Docket ID No. EPA-HQ-OAR-2018-0195

ATTACHMENT K TO HEARTH, PATIO & BARBECUE ASSOCIATION COMMENTS

James E. Houck, Ph.D., "Review of the Puget Sound Clean Air Agency December 5, 2012 letter to Mr. Stephan D. Page of the Office of Air Quality Planning and Standards U.S. Environmental Protection Agency" (April 3, 2013), *previously docketed as* EPA-HQ-OAR-2009-0734-1643, "HPBA Attachment 10"

Review of the Puget Sound Clean Air Agency December 5, 2012 letter to Mr. Stephan D. Page of the Office of Air Quality Planning and Standards U.S. Environmental Protection Agency

Review prepared by James E. Houck, Ph.D.
April 3, 2013

Introduction

This review is in response to a request made by the Hearth, Patio, and Barbecue Association. The letter from Craig T. Kenworthy, Executive Director, of the Puget Sound Clean Air Agency (PSCAA) to Mr. Stephan D. Page of the U.S. EPA states its purpose in the initial paragraph, "We urge you to revise the outdated Standards of Performance for New Residential Wood Heaters (NSPS) to include lower, more health protective emission standards and improved test procedures and fueling methods."

There can be no argument that lower emissions of air pollutants are beneficial to human health and the environment. In addition, it is clear that improved test procedures and fueling protocols are needed. However, a key reason that "improved test procedures and fueling methods" are needed is that the current test procedures and fueling methods produce uncertain results and are not adequately predictive of the real-world particulate emissions from wood heaters in home usage to the level needed to support further refinement in emission standards. It would not be sensible to establish "lower, more health protective emission standards" before developing "improved test procedures and fueling methods" supporting the accuracy, precision, and representativeness needed to document lower real-world emission levels. At this juncture, setting "lower, more health protective emission standards" has little basis for merit.

Tacoma

Mr. Kenworthy discusses the difficulty in reducing ambient particulate levels in the Tacoma area even with 50% of the wood heaters in use being certified and most of these to the stricter Washington standards. He states that this is "living proof" for the need for more stringent standards. This conclusion is flawed for three reasons. (1) A heater currently certified below the lower Washington standard may be or not be indeed below the Washington standard due to the uncertainty in the NSPS procedures and methods. (2) The NSPS procedures and methods, in general, do not accurately predict the emission rates from in-home use and they can perhaps best be described as benchmark tests due to the specificity of laboratory test conditions. (3) Notably, due to the mild temperate marine climate characteristic of Tacoma, a heater's particulate emission levels can be expected to be on average different there than its use in many other geographical locations and certification values are particularly not representative of emissions from in-home use in Tacoma. Wood heaters, out of practical commercial necessity, are designed for optimal performance with NSPS test conditions. Wood heaters will often be started cold every day and operated at lower burn rates in Tacoma due to the mild climate. Method 28 (40 CFR Part 60 Appendix A) prescribes only a hot start and as such is not representative of much of wood heater use in Tacoma. Considerable research has shown that a disproportionate and large amount of emissions occurs during the cold start-up of a wood heater and particularly in the case of catalytic wood heaters this effect is further exacerbated due to the catalyst not being at

operating temperature (or bypassed) at the same time combustion conditions are less than optimum. Further, as any wood certification technician knows, the highest emission rates can generally be expected at lower burn rates. Emission rates calculated by the NSPS Method 28 are calculated by a prescribed weighting of the probabilities of national burn rates. As a consequence of this weighting scheme, emissions at low burn rates represent only a fraction of the calculated weighted certification emission values yet they can be expected to represent a larger fraction of the wood heater use in Tacoma. Different heaters perform differently during the start-up phase and at low burn rates which is not reflected in absolute wood heater certification values or their respective ranking.

The difficulty in reducing ambient particulate levels in Tacoma is only "living proof" that total lower emissions from all airshed source categories of particles achieved by any means will be further needed to achieve attainment, not explicitly "living proof" that "lower, more health protective emission standards" are needed for wood heaters as supported by the current NSPS test procedures and fueling methods. Even assuming that existing NSPS test procedures and fueling methods are adequate to substantiate lower in-home wood heater emissions, simple mathematics demonstrates that replacement of the existing 50% non-certified wood heaters in Tacoma with units certified to even current standards taken at face value would have a dramatically larger impact in reducing airshed particles than requiring new units to have "lower more health protective emission standards". Mr. Kenworthy suggests that replacing non-certified units with certified ones in Tacoma is not viable as "Changeout programs are difficult to implement and are very expensive." Wood stove change out programs have been implemented in numerous other jurisdictions.

