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Assessment of EPA's Residential Wood Heater Certification Program

Test Report Review: Stoves & Central Heaters

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Members of Northeast States for Coordinated Air Use Management

Paul J. Miller, Executive Director
Northeast States for Coordinated Air Use Management

Tracy Babbidge, Bureau Chief
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Jeff Crawford, Bureau Director
Maine Department of Environmental Protection, Bureau of Air Quality

Glenn Keith, Director
Massachusetts Department of Environmental Protection, Air and Climate Programs

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Francis Steitz, Director
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New York Department of Environmental Conservation, Division of Air Resources

Laurie Grandchamp, Chief
Rhode Island Department of Environmental Management, Office of Air Resources

Heidi Hales, Director
Vermont Department of Environmental Conservation, Air Quality & Climate Division

ASSESSMENT OF EPA'S RESIDENTIAL WOOD HEATER CERTIFICATION PROGRAM

Test Report Review: Stoves & Central Heaters

Project Manager

Lisa Rector, NESCAUM

Principal Contributors

Mahdi Ahmadi, Ph.D.
Arthur Marin
Barbara Morin, NESCAUM
Kelly Raymond, NESCAUM
Lisa Rector, NESCAUM

Northeast States for Coordinated Air Use Management (NESCAUM)
Boston, Massachusetts

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Summary for Policymakers

The Northeast States for Coordinated Air Use Management (NESCAUM) in collaboration with the Alaska Department of Environmental Conservation (ADEC) conducted a review of the US Environmental Protection Agency's (EPA's) program to certify that new wood stoves and central heaters meet air pollution standards. For the over 250 certified wood heaters reviewed, this report finds a systemic failure of the entire certification process, including EPA's oversight and enforcement of its requirements. Wood heater manufacturers and the EPA-approved test laboratories they use for certification testing often deviate from test method requirements and the manufacturers' owner's manual instructions, creating the appearance of artificially lowering emissions in the lab in order to meet the certification standards. The descriptions of the wood heaters given in test reports do not always agree with what the manufacturers advertise in their marketing materials. All test reports have missing data elements.

Many of these discrepancies and omissions are clear violations of EPA requirements. Supposedly independent third-party reviewers are charged with flagging these problems, but do not. In fact, EPA notified the testing labs and third-party reviewers of some of the identified testing issues in 2019, but after that notice, this review found more recent test reports continuing to employ the same practices, and EPA continuing to approve them.

The unavoidable conclusion of this report is that EPA's certification program to ensure new wood heaters meet clean air requirements is dysfunctional. It is easily manipulated by manufacturers and testing laboratories. EPA has done little to no oversight and enforcement. Starting in 1988 when EPA first adopted air pollution standards for new wood stoves, it has never conducted a single audit to verify that a wood heater actually performs consistent with its certification test results, a span of over 30 years.

This raises serious concerns for state and local air quality and public health agencies. These agencies rely on a robust and credible certification program to address air pollution problems and public health harms caused by residential wood combustion. In order to protect public health, the agencies are pursuing policies to incentivize cleaner wood burning devices in communities suffering from high levels of wood smoke pollution. This includes providing financial incentives for the exchange of older devices with cleaner new wood heaters. If EPA's program for certifying wood heaters is not assuring that new devices are in fact cleaner than the ones they are replacing, then these efforts may be providing no health benefits while wasting scarce resources.

At its core, EPA's program as currently run allows the continued sale and installation of high-emitting devices, many of which will be in homes located in overburdened communities already suffering from environmental and other inequities. Once installed, these units will remain in use, emitting pollution for decades to come.

Acknowledgments and Disclaimers

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GLOSSARY

Annual Fuel Use Efficiency (AFUE) –The percentage of heat delivered to a home over a year. AFUE differs from "thermal efficiency" in that it assesses performance over a variety of loads and transitional states.

Appliance – A wood heater subject to the Residential Wood Heater (RWH) New Source Performance Standards (NSPS).

ASTM – ASTM International, formerly known as the American Society for Testing and Materials, is an international organization that develops voluntary technical standards.

ASTM 2515 – The ASTM method for measuring particulate matter (PM) in a dilution tunnel. This method is identified as a federal reference method in the RWH NSPS.

ASTM 2618 – The ASTM method for measuring PM emissions from pellet and cordwood boilers. This method is identified as a federal reference method in the RWH NSPS.

ASTM 2779 – The ASTM method for measuring PM emissions from pellet stoves. This method is identified as a federal reference method in the RWH NSPS.

ASTM 2780 – The ASTM method for measuring PM emissions from cordwood stoves burning dimensional lumber. This method is identified as a federal reference method in the RWH NSPS.

ASTM 3053 – The ASTM method for measuring PM emissions from cordwood stoves burning cordwood. This method was approved as a broadly applicable alternative test method for certifications under the RWH NSPS.

CBI – Confidential business information.

Combustion Efficiency – The measure of combustion completeness, how well the appliance burns the fuel. This metric does not reflect the appliance's ability to deliver heat.

CSA B415 – Canadian Standard B415, "Performance Testing Of Solid-Fuel-Burning Stoves, Inserts, and Low-Burn-Rate Factory-Built Fireplaces."

Delivered Efficiency – A measurement of the energy delivered as heat to the building.

HHV – Higher Heating Value of Wood, a measurement of the actual usable energy from the fuel. This value includes the water and hydrogen content of the fuel.

LHV – Lower Heating Value of Wood. This value excludes the water and hydrogen content of the fuel. LHV efficiency values are, on average, 5-10 percent higher than HHV efficiencies.

M5G – The EPA method for measuring PM in a dilution tunnel.

M28 – The EPA method for measuring PM in a dilution tunnel from cordwood stoves using dimensional lumber.

M28 WHH – EPA M28 for Wood-fired Hydronic Heating Appliances.

Nominal Output – The maximum hourly output of an appliance.

New Source Performance Standards, NSPS or RWH NSPS – EPA's "Standards of Performance for New Residential Wood Heaters, New Residential Hydronic Heaters and Forced-Air Furnaces," 89 Fed. Reg. 13672-13753 (March 16, 2015).

RWH – Residential Wood Heating.

Stack Loss Efficiency (SLM) – A measure of efficiency based on fuel input minus all flue gas loss. This measure does not include jacket loss calculations. This is a theoretical calculation of delivered heat.

Thermal Efficiency – Efficiency as determined using the input/output method described in M28 OWHH.

Thermal Storage – A liquid-filled tank that stores excess heat generated by a wood heating appliance.

Executive Summary

In 2015, the U.S. Environmental Protection Agency (EPA) adopted new emission standards for residential wood burning appliances under the Residential Wood Heater New Source Performance Standards (RWH NSPS).[1] These were the first revisions to the standards since 1988, a span of over 25 years, and included consideration of more advanced wood burning technologies and encompassed more wood heater appliance types than under the 1988 standards. The RWH NSPS rule was fully implemented through two steps, with the more stringent Step 2 numerical emission standards going into effect in May 2020.

While the new RWH NSPS requirements were long sought by state and local air quality officials, the final RWH NSPS program as implemented has raised serious concerns about the program's efficacy and the extent to which the updated RWH NSPS will provide in-use emission reductions commensurate with those standards. The 2015 RWH NSPS introduced the use of third-party certifiers accredited by the International Standards Organization (ISO) to implement several critical elements of the new rule, including reviewing certification test reports and conducting compliance inspections. The third-party reviewers are paid by the manufacturers and are often the same companies that perform the certification testing, creating a potential conflict of interest.

Based on these concerns, this study was undertaken to evaluate the effectiveness of the current framework that uses ISO-accreditation and EPA approval to qualify testing labs and an ISO-accredited third-party review to complete a test report review and issue a certificate of conformity, which then becomes part of an application package that goes to EPA's Office of Compliance Assurance (OECA) for review and certification. In this report, results are presented from reviews of available emission certification test reports for almost 250 appliances approved by EPA as compliant with the Step 2 emission standards under the 2015 RWH NSPS. The reviews evaluated (1) completeness of the certification test report data sets, (2) consistency of the EPA-approved test results, and (3) error magnitudes where they can be estimated. The analysis was conducted at the "screening" level, and was intended to identify areas where significant problems exist with the certification testing for which more detailed review by EPA may be warranted. It was not a full and complete review of the test reports, which likely would have revealed many more problems.

The analysis found persistent failures by EPA-approved labs to follow test methods and by third-party reviewers and EPA to identify deficiencies. The review also found a lack of effective oversight and enforcement by EPA. As a result, the existing program

[1] *Standards of Performance for New Residential Wood Heaters, New Residential Hydronic Heaters and Forced-Air Furnaces*, 80 Fed. Reg. 13672-13753 (March 16, 2015).

provides no confidence that new residential wood heaters are performing in a manner that better protects public health than the heaters they replace, and at the level required by federal standards. This has critical implications not only for public health, but also for the perceived cost-effectiveness of investments in residential wood heater change-out programs and tax credits given for the purchase of new wood burning appliances.

The study found that certification laboratories, sometimes at the manufacturer's direction, routinely employ atypical burn practices to improve the emission performance of wood heating devices during certification testing. These unusual practices are not commonly followed by the owners of these appliances after retail sale, and therefore are unlikely to represent actual in-use performance. In June 2019, EPA sent an email to ISO-accredited and EPA-approved labs and third-party certifiers identifying "discrepancies and concerns" it had observed in submitted test reports related to atypical test conditions. The reviewers in this study identified 40 reports certified after EPA sent its email in June 2019. The review found that all 40 of those certified test reports continued to contain at least one of the problematic test practices that EPA had explicitly identified as raising concerns.

There were also instances of prototypes being used for certification testing that are described with different physical parameters (e.g., firebox sizes) than the production models placed into retail sale that they are intended to represent. Different physical parameters between a tested prototype and the model offered for sale can adversely affect conclusions about in-use emissions performance.

In addition to the testing irregularities, this study uncovered a host of attendant issues that further undermine the program's integrity. EPA appears to have not completed any compliance audits in the more than 30 years since the original RWH NSPS rule in 1988. Compliance audits done strategically should be standard practice to verify units in the home perform in a manner consistent with their certification test results completed in the EPA-approved lab. The 2015 RWH NSPS program also lacks transparency as state and local agencies, along with the public, do not have easy access to sufficiently detailed certification test results and enforcement data that could be used to assess appliance performance.

States and communities with wood smoke pollution problems and a desire to reduce air toxics emissions rely on EPA's program to provide air quality improvements. However, EPA's failure to provide oversight and ensure the veracity of certification testing seriously undercuts the integrity of the RWH NSPS program and the likelihood that emission reductions are actually occurring, and sets the course for continued high emissions from new devices for years to come. To address this systemic problem, this study provides a set of recommendations to create a robust and effective RWH NSPS

program. Some of the existing program weaknesses can be minimized through a commitment by EPA to enforce current requirements according to the clear language of the RWH NSPS. Others must be addressed through rule changes or as part of the next update to this NSPS, which is due in 2023.

ES-1. Background

Cordwood, pellets, and wood chips are important fuels for primary and secondary residential heating in the United States. According to the U.S. Energy Information Agency (EIA), 12.5 million homes (11 percent of the national total) used wood as an energy source in 2015, mainly for space heating. Wood heating reduces dependence on fossil fuels and promotes a local, indigenous fuel source. However, wood-burning is also a significant source of criteria and toxic air pollutant emissions.

Based on EPA's 2017 National Emissions Inventory (NEI), residential wood combustion emits approximately 340,000 tons of primary $PM_{2.5}$ annually, making it the largest direct source of particulate matter pollution in the country after road dust and fires (wildfire and prescribed).[2,3] Furthermore, a recent study has concluded that the level of wood burning may be significantly higher than represented by the NEI data.[4] These emissions have serious public health consequences, as residential wood heating can account for 10,000 to 40,000 premature deaths annually in the United States.[5,6] In states with large numbers of residential wood heating appliances, this emission source dominates health impacts from air pollution, especially during colder months.

State and local air quality agencies rely on standards and testing through EPA's emission certification program under the 2015 RWH NSPS to reduce emissions from new wood burning devices and to help attain and maintain the fine particulate matter ($PM_{2.5}$) National Ambient Air Quality Standards (NAAQS). Residential wood heating is a primary cause of nonattainment of the NAAQS for $PM_{2.5}$ in some areas. However, the

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[2] US EPA. *2017 National Emission Inventory* (April 2020). Available at: https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data.

[3] Primary PM is emitted directly from the source, as opposed to secondary particulate pollution that is created when sources emit precursor air contaminants, such as oxides of sulfur (SOx), oxides of nitrogen (NOx), volatile organic compounds (VOCs), and ammonia (NH_3), into the atmosphere that through chemical and physical processes form or help form $PM_{2.5}$.

[4] Commission for Environmental Cooperation. *Residential Wood Use Survey to Improve Black Carbon Emissions Inventory Data for Small-Scale Biomass Combustion*, Final Report. CEC, Montreal, Canada, (April 2019).

[5] Penn SL, Arunachalam S, Woody M, Heiger-Bernays W, Tripodis Y, Levy JI. Estimating state-specific contributions to $PM_{2.5}$- and O_3-related health burden from residential combustion and electricity generating unit emissions in the United States, *Environ Health Perspect* 125:324–332 (2017), http://dx.doi.org/10.1289/EHP550.

[6] Ciaizzo F, Ashok A, Waitz IA, Yim SHL, Barrett SRH. Air pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005, *Atmospheric Environment* 79:198-208, (2013), https://doi.org/10.1016/j.atmosenv.2013.05.081.

true scale of nonattainment is difficult to quantify because there are few regulatory air quality monitors located in rural areas where wood burning is most prevalent.

Residential wood heaters have a long useful life, therefore the benefits of new emission standards accrue slowly. To accelerate the turnover of older higher emitting appliances, government agencies, manufacturers, and nonprofit groups are investing millions of dollars in change-out programs. States and the federal government also offer tax credits that provide consumers with financial incentives to upgrade to new, presumably cleaner-burning wood heaters. In recognition of the public health impacts and financial stakes, this study was undertaken to investigate concerns about efficacy of the testing, review, and certification process adopted in the 2015 rule, and EPA's oversight and enforcement of the overall certification process.

ES-2. Methodology

In undertaking this study, the research team created a list of certification test reports to review using EPA's wood heater database to identify models that had been certified as Step 2 compliant. The team identified 131 cordwood stoves, 96 pellet stoves, and 28 central heating appliances that met these criteria, for a total of 255 devices. The 2015 RWH NSPS requires that a manufacturer post on its website a complete test report and summary report within 30 days of receiving certification, therefore the team attempted to locate all the test reports and post them to a central repository. However, difficulties were encountered finding some of the Step 2 appliance test reports, primarily pellet stove reports. Some manufacturers posted links to incorrect reports. In other instances, the reports could not be found after exhaustive online searches and a detailed review of the manufacturer's website. In some cases, reports were located with assistance from EPA. In total, 13 reports could not be found, and the team was unable to complete reviews of those certification test results.

For the 242 located reports, the next step in the process was to examine applicable regulations and guidance to identify criteria that would serve as the review's foundation. A regulatory basis document was created to catalog the review elements and the applicable regulatory citations. Given the large number of reports to review, the team chose to conduct a screening-level analysis focused on completeness of the reports, elements that could trigger certification revocation procedures, and elements that could trigger compliance audits of the tested devices.

Individual reviewers examined the test reports and entered data from these into a spreadsheet tool, which automatically created a preliminary determination as to whether significant problems existed with the certification testing for specific models based on the number of flags generated by data inputs. The initial reviewer was also able to include

notes, comments, and recommendations. The review tool automatically generated warning flags based on data input to allow for objective determinations rather than subjective opinions. Once reviewers completed the data input, the review tool automatically generated summary sheets, which underwent review by a committee comprised of staff from multiple state and local air quality agencies. After assessing the findings, the committee arrived at a final determination on the adequacy of each certification test.

ES-3. Findings

This section summarizes the results of the investigation and provides examples from test reports to highlight the emission ramifications associated with some testing variables and assumptions. The analysis found considerable testing and review irregularities across all three categories of residential wood heating devices: cordwood stoves, pellet stoves, and central heating systems. Similar deficiencies were found on models from all three categories. For the purposes of brevity, this Executive Summary focuses primarily on the cumulative analysis results. Some specific issues with test assumptions and decisions identified through this investigation are highlighted as examples of the larger universe of failures uncovered. Readers are encouraged to review the full report for more scope and detail on the findings for specific aspects of the study.

ES-3.1.1. Cordwood Stove Findings

Reviewers identified 131 cordwood stoves for review. Of the 131 appliances targeted, reports could not be located for two appliances. None of the remaining 129 reports was determined to be complete. On average, the review found 8 revocation elements and 8 audit elements per test report. Deviations included failure to report mandatory elements, improper fueling procedures, and inaccurate firebox measurements.

ES-3.1.2. Pellet Stove Findings

The team identified 96 Step 2 certified pellet stove models to review as part of this research, but 10 test reports could not be found. Of the 86 pellet stove tests reviewed, all contained deficiencies, with an average of four revocation elements and five audit elements per test report. Although the rule requires EPA to review these reports for completeness, not a single report analyzed as part of this study was complete, yet each of these stoves was certified by EPA. Additionally, reports did not include mandatory elements such as PM measurements (6 appliances missing 1-hr filter data) or CO data (8 appliances had no data and 13 tests reported "zero" for CO emissions). Seventy-three percent of test reports contained contradictory information such as the Btu output from high load testing not matching the advertised Btu output.

ES-3.1.3. Central Heating System Findings

Reviewers identified 28 appliances for test report review; 15 cordwood boilers, 8 pellet boilers, 1 chip boiler, and 3 cordwood furnaces. None of the reports contained complete datasets or documented appliance settings to determine how the system operated during certification testing. All central heating unit test reports were incomplete. One test report could not be found. The review found that on average each central heating test report contained 9 revocation criteria flags and 12 audit criteria flags. The amount of data missing from each test report made it impossible to complete a full review of any of the 27 located reports.

ES-4. Recommendations for Program Improvement

A strong and broad response is needed to correct the failures of the RWH NSPS program identified through this study. Some of these program weaknesses can be minimized in the near-term if EPA makes a firm commitment, and follows through in good faith, to fully enforce the existing requirements according to the clear language of the RWH NSPS. Others must be addressed through rule changes.

ES-4.1. Third-Party Review Process

The EPA Inspector General should conduct an investigation of the third-party review system, and the responsible ISO bodies should call for an inquiry into their accreditation processes. EPA-approved laboratories that conduct certification testing should not be eligible to participate in the third-party review process. EPA should initiate action against third-party certifiers that have not adhered to test method and rule requirements. Finally, EPA should reassess the validity and viability of the third-party review process as a cornerstone of this program in the next update to the RWH NSPS.

ES-4.2. Review of Certification Test Results

EPA should conduct a detailed review of the problematic certification test reports identified in this study. The Agency should hold hearings and, where appropriate, revoke certification for models failing to meet the 2015 RWH NSPS rule requirements.

The findings of this report suggest that some manufacturers and EPA-approved laboratories may be "optimizing" certification tests to qualify models as Step 2 compliant by employing methods inconsistent with the approved protocols. At a minimum, models should undergo compliance audits as allowed per 40 CFR § 60.533(n) to verify the ability of production units to meet the emission standards to which the prototype was certified. To date, EPA has not conducted a single compliance audit during the more than 30 years this program has been in place. To address this, EPA should implement routine compliance audits on 10 percent of appliances each year. The audits should begin by targeting stove models that conducted non-representative tests. Appliances should not be

allowed to recertify their appliances without retesting. Waiver provisions that allow manufacturers to avoid retesting of appliances should be eliminated. Retesting should require addressing deficiencies identified in the appliance review sheets, and remote witnessing of testing.

ES-4.3. Targeting Public Funding to Appropriate Appliances

Government funds for wood heater change-out programs should be used only for the cleanest appliances with valid test reports. Government agencies and nonprofits funding change-out programs should disqualify units that are certified as Step 2 compliant but fail to meet the rule's requirements. Taxpayer-supported incentive programs, such as the 26 percent federal tax credit created under the BTU Act, EPA Targeted Airshed grants, and state-supported activities, should only apply to those appliances included on the list of approved models developed by the Alaska Department of Environmental Conservation. This currently is the only thorough review of certification test reports applying the 2015 RWH NSPS requirements.

ES-4.4. Improving Certification Test Methods

Current cordwood test methods used to certify residential wood heaters are poorly designed and often lack the specificity to ensure viable and comparable emission results. EPA should revoke or modify problematic test methods. The ASTM 3053 test should be revoked as a Broadly Applicable Test Method. EPA should expedite rulemaking or guidance to close loopholes and reduce deficiencies in ASTM and CSA test methods. Over the longer term, EPA should fully fund efforts to develop new test methods that bring integrity, reliability, and reality to testing outcomes.

ES-4.5. OECA Enforcement and Oversight

EPA should establish residential wood heaters as a high priority enforcement sector and immediately begin a permanent and effective enforcement initiative. EPA should take enforcement action against third-party certifiers that do not adhere to method and rule requirements. Enforcement action should be taken under 40 CFR § 50.535(b) against EPA-approved laboratories that fail to follow required procedures or practices with the goal of assuring lab independence and competence while eliminating coordination between labs and manufacturers that inappropriately "optimize" test results and modify appliances during testing. Finally, EPA should request a revision to ISO procedures to ensure the certification system's integrity and competence.

ES-4.6. Program Transparency

The results of this analysis demonstrate that significant improvements in transparency are needed for the certification and enforcement components of the RWH NSPS. For example, EPA-approved laboratory inspections and compliance assurance activities are

treated as confidential business information (CBI). There is no clear justification why these elements would be considered CBI as they do not pertain to typical CBI elements, such as product designs or manufacturing processes. Instead, EPA should eliminate claims of CBI for all compliance assurance monitoring activities. EPA should develop a strategy to ensure all manufacturers post complete non-CBI test reports and take enforcement action against all manufacturers who post incomplete non-CBI test reports, as defined by the rule. EPA should eliminate the use of confidential ISO compliance assurance audits, and all audit findings should be posted on the Enforcement and Compliance History Online (ECHO) database maintained by EPA. EPA should develop and require the use of a standardized certification report template.

ES-4.7. Investigating EPA Program Oversight and Enforcement

The EPA Inspector General or Congress should conduct a review of EPA's OECA and Office of Air Quality Planning and Standards (OAQPS) with a focus on identifying practices to improve Agency oversight and enforcement of the 2015 RWH NSPS program.

ES-5. Conclusions

This study covered 255 Step 2 certified wood heater models (131 cordwood stoves, 96 pellet stoves and 28 central heating appliances) to assess the ability of EPA's program to assure compliance with RWH NSPS regulations. Thirteen of the identified models did not have publicly available certification test reports, as required by the regulations. For the remainder, no report was found to be complete and in full compliance with RWH NSPS requirements. Seventy-two percent of the ISO/EPA certified reports contained issues listed as Criteria for Revocation of Certification under the 2015 RWH NSPS; 24 percent of the test reports were too incomplete to make determinations; and the remaining 4 percent had minor issues.

The third-party certification review process is highly ineffective at identifying and reporting testing irregularities. The documented failures in the third-party process may be due to poor program design, the lack of competency of the groups involved, improper complicity between third-party reviewers and manufacturers, or some combination of the three. Study results also highlight the lack of EPA's use of the auditing program to ensure production models are substantially similar to the prototypes used in certification testing, and that those offered for sale are meeting the applicable emission standards.

This analysis also uncovered a lack of transparency in the RWH NSPS program. Reviewers were often unable to access key data and information on certification testing. An overly broad assertion of confidential business information has removed non-proprietary compliance assurance activities from public review.

Based on the identified shortcomings in this review, the 2015 RWH NSPS certification program fails to assure that new residential wood heaters are uniformly cleaner than past devices before the new standards went into effect. A flawed testing and review system coupled with a historical lack of EPA enforcement of basic program elements work in tandem to undermine the public health goals of the program. The end result is a program devoid of any credibility to ensure that new residential wood heating appliances are meeting federal emission standards, and instead gives every indication that scarce public resources are being misspent on incentive programs meant to encourage the more rapid introduction of cleaner wood burning appliances that truly reduce emissions.

1. INTRODUCTION

In 1988, EPA first established emissions limits for new residential wood heaters (RWH) under the Clean Air Act provisions governing New Source Performance Standards (NSPS). In 2015, EPA updated its original RWH NSPS rule using a two-step process to phase in more stringent emission standards. The initial "Step 1" limits generally aligned with the then-current emissions performance of most covered devices, while more stringent "Step 2" emissions limits took effect for new wood burning appliances sold after May 15, 2020. This was intended to provide manufacturers with a period of several years to design and manufacture cleaner devices.

