Operation and Fueling (O/F) Workgroup Meeting Notes from November 17, 2016 Teleconference

(Note: Voting Members are in bold-face)

Meeting led by **John Crouch** (HPBA, Co-Chair of O/F Workgroup) and **Lisa Rector** (NESCAUM, Co-Chair of Steering Committee)

Meeting Invitees (not necessarily all present): Bob Lebens (WESTAR, Co-Chair of Steering Committee), **Rod Tinnemore** (Washington) **& Phil Swartzendruber** (Puget Sound Clean Air Agency), **Marc Cohen** (Massachusetts), **Cindy Heil** (Alaska), John Wakefield (Vermont), **Lisa Herschberger** (Minnesota), Anne Jackson (Minnesota), **Randy Orr** (New York) **& John Barnes** (New York), Adam Baumgart-Getz (EPA OAQPS, Wood Heater NSPS Group Leader), Amanda Aldridge (EPA OAQPS, Wood Heater NSPS Lead), Stef Johnson (EPA OAQPS, Measurement Group Leader), Mike Toney (EPA OAQPS, Measurement Group), Bob Ferguson (Consultant to HPBA, President of Ferguson, Andors & Company), **Tom Butcher** (Brookhaven National Lab, BNL), Rebecca Trojanowski (BNL), Adam Bennett (BNL), **Gregg Achman** (Hearth & Home Technologies), **Allen Carroll** (Applied Ceramics), Rick Curkeet (Intertek), **Ben Myren** (Myren Labs), **John Voorhees** (US Stove), **Tom Morrissey** (Woodstock Soapstone), Dan Henry (5G3 Consulting), Mark Champion (Hearth Lab Solutions), John Steinert (Dirigo lab), Doug Towne (Dirigo lab), Gaetan Piedalue (Polytests lab), Jared Sorenson (OMNI lab), Sebastian Button (OMNI lab), Alex Tiegs (OMNI lab), Kelli O'Brien (ClearStak), Jeff Hallowell (Biomass Controls), Lee Mitchell (Applied Catalysts), Martin Morrill (Applied Catalysts), Jill Mozier (EPA contractor, meeting note taker)

Primary Conclusions from Meeting:

- To educate state regulators who may not be familiar with the method, Mike Toney reviewed EPA's Method 28 (M28) fueling and operational procedure for wood heater certification testing.

- The stringency of the M28 burn rate categories – the low burn rate category in particular – were discussed, including that such prescribed burn rate restrictions are not in European, Australian and New Zealand methods. The low burn rate category's effect on stove design was also discussed, as well as the possibility of moving away from prescribed burn rates to burn rates defined by the individual stove design. For example, instead of the prescribed 4 burn rate categories, it was noted that stoves could be tested at their highest and lowest settings (per the stove's individual design) as well as a couple medium burn rates in between the stove's high and low settings.

- The long "tail" of the test (which can be one-half the total test duration) was discussed and it was noted that this tail is a key mechanism in product design, not merely in terms of getting low emissions (for the g/hr metric), but also to get the required low burn rate under 1 kg/hr.

- The possibility of cutting-off the test at 90% fuel burned/consumed instead of 100% was discussed to shorten the test and still capture the bulk of PM emissions. The possibility of using a multiplier [on the PM limit/passing grade] to fairly judge PM test results from a 90% test was also discussed, due to the g/hr metric crediting longer test runs. Data is being collected with a TEOM currently that can inform such a "conversion/correction" or "equivalency" factor. This factor could theoretically be calculated from knowing how much PM is remaining (to be emitted between 90% and 100%) and how much time is left (to burn/consume that last 10% of fuel). It

was noted that industry has some sensitivity to this terminology. It was also noted that these are preliminary O/F workgroup discussions only and EPA would have to make the final determination as to whether such a method change and equivalency were supported by the data.

- Re-defining the low burn rate as how low the stove can be set [instead of increasing the method's lowest prescribed burn rate setting] was discussed. With such a redefinition, it was noted that the lowest burn rate becomes a design/manufacturing decision and avoids the design having to hit a target burn rate. The use of a tamper-proof stop to ensure that stoves could not be operated in homes at lower burn rates than tested at was discussed as a way of easing regulator concerns. It was noted that basing the method (e.g., burn rates) on design categories may be something regulators and industry can come to agreement on.

To-Do List:

- Regarding which topics to pursue as a workgroup first, Lisa Rector will draft a list of fueling and operational topics for John Crouch to review and edit. Lisa will put the list into a Survey Monkey and distribute the survey to the entire workgroup. The workgroup will rank order the list of operational and fueling topics both in terms of importance and ease/difficulty. The workgroup should respond to the Survey Monkey within a week of receiving it, so that the group may review the results in December.

Highlights from Meeting:

- Lisa Rector opened the meeting, noting that the objective of today's call is to discuss Method 28 (M28) and answer state regulators' questions regarding how M28 compares to other methods. Lisa noted that some lab folks are on the call as well as Stef Johnson and Mike Toney from EPA. Mike Toney will deliver the presentation on M28.

