be used to report the first-hour emission rate, to provide data for phased emissions, and real-time data reporting requirements. All measurements shall run through the entirety of the test to obtain full run data.

10.5. TEOM - Flow and Leak checks are done before and after every test run per *NYSERDA Standard Operation Procedures for Thermo 1405-D TEOM for use in a dilution tunnel with wood-fired stoves, hydronic heaters, and furnaces*. Additional quality control measures are included in the TEOM Operating Procedure.

10.6. *Test Specimens.* Appliances shall be supplied as complete systems, including all controls and accessories necessary for installation at the test facility. A full set of specifications, designs, and

assembly drawings, and the owner's manual shall be provided when the product is placed under certification by a third-party agency.

10.7. Preparation of Apparatus

10.7.1. Wood Heater Installation for Certification Testing. Assemble the wood heater appliance and parts in conformance with the manufacturer's provided User Guide. These instructions must match all instructions materials developed by the manufacturer and/or their distributors. Place the wood heater on the platform scale and connect the chimney to the appliance. Clean the flue with an appropriately sized wire chimney brush before initiating Run 1 of the certification test. Test documentation should include the date and time of flue cleaning.

10.7.2. Wood Heater Temperature Monitors.

10.7.2.1. 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 the catalyst face area. Record these locations.

10.7.2.2. Using a thermopile or thermocouples, measure and report the average temperature of the convection air at the outlets to the room. This measurement is not intended to be quantitative but to indicate relative heat output in all phases of the test run.

10.7.2.3. Using an IR temperature measurement, report the temperature of the burn pot within ten minutes of the start of the test run.

10.8. ***Flue Gas Measurement System Setup and Calibration***

10.8.1. Install Flue Gas Sample probe 2 in. (50 mm) above the flue gas temperature measurement in the stack.

10.8.2. Setup Flue Gas Measurement System with an appropriate sample flow rate to reach 90% of the final reading within 30 seconds when beginning at ambient levels and responding to a high-level calibration gas. Establish the calibrated span for the appliance.

10.8.3. Flue Gas Measurement System shall record CO and CO_2 concentrations at one-minute intervals.

10.9. Conditioning

10.9.1. Wood Heater Aging Prior to Certification Testing. A wood heater of any type must be aged at least 20 hours before initiating a certification test. The aging procedure shall be conducted by the manufacturer or a manufacturer's agent.

During aging, the appliance shall be operated at various burn rates. Documentation for wood heating aging must be included in the test report to include data on individual hourly burn rates.

10.9.1.1. The manufacturer shall supply wood heater aging information for the final test reports. Aging data that must be reported includes all fuel parameters (pellet brand and type, content, fuel loaded, fuel consumed), air settings used, time spent in each air setting phase, amount of fuel burned, and appliance burn rates.

10.9.1.2. If an appliance uses a catalytic combustor, it must be engaged according to the manufacturer's instructions and operate with the catalyst engaged for at least 50 hours during the break-in period. In addition to the reporting requirements listed in 7.9.1.1, catalytic appliances shall also report hourly catalyst exit temperature data to include the dates and hours of operation.

11. Procedure

11.1. Test Facility Conditions. The test facility shall meet the following requirements during testing.

11.1.1. The test facility temperature shall be maintained between 55 and 88 °F (12.8 and 31.1 °C) during each test run.

11.1.2. 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 0.005 in. H_2O (1.25 Pa) on the wood heater measured when the wood heater is not operating.

11.1.3. 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 3 to 6 ft. (1 to 2 m) from the front of the wood heater in the 90° sector in front of the wood heater.

11.1.4. Measure and record the test facility's ambient relative humidity, barometric pressure, and temperature before and after each test run using equipment as specified in Section 8.

11.2. Test Fuel. The test fuel shall conform to the following requirements and meet specifications as required by the fuel loading calculator.

11.2.1. For EPA research purposes, allowable pellet fuel shall consist of a hardwood pellet with an ash content greater than 0.40%.