A wood heater model line is certified as compliant with the RWH NSPS emissions limits if emissions from a prototype appliance, as measured by an EPA-approved testing laboratory, conform to the rule requirements. The 2015 RWH NSPS updates retained key elements of the previous 1988 RWH NSPS rule, allowing manufacturers to test a prototype to certify a model line. However, EPA delegated critical program oversight and compliance assurance activities traditionally performed by EPA to International Standards Organization (ISO) accredited third-party certifiers approved by EPA. Those activities include certification and competency assessments of the EPA-approved test laboratories, review of test reports, and annual inspections to confirm that manufactured appliances reasonably reflect the prototype used for certification testing.

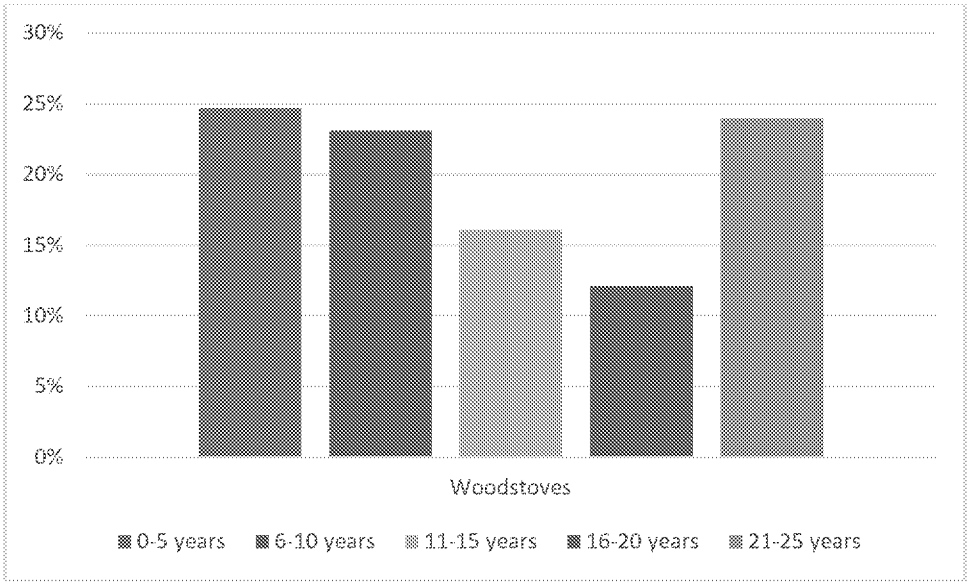
State and local agencies rely on EPA's federal certification program to ensure that new RWH models do not exceed the Step 2 limits in the RWH NSPS. Because there is no mechanism for follow-up assessment of performance in the field, it is essential that the procedures used to certify new wood burning devices accurately reflect emissions under normal use. This is crucial because, once installed, wood burning appliances typically remain in use for decades. A 2018 survey found that almost 25 percent of installed cordwood stoves were more than 20 years old (Figure 1).

In comments to EPA on the proposed 2015 rule, state agencies raised concerns about the third-party review system's efficacy and oversight.[7] In 2018, EPA released an Advanced Notice of Proposed Rulemaking (ANPRM) to solicit additional comments on improving the 2015 RWH NSPS program. Once again, states voiced concerns in comments on that

[7] NESCAUM Comments on Proposed Standards of Performance for New Residential Wood Heaters, New Residential Hydronic Heaters and Forced-Air Furnaces, and New Residential Masonry Heaters [79 Fed. Reg. 6330-6416 (February 3, 2014)], submitted May 5, 2014. Available at https://www.nescaum.org/documents/nescaum-comments-resid-wood-heaters-nsps-20140505.pdf.

ANPRM about the efficacy of the third-party review system and EPA's oversight of that program.[8]

Figure 1. 2018 National Survey - Reported Age of Woodstove[9]



In 2019, the Northeast States for Coordinated Air Use Management (NESCAUM) met with state agencies working on RWH programs. At that meeting, the states requested that NESCAUM undertake a review of certification test reports for appliances certified as meeting the 2015 RWH NSPS Step 2 emissions limits to assess the certification program's efficacy. That review employed procedures similar to those in a study conducted by Brookhaven National Laboratory for the New York State Energy Research and Development Authority (NYSERDA) in 2011 on EPA's Voluntary Hydronic Heater Program.[10] This report presents the results of the NESCAUM review and assesses the rigor of the current regulatory framework used to certify residential wood heating appliances. The report includes information on the following topics:

- the impact of residential wood heating,
- the regulatory structure of the federal RWH certification program,

[8] NESCAUM Comments on Advanced Notice of Proposed Rulemaking for New Source Performance Standards for Residential Wood Heaters, New Residential and Hydronic Heaters and Forced-Air Furnaces [83 Fed. Reg. 61585-61593 (November 30, 2018)], submitted February 12, 2019. Available at: https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0196-0017.

[9] Commission for Environmental Cooperation. *Residential Wood Use Survey to Improve Black Carbon Emissions Inventory Data for Small-Scale Biomass Combustion*, Final Report. CEC, Montreal, Canada (April 2019).

[10] Butcher, T, *Review of EPA Method 28 Outdoor Wood Hydronic Heater Test Results*, NYSERDA, Albany, NY (2011).

- an overview of test methods used by the certification program,
- the regulatory requirements for certification testing,
- the methodology used to assess program efficacy,
- the findings from the review process, and
- conclusions and recommendations.

2. BACKGROUND ON THE RESIDENTIAL WOOD HEATING SECTOR

2.1. Residential Wood Heating Emissions and Public Health Impacts

Cordwood, wood pellets, and wood chips are important primary and secondary residential heating fuels in the United States. According to the US Energy Information Agency (EIA), 1.8 million US homes use cordwood or wood pellets as their primary fuel. Another 10.3 million households use wood fuels for supplemental heating, which translates into 11 percent of all homes relying on wood as an energy source in 2015. Twenty-five percent of rural households use wood for heating compared with six percent of urban households.

While many view wood as a clean energy source, wood combustion is responsible for a disproportionately large share of pollutant emissions. According to EPA's National Emission Inventory, residential wood heating contributed approximately 340,000 tons of primary $PM_{2.5}$ in the United States in 2017.[11,12] After road dust and fires (wildfire and prescribed), residential wood heating was the largest source of primary $PM_{2.5}$ in the country, exceeding emissions from the highway and off-highway motor vehicle sectors combined (Figure 2).

Wood's importance as a fuel is regional in scale. Areas reliant on home heating oil with forested areas nearby tend to experience higher use.[13] Wood heating is highest in New England, where 21 percent of households use wood.[14] While wood heating may be regional, its impact has national significance. As highlighted in Figures 3 and 4, wood heating emissions were responsible for 98 percent of $PM_{2.5}$ emissions from the residential fuel combustion category. However, wood heating provided only 4 percent of the energy (in British thermal units) used for home heating.

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[11] US EPA. *2017 National Emission Inventory* (April 2020). Available at: https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data.

[12] Primary PM is emitted directly from the source, as distinguished from secondary PM, which is formed in the atmosphere by reactions of precursor air contaminants, such as oxides of sulfur (SOx), oxides of nitrogen (NOx), volatile organic compounds (VOCs), and ammonia (NH_3).

[14] EIA, 2020. *Winter Fuels Outlook*. Available at: https://www.eia.gov/outlooks/steo/report/winterfuels.php#:~:text=Wood,as%20a%20supplemental%20heating%20fuel.

Figure 2. Contributions by Source Category to National $PM_{2.5}$ Inventory (2017 NEI)[15]

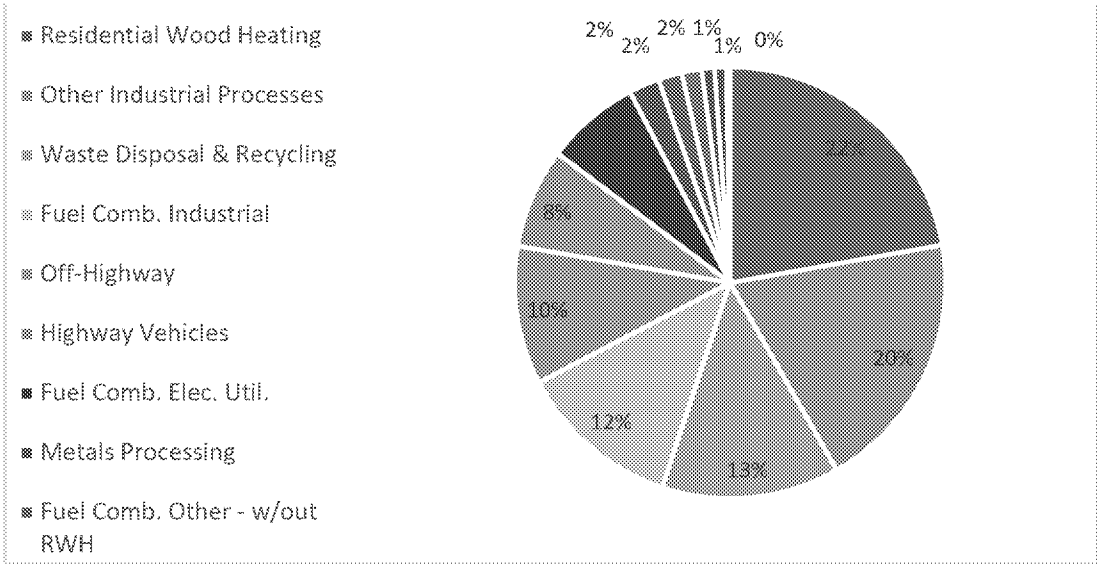
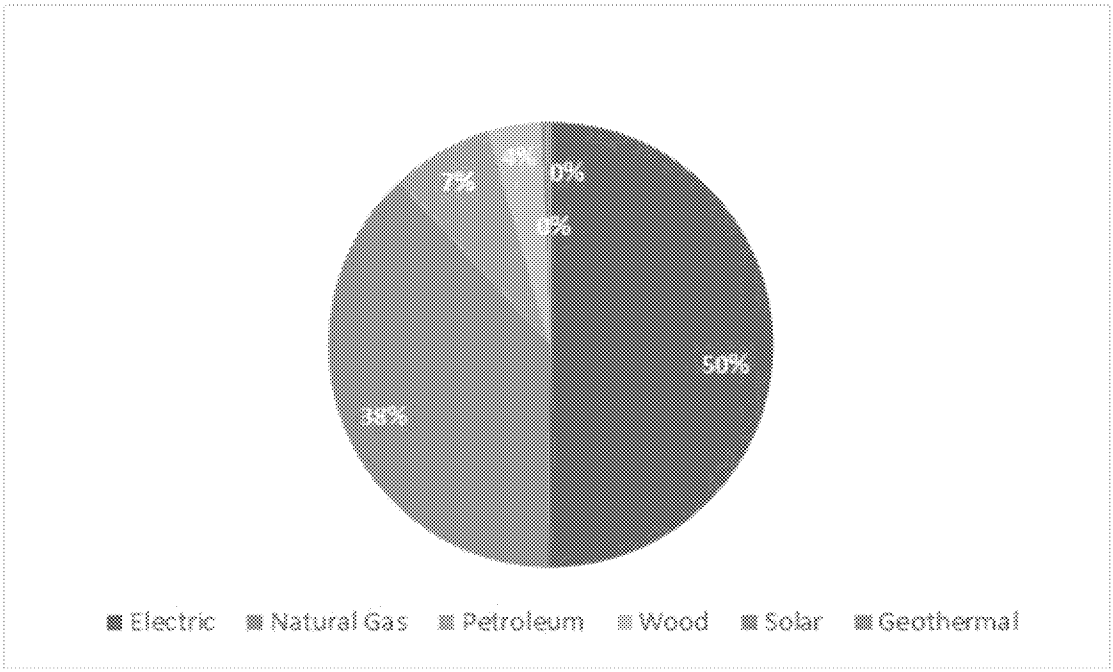
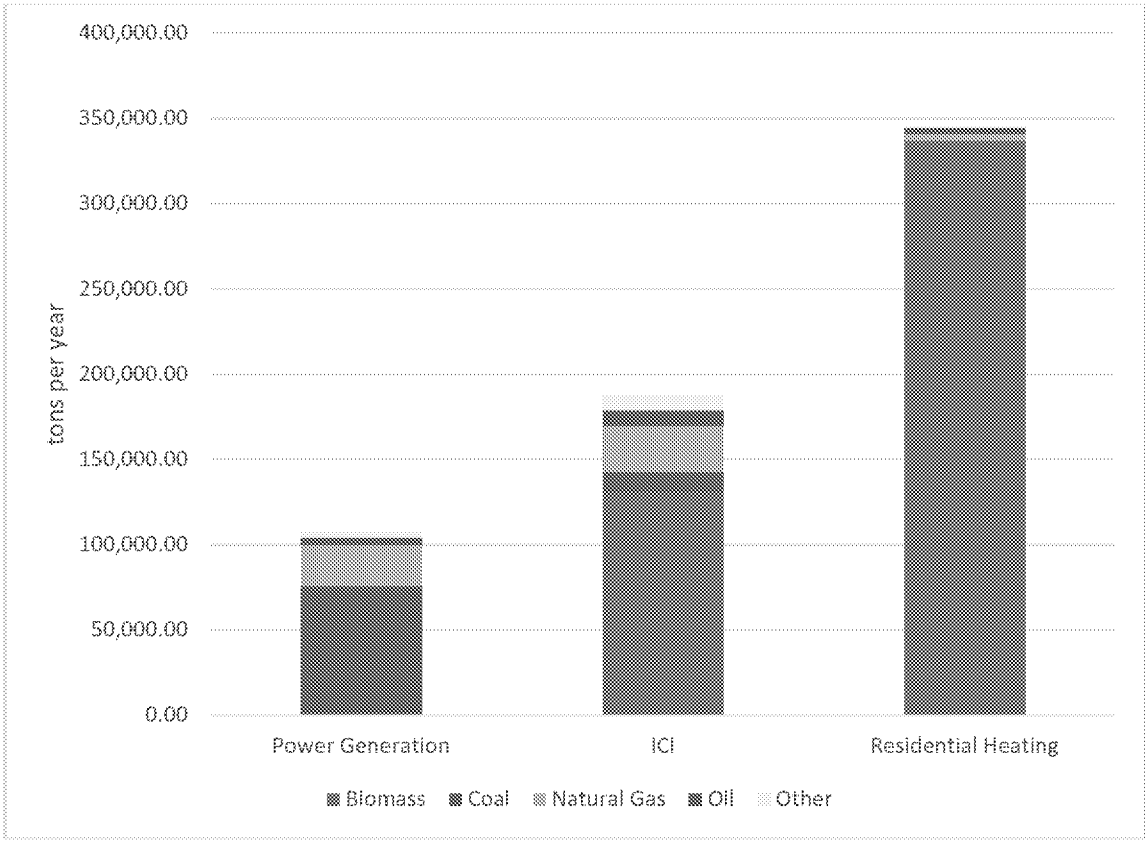


Figure 3. Energy Use for Residential Heating by Fuel Type (BTUs)



[15] US EPA. *2017 National Emission Inventory* (April 2020). Available at: https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data.

Figure 4. Fuel Combustion PM2.5 Emissions by Sector (tons per year)[16]



Exposure to $PM_{2.5}$ in wood smoke is associated with increased risk of respiratory and cardiac mortality, lung function decrements, exacerbation of lung disease, lung cancer, developmental and immunological effects, and premature mortality. A large percentage of the general population is particularly susceptible to those effects, including children, the elderly, and persons with respiratory or heart disease.[17] Studies estimate that RWH air pollutant emissions account for 10,000 – 40,000 premature deaths annually in the US.[18,19]

Wood combustion also emits polycyclic organic matter (POM), benzene, aldehydes, and other air toxics associated with respiratory and carcinogenic effects. EPA estimates that RWH accounts for 44 percent of POM emitted by all stationary and mobile sources and is

[16] ICI = Industrial, Commercial, and Institutional emission sources.
[17] Naeher LP, Brauer M, Lipsett M, Zelikoff JT, Simpson CD, Koenig JQ, Smith KR. Woodsmoke health effects: a review, *Inhal Toxicol* 19(1):67-106 (2007), doi:10.1080/08958370600985875.
[18] Penn SL, Arunachalam S, Woody M, Heiger-Bernays W, Tripodis Y, Levy JI. Estimating state-specific contributions to $PM_{2.5}$- and O_3-related health burden from residential combustion and electricity generating unit emissions in the United States, *Environ Health Perspect* 125:324–332 (2017), http://dx.doi.org/10.1289/EHP550.
[19] Ciaizzo F, Ashok A, Waitz IA, Yim SHL, Barrett SRH. Air pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005, *Atmospheric Environment* 79:198-208 (2013), https://doi.org/10.1016/j.atmosenv.2013.05.081.

responsible for 25 percent of the cancer risk and 15 percent of the noncancer respiratory effects attributed to area source air toxics emissions.[20] In states where RWH is more prevalent, this emission source dominates health impacts from air pollution, especially during colder months.

Modeling and monitoring studies have demonstrated that wood smoke is a significant source of the PM measured in ambient air in many United States locations. Studies conducted by the Vermont Department of Environmental Conservation and NESCAUM found that, during the coldest and calmest winter days in Rutland, Vermont, wood smoke accounted for half or more of measured $PM_{2.5}$ levels.[21] A study in rural New York State found that more than 90 percent of carbonaceous $PM_{2.5}$ was associated with wood smoke and that winter nighttime peak $PM_{2.5}$ levels can exceed 100 $\mu g/m^3$.[22] These results are consistent with a field study by NESCAUM in the Adirondacks region that found significant localized pollution from wood burning that is closely associated with the higher population densities of towns and villages.[23] A 2016 study for New York State used modeling to assess wood heating impacts. Results from that study indicated that "a single polluting, wood-burning boiler or stove can lead to pollution levels above health-based air quality standards in the immediate vicinity of the source."[24] Wood smoke issues are not isolated to mountainous areas where valley temperature inversions exacerbate PM emission levels. Studies in Connecticut have found that, on cold winter days when ambient concentrations of $PM_{2.5}$ are elevated, observed wood smoke contributes more than 50 percent of hourly $PM_{2.5}$ concentrations.[25]

Modeling techniques have been used to evaluate the impact of RWH on air quality in locations that lack air quality monitoring data.[26] The results indicate that RWH can cause

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[20] US EPA. *National Air Toxics Assessment, 2011 NATA: Assessment Results* (2015). Available at http://www.epa.gov/national-air-toxics-assessment/2011-nata-assessment-results#nationwide.

[21] Allen GA, Babich P, Poirot R. *Evaluation of a New Approach for Real Time Assessment of Wood Smoke PM*, Paper #16. Presented at the Air & Waste Management Association Visibility Specialty Conference on Regional and Global Perspectives on Haze: Causes, Consequences and Controversies, Asheville, NC (October 25-29, 2004).

[22] Graham J, Johnson P. *Assessment of Carbonaceous PM2.5 for New York and the Region*. NYSERDA Report 08-01, Albany, NY (March 2008). Available at http://www.nescaum.org/documents/assessment-of-carbonaceous-pm-2-5-for- new-york-and-the-region/.

[23] Allen GA, Miller PJ, Rector LJ, Brauer M, Su JG. Characterization of Valley Winter Woodsmoke Concentrations in Northern NY Using Highly Time-Resolved Measurements, *Aerosol and Air Quality Research* 11:519–530 (2011), doi:10.4209/aaqr.2011.03.0031.

[24] Weiss L, *et al. New York State Wood Heat Report: An Energy, Environmental, and Market Assessment*. NYSERDA, Albany, NY (April 2016).

[25] Connecticut Dept. of Environmental Protection, Bureau of Air Management. *Evaluation of Wood Smoke Contribution to Particle Matter in Connecticut*. Hartford, CT (February 7, 2011). Available at http://www.ct.gov/deep/lib/deep/air/wood_stove_furnaces/ctdep_woodsmokefinalreport.pdf.

[26] Weiss L, *et al.*, *New York State Wood Heat Report: An Energy, Environmental, and Market Assessment*. NYSERDA, Albany, NY (2016).

high ambient $PM_{2.5}$ levels in some locations, even in states that do not have designated $PM_{2.5}$ non-attainment areas.

2.2. Uses of the EPA Certification Program

As discussed in this section, a number of programs rely on the RWH NSPS certification program to identify clean burning appliances needed to meet federal health standards for $PM_{2.5}$ or to address local air pollution concerns.

2.2.1. State and Local Regulations

State and local agencies have developed ordinances and regulations that rely on EPA certification to identify clean RWH devices. Examples of such state actions are provided at: https://www.epa.gov/burnwise/ordinances-and-regulations-wood-burning-appliances.

2.2.2. Tax Incentives and Rebates

Federal, state, and local governments use the EPA certification program as a basis for identifying RWH appliances that are eligible for tax incentives or rebates. These programs cannot achieve optimal emissions reductions if certified stoves do not perform well in the field. Recently, the federal government passed the Biomass Thermal Utilization Act (BTU Act), which gives a 26 percent federal tax credit to any residential wood heating system with an efficiency of 75 percent or more. IRS regulations for this program are not yet in place, but many believe that the EPA database should be the authority to determine which appliances can obtain that tax credit. The following state programs also provide tax incentives or rebates:

- Alabama – 100 percent tax deduction for RWH systems
- Arizona – $500 tax deduction
- Georgia – 100 percent tax deduction for RWH systems
- Idaho – 100 percent tax deduction applied over several years
- Maine – rebates of up to $6,000 for cordwood or pellet boilers
- Maryland – rebates of up to $500 for cordwood stoves and $700 for pellet stoves
- Montana – up to a $1,000 tax credit
- New Hampshire – rebates of 40 percent of the purchase cost ($10,000 cap) for automated wood-fired heating systems
- New York – rebates of $2,000 for pellet stoves and up to $23,000 for boilers
- Vermont – rebates of $6,000 for pellet boilers or furnaces, $650 for pellet stoves

2.2.3. Change-out Programs

Over the past decade, millions of taxpayer and enforcement settlement dollars have supported the purchase of new wood-burning appliances. These programs, which have taken place in many areas of the United States, seek to reduce RWH emissions by

replacing older wood-burning appliances with new ones that are NSPS-certified. In the western United States, change-out programs have been used to reduce PM emissions in non-attainment areas. EPA's Targeted Airshed grant program has also spent tens of millions of dollars to support change-outs in a subset of nonattainment areas having the worst levels of $PM_{2.5}$ pollution.

One of the most frequently touted change-out programs took place in Libby, Montana. During 2005 to 2008, every non-EPA-certified stove in that community was replaced. Replacing non-certified stoves with those that had been EPA-certified was expected to reduce this source category's impact by more than 75 percent. However, follow-up studies found that PM emissions from wood heating only declined by 28 percent.[27] Another study of this change-out program found that indoor PM emission reductions across homes and years were variable. A subset of households did not experience any reduction in PM following the change-out, while almost a quarter of the homes measured higher PM levels after than before the change-out.[28] This history indicates that without reliable certification procedures, replacing old stoves with newer models may not result in pollution reduction benefits.

2.3. EPA Certification Process

To obtain EPA certification of a new wood appliance model, the RWH NSPS requires completion of a valid certification test on a prototype of that model, conducted according to the specifications in the rule, that shows compliance with the applicable standard. Before performing the certification test, manufacturers must:

- Secure the services of an ISO-accredited/EPA-approved laboratory to conduct the test.
- Secure the services of an ISO-accredited/EPA-qualified third-party certifier to review the test report.
- Send a 30-day notification to EPA of the intent to test, using the form developed by EPA. The submission must identify the EPA-approved test laboratory, third-party certifier, test methods, model name, and test dates.

After an EPA-approved laboratory conducts the certification test, the test data must be submitted to EPA within 60 days. The manufacturer must then submit the draft test report to an ISO-accredited third-party reviewer for review. The third-party reviewer must

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[27] Ward T, Palmer C, Noonan C. Fine Particulate Matter Source Apportionment Following a Large Woodstove Changeout Program in Libby, Montana, *Journal of the Air & Waste Management Association* 60:688-693 (2010), doi:10.3155/1047-3289.60.6.688.