- Lisa Rector noted that the following people were in attendance at the beginning of the meeting: John Crouch, Bob Lebens, Gaetan Piedalue, Gregg Achman, Cindy Heil, Jeff Hallowell, John Barnes, John Voorhees, Stef Johnson, Lisa Herschberger, Randy Orr, Rick Curkeet, Rod Tinnemore, Mike Toney, Rebecca Trojanowski, John Wakefield, Dan Henry, as well as others who had not yet joined the call or who did not announce themselves.

- Mike Toney thanked everyone and noted that he would give a brief history of M28 which is a fueling and operational procedure for wood stoves, not a sampling and analytical measurement method for particulate. Mike noted that M28 began with a regulatory negotiation ("reg neg") between environmental groups, industry, and EPA and that it was executives from chemical manufacturing that originally pointed EPA to wood smoke.

- Mike explained that M28, published on February 26, 1988, includes multiple test runs with multiple burn rates (dry basis burn rate in kg/hr). M28 also includes how to set up the lab to monitor for PM. The fuel is crib wood, Douglas fir lumber C grade or better, in a combination of 2x4's and 4x4's depending on the volume of the stove. If the stove ("useable firebox") volume is less than 1.5 ft^3 then all 2x4 lumber is used. If the firebox volume is greater than 1.5 ft^3 but less

than or equal to 3.0 ft^3 then both 2x4 and 4x4 lumber is used, with about half the weight of test fuel in 2x4's and half in 4x4's. If the usable firebox volume is greater than 3.0 ft^3 then all 4x4's are used.

- Mike noted that Section 8 of M28 lists the Category 1, 2, 3 and 4 burn rates (in average kg/hr and lb/hr, dry basis) and further noted that in 1990 (2 years after the 1988 rule) the initial lowest category [Category 1 <0.80 kg/hr] went away. Mike explained that it was a phased approach that resulted in the requirement after July 1990 that at least one test run be conducted with a burn rate of 1.00 kg/hr or less. Mike noted that most test runs came in at 0.999 kg/hr, and so the burn rate became what it is today. Section 8.1.1.3.2 of M28 states that *After July 1, 1990, if a wood heater cannot be operated at a burn rate less than 0.80 kg/hr, at least one test run with an average burn rate of 1.00 kg/hr or less shall be conducted*.

- Mike noted that these are the 4 burn rates that must be achieved and that the required PM limit for non-catalytic and catalytic stoves were different under the 1988/1990 rule. Mike also noted that prior to testing catalytic stoves had to be operated for at least a 50-hour burn-in time, while non-catalytic stoves were required to be operated for at least a 10-hour burn-in time.

- Mike explained that M28 requires the stove to be installed on a platform scale with an insulated pipe (i.e., chimney with a minimum of 1 inch of "solid pack insulating material surrounding the entire flue"). Mike noted that 100% of the smoke must be caught at tip of the exhaust by the dilution tunnel hood [as instructed in Method 5G]. Thermocouples must be located within a vertically-oriented 6-inch-long and 2-inch diameter pipe shield (open at both ends). The lab's ambient/room temperature monitor must be located within 3 to 6 feet from the front of the stove. The lab temperature must be maintained between 65 and 90 degrees F during the test run. An anemometer must be used to measure the air velocity in the room before the pretest ignition period and immediately following test run completion. The lab's humidity (ambient relative humidity), barometric pressure and temperature must be measured before and after each test run. Mike noted that a blank sample train must measure pollution in the corner of the lab so that this pollution may be subtracted from the sample.

- Regarding the test fuel charge, Mike explained that once the test fuel load is established [the crib constructed outside the stove], the pre-burn charge ("pretest fuel charge") should burn for one hour and should consist of whole 2x4's (or a combination of 2x4's and 4x4's) that are no less than 1/3rd the length of the test fuel pieces, with test fuel pieces being 5/6th the length of the usable firebox (regardless of volume). Mike noted that he liked the single pre-burn of the ASTM method. Mike explained that the purpose of the pretest ignition period is to achieve uniform charcoalization of the test fuel bed prior to loading the test fuel charge. Uniform charcoalization includes small even pieces and is evidenced by the absence of large pieces.

- Mike noted that the moisture content of each piece must be measured 4 hours before the test and must be within a 19 to 25% moisture content range (dry basis). The test fuel is kept inside the facility in a controlled area to control the moisture content. Five-inch spacers are used and

non-galvanized nails must be used to attach the spacers to the test fuel pieces – that is, everything is uncoated to avoid polluting.

- Mike noted that Section 8.9 of M28 points to Method 5G as the sampling method. [Note: the 2015 NSPS points to ASTM E2515-11 as the sampling method. Method 5H is no longer allowed for certification testing.]