11.2.2. Fuel Analysis – pellet fuel shall be analyzed and reported (in the test report) using the following methods:

11.2.2.1. Moisture: ASTM E871

11.2.2.2. Ash: ASTM D1102

11.2.2.3. Heating value: ASTM E711-87

11.2.2.4. CHN: ASTM D5373-21

11.2.2.5. Chlorine: ASTM D4208

11.2.2.6. Metals: ISO 16968

11.2.2.7. Bulk density: ASTM E873

11.2.3. Fuel Temperature. The test fuel at the beginning of the test run shall be at the ambient test facility temperature of 13 to 31 °C (55 to 88 °F). Using the IR temperature sensor, measure the temperature of the fuel in the burn chamber prior to initiating the test run.

11.3. Manufacturer participation in certification testing

11.3.1. A manufacturer representative may observe testing in person but may not provide instructions to the certification lab, in any form, with testing staff or equipment once the certification tests begin, unless the representative notices improper appliance operation. If the representative notices improper appliance operation, the representative may request halting the certification test. This request must be in written form and documented in the test report.

11.3.2. During certification testing, the appliance may not be connected for remote access. Nor may the appliance be operated remotely.

11.3.2.1. A remote connection may be allowed for witnessing or recording of the test by a regulatory agency or their appointed representative.

11.4. Test Equipment.

11.4.1. Prepare the tunnel per ASTM E2515.

11.4.2. Ambient PM sampling equipment as defined by the TEOM Protocol.

11.4.3. Prepare all other equipment as defined ASTM E2515 (dilution tunnel specifications only) and CSA B415 for CO and CO2 measurements only.

11.5. Test Run Procedure.

11.5.1. Before each test series, the burn pot and ash container shall be cleaned, and testing shall begin without any ash or other materials in the appliance. Clinkers, slag, and ash piles shall be removed from the burn pot before each run.

11.5.2. Before initiating the compliance test series, clean the flue and dilution tunnel with an appropriately sized wire chimney brush before each certification test series. Test documentation should include the date and time of flue cleaning.

11.5.3. Record appliance weight, temperature measurements, and gas concentrations at 1-minute intervals.

11.5.4. Wood Heater Operation and Adjustments. Record all adjustments made to the air supply controls, adjustments, addition or subtraction of fuel, and any other changes to wood heater operations that occur during the test period.

11.5.5. Appliance Operational Protocol

11.5.5.1. Stove temperature: Pre-ignition internal and external stove temperature must not be greater than 10 ˚F above the ambient temperature for Run 1. There is no stove starting temperature requirement for Runs 2 and 3 except in the case of a failed first run. In this case, if Run 1 is invalid or incomplete, the stove must meet Run 1 conditions for at least one valid run. Temperature measurements for the external and internal temperatures shall be taken within 15 minutes before starting the test and shall be reported in the test report using the IR temperature sensor.

11.5.5.2. Tare the appliance scale and then add the fuel before starting the test. Record appliance scale weights at the start and end of each phase of the test run.

11.5.5.3. Appliance Operation – the individual test run consists of eight phases at four different operational conditions. Table 1 summarizes the test run operations. The phases must be run in the order listed below and for the time durations listed below. During the off phases sampling continues.

11.5.5.3.1. For units with automatic controls the unit settings must be moved to the setting listed in the protocol and the appliance is allowed to operate as controlled by the appliance. Fan settings are only adjusted if manually set. Manually controlled units are operated by manually moving settings to meet method requirements.

11.5.5.3.2. Off phases are meant to turn off fuel feeds. Units that can accomplish stopping the fuel feed without turning the unit off shall do so.

11.5.5.3.3. The medium setting is defined as the setting that achieves a burn rate at the midpoint (+/- 10%) between the minimum and maximum burn rates. The stove output settings may be adjusted during the medium burn rate phase (Phase 7) do ensure the appliance meets the required burn rate.