[28] Noonan C, *et al.* Residential indoor PM2.5 in wood stove home: follow-up of the Libby Changeout Program. *Indoor Air* 22:492-500 (2012), https://doi.org/10.1111/j.1600-0668.2012.00789.x.

review the test report and identify all issues that do not comply with RWH NSPS requirements. If the ISO-accredited third-party reviewer determines that the test was completed according to the RWH NSPS requirements and that the test report is complete, the reviewer issues a certificate of conformity.

Upon receipt of the certificate of conformity, the manufacturer can then submit an application package for certification to EPA's Office of Enforcement and Compliance Assurance (OECA). OECA reviews the submittal to determine that it is complete and accurate. A complete application package includes the following items:

- Certificate of conformity by an ISO/EPA-approved third-party certifier.
- Quality Assurance (QA) plan.
- Full emissions test report from an ISO-accredited/EPA-approved laboratory, including all documentation.
- Model name and design number.
- Engineering drawings and specifications of components that may affect emissions.
- Identification of confidential business information.
- Copy of warranties.
- Statements about stove construction materials; assurance program; sealing and storing the tested unit; manufacturing, labeling and owner's manuals; contracts with an EPA-approved laboratory and third-party certifier and approval to allow those entities to submit information on behalf of the manufacturer; posting of test report on manufacturer's web site; and acknowledgments that the certificate cannot be transferred and that it is unlawful to sell a unit without a valid certificate of compliance.
- Contact information for the manufacturer's responsible representative.
- A statement that the manufacturer has complied with and will continue to comply with all requirements pertaining to the certificate of compliance and that the manufacturer remains responsible for compliance regardless of any error by the EPA-approved test laboratory or third-party certifier.

OECA policy has targeted a timeframe of 90 days to review an application package. The 90-day timeline is a policy decision rather than a regulatory requirement. If, after review, OECA certifies the model line, the RWH NSPS requires the manufacturer to:

- Publicly post the complete non-CBI test report,
- Implement the QA plan via an ISO-accredited/EPA-approved third-party certifier, as detailed in the application, and
- Submit sales data per model, by state, every two years to OECA.

2.3.1. Third-Party Report Review

The requirement for third-party conformance certifications was first introduced in the 2015 RWH NSPS, and EPA must approve the third-party reviewers. The application process includes demonstrating that a nationally recognized accrediting entity has accredited the reviewer to perform certifications and inspections under ISO-IEC Standards 17025, 17065, and 17020.

According to the 2015 RWH NSPS, the third-party certifiers must "[h]ave no conflict of interest and receive no financial benefit from the outcome of certification testing." The company that conducts a certification test, however, is allowed to also provide third-party review services for that test. The role of the third-party reviewer includes:

- Witnessing the test (optional component).
- Reviewing the test report to determine that all requirements of the RWH NSPS related to RWH testing were completed appropriately.
- Issuing a certificate of conformity.
- Conducting compliance assurance inspections to ensure that production models match the prototype that was tested.
- Assessing whether the manufacturer's QA plan meets the requirements of the rule.

Pursuant to the 2015 RWH NSPS, EPA relies heavily on the third-party reviewer to complete comprehensive reviews of test reports. Review of the test report by the ISO-accredited third-party must include confirmation that the following RWH NSPS requirements were met:

- Emissions testing was conducted in accordance with all regulatory requirements.
- The test report is complete and accurate.
- Instrumentation used for testing was properly calibrated.
- Testing data provides sufficient information to confirm that the appliance meets the emission standards listed in the regulation.
- The manufacturer's QA plan is sufficient.

If all of the above conditions are met, the third-party reviewer can issue a certificate of conformity.

2.3.2. Third-Party Compliance Assurance Monitoring Programs

Another new component of the 2015 RWH NSPS is the use of third-party reviewers to conduct QA audits of manufacturing facilities. These inspections are part of the compliance assurance monitoring programs submitted by manufacturers to EPA in the

application package for certification. The third-party certifier conducts regular (at least annual) unannounced inspections of the manufacturing facility to ensure that the manufacturer's QA plan is being implemented. Upon completion of the inspection, the third-party inspector must submit inspection reports to the manufacturer and OECA. Inspection reports must identify any deviations from the plan and specify corrective actions.

2.3.3. Approved Laboratories

The 2015 RWH NSPS requires all laboratories conducting certification tests for any appliance regulated under the RWH NSPS to obtain ISO/IEC 17025 accreditation. ISO/IEC 17025 is a quality management program designed to ensure testing laboratories are following proper procedures. To obtain ISO/IEC 17025 accreditation, laboratories must enter into a contract with an ISO accrediting agency and prepare documentation outlining the procedures that the laboratory uses, specific activities the laboratory undertakes, QA plans, and records that provide evidence that QA plans are put into practice.

The ISO accreditor reviews and assesses the documentation supplied by the laboratory and provides a report detailing any corrective action needed. When all needed corrective actions have been completed, the accreditation documents are submitted to a review body for approval. If approved, the laboratory receives a certification of accreditation. Once the laboratory obtains this accreditation, it can apply to the EPA Administrator for approval to conduct testing under the RWH NSPS rule. As part of that application, laboratories must:

- Submit documentation of accreditation under ISO-IEC Standard 17025.
- Agree to participate biennially in an independently operated proficiency testing program with no direct ties to the participating laboratories.
- Agree to allow the Administrator, regulatory agencies, and third-party certifiers access to observe certification testing.
- Agree to comply with calibration, reporting, and recordkeeping requirements that affect approved testing laboratories.
- Agree to perform a compliance audit test (at the manufacturer's expense at the testing cost normally charged to such manufacturer) if the laboratory is selected by the Administrator to conduct the compliance audit test of the manufacturer's model line.
- Have no conflict of interest and receive no financial benefit related to the outcome of testing.

- Agree to not perform initial certification tests on any models manufactured by a manufacturer for which the laboratory has conducted research and development design services within the last five years.
- Agree to seal any wood heater on which it performed certification tests immediately upon completion or suspension of certification testing with a laboratory-specific seal.
- Agree to immediately notify the Administrator of any suspended tests (including the reason(s) why and the projected retest date) and submit the operation and test data obtained for the suspended tests.

EPA certifies laboratories for operation under the RWH NSPS regulation for a five year period. After five years, the laboratory must submit a request for renewal.

2.4. EPA Certification Test Methods

The 2015 RWH NSPS specifies test methods to be used for certifying an appliance's compliance with that regulation. Those methods can be segregated into those that specify pollutant measurement procedures and those that address operation and fueling protocols.

2.4.1. Emission Measurement Methods

EPA references two test methods in the 2015 RWH NSPS for emission measurements:

- ASTM 2515-11 to measure particulate matter emissions.
- Canadian Standards Administration (CSA) B415.10-10 for efficiency, heat output, and carbon monoxide measurement.

2.4.2. Operation and Fueling Protocol for Stoves

EPA's operation and fueling protocols are specific to the type of stove being tested. Cordwood stoves may be tested using either EPA Method 28R, which uses dimensional lumber, or ASTM 3053-17, which uses cordwood. Both methods consist of individual runs that are conducted under steady-state conditions with no replicate testing. Pellet stoves use ASTM 2779-10, which is a single integrated test run. Table 1 summarizes those methods for certifying stoves.

Table 1. Comparison of Key Characteristics of EPA and ASTM Test Methods

Element	EPA M28	ASTM 3053-17	ASTM 2779
Appliance type	Variable & single burn rate stoves	Variable & single burn rate stoves	Pellet stoves
Summary	Four steady state runs at defined load categories	Two steady state load categories (low and medium) and one run with start-up, reload to high fire	One integrated run that encompasses four different fuel loads, coal bed conditions, and heat loads
Operational Parameters			
Number of loading events	1	1 in low and medium runs, 2 in start-up/high run	0
Start-up	No	Yes, combined with high fire	No
High fire	Yes	Yes, combined with start-up	Yes
Medium fire	Two burn rates assessed	Requires a burn setting higher than low but no other requirements	Yes, defined as 50% or less of high fire
Low fire	Yes	Yes	Yes
Replicates	None	None	None
Long charcoal tails	Yes	Yes	No
Precision and variability data	No	No	No
Fueling Parameters			
# of different load sizes by weight	1	2	NA
Fuel load volumes	7 lb/ft^3	10 lb/ft^3 for high; 12 lb/ft^3 for low and medium fire runs	NA
Fuel requirements	Dimensional Douglas fir at a specified moisture content	Any fuel species within allowed specific gravity range at a specified moisture content	No specifications

2.4.3. Operation and Fueling Protocol for Central Heaters

EPA requires the ASTM 2618 operation and fueling protocol in certification tests for cordwood hydronic heaters that do not have external thermal storage. Cordwood hydronic heaters with thermal storage can choose among three different test methods: (1) EPA Method 28WHH, (2) ASTM 2618-13, or (3) EPA Method 28WHH-PTS (for units with partial thermal storage). Pellet boilers without thermal storage must use ASTM 2618-13. Pellet boilers with external thermal storage must use an approved Alternative Test Method (ATM). Furnaces use CSA B415.1-10. Table 2 summarizes key elements of the central heating test methods.

Table 2. Comparison of Test Methods for Hydronic Heaters

	ASTM E2618-13	CSA B415.1-10	EPA M28WHH-PTS
Manual Loaded Fuel: Crib, Cord, or Both	Crib, Cordwood, or Pellet	Crib and Cordwood	Cordwood
Fuel Feed	Both	Both	Manual
PM Measurement Method	Dilution tunnel	Dilution tunnel	Dilution tunnel
PM Measurement	Total PM	Total PM	Total PM
PM Emission Metric	Weighted average or individual run, lb/MMBtu output	Simple average of test runs, lb/MMBtu output	Simple average, lb/MMBtu output
Wood Fuel Species	Any within specified density range	Any within specified density range	white or red oak
Moisture Range (dry basis)	19-25%	18-28%	19-25%
Method of Efficiency Determination	Thermal output	Stack loss method	Thermal output
Burn Rate Categories	Maximum output 25-50% 15-24% < 15%		Maximum output 25-50% 15-24% < 15%
PM Emission Rate (g/hr)	Yes – run average	No	Yes – by phase of burn cycle
Measures Start-up	No	No	Yes
Thermal Storage	Annex that applies to cordwood appliances only	No	Partial
Cold Start	Yes, if used with storage	No	Yes – Cat I and II
Upper Size Limit	No	500,000 Btu/hr	350,000 Btu/hr
Fuel Loading for Handfed Units (minimum)	10 lb/ft^3	10 lb/ft^3	10 lb/ft^3

2.4.4. Alternative Test Methods

Manufacturers can request approval from EPA to use an alternative test method (ATM). ATMs are most often requested if there is no designated test method in the rule that is applicable to the appliance that will be tested. Pellet boilers using thermal storage are an example of an appliance category that requires an ATM.

3. METHODOLOGY

3.1. Study Approach

The project team used an approach similar to that used in a 2011 assessment of EPA's voluntary program for outdoor wood boilers[29] to assess the efficacy of the 2015 RWH NSPS certification program. The study reviewed available certification test reports for appliances certified as compliant with the Step 2 emission standards, evaluating: (1) completeness of the EPA-certified test reports, (2) conformance with test methods, and (3) error magnitudes (where sufficient information was available to estimate this parameter). The review, which is considered to be at the "screening" level, is intended to identify appliance models that have significant certification procedure issues, provide that information to EPA for a more detailed review, and present recommendations for improvements in the certification process.

The first step in the process was to identify the requirements that would constitute a complete certification application package according to the applicable regulations and guidance. This provided the criteria for determining report completeness. A regulatory basis document that compiles the identified review elements and the applicable regulatory citations is on the website https://dec.alaska.gov/air/burnwise/manufacturers-vendors/ maintained by the Alaska Department of Environmental Conservation (ADEC).

Once the team finalized the list of review criteria, an Excel-based tool was created to input test report data and related elements in a standardized format. Because the original Excel spreadsheet was large and complex, Excel summary sheets were created to streamline the review process. The summary sheets, which were used for the reviewers' assessments, pulled information from the original spreadsheet with the previously entered reports. To assess the review tool performance, three people reviewed the same report independently. A comparison of the three different reviews found that all three reviewers identified the same flags. All three reports obtained the same preliminary review determination. One reviewer spent additional time checking calculations in the underlying data. The reviewer who completed those calculations found additional issues. However, it was determined there were not sufficient resources to conduct an in-depth review of each report. Based on this effort's findings, the team agreed that the tool was sufficient to allow multiple people to complete test report reviews. A sample of the summary review sheet is provided in Figure 5.

[29] Butcher, T, *Review of EPA Method 28 Outdoor Wood Hydronic Heater Test Results*, NYSERDA, Albany, NY (2011).

Figure 5. Example of the Review Template for Cordwood Stoves

Cordwood Summary Sheet Template

Summary of Review								
Manufacturer								
Model					Control approach			Non-Catalytic
Prelim review recomm.								
Red flags		Orange flags			Yellow flags			
Final Determination								Basis:
Testing Information	***Determination***							***Notes***
Test method								
Test Lab								
Third-party certifier								
Report certified								
Test Report Elements	***Determination***							***Notes***
Wght Avg PM emissions (g/			PM Highest 1-hr (g/hr)					
Wght Avg HHV Efficiency (%								
Wght Avg CO (g/hr)			Wght Avg CO (g/min)					
Max heat output (Btu/hr)								
Manufacturers instructions								
Firebox vol. test report								
Firebox dimensions			Longest dim. (in)					
Firebox calculations								
Efficiency calculations								
Burn rate calculations								
Raw data sheets								
Pre-burn completed by								
Pre-burn data								
Lab technician notes								
Doc. of run appropriateness								
Doc. of run validity								
Doc. of run anomolies								
Doc. of run burn rates								
Photos of the fuel loaded								
Test Run Data	***Determination***							***Notes***
Run #								
Run Category								
Burn rate (kg/hr)								
PM emissions by run (g/hr)								
PM 1-hr filter pull (g/hr)								
Filter data								
Train precision (%)								
Negative weights								
Negs handled appropriately								
Heat output by run (Btu/hr)								
CO by run (g/hr)								
HHV efficiency (%)								
Lowest burn rate tested								
All run data								
Appliance Fueling	***Determination***							***Notes***
Fuel species				Maple				

Log length (in)								
Direction of longest dimens								
Log direction for testing								
Squared (ASTM test only)								
Debarked (ASTM test only)								
Load density (lb/ft3)								
Fuel moisture content load (%db)								
Fuel piece configuration								
Owners Manual Req.	**Determination**							**Notes**
Stack height								
Location recommendation								
Guidance on proper draft								
Fuel loading & reloading								
Fuel selection recomm.								
Improper fuels warnings								
Fire starting procedures								
Proper use of air controls								
Proper operation low								
Ash removal procedures								
Replacement parts								
Federal warning (C or NC)								
Warranty rights								
Catalyst operation								
Cat maintenance procedure								
Determining catalyst det. o								
Reporting	**Determination**							**Notes**
Summary tables complete								
All run data submitted								
Test report complete								
Owner manual complete								
Test dates								
30 Day notice submitted to								
Tested on the proposed dat								
Tested in consecutive days								
60 Day report to EPA								

After completing the review tool, reviewers used EPA's wood heater database (https://cfpub.epa.gov/oarweb/woodstove/index.cfm?fuseaction=app.about) to identify wood burning devices that had been certified as Step 2 compliant. The study identified 255 appliances certified as Step 2 – 131 cordwood stoves, 96 pellet stoves, and 28 central heaters.

The 2015 RWH NSPS rule requires manufacturers to post complete test reports publicly on their company website. The team attempted to locate the test reports for all Step 2 certifications and post them to a central repository but encountered difficulties in obtaining test reports for approximately 20 percent of the appliances. Some websites had links to incorrect test reports. In other instances, the test reports could not be found after exhaustive online searches and a detailed review of the manufacturer's website. In some cases, test reports were located by requesting assistance from OECA.

Individual reviewers examined the test reports and entered data either into the initial spreadsheet or directly into the review tool. The reviewer was also able to enter notes,

comments, and recommendations. Reviews were initially entered into the large spreadsheet, and summary report sheets were exported from the review tool. Both the review tool and summary reports automatically generated warning flags, which provide an objective identification of significant problems with the testing or reporting.

A committee, comprised of staff from multiple state and local air quality agencies, met weekly to review summary data. During review meetings, the reviewer presented the findings for each summary sheet, and the committee discussed the results. After reviewing the findings, the committee made a final determination about issues in each report. In some cases, summaries underwent additional review or revisions based on EPA feedback.

In September 2020, manufacturers of room heating appliances were notified that summary sheets had been completed for their certification test reports. The manufacturers were given the opportunity to request a review of the sheets before ADEC publicly posted the information. The initial posting occurred in November 2020, and an update occurred in February 2021. Manufacturers were allowed to address deficiencies identified by reviewers by providing new information to ADEC or by highlighting where the information existed in the report. Manufacturer review only slightly modified review findings. After manufacturers reviewed existing or submitted new data, less than 10 percent of the deficiencies could be resolved.

ADEC maintains a copy of the original review sheet and the updated version. Summary sheets for cordwood stoves and pellet stoves can be found on the ADEC website https://dec.alaska.gov/air/burnwise/manufacturers-vendors/. The information in this report was current as of February 2021. ADEC plans to update the summary sheets as it compiles new appliance reviews and as manufacturers submit revised and additional information. Central heating appliances were not included as part of ADEC's initial regulatory efforts. However, summary sheets and reviews were also completed for these appliances in this study.

3.2. Review Elements

Given the large number of test reports, the team conducted a focused screening-level review. The first step was to determine the completeness of the reports. The second step was to determine the need for follow-up action. Defect and deficiency flags generated by the review were segregated into three categories: (1) required reporting to assess report completeness, (2) revocation elements, and (3) questionable practices that should trigger compliance audits. These review elements were based on the specifications in the RWH NSPS rule and the test methods that the rule references. The regulatory basis for each element is detailed in a report posted by ADEC called "ADEC Regulatory Basis," which can be accessed from the ADEC webpage link given in the above paragraph. Results of

appliance reviews can be found in the following Sections 4.1 through 4.3. Reviewers also assessed overarching rule reporting and compliance monitoring components. The results of this effort can be found in Section 4.4.

Based on the identified deficiencies, the study divided test reports into three categories: (1) findings to be submitted to OECA with a request it take action under the revocation of certification provisions in the RWH NSPS [40 CFR § 60.533(l)/60.5475(l)], (2) findings to be submitted to OECA with a request it take action under the audit provisions in 40 CFR § 60.533(n)/60.5475(n), and (3) no action. The following sections detail the review elements that determined categorizing for EPA action or no action.

3.2.1. Report Completeness

Reviewers evaluated reports to determine whether they included the elements required in the RWH NSPS for a complete test report. The required elements, as identified in 40 CFR § 60.537/60.5479, are as follows:

- Full test report
- Raw data sheets
- Laboratory technician notes
- Calculations
- Test results for all test runs
- Discussions of the appropriateness and validity of all test runs, including runs attempted but not completed
- Detailed discussion of:
    - all anomalies
    - whether all burn rate categories were properly achieved
    - any data not used in the calculations
    - for any test runs not completed, the data that were collected, and the reason that the test run was not completed
    - documentation that the burn rate for the low burn rate category was no greater than the rate that an operator can achieve in-home use and no greater than is advertised by the manufacturer or retailer.

Reports that contained all the elements listed above were deemed complete. Reports with two or fewer items flagged as missing were determined to be incomplete-minor. Reports flagged for three or more elements were deemed incomplete – major. If no test report could be found for the appliance, the appliance name was sent to OECA.

3.2.2. Recommendation for Action – 40 CFR § 60.533/60.5475(l)

The elements identified in 40 CFR § 60.533(l)/60.5475(l) were reviewed to identify appliances that should be recommended for revocation procedures. The regulatory language states that a revocation determination "will be based on all available evidence, including but not limited to" the specific elements listed in that section. Note that the RWH NSPS does not require a compliance audit to trigger revocation action. Instead, revocation is based on the documentation submitted to EPA. The following elements are listed in those sections as evidence that EPA should consider when making revocation decisions:

- § 60.533/5475(l)(ii) A finding that the certification test was not valid, based on problems or irregularities with the certification test or its documentation. A flag for this criterion was triggered by anomalies or irregularities in the test results. For example, reporting negative emission rates or reporting theoretically impossible efficiency results would trigger a flag under this criterion.

- § 60.533/5475(l)(iii) A finding that the labeling of the wood heater line, the owner's manual, or the associated marketing information does not comply with the requirements of § 60.536/60.5478, which specify that each affected wood heater offered for sale by a commercial owner must be accompanied by an owner's manual that includes the information listed in that section pertaining to installation and to operation and maintenance. That information "must be adequate to enable consumers to achieve optimal emissions performance" and "consistent with the operating instructions provided by the manufacturer to the approved test laboratory for operating the wood heater during certification testing, except for details of the certification test that would not be relevant to the user." Examples of flags generated under these criteria include reports that list firebox volumes, fuel requirements, or heat outputs that differ from those used in the certification test.

- § 60.533/5475(l)(iv) Failure by the manufacturer to comply with reporting and recordkeeping requirements of § 60.5479. An example of flags generated under this reporting criterion would be (1) failure to conduct testing at a burn rate no lower than the homeowner can achieve during in-home use and no greater than advertised by the manufacturer or retailer, (2) failure to measure or report carbon monoxide, (3) failure to measure or report efficiency, or (4) failure to measure or report 1-hour filter values as required under sections § 60.534 or § 60.476.

- § 60.533/5475(l)(vii) Failure of the approved laboratory to test the wood heater according to the specified methods. Examples of flags generated under this

criterion include failure to follow procedures specified in the test methods, such as conditioning requirements, burn rate criteria, or train precision, and failure to provide required calculations.

3.3. Recommendation for Action – 40 CFR § 60.533(n)/60.5475(n)

40 CFR § 60.533(n) and § 60.5475(n) provide EPA with the authority to conduct audit tests or to direct the manufacturer to have an audit test performed by an approved laboratory selected by EPA at the expense of the manufacturer. Reviews that did not flag revocation elements but instead identified deficiencies potentially affecting appliance performance or indicated the use of procedures allowed by the test methods but raised questions about test appropriateness were recommended to EPA for action under the audit provisions in 40 CFR § 60.533(n) or § 60.5475(n). These elements may not be directly addressed by test methods or rule requirements but could affect in-use emissions performance.

3.4. Recommendation for No Action

Certification test reports that were determined to be complete and that followed the test method and rule requirements obtained "no action" recommendations.

4. REVIEW FINDINGS

The review team assessed certification test reports for 242 out of 255 room and central heaters approved by EPA as Step 2 compliant. Test reports could not be found for 13 devices. The reports were grouped for analysis by appliance type (room heaters or central heaters), and the room heaters were further divided into two subcategories – cordwood and pellet stoves. This section presents the analysis findings.

4.1. Cordwood Stoves

The team identified 131 cordwood stoves for review, but could not find test reports for two of the stoves. Three PM emissions control approaches are typically employed in cordwood stoves: (1) catalytic controls, (2) non-catalytic controls using secondary combustion to reduce emissions, and (3) a combination of secondary combustion and catalytic controls, typically referred to as the hybrid approach. Eighty-five of the appliances reviewed had non-catalytic controls, thirty-one had catalytic controls, and thirteen used a hybrid approach.

Cordwood stove certification tests can be conducted using either of two test methods: (1) M28R, which is conducted on dimensional lumber fuel, or (2) ASTM 3053-17, which uses cordwood fuel. Sixty of the appliances evaluated used M28R for certification testing, and sixty-nine used ASTM 3053-17. The control approach and test method for two appliances could not be assessed because reviewers could not find their certification test reports on the manufacturers' websites.

4.1.1. Complete Test Reports

The RWH NSPS requires manufacturers to submit "[a]ll documentation pertaining to a valid certification test, including the complete test report and, for all test runs: Raw data sheets, laboratory technician notes, calculations, and test results" as part of the application for a certificate of compliance with that standard [40 CFR § 60.533(b)(5)]. Within 30 days of receiving certification, "the manufacturer must make the full non-CBI test report and the summary of the test report available to the public on the manufacturer's Web site" [40 CFR § 60.537(g)].

For cordwood stoves, the reviewers identified 131 devices certified as Step 2 and were able to obtain test reports for 129 of them. The reviewers assessed report completeness by identifying the number of non-reported elements on the summary sheets. The summary sheets listed 36 reporting elements. Report completeness was based on the number of missing elements. Table 3 provides the findings for some of the critical reporting elements. Based on its assessment, each report was assigned to one of the following five categories:

- *Complete:* All non-CBI elements were included in the report.
- *Incomplete-Minor:* One to three elements (less than 10 percent) were missing from the test report.
- *Incomplete-Major:* Four to ten (10 – 30 percent) elements were missing from the test report.
- *Incomplete-Seriously Deficient:* More than ten elements (>30 percent of the test reports) were missing from the test report.
- *Missing:* Test report could not be obtained by searching the manufacturer's website and by conducting additional web searches.

