EPA Notes Steering Committee Meeting May 26, 2016 Teleconference

Meeting led by Lisa Rector of NESCAUM

Meeting Invitees: Lisa Rector (NESCAUM), Bob Lebens (WESTAR), Rob Kaleel (LADCO), Mary Uhl (WESTAR), Arthur Marin (NESCAUM), George Allen (NESCAUM), Rod Tinnemore (Washington), Phil Swartzendruber (Puget Sound Clean Air Agency), Cindy Heil (Alaska), Dave Shephard (Vermont), John Wakefield (Vermont), Lisa Herschberger (Minnesota), John Barnes (New York), Marc Cohen (Massachusetts), Jack Goldman (HPBA, President & CEO), Ryan Carroll (HPBA, Government Affairs Director), John Crouch (HPBA, Public Affairs Director), 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), Jill Mozier (EPA's Contractor, Meeting Note Taker)

Primary Conclusions from meeting:

- In order to make timely progress on the considerable amount of work before the Fueling/Operational Workgroup, it may make sense to break this group into two parallel-tracked sub-groups: an Operational WG and a Fueling WG. These WGs could then present summaries to the Steering Committee regarding recommendations. This would allow experts in one area (e.g., in forestry products) to contribute their expertise in a more efficient manner. On the other hand, breaking the group into sub-groups presents a management challenge. The best course of action will be decided upon next week by the Steering Committee, after input from Lisa Rector (NESCAUM) and John Crouch (HPBA).
- It was agreed that to gain wider perspectives and keep all stakeholders updated, the group could ideally present status updates to stakeholders not directly involved in these meetings and groups, such as small manufacturers and environmental groups.
- It was agreed that it would be helpful to hear presentations from groups who already have been involved in such work – such as the ASTM and European "BeReal" test method efforts.
- Lisa invited HPBA to join the discussion again next week.

To-Do List for group before next call:

- Lisa and John will teleconference individually and discuss prioritizing the list of items for the Fueling/Operational Workgroup(s) to address and present their resulting list of priorities to the group next week;
- Lisa and John will also discuss the pros and cons of breaking up the Fueling/Operational Workgroup into two sub-workgroups;
- HPBA will confirm names to participate in the Fueling/Operational Workgroup(s) and present these names to the Steering Committee next week;
- Lisa will convert the Fueling/Operational items in the PowerPoint slides into a Word document list, and e-mail this document to the group, to better guide discussions;
- Lisa will e-mail bios of the experts on the PM Measurement Method Workgroup [Lisa e-mailed this to the group on 5-27-2016]; and
- Regarding HPBA's desire to be included on the Steering Committee, Lisa will draft a document for the regulatory people to review and okay, and then distribute to the entire group next week.

Meeting Highlights:

- Lisa noted that the purpose of today's meeting would, in addition to hearing back from HPBA regarding names for inclusion in the group, be more of a brainstorming exercise following up last week's meeting. The brainstorming would focus on the Fueling/Operational Workgroup (F/O-WG), in order to expedite getting that WG going. Lisa noted also that the Steering Committee (SC) should also think of remaining questions, so next week's meeting can be a meeting in which decisions are made.

- Lisa asked HPBA for their initial thoughts based on last week's meeting. Jack Goldman referred to his comments at last week's meeting and noted concern about getting this work done on a schedule (which might be useful for the 2020 standard), as the schedule and scope seems ambitious. John Crouch concurred and noted that we have to get moving quickly, given the aggressive timeline and scope. He further noted that the SC should be prepared for the eventuality that the F/O-WG may ask for revisions to the scope or for more time. John clarified that, regarding the slides from last week, there are lots of thorny issues in this process. The original method was probably prepared by a couple people in Oregon in the mid-1980's. So [the F/O-WG mission] is really foundational. Ryan Carroll concurred.

- Lisa agreed that the list of issues for the F/O-WG is large and wondered if that WG is really two WGs – a Fueling WG and an Operational WG. Perhaps a Fueling WG could focus on species, size, and other fuel-specific issues and then another WG could focus on the rest [operational piece]? For example, Lisa suggested the WG may want to bring in forestry people, who won't want to discuss the operation of the device, but would bring expertise regarding species, etc. Or, instead of making two WGs that each report to the SC, is it one WG that divides and then comes back together again [before reporting to the SC]? Lisa agreed that the SC needed to prioritize the list and possibly segment the F/O-WG further.

- John noted that there were months spent on [such issues] during the ASTM process. However, he pointed out that, with more WGs, it may be harder for the States to remain involved in the process. He would like the States to understand and be comfortable with the process and that might come from being involved "in the weeds" – so they have some comfort with the decisions which will be made. It may be that the States want to or can only be involved at the SC level, but there is a real trade-off to that. He noted that there can be excruciating level of detail, but the devil is often in the details. Lisa noted that this is a good question for the States – that is, balancing the benefits of participating with their expertise/comfort zone.

- Lisa asked the group if they want to separate the F/O-WG into separate but parallel tracks, noting that there were pros and cons to each approach and not necessarily a right answer. John concurred. Lisa further noted that, even if we separate the groups, it's a huge amount of work. Therefore it's important that we go through the list and prioritize. Lisa suggested that she capture the items in last week's PowerPoint presentation into a Word document in order to create a process flow. Even if this is not exactly a prioritization, a process flow can organize the discussion in a way that makes sense with the process. John agreed this would be helpful.

- John further noted that there may be some people better prepared to speak about process and others more interested in outcome. The outcome people may help with prioritization, as we still need to know what the priorities are. He elaborated that we partially know through sidebar conversations what the priorities are for some individuals, but we need to actualize these into a list for the whole group. Lisa agreed and asked others to voice their opinions.

- Cindy Heil noted these ideas are productive and suggested that someone should just start laying things out – breaking the WG into two or even more groups. She recognized that [more groups] may make it more difficult to keep everyone apprised of what is happening, but the end goal is timeliness. Breaking apart [the F/O-WG] and then bringing it back together will allow timeliness, even if we can't all be involved in every call. She further suggested that everyone could be kept apprised of happenings via summaries. Cindy therefore concluded that the WG should be broken apart, recommendations should be obtained regarding what people should work in each sub-WG, and then the work should begin [ASAP]. John concurred.

- Lisa suggested that, in order to get the process started, she and John Crouch could discuss priorities first and then present their resulting list of priorities to the group. John agreed. Lisa concluded that she and John have the homework of bringing to the SC a straw proposal for moving forward with the WG[s].

- John added that the [original] process had envisioned one recommendation. But the WG[s] may want to hold a webinar presentation for issues in which there were several potential answers/recommendations. Such a presentation could lay this out for the SC and explain how/why each answer is recommended. Lisa agreed and noted that quarterly update calls from the WG[s] to the SC were originally envisioned. She further noted that the SC could help work through what the best answer is, especially when there are issues to be resolved.

- Lisa asked if HPBA had any names for people to be included in the WG[s]. Jack replied that HPBA did have names but didn't want to [publicly] nominate anyone without those people first being contacted for confirmation [that they were okay with being nominated]. Jack mentioned Bob Ferguson and Rick Curkeet as being instrumental regarding operational issues, and that Rick would also be helpful regarding other fuel issues. So those are first 2 names. HPBA wondered if State people would be volunteering to be involved in the F/O-WG[s]. Lisa replied that she and Bob Lebens would be involved, but that they hadn't yet received other State names of people who could make the commitment. However, they were still figuring that piece out.

- John noted that HPBA was working to include a Canadian manufacturer on the WG, since Canadian manufacturers are important in the US market and because they are knowledgeable, with respect especially to the CSA test method (relied on in the NSPS for forced-air furnaces and for efficiency for all devices). Lisa asked about manufacturers in general [being proposed for the WGs] and John responded that HPBA definitely plans to include some manufacturing and lab names, but hadn't yet confirmed these names. John further noted that HPBA would like to have smaller manufacturers involved. However, generally small manufacturers don't have the capacity to volunteer, so primarily larger manufacturers will be involved. Nonetheless, John

noted that HPBA is sensitive to the fact that cost is very important to small manufacturers and would like the States to be aware of that too.

- Lisa suggested that the group should set up meetings that present status updates to smaller manufacturers and to environmental groups both, to bring them in as this process develops. In this way, such groups can provide some feedback, especially when we are ready to make some recommendations. John agreed that we have to try for such involvement.

- John noted that as NESCAUM caucuses with the States, HPBA will caucus with the manufacturers. He further noted that it's important to remember that manufacturers participated in the ASTM process, so they've thought seriously [on these topics] – in some cases a month on each topic – and we [HPBA] have their feedback.

- Lisa agreed that we need to recognize the ASTM work along with other efforts such as the European "BeReal" test method effort (a European Union effort, already in the round-robin testing phase, that began in late 2013 with the goal of developing real world test methods). In general, Lisa noted that we may want to have presentations of the efforts that have gone before. John agreed that this should happen at the WG level. Adam Baumgart-Getz asked if Bob Ferguson could give a presentation. John said yes, absolutely, and that Ben Myron could also present (e.g., regarding exactly what can and cannot fit in stoves for testing, etc). Lisa agreed that Bob's presentation was great and also suggested presentations by European experts in the BeReal effort. John noted familiarity with the effort and re-iterated that these presentations should probably happen at the WG level, as the presentations can be lengthy. Lisa agreed that the group needs to figure out how to parse the project into "digestible bites" and noted that another challenge is the time difference between the West Coast, East Coast and Europe.

- Lisa noted that the group had come to agreement regarding Lisa's and John's homework and items to bring before the group for next week's call. Lisa further noted that next week the group could put more meat around the idea of an Operational WG and a Fueling WG. John agreed that HPBA would have more names by next Thursday, but that they wouldn't be involved directly until the WG work starts. Lisa asked the group if anything more needed to be said regarding the fueling and operational WGs.

- Adam noted that Lisa and John had hit all the major points, but opined that, all else being equal, the WG is probably best left as one group rather than two, due to management difficulties. He suggested that the group could be split up later, down the road, if necessary. Lisa said she and John would discuss this and decide if they agree or disagree.

- Lisa also offered to draft a document for the regulatory people regarding Jack's interest in having HPBA people serving on the SC. Lisa would distribute the draft to the regulatory people, getting their okay, before distributing to the entire group next week. Jack thanked Lisa for that effort and said he looked forward to the document.

- Lisa asked if anyone had questions regarding the PM measurement group. John noted that we focused on the F/O-WG first, but HPBA's sense is that there are a lot of atmospheric people on the PM WG [rather than production lab people]. Lisa noted that the labs would be brought in eventually and asked George to speak more on the PM group. George noted that while none on the group currently are production lab people, all have dilution tunnel experience and most [not all] have done some wood smoke sampling through dilution tunnel techniques. George went through the list of experts on the PM group briefly, noting the experience of each. George concluded that eventually the labs would be brought in. Lisa elaborated that at first the PM group is approaching the question from a purely scientific ["what's possible"] perspective, but that the practical experience of labs would definitely be brought in.

- John noted that he understood and that HPBA was seeking to pay Dr. Houck, an analytic chemist with a lot of production lab experience, to take part in the PM group. John noted that in the interest of full disclosure, Dr. Houck would not be volunteering his time [HPBA would pay him], but that Dr. Houck is an independent character. Adam noted that full disclosure and openness was a good idea and appreciated it. Jack agreed.

- George noted that he had biographical sketches of the current experts on the PM WG. [Lisa e-mailed these bios out to the group on 5-27-2016.]

- Lisa and John agreed to speak further later in the day. Lisa noted that she thought HPBA's involvement at this juncture was critical and invited them to join the discussion next week. Jack thanked everyone and said he looked forward to participating next week.

- Meeting adjourned.

EPA Notes Steering Committee Meeting June 2, 2016 Teleconference

Meeting led by Lisa Rector of NESCAUM

Meeting Invitees (not all present on call): Lisa Rector (NESCAUM), Bob Lebens (WESTAR), Rob Kaleel (LADCO), Mary Uhl (WESTAR), Arthur Marin (NESCAUM), George Allen (NESCAUM), Rod Tinnemore (Washington), Phil Swartzendruber (Puget Sound Clean Air Agency), Cindy Heil (Alaska), Dave Shephard (Vermont), John Wakefield (Vermont), Lisa Herschberger (Minnesota), John Barnes (New York), Marc Cohen (Massachusetts), Jack Goldman (HPBA, President & CEO), Ryan Carroll (HPBA, Government Affairs Director), John Crouch (HPBA, Public Affairs Director), 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), Jill Mozier (EPA's Contractor, Meeting Note Taker)

Primary Conclusions from meeting:

- The Fueling/Operational Workgroup should remain one group, not two subgroups, because many of the fueling issues and test cycle operational issues are interrelated.
- The proposed list from HPBA for inclusion on the Fueling/Operational Workgroup is John Crouch, Bob Ferguson, Ben Myren, Rick Curkeet, Dan Henry, John Voorhees and Greg Achman. (Lisa Rector and Bob Lebens will also serve on this workgroup, with additional people from the regulator community TBD.)
- It is imperative that the Steering Committee determines how to make decisions regarding especially issues on which the workgroup and/or Steering Committee disagrees, but which are critical for future work to proceed (e.g., fuel questions). The group discussed the advantages to a majority or supermajority decision making structure within the Steering Committee with a minority/dissenting report (for EPA's consideration), but did not yet come to agreement on this.
- HPBA noted that it would like to have 2 or 3 members serving on the Steering Committee, with the understanding that some portions of meetings will be for regulators only.

To-Do List for group before next call:

- The group should respond with comments to the list of priorities Lisa Rector and John Crouch developed for the Fueling/Operational Workgroup by COB Friday June 3, 2016.
- John Crouch will provide one to two paragraphs listing the expertise of each HPBA-proposed member for participation in the Fueling/Operational Workgroup.
- The regulators in the Steering Committee will discuss HPBA's proposed list of people for inclusion in the Fueling/Operational Workgroup and determine a full list of participants in this workgroup overall, as well as a chair/facilitator for this workgroup. The regulators on the Steering Committee will inform HPBA of their decision.
- The regulators on the Steering Committee will discuss and decide upon HPBA's role in (including numbers serving on) the Steering Committee, and inform HPBA of their decision.
- The regulators on the Steering Committee will determine what the decision making process should be on the Steering Committee, in the event of disagreement, and inform HPBA of their decision.

Meeting Highlights:

- Lisa confirmed who had called in and then discussed some of last week's to-do list, noting that she wanted to go over the Fueling/Operational Workgroup (F/O-WG) and the Steering Committee (SC) membership. Regarding SC membership, Lisa explained to HPBA that the States would like time to digest and discuss on their own what will happen moving forward. HPBA indicated understanding. Lisa explained that she and John had discussed splitting the F/O-WG into two committees, but they decided to keep it as one, since many of the fueling issues will tie into the test cycle.

- Lisa reviewed the prioritized list for the F/O-WG that she and John Crouch had developed (which she e-mailed out to the group on 6/1/2016). This list of priorities includes the following: **(1) Fuel** (species/density issue – one species, two species or multiple species within a density range); **(2) Test Cycle; (3) Fuel load configuration; and (4) Efficiency calculation within recommended fuel protocol**

- Lisa noted that the first issue the F/O-WG will have to determine regards **(1) Fuel** – will it be a multitude of fuel types (within a density range) or only one or two fuel types. That's a threshold question that has to be answered to allow moving forward on other issues. In discussing this further after last week's call, Lisa and John realized that much will come down to policy decisions. Data will inform, but it nonetheless must be recognized that this [the NSPS required certification method] is part of a national program. Therefore every species from north to south and east to west cannot be represented and will require a policy call – including a policy call on the first priority issue of fueling. Lisa noted that determining what type of fuel it is and other fueling characteristics (piece sizing, bark, knots) may be put off until **(3) Fuel load configuration**.

- Lisa touched on **(2) Test Cycle** and then, regarding **(3) Fuel load configuration**, Lisa noted that what the fuel charge is -- to accommodate a broad array of devices – must be determined. John Crouch gave examples. In the ASTM process for example, once you define the amount of fuel (pounds) per cubic foot and then talk about size in a given species or density, sometimes you end up with a fuel load that can't fit in all stoves (especially the smaller European models). On the hand, sometimes the resulting load can be so tiny in a large stove that it's not realistic. John explained that therefore when you start thinking about how many pounds per cubic foot, it becomes a policy question due to practical restraints on both ends. This is not necessarily data driven, but it merely doesn't pass the laugh test. John noted that this is also an argument for the operational process and fuel loading not being separated [into two groups or subgroups].

- Lisa suggested moving piece sizing to **(3) Fuel load configuration**. John agreed it's critically important because that's how the wood starts to smoke – and it should be representative of what consumers use. Yet we can't survey all consumers across the nation in different climates – therefore it's a judgment call. Lisa asked John if it's piece size (surface to air ratio) or is it spacing or is it both [that's most important]. John said spacing is important, but the piece size (surface to air ratio) is most important because it controls how the piece smokes/emits. Regarding using two-by-fours, John noted that consumers rarely use such a small load. Yet stoves are consequently tuned for too-small pieces.

- Regarding **(4) Efficiency calculation within recommended fuel protocol** noted above, Lisa explained this is the last key big picture issue – that is, the recommended method must have a way/calculation to determine efficiency. Everything now is based on the CSA [Canadian method for efficiency determination]. If EPA will be moving to a new protocol, then the new protocol should also measure efficiency.

- Lisa confirmed with John Crouch that she had accurately represented their one-on-one discussion. John agreed this represented their discussion and noted that this is a ton of work. So the question is how fast can the F/O-WG get going? Lisa asked for the group to respond to the list of priorities for the F/O-WG by COB tomorrow (Friday)

- Lisa moved onto the composition and list of names for the F/O-WG and noted that she was hoping to get names from HPBA at this meeting. Lisa also noted that she and Bob Lebens are in this WG. John Crouch responded that HPBA had vetted some folks including 2 labs, 2 manufacturers and 2 consultants. The proposed list from HPBA for inclusion on the F/O-WG is John Crouch, Bob Ferguson, Ben Myren, Rick Curkeet, Dan Henry, John Voorhees and Greg Achman (from Hearth and Home Technologies). Not all, but most on these list have been vetted and have agreed to serve. John gave a brief background on each and asked if anyone on the SC would like more background on each. Lisa Herschberger noted that she did not know all the names on the list and would appreciate a brief summary on each. Lisa suggested that John Crouch provide a paragraph or two summarizing their expertise. John agreed.

- Lisa moved onto the SC discussion, after hearing no further comments regarding the F/O-WG and began by providing some background to the process so far. She noted that last fall [2015] there were discussions regarding the SC and how it would be run and that the group learned in fall that FACA [EPA-lead] is not a possibility. In the fall, the States and EPA started discussing a process that was put into the EPA paper [available at https://www.epa.gov/sites/production/files/2016-03/documents/discussion_paper_-_process_for_dev_imp_cwtm_030916.pdf]. In New Orleans at the Expo, the group learned that HPBA wanted a role on the SC. Lisa noted that the group hasn't yet circled back to that and it would be helpful to hear from Jack [Goldman, HPBA President] regarding HPBA's anticipated level of participation, especially vis-à-vis regulatory issues that would be at discretion of regulators. Lisa wondered how to "draw that circle" [of appropriate participation] moving forward and asked if Jack agreed with Lisa's portrayal of the background story so far.

- Jack Goldman agreed Lisa's portrayal was the accurate short version and noted that HPBA would like to be involved as much as possible, recognizing that some issues are for the other members. Jack suggested that the group could identify those issues/parts of meetings and HPBA could excuse itself from those parts of meetings, similar to the discussion that was planned for later in today's meeting.

- Lisa asked what the distinction between a regulatory and a policy decision is, and how can the group determine that. Adam Baumgart-Getz noted that, where practical, we'd like to identify

[regulatory issues] ahead of time. It's inevitable that something will come up that we'll need to think about before proceeding with non-regulators on the phone. Lisa asked for examples of regulatory versus non-regulatory issues. Adam explained that in some sense everything impacts a regulatory policy issue. For example, the issue of using specific species of wood or specific densities in the end is a policy decision with regulatory components. However, this is also an issue where industry will bring much expertise to the table. So it's actually an example that's not strictly regulatory [for regulators only] in nature.

- Lisa noted that it will be difficult to define what's regulatory and what's policy. She suggested going back to consider the process the WGs will use – that is, the goal is consensus but consensus is not the mandate. Likewise, on the SC, the goal can be consensus [but not the mandate]. If the F/O-WG can't decide (e.g., regarding first fuel question), does the SC decide, or does EPA decide? What if the regulators have one opinion and the industry representatives have a different opinion?

- Adam suggested that if there is a clear split, where industry and regulators disagree – but if these [even intractable] positions don't stop future work from proceeding – then perhaps the group should merely identify the areas of agreement and disagreement and move on. If, on the other hand, the disagreement affects future decisions [and work can't proceed], that's a more difficult problem to resolve. Lisa noted that the very first fuel species question could be an example [of such a difficult decision that impedes work from proceeding].

- John Barnes asked how the group was defining consensus (i.e., does everyone vote, is it a simple majority or a supermajority?). Lisa noted that the decision making process so far was as she had outlined – that is that consensus is a goal not mandate – with both sides identifying positions and moving forward. But, Lisa also noted, that fuel species is an underpinning issue that ties into everything else. So the F/O-WG and SC could hit a stumbling block right away. Therefore the group needs to define a mechanism for who decides when consensus is not possible. Adam interjected that one thing to remember is that there will be some testing of wood throughout this process. So there will be the ability to supply data to help inform [some] decisions.

- Jack noted that one thing he'd like to make clear is that this issue will exist whether HPBA is called/allowed to participate or not. There could be significant differences of opinion [outside of HPBA and regulators] and some HPBA members could agree with some SC [regulator] members, while other members may disagree. So this is a broader issue. Jack noted that his understanding is that this whole process will be subject to a comment period at the end of EPA's decision and that he imagines there's nothing wrong with helping to inform EPA's decision with a minority decision paper. A minority report could be presented to EPA. In the end, EPA has to make the [final] decision anyway. Lisa noted she was glad HPBA was on this call to provide its perspective. The decision making process needs to be fleshed out. Who decides? Or do we take a two track process [in the event of disagreement over the fuel species question]? For example, if you go down pathway of one species, this is how you do it; but if you go with multiple species, this is how you do it. This approach would exponentially increase F/O-WG's workload. Jack noted that

he couldn't answer these questions but again noted that these questions go beyond HPBA's role [to a more general question regarding how decisions will be made by the group].

- Lisa offered for the sake of argument to assume the SC is where this species question is decided and asked Jack if he imagined a consensus approach or majority approach. Jack noted that consensus is a very high bar to meet, and that perhaps NESCAUM and WESTAR have experienced this in their organizations as well. Jack noted that in his opinion nothing is black and white in life. If a majority voted to go a certain way, then the other technical people should have the ability to file something with EPA saying why they didn't agree with the majority opinion. That's how the process works within HPBA – people are identified in the record as disagreeing and why. This helps inform people down the line. In this case, it is EPA who makes decisions. Jack imagined that EPA will either get info before or after the FRM is issued and would prefer to get information beforehand. Jack stated that he'd rather hear all sides beforehand and that the way to achieve this is a majority decision with dissenting reports. Lisa noted that was helpful, but the difficult part remains if it's a foundational decision that snowballs [and affects work proceeding]. The group still needs to flesh out how to deal with this scenario.