- Mike noted that enough pretest fuel should be used to allow one-hour of pre-burn. This can be adjusted if needed and the pre-burn may last longer than one-hour, but must be at least one-hour. [Note that M28 states the following: Set the air inlet supply controls at any position that will maintain combustion of the pretest fuel load. At least one hour before the start of the test run, set the air supply controls at the approximate positions necessary to achieve the burn rate desired for the test run. Adjustment of the air supply controls, fuel addition or subtractions, and coalbed raking shall be kept to a minimum but are allowed up to 15 minutes prior to the start of the test run … During the 15-minute period prior to the start of the test run, the wood heater loading door shall not be open more than a total of 1 minute. Coalbed raking is the only adjustment allowed during this period.]

- When the kindling and pretest fuel have been consumed down to between 20% to 25% the weight of the test fuel charge, the remaining weight should be recorded and the test run started. After loading the test fuel, Mike noted that the test fuel charge may be adjusted for up to 5 minutes before closing the door and adjusting the air supply inlets. Mike further noted that after that the test fuel may not be touched until 60% of the fuel has been burned, unless no weight loss has occurred for 10 minutes, in which case the door may be opened and the test fuel poked to re-ignite. [Note that M28 states the following: The wood heater door may remain open and the air supply controls adjusted up to five minutes after the start of the test run in order to make adjustments to the test fuel charge and to ensure ignition of the test fuel charge has occurred. Within the five minutes after the start of the test run, close the wood heater door and adjust the air supply controls to the position determined to produce the desired burn rate. No other adjustments to the air supply controls or the test fuel charge are allowed … [except that] …The test fuel charge may be adjusted (i.e., repositioned) once during a test run if more than 60 percent of the initial test fuel charge weight has been consumed and more than 10 minutes have elapsed without a measurable (<0.05 kg (0.1 lb) or 1.0 percent, whichever is greater) weight change. The time used to make this adjustment shall be less than 15 seconds… Secondary air supply controls may be adjusted once during the test run following the manufacturer's written instructions … No other air supply adjustments are allowed during the test run.]

- After the test run, Mike explained that the tester pulls the sampling train, analyzes the filter and then goes through the equations to convert from mg of PM catch to g/hr. Mike explained that Sampling/Analytical Method 5H was a direct sampling method not a dilution tunnel method [as Method 5G is] and employed no conversion factor like 5G used. Method 5H used injected gas to get velocity. Mike further explained that 2 filters are used (front and back) to get total PM. [Note that Method 5G states the following: The filter holders shall be placed in series with the backup

filter holder located 25 to 100 mm (1 to 4 in.) downstream from the primary filter holder.] Mike explained that under Method 5G a single train or double train may be used: 5G1 describes using one sample train, while 5G3 describes the use of a dual sampling train. Mike noted that the correction factor used for 5G1 and 5G3 were part of the negotiation (a bumping up of the numbers) and that most tests for regulatory purposes were done using Method 5G. [Note: Since promulgation of the 2015 NSPS, Method 5H is no longer allowed for certification testing and the correction factor which bumped up PM values measured by 5G is no longer used.] Mike noted that he would explain M28 further or answer any questions the workgroup may have.

- Lisa Rector asked if people not as familiar with M28 have questions to establish the differences between M28 and other methods.

- To clarify for the workgroup, Dan Henry commented that what Mike has shared is that M28 contains prescribed minimum burn rates that have to be met to meet the required burn rate categories in the method. Dan noted that the low burn rate category has to be below 1 kg/hr, the medium burn rate categories are between 1 and 1.25 kg/hr [for Category 2] and between 1.25 and 1.90 kg/hr [for Category 3], with the maximum burn rate [Category 4] being whatever the high burn is [for that stove] over 1.9 kg/hr. Dan further noted that the strict 25% fuel weight requirement also makes it a much more restrictive method than the EN, Australian and New Zealand methods. This is why these people [e.g., from Europe, Australia] would come to the US and fail the M28 requirements, Dan concluded. Lisa Rector noted that Dan raises some good points and with the remaining time on this call perhaps the key components that are differences in the various protocols/methods could be overviewed.

- John Crouch noted that people in the workgroup may need more from Mike Toney. John asked Mike to explain what happens on the back end of a test. He asked Mike to explain how one knows that the test is over. John commented that, when the metric is g/hr, the length of time of the test is fundamental due to this metric. John further noted that with new methods, he sometimes hears folks advocating things they don't understand regarding the metric. John also asked Mike to discuss what the lab does after the fire is over.

- Mike Toney explained that the end of test is when test fuel weight gives a 0 reading or no difference/no change in the test fuel weight for 30 seconds, whichever is less. Mike noted that this is the end of the test. [Note that M28 states the following regarding Test Run Completion: Continue emission sampling and wood heater operation for 2 hours. The test run is completed when the remaining weight of the test fuel charge is 0.00 kg (0.0 lb). End the test run when the scale has indicated a test fuel charge weight of 0.00 kg (0.0 lb) or less for 30 seconds. At the end of the test run, stop the particulate sampling, and record the final fuel weight, the run time, and all final measurement values.]