Review Essay

An anonymously authored, un-referenced, unpublished, and apparently un-reviewed essay is attached to the letter to ostensibly offer substantiation of the efficacy of current NSPS test procedures and fueling methods to support "lower, more health protective emission standards." The essay is flawed and the level to which it lacks logic makes it difficult to provide meaningful comment. It uses immaterial and inappropriate statistical analyses. Finally and disappointingly, the review essay shows a lack of understanding of the fundamentals of wood heater testing, terminology and the existing database. It appears to be an attempt to provide a persuasive argument to satisfy an agenda rather than reviewing the facts in an unbiased fashion.

The essay does not introduce any new data but instead only criticizes documents written by three other authors. One of these authors is a professional engineer with over twenty-five years' experience with wood heater testing and is responsible for the wood heater certification testing program with the largest wood heater accredited laboratory, one is the President of a wood heater research and development laboratory also with over twenty-five years of experience, and one holds a Ph.D, has over thirty years' experience with wood heater emission testing and in assessing the human health and environmental impacts from hearth products and has authored over a hundred reports and publications on the subjects.

The data supporting the first document have been primarily generated from EPA's accredited laboratory proficiency testing program. The data supporting the second document were obtained from studies funded by a variety of public and private sectors sponsors, the largest of which have

been Environment Canada and the United States Environmental Protection Agency. Mr. Kenworthy recommends that the EPA, "….not base regulatory decisions solely on one or two analyses performed by others who don't have the express [*Sic*] responsibility to protect public health….." Mr. Kenworthy must not be aware the EPA staff are familiar with the issues, as the data used in the two analyses: (1) have been obtained from research funded or co-funded by EPA, (2) are in EPA's database via the NSPS process, or (3) are in the public domain and readily available to the EPA staff if not already in the libraries of those involved with wood heaters. Further, while it should not need to be said, having or not having the "express [*Sic*] responsibility to protect public health" has no bearing on the analytical and objective review of data and it is inappropriate to suggest otherwise.

Uncertainty in Certification Values Produced by NSPS Methods 5G, 5H, and 28 (40 CFR Part 60, Appendix A)

Both the anonymously authored essay attached to Mr. Kenworthy's December 5, 2012 letter and Messrs. Curkeet's and Ferguson's 2010 article discuss the uncertainty in the certification procedure; both relying to a large extent on statistical analyses. Statistical analyses can be non-intuitive and because of their complexity can be confusing and can distract the reader from the pivotal point. Such is the case here. A simple review of U.S. EPA accredited laboratory data obtained as part of the "proficiency" program demonstrates that the uncertainty associated with NSPS certification procedure is clearly at a level that would not support any further refinement in standards.

As per §60.535(7) Standards of Performance for New Stationary Sources; New Residential Wood Heaters (Federal Register v. 53, n. 38, February, 26,1988), accredited laboratories, "Agree to participate annually in a proficiency testing program conducted by the Administrator." Between 1993 and 2000 a single stove model was used for this proficiency testing program. The results were obtained from EPA for results submitted by eight laboratories during that time period. The variation in results is shown in Figure 1.