Table 3. Assessment of Report Completeness – Cordwood Stoves

Report Element		Reported	Not Reported
Raw data sheets	Data for all test runs	52	79
	Manu. instructions	65	66
	Firebox data	56	75
	Required photos	93	38
	Fuel loading	102	29
	Fuel characteristics[30]	100	31
	Fuel loading density	102	29
	Fuel moisture	107	24
	Filter data	99	32
Calculations	Firebox	32	99
	Efficiency	114	17
	Train precision	68	63
Lab technician notes		98	33
Appliance settings		73	58
Heat output		128	3
Burn rate categories		122	9
Discussion of unused data		74	57
Conditioning		85	46
Test location		125	6
Third-party certifier		113	18
Third-party report		85	46

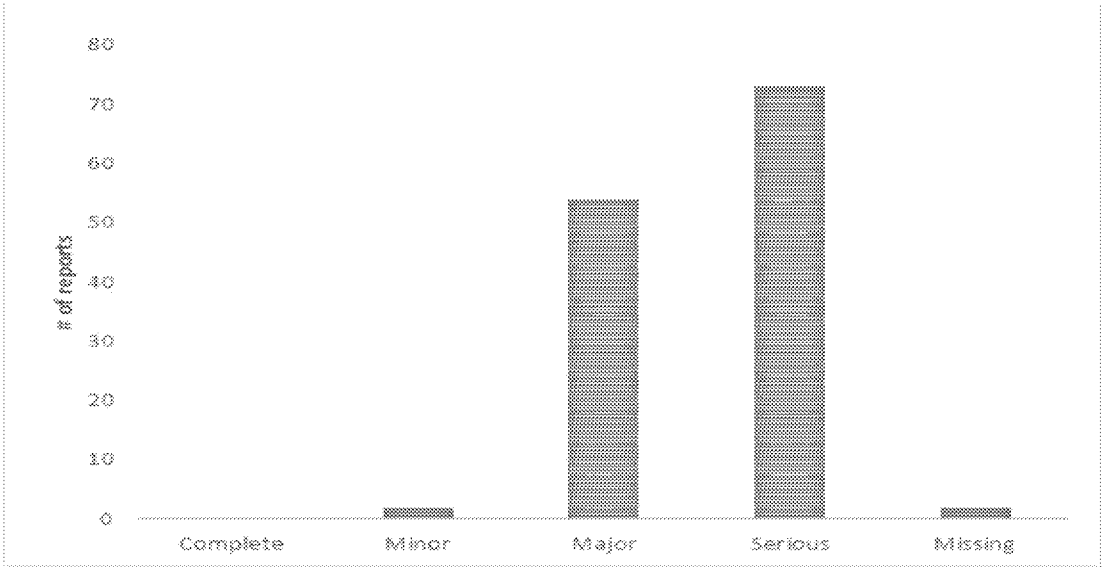
According to the above criteria, none of the 131 identified Step 2 cordwood stoves had complete reports (Figure 6). Two reports had minor deficiencies, 54 reports had major

[30] This element addresses fuel length and for ASTM 3053, the fuel piece characteristics.

deficiencies, and 73 reports had serious deficiencies. Two reports could not be found and were flagged as subject to revocation criteria for lack of public availability.

Of the 129 obtained cordwood stove reports, 13 consisted of only a few pages with little to no information, 21 reports did not include raw datasheets, and 31 reports failed to include laboratory technician notes from the testing.

Figure 6. Cordwood Stove Certification Test Report Completeness



Additional material may have been submitted to EPA OECA as part of the certification application package, but that information was not available to the reviewers. If this additional material was submitted, it illustrates that without access to those elements, states and other parties that rely on EPA's certification process cannot conduct a full review of test results.

We note that during this study, reviewers downloaded different versions of the same test for some appliances, raising concerns about version control and EPA oversight of the data. EPA could resolve this issue by posting the non-CBI reports and all supporting data received as part of certification application packages in a centralized database using its online tools, like the EPA ECHO (Enforcement and Compliance History Online) database. This step would improve access to the complete reports and increase confidence that the reports posted online are the reports EPA reviewed.

4.1.2. Revocation Criteria – Testing Irregularities – Mandatory Reporting Elements

The 2015 RWH NSPS states that a certification can be revoked if EPA finds that the certification test was not valid "based on problems or irregularities with the certification

test or its documentation" [40 CFR § 60.533(l)(ii)]. In this study, evaluating testing irregularities included a review of the handling of negative filter weights, as described in this subsection.

Negative Filter Values

ASTM 2515 uses gravimetric analysis to determine PM measurements. Negative filter weights occur when the filter weight after testing is less than the filter weight measured prior to conducting the test. ASTM 3053-17 does not specify how EPA-approved laboratories should handle negative filter values, either in recovery procedures or in calculations. NESCAUM contacted EPA to determine whether guidance had been provided to EPA-approved laboratories regarding proper procedures for addressing negative values. EPA reported that no guidelines had been requested or provided. Because EPA could not provide guidance on this issue, reviewers turned to test methods from the Oregon Department of Environmental Quality (OR DEQ). ASTM 2515, the PM measurement method, is a derivative of EPA Method 5G, which is itself derived from an OR DEQ measurement method. The original OR DEQ method required acetone rinses of the testing train to ensure all particulate materials had been captured. The OR DEQ method clearly articulates that "[t]he blank corrections for the filter and/or rinse samples are '0', if the blank filter or rinse samples yield negative weight gains."[31]

If negative filter weight values were reported, reviewers assessed whether the EPA-approved labs used acetone rinses or other activities to ensure all particulate matter had been recovered. The summary sheet tracked if test reports included negative filter weights. A separate cell tabulated if the negative values were handled appropriately.

Reports were classified as handling negative values appropriately if they indicated that the tester used procedures like acetone rinses to ensure capture of all materials. Reports that assumed negative values were captured elsewhere without identifying any recovery procedures were deemed "handled inappropriately."

Reviewers found that for the 129 located test reports:

- 25 percent (32) of test reports did not provide filter weight information,
- 45 percent (58) reported negative filter weights, and
- 32 percent (41) reported no negative filter weights.

Of the 58 reports with negative filter weights:

[31] Oregon Department of Environmental Quality, *Source Sampling Manual*, Volume 1, revised November 2018, p. C-8.14.

- 9 reports appeared to use recovery methods to assure all materials were included in the filter measurement data.
- 49 reports appear to assume, without confirmation, that the PM filter mass lost was captured elsewhere.

Reports that had negative values and did not report the use of recovery procedures were flagged for revocation criteria. Given the large number of reports with negative values, the lack of EPA guidance on proper procedures for handling negative values is a significant omission in the RWH NSPS program.

4.1.3. Revocation Criteria – Compliance with § 60.536 Requirements

Another revocation criterion specified in the 2015 RWH NSPS is a finding that "the labeling of the wood heater model line, the owner's manual or the associated marketing material does not comply with the requirements detailed in 40 CFR 60.536" [40 CFR § 60.533(l)(ii)]. 40 CFR § 60.536(g)(1) states that information in the owner's manual and associated material "must be consistent with the operating instructions provided by the manufacturer to the approved test laboratory for operating the wood heater during certification testing, except details that would not be relevant to the user." To assess conformance with these requirements, reviewers compared public information published by the manufacturer with the test report information on appliance parameters (firebox volume, heat output, and efficiency ratings) and the manufacturer instructions to the EPA-approved laboratory. The public information reviewed included owner's manuals, product brochures, and websites because "associated marketing materials" are included in this requirement.

Appliance Parameters – Firebox Volume

Firebox volumes are a foundational metric for conducting certification testing. The firebox volume determines the amount of fuel and the log length used for certification testing. Discrepancies in the firebox volume and its required fuel parameters will influence measured PM emissions during testing. Reviewers compared the firebox volume used for certification testing with the firebox volume in manufacturers' marketing materials, including the owner's manual, websites, and product brochures. Of the 129 cordwood stove test reports reviewed:

- 46 percent (59) reported a different firebox volume in marketing materials than the volume reported in the certification test report. 71 percent (42 of the 59) reported differences greater than five percent;
- 11 percent (14) did not list the firebox dimensions in marketing materials or did not report firebox volume in the test report; and
- 43 percent (56) had firebox volumes that matched.

The reviewers categorized the extent of the deviation in firebox volume for appliances with firebox volumes that did not match. Units with variations less than 5 percent were flagged for audit criteria. Appliances with a deviation greater than 5 percent were flagged under revocation criteria.

Appliance Parameters – Heat Output

Heat output is an important metric because the test methods require testing at maximum heat output. When the maximum heat output reported in the manufacturer's materials is greater than the maximum output reported during testing, the certification test may not be adequate or representative. The comparison of the maximum heat output in the certification test report with that listed in the manufacturer's materials found that:

- 75 percent (96) of the appliances reported higher heat output values in the marketing materials than the output reported in the certification testing report,
- 3 percent (4) did not report maximum heat output ratings in the marketing materials, and
- 22 percent (29) had maximum heat output data in the marketing materials that matched the test report.

Appliances were flagged for revocation criteria if the heat output ratings in the manufacturer's materials deviated by more than 10 percent from the heat output achieved during certification testing.

Appliance Parameters – Efficiency

The comparison of efficiency data reported in marketing materials and in certification test reports found that 28 percent (36) of the appliances had conflicting data, 7 percent (9) did not report efficiency information in their marketing materials, and 65 percent (84) had data that matched. Appliances were flagged for revocation criteria if the efficiency ratings in the marketing materials deviated from the average efficiency ratings given in the test reports.

Manufacturer's Instructions to Testing Laboratories

The 2015 RWH NSPS requires the manufacturer's instructions used for certification testing not contradict the operational instructions found in the owner's manual. Specifically, 40 CFR § 60.536(g)(1) states that the information in the owner's manual "must be consistent with the operating instructions provided by the manufacturer to the approved test laboratory for operating the wood heater during certification testing, except details that would not be relevant to the user."

Reviewers compared the manufacturer's instructions to the EPA-approved testing laboratories and the information in the owner's manual for air setting and fuel loading, which are two parameters identified in § 60.536(g). Of the 129 test reports reviewed, 64 test reports (51 percent) did not contain the manufacturer's instructions to the testing laboratory. Reviews assessed fuel loading procedures and air setting data in the 65 reports that had instructions. Areas not considered contradictory instructions were where manufacturers gave specific instructions, such as fuel placement, piece size, and spacing, to the lab but did not include those directions in the owner's manual. Contradictions were identified as lab instructions clearly deviating from instructions in owner's manuals. Issues such as bypass operation and air settings were identified as contradictions. The review found that 39 percent (25) of the test report instructions contradicted the owner's manual instructions. Significantly more reports would be flagged for this criteria if EPA determined that all directions given to the lab by the manufacturer must be included in the owner's manual as instructions.

Assessing the Impact of Contradictory Instructions

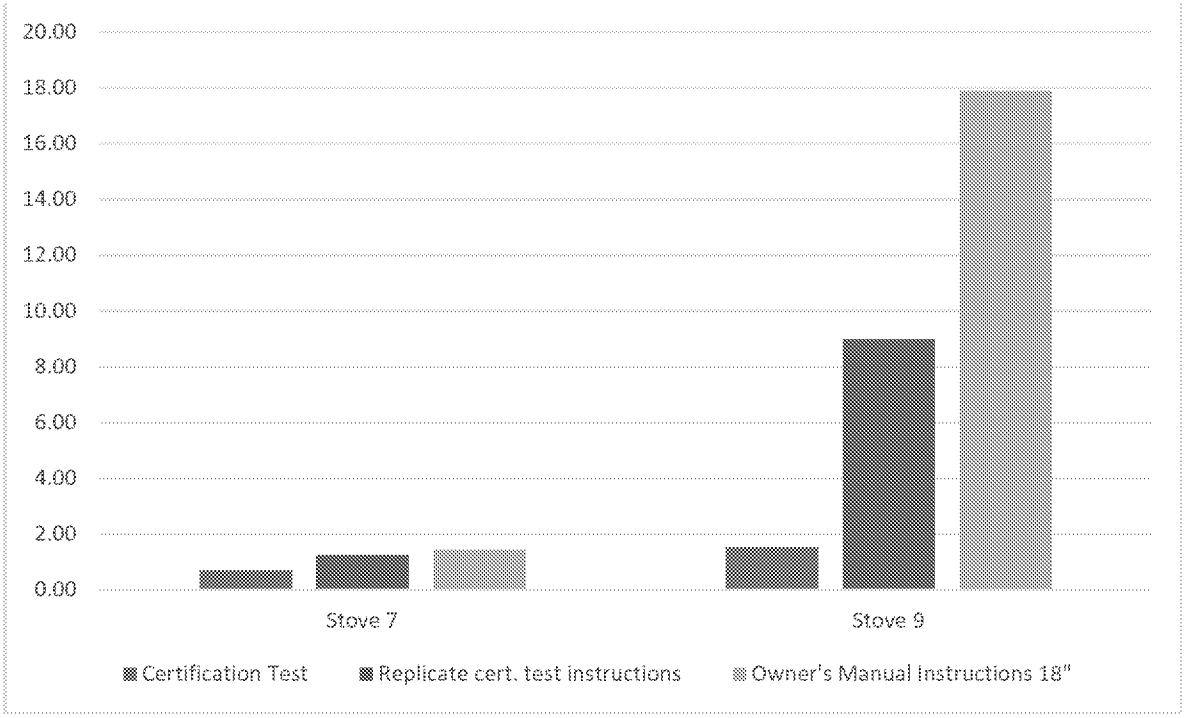
NESCAUM tested two medium-sized Step 2 certified stoves to assess the effect of contradictory manufacturer's instructions on emissions measurements (labelled here as "Stove 7" and "Stove 9"). Each stove was tested in two ways: (1) according to the test method used in the certification test and the instructions provided to the certification laboratory, and (2) using the ASTM3053-17 cordwood test and the instructions in the owner's manual. Stove 7 had hybrid (non-catalytic and catalytic) emissions controls and was certified using M28R as emitting less than 1 gram of PM per hour (g/hr). Stove 9 had non-catalytic emission controls and was certified using ASTM 3053-17 at 1.6 g/hr. Figure 7 shows the difference in fuel loading configuration in the two Stove 9 tests.

Figure 7. Fuel Loading Configuration – Stove 9

For each of the two stoves, the emission rates reported in the certification test report were compared to those measured in the NESCAUM study test that replicated the certification testing instructions and with the test performed using the instructions in the owner's manual. Those comparisons are shown in Figure 8. For Stove 7, the difference between the certification value and the replicate test, both of which were conducted with the M28R procedures, was less than 0.5 g/hr. Testing Stove 7 with the ASTM 3053-17 cordwood test according to the owner's manual instructions increased emissions by 100 percent from the certified value and 13 percent from the study test that replicated the certification testing procedures for that stove.

Stove 9 showed far more variability, although in that stove, ASTM 3053-17 was used for all tests. In Stove 9, the emission rate in the study test that replicated certification procedures was almost 500 percent of that in the certification test, an increase of more than 6 g/hr. The emission rate in the test performed according to the owner's manual instructions was more than 1,000 percent of the certification value, an increase of 16 g/hr. Results from this analysis indicate the need for consistency in operating instructions. It also highlights the need for EPA to conduct compliance audits to identify stoves, like Stove 9, for which certification results cannot be consistently reproduced.

Figure 8. Comparison of Emissions Rates (g/hr) in Tests on Two (2) Step 2 Certified Stoves



4.1.4. Revocation Criteria – Failure to Follow Test Methods

Failure to follow the test methods specified in 40 CFR § 60.534 is a criterion for revocation under 40 CFR § 60.533(l)(vii). Several elements were evaluated to determine whether certification tests were performed according to the specified methods.

Reporting Elements

Reviewers examined the test reports to determine whether they included the PM emissions in the first hour of the test [40 CFR § 60.534(d)], as well as the efficiency, heat output, and carbon monoxide emissions per CSA B415.1-10 [40 CFR § 60.534(e)] as required in the test methods.

One Hour PM Emission Rates

The RWH NSPS requires reporting the first hour of PM emissions for each test run. The test methods for space heaters require emissions data to be reported in grams per hour and grams per kilogram. Reviewers identified four issues associated with the first-hour reporting requirement: (1) failure to report any first-hour data, (2) failure to report first-hour data for some of the test runs, (3) failure to report the first-hour values in grams per hour or grams per kilogram, and (4) negative PM emission rates for first-hour values. Of the 129 test reports reviewed, 17 reports (13 percent) contained the following issues with the first-hour reporting requirement:

- 13 test reports were missing first-hour values for some runs.
- 4 test reports contained filter weights rather than required reporting metrics.
- 1 report contained negative values for first-hour emission rates.

Appliances were flagged for revocation criteria based on any of the above identified issues.

Efficiency

All test reports reviewed contained efficiency information. However, 19 test reports did not contain the underlying calculations to show how the efficiency value was derived.

Heat Output

Only 1 of the 129 test reports did not contain heat output information.

Carbon Monoxide Emissions

Carbon monoxide (CO) reporting issues were flagged in 10 (8 percent) of the 129 reports reviewed. The RWH NSPS requires reporting of CO data for each run. Reviewers flagged test reports that did not report individual run CO data as subject to revocation criteria.

Fueling Parameters

40 CFR § 60.534 requires conducting certification tests according to the specifications in the approved test methods. The reviewers evaluated the test reports to determine how the fueling specifications, calculations, and appliance conditioning conformed with test method requirements.

Fuel Length

Standardizing fuel length is critical in replicating test results for research or audit purposes. M28R contains specific language concerning the length of the fuel that can be used for testing. ASTM 3053-17 does not contain fuel length requirements, so ASTM 3053-17 tests were not reviewed under this criterion. M28R specifies that

ASTM 2780 must be used to guide fueling protocols. Section 9.4.1.6 of ASTM 2780 states that "each test fuel piece ... shall closely approximate 5/6 the dimensions of the firebox length." The method defines firebox length as "the longest horizontal firebox dimension." To determine whether a test complied with this requirement, the review team identified the longest firebox dimension reported, multiplied by 5/6, and subtracted 1 inch. This calculation was then compared to the fuel length used for testing. If the length of the fuel used was less than the calculated value, reviewers determined that the fuel did not meet the requirements of the test method.

Of the 60 reports reviewed that used M28R as their certification test:

- 50 percent (30) did not meet the method requirements for fuel length.
- 35 percent (20) could not be determined because the report did not contain required reporting elements, such as fuel length (10) or firebox dimensions (10).
- 17 percent (10) complied with the method requirements.

This is a required element in the test method, therefore reports that did not conform to this requirement were identified as subject to revocation criteria. Reports that did not contain sufficient information to make this determination were flagged for audit criteria.

Fuel Shape

Fuel shape assessments were only completed for the 69 test reports using ASTM 3053-17, as fuel shape is not relevant for M28R, which uses dimensional lumber. Section 3.2.3 of ASTM 3053-17 defines the acceptable fuel shape as "typically round wood 12 to 24 inches long that has been split into triangular, half-round, quarter-round, wedge-shaped, or trapezoidal segments." Squared wood is not included in that definition. In 2019, EPA reinforced this requirement in several emails sent to EPA-approved testing labs, which are attached as Appendix A.

Of the 69 ASTM 3053-17 reports reviewed:

- 61 percent (42) used squared wood for more than 50 percent of the pieces.
- 25 percent (17) did not provide sufficient data to make a determination about fuel shape.
- 14 percent (10) contained sufficient data to show compliance with fuel shape requirements.

Test reports that did not comply with method requirements were flagged under revocation criteria. Where there was insufficient information for a determination to be made, the report was flagged for audit criteria.

Train Precision

Section 11.7 of ASTM Method 2515 requires the use of two sampling trains, which are the media collection systems used in the testing. The PM results from the sampling trains are used to calculate two indicators of measurement accuracy and precision. The first indicator, train precision, assesses the PM catch measurements between the two trains. ASTM 2515 specifies that train precision cannot exceed 7.5 percent. The second calculation compares the emission factors in grams per kilogram (g/kg) for the two trains and cannot exceed 0.5 g/kg. The RWH NSPS rule requires a certifier to complete all the test method calculations and include those calculations in the test report.

Reviewers found that 43 percent (56) of test reports did not contain train precision calculations. Failure to report these data limits a reviewer's ability to assess the PM measurement quality in the certification testing. Of the 73 reports that did report train precision, 16 percent (12) exceeded the train precision limitations. None of the tests exceeded the g/kg criterion. Reports that did not complete this calculation or exceeded the 7.5 percent precision requirement were flagged for audit criteria.

Conditioning Requirement

Both ASTM 3053-17 and M28R include specific requirements for conditioning ("aging") of the appliance before conducting certification testing. Failure to follow these conditioning requirements calls into question the validity of a certification test. Section 2.1.4 of M28R specifies that the heater must be operated for a minimum of 50 hours using a medium burn rate prior to beginning the test. M28R/ASTM2780 requires reporting of the following elements concerning conditioning:

- Time and weight for all fuel added (ASTM 2780, Section 9.1.4).
- Flue gas temperature at least once per hour during testing (ASTM 2780, Section 9.1.5).
- For catalytic appliances, hourly catalytic combustor exit temperatures (ASTM 2780, Section 9.1.6).

ASTM 3053-17 includes conditioning requirements that are similar to those detailed in M28R. Section 8.1.4 states that the appliance must be run a minimum of 50 hours at the medium combustion air setting using the fuel specified in section 8.4 [of that method] with a moisture content of 18 – 28 percent dry basis. Like M28R, ASTM 3053-17 also requires reporting of specific elements, including:

- Weight and moisture content for all fuel added.
- Flue temperature recorded at least once during each hour of operation.
- For catalytic appliances, recorded hourly catalytic combustor exit temperature.

Both methods also require reporting of additional information to assure that the medium burn rate and fueling parameters are met.

Of the 129 test reports reviewed:

- 34 percent (44) contained no data on conditioning,
- 50 percent (65) did not contain sufficient data to determine compliance with conditioning requirements,
- 12 percent (16) had data that indicated conditioning requirements may not have been met, and
- 4 percent (4) contained sufficient data to confirm compliance with conditioning requirements.

Most of the reports met the requirement for the number of conditioning hours but did not supply data to assess compliance with fueling and burn rate requirements. Appliances that failed to include any conditioning data were flagged for revocation criteria. Appliances with incomplete data were flagged for audit criteria.

4.1.5. Revocation Criteria – Documentation of Low Burn Rate Testing

40 CFR § 60.534(a)(1) states that "the low burn rate category must be no greater than the rate that an operator can achieve in-home use and no greater than advertised by the manufacturer or retailer." Reviewers analyzed air setting data in the test reports to identify low burn rate settings, and found that many test reports do not clearly identify the air settings. Some stoves appear to have been tested as fully completed appliances with multiple air settings, while other tests appear to have been performed on prototype appliances with a fixed air stop setting. The level of detail provided on settings varies significantly from report to report. Some provide specific air setting measurements, some state that the setting was fully opened or fully closed without further details, and others fail to report any air setting data. Some test reports state that the unit was tested at the low load defined by the manufacturer but do not provide data to support that statement.

The paucity of information about this element in the test reports made it difficult to determine if testing was completed in compliance with the rule requirements and if air settings in production units match the air setting configuration used in the prototype during certification testing. None of the test reports contained sufficient information to allow a clear determination of conformance with the requirement. Test report reviews found that:

- 43 percent (55) of test reports provided information that raised questions whether testing at the lowest setting was conducted or failed to provide supporting information to make a determination.

- 21 percent (27) of test reports provided no statements or data to communicate that testing was conducted at the lowest air setting.
- 36 percent (47) of test reports stated that testing was conducted at the lowest air setting but provided no data to support that statement.

Many test reports include an affirmative statement that they tested at the low burn rate. However, they failed to provide detailed information sufficient to assure compliance. Other reports provided information that raised questions, such as measurement information indicating air settings were not closed or not reporting on all settings. Appliances that made an affirmative statement without data were not flagged but reviewers recommend EPA assess these reports for compliance. Appliances with information that raised concerns were flagged as "could not be determined." This flag requires more information for a complete determination. No report raised a revocation flag as not meeting rule requirements.