- Mike continued that after the end of the test, the lab cuts off the sampling pumps and records the end sample volume. Mike noted that this end sample volume is critical and is needed or the whole test is blown/failed. Both the initial sample volume and the end sample volume must be collected. In addition, the surface temperature of the stove must be recorded from temperature

monitors located on the left, right, back, bottom and top surfaces for a total of 5 temperature monitors. If there is a catalyst, Mike noted that there also must be a thermocouple 1 inch behind [downstream of] the catalyst. Mike explained that these temperatures are averaged together and must stay within a range prescribed by M28. [Note that M28 states the following: The average of the wood heater surface temperatures at the end of the test run shall agree with the average surface temperature at the start of the test run to within 70 C (126 °F).]

- Next, Mike explained that the sampling train is removed and inspected for leaks. If a leak is discovered, the data must be adjusted. The filter is taken from the filter assembly, weighed, and then desiccated until a stable weight is reached. Mike noted that the lab has already recorded the initial weight prior to the test. Once a steady filter weight is reached, the lab subtracts the difference and this difference is the PM catch.

- Mike noted that the calibration of the meter box must be reviewed and the appropriate calculations performed with the provided equations. Mike noted that if Method 5G3 is being used, then the two trains are compared and must be within 7.5 percent of each other. [Note that Method 5G states the following: Calculate an emission rate [with provided equations] for the sample from each sampling train separately and determine the average emission rate for the two values. The two emission rates shall not differ by more than 7.5 percent from the average emission rate, or 7.5 percent of the weighted average emission rate limit in the applicable subpart of the regulations, whichever is greater. If this specification is not met, the results are unacceptable. Report the results, but do not include the results in calculating the weighted average emission rate. Repeat the test run until acceptable results are achieved, report the average emission rate for the acceptable test run, and use the average in calculating the weighted average emission rate.]

- Regarding the weighted average calculation/proportionality, Mike noted that the [sample flow rate] measurements taken within 10-minute sampling intervals must be within 10%. [Note that Method 5G states the following: The proportional rate [PR] variations shall be calculated for each 10-minute interval by comparing the stack to nozzle velocity ratio for each 10-minute interval to the average stack to nozzle velocity ratio for the test run. … If no more than 10 percent of the PR values for all the intervals exceed 90 percent ≤ PR ≤ 110 percent, and if no PR value for any interval exceeds 80 percent ≤ PR ≤ 120 percent, the results are acceptable. If the PR values for the test run are judged to be unacceptable, report the test run emission results, but do not include the results in calculating the weighted average emission rate, and repeat the test run.]

- Mike further noted that all math must be double-checked. Then beakers are cleaned and the probe weighed. This post-run work must be performed meticulously and the calculations checked. The results are sent to the manufacturer who sends the results onto the regulator, or the lab may send the results directly to the regulators [per manufacturer instructions / permission].

- John Crouch remarked that everyone who has sat through a test has been there at the [long] tail end of a long test. Mike agreed, noting that the length of the test is related to the stove combustion's specific combination of time, temperature and turbulence ["the three T's" of wood combustion]. Mike noted that some test's [emission results] will barely get in [that is, barely meet the limit], but a long tail [a longer test time] can result in emission results meeting the limit [because the g/hr metric of the limit has time in the denominator]. Mike further noted that sometimes the test fuel will suddenly drop and emit more PM, which can also cause a test failure. Other times, the fire may go out. But Mike noted these are not generally problems in a well-designed test. John Crouch concluded that stoves may inadvertently fail [an M28 test] for many different factors.

- In response to Ben Myren noting he had a comment regarding cordwood testing, John Crouch suggested that the discussion stay focused on M28 with a goal to ensure people understand the acronyms and terms. John suggested the workgroup discuss the way stoves have been tested for 30 years and wondered what else would be useful to flesh out from what Mike Toney had mentioned. John suggested the additional blanks required to capture additional parameters be discussed, including the time required currently to process all the required measurements.

- Rick Curkeet explained that when the test run is over there are 2 hours' worth of work in just recovering filters and doing calibration post-test quality tests. The process is not complete until 24 to 48 hours after the test, due to the drying process required for the filters. However, Rick pointed out that typically by that point the lab is onto another run, because by then it is known if the first run was a valid test. Rick noted that it's a difficult process which takes a full week if the testing is going well. If tests need to be repeated, it is hard to find the time within the schedule, although invalidated or failed tests are a fact of life. Rick estimated that less than 25% of the time are there no issues in those 4 runs. Regarding the tail out of the test, Rick noted that it is important to understand that this is the key mechanism in product design – not merely in terms of getting low emissions, but also to get to low burn rates under 1 kg/hr. Rick further noted that it's a pretty intentional feature in design to get to low burn rates. The long duration is also needed to get back to 0 weight with enough time to get burn rate into the required range. Rick explained that one of the reasons additional tests are often required is that it is difficult to predict what burn rate will result, especially at the low setting. If the burn rate comes in just above 1 kg/hr, then the lab must still run 2 tests at Category 2 and will need to run a 3rd test to get down to Category 1. Rick noted that the new NSPS M28R [that is, the revised Method 28] refers to ASTM E2780 but EPA requires the same 4 burn rates [as in M28]. Therefore, the test process for the current NSPS is virtually identical to the original M28.