Table 1. Overview of IDC Pellet Stove Operation Protocol

Phase	**Air and Fuel Settings**	**Fan Settings*** *Only if manual setting allowed	**Duration** (minutes)
1	high	high	75
2	low	high	75
3	off	off	15
4	low	high	45
5	high	low	50
6	off	off	25
7	medium	medium	75

11.5.5.3.4. Phase 1, start-up to high operation: The appliance shall be ignited according to the instructions in the owner's manual and heater controls adjusted to the high load condition. If the appliance has automatic start up procedures, start the unit such that it will move into the high-output operation once start-up has been completed. If separate fan operational controls exist, they must be set to the highest position. This phase shall last for 75 minutes.

11.5.5.3.5. Phase 2, high to low load operation: Adjust the heater controls to the low load conditions immediately at the start of the phase. If separate fan operational controls exist, they must be set to the highest position. This phase shall last for 75 minutes.

11.5.5.3.6. Phase 3, low to off operation: Adjust the heater controls to no heat demand at the start of the phase. If separate fan operational controls exist, they must be set to the off position. This phase shall last for 15 minutes.

11.5.5.3.7. Phase 4, start-up to low operation: The appliance shall be ignited according to the instructions in the owner's manual and adjust heater controls to the low load condition. If the appliance has automatic start up procedures, start the unit such that it will move into the low-output operation once start-up has been completed. If separate fan operational controls exist, they must be set to the highest position. This phase shall last for 45 minutes.

11.5.5.3.8. Phase 5, low to high operation: Adjust the heater controls to the high load conditions immediately at the start of the phase. If separate fan operational controls exist, they must be set to the lowest position. This phase shall last for 50 minutes.

11.5.5.3.9. Phase 6, high to off operation: Adjust the heater controls to stop combustion at the start of the phase. If separate fan operational controls exist, they must be set to the off position. This phase shall last for 25 minutes.

11.5.5.3.10. Phase 7, start-up to medium operation: The appliance shall be ignited according to the instructions in the owner's manual and adjust heater controls to the medium load condition. If the appliance has automatic start up procedures, start the unit such that it will move into the medium-output operation once start-up has been completed. If separate manual fan operational controls exist, they must be set to the mid-point position. If needed, the stove may be adjusted to ensure achievement of the medium burn rate. This phase shall last for 75 minutes.

11.6. Test Run. A complete test run requires the completion of all seven phases in sequential order.

11.7. Test Run Requirements. The following describes the required parameters for each test run. Each emission test run shall include all phases of the operational and fueling protocol run in order as described.

11.7.1. The appliance burn pot shall have a starting temperature within +/- 10 ˚F of ambient laboratory temperature at the beginning of one run.

11.7.2. The appliance burn pot has been cleaned.

11.7.3. The appliance ash pan is empty at the beginning of each test run.

11.8. Failure to Operate in All Test Conditions

11.8.1. If the appliance fails two runs due to incomplete or invalid test runs, it shall be determined that the appliance has failed the certification test and requires a modification to the appliance design or repair as needed. All data for incomplete runs shall be reported. Incomplete failed test runs are defined as the following:

11.8.2. If a wood heater fails to complete all eight phases of the test run, the run shall be considered an incomplete test run.

11.8.3. If a test run violates the parameters of the test method, the run is invalid.

11.8.4. If during certification testing a critical component of the stove is damaged or breaks, the certification test will be stopped and considered invalid.

11.8.4.1. If damage is noted during a test, repairs shall be made by the manufacturer (or by laboratory personnel with written direction from the manufacturer). If the repair involves components that would need aging, the appliance shall then undergo another round of wood heater aging as specified in section 10.9. These components may include but are not limited to catalyst elements, gaskets, and refractory components. The aging process is intended not only to 'cure' the stove but also to cycle parts that may fail with extended use. Alternate aging techniques may be approved by the administrator, depending on the nature of the failure, material, and critical nature.

11.9. Test Run Completion. Once three valid runs have been completed, the testing is complete. No additional runs may be completed.