- Phil Swartzendruber noted that he liked the majority vote and minority report approach. Regarding how to resolve foundational issues, Phil recognized the problem with going down rabbit holes but also noted that it may be crucial to look down both rabbit holes, as further investigation could put some issues to rest (or at least to a sounder sleep). The group shouldn't brush off such issues too readily. Lisa asked if this is how the SC or the F/O-WG should handle decisions. Phil responded that both the SC and F/O-WG should handle decisions with a majority vote and a minority report.

- Jack offered additionally that, for big decisions, the group may wish to consider a supermajority [instead of a simple majority]. He noted he was not espousing it necessarily, but pointing out the advantage to a supermajority process is that it forces people to agree a bit more, instead of merely dissenting, because more back and forth and give and take happens. Jack gave the example of some Supreme Court decisions that involved important enough issues to send a signal [using consensus]. Requiring consensus in these cases may have changed the final decision somewhat to accommodate dissent. Jack was not advocating a high supermajority, but perhaps a 60% supermajority should be considered. He noted that he couldn't imagine any group that would want [important] policy decided by a 52% majority. A supermajority forces people to face differences [in the event that a supermajority is not initially reached] and obtain that critical mass on important decisions. John Barnes agreed this was a good idea because the group wouldn't want key decisions made by one vote; important issues required more agreement.

- Regarding majority and supermajority structures for decision making, Bob Lebens noted that how representative the group is becomes very important. The original composition goes directly to the fairness of the majority or supermajority opinion. Phil agreed this was a very good point and why he favors a majority decision with a minority opinion/report. Phil noted that there are many issues where we could argue and discuss for a year and not get anywhere. So we need to

draw the line and move on. For topics that we can get data on, this approach of majority decision and minority report may work.

- Lisa noted that these were all very good thoughts and suggested that the regulators discuss this later on the call and then get back to HPBA regarding the conclusions of that internal discussion. Many people have already noted that if there is a more inclusive SC, there will also still be a regulatory caucus. This means perhaps double the meetings, so we need to consider the time commitment. Lisa then asked Jack if he had a number or names in mind for HPBA involvement on the SC.

- Jack noted that he did not, off hand, but it again raises John's point regarding how many people comprise the SC. Fifty industry people would be great, but that's not fair. Perhaps 2 or 3 is fair. John Crouch noted that he was looking forward to very intense WGs, having experienced this in ASTM, and that he wasn't eager to twist people's arms to serve on both the SC and the WG. In his opinion the work happens at the F/O-WG level.

- Lisa noted this was helpful to know and explained to HPBA that, since EPA people are participants, there are either 8 or 9 state agencies represented. Lisa clarified that EPA is not a voting member, not a participant but rather just an observer. Adam agreed. Jack again noted that HPBA would be fine with 2 or 3 on the SC, understanding that there are certain regulatory issues we will not be involved in.

- Lisa thanked HPBA and noted that if they didn't have other issues to discuss, the regulators in the SC should caucus. HPBA agreed. Lisa noted the group would circle back with HPBA and de-brief. The group would discuss HPBA's ideas and let them know the outcome. John Crouch asked the States to think about how soon we can get start the F/O-WG. Lisa agreed and noted it needed to start ASAP.

- Lisa concluded that the SC would talk about (1) the proposed HPBA names for the F/O-WG and come out of the call with names of F/O-WG participants as well as a chair/facilitator for the F/O-WG. The SC [regulators] would also decide on (2) HPBA's role on the SC and (3) the SC's decision making process. The group will discuss those 3 issues in the regulator caucus.

- HPBA signed off the call and the Regulator Caucus portion of the call continued.

EPA Notes Steering Committee Meeting June 9, 2016 Teleconference

Meeting led by Lisa Rector of NESCAUM

Meeting Invitees (not all present on call): Lisa Rector (NESCAUM), Bob Lebens (WESTAR), Rob Kaleel (LADCO), Mary Uhl (WESTAR), Arthur Marin (NESCAUM), George Allen (NESCAUM), Rod Tinnemore (Washington), Phil Swartzendruber (Puget Sound Clean Air Agency), Cindy Heil (Alaska), Dave Shephard (Vermont), John Wakefield (Vermont), Lisa Herschberger (Minnesota), John Barnes (New York), Marc Cohen (Massachusetts), 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), Jill Mozier (EPA's Contractor, Meeting Note Taker)

Primary Conclusions from meeting:

- Among the Steering Committee members present, there seemed to be some agreement that a suitable decision making structure framework (for the Steering Committee) is a simple majority with industry given 25% of the vote. Some however prefer a supermajority. The Steering Committee as a whole will need to consider this and decide via a Survey Monkey Lisa Rector will send-out to the group.

- Steering Committee members who are not present at any given meeting are responsible for reading the meeting notes to bring themselves up-to-speed and allow things to move forward.

- The group is not yet ready to invite HPBA to next week's call, as decisions still need to be made.

To-Do List for group before next call:

- Everyone in the group needs to consider the difference between regulatory and non-regulatory decisions and come up with lists of what is a regulatory decision versus what isn't.
- George Allen will ask the PM Measurement Workgroup members if anyone in that group is also interested in being on the Fueling/Operational Workgroup.
- Lisa Rector will compile names for the Fueling/Operational Workgroup and circulate the names to the Steering Committee. At the next meeting (or via the Survey Monkey sent-out by Lisa) the group must decide who is on the Fueling/Operational Workgroup.
- Adam Baumgart-Getz will determine if EPA has any issues/sensitivities with meeting notes from the PM Measurement Workgroup being distributed to the States.
- Lisa Rector will e-mail out a Doodle Poll regarding upcoming meeting times.
- Lisa Rector will call Jack Goldman of HPBA to explain that the Steering Committee needs another meeting to determine how to proceed with industry involvement and decision making structure.
- Lisa Rector will send out a Survey Monkey to the current Steering Committee laying out decisions that need to be made before moving forward (e.g., decision making structure).
- Any Steering Committee member that cannot be present on next week's call needs to make their opinions known on the Survey Monkey and/or call Lisa or Bob Lebens to give them their proxy vote.

Meeting Highlights:

- Lisa noted HPBA's stated desire to have 2 to 3 people on the Steering Committee (SC) plus 8 people on the Fueling/Operational Workgroup (F/O WG). Lisa and Bob Lebens discussed this after last week's meeting and realized that there is some redundancy in the 8 people HPBA proposed for the F/O WG, because these 8 people really only cover 3 categories of expertise. Lisa suggested that one way to handle this redundancy (which may or may not be applicable to both WGs), is to designate participant observers as well as participant voting members. In other words, there could be observers who can participate but not vote, as well as full voting members. Lisa noted, for example, that HPBA has proposed 3 non-catalytic manufacturers on the F/O-WG and the [regulator portion of the] SC could decide that all 3 proposed people can participate but only one can vote (i.e., the 3 together equal 1 vote). The same is true regarding the lab names HPBA proposed. Lisa noted that Bob had pointed out it's important to consider who is represented by the group members. There is a tension between the goal of equality of representation versus regulatory concerns. Lisa noted that regulatory needs will necessarily trump industry concerns; regulators have a different (higher level of) authority in the SC than non-regulators.

- Phil said [the 1 vote for 3 industry people concept] is a reasonable idea, although he's not sure HPBA will agree. Phil said it's important to determine the total number of votes (in the event of disagreement) and decide if it's balanced enough. He noted that there may be some advantage to setting the number of votes regarding a particular issue beforehand (e.g., x votes for regulators and y votes for industry). But he wondered if industry would find this agreeable enough.

- Lisa noted surprise that although HPBA requested that 2 to 3 industry people serve on the SC, last week some SC [regulatory] members seemed willing to allow HPBA more representation on the SC than HPBA requested. Phil responded that this was not necessarily his impression from the group/SC and suggested he would want the ratio to look something like 2 industry representatives to 6 or 8 regulatory representatives.

- Lisa noted that HPBA/industry would like 2 to 3 slots on the SC and regulators currently have 8 to 9 slots (although unfortunately on today's call only 4 states are represented). Lisa further noted that John Wakefield would like to participate but may not be able to be involved in every discussion. John can't make a full commitment so he needs to be an observer rather than a voting member. John Wakefield regretfully confirmed this as the case. Lisa also noted that Rod Tinnemore was not on the call. Regular participation from some states may be an issue [if today's number of states on the call is any indication].

- Adam noted that one added complication is that the group is attempting to talk about number of votes while simultaneously attempting to determine people who can regularly participate. Adam suggested that the group instead consider/determine an appropriate percentage of votes that [the regulators on] the SC are willing to give to industry. Meanwhile, the group can nail down members and numbers. Adam noted that if the group thinks 2 to 3 industry people is

appropriate and that translates to roughly 20-25% of the vote. Adam asked what people thought of this idea. Lisa agreed it was a good approach.

- Lisa further noted that Phil's 2 to 8 ratio is 25%. Phil confirmed he is fine with 25%, but suggested such a decision should be decided upon by the larger group [not present on call today], although it's fine to have the discussion now. Lisa noted that SC members who are not present will need to review the meeting notes [in order to keep things moving forward]. Marc Cohen agreed with 25% as well.

- Lisa Herschberger suggested it'd be instructive to take a step back and consider end goals – for example, does the group want everyone to support a decision or do we merely need industry to inform our [the regulators'] decision making process. The end goal hasn't been made clear.

- Lisa Rector noted, regarding NESCAUM's position, that NESCAUM never saw this as a consensus or a regulatory negotiation (reg neg) process. That's how ASTM works and NESCAUM has other access to such vehicles. This method development process, according to NESCAUM, isn't supposed to be something that everyone necessarily agrees on. The process needs to be driven by the regulators, but we want and need industry input. If we get industry agreement that's great – consensus is an objective but it's not a mandate. The risk in the end is coming up with a method that not all regulators like/can live with. Some states have already said that [if they don't like the method] they'll put forth their own method. We'd like one national method; we'd like to avoid some state/regulators using a different method they develop. The key piece to this process is identifying points of agreement and contention that ultimately allow EPA to determine how to proceed.

- Lisa Herschberger concluded that [considering Lisa's above point] Lisa's original proposal [process goal] makes the most sense. In that case, industry should provide input but not have a vote, especially if that vote doesn't really have power anyway. So one idea is to have no [industry] vote and explain why.

- Lisa Rector noted that this is essentially how the process was first envisioned in EPA's Discussion Paper -- that is, that the SC would be looking for consensus among regulators. We [NESCAUM et. al.] don't represent industry. Since the Discussion Paper however, industry involvement has been deemed important to this process and industry wants some role. Lisa noted that it will be difficult if we don't have industry buy-in. She also noted that it's been good to have HPBA on recent calls, but we're struggling with how to proceed when we get down to difficult issues. If some states can't live with certain things, then not all states will be able to get behind a single recommendation to EPA. Lisa concluded that she feels comfortable with a 25% role for industry. She's still wondering however if it's a simple majority or a supermajority.

- Adam noted that one reason we should decide the ratio/percentage that industry has [for voting purposes] is because this ratio informs whether a simple or supermajority is appropriate. If industry has a 25% vote, then perhaps a majority is fine or a majority plus 1. This [level of agreement] will be easier to get to as a group as well.

- Lisa noted that if there is an industry position that deviates from the way voted to go forward, we want to capture it but not get bogged down. Lisa asked if John Wakefield agreed. John responded that it was a difficult question for him and he'd like to refrain from comment for now.

- Lisa suggested moving onto the question of whether the decision structure should be a simple or supermajority. Phil opined that with the 25% vote, a simple majority will suffice. Marc asked how the terms majority and supermajority were being defined by the group. Lisa responded that a simple majority was 51% while a supermajority is something like two-thirds or 75%. Marc noted then that he prefers a supermajority so that more people are on the same page.

- Lisa noted that she agreed with Adam's proposal of a simple majority with a 25% vote for industry. Lisa further opined that a supermajority will essentially require regulators to stick together on every single vote. In that case, this would become more of a consensus process like ASTM's process. Therefore, Lisa agrees with Phil [and Adam] for a variety of reasons. If folks want regulators to be in 100% agreement then supermajority is the way to go, but it will likely slow the process. Lisa also observed that the group was split on the decision making process, even among this small group [present on today's call].

- Amanda Aldridge observed that many in the group were clearly concerned that industry will stall this process or make it contentious, while EPA is very concerned about the timeline. She wondered if there was any precedent for an agreement up-front [for all members of the SC] that stated something to the effect that voting rights could/would be rescinded if a member stalls the group from moving forward with the majority decision. She suggested that perhaps such a cooperative agreement could be drawn up so that all parties agree to keep the process moving along, and asked if anyone had any experience with such an agreement. Lisa noted that she did not know of such an agreement. Phil responded that he's not been part of a process where there is a signed document with such an agreement, but has been involved in a group with an outside facilitator. The facilitator had the group agree to principles about working earnestly etc., but nothing was signed by the group members.

- Amanda noted that, in the past, EPA has talked to [opposing] parties and would seek common ground. However, this process and our timeline doesn't allow for that. Perhaps such an agreement could merely be stated and agreed to verbally up front [rather than a signed document]. Amanda further noted that she is personally comfortable with calling up any person who disagrees with the majority decision and just reiterating what the majority thinks and that the process shouldn't be stalled anymore.

- Marc noted that Amanda's approach was an argument for a simple majority. He further noted that Massachusetts had hired a mediator for a group of industry and regulators. This mediator ran everything and he did his job in the event of a disagreement.

- Amanda suggested that the group keep this all in mind, start with a simple majority, and have some principles either spoken or written about group's intent to move forward with agreement. Amanda noted that even this discussion is taking longer than she had hoped it would.

- Lisa agreed that this was difficult. She also noted that she is still grappling with what is a regulatory decision versus what isn't on the SC. Lisa stated that the group needs to think about this and come up with a list of what is a regulatory decision and what isn't. Lisa noted that it's important that the group is clear on this as well.

- Moving onto the technical F/O-WG, Lisa asked the group their thoughts on the numbers and/or names. What percentage should be industry versus regulators?

- Marc (or John?) responded that the WG composition should be based more on available expertise than on percentages. Lisa Herschberger noted that she was hoping some academics with expertise would participate, but experts different from those people who developed the ASTM method.

- Lisa agreed that the people HPBA proposed for the F/O-WG were all involved in the ASTM effort. Therefore her concern is such a F/O-WG will end up with the ASTM method.

- Lisa asked that, besides herself and Bob Lebens, is there anyone else who wants to be on F/O-WG? Lisa Herschberger responded that she would be interested but had not been given the time to participate at this level. Marc responded that it's a possibility. Phil responded that he unfortunately has no availability and not much expertise for that WG. The group discussed some other names of interest for participation in the F/O-WG including: Dave Shephard, John Barnes, Tom Butcher, Tom Morrissey, Chris Neufeld, John Ackerly, Mario Voller or Kristoff Schmidtl (from the European BeReal effort), Colorado State University people, John Watson, Phil Hopke, and other people on the PM Measurement WG. Lisa asked George Allen to ask the PM Measurement WG people if anyone else might be interested. George agreed. (Lisa and EPA again clarified that EPA employees were observers not participants.) Lisa noted that she would compile names and circulate to the SC, as next week the group must decide who is on F/O-WG.

- Lisa noted that another question from the last PM Measurement WG meeting is whether or not the notes from this WG should be circulated to the states. Phil responded that whatever mail comes to him is considered public record. Adam noted that he would check with EPA regarding any potential EPA sensitivities [with the PM Measurement WG's meeting notes being circulated to the states]. Lisa, Amanda and Adam recognized that the note-taker [Jill Mozier] is a contractor to EPA. Lisa Herschberger noted that it'd be good to be able to see the notes. Rather than decisions being made behind the scenes, it'd be helpful for the SC to know if we like the WG's decisions or not. Lisa Rector noted that her preference is also to circulate the meeting notes [to the states], but will wait on EPA to check regarding any potential sensitivities.

- Marc (or John?) noted that it would be good for the two technical WG's to share information. Lisa noted that such sharing/mixing of technical WG conclusions is more of a SC function.

- George Allen noted that, regarding the PM Measurement WG, the next call is June 24th and there's a short list of key topics to discuss on this call to inform work that's happening this summer.

- Lisa asked the group if HPBA should be invited to next week's call or not. Phil responded that the group needs to hold off [on inviting HPBA] until the rest of the SC is brought up to speed. Lisa Herschberger agreed but would like the SC to be brought up to speed sooner [than next week's call].

- Lisa noted that she and Cindy Heil are already gone for next 3 weeks. Lisa will probably call-in next week and following that Bob too would be off. Lisa will put out a doodle poll to determine next calls.

- Lisa noted that she spoke to Jack [Goldman of HPBA] yesterday to tell him why he wasn't going to be invited to call today. Jack told Lisa that HPBA is available next week but the week after that HPBA is at a board meeting. Lisa will give Jack another call and let Jack know that the group didn't have a quorum and therefore the SC is not yet ready to move on [with HPBA involved].

- Adam noted that after the Discussion Paper and regrouping, there was some discussion regarding how to keep moving forward through summer. He suggested there's a certain responsibility for active SC members to go over meeting notes. This responsibility would be a way to keep moving forward. Lisa agreed in general but noted that the topics of today's call are big picture decision making topics regarding process. Lisa's sense is that the group wants to have more people involved. Adam agreed regarding today; but in general, moving forward, he would like people to review notes. Lisa agreed.

- Lisa said she will call in from vacation if necessary. She will also let people know that this is when the decision is being made. Therefore, those who can't make the meeting need to call Lisa Rector or Bob Lebens prior to voice their opinion and allow proxy. Lisa and Bob need proxies of everyone not present.

- Amanda suggesting that Lisa lay out what decision must be made and ask SC members to vote offline, since much has been discussed already. Lisa agreed this was a good idea and said she'd put together a Survey Monkey.

- Lisa noted that Bob would be leading next week's call and adjourned the meeting.

- [Note: Jill Mozier, note-taker, will not be available for next week's call on June 16th. Someone else may wish to take notes for the group.]

EPA notes Steering Committee Meeting July 7, 2016 Teleconference

Meeting led by Lisa Rector of NESCAUM

Meeting Invitees (not all present on call): Lisa Rector (NESCAUM), Bob Lebens (WESTAR), Rob Kaleel (LADCO), Mary Uhl (WESTAR), Arthur Marin (NESCAUM), George Allen (NESCAUM), Rod Tinnemore (Washington), Phil Swartzendruber (Puget Sound Clean Air Agency), Cindy Heil (Alaska), Dave Shephard (Vermont), John Wakefield (Vermont), Lisa Herschberger (Minnesota), John Barnes (New York), Marc Cohen (Massachusetts), 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), Jill Mozier (EPA's Contractor, Meeting Note Taker)

Primary Conclusions from Meeting:

- The Steering Committee decided upon its voting membership and its voting structure. The Steering Committee, as it stands now, will consist of 5 state votes (Washington, New York, Alaska, Massachusetts, and Minnesota) plus 2 MJO votes (NESCAUM and WESTAR) plus 2 HPBA votes, for a total of 9 voting members. The Steering Committee decisions, as necessary, will be based on a simple majority of votes, with a requirement for a state/MJO quorum (preliminarily set at 5 state and/or MJO votes) and proxy voting (if voting members cannot be present on a call when a vote is to take place).

- The MJOs NESCAUM and WESTAR will represent their non-participating constituent state interests in any vote taken.

- Regarding Steering Committee meeting frequency, the group decided that the Fueling & Operational Work Group needs to be established before the Steering Committee can meet less frequently than weekly. The meetings will continue in the Thursday time slot on a weekly basis through the end of August, if necessary. After August, the Steering Committee will go to monthly calls but will hold a second monthly time slot tentatively open, in case the Committee is needed to make a decision or provide feedback to the work groups.

- With HPBA on the meeting call next week, the entire Steering Committee will go over HPBA's proposed names for inclusion in the Fueling & Operational Work Group and seek agreement from the Steering Committee as a whole. Based on the Survey Monkey results, the state and regulator portion of the Steering Committee is not in favor of all HPBA proposed names being voting members on the work group, but most in the group are open to the HPBA proposed people participating in some fashion on the work group.

- The Fueling & Operational Work Group so far consists of Lisa Rector, Bob Lebens, Lisa Herschberger, Marc Cohen and Cindy Heil. Other names will be considered at next week's meeting. EPA staff members Amanda Aldridge and Mike Toney would participate in the work group, but not as voting members. Other EPA members (Stef Johnson and Adam Baumgart-Getz) would participate pending availability.

To-Do List for group before next call:

- Lisa Rector and Bob Lebens will call HPBA and inform them of the Steering Committee's decisions regarding membership and structure and invite two of them to officially join the Steering Committee and next week's meeting.

- Lisa will send meeting invitations out to the group for the Thursday time slot through August.

- Lisa will compile a list of names for the Fueling & Operational Work Group and have them ready to discuss with entire Steering Committee, including HPBA, next week.

- Lisa will research Amanda's suggestions of Tony Ward and Curtis Noonen for potential participation in the Fueling & Operational Work Group. Bob will contact potential participant from Oregon again to request he participate. John Barnes will contact Randy Orr (sp?) to request he participate.

- All members of the Steering Committee should review the Survey Monkey results (available at https://www.surveymonkey.com/results/SM-9ZLZMCMT/).

Meeting Highlights:

- Lisa opened the meeting, thanking everyone and noting who was present and who could not make the call. During this meeting, Lisa hoped to review the survey from the group and determine if the Steering Committee (SC) could move forward. HPBA had been asking Lisa when they could participate again. Lisa asked George if he had updates from the PM Workgroup.

- George noted that he did not have updates from the PM Workgroup yet, although the group continues to move ahead and would have another meeting the end of July. George asked Lisa if August 1st meeting with labs would be pushed back, which would give the PM Workgroup more time. Lisa said that meeting could potentially happen later, that she was waiting to hear back from EPA.

- Lisa began reviewing the Survey results available at https://www.surveymonkey.com/results/SM-9ZLZMCMT/), noting there were some clear cut decisions made.

- Regarding Q1 ("Do you think HPBA should sit on the Steering Committee?"), nearly everyone but one respondent agreed that HPBA should sit on the SC.

- Regarding Q2 ("If the HPBA sits on the Steering Committee, what should their role be?"), there was no clear consensus. Therefore, Lisa suggested asking individual members of the group.

- Rod responded that it was a difficult question to answer, but he was clear that not every single HPBA proposed member/participant should get a vote. Phil asked if the thoughts on this issue would change if the decisions being voted on were minor instead of major decisions. Lisa noted

that the line between minor and major is a difficult call to make, because there is no clear delineation between regulatory versus non-regulatory decisions.

- Cindy asked how many seats HPBA would have on the SC -- if only one, then HPBA can have a vote. Cindy noted that a lot also depends on whether it's a simple versus supermajority (Q3). Lisa clarified that HPBA proposed 3 to 4 seats, in which case a simple majority would give them too much power. Cindy suggested 2 seats with a simple majority as a compromise. Another member of the group suggested looking at Q3 first ("For Steering Committee decisions should they be decided by: simple majority, super majority (65-80%), consensus or other") and then answer Q2 (regarding HPBA's role). Lisa noted that Q3 is a very split ticket between simple and super majority, although it's clear that no one wanted consensus.