4.1.6. Audit Criteria – ASTM 3053 Test Reports

Unlike other test methods, ASTM 3053-17 allows manufacturers to supply instructions to EPA-approved laboratories for key elements of the test. The method:

- Allows the manufacturer to define a usable firebox volume without defining criteria for those determinations. In contrast, M28R requires using the actual dimensions of the firebox with allowances to subtract areas not deemed as useable firebox volume. Firebox volume is a critical component in determining the amount of fuel used in certification testing.
- Provides no requirements for fuel length. This allows the manufacturer to modify fuel lengths to achieve appliance performance that may not reflect homeowner operation.
- Allows manufacturers to specify fuel shape and to debark fuel pieces so that they more closely resemble dimensional lumber than cordwood.
- Allows the manufacturer to provide instructions to the EPA-approved testing laboratory that include specifications for fuel dimensions and loading and spacing configurations that more closely resemble crib wood testbeds than the less-structured loading patterns typical in consumer use.
- Lacks parameters to adequately define the medium burn rate.

Some of these elements have been addressed previously in the discussion of revocation criteria. Additional factors that triggered flags for auditing include fuel length, debarked wood, fuel placement, and delineation between medium and low test runs.

Fuel Length

ASTM 3053-17 does not include fuel length requirements. However, EPA's Clean Air Act National Stack Testing Guidance[32] informs certification testing. Section VII(5) of EPA's guidance recommends testing with expected in-use fuel conditions "that would present the greatest challenge in meeting applicable emissions standards." Furthermore, the guidance states:

- In light of the fact that: (a) **the Act requires that facilities continuously comply with emission limits** [emphasis added]; (b) the NSPS, MACT, and NESHAP programs all require that performance tests be conducted under such conditions as the Administrator specifies; and the NSPS and MACT programs further require that such tests be conducted under representative operating conditions; EPA recommends that performance tests be performed under those representative (normal) conditions that:

  - represent the range of combined process and control measure conditions under which the facility expects to operate (regardless of the frequency of the conditions); and
  - are likely to most challenge the emissions control measures of the facility with regard to meeting the applicable emission standards, but without creating an unsafe condition.

40 CFR § 60.536 also requires that marketing materials and specifically the owner's manual contain information that must be adequate to enable consumers to achieve optimal emissions performance. Based on emission testing conducted by NESCAUM, the use of longer fuel lengths does not improve emissions performance. Therefore the recommendations to use wood in certification testing shorter than detailed in the owner's manual appear to contradict this requirement. Of the 69 tests reviewed using ASTM 3053-17, 84 percent (58) used fuel that was shorter than the maximum fuel length recommended by the manufacturer in the owner's manual or other related marketing materials, and only 8 tests used the same length recommended as a maximum.

As a guide, reviewers also analyzed how many appliances complied with the 5/6 fuel length rule contained in M28R. Using the M28R calculation, the reviewers found that 58 percent (40) of the ASTM 3051-17 tests would not meet the M28R fuel length criterion, and 22 percent (15) did not have sufficient data to make a determination. Reports that did not include fuel length data or used wood deemed too short using the M28R calculation were flagged for audit criteria. Only two cordwood stoves were tested

[32] US EPA. *Clean Air Act National Stack Testing Guidance*. US EPA Office of Enforcement and Compliance Assistance (2009).

with fuel that met the 5/6 guideline and was not shorter than recommended by the manufacturer.

Debarked Wood

Of the 69 ASTM 3053-17 tests reviewed, 90 percent (62) used debarked wood or failed to provide information about whether there was bark on the fuel. This indicates that using debarked wood in the tests is a common practice, but it is not representative of most homeowner fuel use. Reports that did not include pictures sufficient to determine fuel characteristics or used debarked fuel were flagged for audit criteria.

Fuel Placement

Reviewers assessed fuel placement by determining the firebox's longest dimension to apply a typical loading pattern for the stove. If the appliance's longest dimension was its width, the appliance was deemed an east/west stove. If the longest dimension was its depth, it was considered to be a north/south stove. Reviewers then assessed the fuel configuration pictures that must be included in the test reports per ASTM 3053-17 sections 8.5.9.3 and 8.6.9.1. Of the 69 ASTM 3053-17 tests reviewed:

- 51 percent (35) did not load fuel in the configuration typical of homeowner use (e.g., an east/west stove that was fueled north/south or crisscross),
- 6 percent (4) used the expected homeowner configuration, and
- 43 percent (30) did not provide data on fuel placement and did not provide pictures sufficient to determine loading direction.

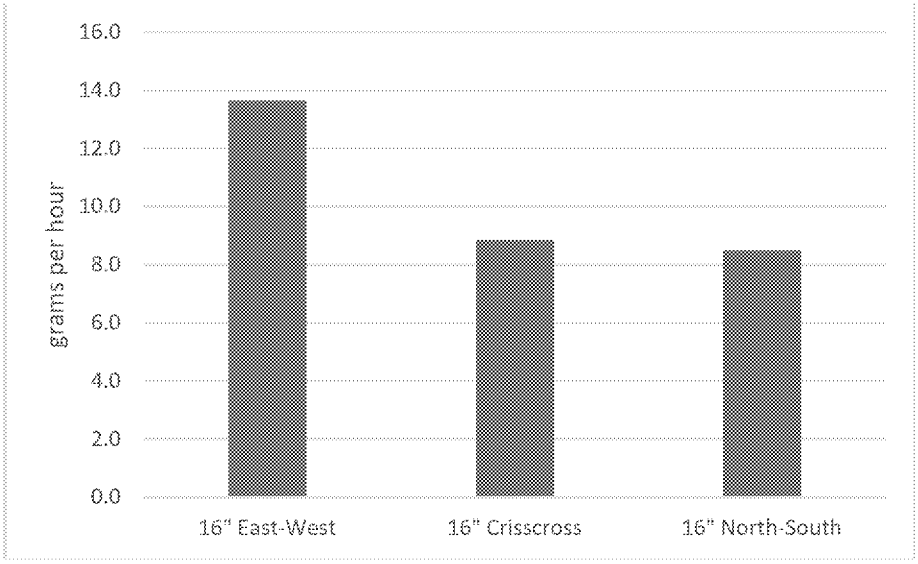
Reports that did not include pictures sufficient to determine fuel loading patterns or used patterns that were not deemed appropriate were flagged for audit criteria.

As part of NESCAUM's test method research, emission testing was completed on a medium-sized, non-catalytic, east/west stove. Testing evaluated the emission impact of the three different fuel configurations found in certification test reports, as shown in Figure 9. For an east/west stove, an east/west fuel configuration would be most representative of in-home use.

Figure 9. Three Common Fuel Loading Configurations for Cordwood Stoves

As shown in Figure 10, using the less representative north/south and crisscross configurations in the east/west stove resulted in lower emissions.

Figure 10. Emission Impact of Fuel Piece Configuration

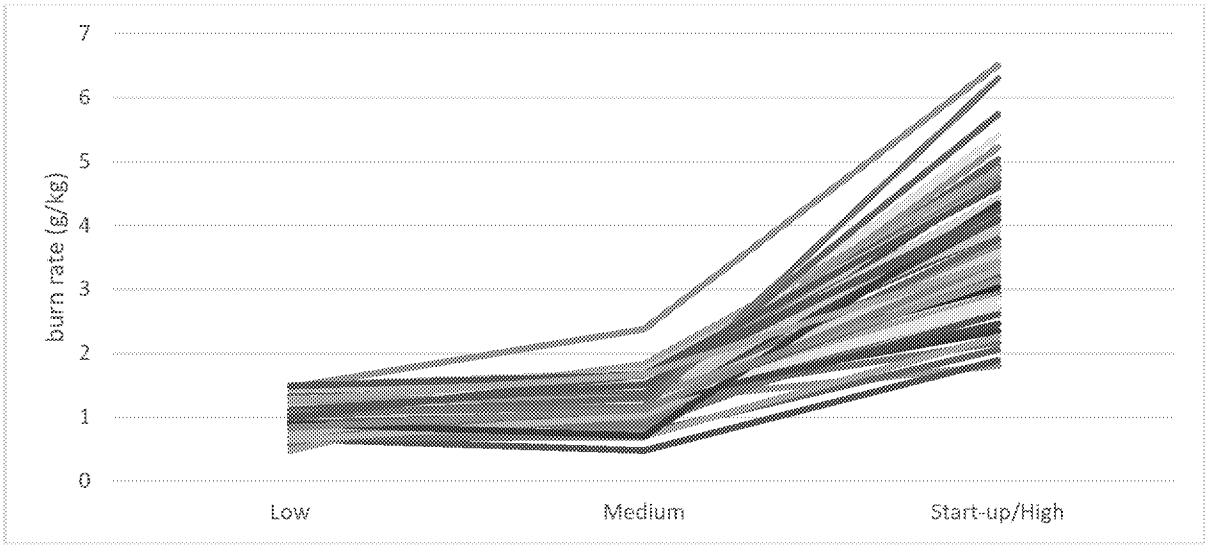


Delineation Between Low and Medium Runs

ASTM 3053-17 does not include specifications for medium burn rate runs. Instead, it only requires that the appliance be tested at an air setting higher than the one used for the low setting. This is important because the medium and low test runs represent 80 percent of the weighting in calculating the certification value. Because the emission standard metric is in terms of emissions over time (g/hr), practices that extend burn times reduce the emission rate measured in the certification test when recognizing the largest amount of PM emissions occur at the start of the test. Analysis of the 69 ASTM 3053-17 tests found that almost two-thirds (46) of the medium air setting's burn rates were within 0.3 kg/hr of the burn rate for the low burn. This gap is 50 percent less than the typical

range EPA provides within M28R for a single burn rate. For example, the range of allowable burn rates in Method 28R for Category 2 is 0.80 to 1.24 kg/hr. Figure 11 shows the burn rates for the low, medium, and high burns in all the ASTM 3053-17 tests. Clearly, the burn rates in the medium burn runs are skewed closer to the low burn rates and are not representative of mid-point testing. In several instances, the medium-fire phase's burn rate was lower than that in the low-fire phase. In some cases, test reports used the same setting, fully closed, for both the low and medium burn, in violation of test method requirements.

Figure 11. ASTM 3053-17 Comparison of Low, Medium, & High Burn Rates



Other Issues Identified with ASTM 3053

In addition to the issues listed above, reviewers identified other irregularities in ASTM 3053-17 test reports, including:

- Review of testing times indicates that ASTM 3053-17 test runs are significantly longer than M28R on similar stoves. Fuel species, fuel loading volumes, and fuel placement parameters can extend testing times, leading to test runs that last two to three times longer than similar M28R runs. NESCAUM research found that 30-50 percent of the testing time was spent burning the last 10 percent of the fuel load, known as the charcoal tail. During this time, no PM emissions occurred. Larger fuel loads further extend the time of the charcoal tail. Extending the burn-times, along with the less stringent emission standard for cordwood testing in the RWH NSPS, may allow manufacturers to meet the emission standard, in g/hr, without optimizing the design of their appliances.
- Reviewers noted that the stoves' average temperature was significantly higher in the low and medium runs of the ASTM 3053-17 tests than in similar appliances

tested using M28R procedures.

- Reviewers noted that some tests reported different species for different burns. Specifically, fuels with lower densities were used for the start-up/high runs, and higher density fuels were used for low and medium runs. Some reports also reported that the test "mainly used X species," indicating that multiple species were used but not reported. Of the 69 appliances that tested with ASTM 3053-17, 13 percent used a mixture of fuel species, and 6 percent failed to report which fuel species was used in testing
- The method states that the emission rate from only one start-up/high fire run is used in the calculation of the certification value, although a start-up/high fire burn precedes both the low and medium burns. Some test reports used the start-up/high fire emission testing from the first day of testing, some used the second day, some averaged emissions of multiple start-up/high fire runs, while others measured emissions on an additional day of testing. Some test reports reported emission measurements for all runs, some claimed to have only obtained measurements for one of the start-up high fire runs, but report data suggested additional data might have been gathered.

Cumulative Analysis of ASTM 3053-17 Deficiencies

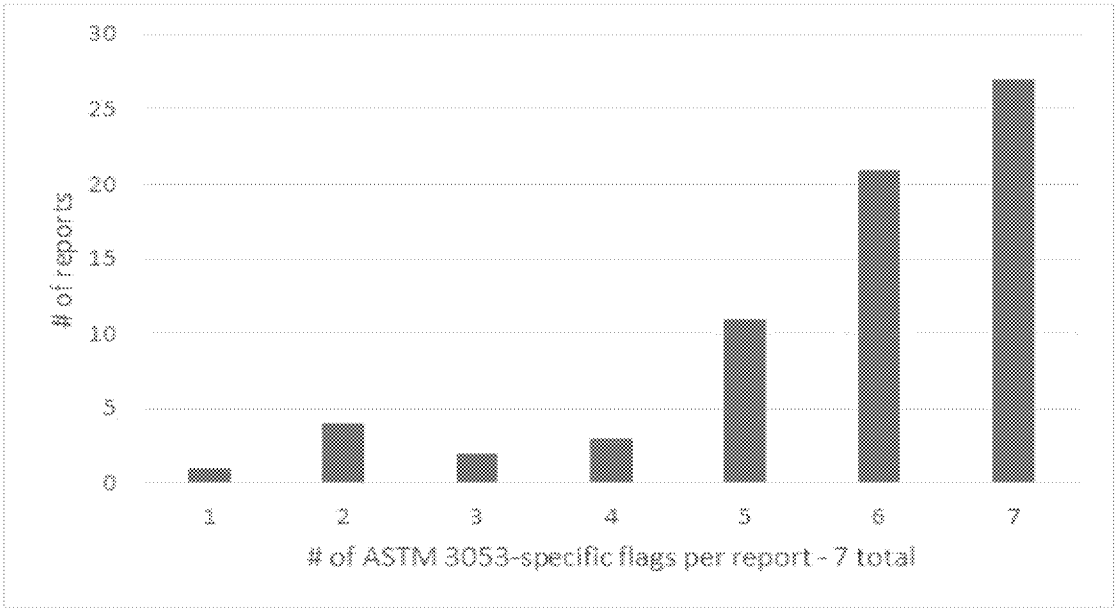
As discussed above, reviewers noted that ASTM 3053-17 tests often included several operational and fueling deficiencies. To assess the cumulative impact of the lack of specificity in the ASTM 3053-17 procedures, reports were reviewed to identify the following seven deficiencies:

1. Wood used was shorter than 5/6 of the longest dimension.
2. Certification testing used shorter wood than the maximum recommended by the manufacturer in the owner's manual or marketing materials.
3. Fuel placement was atypical.
4. Firebox dimensions listed in the test report did not match manufacturer materials.
5. Medium burn rates were within 0.3 kg/hr of low burn rates.
6. Fuel was squared.
7. Fuel was debarked.

As highlighted in Figure 12, all of the ASTM 3053-17 tests had at least one deficiency, and one-third had all seven. Of the 69 ASTM 3053-17 test reports reviewed:

- 96 percent (64) had three or more deficiencies
- 87 percent (59) had five or more deficiencies

Figure 12. Number of ASTM 3053 Deficiencies per Test Report



The incorporation of multiple factors that tend to reduce emissions and that are atypical of in-use stove operation raises questions about the efficacy of the ASTM 3053-17 protocol in assuring compliance with NSPS standards.

We note that beginning in June 2019, US EPA's OAQPS Measurement Technology Group (OAQPS-MTG)[33] sent several emails to ISO-accredited and EPA-approved labs and third-party certifiers raising many of these ASTM 3053 testing issues (*see* Appendix A). In the initial email sent June 13, 2019, OAQPS-MTG stated that it had reviewed certification test reports and identified "discrepancies and concerns" related to testing. These issues included:

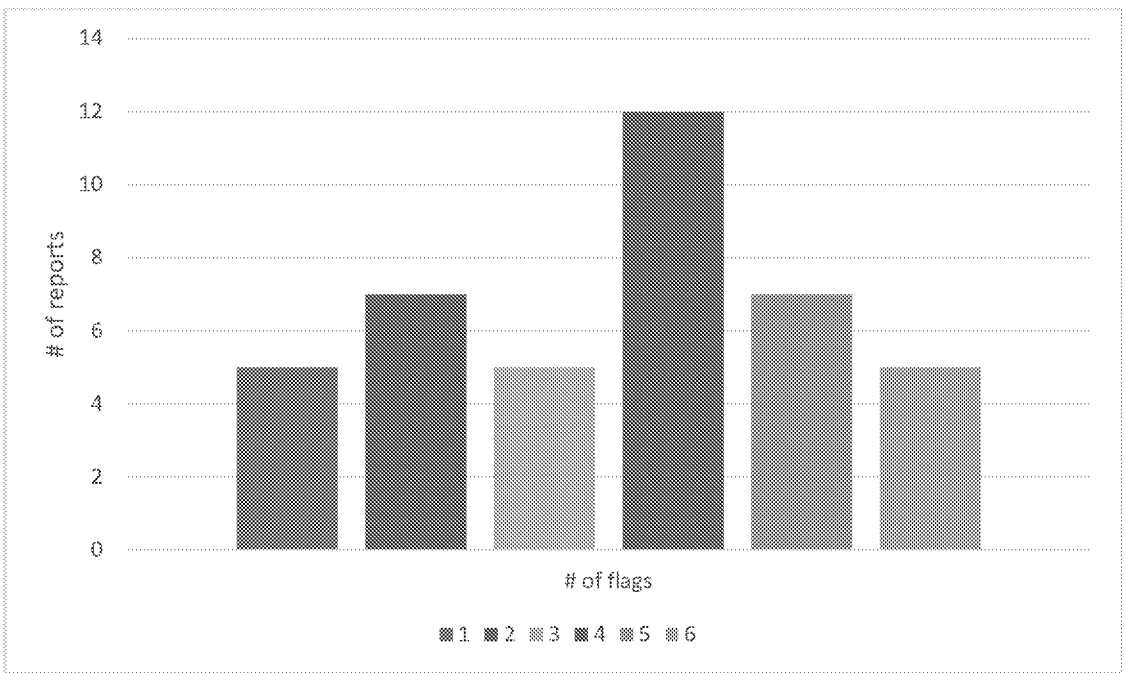
- Lack of reporting on the fuel species used for testing.
- Removing bark from fuel pieces prior to testing.
- Shaping or extreme sorting to constitute preference for a particular shape of fuel or fuel load.
- Loading and lighting of fuel inconsistent with instructions in the appliance owner's manual.
- Using complicated fuel placement instructions that did not reflect homeowner use.
- Manipulating the ash bed.

[33] OAQPS-MTG leads emissions testing requirements. However, a different EPA office handles report certifications. Certification of appliances is the responsibility of EPA's Office of Compliance housed within OECA.

- Failing to meet method-required fuel loading specifications by including shortened fuel pieces, partial loading, or not using the full firebox area to calculate fuel loading.
- Limiting fuel loading during compliance testing.
- Using instructions that expressly override specified sections of the test method or the subpart rule language (inside or outside of the test method requirements).

OAQPS-MTG indicated that manufacturers would need to revise and resubmit corrected compliance test reports where these issues exist. To assess responses, the reviewers for this study looked for updated and revised test reports after the EPA emails were sent, but were unable to locate any. Adding to the difficulty of trying to review subsequently modified test reports is that the EPA OECA Office of Compliance has not issued guidance to require revision tracking of certification reports. Reviewers did identify 40 test reports that the OECA Office of Compliance certified after the OAQPS-MTG June 2019 email, and evaluated those to see if they conformed to the identified issues. Reviewers assessed eight elements, which were all the items in the above bulleted list except the ash bed element, as this proved challenging to review. As shown in Figure 13, all of the 40 reports certified after the 2019 June email contained at least one of the problematic activities that OAQPS-MTG had identified as raising concerns. The number of issues flagged ranged from 1 to 6, with each report having 3.5 flags on average.

Figure 13. Certification Reports that Continued to Include Questionable Activities after June 2019 EPA OAQPS-MTG Email (40 total reports)



4.1.7. Summary of Cordwood Stove Certification Test Reports

Of the 129 test reports reviewed, all contained flags for revocation and audits. On average, each certification test report contained nine missing elements, nine revocation flags, and seven audit flags (Table 4). The findings indicate that issues with cordwood stove certification testing and test reports are widespread and not identified by either ISO third-party reviewers or by EPA OECA.

Table 4. Summary of Cordwood Stove Test Report Reviews Deficiencies

	Missing Report Elements (36 total)	Revocation Criteria Flags (17 total)	Audit Criteria Flags (20 total)
Low	2	3	2
Average	11	8	8
High	24	12	15

4.2. Pellet Stoves

Reviewers identified 96 pellet stoves to review as part of this research. Unlike cordwood stoves, pellet stove emissions are reduced by optimizing combustion of the fuel rather than secondary controls like catalytic or secondary combustion approaches. ASTM 2779 is the only pellet stove test method approved for use under the RWH NSPS. ASTM 2779 is a single test run that allows the appliance to start-up and operate for one hour before starting emission testing. Once emission testing begins, the pellet stove must spend one hour at the maximum setting, two hours at a medium setting, and three hours at the lowest burn rate.

4.2.1. Complete Test Reports

The RWH NSPS requires manufacturers to submit "[a]ll documentation pertaining to a valid certification test, including the complete test report and, for all test runs: Raw data sheets, laboratory technician notes, calculations, and test results" as part of the application for a certificate of compliance with that standard [40 CFR § 60.533(b)(5)]. Within 30 days of receiving certification, "the manufacturer must make the full non-CBI test report and the summary of the test report available to the public on the manufacturer's Web site" [40 CFR § 60.537(g)].

The reviewers assessed report completeness by determining whether the review criteria listed in Table 5 were included in the publicly available test reports. Based on that assessment, each report was assigned to one of the following five categories:

- *Complete:* All non-CBI elements were included in the report.
- *Incomplete-Minor:* One to three elements were missing from the test report.

- *Incomplete-Major:* Four to ten elements were missing from the test report.
- *Incomplete-Seriously Deficient:* More than ten elements were missing from the test report.
- *Missing:* Test report could not be found by searching the manufacturer's website and by conducting additional searches.

None of the publicly available pellet stove certification test reports reviewed were complete. The level of report completeness varied significantly. Of the 96 Step 2 pellet stove certifications identified, 10 percent (10) did not have a publicly available test report, and 15 percent (13) contained less than 20 pages with a deficient amount of data. Table 5 highlights findings from the report completeness review.

Table 5. Assessment of Pellet Stove Report Completeness

Report Element		Reported	Not Reported
Raw data sheets	Data for all test runs	41	55
	Manu. instructions	67	29
	Appliance setting	77	19
	Fuel characteristics[34]	50	46
	Filter data	61	35
Calculations	Efficiency	67	29
	Burn rate	66	30
	Train precision	39	57
Lab technician notes		66	30
Average heat output		80	16
Heat output range		80	16
Discussion of appropriateness & validity		39	57
Discussion of anomalies		41	55
Discussion of unused data		41	55
Conditioning		52	44
Test location		43	53
Third-party certifier		26	70
30-day notice to EPA		15	81
60-day report to EPA		35	61

More than half of the 86 available test reports did not include the following required elements:

- Sufficient documentation on appliance conditioning to determine compliance with the test method.

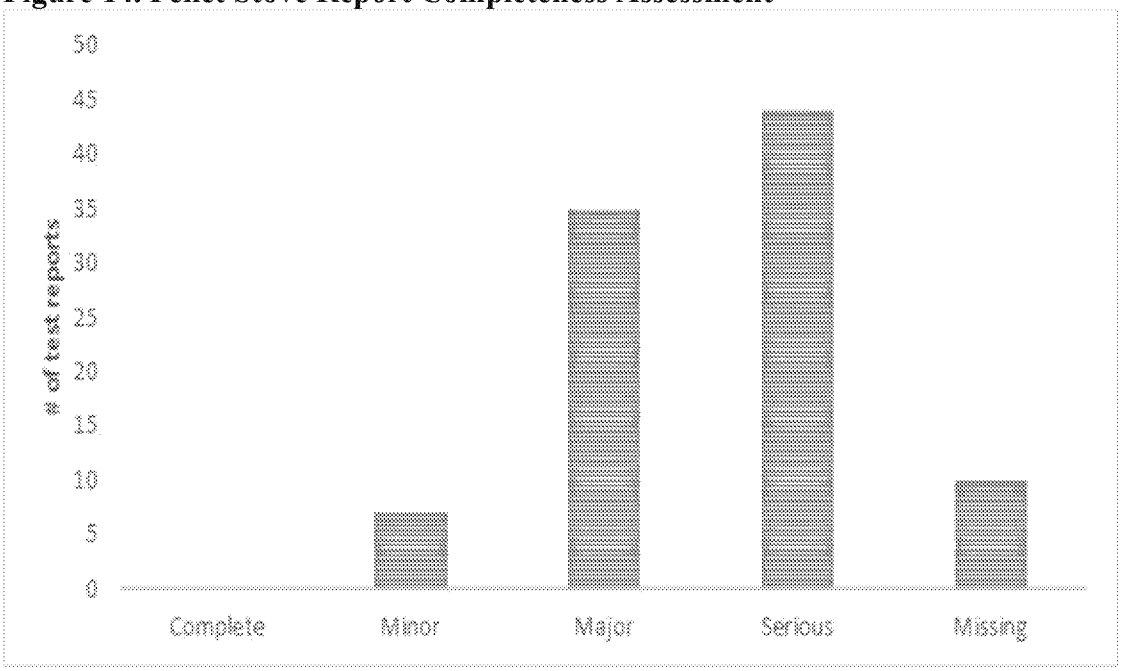
[34] This element addresses fuel length and for ASTM 3053 fuel piece characteristics.