11.9.1. *Additional Test Runs*. If there is an invalid or incomplete run, the test lab must replace that test run with a valid test. The measurement data and results of all test runs shall be reported regardless of which values are used in calculating the emission rate. No test run data can be eliminated from the reporting requirements of this method.

11.9.2. *Invalid Runs.* When a test run fails to meet one of the criteria stipulated in the test method, the data is invalid, and the run must be repeated. Data for the invalidated test run must be included in the test report, but the data must not be used in the calculation of average emission or efficiency values.

11.9.3. *Incomplete Runs:* If an appliance cannot successfully complete all operational elements of the protocol specified in Section 11.5.5, it is an incomplete run.

11.10. PM Data Recording.

11.10.1. All TEOM data shall be collected and reported at 1-minute average intervals. TEOM operation shall follow the procedures listed in *NYSERDA Standard Operation Procedures for use of a Thermo Scientific 1405-D TEOM™ in a dilution tunnel with wood-fired stoves, hydronic heaters, and furnaces.*

11.10.2. TEOM data shall be reported in an Excel or compatible spreadsheet following the minimum data reporting requirements. All electronic files, including raw instrument data, shall be submitted as part of the test report. Spreadsheet files shall be supplied as part of the publicly available test report.

11.10.3. Lab air PM measurement – TEOM. A single channel 1405 TEOM shall be used to measure ambient lab air PM during the test, as configured in *NYSERDA Standard Operation Procedures for use of a Thermo Scientific 1405-D TEOM™ in a dilution tunnel with wood-fired stoves, hydronic heaters, and furnaces*. The sample flow shall be 3 LPM.

12. Quality Control Measures

12.1. Conduct sampling equipment leak check and calibration pre- and post-test.

12.2. TEOM –All QC checks per the *NYSERDA Standard Operation Procedures for use of a Thermo Scientific 1405-D TEOM™ in a dilution tunnel with wood-fired stoves, hydronic heaters, and furnaces* must be followed, including pre- and post-run flow and Leak checks.

12.3. Volume Metering System Checks.

13. Data Analysis and Calculations.

13.1. Emission Calculations. Emissions for particulate matter and carbon monoxide shall be calculated using the following methodology and reported in grams, grams per hour, grams per kilogram and pounds per million British thermal unit (MMBtu) heat output. All calculations shall be conducted using all decimal values provided by the instrumentation or recorded by the operator and must be carried out throughout all calculations. No rounding of intermediate calculation results or truncation of data is acceptable. Only the final calculation of emission rates shall be rounded to three significant digits.

13.2. Emissions, emission rates, emission factors, and heat output data for PM and CO shall be reported as follows. Inputs for all of these calculations shall exclude minutes that do not have valid TEOM data.

13.2.1. Emissions from each active phase of the test (excluding off phases 3 and 6) shall be reported as individual results in grams, grams per hour, grams per kilogram, and lb/MMBtu (heat output). Emissions for the two off phases shall be reported in grams and g/h only. Emissions from the full test run (including off phases 3 and 6) shall be reported in grams, grams per hour, grams per kilogram, and lb/MMBtu (heat output).

Nomenclature:

BR_i – dry fuel burn rate, kg/hr for each interval not including off phases (3 and 6) and the entire test run.

CO_i – Carbon Monoxide, vol % averaged over "on" phases only and for whole test. Excluding minutes without valid TEOM data.

CO_{2i} – Carbon Dioxide, vol % averaged over "on" phases only and for whole test. Excluding minutes without valid TEOM data.

PM – Particulate Matter (grams)

E_{Ti} – PM missions for the full test run and all phases in grams. Excluding minutes without valid TEOM data.

$E_{g/MJ}$ – PM Emissions factor for the full test run and active phases in g/MJ of heat output. Excluding minutes without valid TEOM data.

$E_{g/kg}$ – PM Emissions factor for the full test run and active phases in g/kg of dry fuel burned. Excluding minutes without valid TEOM data.