- Lisa noted her support for a simple majority because she is concerned that requiring a supermajority may deadlock the process; a simple majority allows the process to move forward. Lisa reiterated that if there's a split decision, the process would move forward but the reasons for the split decision would be documented, including what it would have meant to move forward in a different direction.

- Phil noted that using a simple versus supermajority is tied into the number of votes that HPBA will be given. For example, Phil noted that he could not support a simple majority if HPBA has 4 votes. If however HPBA has only 2 votes, then he could support a simple majority.

- Regarding who will be and who will not be a voting member, Lisa noted that EPA doesn't have a vote. Lisa also noted that Vermont decided to not be a voting member, but rather an observer only (because Vermont doesn't have the capacity to track and participate to that degree). Lisa asked the entire group on the call who would be willing to be a voting member?

- In response, Phil noted that he may not be able to be the only one (representing the state of Washington). Phil asked Rod Tinnemore if the two of them could share a vote. Rod replied that he would prefer if Phil took the lead, but Rod would be willing to fill-in for Phil as necessary. It was preliminarily decided that the State of Washington and Puget Sound would be represented by a single vote, instead of two. Bob asked Phil what his reservations were and Phil explained that he needs to speak with his management, there may be a time commitment issue, and there may also be a representation issue since Puget Sound is technically under the state.

- John Barnes (New York) responded to Lisa that he would participate as a voting member, but would not be able to travel. Lisa noted that travel is not necessary.

- Cindy (Alaska) responded to Lisa that she would also participate as a voting member and will attend everything she can. Cindy noted that she would like to vote ahead of time on issues discussed and voted on in meetings she (or anyone) can't make. Cindy clarified that any votes-in-absentia should be taken in advance, to be fair, and that the chips would fall where they may. Lisa said that decisions would be keyed-up ahead of time (e.g., through meeting notes) in order to allow members to vote. Lisa noted that the process will work around that, as no one will

make every call. Lisa also noted that the group had previously discussed a member giving their proxy vote to another member who will be present at a meeting vote.

- Marc Cohen (Massachusetts) responded to Lisa that he would participate as a voting member.

- Lisa reported that Lisa Herschberger (Minnesota) also agreed to participate as a voting member.

- Lisa concluded that so far 5 states agreed to participate as voting members on the SC: Washington, New York, Alaska, Massachusetts, and Minnesota.

- Lisa asked the group if they thought the MJOs, NSCAUM and WESTAR, should also vote. Cindy said yes, the MJOs should vote since they (Lisa and Bob) speak to their member states in order to represent them and are another avenue for a perspective and representative vote that's broader than individual state concerns, noting that MJOs see cross-state issues. Lisa thanked Cindy but noted that she would understand any hesitation the group might have and referred to the difficulty in wearing two hats as facilitator and SC participant.

- Marc responded to Lisa that she has to have a vote since MJOs are noted as the lead(s) in EPA's discussion paper. Lisa clarified that the discussion paper was more of a [non-binding] proposal [and so the point is still up for discussion about whether MJOs should vote].

- Mary Uhl (executive director of WESTAR) joined the call and noted that she thinks of MJOs' role more as bringing back the views of various states to the SC, but not as voting members. Bob clarified for Mary some of the background – that is, that the group was struggling with how to handle HPBA involvement and deciding key issues like membership in workgroups, which required an orderly process for making decisions. He noted that there will be cases where a formal vote is needed, so a structure needs to be in place to allow for forward progress. Mary concluded that she understood and was fine if the group decided that MJOs need a vote.

- Lisa discussed the proposal/idea that HPBA be offered 2 votes within a simple majority voting structure and asked how other members of the SC felt about that. Bob asked to be reminded if HPBA had recommended specific participants and number. Lisa said HPBA suggested 3-4 people but not specific names, although Lisa guessed it would include John Crouch and Jack Goldman.

- Rod suggested also requiring a quorum to keep the voting balance. Rod also suggested that if MJOs hear no feedback from their representing states, then MJO shouldn't vote, noting that MJOs should only be representing constituents. He further recognized that this puts pressure on the MJOs to ensure they are gathering and then representing their state concerns within the SC.

- Lisa noted that so far the SC had only 5 definite votes from states and therefore the group should re-consider MJO voting (or not). Given the 5 state votes, Lisa asked the group under what conditions would people be comfortable with HPBA having a voting role. Cindy re-iterated that she was comfortable with HPBA having 2 votes under a simple majority structure. Lisa asked if others in the group were also okay with this approach.

- Marc said that yes, 2 HPBA votes plus a simple majority is reasonable and works well. Rod also noted agreement.

- Amanda Aldridge joined and asked for clarification/confirmation that it was 2 HPBA votes of 7 total votes. Lisa replied that it may be 7 or 9 total votes, depending on MJO's voting role.

- Lisa asked if anyone in the group was uncomfortable with offering 2 votes to HPBA that are decision making, along with a quorum requirement and proxy votes if states can't make a call during which a vote is held. (Cindy reiterated that the proxy vote must be stated before such a call, not after, to be fair.) Phil noted agreement, if there was the quorum requirement. Lisa clarified (in response to question) that a quorum would be 4 or 5 people depending on whether the total votes were 7 or 9. Plus there must be an opportunity for a proxy vote. Cindy noted that the proxy means there should always be at least a quorum, if not a full vote every time.

- Lisa asked again if this was the decision of the SC. Marc said yes.

- John in NY noted that HPBA will survey its members, so NESCAUM and WESTAR can also survey their own members and if there's a sway [majority opinion among constituent states] then MJOs should vote, if not then MJOs should abstain from a given vote. Lisa asked John for clarification, asking if John was suggesting that MJOs break ties. John said that should be done by the MJOs before the vote [presumably with the MJOs constituent states].

- Lisa noted that Rod was suggesting that MJOs should represent their non-participating states (not their individual views) and then vote. There was some agreement in the group with this. Lisa noted NESCAUM is already caucusing with its states and will know where each of the NESCAUM states stand on the issues. Lisa asked Bob if this is also true of WESTAR.

- Bob noted that WESTAR has a diverse set of states, probably more diverse than the Northeast states [NESCAUM represents]. Residential wood smoke is a great concern to some western states, but is of minimal concern to others. Bob noted that he has reached out to states where it's an important issue. It's incumbent on our states to participate directly, but Bob reiterated that he does outreach to states informally, as some states can't participate. Lisa agreed that Bob has more states to represent and so may need more time to decide.

- Lisa explained that of NESCAUM's 8 states, there are 2 states are on the SC (New York and Massachusetts), 3 states who are very interested and a couple states who don't consider it a priority. So the question is, is it okay if MJOs vote based on interested states? Bob likewise noted that he can't ask states that don't have a stake in this to caucus; he can only represent the states affected by residential wood heat/smoke on this SC. Marc wondered if Lisa and Bob would need to take it up with their managements. Lisa clarified that for some northeastern states, like NJ, this isn't an issue they are concerned about. Other states like New Hampshire, Vermont and Maine doesn't have the capacity to participate even though they are very interested in this topic.

- Lisa reiterated that it's important to hear from this SC group if it's okay for MJOs to represent only interested states [with their SC vote]. Marc responded that he's not comfortable answering that question. Lisa again clarified that states like NJ are not interested and don't have the staff to participate. However, Lisa noted that all NESCAUM directors [from the NESCAUM constituent state air agencies including Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont] would be briefed quarterly. Phil asked if this was a question for directors. Lisa clarified that she already got their go-ahead. Bob added that WESTAR received feedback that the WESTAR constituent states want WESTAR to be engaged in this kind of process, especially where they can't. The WESTART states are looking for WESTAR to help and to represent them.

- Lisa concluded that the SC group thinks that MJOs should be voting but pulling in the interests of their non-participating states. Therefore, the SC voting membership is currently at 5 states/local votes plus 2 MJO votes plus 2 HPBA votes. Bob noted that may change based on how Phil and Rod work things out [whether they are 1 or 2 votes]. Lisa thanked everyone for making the decision.

- With no other issues raised to be discussed regarding the SC structure, Lisa asked the group if the Thursday time slot still works for members and if there is still a need for weekly calls. A SC member (Marc or John?) noted that the Fueling & Operation Work Group (FOWG) needs to be established before the SC can meet less frequently than weekly. Cindy agreed and said the Thursday time slot works. Lisa concluded that the SC would go back to weekly meetings until the FOWG was formed. Lisa will set up weekly meetings until the end of August (and will send invitations out to the group). After August, Lisa noted that the SC will go to monthly calls but will hold a second monthly time slot tentatively open if the SC is needed to make a decision or for providing feedback to the work groups. The group expressed general agreement with this plan.

- Lisa noted that the group needed to next discuss the FOWG and also communicating with HPBA. Regarding Q4 from the Survey Monkey ("How many people do you think should sit on the Operation and Fueling Workgroup?), Lisa noted that many respondents came in between 6 to 12 members. Lisa reviewed the results in more detail for the group.

- Regarding Q5 ("Would you support two types of membership on the workgroups: voting members and participants. Participants could observe and participate in the discussion but not vote unless given a proxy to vote for another member in their absence."), all respondents supported these two types of membership.

- Regarding Q6 ("What should be the decision-making mechanism for the O/F workgroup?"), Lisa noted that most respondents wanted a simple majority.

- Regarding Q7 ("HPBA has put forward eight names for the O/F workgroup: John Crouch, HPBA; Bob Ferguson, industry consultant lead on ASTM woodstove method; Ben Myren, Myren Lab participant in ASTM woodstove method; Rick Curkeet, Intertek and ASTM committee chair; Dan

Henry, industry consultant participant in ASTM woodstove method, John Voorhees, US Stove former employee of Omni and Intertek labs; Greg Achman, HHT. Should all these names be invited, and if so in what capacity - voting/observer/other?), Lisa noted that no one was in support of all HPBA proposed names being voting members. Lisa reviewed the answers to Q7 and noted that her sense overall is that it would okay for all to participate but only a subset should be voting members. Lisa suggested having this as an agenda item for next week with HPBA on the call. Lisa suggested that the group could go through this with HPBA and see if agreement could be reached with HPBA. Cindy agreed this was a good approach and moreover that it was important to get everyone participating on the SC.

- Bob and Lisa will reach out to HPBA regarding which 2 individuals they want to serve as voting members on the SC. Lisa noted that she will e-mail Jack Goldman to set up a call with him tomorrow to discuss.

- Lisa asked if Randy Orr (spelling?) from New York would agree to be on the FOWG. John said he would ask Randy. Lisa also suggested Tom Butcher, Mark Champion, Rebecca, one or two Be Real people (from Europe), John Ackerly and Tom Morrissey. Lisa noted that she will put names together for next week's meeting to discuss with the group, including HPBA. Amanda suggested Tony Ward and Curtis Noonen for the FOWG and suggested that Lisa google their names to see what she thought. Lisa agreed to.

- Bob noted that so far the FOWG only has 3 state representatives: Lisa, Bob, and Lisa H. Marc Cohen then agreed to serve as well. Bob noted that achieving balance will affect how many industry people can serve on the FOWG. Bob encouraged other western representatives to step forward and participate on the FOWG, noting that the FOWG needs a western state or local on it. Lisa asked Bob if he could get someone from Oregon to participate. Bob will try again and get back to Lisa. John will get back to Lisa regarding Randy.

- Cindy agreed to participate in the FOWG. Lisa thanked Cindy and noted that the SC will also have to think about facilitation of the FOWG.

- Lisa and Bob thanked everyone and noted the progress made. Lisa noted that next week HPBA will participate with 2 voting members and the group will discuss membership of the FOWG – names and invitations. The SC will also discuss participants versus voting members, as well as facilitation of the FOWG.

- Amanda clarified that she and Mike Toney will be on the FOWG as participants but not voting members. Stef Johnson will also participate if/when he's available. Amanda therefore requested that Lisa keep Adam and Stef on all the e-mail correspondence and noted that someone from EPA would always participate on the FOWG.

- Lisa suggested everyone review the Survey Monkey results and said she would be sending many invitations on Outlook for the next 2 months.

EPA Notes Steering Committee Meeting July 21, 2016 Teleconference

Meeting led by Lisa Rector of NESCAUM

Meeting Invitees (not all present on call): Lisa Rector (NESCAUM), Bob Lebens (WESTAR), Rob Kaleel (LADCO), Mary Uhl (WESTAR), Arthur Marin (NESCAUM), George Allen (NESCAUM), Rod Tinnemore (Washington), Phil Swartzendruber (Puget Sound Clean Air Agency), Cindy Heil (Alaska), Dave Shephard (Vermont), John Wakefield (Vermont), Lisa Herschberger (Minnesota), John Barnes (New York), Marc Cohen (Massachusetts), Jack Goldman (HPBA, President & CEO), John Crouch (HPBA, Public Affairs Director), Bob Ferguson (Consultant to HPBA, President of Ferguson, Andors & Company), 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), Jill Mozier (EPA's Contractor, Meeting Note Taker)

Primary Conclusions from Meeting:

- The Steering Committee (SC) membership consists of 9 votes, as follows:
    - Phil Swartzendruber and Rod Tinnemore (Washington State, 1 vote);
    - John Barnes (New York);
    - Cindy Heil (Alaska);
    - Marc Cohen (Massachusetts);
    - Lisa Herschberger (Minnesota);
    - Bob Lebens (WESTAR);
    - Lisa Rector (NESCAUM);
    - Bob Ferguson (Consultant to HPBA); and
    - Jack Goldman and John Crouch (HPBA, 1 vote).

  The other meeting invitees listed above are participants, not voting members, including EPA.

- The SC decisions will be based on a simple majority of votes with a requirement for a quorum before any discussions/meeting may occur (i.e., if a call has less than a quorum, the call will be cancelled and re-scheduled). If a quorum exists but not all voting members are present on a call (or if the SC members need more time to consider the issues and their vote), voting will occur at the following week's meeting. The decisions requiring a vote will be e-mailed to the voting members not present to allow their input (e.g., via e-mail) before the vote takes place. Proxy voting is also allowed. When a decision is made and recorded, dissenting opinions will also be summarized for the record.

- The SC will meet weekly until the Operations & Fueling Work Group (O/F group) is set-up. Once the O/F group is set-up, the SC will meet monthly with more frequent meetings scheduled on an as-needed basis (e.g., when issues come up in either work group that the SC needs to discuss and decide in a timely fashion to keep the process moving). The hope is that weekly meetings of the SC will only be necessary through August and that monthly meetings will start in September.

- The O/F group will consist of two co-chairs – one regulator and one non-regulator – plus nominated members who agree to serve. The O/F group co-chairs will be nominated by the SC next week. After reviewing the names of nominees for the O/F group - including their

backgrounds and geographic representation, broadly speaking - the SC decided to nominate and invite the 17 names listed in the attachment to these notes ("Draft Guidelines for the Operations and Fueling Workgroup (O/F)" e-mailed by Lisa Rector to the SC prior to today's meeting). The O/F group may also include a facilitator in addition to the co-chairs, if an appropriate and available facilitator can be identified.

- The SC decided to keep the O/F group open to additional input from non-members and potentially to new members, so that all valuable information may be considered. Any proposed new O/F group members would need to be brought to the SC for nomination and confirmation.

- In addition to the O/F group members, the SC decided to reach out to external advisors as needed (e.g., Christof Schmidl of the European effort BeReal, U.S. forestry/wood species experts), as well as to brief people interested in the process who may have feedback for the SC (e.g., John Ackerly of The Alliance for Green Heat).

- The PM Measurement Work Group (PM group) expects to finish working through the issues relevant to its list of recommendations during next week's PM group meeting on July 27th. A final meeting will be held by early September to finalize and summarize the PM group's recommendations. These recommendations would then be reviewed by experts familiar with wood stove testing (e.g., labs) to determine if the recommendations are technically feasible as well as feasible from a cost perspective. Determination will also be made regarding whether any of these recommendations change the definition of the particulate matter being measured.

- The PM group has made the following preliminary list of recommendations, although some are still in process in terms of potential limits:
    - Switching to Emfab filters is reasonable;
    - A filter temperature range of 80-90EF is appropriate;
    - Tunnel flow rate should be reported;
    - Residence time should be reported;
    - Tunnel temperature should be reported;
    - Filter face velocity should be reported;
    - Pressure drop from filter loading should be reported;
    - Mass (PM) loading should be reported;
    - Chemical dilution ratio should be reported;
    - Post filter equilibration should move close to FRM (ambient desiccation);
    - Relative humidity (RH) should be reported and dew point of tunnel potentially controlled;
    - Cyclones are not an ideal way to deal with moisture in the tunnel, but ensuring no water/condensation in the tunnel is not trivial for some labs so further discussion is needed.

- The PM group is not generating data, but is rather making recommendations which could inform future data gathering. PM group meeting notes are being taken and will ultimately be available to all SC members, once final recommendations are made.

- A central website will be created for all 3 groups: a SC website, an O/F group website and a PM group website. These websites will serve as a repository for data and meeting notes.

To-Do List:

- Lisa Rector will draft an invitation letter for O/F group nominees and send it out to the SC for review.

- The SC will start developing a list of outside experts to help inform the O/F group's work, after finalizing the core membership of the O/F.

- The SC will discuss a briefing strategy for informing people who aren't participants in the O/F group or SC, but who may like to provide feedback to the group(s). The SC will discuss when such briefings should happen, how often they should happen and who will lead the briefings.

- Lisa Rector will discuss with the regulators a nominee for co-chair of the O/F group. HPBA will also decide on a nominee for co-chair of the O/F group. These names will be presented to the SC at next week's meeting.

- Amanda Aldridge will follow-up with Adam Baumgart-Getz and EPA regarding the possibility of using an EPA-trained facilitator for the O/F group.

- Lisa Rector will set up three *Basecamp* websites (https://basecamp.com/) to potentially be used as central repositories for the groups. The SC will decide if the *Basecamp* websites are suitable for this purpose next week.

- The SC members should review the attached document and edit or add-to as needed, in advance of next week's SC meeting. The SC will finalize the O/F group's framework next week.

- SC members should e-mail Lisa Rector any items for next week's agenda.

ATTACHMENT

Draft Guidelines for the Operations and Fueling Workgroup (O/F)
Revised July 21, 2016

- Objectives of the Work Group
  - Develop a cord wood certification fueling/operational protocol that more closely aligns in-use emissions performance with lab certification tests
  - Develop a method that ensures good emission performance in a variety of burn conditions –
    - Operating range of appliance
    - Fuel quality

- Membership
  - Decision-making
    - Decisions will be made by simple majority
    - Voting members have the capacity to be briefed before voting occurs
  - Membership of workgroup – a diverse and robust knowledge or skill set is desired for this group in order to capture a cord wood test that is more 'real' world but at the same time technically possible with respect to precision and reliability.
  - Total number of participants on the work group is still to be determined. The Steering Committee anticipates that the work group will headed by 2- co-chairs. One chair should be a regulator.
  - Knowledge base for membership:
    - At least one member with knowledge of laboratory practices, either from a certified laboratory or academia
    - At least one member from each device-type manufacturer: catalytic and non-catalytic
      - As recommendations for the woodstove method are developed, presentations to other device stakeholders should be made to obtain feedback.
    - At least one member/expert in wood species
    - Membership should represent various geographic interests (East Coast, Midwest, West Coast, Northern regions/Arctic)
    - At least one member from EPA
    - Possibly a member from Europe
    - At least one member representing WESTAR and one member representing NESCAUM
    - Nominations (17 proposed below as members plus C. Schmidl and others TBD as advisors, if needed):
      - Lab
        - Rick Curkeet
        - Mark Champion
        - Tom Butcher
        - Ben Myren
      - Consultant
        - Bob Ferguson
        - Dan Henry

- Regulator
    - Rod Tinnemore
    - Lisa Rector
    - Bob Lebens
    - Marc Cohen
    - Cindy Heil
    - Lisa Herschberger
    - Randy Orr
- Industry
    - Tom Morrisey
    - John Crouch
    - John Voorhees
    - Greg Achman
- European Testing
    - Christoph Schmidl; expert advisor as needed

- Nominations for workgroup chairs

- Criteria to Guide the Group
    - Quantify and improve operational stability and thereby improve the precision and accuracy of final PM measurement.
    - Increased correlation between lab tests and field performance
    - Identify elements of testing specified in the protocol and those determined by operating instructions
    - Structure test method to assess daily performance and annual performance emission rates

- Key issues for O/F Protocol
    - Fuel
        - Species
            - Address need for capacity/flexibility to conduct the testing worldwide
            - Quantify differences of using different species for certification testing?
            - Address impact of moving from a single species fuel to a multiple species/density fuel. Possible configurations include:
                - Single species
                - Mixed load
                - Test with multiple fuels, e.g. run 1 hardwood & run 2 softwood
        - Fuel characteristics
            - Fuel moisture range
            - Fuel density
            - Fuel piece sizing
            - Requirements for bark, knots, etc.
        - Fuel load weight and configuration
            - How much fuel
            - Fuel charge placement - benefits of standard versus random
            - Loading protocols – specified in the method, how scripted can manufacturer loading protocols be?

- Test 'cycle'
  - What are the key operational elements that the method should capture
    - Startup, steady state, idling, shutdown, others (?)
  - What should a test cycle look like
    - hot-to-hot, cold-to-hot, operational profile (scripted operation)
  - What is the duration of the test cycle (burn to zero or burn until emissions end). Should test runs have consistent definition of end and what should that definition be (*e.g.*, when 90% of fuel is consumed in order to eliminate charcoal tail and minimize duration)?
  - How many test runs
    - Operating range (for efficiency)?
    - Precision concerns may necessitate multiple runs
- Adjustments during test cycle
  - Appliance adjustments – can the appliance settings modifications be made during the test
  - Coal bed test parameters
  - Fuel charge adjustments:
    - Note: Cordwood burns in non-uniform patterns, sometimes forming arches that can collapse at odd intervals; accommodation is needed for this practical reality
- Precision
  - Need for replicate testing
- Appliance Operation - Specified procedures for air controls, etc.
  - What are the allowances for manufacturer's instructions
  - What stack height (and draft) should be specified or allowed during testing?
- Other measurements
  - Efficiency - ensure that method provides realistic efficiency values for consumers
  - What other emissions should be measured: CO, NOx, VOC, PAH

- Possible Technical Presentations:
  - Fuel parameters/species variation lit review
  - Test methods
    - BeReal
    - ASTM
    - CSA
    - Consumer behavior

- Need to characterize potential impacts of recommendations
  - How does the change impact the result
  - How does the change impact cost of test
  - How does the change impact the ease of the test
  - How does the changes correlate to existing emission data set

- Data Analysis Considerations
  - How to design and analyze data to control for changes related to appliance technology versus test method changes
  - What data do we need versus what we have already

- Timeline
    - Summer 2016 develop and present recommendations on process and stakeholder outreach
    - Fall 2016 – develop data needs and identify key ranking criteria
    - 2017 – review data on existing and proposed test methods
    - Early 2018 – Draft recommendations
    - Summer 2018 – present recommendations to Steering Committee and EPA

Steering Committee Meeting Notes from July 28, 2016 Teleconference

Meeting led by Lisa Rector of NESCAUM

Meeting Invitees (those present are in bold-face): Lisa Rector (NESCAUM), **Bob Lebens** (WESTAR), Rob Kaleel (LADCO), Mary Uhl (WESTAR), Arthur Marin (NESCAUM), **George Allen** (NESCAUM), Rod Tinnemore (Washington), Phil Swartzendruber (Puget Sound Clean Air Agency), **Cindy Heil** (Alaska), Dave Shephard (Vermont), **John Wakefield** (Vermont), **Lisa Herschberger** (Minnesota), **John Barnes** (New York), **Marc Cohen** (Massachusetts), **Jack Goldman** (HPBA, President & CEO), John Crouch (HPBA, Public Affairs Director), **Bob Ferguson** (Consultant to HPBA, President of Ferguson, Andors & Company), 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), **Jill Mozier** (EPA's Contractor, Meeting Note Taker)

Primary Conclusions from Meeting:

- The Steering Committee (SC) did not have any issues with the content or format of last week's meeting notes and therefore the July 21st meeting notes are considered final.