- John Crouch noted that he personally has had experience with a large catalytic stove failing the delta T [change in temperature restriction]. John asked Rick to explain for the workgroup why that delta T restriction was in the original method and what is was designed to address.

- Rick Curkeet explained that the temperature change criteria in M28 was intended to prevent a process whereby the pre-burn and charcoal bed building would be run at a high rate to heat up the stove (fire bricks) as much as possible, to provide the best temperature for light-off at the

start of the test run. The temperature change limit is meant to reign in high starting stove temperatures by instituting a 125-degree limit which would be exceeded if the stove was heated up too high at the start of the test. [Note that M28 requires the average wood heater surface temperatures at the start of the test run and at the end of the test run be within 125 F of each other.] Rick continued that this prevents manipulation by overheating at the beginning of the test to get better [emission] numbers. Rick explained that the temperature of the stove is very directly related to the mass of the stove. So, big stoves change less in temperature simply because they store more heat compared to light weight stoves. Rick noted that one couldn't aggressively overheat light weight stoves since the stove must be run for 1 hour at the test setting and light weight stoves would cool off quickly enough. Therefore, the tactic [of overheating a stove at the start of the test] couldn't be used for light weight stoves. But heavy massive stoves can generate a lot of heat for a longer period. The delta T [temperature change limit] was meant to prevens this.

- John Crouch noted that this issue was thought to be important in the 1980s. John asked Rick if he could think of another issue that was thought to be important in the 80s, but which turned out to be a non-issue in practice.

- Rick Curkeet noted that there were a lot of judgments made [in the 80s] without substantial-enough data to support [those judgments]. It was a negotiation process with lots of compromising based on what people thought would help, hurt, or make a difference, but Rick noted that he couldn't make a list of all those issues. Rick opined that the test method is the way it is because everyone wanted the fuel crib to be identical from one test to another and from one lab to another. Everyone agreed that Douglas fir crib would make the test reproducible, but this was not a good assumption, according to Rick.

- Mike Toney offered another example [of an issue in the 80s that has become a non-issue]. Mike noted that Shelton labs had a pressure chamber and it was thought that stoves were dirtier at high altitudes. This was a controversy as EPA had an altitude adjustment factor [in the 1988 rule]. EPA performed tests at a high altitude (on Mount Mitchell) and did not find much of a difference in emissions. Then a second study was performed in Crested Butte, Colorado at an altitude of 9,300 feet with the same batch of stoves. These stoves could not meet the high burn rate because they were oxygen starved. EPA took out the altitude correction factor [in the 2015 NSPS] and that issue went away, and the pressure chamber went away.

- John Crouch asked Ben Myren if he could think of other issues and Ben replied that he couldn't think of any issues beyond the ones mentioned. John noted that you can't understand a method fully unless you run it all the way through. John further noted that, as Rick Curkeet explained, a lot of work begins once the meter is turned off [i.e., once the fire is out in a test run].

- Lisa Rector noted that the g/hr metric of the standard is important. Lisa asked the labs on the call how long in terms of total test duration does it take to go from 90% to 100% [of fuel consumed].

- Ben Myren noted that the answer will depend on stove size and on type of stove. For a catalytic stove that's burning on low with a burn rate of ~0.7 kg/hr, it could take an hour or more to go from 90% to 100% [fuel consumed]. For a non-catalytic stove, that time will be less (with the stove trying to squeak under a 1 kg/hr burn rate). Therefore, Ben concluded it is very specific to the stove type.

- Lisa Rector noted that her sense is that another important point is that the burning time is not a linear progression/relationship – that is, that the duration to burn that last 10% or 20% [of fuel] is much longer than the first 10% to 20%. Rick Curkeet agreed, noting that the last 10% to 20% could represent half of the test duration. Lisa noted that one-third to one-half the test duration is important/significant. Cutting the test at 90% would also change how the standard is determined. Lisa concluded that, the impact on calculating the passing grade must be understand when considering cutting the test off at 90%.

- John Crouch agreed and noted that conversely, in terms of creating a real-world test, with some stoves generating 7 or 8000 BTUs, the consumer would have re-loaded before reaching that tail end. John opined that M28 is a test from the 80s and lots of stuff that was deemed important then may not be. John noted, for example, that he doesn't run his stove at four discrete burn rates. Rather, he reloads it. John noted that stakeholders are stuck with the g/hr standard. If Oregon had not been adamant and instead there was a g/kg standard, most emissions could be captured during the first part of the test.

- Lisa Rector noted that there are good reasons to cut off the test [at 90% of fuel consumed], but a recommendation is needed regarding what an equivalent passing grade would be for stoves [under the new shortened test duration].