- Identification of the company that provided a third-party review of the report and the report from the third-party certifier.
- Complete information on appliance settings for the test.
- Dual-train precision information.
- Pellet analysis.
- Testing location.

Approximately one-quarter of the test reports did not include raw data sheets, technician notes, filter data, burn rate, or the manufacturer's instructions to the lab.

The overall completeness findings, based on publicly available reports, are presented in Figure 14. The review found 10 test appliances with missing reports, 7 appliance reports with minor deficiencies, 35 reports with major deficiencies, and 44 reports with serious deficiencies. Appliances without publicly posted test reports were flagged as subject to revocation criteria.

Figure 14. Pellet Stove Report Completeness Assessment



The review of pellet stove certification test reports found many of the same issues identified with the cordwood stove reports. Some of the omitted elements from the publicly available test reports may have been included in the certification applications submitted to OECA. However, without access to those elements, states and other parties that rely on EPA's certification process cannot conduct a full review of test results.

4.2.2. Revocation Criteria – Testing Irregularities

This section details testing irregularities identified during the report review process. Testing irregularities is a criterion for revocation under 40 CFR § 60.533(l)(ii).

Negative Filter Values

Only 61 of the 86 publicly available reports contained data on filter weights. Of the 61 reports with filter data, 46 percent (28) reported negative filter weights, a percentage similar to the cordwood stoves. As discussed in more detail in Section 4.1.2, ASTM 2515 requires that the filters be weighed before and after testing. Negative filter weights are recorded when the filters weigh less after the test than before the test. Of the 28 test reports with negative filter weights, four indicated the use of recovery methods to ensure all particulate mass was captured for measurement purposes. As noted with the cordwood stoves, EPA has not developed guidance on proper procedures for handling negative filter values despite the high number appearing in test reports. Certification test reports with this flag were listed under revocation criteria.

4.2.3. Revocation Criteria – Compliance with § 60.536 Requirements

Another revocation criterion specified in the 2015 RWH NSPS is a finding that "the labeling of the wood heater model line, the owner's manual or the associated marketing material does not comply with the requirements detailed in 40 CFR 60.536" [40 CFR § 60.533(l)(ii)]. 40 CFR § 60.536(g)(1) states that information in the owner's manual and associated material "must be consistent with the operating instructions provided by the manufacturer to the approved test laboratory for operating the wood heater during certification testing, except details that would not be relevant to the user." To assess conformance with these requirements, reviewers compared the appliance's heat output and efficiency ratings specified in the test report with the manufacturer's information. The public information reviewed included owner's manuals, product brochures, and websites because "associated marketing materials" are included in this requirement.

Appliance Parameters – Heat Output

Heat output is an important metric because the pellet stove test method specifies that the test's high heat segment must be conducted at the maximum heat output the appliance can achieve. Reviewers compared the heat output recorded in the high-fire portion of the ASTM 2779 test with the heat output data found in the manufacturer's materials. (This is not the same as the average heat report element of Table 5.) If the heat output in the manufacturer's materials was ten percent more than the maximum output reported during the high-fire phase of the test, a revocation flag was generated. A flag for this item raises questions about the certification test's adequacy and representativeness.

The comparison of the maximum heat output in the certification test reports with that listed in the manufacturers' materials found that:

- 73 percent (63) of the appliances reported higher heat output values in their marketing materials than achieved during certification testing.
- 9 percent (8) did not report maximum heat output ratings in their marketing materials.
- 17 percent (15) had maximum heat output data that matched their test reports.

The results of this metric were similar to the findings from cordwood stoves.

Appliance Parameters – Efficiency

Reviewers compared the efficiency reported in 86 certification test reports with the efficiency data obtained from the manufacturers' marketing materials. The review found:

- 37 percent (32) of the appliances had conflicting data.
- 34 percent (29) did not report efficiency information in their marketing materials.
- 29 percent (25) had data that matched.

Appliances were flagged for revocation criteria if the manufacturer's materials' efficiency ratings deviated from the average efficiency ratings reported in the test report.

4.2.4. Revocation Criteria – Failure to Follow Test Methods

Failure to follow the test methods specified in 40 CFR § 60.534 is a criterion for revocation under 40 CFR § 60.533(l)(vii). Several elements were evaluated to determine whether certification tests were performed according to the specified methods, as discussed below.

Required Reporting Elements

Reviewers examined the test reports to determine whether they included PM emissions measured in the first hour of the test [40 CFR § 60.534(d)], as well as the efficiency, heat output, and carbon monoxide emissions per CSA B415.1-10 [40 CFR § 60.534(e)] as required in the test methods.

1-hr PM Emission Rates

Of the 86 test report reports reviewed, 15 percent (12) did not fully report first-hour PM emissions. In six of those reports, no first-hour PM emissions were reported. In the other six test reports, additional test runs were completed that were missing the first-hour emissions parameter. Appliances that did not measure or report first-hour PM data were

flagged as subject to revocation criteria. Unlike the cordwood stove reports, no pellet stove reports included negative first-hour PM measurements or only filter weights.

Carbon Monoxide (CO) Emission Rates

Of the 86 reports reviewed, 9 percent (8) did not report CO measurements. Of the 78 reports that included CO emissions data, 17 percent (13) stated the CO emissions were zero for the entire test or a portion of the test run. Given the nature of combustion, zero CO emissions are unlikely, and the reports of zero CO raised concerns about measurement accuracy for this pollutant. Appliances that did not measure or report CO emissions or reported a zero-emission rate were flagged as subject to revocation criteria.

Efficiency

All reports contained efficiency data. This reporting element had 100 percent compliance. However, 19 reports failed to provide the underlying calculations to support the reported data.

Average Heat Output and Heat Output Range

Of the 86 reports, 5 did not include average heat output. Six reports did not contain the range of heat outputs. However, all the reports contained either average heat output or the range of heat outputs.

Data from Additional Test Runs

40 CFR § 60.533(b)(5) states that test reports must include any data not used in the calculations and, for any test run not completed, the data collected during the test run and the reason(s) why the test run was not completed. Of the 86 reports, 16 percent (14) reported completing additional test runs. For the 14 tests that completed additional runs, 43 percent (6) had partial data from those test runs but not complete data, and 57 percent (8) did not include any data from the extra test runs. The reviewers flagged under the revocation criteria all certification test reports that did not include complete data from the additional test runs.

Medium Burn Rates

ASTM 2779 section 9.4.1.2 requires that the medium burn rate cannot exceed 50 percent of the high burn rate. Reviewers found that:

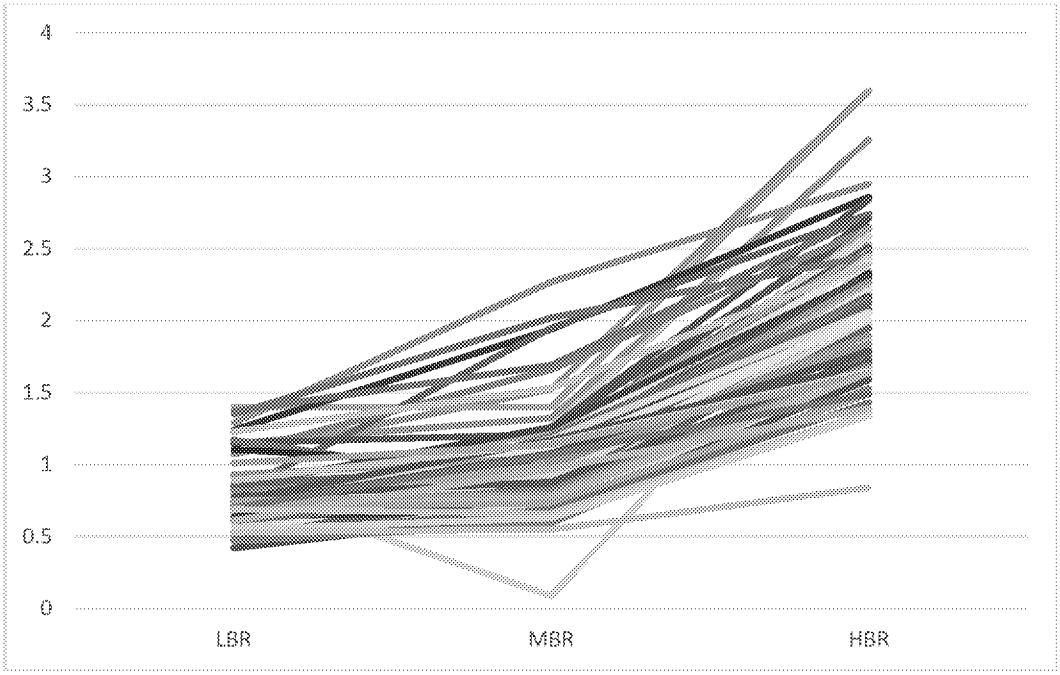
- 29.5 percent (26) appliances did not meet this test method requirement.
- 67 percent (57) appliances met the medium burn rate requirement.
- 3.5 percent (3) appliances did not provide data needed to determine compliance.

Appliances that did not meet the medium burn rate requirement were flagged for revocation criteria unless an ATM had been approved by EPA, which was the case for

one appliance.

Figure 15 provides an overview of the burn rates for pellet stoves. This figure shows a more linear relationship between low, medium, and high burn rates than those observed for cordwood stoves using ASTM 3053-17.

Figure 15. Low, Medium, High Burn Rates for Step 2 Pellet Stoves



Certification Test Report Review: Conditioning

Section 9.1 of ASTM 2779 requires conditioning of appliances prior to conducting certification testing by operating the appliance for 48 hours at a medium burn rate. Reviewers found in the 86 test reports that:

- 5 percent (4) completed and reported conditioning correctly.
- 41 percent (35) failed to report any conditioning data.
- 43 percent (37) provided data that was insufficient to determine if test method requirements were met.
- 12 percent (10) provided data that indicated conditioning did not meet test method requirements.

Of the 10 reports that contained conditioning data not meeting test method requirements, 5 did not show conformance with medium burn rate requirements and 5 indicated only 10 hours of conditioning occurred. Another 12 reports contained data in the report summary indicating only 10 hours of conditioning had been completed. However,

conditioning data was not supplied to confirm those statements. Appliances that did not report or comply with conditioning requirements were flagged for revocation criteria.

While the test method for cordwood stove provides a provision for manufacturers to conduct conditioning, ASTM 2779 provides no such provision, nor could reviewers identify a provision allowing manufacturers to condition pellet stoves before conducting certification testing. Of the 86 reports reviewed, 33 reports stated that the lab completed the conditioning, 17 noted the manufacturer conducted the conditioning, and 36 provided no information on where the appliances were conditioned. Labs are required to report all data obtained from the appliance, so the lack of conditioning data or reporting of who conducted the conditioning suggests that it was done by the manufacturer. Reviewers noted that of the 17 appliances where the manufacturer conducted the conditioning, 7 were completed after the lab indicated it received the appliance.

Multi-Fuel Units

Section 9.4.9 of ASTM 2779 states, "[w]hen alternative fuels are recommended by the manufacturer for use in the pellet heater in the manufacturer's written instructions, conduct a full integrated test run for each of the recommended alternative fuels[.]" Reviewers found that approximately 20 percent of the pellet stoves allow or advertise the use of their appliance with fuels other than wood, such as corn, cherry pits, wheat, rye, and distillers grain. However, certification test reports do not contain testing for those alternative fuels. This deficiency raises concerns about appliance performance when alternative fuels are combusted. Multi-fuel units that did not conduct testing with all the fuels specified in the owner's manual or associated marketing materials were flagged under revocation criteria.

Fueling Parameters

Section 9.3 of ASTM 2779 details requirements for the fuel used in testing. This section includes requirements for analysis of the pellets. According to the test method, all test reports must include the results of an analysis of the higher heating value (HHV) and moisture content of the fuel using specified methods. Units that determine heat output and efficiency using the procedures in section 9.5.1 and Annex 1 of that method must also include ash and ultimate analysis (carbon, hydrogen, nitrogen, and oxygen content) using specified methods. Of the 86 reports reviewed, 49 percent (42) did not include these data. Reviewers also noted that 42 percent (36) did not report the brand or fuel type (softwood, hardwood, mix) of pellet used. Units that did not report the type of pellets used or include analysis of the pellets used in testing were flagged under revocation criteria.

Train Precision

Section 11.7 of ASTM Method 2515 requires the EPA-approved lab to complete two calculations to determine if the precision of the two trains used for PM measurement is sufficient: (1) dual-train precision, which is a comparison of the PM catch in the two trains, cannot exceed 7.5 percent, and (2) the difference in the g/kg measurements for each train cannot exceed 0.5 g/kg. The RWH NSPS requires test reports to include all calculations required by the test method. Additional information on this topic can be found in Section 4.1.4.

The review of pellet stove certification test reports found that 55 percent (47) of the test reports did not include train precision calculations. Failure to report these data limits the reviewer's ability to assess the PM measurement quality. Of the 39 reports that contained train precision information, 15 percent (6) had values that exceeded 7.5 percent. None of the reports violated the g/kg requirement. Units that did not report this calculation or exceeded the 7.5 percent precision requirement were flagged under audit criteria.

4.2.5. Revocation Criteria – Low Burn Rate Testing

40 CFR § 60.534(a)(1) states "the low burn rate category must be no greater than the rate that an operator can achieve in-home use and no greater than advertised by the manufacturer or retailer." Reviewers identified reports where the data indicated the lowest air setting had not been used for the low-fire phase. Many other test reports failed to include data for all air control settings. In these instances, reviewers indicated that compliance with the requirement could not be determined. Reviewers found that:

- 14 percent (12) did not meet the low burn rate requirement.
- 3 percent (3) met the low burn rate requirement.
- 81 percent (70) did not have enough information to determine if the requirement was met.

Test reports where data indicated that testing did not occur at the lowest possible setting or where insufficient data existed to make a determination were flagged under revocation criteria.

4.2.6. Summary of Pellet Stove Certification Test Reports

Of the 86 test reports reviewed, all had at least one element that triggered revocation criteria. As shown in Table 6, on average, each report contained seven revocation criteria flags and five audit criteria flags, and had eleven missing elements. The findings indicate that issues with pellet stove certification testing and test reports are widespread and not identified by either ISO third-party reviewers or by EPA OECA.

Table 6. Summary of Pellet Stove Test Report Reviews Deficiencies

	Missing Report Elements (33 total)	Revocation Criteria Flags (15 total)	Audit Criteria Flags (15 total)
Low	2	3	1
Average	11	7	5
High	29	14	11

4.3. Central Heaters

Wood-fired residential central heating appliances are regulated under Subpart QQQQ of the Part 60 NSPS regulations. While regulated under a different subpart, the requirements for wood-fired central heaters are similar to those used for room heaters. Like room heaters, central heating appliances must be tested using valid certification test procedures, as defined in 40 CFR § 60.5473. That subpart includes the following certification test requirements:

- The Administrator must be notified about the test in accordance with the specifications in 40 CFR § 60.5476(h).
- The test must be conducted by an EPA-approved test laboratory.
- The test must be conducted on a central heater similar to the production model in all material respects that would affect emissions.
- The test must be conducted in accordance with the test methods and procedures specified in 40 CFR § 60.5476.

The team assessed 28 central heaters; 15 cordwood hydronic heaters, 8 pellet boilers, 1 chip boiler, and 3 cordwood furnaces. Certification tests of 9 of the cordwood hydronic heaters, 6 of the pellet boilers, and the chip boiler used ASTM 2618 procedures. Five hydronic heaters were tested according to the EPA M28WHH PTS method. Certification testing of 3 furnaces and 2 pellet boilers used alternative test methods (ATMs). A report could not be found for one cordwood hydronic heater.

4.3.1. Test Report Completeness

Test reports for central heaters were harder to locate on the manufacturers' websites than the stove reports. For 50 percent of the appliances, locating the test reports required contacting EPA. Some manufacturers posted reports at URLs that could not be found by navigating their website or using search engines. This raises questions about the need for a more specific definition of "publicly available."

Reviewers used the list of requirements in the rule as given below to assess the completeness of the posted test reports.

- 40 CFR § 60.5476 discusses general requirements for certification. It states that the manufacturer must "submit a summary and a full test report with all supporting information, including detailed discussion of all anomalies, whether the burn rate categories were properly achieved, and any data not used in the calculations and, for any test runs not completed, the data collected and the reason that the test run was not completed."
- 40 CFR § 60.5475(b)(5) details specific requirements for certification application packages, "including the complete test report and, for all test runs: Raw data sheets, laboratory technician notes, calculations and test results. Documentation must include the items specified in the applicable test methods. Documentation must include discussion of each test run and its appropriateness and validity, and must include detailed discussion of all anomalies, whether all burn rate categories were achieved, any data not used in the calculations and, for any test runs not completed, the data collected during the test run and the reason(s) that the test run was not completed. The documentation must show that the burn rate for the low burn rate category is no greater than the rate that an operator can achieve in home use and no greater than is advertised by the manufacturer or retailer. The test report must include a summary table that clearly presents the individual and overall emission rates, efficiencies and heat outputs."
- 40 CFR § 60.5475(b)(5) specifies that all emission data, including all information necessary to determine emission rates in the format of the standard, cannot be claimed as CBI.
- 40 CFR § 60.5475(b)(12) requires manufacturers to place a copy of the complete certification test report and summary on the manufacturer's website that is available to the public within 30 days of issuing a certificate of compliance.

The RWH NSPS does not specify all the complete test report elements and the summary that must be publicly posted. However, states and other parties that rely on EPA's certification process must have access to all underlying data to conduct a full review of test results.

The level of completeness in the reports varied considerably. None of the certification test reports were complete, and one appliance did not comply with the public posting requirement. Of the 27 reports reviewed, 48 percent (13) were less than 20 pages in length with a deficient amount of data. However, even test reports that had greater information were missing key elements. Table 7 highlights the findings of the completeness determination, and includes the one device with a missing report.

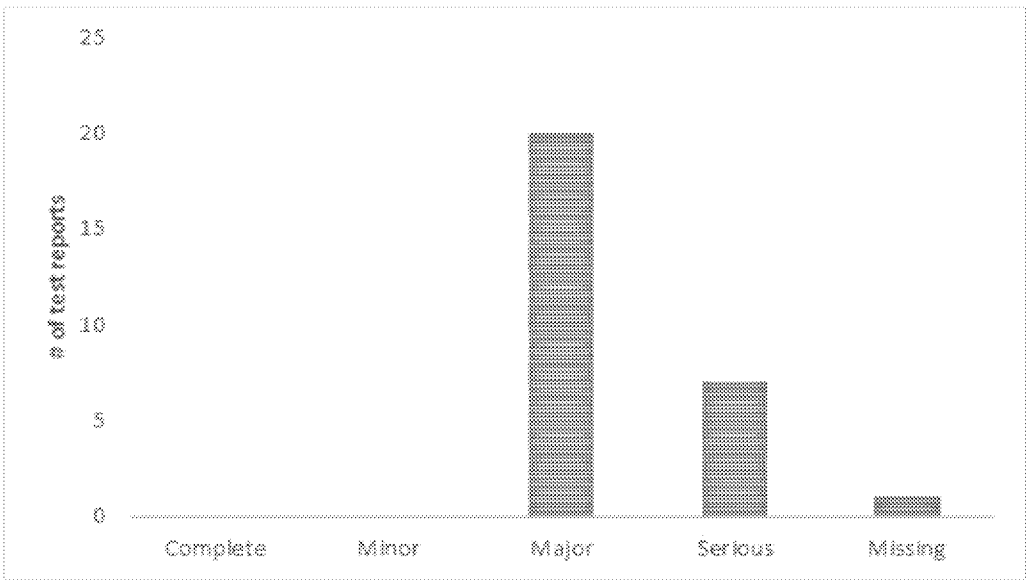
Table 7. Assessment of Report Completeness – Central Heaters

Element	Reported	Not Reported
Instructions to lab on appliance operation	5	23
Raw data	12	16
Lab notes	15	13
Filter data	19	9
Train precision	2	26
Appliance setting	0	28
Burn rate	9	19
Fuel information	9	19
Heat output	27	1
Conditioning	10	18
Photo documentation	7	21

Reports were assigned to one of the following categories based on the report assessments:

- *Complete:* All non-CBI elements were included in the report.
- *Incomplete-Minor:* One to three elements were missing from the test report.
- *Incomplete-Major:* Four to ten elements were missing from the test report.
- *Incomplete-Seriously Deficient:* More than ten elements were missing from the test report.
- *Missing:* Test report could not be found by searching the manufacturer's website and by conducting additional web searches.

Figure 16. Assessment of Central Heating Report Completeness



None of the 27 reports reviewed contained all the data necessary for a complete review. Twenty had three to ten missing elements, seven were missing more than ten elements, and one report could not be located. The appliance for which a report could not be found was flagged under revocation criteria.

4.3.2. Revocation Criteria – Testing Irregularities

The RWH NSPS states that certification for a central heater can be revoked "based on problems or irregularities with the certification test or its documentation" [40 CFR § 60.5475(l)(ii)]. To evaluate testing irregularities, reviewers focused on the handling of negative filter weights. This issue has been discussed in previous sections of this report.

Of the 27 central heating reports reviewed, there was not enough information in 13 test reports to assess this element. Of the 14 certification test reports that included this information, 86 percent (12) reported negative filter weight values. Based on the review, none of the 12 tests that reported negative filter values used recovery procedures to assure that all PM mass had been captured in the weighing process. Further, the negative filter values were not reported in any of the test's summary descriptions in the report.

4.3.3. Compliance with § 60.5478 Requirements

Section § 60.5475(l)(1)(iii) states that a certification can be revoked if EPA determines that "the labeling of the central heater model line, the owner's manual or the associated marketing material does not comply with the requirements of 60.5478." Section 60.5478(f)(1) states that "such information must be consistent with the operating instructions provided by the manufacturer to the approved test laboratory for operating the wood heater during certification testing, except details that would not be relevant to the user." Test reports were assessed to determine whether the laboratory's operational parameters and instructions in the test reports were consistent with those in the manufacturer's materials.

Central Heating Operational Parameters

Unlike the room heaters, reviewers found only limited contradictions between the manufacturer's materials and the testing data. Examples of discrepancies identified included identifying CO emission data as PM results and the reporting of lower heating value (LHV) data without calculating HHV efficiency.

Comparison of Instructions to Laboratories versus Owner's Manual Instructions

Only 5 of the 27 test reports reviewed included the instructions that manufacturers gave to the certification testing laboratory, so it was not possible to make this comparison.

4.3.4. Revocation Criteria – Test Methods

The certification revocation criteria listed in 40 CFR § 60.5475(l)(vii) include the failure of the EPA-approved laboratory to test the central heater using the methods specified in 40 CFR § 60.5476. This section requires that certification tests follow the requirements detailed in the approved methods and specifies that test results must report particulate matter emissions for the test's first hour. Reviewers assessed the reports to determine whether the testing conducted was consistent with the test method requirements

Mandatory Reporting Elements

The rule requires the reporting of first-hour PM emissions, CO, and efficiency. The central heating test methods require reporting of efficiency, heat output, and CO emissions per CSA B415.1-10 [40 CFR § 60.534(e)]. For units testing with ASTM 2618-13, delivered efficiency must also be reported. The reviewers assessed whether those mandatory elements were included in the report's summary data, as discussed below.