- The SC did not have any issues with Basecamp as a central repository. Lisa Rector will post all meeting notes there and e-mails will be sent out to alert the SC members of new notes and other new additions to the site. Task lists will also be developed based on the notes and the task list will generate reminders which also will be e-mailed to the relevant SC members.

- Marc Cohen from Massachusetts confirmed his voting membership on the Operations & Fueling (OF) work group and may be able to co-chair it representing the regulators, pending permission from his management.

- John Crouch from HPBA will be the co-chair of the OF work group representing industry.

- Regarding the draft framework and objectives of the OF work group, the SC agreed with the first objective Lisa had listed – that is, "*Develop a cord wood certification fueling/operational protocol that more closely aligns in-use emissions performance with lab certification tests*." Specifically, both industry and regulators on the SC agreed with the use of the words "closely align", as replicating the real-world is not possible technically or economically. It was noted that the definition of "closely align" clearly involves the use of cord wood, but beyond that it quickly becomes a more complex and nuanced discussion as to what is involved [in that alignment].

- Regarding the second draft objective which originally stated "*Develop a method that ensures good emission performance in a variety of burn conditions...*" the SC decided to revise the wording of this objective as follows: "*Develop a method that measures emission performance under a variety of burn conditions*…"

- Regarding whether or not a third objective should be added to the OF work group's list of objectives charging the OF work group with sketching out a cross-walk methodology from the current EPA method to the cord wood method being developed, the SC agreed this was a high

hurdle which would require data. This cross-walk might involve two leaps and two correction factors (x and y) – from crib to cord (correction factor x, to account for the fuel change) and then an operational leap (correction factor y, to account for the changes in the operational protocol). The use of a potentially conservative correction factor to lower the risk to industry and thereby provide incentives for industry to use the new method (and generate data) was discussed. Regarding whether this objective should be explicitly spelled out in the list of OF work group objectives, the SC noted that this research component aimed at a correction factor is known by virtue of the fact that the SC is discussing it. Including it more formally as an objective at this point in time (prior to the OF work group convening) may be premature. The SC agreed to keep discussing this issue but to simultaneously allow the OF work group to begin their work. The SC and OF work group will have a joint meeting in the future regarding how best to use the new cord wood-based method in a regulatory framework.

- It was noted, regarding the OF work group's draft guidelines, that a metric is needed that looks at both daily performance and annual performance (not only annual), since from a regulatory perspective the health relevance is based on daily performance.

- The SC agreed that the species and fuel characteristics questions will need to be answered by the OF work group prior to moving forward with any operational parameters.

- Regarding whether or not a single wood species exists that is common nationally, it was noted that this is not yet known but will be informed by a survey that EPA is sending to the certification labs. The local transportation limitation of cord wood was noted. It was also noted that the literature reviews to date reveal that while species has an effect, the data is all over the map (contradictory), so even the direction of this effect is not yet clear. It was also noted that appliance differences (not only species differences) are impacting the data in the literature.

- It was noted that the OF work group will ultimately need to review the draft objectives and guidelines document and will likely have changes to it, but it's a good-enough starting point for them. It was further noted that the OF work group should come back to the SC with rationale for any changes or additions to the draft guidelines.

- The SC agreed that the first task for the OF work group should be taking the draft guidelines document and turning it into a work plan, including a prioritization of the guidelines.

- George Allen reviewed the progress made to-date by the PM Measurement work group regarding the following issues and recommendations:
    - dilution tunnel temperature and filter moisture issues, including ensuring the filter is kept at 90% RH by requiring the filter temperature to be 2 C degrees higher than the tunnel dewpoint;
    - residence time and tunnel temperatures, including the need to set the max tunnel temperature at 100 F;
    - more accurate temperature measurements using thermistors (rather than thermocouples);

- using a PM 10 size cut cyclone on the inlet to keep fly ash out;
- the use of field blanks, lab blanks, and dynamic blanks as well as a room air filter sample to get background PM in the lab (Note: Stef Johnson also recommended a proof blank);
- a balance resolution of 0.01 mg;
- automatic sample flow control;
- weighing room environmental conditions being based on actual measurements of RH and temperature (rather than the current use of a fixed correction for water);
- equilibrating at 35% RH using saturated salt solutions in the desiccator (rather than brute force desiccation);
- recording an initial off-weight before equilibration and then another weight after Day 1, before recording final weight, as this data may be useful in determining if the mass loss is due to SVOC or water.

The PM Measurement work group will have a final teleconference in early September.

- The SC decided to post the PM Measurement work group meeting notes to Basecamp.

- With next week's meeting, the SC is hoping the process can transition out of SC initiation duties and into the OF work group meetings.

- Next week's SC teleconference will be used for final changes to the draft OF work group guidelines document. In addition, the regulator co-chair of the OF work group will be finalized and the invitation to OF work group members will be finalized. Finally, the SC will also discuss what experts to bring into that work group as well as what stakeholder briefings to hold.

To-Do List:

- SC members should review and comment on the draft invitation Lisa e-mailed to the group (also attached to these notes) by Tuesday, August 2nd. Lisa will finalize the invitation after August 2nd and send it to any nominees still in need of an invitation (e.g., Tom Morrissey, Tom Butcher, Mark Champion).

- The regulators on the SC will finalize their choice for the OF work group co-chair by next week's SC meeting.

- Bob Ferguson will review the draft guidelines document for the OF work group. Other SC members should also make one final review of this document and provide comments for next week's SC teleconference.

- Bob Ferguson will post data to the ASTM collaboration site that can also be posted to Basecamp. This is data and memo reports used in the ASTM development process pertaining to specific gravity and moisture content ranges and also to operational issues.

- Lisa Rector will post PM Measurement work group meeting notes to Basecamp and will also initiate the OF work group Basecamp site.

ATTACHMENT
Draft Invitation to OF Work Group Members

Greeting!

An effort has been set up to develop recommendations to EPA-OAQPS on a revised cordwood test method for residential wood heaters. This effort is setting up a workgroup to develop recommendations for fueling and operation protocols. Information on this effort can be found on the EPA released discussion paper on the project, at: https://www.epa.gov/burnwise/process-developing-improved-cordwood-test-methods-wood-heaters

This paper lays out a process (Section 6) to revise test methods for residential wood heaters. A key component of that effort is developing recommendations for a revised protocol that not only moves the fuel from crib wood to cord wood but also creates an operational protocol that will create stronger links between certification results and field performance.

To complete that effort, we are first looking for workgroup participant s with expertise in the field of regulatory testing and residential wood heating testing to participate on an Operation and Fuel Technical Workgroup. Your name was put forth by the Steering Committee as highly qualified for this effort. NESCAUM has been tasked with reaching out to you to see if you have interest in this effort.

The expected time commitment is 1-2 calls/month approximately 60-90 minutes in duration, and time to review and comment on draft documents over the next 8-12 months. This group might also be asked to comment/develop recommendations on research agendas, if EPA is able to fund evaluation testing.

Please let us know if you are able to participate in this process. Alternatively, if you are not able to participate, we would request nominations for other individuals whom you think would be well qualified. Thanks very much.

EPA Notes Operation and Fueling (O/F) Workgroup Meeting Notes from September 8, 2016 Teleconference

(Note: Voting Members are in bold-face)

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

Meeting Invitees: Bob Lebens (WESTAR, Co-Chair of Steering Committee), **Rod Tinnemore** (Washington) **& Phil Swartzendruber** (Puget Sound Clean Air Agency), **Cindy Heil** (Alaska), John Wakefield (Vermont), **Lisa Herschberger** (Minnesota), Ann 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), Rebecca Trojanowski (Brookhaven National Lab), **Gregg Achman** (Hearth & Home Technologies), **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 Town (Dirigo lab), Gaetan Piedalue (Polytests lab), Jared Sorenson (OMNI lab), Sebastian Button (OMNI lab), Kelli O'brien (ClearStak), Jeff Hallowell (Biomass Controls), Jill Mozier (EPA contractor, meeting note taker)

Primary Conclusions from Meeting:

- The O/F Workgroup members introduced themselves and the group's objectives, key issues and guidelines were briefly reviewed. The O/F Workgroup's decision making structure will be a simple majority, although the dissenting opinion and rationale will be drafted and included with the majority decision as part of the recommendations to EPA.

- The O/F Workgroup will meet again on Thursday, September 29th at noon EST, with a focus on species. The very next week (October 6th) there will be a presentation on the ASTM effort. After that, the group will meet every 2 weeks, starting October 20th – the first and third of every month – at noon EST.

- After the sessions on species and the ASTM effort, there will be a presentation on the BeReal effort in Europe. Lisa may record these educational sessions as webinars on Basecamp.

To-Do List:

- The O/F Workgroup participants (both voting and non-voting) should log-onto Basecamp and familiarize themselves with the Draft Guidelines document in particular.

- Any documents on Basecamp will be organized topically.

- Lisa Rector and Bob Ferguson will discuss how to condense and/or parse the ASTM presentation. Lisa will also determine if slides from the regulatory perspective should be added.

Highlights from Meeting:

- John Crouch introduced himself as co-chair, noting that he is the Public Affairs Director for the Hearth, Patio & Barbecue Association (HPBA), lives in Sacramento, and has been involved with residential wood heater issues for many years.

- Marc Cohen introduced himself as co-chair, noting that he is an environmental engineer and the biomass regulatory permitting lead for the Massachusetts Department of Environmental Protection, and has also been involved with residential wood heater issues for many years.

- The meeting continued with roll call and introductions:
    - Jill Mozier – EPA contractor with EC/R Inc, worked on the Residential Wood Heater NSPS with EPA since 2012, taking notes during the O/F Workgroup meetings and for the PM Measurement Workgroup and the Steering Committee. (Draft notes will be posted to Basecamp for comment and any corrections will be incorporated before finalizing.)
    - Lisa Rector – senior policy lead with NESCAUM working since 2001 on wood heater issues including test methods, research, modeling and monitoring, also the co-chair of the Steering Committee along with Bob Lebens.
    - Bob Lebens – Technical Coordinator with WESTAR, involved with wood heater issues starting in Oregon in the early 90s, also involved with revisions to NSPS, co-chair of the Steering Committee along with Lisa Rector.
    - Mark Champion – owner of Hearth Lab Solutions, involved with EPA field studies and design of wood heaters for manufacturers since 1990, including the 4 field studies in Crested Butte and product development and testing for industry.
    - Gregg Achman – Vice President of Product Engineering for Hearth & Home Technologies Inc., a prominent manufacturing company of wood heaters with over 100 patents including the brands Quadra-Fire, Harman, Heatilator, Vermont Castings, Pelpro, Monessen, Heat & Glo and others.
    - Cindy Heil – Program Manager at the Alaska Department of Environmental Conservation, responsible for area sources including wood heater emissions, involved in developing SIP for Fairbanks area which has the highest $PM_{2.5}$ design values in nation due primarily to wood smoke
    - Lisa Herschberger – Scientist at the Minnesota Pollution Control Agency working on wood stove pollution for 8 years, authors Minnesota's Residential Wood Combustion Survey Report as well as source apportionment studies, performs outreach on health effects of particles and wood smoke, now in air policy unit working on significance of residential wood combustion sector as other sector sources have decreased.
    - Ann Jackson – Senior engineer working with Lisa Herschberger in the Minnesota Pollution Control Agency, in air policy for 25 years including writing regulations for incinerators.

- Jared Sorenson – Director of Technical Services at OMNI Test Labs, previously employed with Intertek, involved with manufacturing since 1980s and then in compliance testing in late 90s
- John Voorhees – Director of Product Development at U.S. Stove Company since 2014 including compliance, previously in product testing for 15 years including with Intertek
- John Barnes – Chief of the Stationary Source Planning Section in the New York State Department of Environmental Conservation, working on residential wood combustion issues since 2007, assisted NESCAUM with their model rule that became a NY State regulation in 2010
- John Steinert – President of Dirigo Labs since 2010, previously with OMNI since 2007
- John Wakefield – Compliance Section Chief at Vermont Department of Environmental Conservation for past 3 years, responsibilities range from stationary sources to residential wood combustion, completed an outdoor wood boiler change-out program and also designed a woodstove change-out program, here to learn as an observer not as a voting member
- Stef Johnson – Group leader of the Measurement Technology Group at EPA in RTP, NC (a.k.a. Mike Toney's boss), responsible for developing, maintaining, updating and approving EPA test methods, including those applicable to residential wood heaters
- Randy Orr – With the New York State Department of Environmental Conservation's Bureau of Quality Assurance for Stack Testing for last 9 years, performed stationary source permitting prior, responsible for ensuring EPA's (Stef Johnson's) methods are implemented properly
- Rick Curkeet – Chief engineer with Intertek, testing and certifying wood stoves since 1979, also ASTM E06.54 (Solid Fuel Burning Appliances) Subcommittee Chairman since 1986 which includes ASTM standards for wood heaters referenced in NSPS
- Bob Ferguson – President of Ferguson, Andors & Company, consultant servicing the hearth industry since 1980, previously director of R&D at Vermont Castings, previously served on board of HPBA, member of ASTM including chairing or acting as facilitator for ASTM test methods applicable to wood heaters
- Sebastian Button – Safety Testing Manager at OMNI Test Labs, in charge of wood emissions testing for 8 years
- Rod Tinnemore – Environmental Specialist with Washington State Department of Ecology, involved in regulations and air quality related to solid fuel burning
- Tom Morrissey – President of Woodstock Soapstone in New Hampshire, has been designing and manufacturing woodstoves for 39 years, advocate for tighter more science-oriented test methods
- Rebecca Trojanowski – Staff engineer at Brookhaven National Lab supporting test method development for woodstoves and boilers
- Tom Butcher – Research engineer at Brookhaven National Lab, engineer for nearly 40 years, involved with wood heater research and testing since 2010, working on technical aspects for test method development
- Amanda Aldridge – Engineer at EPA, involved in wood heater issues since being EPA lead for the hydronic heater voluntary program, currently EPA lead for Residential Wood Heater NSPS (since Gil Wood retired)

- Kelli O'brien – Lab manager at ClearStak in Connecticut, has worked with NESCAUM and Brookhaven in testing woodstoves and hydronic heaters, also managed sanitation project involving combined heat, biochar, and power system funded by the Bill and Melinda Gates Foundation
- Gaetan Piedalue – Test engineer in EPA-accredited test labs for last 25 years, first with Intertek and now with Polytests Lab (Canada)
- Dan Henry – Co-founder of Quadra-Fire, previously chief technical officer for Hearth & Home Technologies, involved in wood heater designs since 1979, holds several patents for second combustion stoves, certified dozens of models, now retired and consultant to industry
- Doug Town – Quality Assurance manager with Dirigo Labs, 25 years' experience with air testing including source, ambient and indoor air testing, 6 years' experience in residential wood combustion including with OMNI and Dirigo Labs
- Mike Toney – Part of EPA's Measurement Technology Group in RTP, NC involved with developing, maintaining, updating and approving EPA test methods, including those applicable to residential wood heaters, many years' experience with residential wood heater testing under EPA's NSPS
- Note – Other invitees may have been on call, who did not introduce themselves.

- John Crouch concluded introductions by noting that the O/F Workgroup is large and diverse.

- Lisa Rector and NESCAUM use the on-line tool Basecamp, which Lisa introduced the group to with some basic instructions. Basecamp is a web-based method to organize projects with a central repository for everything: files, to-do list, calendars, and discussions. Lisa noted that everyone in the group had an e-mail invitation to Basecamp. [Note: anyone who didn't receive an invitation should e-mail Lisa to ensure access.] Lisa noted that she, John Crouch, and Marc Cohen had already been using the O/F Workgroup's Basecamp. Lisa proceeded to go through each of the tools on Basecamp:
  - The "Docs & Files" include agendas, meeting notes, general docs, data, and recommendations. Any group member can upload a document to Basecamp. Lisa opened the Guidelines document (under "General Docs") and demonstrated the options to share, make list, etc.
  - The "Automatic Check-ins" is a way to update the team.
  - The "Schedule" is for upcoming meeting dates and times.
  - The "To-dos" sends out e-mails as reminders and then these items can be archived once completed.
  - The "Message Board" can be used for discussions.
  - The "Campfire" is for general dialogues, not necessarily topical.

- Lisa noted that pertinent documents from Basecamps for the Steering Committee and the PM Measurement Workgroup would be posted to the O/F Workgroup Basecamp as well. John urged the group to begin working with Basecamp, noting that it becomes logical/intuitive with use.

- Lisa gave an overview of the cordwood test method (CTM) process, also referred to as the Federal Reference Method (FRM) process, of which the O/F Workgroup is an integral first step.

Lisa noted that the process was outlined in EPA's March 2016 Discussion Paper entitled "Process for Developing Improved Cordwood Test Methods for Wood Heaters" (available at https://www.epa.gov/sites/production/files/2016-03/documents/discussion_paper_-_process_for_dev_imp_cwtm_030916.pdf). This process consists of a Steering Committee and two workgroups: the PM Measurement Workgroup and this O/F Workgroup. The ultimate goal is to prepare a CTM. As part of the process, ASTM 2515 plus Method 5 will be reviewed and recommendations for improvement made to EPA. The Steering Committee is providing direction so that the CTM addresses regulatory needs in terms of PM measurement and operational/ fueling aspects while also ensuring the CTM is feasible to implement by industry.

- The Steering Committee developed the framework for the two Workgroups. Lisa noted that the O/F workgroup process is not intended to be contentious, although consensus may not always be achieved. Because consensus will not always be possible, dissenting opinions will be presented (along with the majority decision) so that EPA can understand these opinions and viewpoints. John Crouch and Marc Cohen are chairing the O/F Workgroup and George Allen is chairing the PM Measurement Workgroup. Lisa noted that EPA is sitting in, not as voting members, but in an advisory role [regarding regulatory process needs]. Lisa noted that the following people were members of the Steering Committee: Lisa Rector (NESCAUM), Bob Lebens (WESTAR), Jack Goldman and John Crouch (HPBA), Phil Swartzendruber and Rod Tinnemore (Washington State), John Barnes (New York), Cindy Heil (Alaska), Marc Cohen (Massachusetts), Lisa Herschberger (Minnesota), and Bob Ferguson (Consultant to HPBA). There were no further questions regarding the Steering Committee.

- Lisa discussed the **Objectives for the O/F Workgroup**, which are outlined in the Guidelines document (under "Docs & Files" on Basecamp) –
    - Develop a cord wood certification fueling/operational protocol that more closely aligns in-use emissions performance with lab certification tests
    - Develop a method that measures emissions over a variety of burn rates and conditions
        - Operating range of appliance
        - Fuel quality
    - Quantify and improve operational stability and thereby improve the precision and accuracy of final PM measurement.
    - Increase or develop correlations between lab tests and field performance
    - Identify elements of testing specified in the protocol and those determined by operating instructions
    - Structure test method to assess daily performance and annual performance emission rates

- Lisa noted, regarding quantifying and improving operational stability and thereby improving the precision and accuracy of the final PM measurement, that real-world alignment may decrease precision. Therefore, it's a balancing act.

- Regarding recommendation considerations, Lisa noted that the O/F Workgroup has a long list of issues to consider (as listed in Draft Guidelines document). The Steering Committee would like

the O/F Workgroup to address or characterize the potential impacts of any recommendation using 4 criteria:

- How does the change (e.g., moving to cordwood) impact the result?
- How does the change impact cost of test?
- How does the change impact the ease of the test?
- How does the change correlate to existing emission data set?

- Lisa reviewed the Key Issues the O/F Workgroup would need to consider. Regarding the first - Fuel Species – Lisa noted that the issues of species will be a constraining factor because state regulations restrict the movement of cordwood to within 50 miles. Therefore, the process will need to ensure labs have access to cordwood, so as not to create competitive advantages. Lisa briefly noted the following **Key Issues** from the Draft Guidelines document:

Fuel

Species

- *Address need for capacity/flexibility to conduct the testing worldwide*
- *Quantify differences of using different species for certification testing?*

Address impact of moving from a single species fuel to a multiple species/density fuel. Possible configurations include:

- *Single species*
- *Mixed load*
- *Test with multiple fuels, e.g. run 1 hardwood & run 2 softwood*

Fuel characteristics

- *Fuel moisture range*
- *Fuel density*
- *Fuel piece sizing – length, diameter, etc.*
- *Requirements for bark, knots, etc.*

Fueling Protocols

Fuel load weight and configuration

- *How much fuel*
- *Fuel charge placement - benefits of standard versus random*
- *Loading protocols – specified in the method, how scripted can manufacturer loading protocols be?*

Testing Parameters

Test 'cycle'

- *What are the key operational elements that the method should capture?*
- *Startup, steady state, idling, shutdown, others?*

What should a test cycle look like?

- *hot-to-hot, cold-to-hot, operational profile (scripted operation)*

What is the duration of the test cycle?

- *burn to zero, burn until emissions end or something else*

Should test runs have consistent definition of end and what should that definition be (e.g., when 90% of fuel is consumed in order to eliminate charcoal tail and minimize duration)?
How many test runs?
Operating range (for efficiency)? Precision concerns may necessitate multiple runs

Device Operation
Adjustments during test cycle
Appliance adjustments – can modifications to the appliance settings be made during the test?
Coal bed parameters
Fuel charge adjustments

Method Precision
Need for replicate testing
Appliance Operation - Specified procedures for air controls, etc.
What are the allowances for manufacturer's instructions?
What stack height (and draft) should be specified or allowed during testing?

Other measurements
Efficiency - ensure that method provides realistic efficiency values for consumers
What other emissions should be measured: CO, NOx, VOC, PAH?

- Lisa further noted that the O/F Workgroup should develop a research agenda reflecting what data exists already versus what data is still needed. The Workgroup should develop specific recommendation for additional research.

- Lisa noted that the O/F Workgroup would employ a decision making structure based on a simple majority vote, although the group would strive for consensus. There are voting participants and non-voting participants. Voting members have the capacity to be briefed before voting occurs. For the minority (dissenting) opinion, a leader will be chosen to draft the minority position and that minority position will be included in the recommendation to EPA.

- The O/F Workgroup can request input from the Steering Committee, but that request should come with options and recommendations. In addition, the Workgroup's recommendations will be presented to a larger group of stakeholders including labs, manufacturers, environmental groups and advocacy groups.