- John Crouch noted that Mike Toney had touched on an issue that people may not appreciate the importance of – that is that the equivalency between Method 5H and Method 5G is based on 4 data points. John explained that basically there were two datasets and there had to be a way to relate them to each other. Once this equivalency factor was chosen and frozen, it had unintended consequences. Mike Toney explained that Equation 5G-4 in Method 5G is the conversion which takes the emissions from Method 5H raised to a power of 0.83 and multiplied by the constant 1.82 to obtain the 5G emissions. Mike further noted that he likes that there is no correction factor in the ASTM method.

- John Crouch noted that Dan Henry was a manufacturer during this period and asked Dan to describe the impact of the conversion/correction factor. Dan replied that this had a big impact, in that the correction factor between 5H and 5G put Dan in the position of not certifying anything using 5G because it essentially results in a penalty. Dan opined that the correction formula was inaccurate, that the methods were compatible. However, since the correction factor would increase the certification number [that is, increase the calculated PM emission rate], Dan elected to test using the direct stack method [in Method 5H] not the dilution tunnel method [in Method 5G].

- John Voorhees explained that the correction factor is not linear and no one imagined stoves would become so clean. John explained that the correction factor was a penalty at low PM emission rates. Dan Henry noted that as a result of the reg neg [compromises], two numbers diverted rather than came together at 0, which makes no sense.

- Lisa Rector noted that she understood that the 5H-to-5G conversion factor resulted in a penalty, but currently she is instead suggesting that manufacturers might get a multiplier. For example, using random numbers for illustration purposes, Lisa noted that perhaps if a test stops at 90%, the passing grade/limit becomes 10 instead of 2. Lisa noted that [legally] any conversion factor cannot make the standard more stringent. Therefore, if the test method is going to increase the number [PM emission rate] then a multiplier would need to reflect that in a calculation. Lisa further noted that, if an equivalency/correction factor is not going to be employed, the new cordwood method might as well stick with 4 burn rates. John Crouch noted that he understood what Lisa was saying, but wanted regulators to understand why industry's hackles go up at the mention of "correction factors".

- John Voorhees suggested that, with a new method, there needs to be a paradigm shift. The history can't really inform the new method, nor should an equivalency factor be used. Rick Curkeet agreed, noting the difficulty with using g/hr units as if that's the proper way to categorize emissions. Rick noted that he's argued for years that removing the influence of this variable can be accomplished easily by switching to g/MJ or lb/BTU. Rick further noted that emissions relative to heat output is a fair way to compare all units – from woodstoves to boilers. Rick explained that the g/hr metric is heavily influenced by how long it takes to burn the last 10 to 15% of the fuel, while relatively no emissions are being produced [during this tail end period].

- Mike Toney suggested for Lisa that a Method 5G sampling train could be run (sample trains A and B) with Douglas fir at any burn rate from beginning to end. Then when trains A and B are burned to 90%, a 3rd sample train should be started. Mike also suggested that a 4th train could be run that starts at the beginning and ends at 90% [of fuel consumption] in addition to the previous 3 trains he suggested. Lisa agreed, but noted that this could also be calculated currently with the TEOM data [being collected under Mark Champion's current EPA-funded testing] since the TEOM takes data measurements every 15 seconds.

- John Crouch noted that the point is, there won't be much PM produced at the tail end. Lisa agreed that this is the dataset needed – that is, at 90% how much emissions are left and how much time is left. Lisa noted that these are the 2 numbers needed to get the equivalency. John again noted that industry people tense up when the term "equivalency factor" is used, but also noted that discussing the term/lingo at this point is getting too far into the weeds.

- To close the loop, Adam Baumgart-Getz suggested that what Lisa is saying and what the conversation has been circling around is the following: With the TEOM data the emissions at 90% are known and what the emissions are/would have been at 100% is also known. There may be reasons the stakeholders would prefer to not go the way of a conversion factor [or call it

that], but the point is that we currently have the ability to look at the data in a straightforward way.

- Lisa Rector noted that she appreciated John Crouch raising industry's sensitivity to equivalency or correction factors. This sensitivity is helpful for the workgroup to understand as it moves forward.

- John Voorhees clarified for the group regarding the Category 1 burn rate, that this low burn rate is actually defined as under 0.80 kg/hr. The stove may alternatively be tested under 1 kg/hr, but the tester must first prove that the stove cannot get down under 0.80 kg/hr. John pointed out that this is one more testing requirement that must be done. Mike Toney confirmed this was the case under M28. Lisa Rector noted that she's only seen summaries and asked if there are failed runs, showing that the stove couldn't get below a burn rate of 0.8 kg/hr. John Voorhees replied that they are not failed runs per se, but the tester does have to prove that the run on the lowest setting is under 0.8 kg/hr or between 0.8 and 1.0 kg/hr. Rick Curkeet explained that there are two options: try to get under 0.8 kg/hr and show that the fire went out or do the run twice and prove the fire went out twice.