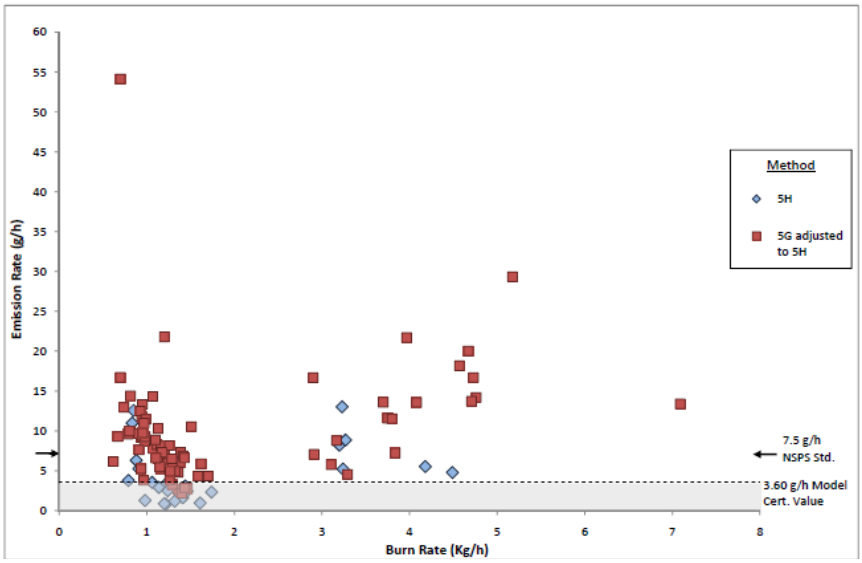

Figure 1. Variability in 5H Particulate Emission Rates as Compared to the U.S. EPA Certification Value. U.S. EPA NSPS Proficiency Testing Program (40 CFR §60.534) data show testing by eight laboratories with a single certified stove model (1993-2000) following NSPS Methods 28 and 5G or 5H. (Data courtesy U.S. EPA)

The results of the tests, as shown in Figure 1, illustrate the uncertainty in results between laboratories and within a given laboratory due to such factors as different equipment, different technicians, different ambient conditions, different fuel, and the fundamental precision of the tests. It is an often heard statement among accredited laboratory staff that wood certification testing is an "art" not a science.

Comparison of Particulate Emission Rates from the In-Home Use of Certified Wood Heater Models with U.S. EPA Certification Emission Values

The Hearth, Patio and Barbecue Association commissioned a study to assess the ability of wood heater NSPS certification values to predict field rankings among wood heater models and the degree to which they correspond to the magnitude of actual in-situ emissions for a given model. Published U.S. EPA certification values in units of grams/hour (g/h) were compared to measured 5H adjusted emission rates (g/h) for certified wood heater models. In total, 409 emissions tests from 85 wood heaters comprised of 41 certified models were reviewed. These data were obtained from all relevant studies that could be identified. To be considered valid a sample had to be for a certified wood heater model for which the certification value could be identified and the fuel species (or type), fuel moisture (% dry basis), and burn rate (dry kg/h) have had to been reported.

Emission data from in-home sampling programs plus laboratory studies designed to simulate in-home use of wood heaters were reviewed. Two sampling systems that have undergone U.S. EPA quality assurance reviews were used for the field studies included in this evaluation. These were the Automated Woodstove Emission Sampler (AWES) and the Virginia Polytechnic Institute (VPI) sampler. The data collected by the AWES and VPI sampler are the primary source of data for U.S. EPA's AP-42 emission factors for wood heaters. Laboratory measurements were made using either Methods 5G or 5H (40 CFR Part 60 Appendix A) while the heaters were operated in a fashion simulating in-home burning conditions. The methods used to convert AWES and VPI data to method 5H equivalent data were developed as part of the documentation for AP-42 Section 1.10 Residential Wood Stoves and were followed here. Laboratory programs measured emissions directly by method 5H, method 5G, or both. Where necessary, Method 5G values were converted to 5H equivalent values as per 40CFR Part 60 Appendix A. There were 208 valid AWES samples and 165 valid VPI samples in the database. In addition, there were 36 individual valid laboratory samples.

The AWES system was deployed in homes in Klamath Falls, OR, Portland, OR, Whitehorse, YK, Glens Falls, NY as well as other areas in upstate New York and Vermont. The VPI sampler was deployed in homes in Crested Butte, CO. The field studies were sponsored by the U.S. Department of Energy BPA, the U.S. Environmental Protection Agency, Environment Canada, Oregon Department of Environmental Quality, Wood Heating Alliance, CONEG Policy Research Center, and the New York State Energy Research and Development Authority. The in-situ samples were generally collected over a time period of approximately one week each.

Laboratory studies collected emissions utilizing either the U.S. EPA reference method 5G or 5H with the heaters operating as they would normally be operated in homes. The laboratory studies were sponsored by the U.S. Department of Energy BPA, the U.S. Environmental Protection Agency, and Environment Canada.