- Regarding the timeline, Lisa noted that the Workgroup is already starting a bit behind schedule. The following is the draft timeline, although both the regulators and HPBA would love to shorten the timeline by speeding up the process –

  Summer 2016:
  - Develop and present recommendations on process and stakeholder outreach
  - Prioritize issues

  Fall 2016

- Develop initial data needs
- Identify key ranking criteria

2017

- Review data on existing and proposed test methods
- Discuss and draft recommendations

Early 2018

- Draft recommendations completed

Summer 2018

- Present recommendations to Steering Committee and EPA

- John Crouch noted that the ASTM process took 4 years and 2 years were spent on the cold start alone. John explained that some of the issues/bullets feed back into other issues in ways which interrupt the forward motion of the process, requiring taking a step back. John concluded that he assumes this will be a 4-year process, that he's committed for that timeframe and he hopes other members are as well.

- Marc Cohen noted that the goal is 2018 because it's two years before the 2020 NSPS standards come into place. Lisa further noted that the ASTM group did a lot of work already which means the O/F Workgroup is not starting from scratch. This workgroup can build off the ASTM work and can also use the European BeReal work as well as the Australian method as starting points for discussion. Nonetheless, Lisa recognized it was an aggressive timeline.

- John Crouch asked Gregg Achman to speak as a representative of manufacturers regarding how 2020 impacts planning now. Gregg noted that his company is already needing to plan this year for 2020 – including the number of units to be tested and getting engineers lined up. With 20 to 30 different models with different k values [meaning each requires certification], his company needs to be in the test lab every quarter from now until 2020 just to get models certified with crib. Gregg further noted that, closer to 2020, his company will attempt to certify with cordwood, but that will depend on the time and resources required to go from the 4.5 g/hr (2015 standard) to the 2 g/hr (2020 standard) in R&D, then testing and finally certification. Gregg reiterated that work for 2020 is beginning now in 2016.

- Marc requested that everyone in the O/F Workgroup review the Draft Guidelines document on Basecamp, as it's detailed and will focus group members on what needs to be accomplished. Marc further noted that NESCAUM took the lead in developing the model rule for outdoor hydronic heaters/boilers and decided to move ahead with regulations for the northeast. This process has evolved into EPA's current NSPS. So as this group moves forward from dimensional crib wood to cordwood, to better reflect in-home use, there exists a good baseline of people involved from both the regulatory side and from industry. Marc concluded that this is a group that can and should be effective in moving this process forward.

- Dan Henry noted that a very problematic issue the ASTM had in developing its CTM is the ridiculousness of applying the low burn rate requirements for crib wood to cordwood. The Australian and European approaches don't employ such low burn rates and their test methods

are much simpler – that is, if it burns clean you pass, if not you fail. Dan noted that the minimum burn rate categories are a severe handicap to clean burning. A method is needed that allows a stove to be turned down reasonably and that ties the stove to in-home use based on climate zone. That would accelerate and enhance this process dramatically, would be positive all round and would reduce the impact of species. Dan recommended that the group start looking at limiting such burn rate requirements and stop measuring at such ridiculously low rates.

- Lisa Rector noted that they were looking at a method that based burn categories on stove controls. This would not be the typical EN (European) method, but rather an operational protocol that involves multiple fuel loads. The method would not be based on burn rates per se, but rather based on air settings – an operationally-based method tied to the appliance, rather than based on fixed numbers (for burn rates). That's being looked into, but such a method would need to be tied back to the NSPS in some way so that EPA can determine compliance with the standard. Currently there are 4 burn categories and we need to supply information to EPA that helps with correlation to the standard, even if such a method doesn't necessarily stick to burn rates. For example, giving EPA a division by 10 correlation would help. The challenge is how to move to better performance but do so in a way that EPA can use the results from the method.

- Stef Johnson noted that EPA, when developing the CTM, will go through proposal, public review and finalization of the method. The recommendations that Lisa's mentioned, that this O/F Workgroup will prepare, will hopefully streamline the comments and response so that only relatively minor tweaks are required to the proposed CTM before it becomes the final CTM/FRM.

- Bob Lebens expressed appreciation for the industry folks who have labored long and hard on the ASTM process, noting his appreciation for their willingness to participate in a process that some may see as duplicative. However, he is hopeful that much of the ASTM method/discoveries can be used to make recommendations. Bob also noted that the Workgroup reaching consensus to the greatest degree possible will make EPA's job easier.

- Rod Tinnemore noted that the regulators realize this isn't a slam dunk process, that there are a whole lot of details here. Rod noted that the process will move as fast as it can. He shares some skepticism regarding timeline but is not certain, since there are things in place already. Rod noted he wished this process began a decade ago. He concluded that at least the issues are well outlined and thorough, allowing the group to know what needs to be tackled.

- Cindy Heil noted that she hoped people would think outside the box. She knows of the effort put in the ASTM method and also knows there's familiarity and comfort there. However, what is needed now is innovation and unique thinking, because there will be no changes in engineering and design unless the group thinks outside the box. Cindy noted that she sees what's on the ground and deals with health issues and people. Monitoring has shown spikes in the morning and night. Huge amounts of material being put out into the atmosphere, even from supposedly clean, certified stoves, because people don't follow manufacturer's recommendations. So the

group needs to think about that, and using lots of different species. This problem doesn't fit into a nice box, it's haphazard and messy. Cindy noted that she's in the trenches and industry is in the trenches in a different way. The bottom line is there are health issues and we have to have wood stoves in Alaska. Woodstoves can't be banned in Alaska because the supplemental heat is needed. Cindy implored the group to be patient but to think in new ways. The ASTM method is a bridge but Cindy noted she thinks there's a different approach the group can take.

- Bob Ferguson noted that the good news is that everyone has the same objective. It has been recognized over the years, since the Oregon days, that using crib is not helpful for translating stove designs into in-home use. So everyone recognizes the test method should reflect in-home use. But, like Cindy said, people will do whatever they want. We have uncontrolled fuel and uncontrolled operators. So we do the best we can to educate people to operate well. Bob noted that there is a common objective and as someone working on the ASTM method for many years, Bob explained that the ASTM developers never looked at the ASTM method as being the end of the process. The ASTM method is considered a stepping stone. We tried to develop a test method that passed the reasonable test, so that manufacturers will use it and generate data. Data is absent from this. People need to go out and burn wood so we can understand how to improve the test method based on data. Bob concluded that the ASTM developers always considered the method an interim step to generate data, never as an endpoint.

- John Crouch noted that it was important to prioritize steps in this process and wondered whether a session based on the Be Real method should be next. Or a more foundational session on the crib method, or ASTM method, or should the first session be on fuel/species? (John noted that the question of fuel/species held up the ASTM process for a long time and also noted that the ASTM process determined there is no fuel that can be used everywhere.) John noted that there are lots of things the group could discuss next, but those sessions should be teed up now. John asked what the states' top 3 priorities are for this process.

- Marc noted that it would be really educational to get presentation from the BeReal effort. The states' interest is to get a test method that is more representative of what's actually going on in the home. The test method should reflect emissions from operating the stove similar to how a homeowner operates it, including different wood species and moisture contents. The goal should be to reduce the number of variables and yet have this test method reflect what's going on in the real world.

- John Barnes noted that it's been mentioned that the ASTM process spent a long time on species and wondered if the ASTM findings could be condensed, in order to bring the rest of the group up to speed. John Crouch replied that yes, there could be an hour or hour-and-a-half presentation on the species issue.

- Lisa Herschberger noted that it'd be valuable to have presentations that bring people up to speed on what is known and what we can agree on to help prioritization. For example, knowing what was done on the ASTM process might help capture where agreement is, rather than first going through the Draft Guideline's list. It would be helpful to first have the information to

understand why we are working on one aspect or another, before prioritizing (the items on the Guideline's list).

- Bob Ferguson replied that industry and ASTM representatives did give a presentation back in February to EPA and a few others (including NESCAUM) that tried to provide a history of the ASTM process, including the rationale behind number of decision points. It's a very long presentation, but Bob may be able to distill it down. Bob noted that there is a handout, but he's not sure how it reads without some guidance. Bob offered to give that presentation, although no one (including himself) will want to go through the full 80 slides. That presentation does exist, however.

- Lisa Rector agreed it was a long presentation that took a full day. She noted that she and Bob could perhaps parse it into several meetings. Lisa also noted that there may be regulatory-side information to add, but the ASTM presentation may be a good way to jump start the preparation. Bob Ferguson agreed to help Lisa and to also go through the presentation and update it based on last 6 or 7 months, since evolution has happened in the draft method.

- John Crouch noted that, like Marc, he also wanted to see a presentation on the BeReal effort. First, however, perhaps the ASTM presentations should be given in 2 or 3 meetings. Bob Ferguson agreed that both presentations are needed and he would also like to know about the BeReal effort. Lisa noted that Christof Schmidl can give the presentation but it will be impossible to get Cindy in on that presentation, give then time difference between Europe and Alaska. Cindy noted not to worry about her. Lisa explained that it took Christof about 2 hours to go through the presentation and they have data too.

- Lisa suggested going through ASTM process first and also setting up something with BeReal. Lisa noted that she wouldn't want to bore the labs and manufacturers, but if the states and locals need to go over any foundational issues or the ASTM process, that could be set up on a separate call. Bob Ferguson suggested that he and Lisa discuss this further, although he's unavailable until the 19th. Bob will look into trimming the presentation and will then speak separately with Lisa about it.

- Tom Butcher noted that there would be great value in a session on just species, that perhaps one slice of Bob's presentation could address species. Cindy and Lisa Herschberger agreed.

- John Crouch suggested that (since ASTM can't be teed up in two weeks) the presentations start with a species focus in 2 weeks, then 2 weeks later a presentation on the ASTM effort (i.e., current cordwood method that's on ballot), and finally 2 weeks after that a presentation on the BeReal effort. Marc agreed this was a great plan. Lisa added that she could record them as webinars on Basecamp. John Crouch also suggested organizing the documents on Basecamp so it's not just a pile of documents.

- There was general agreement that the group would meet every 2 weeks. Due to Marc's and John's travel plans, the O/F Workgroup would meet in 3 weeks on Thursday, September 29th at

noon EST, with a focus on species. Then the group will meet the first and third Thursdays of every month. (Therefore, there's a meeting in 3 weeks and again in 4 weeks, but then every 2 weeks after that.) **Meeting adjourned**.

EPA Notes Operation and Fueling (O/F) Workgroup Meeting Notes from September 29, 2016 Teleconference

(Note: Voting Members are in bold-face)

Meeting led by **John Crouch** (HPBA, Co-Chair of O/F Workgroup), **Marc Cohen** (Massachusetts DEP, Co-Chair of O/F Workgroup), **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), **Cindy Heil** (Alaska), John Wakefield (Vermont), **Lisa Herschberger** (Minnesota), Ann 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), **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 Town (Dirigo lab), Gaetan Piedalue (Polytests lab), Jared Sorenson (OMNI lab), Sebastian Button (OMNI lab), Kelli O'brien (ClearStak), Jeff Hallowell (Biomass Controls), Jill Mozier (EPA contractor, meeting note taker)

Primary Conclusions from Meeting:

- O/F Workgroup meetings will be held on October 6, 13 and 20, 2016 with the beReal presentation by Christoph Schmidl happening from 11am until noon on October 13th.

- The details of today's presentations are noted below in the meeting highlights as well as in the presentations posted to Basecamp. This is background material to educate the group; no official conclusions have yet been drawn by the group (except for the next bullet).

- It would be very useful to research the typical degree of variation in cordwood piece length and weight (before getting outside the norm), burned across the nation.

To-Do List:

- Lisa will set up the October 13, 2016 presentation by Christoph Schmidl of beReal.
- Lisa will upload Tom Butcher's presentation regarding wood species to Basecamp.
- Anyone in the group who has additional suggested citations regarding wood species studies should e-mail those suggestions to Tom Butcher of BNL.
- Anyone in the group with questions for Bob or Tom should post their questions to Basecamp.

Highlights from Meeting:

- Marc Cohen, John Crouch and Lisa Rector opened the meeting. Marc reviewed the agenda (attached) and Lisa did the roll call. Note that the attached agenda reflects revisions decided upon in this meeting and includes the agenda for today (September 29), October 6, October 13 and October 20, 2016.

- Regarding scheduling, Lisa noted that she had tentatively blocked 11 to noon on October 20th with Christoph Schmidl of BeReal. That would mean a 2.5 hour call on October 20th (due to the other agenda items for that call) which may be too long. Lisa noted that there are 3 options: do the BeReal call on October 13th; do the marathon call on October 20th; or push the BeReal call to November 3rd. Marc suggested doing 11 on October 13th, as this is the most manageable and the presentation would be helpful sooner rather than later. John Crouch noted concern that since Bob Ferguson's presentation is spread out over 3 calls, interrupting those calls may lose the thread (of understanding). Marc noted that the BeReal effort looks at how homeowners really operate their stoves and this was also an important consideration during the ASTM test method deliberations. Therefore looking at the outcome of the BeReal survey will aid the group's understanding rather than interrupting the flow of information. Bob Ferguson agreed, noting it made sense to have the call on October 13th from 11 to 12.

- Lisa noted that the calls are every week starting today for 4 weeks. No one noted a problem with this. Lisa will e-mail Chris Schmidl and set up his presentation on October 13, 2016. Lisa further noted that these 4 calls are background calls with the calls in November starting to focus on discussion items. Marc and John agreed.

<u>Tom Butcher's Wood Species Impact Discussion:</u>

- Marc introduced Dr. Tom Butcher from BNL who began presenting slides entitled "Summary of Literature Review for Wood Species Impact on Emissions" by R. Trojanowski and T. Butcher of BNL. [Note: These slides are posted to Basecamp.]

- Tom noted that he would go over some things that BNL has looked at in the literature regarding wood species and go over what's already known, starting out with a primer on wood species that many in the group may already know. Tom further noted that he's sure that there's literature out there he has missed and therefore asked everyone in the group to send him additional literature (or citations) that should be reviewed. Tom also noted that the BNL work is admittedly slanted toward red oak and Douglas fir, as that pertains most to the research BNL is currently doing.

- Regarding the primer on species, Tom noted that hardwood (deciduous) trees generally have broad leaves which are shed in the fall, usually (not always) are of higher density than softwoods, and have vessels/elements that transport water similar to "pores". Softwoods (conifers) have needles all year, medullary rays and tracheids transport water and produce sap, faster growing than hardwoods and generally lower in value. Note that tracheids are long, thin longitudinal cells in softwoods that act as pores, take up 90% of the volume of the tree and serve to carry sap. Sap gets secreted into the tracheids when the tree is injured.

- Regarding softwood structure, Tom noted that medullary rays are sheets extending through the tree perpendicular to the growth rings, consisting of parenchyma cells that allow sap to flow outward to heal injury. Tracheids are an element of the plant's vascular tissue and consist of elongated narrow tube like cells with cell walls composed of lignin. Tracheids help transport water from the roots to the rest of the plant.

- Tom noted that Barbara Cole from the University of Maine did research on the extractive components of wood. Wood extractives are non-cell wall components that can be removed using solvents (e.g., pet. ether, acetone, ethanol, water). These are relatively small molecules ($<C_{40}$) and usually comprise 1-5% of the wood. Wood extractives are under genetic control and therefore vary by species. Softwoods have more extractives than hardwoods. Barbara Cole's research also notes that softwoods have resin acids (40-45% of extractives), fatty acids (40-60%), monoterpenes (turpentine) and phenolics. Hardwoods, on the other hand, have no resin acids or monoterpenes, but do contain fatty acids (60-90%) and phenolics. Tom noted that the point is the structure and composition vary significantly between softwoods and hardwoods.

- Regarding wood densities, Tom showed a slide that indicates that densities/specific gravities of tree species don't necessarily differentiate well between soft and hardwoods. For example, the densities of hardwoods on this slide vary from 0.60 (black maple) to 0.71 (white oak) while the softwood on this slide has a density right in the middle of that range at 0.64 (southern longleaf pine).

- Regarding wood side hardness, Tom pointed out that hardwoods do have higher Side Hardness (N) values than softwoods. On Tom's slide, hardwoods vary in hardness from 3,800 for black ash to 6,500 for some birch, while softwoods vary from 1,600 for spruce to 3,200 for Doug-fir. Marc asked if these values are derived from something similar to the Rockwell hardness test and Tom confirmed they were.

- Regarding an overview of the literature, many European studies (on different wood species/types such as cordwood, pellets and "garden biomass" on modern stoves and boilers) have collected PM_{10}, $PM_{2.5}$, PM_1, EC, OC and odor data. Tom noted that these European studies show high inter-species variability dependent on the location of the tree and growth conditions as well as the combustion environment.

- Tom discussed the 2009 Kinsey et.al. study ("Evaluation of methods for the physical characterization of the fine particulate emissions from two residential wood combustion appliances") which looked at 3 burn phases of a non-catalytic woodstove burning northern red oak and Douglas fir cordwood at two different moisture levels. On the slide showing results, Tom compared Stove-Dry Oak to Stove-Dry Fir and noted that from this particular study one could conclude that the oak is worse (higher emitting/"dirtier") than the Douglas fir, although the error bars are large.

- Next, Tom discussed the study by Fine, Cass and Simoneit ("Chemical Characterization of Fine Particulate Emissions from Fireplace Combustion of Woods Grown in: Northeast, Midwest & Southern US") that identified the top 21 wood species in the US, selected 18 for testing and divided them into four groups based on geographical location. BNL looked most closely at the study results pertaining to Northern red oak (moisture content of 14%, DB) and Paper Birch (MC of 9%, DB) from the Northeast and, from the Midwest and West, American beech (MC of 13%, DB) and Douglas fir (MC of 19%, DB). The study's methodology included oven-drying the cord wood and burning it in a conventional masonry heater while sampling 4 meters above the fire using a dilution source sampler (with cyclone separators).

- Tom further noted that results showed a mixed bag which made it hard to conclude much regarding hardwood versus softwood: American Beech at 9.3 ± 1.0 g/kg; Northern Red Oak at 5.7 ± 0.6 g/kg; Douglas Fir at 4.0 ± 0.8 g/kg; and Paper Birch at 2.7 ± 0.3 g/kg. In addition to fine particulate emission rates, results provided EC & OC, ion species and elemental species. There were a series of 6 sampling trains operating in parallel: 2 for EC/OC; 2 for gravimetric mass determination (1 L/min, Teflon filter); and 2 for gravimetric mass, IC and XRF analyses (15 L/min, Teflon filter). Uncertainties were based solely on analytical & measurement errors. Interestingly, there was no observed correlation between wood moisture content & fine PM rate. The authors believed increased emissions were a result of sap inclusions within wood. The average particle size distribution showed little variation from wood to wood (with the peak at 100- 200 nm).

- Next, Tom discussed the 2015 Gullet et.al. NYSERDA study entitled "Environmental, Energy Market, and Health Characterization of Wood-Fired Hydronic Heater Technologies" which looked at Red Oak versus White Pine cordwood as well as pellets. Tom noted that since efficiencies were very low due to cycling, it was best to examine the Heat Input graphs, rather than the Heat Output graphs. In this study, White Pine is higher emitting/dirtier than Red Oak. Species-wise, this is the opposite of what the earlier studies concluded, Tom pointed out.

- Next, Tom discussed the OMNI/Fairbanks study which looked at Birch (hardwood) versus Spruce (softwood) burned in both an EPA certified woodstove and a conventional woodstove. In both types of stoves, emissions were higher from the Birch than from the Spruce.

- Marc noted that these studies are showing different results from woodstoves versus hydronic heaters when comparing hardwoods to softwoods. Tom agreed, although noted there were also the differences in the testing methodology, researchers, etc – so there could be many reasons for the differences. Tom noted that the bottom line is that BNL didn't see a clear case that one species is always worse or better (higher or lower emitting) than another species. Marc noted that this meant there really wasn't anything to conclude. Tom agreed, noting that he wished the situation were different, but there is not a clear picture regarding species and emissions.

- Tom proceeded to discuss the next slide regarding the OMNI/Fairbanks study which looked at EPA qualified outdoor hydronic heaters and Non-qualified outdoor hydronic heaters when burning Birch and Spruce. For the EPA qualified HH, again the hardwood (Birch) is higher

emitting than the softwood (Spruce). But for the conventional non-qualified HH, the picture is not so clear and it suggests the Spruce is higher emitting than the Birch, especially at the low burn rate.

- Lisa noted that this OMNI study looked at Birch, not red oak, as the hardwood, but in one of the previous studies Tom discussed, Beech had higher emissions. Marc noted that's what he recalled as well.

- Next, Tom discussed a European study authored in part by Christoph Schmidl entitled "Odor, gaseous and PM10 emissions from small scale combustion of wood types indigenous to Central Europe." The authors looked at many different species, using two different stoves. Tom noted that, for the purposes of discussion, he'd focus on Stove A and look only at actual cordwood fuels (not wood pellets, wood briquetts, dry leaves, pine cones and pine needles which were also examined in the European study in addition to 12 cordwood species). Tom noted this was a careful study which produced good data, based on a scripted operating procedure which was the same for all species examined. Nonetheless, Tom noted that the results are all over the place – for example, when looking at the PM10 results (in mg/MJ). The bar chart shows that oak is worst in this study.

- Tom concluded that, based on BNL's literature survey, there is not a clear case on species trend based on the data. Marc and Lisa thanked Tom and Lisa noted that she would post Tom's slides to Basecamp.

- Lisa noted she understood the trends are all over the place, but asked if it were still likely true that species impacts emissions and the impact on emissions is as yet unknown, or even this is not the case. Tom replied that was a great question and explained that, all things considered, if you want good repeatability, the same species should be used in testing. Tom further noted that the softwood versus hardwood structure differences alone are a good reason to suspect different results. Tom again asked the group, that if BNL missed any major studies, he'd appreciate group members letting him know.

- Lisa Herschberger asked if any of studies looked at the composition of the PM to see why the results are different to help explain them. Tom replied "not really" and noted that the Fine, Cass and Simoneit study on masonry heaters looked at organics in the PM, but didn't link those results back to the species involved.

- Marc asked, in terms of the fuel loading in each study, if that information was available (e.g., weight of wood fuel over volume in meters^3 of firebox). Tom replied that such data is available for most of the studies, but he didn't prepare that in the summary format.

- John Crouch noted that burn rates are typically higher in Europe [than in the US]. For example, the European study indicated burn rates of 2.7 and 2.8 – these are high burn rates. Tom agreed, noted they were consistently high although there was some variability. John noted that Americans need to look at that as Europeans often burn at higher burn rates - both in terms of

testing conditions and in–home conditions, because Europeans use smaller appliances and burn them hotter. Lisa thanked John, noting she was wondering the same. John also noted that Europeans tend to test with hardwoods which will burn hotter (in g/kg) than softwoods, and asked Bob Ferguson to correct him if he was wrong. Bob agreed that was the case and explained that, generally for the same air setting, the softwood will burn faster. That is, one has to set the stove at a higher air setting to get the same burn rate on hardwoods as softwoods. Bob also noted however that the run on hardwoods is a lot longer than on softwoods.