- Rick noted however that if the stove has a fixed tamper-proof stop, as long as the run comes out under 1.0 kg/hr it is considered a valid test. (Rick clarified that in the case of stoves with tamper-proof stops, the tester need not prove that the stove cannot get below 0.8 kg/hr, as is necessary on stoves that don't have such a tamper-proof stop.) Lisa asked if Category 1 is typically the lowest setting on the stove. Rick Curkeet replied that yes, almost every manufacturer went to fixed stops on their stoves to avoid having to pay for 2 tests to prove that the stove couldn't get below 0.8 kg/hr.

- Lisa Rector asked what happens with stoves with lowest burn rates above 1 kg/hr. Rick replied that these stoves cannot get certified and must be redesigned.

- John Voorhees noted that in the US it's a technical issue, rather than a marketing issue like it is in Europe. John noted that often a European stove will do well [under M28 testing] in its tiny version, but in its medium version it can't meet [M28's low burn requirement] and has to get thrown out. Rick agreed, noting that European stoves often cannot burn under 1 kg/hr. Ben Myren noted that the same is true in Australian and Kiwi stoves. John Crouch agreed, noting that the Australia and New Zealand methods do not have low burn rate [requirements].

- Lisa Rector noted that there is tension regarding where the regulators are and where industry is, in terms of this aspect of the test method. Lisa explained that when regulators hear a suggestion that the Category 1 burn rate should be increased, there is a concern that the stove can operate [in homes] at a lower burn rate then tested. In the beReal protocol, the low, medium and high settings are determined by how the stove is designed, rather than by prescribed burn rates. There was general agreement with this. Lisa noted that this [beReal approach] solves a number of issues, while increasing the prescribed EPA/M28 burn rates up to 1.15 kg/hr doesn't preclude stoves from being able to be burned lower [in homes]. Lisa noted that [instead of increasing the

lowest prescribed burn rate setting] if the low burn rate is defined as how low the stove can be set, the lowest burn rate becomes a design/manufacturing decision and it also avoids the design having to hit a target burn rate.

- John Voorhees agreed with Lisa, noting that the lowest burn rate should be whatever that stove can get down to.

- Regarding the 4 burn rate categories, Lisa suggested that perhaps there be a High (highest setting) and then Low (lowest setting) and then a couple medium burn rates. Lisa further noted that the workgroup needs to hear how EPA could handle that. This workgroup needs to identify these issues and then hear from EPA regarding what the Agency needs.

- Mike Toney offered that perhaps a stove can burn medium low, medium high and high, but low is set and tamper proof and that low is above 1.0 kg/hr. This means the stove would be burning hotter, although not as long. Mike noted that the industry might drive itself – that is, industry will seek to design a stove that can burn at lower settings in order to beat the competition.

- Lisa Rector noted that she couldn't speak for all agencies, but the concern [for many regulators] in moving the low burn category up [to a higher number defining/prescribing the low burn rate] is that the stove could go still go lower [in homes]. But, if the low burn category is defined by settings on the stove rather than a prescribed burn rate, then that addresses these regulators' concern. Mike noted that if the manufacturer puts a mechanical stop in, then the stove would always burn there [no lower]. Lisa noted that if the new test method sets things up so that low is the lowest setting that the homeowner can operate the stove at, and if that's 1.2 kg/hr, then regulators would still need to discuss it. But, Lisa noted she thinks that would address some of the regulators' concerns. Lisa concluded that basing things [in the method] on design categories may be something regulators and industry can come to agreement on.

- Mike Toney noted that if a stove has a slide and a stop on the right [setting the high burn rate] and a stop all the way to the left [setting the low burn rate], and if one is trying to chase burn rates, lots of money will be spent chasing those burn rates. Rather, Mike suggested that the medium burn rate be defined as whatever is right in the middle. John Voorhees noted that it's more of a design thing, since air is not linear – there's the high setting and the lowest setting and like Lisa said between 40% and 60% of those two runs is the medium burn rate. This medium burn rate may be 1 inches or 2 inches [open on the air setting], but it would be prescribed in the owner's manual or marked on the stove. John Voorhees noted that Lisa hit on it – that the medium burn rate is defined by whatever position that is and then this position is designated in the owner's manual so that the consumer can operate the stove correctly.

- Lisa noted that the workgroup has some key issues to circle back to – key aspects that are handled differently by different methods – with the opportunity for the workgroup to rethink how improvements might be made when moving to an alternative compliance method. Lisa noted that discussing how burn rate categories are defined is important.

- Lisa further noted that she would like to run through some of the key items that the workgroup needs to discuss and how those items should be ordered for further discussion. Lisa has a list of some key topics – for example, how to define burn categories, species questions – and she wondered if she could list them and then the workgroup could discuss what issues to dig into first. Lisa noted that this group will need to dig in, lay out different topics, how to order them, and then move forward. John Crouch agreed, noting that Lisa was speaking of the short list that he and Lisa had discussed in the past.