First-hour PM Emission Rates

Of the 27 central heating certification test reports reviewed, 8 reports did not contain first-hour PM data. Of the remaining 19 reports, nearly one-third (6) reported negative, first-hour PM emission rates. A negative PM emission rate for the first hour of a test suggests that there were issues with the test. A review of the data found that first-hour values for central heating tests were substantially lower than those for room heating appliances. This finding seems counter-intuitive, as central heating appliances tend to burn more fuel during the initial high-load periods. Additional review of central heating testing should be considered to determine if certification testing follows appropriate protocols for measuring this metric. Appliances that did not report first-hour values or reported negative first-hour values were flagged under revocation criteria.

Appliance Conditioning

ASTM 2618 requires conditioning of appliances at a medium heat draw for 48 hours prior to conducting certification testing (Section 11). However, the method does not define "heat draw" or "medium heat draw." NESCAUM contacted EPA for guidance on this issue and was advised to develop a range somewhere between the lower limit of Category II and the upper limit of Category III testing ranges. Using this approach, reviewers found that of the 27 certification test reports reviewed:

- 7 percent (2) of the appliances appeared to comply with the requirement.
- 7 percent (2) of the appliances appeared not to comply with the requirement.
- 22 percent (6) of the appliances did not have sufficient data in their test reports to determine compliance.

- 63 percent (17) of the appliances did not have conditioning data in their complete test report.

Appliances with reports indicating that the test method's conditioning requirements were not met or which did not have conditioning data in the complete test report were flagged under revocation criteria.

This element highlights a common concern from reviewers regarding the lack of specificity in the test methods. This requirement would benefit from EPA guidance on proper procedures for completing conditioning.

Train Precision

Section 11.7 of ASTM Method 2515 requires the EPA-approved laboratory to complete two calculations to determine if the precision of the two trains used for PM measurement is sufficient: (1) dual-train precision cannot exceed 7.5 percent, and (2) the difference in the g/kg emissions in the two trains cannot exceed 0.5 g/kg. The RWH NSPS requires a test report to include all calculations required by the test method, including these metrics. The reviewers found that 93 percent (25) of the test reports did not contain train precision data. Failure to report these data limits reviewers' ability to assess the data quality of PM measurements. Appliances that did not report train precision information were flagged under revocation criteria.

Efficiency

Section 13.4.5.1 of ASTM 2618-13 states that whenever the efficiency calculated using the stack loss method is lower than the delivered efficiency, the test report must include a discussion of the reasons for those results. The stack loss method calculates the absolute maximum efficiency value that the appliance can achieve during test operations, and the delivered efficiency reports the heat delivered. Theoretically, delivered efficiency cannot exceed the efficiency calculated by the stack loss method unless the boiler is a condensing boiler. Condensing boilers may exceed stack loss efficiency calculations because they capture heat from the flue's water vapor.

Reviewers completed a comparison of stack loss versus delivered efficiency for all appliances. One of the 27 central heating appliances reviewed was a condensing boiler and was excluded from this analysis. Of the other 26 appliances, ten had at least one test run for which the delivered thermal efficiency values exceeded stack loss values. For six of those ten reports, that discrepancy occurred in every test run. Failure to discuss this issue in the test report is a method violation and raises concerns about the test's validity. Appliances that had this discrepancy and failed to address it in the test report were flagged under revocation criteria.

Use of Unapplicable Sections

ASTM 2618 can be used in both cordwood and pellet boiler tests, but the method has separate operational components for each fuel type. Section 12.3 of the method details testing requirements for automatically-fed appliances (pellet or chip boilers). Section 12.2 details operational elements that apply to manually-fed boilers only. The operational components of ASTM 2618 go into greater specificity for manually-fed appliances than automatically-fed appliances. According to Section 12.3, automatically-fed appliances must operate in each test category to use ASTM 2618. Section 12.2 allows manually-fed appliances to conduct two Category 2 tests in lieu of a Category 1 test if the device cannot maintain a fire in Category 1. Section 12.2 also states if an appliance overheats while attempting to operate in any burn category, it cannot use ASTM 2618 for testing.

A reviewer found an automatically-fed appliance used Section 12.2 components to eliminate the requirement to test in Category 1. The reviewer also noted that the appliance overheated in Category 1. It appeared that the appliance used test method practices that were not allowed for the appliance type tested. The review team contacted EPA in September 2020 to determine if an alternative test method had been granted to allow this deviation and learned that no ATM had been given, but the Agency did not explain why it had accepted the appliance's certification test report.

4.3.5. Revocation Criteria – Low Burn Rate Testing Revocation Criteria – Failure to Follow Test Methods

40 CFR § 60.5476) states, "the low burn rate category must be no greater than the rate that an operator can achieve in-home use and no greater than advertised by the manufacturer or retailer." Reviewers found no information in central heating test reports indicating that they had tested at the lowest burn rate. Based on reviews of the test report, reviewers could not confirm compliance with this provision for any test report.

4.3.6. Summary of Central Heating Certification Test Reports

Of the 27 test reports reviewed, each had at least one element that triggered revocation criteria. As shown in Table 8, each test report on average contained nine revocation criteria flags, twelve audit criteria flags, and eight missing elements. This review's findings indicate that issues with central heater certification testing and test reports are widespread and not identified by either ISO third-party reviewers or by EPA OECA.

Table 8. Summary of Central Heating Test Report Review Deficiencies

	Missing Report Elements (33 total)	Revocation Criteria Flags (12-15 total)	Audit Criteria Flags (23 total)
Low	3	4	6
Average	8	9	12
High	12	12	22

4.4. Overarching Issues

In each appliance category, reviewers identified report issues that raised questions about testing integrity. The following section details those elements.

4.4.1. Summary Reports

Reviewers noted that the information contained in the test reports and the associated summaries varied significantly. 40 CFR § 60.533(b)(5) requires that "[d]ocumentation must include discussion of each test run and its appropriateness and validity, and must include detailed discussion of all anomalies[.]" The discussion materials in each of the test reports often failed to call out anomalies. More than 50 percent of the test reports failed to discuss issues encountered in testing. For example, discussions did not report negative filter weights, proportionality issues, train precision deviations, or other issues found in this review. In some cases, the detailed discussion of each run was only a single sentence. Reviewers also noted discrepancies in the data from the summary reports versus the data contained in the raw datasheets. Overall, reviewers noted a lack of reporting of deviations and discrepancies in test report summaries and specific run discussions. This is an area that would benefit from EPA guidance on reporting requirements.

4.4.2. Owner's Manual

40 CFR § 60.536(g) and § 60.5478(f) provide specific information that must be included in the owner's manual. As part of the certification application package, the manufacturer must submit an owner's manual. EPA reviews these manuals to ensure rule requirements are met. Despite EPA review, however, this study found numerous examples of owner's manuals not complying with the rule requirements.

Reviewers identified 16 elements that must be part of the owner's manual. Table 9 summarizes the findings of the review. Approximately 10 percent of the room heater and 37 percent of the central heater owner's manuals could not be found on the manufacturers' websites (a rule requirement), nor were they included in the test reports. On average, cordwood stove owner's manuals had two missing elements, pellet stove owner's manuals had four missing elements, and central heater owner's manuals had one

missing element on average. Appliances that did not have owner's manuals available or had deficient owner's manuals were flagged for audit criteria, as these elements can be addressed without retesting.

Table 9. Summary of Missing Owner's Manual Elements

	Cordwood Stoves	Pellet Stoves	Central Heaters
Low	0	0	0
Average	2	4	1
High	14	13	2
No owner's manual found	0% (0)	10% (9)	37% (10)

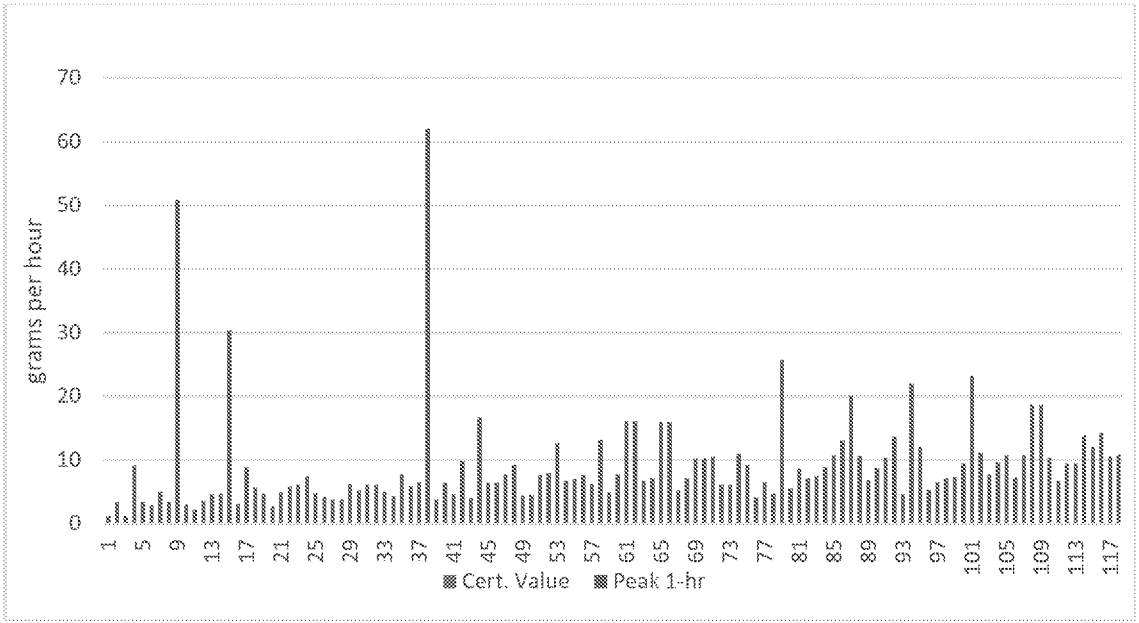
4.4.3. First-hour Values

Reviewers assessed the first-hour metric to determine the performance of the stoves over a short-term period. Reported emission values for certification are the average of multiple runs using average emissions over each individual test run, which can last from 3 to 30 hours or more. Research shows that almost all the emissions from residential wood heating are emitted in the first few hours after fuel loading. Therefore, the first-hour metric provides insights into the ability of an appliance to control for high PM during loading periods.

Space Heaters

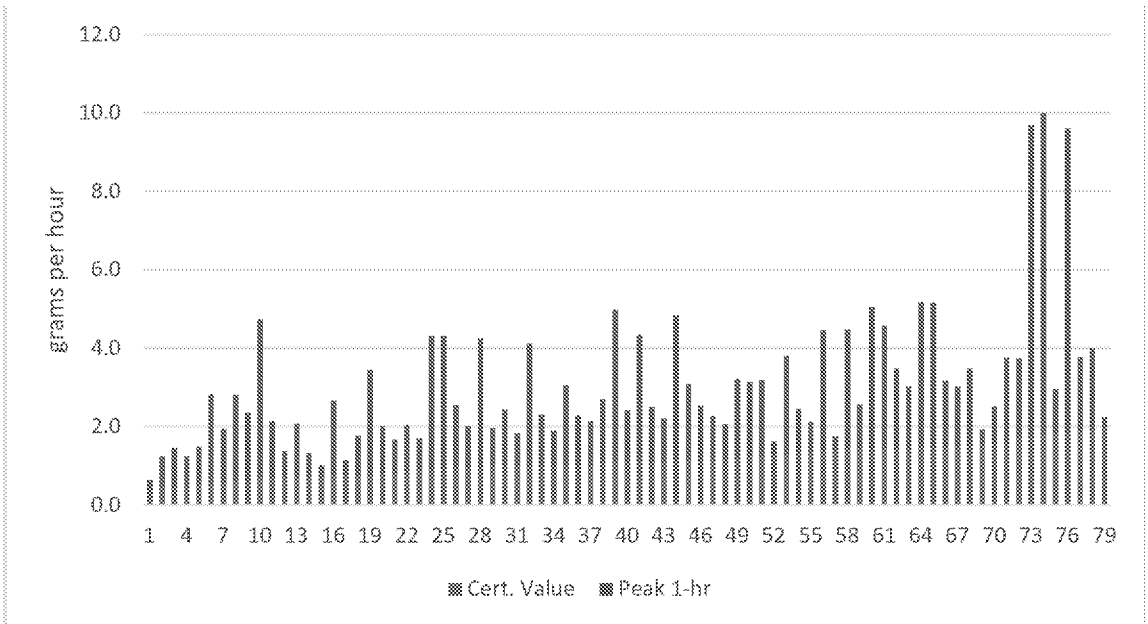
For cordwood stoves, 42 percent (54) had first-hour emission rates that were more than three times higher than the emission standard. On average, first-hour emissions were 616 percent higher than the appliances certification value. The first-hour values ranged from 132 percent to 7,842 percent higher, as shown in Figure 17. Appliances with high first-hour PM values are not necessarily those with higher overall emissions, nor are higher first-hour values associated with a particular control approach (catalytic or non-catalytic).

Figure 17. Certification Values vs. Peak First-hour Values for Cordwood Stoves



Patterns for first-hour PM emission rates for pellet stoves differed from cordwood stoves (Figure 18). Only 15 percent (13) had first-hour emissions three times higher than their average values. On average, first-hour emissions were 175 percent higher than the appliances certification value. The first-hour values ranged from 14 percent to 576 percent higher. Comparing first-hour values for pellet stoves indicates that the first hour of operation may not be the period of highest emission rates.

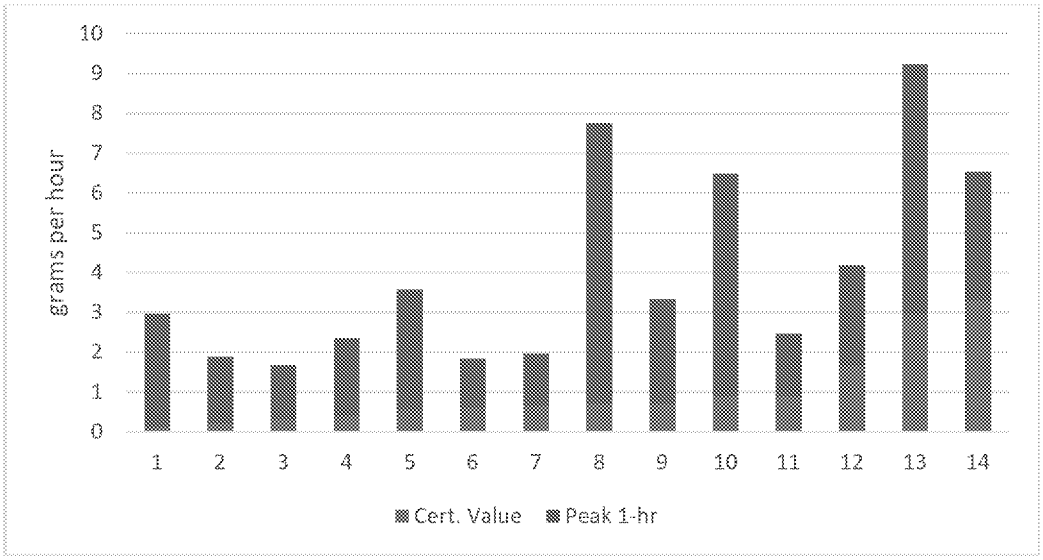
Figure 18. Certification Values vs. Peak First-hour Values for Pellet Stoves



Central Heaters

Reviewers also analyzed first-hour emissions for cordwood and pellet central heaters, as shown in Figure 19. Sixty-four percent (9) had first-hour emissions three times higher than their average values. On average, cordwood central heaters' first-hour emissions were 813 percent higher than the appliances' certification values. The first-hour values ranged from 98 percent to 2,367 percent higher. On average, the first-hour emissions for pellet central heaters were 356 percent higher than the appliances' certification values. The first-hour values ranged from 147 percent to 731 percent higher.

Figure 19. Certification Values vs. Peak First-hour Values for Central Heaters



4.4.4. Audit Criteria – Laboratory Receipt Dates

Under the test methods and rule requirements, test reports need to include the dates of certain events, such as appliance conditioning dates, the date the EPA-approved lab received the appliance, and certification testing dates. Reviewers noted numerous incidents where the dates reported were difficult to reconcile with the timing needed to undertake the steps reported. Examples of contradictory information include:

- The lab completed the conditioning, which requires 48-50 hours of operation, but the lab reported not receiving the unit until the day of or day before testing.
- The lab reported it had completed the conditioning, but the conditioning was completed before the lab reported that it had received the appliance.
- The manufacturer completed the conditioning, but the conditioning was completed after the lab reported that it had received the appliance for certification testing.

These discrepancies raise questions about how the certification test lab defines appliance receipt and what data is gathered during conditioning. Table 10 summarizes the reports with date receipt questions.

Table 10. Summary of Reports with Date Issues

	Room Heaters	Central Heaters
Reports with date issues	76	14
Reports that did not contain date issues	54	3
Reports where determinations could not be made due to missing data	84	10

Reviewers also noted that some appliances seemed to remain at the EPA-approved lab for an extended amount of time – more than a month – before conducting certification testing. Reporting the reason for testing delays in certification test reports would clarify the reason for lags in time between lab receipt and testing.

4.4.5. Audit Criteria – Laboratory Pre-testing

Per 40 CFR § 60.535 and § 60.5477(d)(2)(vi), EPA-approved labs must agree not to perform a certification review on any model from a manufacturer for which the lab conducted research and development design services within the previous five years. The term research is not defined in the rule, but it is generally understood to include gathering information or data on the device's performance.

Reviewers noted numerous examples in certification test reports indicating that the EPA-approved lab conducted pre-testing that could be construed as research, including emission testing, immediately prior to conducting certification testing. This assessment was based on statements in the reports, such as:

- "At the reception of the unit we do preliminary test runs to ensure the unit can reach the limit of the standard. We use those run{s}for aging of the unit."
- "The wood heater has been received in good shape by the carrier. A few screening tests have been done to ensure the repeatability of the results."

Other test reports indicated that the manufacturer ran the appliance in the EPA-approved laboratory facilities to conduct conditioning (i.e., aging) and testing to obtain emission data on the appliance prior to the laboratory conducting the certification test. Reviewers made this determination when the report stated that the manufacturer conducted the conditioning, but conditioning took place after the certification test laboratory received the appliance. Reviewers noted that some conditioning data appeared to resemble certification test loads.

The analysis estimated that 36 to 96 percent of cordwood stoves had EPA-approved laboratory-run tests to confirm emissions performance before the official certification test. The 2015 RWH NSPS stipulates that all testing data obtained by the certification lab must be submitted as part of the test report, whether or not it is used to for certification purposes. Issues with receipt dates, noted above, could be used as a basis for excluding test data. EPA should clarify requirements regarding these elements to assure that certification tests are done appropriately.

4.4.6. Audit Criteria – Appliance Modifications During and After Testing

Review of the reports found evidence that stove design elements were modified during testing or that prototypes tested were not complete models. For example, it appears that several units received at EPA-approved laboratories did not have defined air-stop settings. Reviewers also found examples of EPA-approved laboratories modifying the stop points during the certification test. As noted above, EPA-approved laboratories cannot conduct certification testing for a manufacturer if they have provided research and design services for that manufacturer in the previous five years. EPA should clarify what design and engineering activities EPA-approved laboratories can and cannot undertake prior to certification testing for the 2015 RWH NSPS.

4.4.7. Compliance Assurance Plans

In its certification application, the manufacturer must submit to EPA a compliance assurance plan. This plan must include regular unannounced audits at least once per year. EPA does not conduct the audit visits, as it has delegated inspection activities to the third-party certifiers under the 2015 RWH NSPS. As part of the compliance assurance plan, the third-party certifier must submit reports to EPA within 30 days of conducting an inspection. The reports are required to include deviations from the manufacturer's compliance assurance plan, and if deviations are identified, a plan for corrective action.

Reviewers did not find any information on compliance assurance plans in the publicly posted documentation. Reviewers then reached out to EPA to obtain information on compliance assurance plans, audit reports, and corrective actions. EPA OECA staff informed reviewers that both the plan and the inspection reports are submitted as confidential business information. Reviewers then checked EPA databases that are required to report compliance assurance and inspection activity. Reviewers found no data for these activities in any EPA database they reviewed. Furthermore, reviewers could not find any enforcement activity for this sector as having taken place in the last 20 years.

4.4.8. Compliance Audits

The RWH NSPS rule provides EPA with authority to select appliances for compliance audit testing, which is an available process separate from the revocation criteria. Audit testing is a useful procedural check to verify that production units offered for sale are meeting the emission standards to which the prototype was certified. The process requires the EPA Administrator to notify the manufacturer in writing of the selected heaters/model lines (name and serial number) to test. EPA can also specify the lab that will perform the audit test, which does not need to be the same lab that conducted the selected device's certification test. The manufacturer bears the costs of audit testing. Reviewers examined EPA records and could find no evidence that EPA has ever conducted a compliance audit under either the 1988 or 2015 RWH NSPS.

4.4.9. Sales Reporting Requirements

40 CFR § 60.537(d) and § 60.5479(d) require manufacturers to submit reports to EPA every two years that provide sales for each of their models by state. The rule does not specify that this information is confidential business information (CBI). However, in response to a request from NESCAUM seeking the manufacturer reports, EPA responded that all manufacturers have submitted sales data to EPA OECA as CBI.

NESCAUM also requested sales data aggregated by appliance type (pellet, non-catalytic, catalytic) at the state level. The only information EPA would provide is shown in Figure 20 below. While the release of sales information for individual models may raise CBI concerns, releasing aggregated state sales data for each appliance type would provide significant value for many state programs. Specifically, total sales data by state and by type of stove would help states understand how quickly units are changing over time and what types of appliances are entering their markets. This information also becomes significant in understanding the impacts of model types if they are found to be generally non-compliant under a more rigorous certification program.

Figure 20. Sales Data Supplied by EPA

Wood Appliance Sales Summary

March 9, 2020

Years Reported	2015-2017	% of Market	2017-2019	% of Market
Appliance type				
Wood and Pellet Stoves	190,332	98.72	219,537	97.01
HH	1,117	0.58	1,017	0.45
FAF	1,354	0.70	5,756	2.54
Total Units	192,803		226,310	

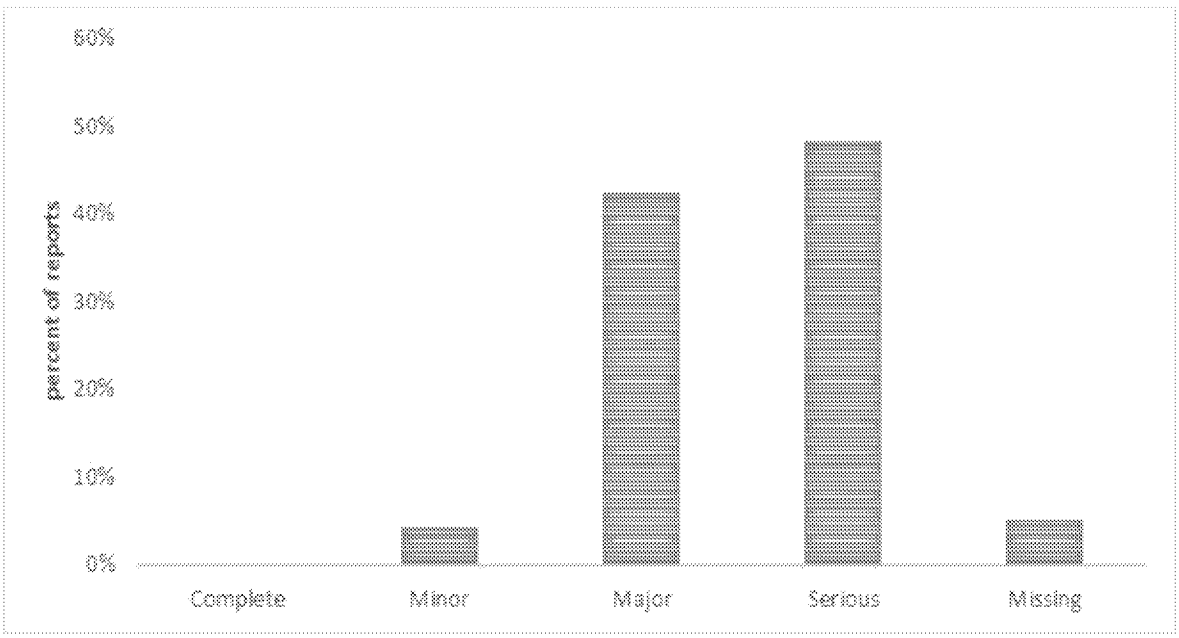
5. RECOMMENDATIONS AND CONCLUSIONS

This study's primary purpose was to evaluate the efficacy of the 2015 Residential Wood Heater NSPS program's third-party system for emission certification testing and review and EPA's oversight and enforcement of this process. The investigation revealed serious and systemic problems throughout the process, from conducting the test to report reviews. The study also identified weaknesses with existing certification test protocols that allow manufacturers and EPA-approved laboratories broad discretion in conducting tests. Those decisions significantly influence measured emissions when testing to certify new residential wood heaters.