- Lisa asked, regarding loading protocols, if the study authors loaded the same type of charge (i.e., were they normalized by weight) and did they measure emissions over the entire fuel charge or over just one period of time. Tom noted that the European/Schmidl study used a pretty rigorous/constant loading protocol, but Tom did not know if they measured emission over the entire fuel charge or over just one period of time. Tom also noted that the answer would only apply on study-by-study or researcher-by-researcher basis.

- Tom noted that he wished, for example, that the softwoods in the studies had consistently come out 25% higher than hardwoods, so we would know what was going on. But he didn't see that in the studies. Lisa thanked Tom and noted again that she'd put his slides on Basecamp.

Bob Ferguson's ASTM Cordwood Test Method Development Discussion:

- Bob Ferguson began presenting his slides entitled "A Discussion of the Development of the Proposed ASTM Cordwood Test Methods for Room Heaters – Part 1". [Note: These slides are posted to Basecamp.] Bob noted that this is a revisited presentation that he gave to EPA and some states back in February, which has been updated to include developments that occurred between February and September (now). He has broken up this large presentation into 3 parts and encouraged people to ask questions along the way, as needed.

- Bob noted that the presentation will cover the development timeline, background, highlights of proposed method (meaning Section 9 which is the meat of method). The Section 9 procedure includes the pre-conditioning (stove breaking in), test facility, usable firebox volume (UFV), and test fuel load requirements (including a test fuel load calculator, to make the determination easier for people following the method).

- Next, Bob reviewed the Cordwood Method Development Timeline, beginning in June 2009 through November 2010 when ASTM E2780 was developed and published. Bob explained that ASTM E2780 is an updated M28 with a cordwood annex attached to what was otherwise a crib standard. Then there was a lull in development from November 2010 until 2013. From February 2013 to July 2014, development of the current draft ASTM Cordwood Test Method began. This method initially used a hot-to-hot test cycle, like M28, but used cordwood instead of crib. There were at least 12 calls/meetings and 9 drafts of that method, including a task group (TG). Starting in August 2014, the method was changed to a cold start. Through August 2015, there were 23 calls/meetings and 10 drafts created. The key documents and method drafts were provided to the TG e-mail list and posted on ASTM's website. Bob noted that anyone can go there; one doesn't have to be an ASTM member to view these. It's an open process.

- Bob continued, explaining that the subcommittee ballot is the first level and there was a successful sub-committee ballot in September 2015 with only minor revisions. The revisions were addressed in a subsequent draft, followed by concurrent sub-committee/main committee balloting in January 2016. Substantive negatives and comments were received from NESCAUM and EPA. (Bob noted that negatives and comments are treated the same way in the ASTM process.) There were 6 additional meetings/calls to address those comments and negatives, including reviewing all the references/supporting materials. A revised draft, including revisions based on those negatives and comments that were found to be persuasive, was released September 8, 2016. That revised draft went out for first round of balloting which closes October 17, 2016. Bob again noted that the process is open. If successful, the sub-committee ballot will move to main committee balloting. This is a second opportunity for comment. If main committee balloting is successful, it will move to ASTM review and then onto editors for form and style, and ultimately publication as a new ASTM Standard Test Method.

- Next, Bob moved onto the Background slide, noting that the primary driver for the new cordwood fuel and operating test method has always been to have a method that more closely represents the way stoves are used in homes. With crib fuel, there is no consistency, a lack of correlation between lab versus field performance. Dr. Jim Houck published a paper in February 2012 which demonstrated that cribs don't predict cordwood performance. Specifically, Houck found that (1) stoves with low crib certification results can perform less well on cordwood than stoves with higher crib scores, and vice versa; and (2) the average emission rates for certified stoves are much higher when tested under real-world conditions with cordwood. Bob noted that, for the past thirty years, by necessity, the engineering mission for manufacturers has been to optimize performance for the fuel and test conditions specified in Method 28, and not necessarily to optimize performance under real world conditions.

- Bob further noted that the original decision to use cribs (in the early 1980s based on Oregon's work) assumed there would be better test method precision but we know that the inherent variability when burning wood, even cribs, overpowers other sources of imprecision. Bob also noted that tightening test parameters in an attempt to improve precision in the lab will only increase the lack of real world representativeness. In light of this, everyone agrees that moving to cordwood and specifying O/F procedures that better represent in-home use is where we want to get to.

- Bob noted that Houck's paper pointed out cold starts by homeowners occur commonly. Therefore, the lack of a cold start in the lab is key problem regarding why lab performance is not lining up with field performance.

- Bob explained that the ASTM TG felt that using cordwood for the test fuel, with the possibility of some additional variability in results, is a good trade-off that should have positive benefits for the homeowner and the environment. Stoves will have to be designed to have good performance even with variation between test fuel loads. Accordingly, in terms of defining the test fuel loads, ASTM has attempted to recognize the inherent variability that can be expected

with cordwood (every fuel piece is different) and then add some controls regarding how the test loads are assembled to help ensure that the test loads are generally toward the middle half of the distribution of possibilities.

- Lisa asked Bob how ASTM defines an outlier piece of cordwood. Bob explained that the TG recognized the fact that anything from sawdust to half a tree could be in a woodpile, but tried to reduce the width of the variability in piece sizes that went in. There was lots of discussion, but no scientific way was developed. The piece sizes are not based on the middle 50% of a bell curve, for example. So there was no official method [for determining allowable piece size], the TG just recognized that we wanted as much variability as we could, without getting too far afield.

- John Crouch noted that everyone would welcome a survey [regarding typical piece sizes used in the field], if someone wants to fund that study. But the TG didn't want pieces to be specific to any states; rather the draft ASTM method attempts to represent the national average in terms of piece sizing.

- Lisa noted that the beReal process did put out a survey, which might be interesting to contemplate. John noted that the beReal process was not random. Lisa agreed, noting that no one will ever have the funds to do a nationwide random sample. Everyone agreed.

- Bob noted that in the past Skip Arnett and OMNI monitored woodpiles and some of those studies provided fuel weight. Bob explained that somewhat uniform pieces can vary by 100% in weight, meaning some pieces can weigh twice as much as other pieces of similar size. Bob again explained that the ASTM members merely attempted to stay in the middle of what we perceived typical piece size to be.

- Lisa noted that it should be recorded in the notes that useful research would regard how much variation in piece length and weight is typical in the field, before getting too far out of the norm. Everyone agreed this was important to research.

- Bob continued his presentation, noting the slide that showed photos of cordwood versus the dimensional crib wood lumber. It was also recognized by the ASTM TG that the manufacturers must provide concise information to consumers about how to achieve the best in-home performance. This includes information about the fuel itself plus kindling and start-up instructions, loading and reloading, etc., that will help achieve the best possible results. Bob further noted that EPA recognized the importance of these instructions, both during the ASTM test method development process and also in the new NSPS, where use of improperly seasoned fuel and failure to follow manufacturer's instructions are considered violations of federal law.

- In summary, the ASTM TG concluded that the move to cordwood and the specification of other operating conditions that better reflect homeowner use patterns including adding a cold start, should significantly improve the representativeness of lab test results when compared to in-home performance. The TG also recognized the importance of providing concise operational

information to the stove user. This will become even more important as the stove technologies evolve in response to the challenges presented when testing with cordwood using this new protocol.

- Bob further noted that the TG relied both on the members' extensive experience in woodstove design and testing, but also on test data, some of which were developed expressly to inform TG's consensus based decision-making. For example, the test program undertaken by Mark Champion (starting in November 2014 and continuing into summer 2015) is the poster child in this regard, but other data development was also undertaken (e.g., by Myren Consulting, Polytest and several manufacturers). The extensive data and observations used to formulate the proposed cordwood method were made available for review by all TG members and any other interested parties. Bob noted that every effort is made to achieve the widest exposure and stimulate the most feedback possible.

- Bob further explained that concerns, comments and suggestions from all sources, including EPA and the participating states, were considered on the merits during the method development process. Based on the data-driven approach, some were supported or accommodated in the method drafts while others couldn't be supported and were dropped. No comments, suggestions or feedback were dismissed without consideration by the TG. There are over 100 names on the TG e-mail list, including a number of state and federal regulators. While some didn't participate in conference calls, everyone on the distribution received all TG e-mails including drafts, proposals, data or supporting materials and meeting reports. Everyone also had access to the ASTM Collaboration Area where those materials were also made available on-line.

- Bob noted that the next part of the presentation went over Section 9. Section 9, in every ASTM method, is always the test procedure. Section 9.1 regards the Pre-conditioning of the wood heater. Bob explained that each heater is burned for a certain amount of time to break it in. The conditioning time changed during the development of ASTM 2780. (Bob noted that ASTM E2780 is the successor to EPA M28 and is also the predecessor to the current ASTM draft cordwood test method.) With E2780, the pre-conditioning time was changed to 48 hours for all appliances, based on 8-hour day shifts. This leveled the playing field for everyone. ASTM did get comment from EPA that EPA wanted to go to 50 hours. So ASTM added the extra 2 hours, as it was not worth further discussion.

- Section 9.2 regarding installing the wood heater in the test facility. The ASTM draft cordwood method uses the same flue gas and surface temperature requirements as in M28 and E2780. The flue gas temperature is needed for CSA B415.1-10 Efficiency Determination AND to demonstrate cold start conditions are met. (Marc asked if the Canadian method is a stack loss method and Bob confirmed that it was.) The stove surface temperature is needed only to demonstrate that cold start conditions have been met. Bob further noted that there are no Stove Body ΔT or ΔQ requirements in this method. As background, Bob explained that Stove Body ΔT was an EPA M28 requirement that the average stove body temperature at the end of a test run must be within 125°F of the average stove body temperature at the end to the test run. This was intended to prevent overly hot starts on lower burn rate test runs. However, it does

not account for difference in stove mass for any given size stove. For example, a soapstone stove has much higher mass than a steel stove of the same size. (John explained that it was also very difficult for large catalytic fireboxes. Bob agreed and noted that for some stoves it worked fine, while for others it didn't.) Stove ΔQ was added to ASTM E2780 as way to account for the differences in stove mass in terms of the amount of heat stored in the stove relative to the total amount of heat input from the fuel. Bob explained that 100 lb stoves versus 600 lb stoves present a huge difference in the amount of energy stored in the stove for any given increase in burn rate. So the ΔQ was a way of leveling the playing field for low mass versus high mass stoves. But, there is no ΔT or ΔQ requirement in the ASTM draft cordwood method, because Mark Champion's data showed no need to retain either. In an effort to mimic realistic operation in the lab, stove temperatures are allowed to be where they may be, based entirely on the realistic fueling and operating protocol.

- Bob noted that the ASTM draft method also started requiring photographic records of the test, to eliminate any concerns/questions of what's going on. Photos of the complete test set-up are required. This is a theme throughout the method where photographic or video documentation is required in addition to the typical data gathering. Any interaction with the stove requires photos. This is evidence that the test method is done appropriately. Bob noted that ASTM and industry doesn't like the idea of people taking advantage of the test method any more than a regulator does; we want a level playing field too.

- Bob began going over Section 9.3 the usable firebox volume (UVF) determination. The UVF determination relies in large part on Manufacturer's Written Instructions. The prior language (M28/E2780), in which nearly every open space was included in the usable volume, raised many concerns as the test fuel loading density was increased from 7 lb/ft^3 to 10 and 12 lb/ft^3 for cordwood testing. In some cases, it was shown that it was difficult or impossible to get the last fuel piece into the stove or with a fuel piece in a location that could interfere with the functionality of the combustion process.

- Regarding Section 9.4 Test Fuel Load Requirements, Bob noted that this issue required many phone calls/meetings and the more random the fuel the more important it is to have good documentation. Codifying a more random fuel load became very complicated. All stoves are capable of holding more cordwood than crib due to the lack of spacers. There was discussion of a sliding scale based on firebox volume, recognizing that smaller stoves can be harder to load. Ben Myron did a bunch of loading and photos to put visual on the different loading densities. So there was a lot of discussion on this topic, and concerns were resolved with a later proposal. There were several discussions of a volume-to-volume ratio concept, that is maintaining a ratio of firebox volume to wood volume. This removed the fuel specific gravity (or species) from the test fuel load determination. But, it introduces the potential for big differences in test fuel load weight which can, in turn, impact emissions. Going back to the 1970s, Bob explained there are studies on fuel loading densities. This variability was problematic. After much deliberation, it was determined that using test fuel load density was the most straightforward approach. In other words, mass of fuel based on usable firebox volume – lb. of wood/ft^3 of firebox volume.

- Bob next explained the concept of attended vs unattended fires. Attended versus unattended fires implicates how much fuel is placed in the stove per load. Low Fire falls into the unattended category, while High fire is attended. Medium Fire could go either way but TG classified it as unattended.

- Bob explained that the ASTM discussion then moved to load density requirements. It was generally agreed that the high fire load density (attended fire) should be lower than the load density for the low and medium fire test runs. Homeowners will place less fuel in the stove when trying to achieve a high heat output, especially from a cold start. During high fires, the homeowner is not looking for a packed stove to achieve an overnight burn. The fire is likely to be attended and if more heat is needed, extra fuel pieces will be added. The High Fire Load Density was increased from an initially proposed value of 7 lb/ft^3 to 10 lb/ft^3 based on the visual appearance of the test fuel load in actual fireboxes. For Low Fire, load densities from 12 – 15 lb/ft^3 were considered. Based on trial loading conducted by Ben Myren and others, it was realized that loading above 12 lb/ft^3 would be problematic for many stove models. The loads simply wouldn't fit due to the typical obstructions and inaccessible volume in many models. For example, space above bricks might be counted in UFV determination but wood in the test fuel load won't necessarily occupy that space. The final conclusion based on all the TG input, is the following:
    - Nominal High Fire Test Load Density – 10 lb/ft^3;
    - Nominal Low and Medium Fire Test Load Density – 12 lb/ft^3;
    - It should be noted that these represent 43% and 71% increases over M28.

- Since many had to leave the call at this point (the scheduled ending time), it was decided to pause Bob's presentation here. [Note: The presentation ended on Slide 19; Bob's next presentation should resume on Slide 20.]

- Everyone should post their questions for Bob (or Tom) to Basecamp.

- Lisa and Marc thanked Bob for the great presentation.

- **Meeting adjourned**.

September 29, 2016 Agenda
Cord Wood FRM
Operation and Fueling (O/F)
Technical Workgroup

1. Call to order, Announcements, Roll call,
2. Review agenda for next three calls
    a. Sept 29:
        i. Brookhaven Wood Species Literature Review, Dr. Tom Butcher
        ii. Intro to the ASTM test method, test fuel load concepts, Bob Ferguson
    b. October 6:
        i. Wood density as possible solution to the species issue, Rick Curkeet
        ii. ASTM part 2 - Test fuel properties, and moisture content, high fire test category, cold starts etc, Bob Ferguson
    c. October 13:
        i. BeReal's Christoph Schmidl
    d. October 20:
        i. EPA Research Efforts, Adam Baumgart-Getz
        ii. ASTM part 3, low and medium fire, overall efficiency, test method outputs, weighted averages, Bob Ferguson
        iii. General Questions and discussion of ASTM
3. Presentation: Brookhaven Review of Literature on Wood Species Impact – Dr. Tom Butcher, BNL
    a. Q/A & Review
4. Presentation: Intro to the ASTM test method, Test fuel load concepts, Bob Ferguson
    a. Q/A & Review
5. Final Questions, comments, items

EPA Notes Operation and Fueling (O/F) Workgroup Meeting Notes from October 6, 2016 Teleconference

(Note: Voting Members are in bold-face)

Meeting led by **John Crouch** (HPBA, Co-Chair of O/F Workgroup), **Marc Cohen** (Massachusetts DEP, Co-Chair of O/F Workgroup), **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), **Cindy Heil** (Alaska), John Wakefield (Vermont), **Lisa Herschberger** (Minnesota), Ann 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:

- The next two O/F Workgroup meetings will be held on October 13th at 11 am EST (Christoph Schmidl's beReal presentation) and October 20th at noon EST (Rick Curkeet's specific gravity/density presentation).

- The details of today's presentation are noted below in the meeting highlights as well as in Bob Ferguson's presentation slides posted to Basecamp. This is background material to educate the group; no official conclusions have yet been drawn by the group.

- Regarding measuring moisture content in cordwood, the ASTM Task Group (TG) working on ASTM's cordwood method has not seen data comparing (a) the ASTM draft, (b) the SUNY ESF method, and (c) the ASTM oven dry methods directly to each other on well-equilibrated fuel pieces. The ASTM TG would like to see data collected from all three methods on the same fuel pieces at the same time.

To-Do List:

- The group should post any questions based on Bob Ferguson's presentation, regarding the ASTM cordwood method, to Basecamp.

Highlights from Meeting:

- John Crouch and Lisa Rector opened the meeting, introducing Bob Ferguson as today's presenter. [Lisa Rector could not stay on the line for the rest of the meeting.] John thanked everyone for joining the O/F meeting and webcast and noted that Rick Curkeet's presentation

regarding density will be held on October 20th. There were no process/administrative questions from the group.

- John turned the meeting over to Bob Ferguson, noting that Bob had uploaded a lot of material regarding the ASTM process to Basecamp, which the group could download to view at any time.

Bob Ferguson's ASTM Cordwood Test Method Development Discussion (continued from last week):

- Regarding the volume of ASTM material uploaded, Bob noted that the ASTM process was long and some issues were wrestled with for years, only to be re-visited again. Bob noted that the ASTM process is a consensus process that is not afraid to address issues again, as needed. Bob further explained that this presentation was given to EPA in February and took 5 hours, but he was trying to cover the material as quickly as possible.

- Bob picked up with where he left off last time, beginning with Slide 9.4.1.2 *Test Fuel Sub-load Concept*, slide #20. Bob noted that determining the composition of the test fuel loads also consumed a big part of the Task Group (TG) interactions. The starting point for defining the load composition was CSA B415.1-10. The CSA technical committee debated this issue throughout their standards development effort. CSA came up with a table, which divided up firebox volumes into several categories based on firebox volume and cross-section, weight and number of cordwood pieces (see table on slide #20 in ASTM Cordwood TM Presentation Part 1, on Basecamp). This fuel load composition was adopted for the Cordwood Annex in ASTM E2780, but unfortunately there was little or no use of the Cordwood Annex. So it really wasn't tested on woodstoves.

- When the interest in cordwood testing for room heaters was reinitiated, it soon became obvious that the CSA wood load table did not have adequate resolution for the firebox volumes associated with woodstoves. The CSA load table was focused primarily on much larger central heater fireboxes (up to 20 ft^3). Most woodstoves fall within the lowest delineation (<4 ft^3). The piece size gradations were simply too course. Therefore, an initial proposal was made to simply increase the resolution for firebox volumes in the range of interest, to make the table more granular (see table on slide #21). However, the TG concluded that there was too much potential variation in the load composition using the simplest table concept. The TG determined that what was needed was a means to allow some of the randomness associated with cordwood, along with some control over how far the wood pieces and load configuration could stray from the middle of any typical distribution (of piece size, geometry and number of pieces). In other words - to account for the randomness but still have some control over the load. Thus, a number of fuel load and wood piece sizing criteria were evaluated, in attempt to keep a simple table.

- Bob discussed the table on slide #23. In this case, the table approach was expanded to be more granular in terms of defining piece weight and composition of the overall test fuel load across the full range of woodstove sizes. Tables relating load volume to firebox volume were also proposed. (See table on slide#24). The concept was that the test fuel loads, in term of the number of pieces and volume occupied in the firebox, would be the same regardless of the

specific gravity (SG)/species of the fuel used. However, it could result in widely different fuel load weights and the TG still needed to define the fuel load composition and fuel piece specs.

- Thus "GO-NO GO" gauges were proposed as a way to better control individual fuel piece cross-sectional dimensions. (See diagrams of circular and square portals on slide #25.) However, weaknesses were ultimately uncovered for each of the initial options. For example, slabs fit through.

- Therefore, the *Test Fuel Sub-load Concept* was attempted. Thus was born the concept of separating the test fuel load into two parts, strictly for the purposes of defining the overall load composition. A single fuel load still results. The first part, or core sub-load, represents the more typically sized fuel pieces in any cordwood pile. There are somewhat tighter limits on the range of individual piece weight that can be used. It always consists of three fuel pieces. It comprises 45 – 65% of the total load weight. This was done to eliminate a totally homogeneous sub-load (all the pieces nearly the same), some piece weight variation is required but still controlled. The smallest piece in the sub-load cannot exceed 67% (two-thirds) of the weight of the largest piece. Bob noted that much of this may not make sense initially, but Bob will take questions and it may make sense after progressing through the presentation material more.

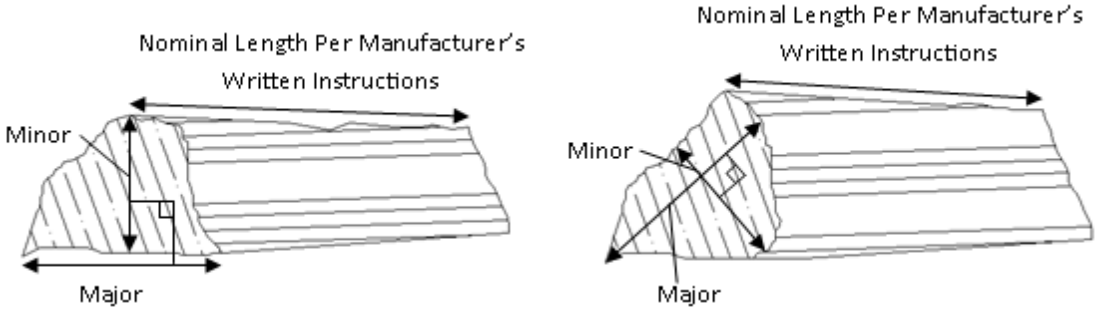
- The second part of the fuel load, or remainder sub-load, comprises the rest of the test fuel load. This can vary from 35 – 55% of the total fuel load weight. The number of pieces in this sub-load varies depending on the firebox volume and/or test run category. In each case, however, there is a range in the number of pieces allowed (so as to not over-specify this):

  Low & Medium Fire Tests:
  - ≤ 3 ft^3 – 2 or 3 fuel pieces
  - >3 ft^3 – 3 or 4 fuel pieces

  All High Fire Tests
  - 1 – 3 fuel pieces

  The weight range for each individual fuel piece is also broader than for the core sub-load.

- In all cases, there is a required minimum ratio of the minor and major fuel piece cross-sectional dimensions (to eliminate fuel pieces that don't look like typical cordwood).



The minor dimension must be at least 40% of the major dimension. The full test fuel load ends up looking like a reasonable representation of what a stove user might load into the stove. A mix

of pieces of similar size plus some larger and smaller pieces. Bob noted that when people started using it, this was found to be workable. The allowable ranges were identified by experimentation.

- This protocol might seem complex at first look or to the uninitiated. However, the concept was fully exercised across a range of firebox volumes and configurations by test labs and manufacturers alike and as each issue was uncovered it was worked through by the TG. For example, the allowable weight ranges for the two sub-loads were determined by experimentation which identified the need for some flexibility (weight ranges) when working with cordwood. Using this methodology allows overall test fuel load weight range to be tightened to ±5% of the nominal. Previous tolerances have been ±10%.