- Lisa noted that this short list included both fueling and operation topics. Regarding fuel, the topics included species, moisture content, piece sizing, bark, fuel load weight and load configuration. On the operational side, the workgroup needs to think about how to define what a test run is (which is different in different methods such as M28, EN, beReal, as the workgroup has learned). Options include steady state, single point of operation versus a more operational protocol like beReal. Topics to discuss include when does the test end and what are the burn rates. Lisa asked the workgroup how to proceed and if there were topics that needed to be addressed first.

- Ben Myron suggested that Lisa put the list out to the workgroup and have people prioritize the topics. Then Lisa could tally up the results to determine how to proceed. Ben noted that industry and labs may have one perspective and regulators a different perspective, but everyone could vote on the order/ranking.

- Lisa agreed Ben's was a great idea and offered to set up survey monkey. Lisa explained that the survey will be somewhat anonymous and it will ask respondents to list topics and rank order them. Ben agreed with this plan.

- John Crouch noted that Lisa's list boils down to 2 major topic groups – (1) fuel issues and (2) operational issues. John asked Rick and the lab folks if all the topics generally cluster into those two groups. Ben agreed they did. Lisa noted that some subtopics have been identified within those 2 major groups, but this is a way to move the workgroup forward and come to agreement on recommendations for moving forward.

- John Crouch noted that an important question to be part of the survey monkey is to rank order them. The ASTM group found that procedural/operational questions looped back into fuel questions and vice versa. But if the goal is to make the method more consistent with homeowner operation, John noted that he thinks the workgroup should start with operational not fuel questions, noting he could be wrong.

- Lisa suggested that workgroup respondents rank the topics in order of importance and rank in terms of ease, noting that all topics are hard but some topics are harder than others. Lisa noted that that way the survey provides a dual factor analysis – how hard and how important. Lisa noted that she would draft the list and send out the survey monkey after John reviewed her draft list. The next call is December 15th which allows plenty of time to do the survey monkey after John and Lisa talk first.

- Lisa asked if there were other topics to discuss and Rod Tinnemore noted that he had e-mailed a question on the chat feature of the presentation. The question is does M28's low burn include a tail or a new load at the beginning of the low burn to represent an overnight burn.

- Ben Myron noted that the M28 process is to establish a coal bed, load the test fuel on top of the coal bed and then burn up the test fuel load. Under the M28 protocol, nothing [no additional fuel] is added during that test. The tester can adjust [e.g., open door and poke] once after 5 minutes and when 60% or more is burned and the fire is in danger of going out. That's all that is allowed.

- Rod asked if the ASTM protocol follows the same general approach, so that it too is not capturing an end of day burn for overnight. Ben replied that the ASTM draft CTM is the same as M28 in this regard – that is, that the tester can't do anything to the fuel load after adjusting the air settings, until 60% is of the load is burned out and the fire is in jeopardy of going out. Nothing is added to the load, rather the tester just lets it burn.

- John Crouch noted that the low burn test was designed to mimic an overnight test and wondered why Rod thought it wasn't doing that. John noted that the low burn test starts with charcoal after a 1 hour pre-burn. The charcoal bed is raked and then the meter is turned on before the fuel is loaded. The door can be cracked for 5 minutes (and John noted that this is not unreasonable) and then the tester can't mess with the stove. So, John concluded that the low burn was designed to mimic an overnight burn.

- Lisa noted that, as John Crouch pointed out earlier, consumers will add fuel before getting back down to 0 weight. M28 and other methods (except for beReal) don't mimic this consumer behavior. Lisa noted that with her wood stove she doesn't put in a fuel load and burn it down to nothing. Rather she will burn it down to something and then add more wood. That's an operational characteristic that isn't captured in the current method. Lisa noted that this is typical operation, but the question is how important is that operation for emissions and design.

- Ben Myron noted, regarding the cold-start high burn under the draft ASTM CTM, that when the measurement of the high burn begins on top of the kindling, the bed is not anywhere close to charcoal. There is still a lot of burning wood in the firebox. John Crouch pointed out that in terms of M28 however, there is a robust charcoal bed and the low burn is meant to mimic an overnight burn with a long, long tail.

- Lisa asked Ben if he wanted to make his earlier point about cordwood and Ben replied that he would hold off until the workgroup gets into the weeds of the method. Ben will raise these issues again. Ben noted however that one thing the workgroup will find out regarding cordwood is that the two methods are extremely different – methods for crib wood versus cordwood are very different. Ben opined that M28 cannot be used on cordwood.

- Lisa thanked Ben for his comments and noted to John Crouch that she would draft something up in a Word doc and send it to John, then put the final version in a Survey Monkey and e-mail it out to the entire workgroup. Lisa noted she would get that done this week, since she is out next week. This will give everyone a week to answer. Then the workgroup can review it in December. John noted that he would turn-it-around as soon as he sees it.

- Happy Thanksgiving to everyone. **Meeting adjourned.**