$E_{g/hr}$ – PM Emissions rate for the full test run and all phases in grams per hour. Excluding minutes without valid TEOM data.

ER_{COi} – CO emission rate for interval i, g/hr.

EF_{COi} – Average CO emission factor for interval i, g/kg

$EF_{COi\ g/MJ}$ – CO emission index, g/MJ output

E_{TCOi} – Total CO emissions, grams

HHV – Higher heating value of fuel = Use accredited test results

LHV – Lower heating value of fuel = Use accredited test results

MC = Fuel moisture content, dry basis, %

N = Total number of test runs

Q_{out} – Total heat output in Btu's (megajoules, MJ). Excluding minutes without valid TEOM data.

SC_i – Scale weight at specific time interval, lb

Tavg – Average convection outlet temperature deg F (deg C)

T1– Pre-Catalyst Temperature 1 ˚F (˚C)

T2 – Post-Catalyst Temperature 2 ˚F (˚C)

T_{tunnel} – Tunnel Temperature ˚F (˚C)

$T_{a(i)}$ –Room Ambient Temperature before Test ˚F (˚C)

$T_{a(f)}$ – Room Ambient Temperature after Test ˚F (˚C)

$T_{S\ (i)}$ – Initial Outlet Temperature ˚F (˚C)

$T_{S\ (f)}$ – Final Outlet Temperature ˚F (˚C)

T_S – Overall Time-Averaged Flue Gas Temperature in Stack ˚F (˚C)

W_{di} – Fuel consumed (dry kg) for a phase interval or whole test. Excluding minutes without valid

TEOM data.

W_{app} – Weight of empty appliance in pounds (kg)

Θ_i – Length of test phase or full run (in hours), excluding minutes without valid TEOM data

13.3. Determine Burn Rates, excluding minutes without valid TEOM data.

For phases 1, 2 4, 5, 7, 8 and the full run, calculate dry wood burned:

$Wdi = (\text{Initial } SC_i - \text{Final } SC_i) / (1+MC/100)$

For the same phases, calculate dry burn rate:

$BR_i = W_{di} / \Theta_i$, kg/hr

13.4. PM and CO Emissions. All calculations exclude data for minutes without valid TEOM data.

Calculate the CO emissions factor (g/kg) and CO (grams) as follows, excluding minutes without valid TEOM data. 0.508 is the assumed fractional ultimate analysis for Carbon.

$EFco_i = CO_i \times 1000 \times 0.508 \times (28/12) / CO_{2i}$, g/kg

Grams CO for subsequent phase and full run calculations:

$E_{TCOi} = EF_{COi} \times W_{di}$

13.4.1. Calculate the CO emission rate (g/hr) and factor (g/MJ) by phase and full run CO as follows, excluding minutes without valid TEOM data. Phase calculations exclude the two off phases. Full run calculations include all 8 phases.

$EF_{COi\ g/MJ} = E_{TCOi} / (Q_{out} \times 0.001055)$, g/MJ

$ER_{COi} = E_{TCOi} / \Theta_i$, g/hr

13.4.2. Calculate PM emissions for each on phase and the entire run. Phase calculations exclude the two off phases. Full run calculations include all 8 phases. For the two off phases (3 and 6), calculate g and g/h only, excluding minutes without valid TEOM data.

$E_{g/MJ} = E_{Ti} /(Q_{out} \times 0.001055)$, g/MJ

$E_{g/kg} = E_{Ti} / W_{di}$, g/dry kg

$E_{g/hr} = E_{Ti} / \Theta_i$, g/hr

13.5. Efficiency calculations. The efficiency calculations include CO and CO2 stack concentration data for all minutes only during "on" phases, even those without TEOM data. They do not include data from the two off phases.