- The ASTM TG developed the *Test Fuel Load Calculator* to de-mystify the procedure AND, equally as importantly, to ensure consistent application of the fuel loading requirements across all testing entities. The calculators standardize the application of the test load parameters from the method into Excel spreadsheets. The Excel spreadsheets have been made available to the TG and all other interested parties for "beta" testing and review since the earliest versions. The early versions were used as part of Mark Champion's extensive test program and were put to the test by his very experienced lab technician. The feedback was always very positive and the conclusion was that this system worked well.

- The spreadsheets continued to evolve and now include more information than just the test load composition. They are now interactive. Input the key data and the spreadsheet calculates and then evaluates whether the test load requirements have been achieved. Problematic fuel pieces are identified. Adjustment to individual fuel pieces can then be made until a fully compliant load is achieved. There is a learning curve to using the calculator spreadsheets, but they are quickly mastered. Subsequent test runs for a given model may use the first run as a template to very quickly reproduce a valid test load. So the calculator expedites the process, Bob explained, especially on subsequent loads.

- Based on the method requirements, there are three separate calculators:
    - Low & Medium Fire Tests with ≤ 3 ft^3 useable firebox volume (UFV)
    - Low & Medium Fire Tests with > 3 ft^3 UFV
    - High Fire Test with all UFV

  The load calculator workbook will be available from ASTM as an adjunct to the method. It is password protected to prevent tampering.

- Bob demonstrated the Load Calculator on the webcast (See slide #33 on Basecamp). Data is entered in yellow boxes (e.g., usable firebox volume, the weights of the core load pieces, the weights of the remainder pieces, the kindling weight, the start-up fuel weight, the residual start-up fuel weight and the fuel load ending weight). Other colors are outputs. The calculator will give allowable piece load weight for core load. If any piece is out of range, it will immediately tell you that in red. This holds true for all the parameters. If there is any red on the calculator that means your load is not in compliance with the standard. (Otherwise, it's "In Range".) There are

also requirements for kindling amount and start-up fuel load. The calculator will also ensure these are within the allowable ranges. On the other side of the calculator, Bob noted that the calculator will give you the dry load basis. All calculations are done automatically, which ensures people don't have to attempt to interpret [or misinterpret] the standard.

- Bob showed photos from Mark Champion's testing, showing newspaper, kindling, start-up fuel, core loads and remainder loads for several different size UFV (1.42, 1.80, 2.10, and 3.1 ft^3 UFV). Bob noted that these loads looked reasonable for the stoves. Bob asked the group if there were any questions.

- Lisa Herschberger asked about the balance between reproducibility/controlling variability versus allowing for some real-world variability and how that balance was addressed by the ASTM TG. Bob explained that the TG realized the method couldn't be all things to all people in the field. There couldn't be infinite variability. Therefore, the TG talked about trying to stay more towards the middle of loading. Bob noted that it was not super scientific, but it was based on many people with decades of design, testing and wood stove use experience. It was a meeting of the minds to allow some of the randomness, while cutting off extreme ends of possibilities. The TG didn't do specific testing of a no control option versus some X level of control. Rather, the TG relied on the best judgements of experts to come up with a fuel load that has some randomness in order to be representative, while controlling to the extent the TG could/felt reasonable.

- Lisa Herschberger asked what the method might look like if someone wanted to make it more variable. Bob explained that the method (in that hypothetical case) wouldn't put any constraints on piece length or weight, or the method might prescribe a certain weight but allow infinite variations to achieve that test load weight. That would allow infinite variation, but it wouldn't ensure any consistency regarding the load type in the lab. The TG wanted a balance of difference and similarity.

- Lisa Herschberger wondered if, in an extreme case, a tester could follow ASTM and then use one giant load and see how the stove responded. Lisa continued that she imagined, if the stove met the emissions limit in both cases, it would be a very good stove. Bob noted that a manufacturer/tester could also go to the other extreme of loading a stove with 20 small pieces. Bob explained that both of those extremes (one large piece or many small) will present challenges for the stove designer, in terms of actually being able to design a stove that could control emissions from very small pieces to very large. Ideally that would be the case/possible, but a consumer controlled product doesn't make for an ideal world. If there were lots of research money, we could test at the extremes [of fuel load] to see what happens, Bob noted. But the ASTM TG attempted to get to a starting point so people [manufacturers] would start burning with cordwood. Bob again noted however that the ASTM process allows re-opening when new information is available.

- Rick Curkeet noted that the ASTM TG also approached it from the other direction. That is, the TG didn't want the method to be so open or unregulated that manufacturers would hunt for the best load to give the lowest emissions. Rick explained that the TG didn't want to allow, for

example, putting 2 big pieces in at a low fire for a long burn, resulting in low emissions [with time in the denominator]. Rick noted that that's not what consumers would do. Bob agreed, noting it was the balance between randomness and control/consistency. Bob explained that the TG did take a tremendous amount of input regarding this issue; the TG spent a huge amount of time on this over a few years, along with a couple other issues. How the TG defined the load took a lot of discussion. Lisa Herschberger thanked both Bob and Rick.

- Bob started going through Part 2 of the ASTM Cordwood Test Method for Room Heaters: *Highlights of the Proposed Method*, including Section 9 Procedure pertaining to Test Fuel Load Requirements (Test Fuel Properties) and the High Fire Test Category. Bob noted that Rick was supposed to give his presentation on specific gravity/density which would have been helpful for this, but Rick will give that presentation on Oct 20th.

- Section 9.4.2.1 of the ASTM CTM regards *Fuel Species and Properties*. Based on the work done during the development of CSA B415.1-10, fuel specific gravity was chosen over fuel species as the more reliable way to define and differentiate key properties. Fuel species within the allowable Specific Gravity (SG) range are generally available throughout the country. This solves a number of regional fuel availability problems. There are tight restrictions on shipping cordwood between and even within states. Cordwood has to be locally sourced (as it can't be shipped more than 50 miles in most places). Split cordwood can be difficult to identify in terms of exact species, and cordwood loads are often a mixture of species.

- The CSA B415.1 SG range of 0.60 – 0.73 was ultimately expanded to 0.48 – 0.73 to allow the use of some softwood species (including Douglas fir). This was requested by Rod Tinnemore with support from the West Coast manufacturers. It was commented that lower specific gravity species are less likely to be used anywhere hardwood species are available. And, in general, given the chance, stove users are more likely burn the highest specific gravity fuel they can find in their location (because of economics - $$ per BTU). This included a range of hardwood species in at least the mid-west and northeast. Some higher SG fuels are burned in all regions. An article by Dr. Houck summarized his findings regarding the split between hardwood and softwood use across the country. It must be noted that Pacific Northwest and some mountain states are not included in his table of survey results. The table published in Hearth and Home in 2007. See slide #5 from the ASTM Cordwood TM Presentation Part 2 on Basecamp.

- Test fuel moisture determination evolved over the course of the test method development before finally reaching the current requirements. Options considered included: Continuing with EPA M28 and ASTM E2780 procedure (a minimum of three readings per test fuel piece); Using the moisture meter manufacturer's electrode penetration guidelines which are based on extensive research including the USDA Forest Products Lab; Increasing to a minimum of five readings with two probe penetration depths following the HH test procedure; Tightening the location and depth accuracy requirements for probe penetrations; Evaluating the BNL/SUNY procedure [This was done during the initial method development and again after receiving a negative regarding moisture determination during the last ballot cycle (Jan. 2016)].

- The State University of New York College of Environmental Science and Forestry (SUNY ESF) method is intended to provide a solution to the consequences of forced drying of high moisture wood to be used for testing without significant additional conditioning. The TG felt that forced drying without additional conditioning is not an acceptable process as it creates potentially large moisture gradients within fuel pieces which is likely to produce combustion patterns that are not representative of real-world seasoned cordwood. Experience with forced drying has shown that core moisture content (MC) can be above 40% while the outer layers are below 10%. If it is necessary to force dry wood to obtain an adequate supply, the proper process is to dry cut and split pieces at a moderate temperature (<140°F) and then allow for a minimum period of 3 to 4 weeks of conditioning at ambient temperature and humidity to allow the moisture gradient to re-equilibrate and stabilize. Samples can be checked to verify that the gradient is not too large.

- It is preferable for labs to use wood fuel that has been naturally seasoned and stored under controlled conditions for at least several months before measurement and use. This, after all, best reflects homeowner use practices, which is the one of the core design principles that has guided the development of this method. Wood fuel that has been handled in this manner does not require special procedures to accurately determine MC. It may also be necessary for the labs to store test fuel in a temperature and humidity controlled environment to prevent the fuel from drying below the prescribed MC range (as Bob explained wood can dry out to below what homeowners typically use). Wood pieces that have been conditioned for a substantial period of time under reasonably controlled conditions develop a moisture content gradient, from center to surface, with a parabolic distribution. Hence, measurement of MC at the $1/4^{th}$ to $1/5^{th}$ of the piece depth, as recommended by the meter manufacturer, provides a good measurement of the average MC across the gradient. The accuracy of the available moisture meters is claimed to be +/- 2% MC above 20% MC (that is, a 20% can be an 18% or a 22%). If it is assumed that the error is random and averaging the many readings taken under the proposed procedure reduces the uncertainty of the average to a small value. For a typical fuel load in the draft ASTM method, the average fuel moisture of the test fuel load will be determined by at least 12 total readings and often 15 or more.

- The accuracy of the MC determination has no significant influence on the appliance test results as it is only used to determine the actual dry weight of the fuel. This weight is used to calculate dry burn rates and total heat input in efficiency determinations. In both cases an error on the order of +/- 2% in the MC determination results in a negligible effect on the key results. Note that the effect on B415.1 stack loss efficiency calculation is small since any error in the dry weight determination and thus the total heat input is present in both the numerator (Heat Input – Heat Loss) and the denominator (Heat Input). The net effect is that a 2% error in MC results in less than a 0.5% error in efficiency (because errors essentially cancel each other out, Bob clarified). The critical determination is really whether the MC of the individual fuel pieces and the average MC of the test fuel load fall within the allowable ranges.

- Experiments comparing the moisture determination protocol in the ASTM draft to oven-dry moisture determination have been undertaken by several labs and companies. Mark Champion

did a comparison study as part of the previously mentioned cordwood method development testing he conducted. (See table from slide #10, below)

		Pin readings, 1/5 to 1/4 depth				Into Kiln, 212 deg F, 12/26 1400, drying weights, lbs						
Sample	Wet Weight, lb	Left	Center	Rgt	Pin Avg	12/27			12/28	Min Weight	Calc MC, dry	Pin Error, MC %
1	4.20	18.8	20.6	22.7	20.7	3.55	3.53	5.13	3.52	3.52	19.3	1.4
2	6.49	18.5	19.6	21.1	19.7	5.52	5.44	5.42	5.42	5.42	19.7	0.0
3	5.98	15.1	17	23.2	18.4	5.13	5.08	5.07	5.06	5.06	18.2	0.3
4	4.42	15.5	15.3	18.2	16.3	3.8	3.78	3.78	3.77	3.77	17.2	-0.9
5	4.54	17.8	20.6	22.7	20.4	3.79	3.76	3.75	3.74	3.74	21.4	-1.0
6	7.15	24.2	23.8	26.1	24.7	5.94	5.82	5.81	5.8	5.8	23.3	1.4
7	6.24	13.9	9.3	19.1	14.1	5.51	5.47	5.46	5.45	5.45	14.5	-0.4
8	6.14	23.2	23.7	26.1	24.3	5.08	4.98	4.98	4.97	4.97	23.5	0.8
				Load Straight Average	19.8						19.6	0.2

- So far, the TG has not seen data comparing the ASTM draft, SUNY ESF method and ASTM oven dry methods directly to each other for well-equilibrated fuel pieces. In other words, the TG has never all three methods on the same fuel pieces at the same time. Bob noted that ASTM would like to see such research.

- The Current Proposal Requirements include: A minimum of three readings per piece – two ~3" from ends, one at the center, all on different sides of the fuel piece; Electrode penetration 1/5 to 1/4 of the piece thickness at the measurement location (to give the approximate average moisture across the gradient); An expanded allowable average moisture range for each fuel piece to 18 - 28%, recognizing the need for more flexibility since managing cordwood on a frequent testing basis can be challenging; An average MC requirement for the full test fuel load of 19-25% Dry Basis (which is consistent with other test methods). Accelerated drying was added by the TG with conditions on maximum temperature and the requirement for a minimum of three weeks before using fuel, to allow fuel MC to re-equilibrate. Moisture content requirements were added for kindling and start-up fuel after the cold start requirement was added to the method.

- Regarding Section 9.4.2.6 *Test Fuel Piece Length*, Bob noted that the method is per the manufacturer's recommendations for nominal fuel piece length. All fuel pieces in test fuel load must be ±1" of the nominal length.

- Regarding the *High Fire Test Category* (ASTM CTM Section 9.5), Bob noted that when the current ASTM cordwood test method development process began in 2013, all test runs were hot-to-hot test cycles, following the precedent from EPA M28, ASTM E2780 and CSA B415.1-10. Much of the method development activity was focused on defining the test load parameters as described earlier in this presentation. However, beginning in July 2014 the importance of adding a cold start to the test protocol was brought to the TG (thanks to James Houck's work).

- Dr. James Houck had pointed out, based on his research, that a key difference in lab testing results compared to in-home performance, beyond the obvious use of cribs versus cordwood as the test fuel, was the fact that homeowners start their stoves from a "cold" condition with some significant frequency. Although this was not actually new information in 2014, it finally attracted the attention of the ASTM TG with the realization that moving to cordwood without including a cold start was only achieving part of the stated goal – development of a new cordwood test method that more closely represents the way stoves are used in homes. This opened a gigantic can of worms and the TG discussed it for months, Bob noted.

- Adding the cold start to the test method would become the dominant subject before the TG for many meetings. At the beginning of the process, we looked at the only ASTM solid fuel method that includes a cold start: ASTM E2618-13, Annex A2 for testing hydronic heaters that employ partial thermal storage was examined. Although many of the issues addressed in the PTS HH Annex are similar in nature to those for a room heater method, the specific differences in the appliances and how they operate obviously implicates many differences in many of the details.

- One place there was similarity that carried over was in the definition of the conditions that defined a cold start. In a PTS HH, they run the heater and then allow the system to cool until the thermal storage is 125±5°F. They then shovel all remaining fuel and ash out and start the test run. The TG Proposed that for a wood stove/room heater the average surface temperature and the flue gas temperature must be less than 40°F above ambient (which means a maximum of 130°F if the lab is at the maximum allowed 90°F). Two factors drove the TG to the current limit: the amount of heat stored in the test unit at the 40° ΔT limit represents a fraction of 1% of the total heat input during a high fire test run. This was not felt to have a measurable impact on the test results. The other factor which drove the TG to the current limit is the practical consideration for "production" testing situations, where waiting for the last few hundred BTU to dissipate wastes expensive lab time.

- However, during the most recent round of balloting, a negative and comment were received regarding the 40°F limit over ambient for the average surface temperature and the flue gas temperature. The TG eventually agreed to reduce the starting temperatures to 10°F over ambient after recognizing that a fan could be used to remove residual heat from the stove and lower the temperatures without causing significant delays in the lab.

- Regarding *General High Fire Test Requirement Highlights*, Bob explained that the primary air control(s) are always at their maximum setting. The nominal load density requirement is 10 lb/ft^3 because the initially proposed 7 lb/ft^3 resulted in a volume of fuel in the stove that looked too small (Bob noted he didn't have photos, but Ben Myron did a lot of research into this). An exception to this load density requirement was also added. Rather than adopt an unproven sliding scale to accommodate small or atypical fireboxes, the following exception was added: if it is physically impossible to achieve the minimum 9.5 lb/ft^3 (the low end of the tolerance) despite exercising all of the piece size and other fueling flexibility allowed in the method, the stove must be operated with the actually achievable maximum load density. This exception must be fully

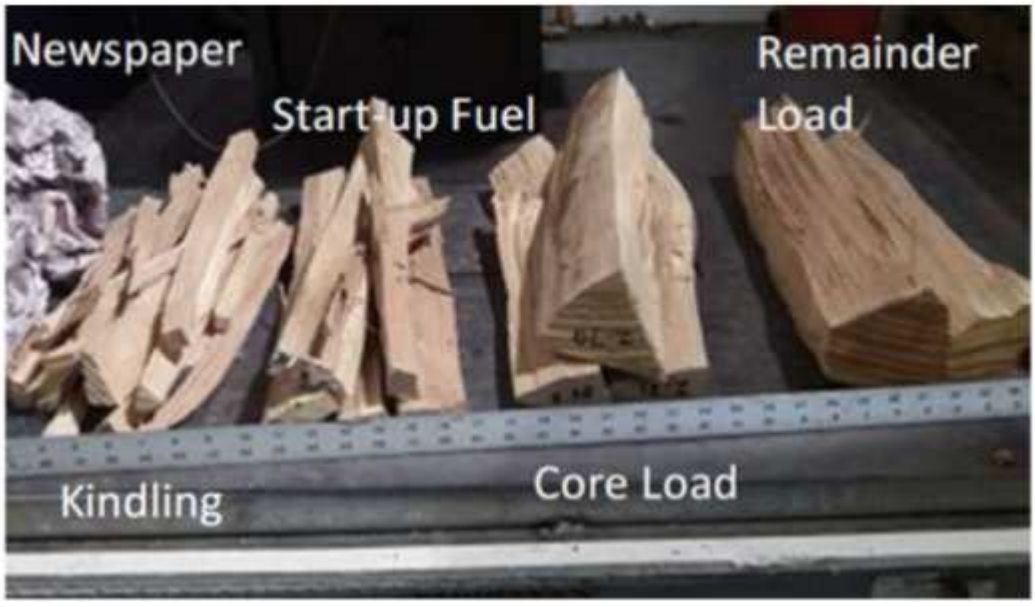
documented and the load density that is achieved reported. It must also be confirmed that the average stove body and flue gas temperature are below the required limit as part of the data recording requirements.

- John Crouch explained that the reasoning behind this is that the method might inadvertently disqualify some small woodstove (e.g,. stoves from Europe, some of which have firebox volumes less than 1 ft^3). ASTM's intent is a 9.5 ft^3 load, but if that is not possible, then the manufacturer/tester should load the firebox as fully as possible. This exception allows smaller stoves not to be disqualified. The ASTM TG wanted to work around the exceptions, which would immediately crop up.

- Regarding Section 9.5.6 *Kindling*, Bob noted that kindling may be up to 20% of the test fuel load weight, with a moisture content between 6 and 12% DB.

- Regarding Section 9.5.7 *Start-up Fuel*, Bob explained these are slightly larger pieces than kindling and can be up to 30% of the test fuel load weight, with a moisture content the same as test fuel load (between 19 and 25% DB).

- Both the amount of kindling and start-up fuel were based on testing and observation. Higher amounts were proposed at various points but ultimately rejected. Visual appearance of the quantities played a role in the decision (i.e. does it look right?). Simply asked, did the amounts look reasonable from a homeowner's perspective AND is there enough fuel to consistently get the stove going before the main test fuel load is added and keep the test fuel load burning after it loaded.? See photos on slide #20 including –



- Emission sampling begins immediately before the kindling is ignited. Both the kindling and start-up fuel are placed and ignited in accordance with the manufacturer's instructions. This allows

possible innovations in the way the stove is started to minimize emissions (e.g., top-down burn). Bob noted that the ASTM TG didn't want to stifle innovation.

- Kindling and start-up fuel are burned until 10-20% of the test fuel load weight is reached. This remaining fuel is referred to as "residual start-up fuel" but could contain some partially burned kindling. This range was based on testing by Mark Champion and others. It was observed that the 20-25% "charcoal bed" range from EPA M28/ASTM E2780 was too high, due to the increase in the nominal loading density. With the increase in the nominal loading density from 7 to 10 lb/ft^3, the charcoal bed weight increases proportionally. Thus it was difficult to get the test fuel load in with that much residual fuel in the stove. There can be too much raw wood and flaming.

- Bob showed photos of various size fireboxes with the newspaper, kindling and start-up fuel all in together and the significant flaming and raw fuel that results with 25%, 20%, 15%, and 10% residual start-up fuel load remaining, and finally photos of the test fuel added when 10% of the residual start-up fuel is left. See slides #23 to #28 on Basecamp. These photos are from the stoves that Mark Champion tested.

- Bob noted the following conclusions regarding the residual start-up fuel weight range:
    - Lowering the residual start-up fuel weight range appears to make sense based on available data and observations. The originally proposed 25% upper limit (and maybe even a 20% upper limit) could result in start-up conditions at the point the test fuel load is added that are not very representative of conditions when a homeowner might actually add the first fuel load after a cold start. There is also some thought that loading at the high end of the currently proposed range could contribute to increased variability of results.
    - Lowering the range to 10 – 15% may be warranted.
    - It was ultimately agreed by the ASTM TG that 10 - 20 % would be the best option.

- Other high fire test requirements include:
    - Residual fuel bed must be documented by photo or video before and after any adjustments and before test fuel load added.
    - Test fuel must be loaded in accordance with the manufacturer's instructions. The test fuel load must be documented by photo or video before and after loading.
    - Maximum load time is 30 seconds per cubic foot (ft^3) UFV with a minimum of 60 seconds (that is, the least amount of time is 60 seconds – Bob noted this isn't much time, as maneuvering is needed for small stoves and more pieces are needed for large stoves). Bigger fireboxes can take longer to load than smaller ones. To be clear, the entire fuel load (core and remainder portions) must be loaded within the maximum loading time. So, for example, a 3 cubic foot stove would have 90 seconds to load.
    - Emissions are sampled during this time, so no PM are being missed.

- There are provisions for: Using a portable propane torch (in accordance with the manufacturer's written instructions and limited to 60 seconds). There are also provisions for automatic ignition systems, so that the stoves are allowed to operate as designed. Likewise, there are provisions

for supplemental energy input. Any supplemental energy that is added (other than the 60 seconds of propane torch use) must be accounted for in the overall energy efficiency determination. ASTM is trying not to stifle innovation, but at the same time, is also accounting for all energy when determining efficiency.

- The fuel load door can be in any position per the manufacturer's written instructions during the first five minutes after the test fuel load is added. Fuel adjustments may also be made during this time.

- Test fuel pieces may also be adjusted once, until 15 minutes after the maximum load time has lapsed or until 15% of the test fuel load weight is consumed, whichever is less. This might be done if a fuel piece fell forward onto the glass – a situation that a homeowner would correct in order to keep the glass clean. (Bob noted that the ASTM TG was trying to replicate homeowner behavior.) Any fuel adjustments need to be less than 30 seconds in duration and fully documented with before and after photos or video (so people can't game the system).

- The test fuel load may be adjusted one additional time after 60% of the test fuel load weight is consumed AND only if there is no measurable weight loss in a 10-minute period. This adjustment also must be documented with before and after photos or video.

- Regarding Section 9.5.9.8 *High Fire Test Run Completion*, Bob noted that the proposed 90% ±1% of test fuel load weight burned was based on the testing conducted by Mark Champion. What stood out in the majority of the high fire test runs was that even at maximum primary air settings, the stoves still "tailed" for long periods of time. The charcoal is generally in a somewhat compact configuration with the bottom of the pile not engaged to any great degree in the fuel combustion that is occurring.

- Bob explained that waiting for the last 10% of the fuel weight to be consumed was in some cases almost doubling the test run duration. The consequence that emission rates (g/h) and heat outputs (Btu/h) were reduced in ways that it was agreed were misleading on the low side. This might lead to consumers oversizing stoves, Bob noted.