Figure 2 is a plot of the individual emission rates (g/h) determined for each of the 409 valid "real-world" samples versus the U.S. EPA certification values for each certified heater model. Figure 3 shows the U.S. EPA certification value for each heater model and the mean emission rate for each heater model averaged across all samples for that heater model. (Table 1 is a compilation of the same data.) As can be seen from Figures 2 and 3 and Table 1, there is no clear correlation between certification values and the in-situ emission rates and in most cases the magnitude of the emission rate for a given sample is larger than the certification value of the heater. The overall average of all 409 samples was 10.5 g/h as compared to the average certification value of the 41 certified heater models reviewed here of 3.9 g/h.

While the data set is imperfect, it is clear that certification values do not predict the "real-world" performance of certified wood heaters nor do certification values predict the relative ranking of certified wood heaters under in-home usage. When Figures 1 and 2 are studied, it is intuitively obvious that the database does not support the efficacy of promulgating lower, more health protective emission standards with the current NSPS testing procedures.

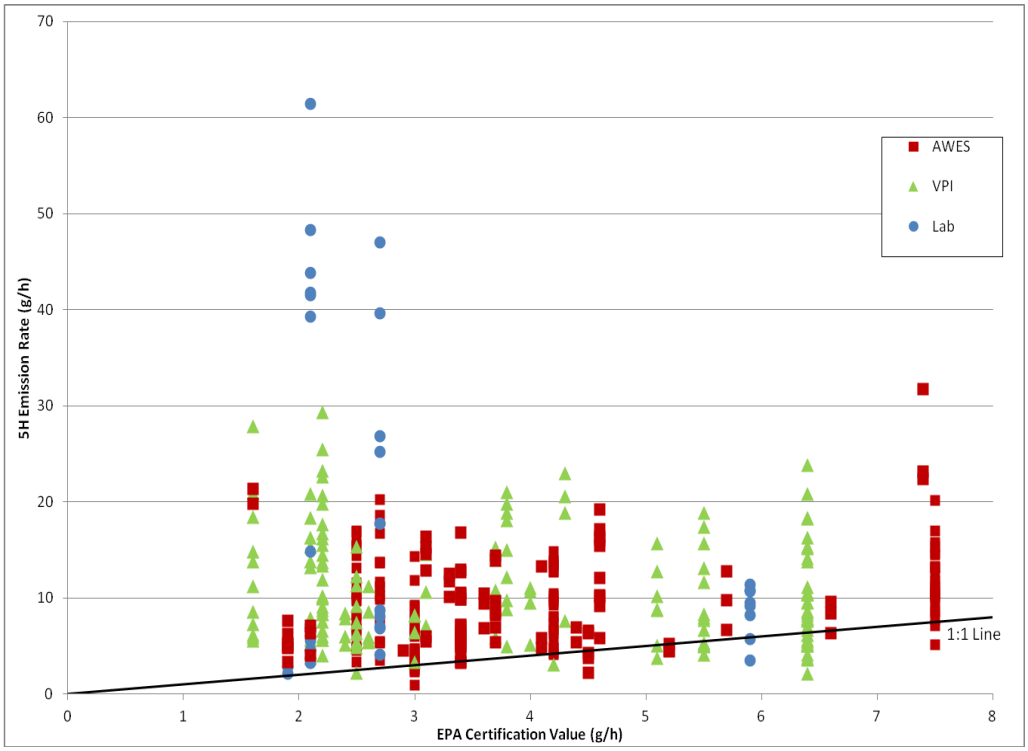

Figure 2. Emission Rates by Test Run versus EPA Certification Values for Heater Models . ("Lab" refers to tests conducted in the laboratory using consumer burn practices not EPA Method 28.)