Ultimate Analysis of dry fuel (fraction by weight):

CA – Carbon; assumed value is 0.508

HY– Hydrogen; assumed value is 0.064

OX – Oxygen; assumed value is 0.418

Overall stove efficiency calculations are based on a method that quantifies three components of energy loss through the stack and is calculated by the following equation:

$$\eta = (1 - \frac{E_{CL} + E_{SL} + E_{LL}}{E_{in}})$$

where E_{CL} is chemical heat loss, E_{SL} is sensible heat loss, and E_{LL} is latent heat loss per kg of dry fuel burned, and E_{in} is the fuel energy input rate.

The method is called Total Combustible Carbon (TCC) as it assumes E_{CL} is equivalent to the energy that could have been released by incinerating all incompletely burned carbon components in the stack gas. Since all energy rates are expressed per unit mass of the burned dry fuel, scale readings and total mass of the burned dry fuel are not required in this method. The efficiency can be calculated for the entire test when the input variables are averaged over "on" phases only. Phase efficiency is calculated by the same procedure for "on" phases.

The rate of the energy input, $E_{in}(\frac{kJ}{kg})$, is calculated by:

$$E_{in} = HHV \times 0.429923$$

where HHV is the higher heating value of wood in $(\frac{Btu}{lb})$ and 0.429923 is the conversion factor in $(\frac{kJ}{kg}.\frac{lb}{Btu})$.

To calculate the latent heat loss rate, E_{LL}, water mass emitted from the combustion of one kilogram of dry fuel is calculated by the following equation, assuming that the combustion is complete:

$$m_{H_2O} = 9HY + \frac{MC_d}{100}$$

m_{H_2O} is in kg per kg of the burned dry fuel, HY is the mass fraction of hydrogen in the fuel, and MC_d is mass % of moisture per unit mass of dry fuel.

The latent heat loss per kg of burned dry fuel, $E_{LL}(\frac{kJ}{kg})$, is calculated as:

$$E_{LL} = m_{H_2O} * 2442$$

where 2442 $(\frac{kJ}{kg})$ is the water heat of vaporization.

In this simplified TCC method, the chemical energy loss per unit mass of burned dry fuel, $E_{CL}\left(\frac{kJ}{kg}\right)$, is calculated as:

$$E_{CL} = \frac{CA}{12} \times 400{,}000 \times \frac{CO_{eq}}{CO_{2,\ inc.}}$$

where 400,000 ($\frac{kJ}{kmol\ C}$) is the estimated lower heating value of the incompletely burned carbon components in the stack gas, expressed on a per-mole-of-carbon basis. CO_{eq} is the molar % of carbon monoxide equivalent of all incomplete carbon components that is calculated as:

$$CO_{eq} = C_F \times CO_s$$

where CO_s is the volumetric % of carbon monoxide in the stack averaged over "on" phases only and for the whole test, excluding off-phases. C_F is a dimensionless factor that is equal to 1 for pellet stoves. For appliances with significant incomplete combustion, the value of C_F should be adjusted experimentally.

The carbon dioxide from incineration, $CO_{2,\ inc.}$, is the volumetric % of CO_2 if all unburned hydrocarbons in the stack were completely combusted, and it is given by:

$$CO_{2,\ inc.} = CO_{2,\ s} + CO_s$$

where $CO_{2,\ s}$ is the volumetric % of carbon dioxide in the stack averaged over "on" phases only and for the whole test, excluding off phases.

To calculate E_{SL} we first calculate the molecular weight of the dry stack gas, MW_{ds} $\left(\frac{g}{mol}\right)$, assuming all hydrocarbons are burned:

$$MW_{ds} = \frac{44 \times CO_{2,\ inc.} + 32 \times \left(20.9 - CO_{2,\ inc.}\right) + 28 \times 78.1}{100}$$

where 44 ($\frac{g}{mol}$), 32 ($\frac{g}{mol}$), and 28 ($\frac{g}{mol}$) are molecular weights of CO_2, O_2, and N_2, respectively. The O_2 concentration for the completely burned stack gas is calculated by subtracting $CO_{2,\ inc.}$ from the average atmospheric molar percentage of oxygen. In this formula, the average molar percentage of nitrogen in the dry stack gas is taken as 78.1, given that nitrogen is the only other gas.