5.1. Program Issues

The study attempted to review 255 Step 2 certified wood heater models (131 cordwood stoves, 96 pellet stoves, and 28 central heating appliances) to assess the RWH NSPS program's ability to assure compliance with regulatory emission limits. Reviewers could not find test reports for 13 appliances. Pellet stoves accounted for 10 of the 13 missing reports. Of the remainder of devices, none of their certification reports was found to be complete, and each report contained at least one revocation criteria flag (Figure 21).

Figure 21. Summary of Report Completeness



The study found numerous deficiencies in the test reports, and documented significant deviations from test methods and regulatory requirements. Even when manufacturers submitted additional information for review to address identified deficiencies, the majority of the deficiency flags, whether audit or revocation criteria flags, remained. Table 11 summarizes these findings.

Table 11. Summary of Test Report Review Deficiencies

Deficiency Rates Ranges (avg)	Missing Report Elements	Revocation Criteria Flags	Audit Criteria Flags
	Cordwood Stoves		
Low	2	3	2
Average	11	8	8
High	24	12	15
	Pellet Stoves		
Low	2	4	1
Average	11	7	5
High	29	14	11
	Central Heaters		
Low	3	4	6
Average	8	9	12
High	12	12	22

This analysis found that test methods used to certify residential wood heaters are poorly designed. They lack clarity and specificity for many testing aspects, which reduces testing precision. This analysis shows that manufacturers and EPA-approved laboratories are able to use test method vagaries or voids to employ test strategies that may improve certification testing results but do little to improve appliance performance for consumer use. This undermines the public health and air quality goals of the RWH NSPS program because it allows certification of some units as Step 2 compliant without necessarily incorporating improved design and engineering practices that achieve real-world emission reductions.

The third-party certification review process as conducted was shown to be highly ineffective at identifying and reporting testing irregularities. The study found that third-party certifiers are issuing certificates of conformance for appliances that appear not to meet regulatory test requirements. The documented failures in the third-party process may be due to poor program design, the lack of competency of the groups involved, improper complicity between third-party reviewers and manufacturers, or some combination of the three.

Study results also found that EPA has not used the RWH NSPS auditing provisions to verify that production models are substantially similar to the prototypes used in certification testing, and that those offered for sale are meeting the applicable emission standards. Lack of basic auditing undermines confidence in the RWH NSPS program and its ability to ensure that new residential wood heating appliances are meeting the federal emission standards in the real world.

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A major challenge in conducting this study's review of the RWH NSPS program was in obtaining key information from EPA, which demonstrates the need for greater transparency. For example, EPA-approved laboratory inspections and compliance assurance activities are treated as confidential business information (CBI) by EPA and therefore unavailable for public review. By contrast, state and local programs must report all data into EPA's Enforcement and Compliance History Online (ECHO) database and other online reports or dashboards created to assess program efficacy.

These study results provide detailed documentation of the 2015 RWH NSPS program's failures to protect the public from the adverse health effects associated with exposure to wood smoke from new residential wood heaters. Some models certified to the Step 2 standards are not likely to consistently achieve those emission levels when in-use due to a host of weaknesses uncovered with the rule's testing and enforcement elements.

Despite the responsibility and clear authority provided in the Clean Air Act, EPA has failed to effectively enforce the New Source Performance Standards for Residential Wood Heaters requirements. The Agency has not provided the needed oversight, nor has it used the legal remedies provided, including revocation of certificates of conformance or audit testing, to enforce the rule.

5.2. Recommendations for Program Improvement

A strong and broad response is needed to correct the failures of the RWH NSPS program identified through this study. Some of these program weaknesses can be minimized in the near-term if EPA makes a firm commitment, and follows through in good faith, to fully enforce the existing requirements according to the clear language of the RWH NSPS. Others must be addressed through rule changes.

5.2.1. Third-Party Review Process

The EPA Inspector General should conduct an investigation of the third-party review system, and the responsible ISO bodies should call for an inquiry into their accreditation processes. EPA-approved laboratories that conduct certification testing should not be eligible to participate in the third-party review process. EPA should initiate action against third-party certifiers that have not adhered to test method and rule requirements. Finally, EPA should reassess the validity and viability of the third-party review process as a cornerstone of this program in the next update to the RWH NSPS.

5.2.2. Enforcement of Certification Test Results

EPA should conduct a detailed review of the problematic certification test reports identified in this study. The Agency should hold hearings and, where appropriate, revoke certifications for models failing to meet the 2015 RWH NSPS rule requirements.

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The findings of this report suggest that some manufacturers and EPA-approved laboratories may be "optimizing" certification tests to qualify models as Step 2 compliant by employing methods inconsistent with the approved protocols. At a minimum, models should undergo compliance audits as allowed per 40 CFR § 60.533(n) to verify the ability of production units to meet the emission standards to which the prototype was certified. To date, EPA has not conducted a single compliance audit during the more than 30 years this program has been in place. To address this, EPA should implement routine compliance audits on 10 percent of appliances each year. The audits should begin by targeting heater models that conducted non-representative tests. Appliances should not be allowed to recertify their appliances without retesting. Waiver provisions that allow manufacturers to avoid retesting of appliances should be eliminated. Retesting should require addressing deficiencies identified in the appliance review sheets, and, given today's communication technologies, remote witnessing of testing.

5.2.3. Targeting Public Funding to Cleanest Appliances

Government funds for wood heater change-out programs should be used only for the cleanest appliances with valid test reports. Government agencies and nonprofits funding change-out programs should disqualify units that are certified as Step 2 compliant but fail to meet the rule's requirements. Taxpayer-supported incentive programs, such as the 26 percent federal tax credit created under the BTU Act, EPA Targeted Airshed grants, and state-supported activities, should only apply to those appliances included on the list of approved models developed by the Alaska Department of Environmental Conservation. This currently is the only thorough review of certification test reports applying the 2015 RWH NSPS requirements.

5.2.4. Improving Certification Test Methods

Current cordwood test methods used to certify residential wood heaters are poorly designed and often lack the specificity to ensure viable and comparable emission results. EPA should revoke or modify problematic test methods. The ASTM 3053 test should be revoked as a Broadly Applicable Test Method. EPA should expedite rulemaking or guidance to close loopholes and reduce deficiencies in ASTM and CSA test methods. Over the longer term, EPA should fully fund efforts to develop new test methods that bring integrity, reliability, and representativeness to testing outcomes.

5.2.5. OECA Enforcement and Oversight

EPA should establish residential wood heaters as a high priority enforcement sector and immediately begin a permanent and effective enforcement initiative . EPA should take enforcement action against third-party certifiers that do not adhere to method and rule requirements. Enforcement action should be taken under 40 CFR § 50.535(b) against

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EPA-approved laboratories that fail to follow required procedures or practices with the goal of assuring lab independence and competence while eliminating coordination between labs and manufacturers that inappropriately "optimize" test results and modify appliances during testing. Finally, EPA should request a revision to ISO procedures to ensure the certification system's integrity and competence.

5.2.6. Program Transparency

The results of this analysis demonstrate that significant improvements in transparency are needed for the certification and enforcement components of the RWH NSPS. For example, EPA-approved laboratory inspections and compliance assurance activities are treated as confidential business information (CBI). There is no clear justification why these elements would be considered CBI as they do not pertain to typical CBI elements, such as product designs or manufacturing processes. Instead, EPA should eliminate claims of CBI for all compliance assurance monitoring activities. EPA should develop a strategy to ensure all manufacturers post complete non-CBI test reports and take enforcement action against all manufacturers who post incomplete non-CBI test reports, as defined by the rule. EPA should eliminate the use of confidential ISO compliance assurance audits, and all audit findings should be posted on the Enforcement and Compliance History Online (ECHO) database maintained by EPA. EPA should develop and require the use of a standardized certification report template.

5.2.7. Investigating EPA Program Oversight and Enforcement

The EPA Inspector General or Congress should conduct a review of EPA's OECA and Office of Air Quality Planning and Standards (OAQPS) with a focus on identifying practices to improve Agency oversight and enforcement of the 2015 RWH NSPS program.

5.3. Conclusions

This study covered over 250 Step 2 certified wood heater models (131 cordwood stoves, 97 pellet stoves and 23 central heating appliances) to assess the ability of EPA's program to assure compliance with RWH NSPS regulations. Some of the identified models did not have publicly available certification test reports, as required by the regulations. For the remainder, no report was found to be complete and in full compliance with RWH NSPS requirements. Seventy-two percent of the ISO/EPA certified reports contained issues listed as Criteria for Revocation of Certification under the 2015 RWH NSPS; 24 percent of the test reports were too incomplete to make determinations; and the remaining 4 percent had minor issues.

The third-party certification review process appears highly ineffective at identifying and reporting testing irregularities. The documented failures in the third-party process may be

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due to poor program design, the lack of competency of the groups involved, improper complicity between third-party reviewers and manufacturers, or some combination of the three. Study results also highlight the lack of EPA's use of the auditing program to ensure production models are substantially similar to the prototypes used in certification testing, and that those offered for sale are meeting the applicable emission standards.

This analysis also uncovered a lack of transparency in the RWH NSPS program. Reviewers were often unable to access key data and information on certification testing. An overly broad assertion of confidential business information has removed non-proprietary compliance assurance activities from public review.

Based on the identified shortcomings in this review, the 2015 RWH NSPS certification program fails to assure that new residential wood heaters are uniformly cleaner than past devices before the new standards went into effect. A flawed testing and review system coupled with a historical lack of EPA enforcement of basic program elements work in tandem to undermine the public health goals of the program. The end result is a program devoid of any credibility to ensure that new residential wood heating appliances are meeting federal emission standards, and that gives every indication that scarce public resources are being misspent on incentive programs meant to encourage the more rapid introduction of cleaner wood burning appliances that truly reduce emissions.

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Appendix A: EPA Emails on Certification Testing

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Appendix A: EPA Emails on Certification Testing

Note: The following three email texts sent by EPA are unedited copies of the originals.

Email 1 of 3

From: Johnson, Steffan
Sent: Thursday, June 13, 2019 4:19 PM
To: Alex Tiegs <atiegs@omni-test.com>; 'brian.brunson@intertek.com' <brian.brunson@intertek.com>; 'brian.ziegler@intertek.com' <brian.ziegler@intertek.com>; 'claude.pelland@intertek.com' <claude.pelland@intertek.com>; 'dpower@polytests.com' <dpower@polytests.com>; 'dvoracek@szutest.cz' <dvoracek@szutest.cz>; 'gpiedalue@polytests.com' <gpiedalue@polytests.com>; Henrik Persson <henrik.persson@ri.se>; Jared Sorenson <jsorenson@omni-test.com>; Jes Andersen <jsa@teknologisk.dk>; 'jsteinert@dirigolab.com' <jsteinert@dirigolab.com>; Kelli O'Brian <kelli@clearstak.com>; 'lennart.aronsson@sp.se' <lennart.aronsson@sp.se>; Toney, Mike <Toney.Mike@epa.gov>; 'John Steinert' <john.steinert@pfsteco.com>; 'WTerpstra@PFSCorporation.com' <WTerpstra@PFSCorporation.com>; 'Benjamin.Barker@csagroup.org' <Benjamin.Barker@csagroup.org>; 'Travis.F.Hardin@ul.com' <Travis.F.Hardin@ul.com>; Laura Hinton <lhinton@guardiantestlabs.com>
Cc: Sanchez, Rafael <Sanchez.Rafael@epa.gov>; Lischinsky, Robert <Lischinsky.Robert@epa.gov>; Aldridge, Amanda <Aldridge.Amanda@epa.gov>; Baumgart-Getz, Adam <Baumgart-Getz.Adam@epa.gov>; French, Chuck <French.Chuck@epa.gov>; Boyd, Rochelle <Boyd.Rochelle@epa.gov>; Lowe, Theresa <Lowe.Theresa@epa.gov>; Cozzie, David <Cozzie.David@epa.gov>; Jordan, Scott <Jordan.Scott@epa.gov>; Wayland, Richard <Wayland.Richard@epa.gov>; Hemby, James <Hemby.James@epa.gov

Subject: Reporting Emissions Test Results when using Alt-125, or Alt-127 (ASTM E-3053)
Importance: High

To all EPA Approved Wood Heater Test Laboratories and Third Party Certifiers,

In reviewing some recent test reports that have been submitted to EPA with the intent to certify a wood heater to the Subpart AAA cordwood emissions standard, there are some discrepancies and concerns that we are observing, and we will be asking some manufacturers to revise and resubmit a corrected compliance test report. At least one of these concerns (noted below) is critical and may require re-testing. All of these items are important enough to request a corrected report, and we wanted to let all of you know just why you may be contacted by your client(s) with such a request.

We have seen a number of test reports using the Alternate Test Method and ASTM E-3053 that do not identify the species of cordwood used for the compliance testing. While

it is true that the ASTM method allows selection from a wide list of wood species, the test report must identify the species of fuel used. This is specified not in the test method but in the General Provisions to EPA 40, Part 60.8 (f)(2) which governs content that must be included in the test report. Paragraph (iii) of this section reads: *"(iii) Description of the emission unit tested including fuel burned, control devices, and vent characteristics; the appropriate source classification code (SCC); the permitted maximum process rate (where applicable); and the sampling location."*

We are asking that test reports that did not identify the wood fuel species burned during a compliance test submit an amended test report to this Agency. If you are a third party reviewer and have certified such a test report, we request that you include this item, along with other items listed in the General Provisions, in your review checklist.

We have seen some test reports that reference "manufacturer's instructions" for conducting the certification test, yet those instructions were not included in the test report. The requirement to submit this information is to comply with the General Provisions of 60.8(b) and (c). The guiding principle here is that ONLY the EPA Administrator has the ability to modify a test method for any reason, and these manufacturers instructions do NOT supersede the test method. Also, the National Stack Test Guidance Document (available here: https://www.epa.gov/compliance/clean-air-act-national-stack-testing-guidance) clearly states that the emissions test report "*must demonstrate all information from the test lab such that it is a stand-alone document capable of reproducing the entirety of the test results*". As such, all information pertinent to the operation of the appliance during the testing must be included in the test report (per 40 CFR 60.534). Also, as such instructions are relevant to how the testing was conducted, this documentation is Confidential Business Information (CBI).

We are asking manufacturers that have issued test reports where the manufacturers provided instructions to the test lab regarding appliance operation during the test, and that documentation was NOT included in the emissions test report available to the public, to take corrective action and submit an amended test report to this Agency. If you are a third party reviewer and have certified such a test report, we request that you now include this item, along with other items listed in the General Provisions, in your review checklist.

We have seen some test reports that contain manufacturer's instructions that may run contrary to the test method and rule requirements. Specifically, we have seen instances where manufacturers have directed laboratories to conduct low load testing with air inlet damper settings at "specified distances from fully closed", meaning that the unit may not be getting tested at the lowest operating rate that a homeowner will have access to during the course of normal daily operation. Testing at the lowest setting a consumer will be able to operate the appliance in their home is specifically required in 40 CFR 60.534.

Test labs and third party certifiers who are conducting /observing testing where manufacturers provided such instructions AND where you have knowledge that such devices are capable of combustion with air inlet dampers more fully closed than those setpoints specified by the manufacturer review the rule requirements with their client(s)

and either select the lowest available setpoint or modify that stove model to fix the lowest available air inflow setting at that specified point, to remain fixed thereafter. Furthermore, we insist that laboratories and third party certifiers add the requirement(s) of 60.534 to their checklists and take necessary steps to not look past this requirement in the future. Appliance models found to have been tested in this manner and subsequently certified, will need to be reviewed by EPA on a case-by-case basis. As a reminder, third-party certification is an attestation that all testing was conducted as specified in the regulation; certification of testing that does not meet the regulatory requirements may result in loss of EPA Approval status.

We have seen some test reports where cordwood fuel is used to demonstrate compliance, and the dimensions of the "cordwood" very closely match the dimensions of crib fuel. While we recognize that it may happen that occasionally a wood splitter would produce a piece where the minor cross section is nearly equal to the major cross section of the fuel piece, we expect that this happens infrequently and is not normal for every piece in a fuel load.

We ask that labs and third party certifiers use pieces that approximate hand-split fuel and not something that seems to be far more selective. While fuel pieces are 'selected' for the test based on size and weight and, to some extent, dimension, we expect to see fuel loads that are more random (in terms of piece-to-piece comparisons) than not.

As always, thank you for continuing to support the EPA Wood Burning Appliance Certification Program. Please do not hesitate to reach out to us and ask questions, any time, with respect to any certification tesing you are undertaking; we are happy to offer our technical direction to help you, and your clients, meet the subpart AAA and QQQQ regulatory requirements.

Email 2 of 3

Subject: RE: Reporting Emissions Test Results when using Alt-125, or Alt-127 (ASTM E-3053)
From: "Johnson, Steffan" <johnson.steffan@epa.gov>
Date: 7/15/19 11:31 am

CORRECTION TO ITEM 2 BELOW: NO EMISSIONS TEST INFORMATION IS CONFIDENTIAL. The last sentence is intended to read "is NOT Confidential Business Information".
I regret the confusion this may have caused. Such information MUST be included in the non-CBI report.
Sincerely,
Stef Johnson

Email 3 of 3

From: Johnson, Steffan
Sent: Wednesday, December 4, 2019 10:11 AM
To: bdavis@omni-test.com
Cc: Alex Tiegs <atiegs@omni-test.com>; Ken Morgan <kmorgan@omni-test.com>; Boyd, Rochelle <Boyd.Rochelle@epa.gov>; Sanchez, Rafael <Sanchez.Rafael@epa.gov>; French, Chuck <French.Chuck@epa.gov>; Scinta, Robert <scinta.robert@epa.gov>; Jordan, Scott <Jordan.Scott@epa.gov>; Yellin, Patrick <Yellin.Patrick@epa.gov>; Aldridge, Amanda <Aldridge.Amanda@epa.gov>; Baumgart-Getz, Adam <Baumgart-Getz.Adam@epa.gov>; Hemby, James <Hemby.James@epa.gov>; Wayland, Richard <Wayland.Richard@epa.gov>; Lowe, Theresa <Lowe.Theresa@epa.gov>; Lessard, Patrick <Lessard.Patrick@epa.gov>

Subject: RE: Morso Model 5660B Certification Inquiry
From: Toney, Mike <Toney.Mike@epa.gov>
Sent: Tuesday, December 3, 2019 9:13 AM
Dear Mr. Davis,

Mike Toney forwarded your questions below to my attention, and I will endeavor to address your concerns to an appropriate level.

First off, let me be very clear that the Third Party Certification program is intended to function as an "…independent third party accredited under ISO-IEC Standards 17025 and 17065 to perform certifications, inspections and audits by an accreditation body that is a full member signatory to the International Laboratory Accreditation Corporation Mutual Recognition Arrangement and approved by EPA for conducting certifications, inspections and audits" under subparts AAA and QQQQ of US CFR, Part 60. I state this up front to point out that EPA expects that Third Party Certifiers have processes in place that guide them through situations such as the questions you pose below, or the statements made by the manufacturer in the attached letter and instructions. That said, we're all trying to navigate the rule and cordwood compliance testing is relatively new, so I'll try to shed some light on how the Measurement Technology Group views the compliance test process in order to help you in your Determination Guidances. Keep in mind that the final review is conducted by our Office of Enforcement and Compliance Assistance in Washington, D.C., who conducts a 'trust but verify' review of the submitted test report and associated/required materials prior to granting a model Certification; I say that to let you know that what the Measurement Technology Group may view about a particular test question is <u>not</u> the final word on compliance certification.

Let me begin by turning back the clock to the 1988 NSPS rule that established Subpart AAA. Here is an excerpt from the preamble of EPA's 1988 wood heater rule:

"In response to questions received after proposal from accredited laboratories, a provision has been added clarifying the role of wood heater manufacturers during certification testing. This provision limits instructions by the wood heater manufacturer on wood heater operation to written communications prior to the beginning of the

certification test. The only exception as for the manufacturer who observes that the test is being improperly conducted. He may then notify in writing laboratory personnel of the problem(s). All instructions and notifications relating to the certification test shall be reported in the test documentation. Any special instructions are to be consistent with the operating instructions in the owner's manual, except to the extent that they address details of the certification test (e.g. achieving specific burn rates) that would not relevant to homeowner operation. In other words, the wood heater should not be operated during the certification test in a manner significantly different from homeowner operation in order to increase the likelihood of passing."

That statement holds today, under the new NSPS as well as it did in 1988. This means that while a manufacturer may provide input to the test laboratory on operation of the appliance during the certification test, specific instructions that stray from typical homeowner operation, intended to lower the emissions of the appliance solely for the certification test, are not acceptable.

- MTG believes that examples of such instructions with respect to a cord wood compliance test include (but are not limited to):
- Removing bark prior to use as test fuel.
- Shaping or extreme sorting to constitute preference for a particular shape of fuel or fuel load (not to emulate crib fuel or create 'triangular crib fuel').
- Loading and lighting fuel inconsistent with instructions in the appliance owner's manual.
- Complicated fuel placement instructions that would not ever be followed by a home owner.
- Manipulation of the ash bed inconsistent with, or otherwise in addition to, instructions included in the appliance owner's manual, or in a manner that a homeowner is unlikely to ever follow.
- Failure to meet method required fuel loading specifications (shortened fuel, partial loading, or not using the full firebox area to calculate fuel loading).
- Limiting fuel loading during compliance testing that will be easily overridden by a home user seeking a longer burn time.
- Instructions that specifically override specified sections of the test method OR the subpart rule language (inside or outside of the test method requirements).

For reference, we have put together what we feel reasonably describes cord wood fuel: A cross sectional area end view should not form a perfect (or near perfect) square (except occasionally) but to be of a triangular or trapezoid shape with ill regular lines, some curvy some, zig zag. But not all having the same length (pie shape is fine). It is acceptable to have some bark but not having all the bark stripped off. It is not acceptable for a test fuel load to consist of all bark being stripped off of every piece. We expect to have wood pieces that are torsion shaped or pieces that are rounds, semi-rounds, have rounded edges, or are larger at one end and smaller at the opposite end. No fuel load should consist of pieces all chosen to be the same size/shape characteristics.

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Regarding the comment that states "we to not read that the procedure we have used is illegal, therefor we must assume that we can use the procedure" is not a statement that we ascribe to be true, on its face. Meaning, that we look for common sense and reasonableness in such interpretations. For example, the method does not say that the lab cannot cube the fuel into square, even chunks. It might burn clean, but would a home owner ever operate the appliance in that manner? No. So, use a reasonableness test when reviewing such procedures and ask yourself if you feel it is reasonable for the manufacturer to assume that such instructions, which should also be included in the operators manual, would be followed by the average homeowner during day to day operations. If yes, then I think you have your answer and, if no, likewise, you have your answer.

I would suggest that you pay close attention to items not included in the test method as well, such as instructions for setting a damper for a low burn rate test. Subpart 60.533(b)(5) has some requirements that must be in the test report and while this is a good checklist, the requirement there for documentation of *"...the burn rate for the low burn rate category must be no greater than the burn rate that an operator can achieve in home use and no greater than is advertised by the manufacturer or retailer..."* is of particular importance. So where you have a manufacturer telling you that *"...the damper setting for the low burn rate test should be set to XX millimeters from a fully closed position..."*, it is of key importance for your process to verify that the aforementioned damper is incapable of being closed further during ANY operation in the home than where it was placed during the compliance test. To clarify, the homeowner shall not be able to burn fuel at a lower rate than the lowest achieved during the compliance test, and this must be documented and such documentation included in the report to EPA.

Regarding your question about the room air blower, MTG feels that it is not a good idea to make assumptions about the impact of the blower when burning crib fuel and apply that directly to a cord wood test.

I hope this is helpful. Should you have questions about certification I would recommend you contact Dr. Rafael Sanchez who is copied on this e-mail.

Very sincerely,

Stef Johnson

Steffan M Johnson | Leader – Measurement Technology Group | US EPA Office of Air Quality Planning and Standards | Air Quality Assessment Division | 109 T.W. Alexander Drive, RTP, NC 27710 | Mail Drop: E-143-02 | Phone: (919) 541-4790 | Cell: (919) 698-5096

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