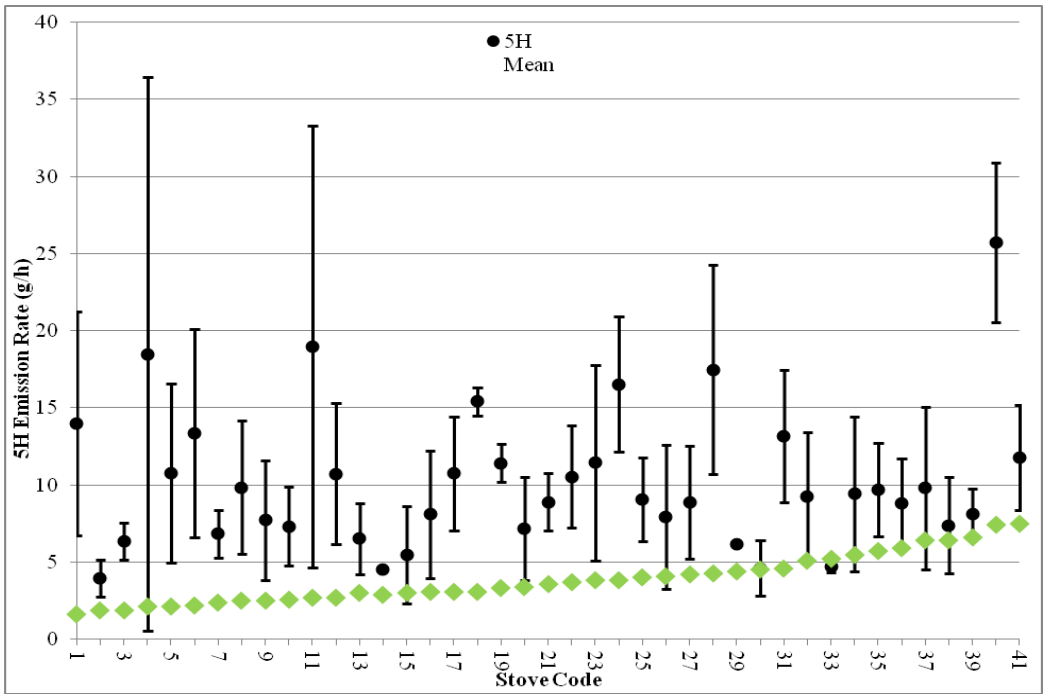

Figure 3. Mean Emission Rates, Standard Deviations around Means, and EPA Certification Values by Heater Model. (Each stove model was assigned a stove code. Green "diamond" symbol is the respective certification value for each stove model.)

Table 1
Mean Emission Rates, Standard Deviations around Means, and EPA Certification Values by Heater Model

Stove Code	EPA Cert. Value (g/h)	5H Mean (g/h)	S.D.	# of Stoves	Total Runs
1	1.6	14.0	7.2	4	13
2	1.9	4.0	1.2	2	7
3	1.9	6.3	1.2	1	3
4	2.1	17.0	18.8	4	22
5	2.1	10.8	5.8	1	12
6	2.2	13.4	6.8	5	27
7	2.4	6.8	1.6	1	4
8	2.5	9.8	4.3	5	24
9	2.5	7.7	3.9	1	11
10	2.6	7.3	2.6	1	5
11	2.7	19.0	14.3	1	11
12	2.7	10.7	4.6	4	19
13	2.9	4.5	-	1	1
14	3.0	6.5	2.3	2	4
15	3.0	5.5	3.1	5	27
16	3.1	8.1	4.1	1	3
17	3.1	10.7	3.7	1	3
18	3.1	15.4	0.9	1	3
19	3.3	11.4	1.2	1	3
20	3.4	7.2	3.3	6	26
21	3.6	8.9	1.9	1	3
22	3.7	10.5	3.3	4	15
23	3.8	11.4	6.3	1	4
24	3.8	16.5	4.4	1	5
25	4.0	9.1	2.7	1	4
26	4.1	7.9	4.7	1	3
27	4.2	8.9	3.7	6	24
28	4.3	17.5	6.8	1	4
29	4.4	6.2	-	1	2
30	4.5	4.6	1.8	1	5
31	4.6	13.1	4.3	2	10
32	5.1	9.3	4.1	1	7
33	5.2	4.7	0.4	1	3
34	5.5	9.4	5.0	2	14
35	5.7	9.7	3.0	1	3

Table 1 (cont.)
Mean Emission Rates, Standard Deviations around Means, and EPA Certification Values by Heater Model

Stove Code	EPA Cert. Value (g/h)	5H Mean (g/h)	S.D.	# of Stoves	Total Runs
36	5.9	8.6	2.8	1	8
37	6.4	9.8	5.3	3	34
38	6.4	7.4	3.1	1	3
39	6.6	8.1	1.7	1	3
40	7.4	25.7	5.2	1	3
41	7.5	11.8	3.4	5	24

Burn Rates, Samplers, Old Studies, and Outliers

The review essay attached to Mr. Kenworthy's December 5, 2012 letter criticizes the evaluation of real-world emissions on a number of bases. These include multiple samplers used to acquire data, the age of the studies, trends associated with burn rates, and the treatment of outliers. It should be noted that the review essay offers no additional new data to substantiate any of its assertions, only non-relevant statistical manipulations.