The mass of the dry stack gas per kilogram of burned dry fuel, m_{ds}, is calculated as:

$$m_{ds} = \frac{CA}{12\ \times \frac{CO_{2,\ inc.}}{100}} \times MW_{ds}$$

The average constant-pressure specific heat of dry stack gas, $C_{ds}(\frac{kJ}{kg\ K})$, can be approximated by the second order polynomial:

$$C_{ds} = 1.003 + 3.488 \times 10^{-5}\left(T_S - T_{a(i)}\right) + 2.036 \times 10^{-7}\left(T_S - T_{a(i)}\right)^2$$

where T_S and $T_{a(i)}$ are in Kelvin or degree Celsius.

The Air-to-Fuel ratio (AFR) is calculated as:

$$AFR = m_{ds} - m_{H_2O} - \left(1 + \frac{MC_d}{100}\right)$$

The mass of the water content of the ambient air, $m_{w,air}$, per kg of burned dry fuel is calculated as:

$$m_{w,air} = \frac{AFR \times 18}{29} \times \frac{\omega}{100 - \omega}$$

where ω is the mass percentage of water in the air and under the valid range of lab conditions is on average $\omega = 1.5$.

The sensible heat loss per kg of burned dry fuel, $E_{SL}(\frac{kJ}{kg})$, is calculated as:

$$E_{SL} = (T_S - T_{a(i)}) \times (m_{ds} \times C_{ds} + (m_{H_2O} + m_{w,air}) \times C_{H_2O})$$

where T_S and $T_{a(i)}$ are time-averaged temperatures of stack gas and initial ambient air in K or $^{\circ}C$, and the specific heat of water vapor is taken as $C_{H_2O} = 1.9(\frac{kJ}{kg\,K})$.

14. ***Reporting Requirements.*** The report shall include the following:

14.1.1. Introduction

14.1.2. Purpose of test: certification, audit, efficiency,

14.1.3. Name and location of the laboratory conducting the test.

14.1.4. Wood appliance identification – manufacturer, model number/name, design type, description of the appliance tested, stove condition, and date the lab received the units, when the unit was placed on the test stand for the first time, description of any testing done prior to the test series, reporting of all emails, notes, or communications about the appliance or test obtained before, during or after testing.

14.1.5. Test information – location of testing, date of tests, sampling methods used, number of test runs, a statement detailing any previous certification testing completed on the wood appliance. A description of all cleaning of the ductwork, dilution tunnel, fuel pot/burn chamber, fuel hopper, and a description of the fuel used.

14.1.6. A list of people who conducted research on the appliance, participated in testing preparation, or witnessed the certification testing. This list shall clearly specify their roles in the testing program for the appliance. The list shall include the participant's name, title, company, contact information and the purpose of their participation.

14.1.7. A statement that the test results apply only to the specific appliance tested.

14.2. Summary and Discussion of Results

14.2.1. Table of results to include test run number, average burn rate for entire run and each on phase, carbon monoxide and particulate emission rate for full run and for each phase, efficiency for each on phase and for the full run, and burn time for total run and each phase (excluding minutes without valid TEOM PM data).

14.2.2. For each test run include CO and PM emission results for active burn phases 1, 2, 4, 5, 7, and 8,

excluding any minutes without valid TEOM data. Calculated results for the emissions shall be reported as total emissions in grams, pounds per million Btu output, grams per MJ, grams per kilogram of dry fuel, grams per hour, and pounds per hour.

14.2.3. For each test run, report CO and PM in grams and g/h only for the two off phases.

14.2.4. A narrative discussion detailing any issues or anomalies that arose during each test run and how those were handled, including comments about the fuel, and loading of the appliance.

14.2.5. A time-series plot of CO emission rate in g/h vs. time, based on 1-minute readings smoothed to a centered 11-minute running average, for the entire test period, for each run, excluding any minutes without valid TEOM PM data. The report shall include a table reporting the maximum 60-minute grams per hour value on a rolling basis for the test run, for each run.