An evaluation of burn rates was not among the primary objectives of the study and their treatment, one way or the other, has little bearing on the key finding that the database does not support the efficacy of promulgating lower, more health protective emission standards with the current NSPS testing procedures. Because burn rates have been strongly implicated in impacting emissions from wood heaters and because burn rates were quantified in the studies from which the emission data compiled in the report were obtained, for illustrative purposes, burn rates were also presented in the report. It was noted in the review essay attached to Mr. Kenworthy's December 5, 2012 that "burn rates used were substantially different from the burn rates specified by EPA certification Method 28….." This is correct for two reasons: (1) the data are real in-home data and the fact they do not correlate with Method 28 data is part of the problem with certification values predicting real-world emissions, and (2) burn rates as calculated by Method 28 are determined differently than are determined by AWES and VPI samplers in the field. (Method 28 uses fuel mass change and the AWES and VPI samplers use temperature in the flue collar to determine burn duration). The issue with the later point has been given serious consideration in revision of the NSPS as the burn rate distribution in the Method 28 written procedure is based on AWES data, whereas its application is to burn rates determined by the Method 28 protocol making an "apples to oranges" scenario.

The review essay attached to Mr. Kenworthy's December 5, 2012 states as a major issue, "Data are from several studies that use different sampling methods, locations, testing protocols, testing locations, span many years…." This was intentional and is necessary to make a real-world unbiased database that encompassed all the relevant data. But this lack of homogeneity between many of the key data sets analyzed also necessarily precluded statistical analysis of the combine data set, a key point that the author of the essay completely ignores. In particular, a statistical treatment of the in-home data set cannot be performed in the fashion provided by the review

essay for two key reasons. (1) Four different sampler types were used to generate the database. Two of these samplers are described in methods in 40CFR Part 60 Appendix A and two underwent, along with their inter-conversion equations, EPA quality assurance review and data from them provide most of the basis for AP-42 wood heater emission factors. Even though data from the four samplers are credible and the best available, undoubtedly there are biases among the data produced by the different samplers. (2) The database is underdetermined in that there are nearly as many (perhaps more) probable sets of variables among the in-home use of wood heaters than there are tests. Demonstrating this variability and difference as compared to laboratory test results is the very point of the original evaluation. Ironically, a weakness in the evaluation is that data from too few locations were used not vice versa. More locations would have improved its representativeness. Finally, the study spanned from the time period immediately preceding the promulgation of the NSPS (1988) to within a few years of present – which is appropriate as that is the same time frame that most certified wood heaters have been manufactured and sold.

A concern about the treatment of outliers was noted in the review essay attached to Mr. Kenworthy's December 5, 2012 letter. As statistical analysis is not possible with the data set it is impossible to identify outliers in the database. Only valid data points were included in the database for the emission rate evaluation. Other than obvious data incompleteness there was no basis for removal or special treatment of any data. What is being confused as "outliers" is the large range of emissions characteristic of real-world wood heater used in homes. In contrast to the NSPS certification that uses specified size and shape of Douglas fir 2 X 4 or 4 X 4 lumber cribs with a narrow range of moisture, prescribed burn rates, hot start, specific draft conditions, etc., wood heaters in homes operate under a range of variables which makes the corresponding range of in-home emission rates large. This range in variables is the fundamental reason certification test procedures are not predictive of real-world emissions from in-home use. These variables include: (1) wood moisture, (2) burn rate, (3) the species of tree used for fuel, (4) wood fuel piece size and shape, (5) kindling practices and wood addition patterns, (6) chimney draft (chimney height, chimney condition, geometry of chimney, chimney connectors and chimney cap, home exhaust fans, e.g., kitchen, bathroom , clothes drier, air infiltration/tightness of home, and creosote accumulation), (7) the stove's condition (new versus various levels of wear), (8) wind gust creating pressure pulses, (9) elevation as it effects available oxygen for combustion, (10) barometric pressure as it effects draft (home elevation, and meteorological conditions), and (11) hot versus cold starts.