14.2.6. PM Plots

14.2.6.1. A time-series plot of PM emission rate in grams/hour vs. time, based on 1-minute data, for the entire test period, for each run. The report shall include a table reporting the maximum 1-minute, 5-minute, and 60-minute grams per hour on a rolling basis for the test run, for each run.

14.2.6.2. A plot of PM emission factor in g/kg based on centered 11-minute running averages for the entire test period except off phases, for each run. The report shall include a table reporting the maximum 60-minute grams per kg on a rolling basis for the test run, for each run.

14.2.7. Summary of other data – test facility conditions, stove temperature measurements, catalyst temperature averages, fuel consumed – total and by phase.

14.3. Discussion. Test run result, specific test run problems, and solutions. Comments on fuel, loading, analysis, and anything that may impact the reported result(s).

14.3.1. Details of deviations from, additions to or exclusions from the test method, and their data quality implications on the test results (if any), as well as information on specific test conditions, such as environmental conditions. An explanation of the deviations, additions, or exclusions shall be provided along with an analysis as to why these elements had no impact.

14.4. Process description:

14.4.1. Appliance operation during the test – shall supply details on air supply settings and adjustments.

14.5. Test fuel properties – Results of sample analysis required by this test method.

14.6. Sampling

14.6.1. A description of the test procedures and test equipment, including a schematic or other drawing showing the location of all required test equipment. Also, a description of test fuel sourcing, handling and storage practices shall be included.

14.6.2. Describe the sampling location relative to the wood heater, include drawing or photographs.

14.6.3. Provide data on ambient sampling.

14.7. Quality Control and Assurance Procedures

14.7.1. Calibration procedures and results certification procedures, sample and analysis procedures.

14.7.2. Test method quality control procedures to include TEOM leak and flow checks, stratification (velocity) checks, tunnel flow range results, and filter temperature range verification.

14.8. Appendices

14.8.1. Results and Example Calculations. Raw data and complete calculations for data included in summary tables.

14.8.2. Raw data. Copies of all files or sheets for sampling measurement, temperature records, and other materials used by lab related to testing.

14.8.3. Calibration Results. Records of all calibrations, check, and audits pertinent to the test equipment to include temperature sensors, thermopiles, scales, dry gas meter, barometer, pump, vacuum gauge, wood moisture meter, pressure meters, or pitot tubes.

14.8.4. Sampling and Operation Records. Copies of all uncorrected records of activities not included in raw data sheets (e.g., wood heater door open, times and durations) as well as photographs of fuel loading and air flow settings.

14.8.5. Correspondence. All correspondence to include written, electronic or verbal communications regarding appliance testing. Items shall include:

14.8.5.1. Request to conduct testing, including discussions of model specific needs for the testing to include fueling information, aging and installation needs, and operation of the appliance during the testing.

14.8.5.2. Scheduling of testing

14.8.5.3. Notice to EPA to conduct test, and any modifications to that request.

14.8.5.4. Notice and submission of data to EPA after testing completed.

14.8.6. Test Facility Information. Report test facility temperature, air velocity, and humidity information.

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

14.8.8. Pretest procedures. Report all pretest procedures conducted at the lab on the appliance to burns, rates, and amounts, and the purpose of the pre-testing.

14.8.9. Conditioning data. Report all conditioning data.

14.8.10. All required data for each test run shall be provided in spreadsheet format both in the printed report and in a computer file such that the data can be easily analyzed, and calculations easily verified. Formulas used for all calculations shall be accessible for review.

14.8.11. For each test run: report TEOM flow and temperature and verification of all TEOM data validation parameters in the TEOM data template as required in *NYSERDA Standard Operation Procedures for use of a Thermo Scientific 1405-D TEOM™ in a dilution tunnel with wood-fired stoves, hydronic heaters, and furnaces.*

14.8.12. Raw data, calibration records, and other relevant documentation shall be retained by the laboratory for a minimum of 7 years.