- After all volatiles in the test fuel have been consumed (all yellow flaming has ceased) essentially 100% of the PM emissions have already been captured by the 90% cut-off point. The other reason was the visual appearance of the fire—in other words, when did the stove look like it was ready to be reloaded? Mark Champion used his judgment, having been a wood burner at home, a stove designer and a stove tester for many years to make that visual determination and then looked at the corresponding data. The 90% test load weight cut-off was very consistent across the stove models. It was also noted that real world stove users rely on the same type of visual cue since they have no way of knowing the remaining fuel weight.

- Bob showed two photos from a 3.1 ft^3 non-catalytic stove depicting all yellow flaming ceasing at 2.8 pounds and also depicting that the stove looks ready to be re-loaded at 2.6 pounds (see slide #36 on Basecamp). All yellow flaming has ceased after 244 minutes from adding the test fuel

load. The remaining load weight at that point was 2.8 lb. At this point, 91% of the test fuel load weight has been consumed. It is projected that the remaining 2.8 lb of charcoal could take 3 hours or more before it is consumed. This would result in a high fire test run over 7 hours in duration and an average high fire burn rate (and corresponding heat output rating) well below the true capability of the stove. This could lead to oversizing stoves in homes and more smoldering burns.

- Bob noted that the ASTM's final determination reflects an elegant solution which is practical in a laboratory environment and a realistic reflection of homeowner behavior (since heat output and visual cues likely trigger a reloading point, especially if high heat output is desired). A more realistic high heat output rating for consumers is thus produced. And this solution addresses concerns of EPA and many state regulators who have repeatedly voiced concerns over "long tails" of tests potentially skewing test results (on a g/hour basis). Finally, Bob noted that in almost all cases, the 90% cut-off allows a low or medium fire test run to be conducted using the remaining high fire test charcoal bed.

- Bob noted that this concluded the second portion of his ASTM cordwood test method presentation, although there is a third section. Bob explained that the presentation represents 3 years of work and apologized for how fast he went through it, noting that going fast was the only way to get through it.

- John Crouch encouraged people to make notes of their questions and perhaps post their questions to Basecamp.

- John noted that the O/F workgroup call will start next week at 11am EST, in order to allow Christoph Schmidl from Germany to present on the beReal method. After next week, the group is back to regular time (noon EST) the week after that. There were no questions and John thanked everyone for their attention and participation.

- **Meeting adjourned.**

EPA Notes Operation and Fueling (O/F) Workgroup Meeting Notes from October 13, 2016 Teleconference

(Note: Voting Members are in bold-face)

Meeting led by **John Crouch** (HPBA, Co-Chair of O/F Workgroup), **Marc Cohen** (Massachusetts DEP, Co-Chair of O/F Workgroup), **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), **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:

- The details of today's presentation are noted below in the meeting highlights as well as in Christoph Scmidl's beReal presentation slides posted to Basecamp. This is background material to educate the workgroup; no official conclusions have yet been drawn by the group, except for the next bullets.

- If funding becomes available, it was agreed that one research need is to test the same wood stove(s) using M28, the ASTM draft cordwood method, and the beReal protocol, in order to compare the three operation and fueling protocols.

- Workgroup members are invited to attend the Central European Biomass conference in Graz, Austria on January 19, 2017, including potentially to special workshops for the US group regarding the beReal effort.

To-Do List:

- Lisa Rector will PDF beReal's on-line survey and make it available to the workgroup.

- Bob Ferguson will post the third part of the ASTM CTM presentation to Basecamp.

Highlights from Meeting:

- John Crouch and Lisa Rector opened the teleconference, introducing Christoph Schmidl on the line from Germany.

Christoph Schmidl's beReal Test Method Presentation:

- Christoph Schmidl presented the beReal project from the bioenergy2020+ conference, from the slides entitled "beReal – Development of a New Test Method for Firewood Roomheaters Reflecting Real Life Operation" (presented at the 24th European Biomass Conference and Exhibition in Amsterdam, 6/6/2016). He noted that he'd be presenting the firewood [cordwood] room heaters portion, although another presentation regarding pellet fuel is also available through Christoph.

- The beReal idea came about several years ago when government regulators and industry realized that **European standards were not giving results with a direct connection to field performance**. The standards were designed to compare performances of different stoves, but not to reflect real-life performance. Representing real-life field performance simply had not been a target/objective in the standard development process.

- The beReal objectives include development of an advanced testing method for biomass room heating appliances (both firewood/cordwood and pellet stoves) that better reflect real life operation, development of a centralized standard evaluation tool for QA purposes, validation of methods at an early stage of development, proof of real life impact by field test demonstration, proof of reliability and reproducibility of testing methods and evaluation tools in Round Robin testing, and development and introduction of a European quality label based on the novel testing method(s).

- Christoph noted that they wanted real life relevance and reproducibility as well as QA, so that the standardized data analysis tool guarantees consistent data analysis. The beReal project members also wanted quality criteria so that test results can be used as real quality criteria. The project members were warned by industry that implementing a new standard would take 10 years. So it was decided that the first step should be to achieve a beReal quality label based on the new method, in order to keep the beReal method alive until it could become a standard 10 years out. (Note that the current test method for firewood/cordwood-fueled roomheaters is EN 13240 and the current method for pellet stoves is EN 14785).

- Christoph gave an overview of the project approach in terms of work packages (WP):
    - WP 1 was the management of the project.
    - **WP 2** was the market and framework analysis meant to answer the question "what is real life operation". This WP included an **online user survey, literature search, and long term field testing/measurements**. (October 2013-March 2015)
    - **WP 3** regarded **method development**. The method development looked at different operation modes (e.g. impact of fuel type, draught [draft] conditions), user behavior/user habits (e.g. ignition/start-up mode), and measurement methods (e.g. flue gas temperature measurement). (April 2014-June 2015)
    - **WP 4** regarded **data evaluation and documentation**, including a web-based online tool and Quick-User-Guide. (December 2014-September 2015)

- **WP 5** regarded **validation**, including the optimization of the testing procedure, comparison of EN & beReal, repeatability of beReal, viability analysis for other technologies, and the final method definition. (July 2014-October 2015)
- **WP 6** regarded **label development**, including a draft of the organization scheme, definition of the classification and label design. (July 2015-December 2015)
- **WP 7** regarded **field demonstration** including a field test to demonstrate/confirm real life relevance. (July 2015-October 2016, ongoing)
- **WP 8** regarded the **round robin reproducibility testing**. (July 2015-October 2016, ongoing)
- Christoph noted that WP 7 and 8 are almost finished and a final workshop in Austria will occur soon, during which results will be disseminated. This is part of **WP 9** regarding **dissemination**.

- Regarding a slide entitled *What is real life?* Christoph noted that the beReal project attempted to answer that question via a European **online survey** (available in 7 languages) regarding user behavior as well as long-term field measurements. The online user survey resulted in more than 2,200 questionnaires being completed. These surveys required more than 15 minutes to complete and included questions such as "How do you ignite your fire?" and other user behavior questions. [Note: the beReal User Behavior Survey is available on-line here: http://www.bereal-project.eu/survey.html]. From these surveys it was determined that ~80% use firewood from hardwood (primarily beech but also birch in northern Europe). The survey also found that ~66% of respondents had a 5 to 10-meter chimney heights. Long term field measurements including investigations about draught/draft conditions were combined with frequency of use responses (generally ~4 months of wood burning), how often users refuel and restart, etc. An evaluation of the survey results with long term field measurement indicated a good fit in some cases and a poorer fit in others. These results also found differences between northern and southern Europe.

- Christoph highlighted some aspects of the **method development process**. The beReal effort investigated parameters influencing emissions and efficiency including: mode of ignition (bottom-up vs top-down); refilling/refueling criterion (balance/scale vs CO_2 criterion); fuel properties (wood type/species, water/moisture content, chemical and physical properties); and chimney draught (natural vs forced draught/draft, different draught/draft levels). The following gaseous compounds were measured: CO, OGC, NO_x, CO_2, O_2). Particulate matter emissions were measured with a hot vs diluted sampling and with a rinsing of the sampling probe. The efficiency determination was made with the indirect method (measuring all losses) and the direct method (calorimeter room).

- Regarding the effect of **draught/draft**, Christoph explained that the beReal effort looked into the effect of draught/draft conditions by testing with 3 different room heaters. There was one test cycle (with 5 batches) for each draft level – 12 Pa, 24 Pa and 48 Pa. The beReal researchers found no correlation of emissions with draft but did find correlation of efficiency with draft. The correlation of draft conditions and gaseous emissions were found to depend on appliance

specifics. However, higher draught/draft conditions were found to result in lower thermal efficiency.

- Regarding **ignition mode**, Christoph noted that there were/are differences of opinion regarding whether lowest emissions happened with top-down versus bottom-up ignition mode. The beReal effort experimented with both (top-down and bottom-up) and the results varied with appliance. The researchers also looked at the difference of beech and spruce for kindling wood and tested two different wood stoves from cold starts with 3 test runs for each of 4 variations, 2 in the top-down mode and 2 in the bottom-up mode:
    - Variation 1 = top-down ignition, spruce kindling (spruce + beech);
    - Variation 2 = top-down ignition, beech kindling (beech + beech);
    - Variation 3 = bottom-up ignition, spruce kindling (spruce + beech);
    - Variation 4 = bottom-up ignition, beech kindling (beech + beech)

  Lower emissions with top-down was true of one appliance, while the other appliance was better with bottom up. Top-down ignition mode was not the best solution for each stove. How emissions correlated with ignition mode was dependent on the appliance. Therefore, Christoph concluded that there is no good/sound general advice [regarding the best ignition mode], since it depends on the appliance.

- Consequently, the beReal researchers concluded that they **couldn't/shouldn't prescribe in the method how appliances should be operated**. Rather, manufacturers need flexibility to design/prescribe the operating mode and the method should reflect this.

- Regarding **thermal efficiency** and the effect of cooling down, beReal researchers compared assessment of thermal efficiency using the indirect (EN 13240) and direct (calorimeter room) approach. They compared tests with room-sealed room heater (3 batch per test cycle). It was determined that the cooling down process and air valve settings after heating operation influence the thermal efficiency performance and therefore should be respected in the beReal Test procedure.

- Regarding the suggested beReal method (test procedure and measurements) for firewood/cordwood, Christoph showed a slide with an **8-Batch [phase] heating cycle** including a cooling down phase (which is also attached to these notes). The test was at a constant controlled flue gas draught/draft of 12±2 Pa, which is the same draft used in the standard currently. Christoph noted that they couldn't design for higher draft, as some chimneys were too low to provide enough draft and therefore such a design would be dangerous.

- Christoph described the 8 test batches, with Batch 1 being the ignition and Batch 2 the preheating. For Batches 1 to 5, the batch mass represents a nominal load (100% batch mass) and for Batches 6 to 8, the batch mass represents a partial load (50% batch mass). These batches are followed by a cool down (until the temperature reaches 50EC, or 122EF). PM measurements are made during Batches 1, 3, 5 and 7, rather than during all Batches, because it was determined that taking PM measurements in all 8 batches was too labor intensive, due to the need to make filter changes. Furthermore, Christoph noted that the beReal researchers had

determined and shown that the **average PM** from Batches 1, 3, 5 and 7 is very similar to the average PM from all 8 Batches. However, the manufacturer may measure PM during all 8 and average – or merely measure PM during Batches 1, 3, 5 and 7 – that is up to the manufacturer.

- Christoph explained that both particles and gases were measured. The gravimetric PM measurements were taken from hot flue gas along with measurements of the gaseous composition (including all the organic compounds – O_2, CO_2, CO, NO_X & OGC). The researchers decided to use the **PM measurement method** used in the current standard, EN 16510-1).

- The fuel was **beech or birch firewood/cordwood with bark** (each piece had >80% bark over surface area). The mass of the ignition batch was ≥ 80% of the fuel mass representing nominal load. The kindling material was ≤ 25% of the total match mass, with starting aids (≤ 3% of the total batch mass, only bio based fire starters allowed; paper and liquid not allowed). The air settings, whether automatic or manual, were fixed for the ignition/preheating phases, nominal load, partial load, and end phases – it was reasoned that homeowners would not be adjusting the air settings during these phases and that the beReal method should reflects homeowner behavior.

- Christoph further noted that the refilling/refueling trigger was according to a **CO_2 criterion**. The stove was refilled when CO_2 was at 25% of CO_{2max} (Note: see additional definition of CO2max criterion on Slide 8 of Christoph's powerpoints on Basecamp). Christoph explained that refilling had previously been defined according to when all the fuel is burned, but this [previously proposed method] requires too-accurate a balance. Therefore the beReal method's refilling/refueling point is based on CO_2 measurement. The CO_2 criterion for refilling/refueling is easier for the labs and improves reproducibility, Christoph noted.

- Regarding QA, Christoph noted that the beReal effort includes a **Quick-User-Guide** as well as an on-line tool. The beReal quality label requires a Quick-User-Guide for each tested appliance. This is a standardized sheet that is a mandatory one-page guideline for operation during testing and also for heating by end users in real-life. The Quick-User-Guide must contain information about preparations, ignition mode, recharging, fuel properties and air settings. The relevant operation characteristics are illustrated by text and by picture for the following:
  1. Preparation & Ignition (including amount & properties of firewood, how to load, air settings)
  2. Recharging at Nominal Load (including wood amount, visual cues for recharging, air settings)
  3. Recharging at Part Load (including wood amount, visual cues for recharging, air settings)
  4. Finishing heating operation

- Christoph noted that the **Online Tool** is a standardized data calculation and result report by an online evaluation tool (http://bereal.bioenergy2020.eu/). This online tool allows input of general test data and uploading of raw data. The username and password is provided by the administrative authority.

- Regarding the **validation process and repeatability** of the method, Christoph noted that in total 9 room heaters were tested (with EN 13240, Roomheaters fired by solid fuel test method),

representing a broad range of products (4kw to 10 kW). Three (3) beReal tests were carried out for each room heater and the coefficient of variation was calculated. The researchers were satisfied with the resulting coefficient of variations, which ranged from 5 to 15% for most of the measurement parameters, including PM. This variation is tighter/better than the current European standard. One exception to this was the OGC measurement, which seems to be a critical measurement parameter. However the OGC levels were close to the limit of detection for these appliances, which explains the larger variation (up to 40% variation) compared to the measurements of the other parameters.

- In **summary**, Christoph noted the following:
    - A new test method for firewood roomheaters called "beReal-Firewood" was developed focusing on real life operation;
    - The findings of a European user survey, long term field measurements and extensive lab testing on the effect of relevant operating parameters were the basis for the beReal test procedure;
    - Validation tests showed in general a good repeatability of beReal testing
    - Main differences in the procedure of beReal-Firewood compared to existing EN type test method are that: ignition and preheating are included, no failed batches and "batch picking" because beReal results represent the whole test cycle, thermal efficiency includes cooling down losses, and PM sampling during the entire batch. Christoph noted that PM sampling always starts before the stove is opened for refueling and ends before the stove is opened for refueling the next batch.
    - Evaluation and demonstration tests ongoing (Field tests & Round Robin Test), with the first results revealing a good real-life relevance and sufficient reproducibility. Christoph noted that for the real-life versus lab results the beReal results are in the range of 1.0 to 1.5 time's difference, with up to 50% higher emissions and lower efficiency in the field (compared to 2 to 5 time's difference for the current European standard).

- Christoph noted that the beReal test can be performed in **one day, or a maximum of 2 days**, for a cost of **$1,000 to $1,500 Euro (or dollars) per day**. Christoph noted that to be affordable the beReal test has to be done in 1 or 2 days, since manufacturers are still testing to the current European standard, with the beReal test performed as an add on.

- John Crouch asked Christoph how much the grant was to perform the beReal effort. Christoph responded that the beReal effort is a **4 year project with a total budget of 4.5 million Euros**.

- John Vorhees asked if a copy of the beReal test protocol is on-line yet. Christoph responded that he would send a **draft version of the beReal test method protocol** to Lisa Rector that Lisa may share it with the group. (Note: Lisa e-mailed this out to the O/F workgroup subsequent to the teleconference.) Christoph explained that this protocol will become public, but should not be referenced yet, as it will take a few more weeks to months to be published. It's already been submitted to the European Commission.

- A workgroup member asked how many countries have signed on to the beReal concept, noting that there were still issues with the EN 16510 standard due to sampling controversy. Christoph noted that this was a difficult question to answer, as the beReal project was not aimed at developing a standard. Standard development would be a bigger project, as there are 14 different countries a standard would apply to. However, Christoph noted that they have received a good feeling from industry regarding the beReal protocol (from ~ 80% of the market). The beReal effort also installed an advisory committee with environmental NGOs and government representatives. Nonetheless, particle sampling is still an open issue with the various countries. There's a Norwegian method and a UK method and there's no final agreement. However, recently a particle research project has begun to develop one sampling and measurement procedure to be applied across Europe. Hopefully this uniform PM method will be implemented in the EN 16510 standard. The beReal protocol already references to this uniform sampling method because the beReal researchers think it's a good solution. Christoph concluded that he did not know if the Norwegians would agree.

- Dan Henry asked if Christoph could give a **comparison of the beReal emissions to the US** required limit. Christoph noted that the beReal effort used a different way of calculating the results compared to the US and he wasn't very familiar with the US method. After confirming that the US units were in g/hr, Christoph explained that in the US emissions are measured in a dilution tunnel at ambient temperatures, but the beReal effort measures hot emissions in mg/Megajoules. Nonetheless, Christoph would ask his colleagues for a conversion, noting that it would be an estimation. Dan Henry noted that that would be helpful for this workgroup, in order to have a sense of how the two compare.

  NOTE: Subsequently, Christoph provided the following comparison chart via e-mail:

beReal results	Firewood Stove 1	Firewood Stove 2	Firewood Stove 3	Pellet Stove	Unit
CO	53.10	44.87	56.87	7.15	g/h
OGC	2.45	5.06	2.99	0.36	g/h
NO_x	1.69	2.57	NA	1.87	g/h
PM (beReal)	0.64	1.46	1.03	0.54	g/h
PM (US)*	1.62	3.49	2.22	0.68	g/h

* calculated as PM(US) = PM + 0.4*OGC (0.4 = estimated fraction of OGC which is condensable at ambient temperature; estimation based on EN standard and previous measurements)

- Lisa Rector noted that one of the objectives of the O/F workgroup is to identify research needs. If the funds are available, perhaps **one research need is to test stoves using M28, the ASTM draft cordwood method and the beReal protocol**. Both Dan Henry and John Crouch agreed this would be very worthwhile and a good item for the wishlist.

- A workgroup member asked if the beReal protocol was consistent with the EN 13240 fueling protocol. Christoph responded that the protocols are similar. The beReal effort allows the manufacturer to design the amount of fuel considered nominal (kg of cordwood is manufacturer-determined). The beReal effort also requires the one-page Quick-User-Guide. Finally, the time required for the testing is different, because in the beReal protocol the refilling/refueling/recharging is based on the CO_2 signal, rather than on the amount of wood burned.

- Tom Butcher asked about the velocity measurements in the stack and how accurate they are. Christoph responded that the beReal researchers tested many different measurement principles and an anemometer was the only device that worked for volume measurements. The anemometers can measure 1 m/sec at high accuracy, although they must be cleaned between tests. Christoph noted that measuring the volume flow and speed using an anemometer requires some effort but works out fine. Regarding any issues with temperature, Christoph explained that the temperatures encountered are okay for the anemometer. The temperature was as high as 500 degrees for one stove, but the anemometer was still functioning alright, as long as it was cleaned regularly. Christoph further clarified that they allow a difference of minus 10% -- that is the volume measurement is considered correct if within that, but if the volume measurement is higher, than the velocity measurement needs to be checked.

- Christoph noted that the beReal researchers will be at a big event/workshop in January in Austria to present the results. If anybody has time or interest to join the workshop, it will provide further details of the beReal method including highlighting differences compared to the current European standard. Christoph also offered to set up smaller group meetings, noting it would be a nice starting point for furthering cooperation between the US and Europe. Christoph further noted that the European intention is to cooperate with US, with an ideal goal of a harmonized standard one day in the future. Christoph noted that Lisa Rector had more information on the conference, as she is giving a presentation. This is also a meeting of the European Energy Commission – so it's a good opportunity to come together.

- Lisa Rector offered to send out an e-mail after the call with the beReal test protocol, with the caveat that the protocol is still draft and confidential. Lisa will also provide the link for the larger energy conference plus other beReal meetings, noting it would be great to have a group [from the O/F workgroup] go over there. Christoph noted that he could/would organize another meeting separate to that workshop to get into further details than will be in the [main] presentation. Central European Biomass Conference is the name. Christoph noted that the beReal presentation is on January 19th, while the conference goes from January 17th to the 20th, with some field trips scheduled for the 17th. Christoph clarified that he could have additional meetings in Graz in the morning on January 19, 2016.

  NOTE: Subsequent to this teleconference, Lisa e-mailed out the following information she had previously received from Christoph regarding the European conference:

*We are currently planning an event in the frame of the **Central European Biomass conference** in Graz in January 2017 where I would like to invite you and your colleges dealing with testing methods on small-scale biomass combustion appliances. The Workshop, which will be jointly organized with IEA Bioenergy Task 32 (Combustion and Cofiring), will be held in two parts:*
Part one: Direct space heating appliances (Stoves)
Part two: Central space heating appliances (Boilers)
…and will summarize existing (standard) methods and upcoming/new methods for assessing emissions and efficiency of these products. One focus will be put on the beReal method and the annual efficiency method for boilers which have been recently developed.
Date of Workshop: 19 January 2017
Venue: Graz (Austria)
I would even be happy to organize some kind of side event where we discuss future "cross-ocean" collaboration possibilities on the topic of testing methods.

- Lisa Herschberger asked where/when the data behind the conclusions be available. Christoph responded that he can provide all publications dealing with different aspects of the beReal effort and that the scientific papers are still being prepared. Everything will be available in January 2017. Regarding measurement data, Christoph explained that there are thousands of data points, so it's too large to publish and they would also need a legal framework in order to share. Currently they are not allowed to pass out the measurement data, but they are willing to – so they will look for a solution. Christoph again noted that several publications with detailed results would be published by January.

- In response to a question from Lisa, Christoph noted that the beReal effort focused not only on firewood/cordwood stoves but also on pellet stoves. The current method for pellet stoves, like the method for firewood/cordwood stoves, has the same problem in that the current test method doesn't reflect real life. Christoph noted that the two beReal methods (for pellet versus cordwood) were very different and showed an overview of the pellet method on the screen (which Lisa e-mailed to the group and which is attached to these notes). Christoph noted that the load is applied 3 times ("phases"): cold start-up and minimum load with shut-down; then hot start with 100% nominal load and high burn with shut-down; then hot start with 65% partial "medium" load and shut-down. Christoph noted that they also developed a [pellet] method for boilers that is a dynamic test method, in which the flue gas is being continually measured to estimate the real life performance of the boiler.

- Lisa Herschberger asked Christoph why they hadn't developed a cordwood method for boilers. Christoph responded that they had, but it was still in development. He further explained that the method applied here is simply linked to the size of heat storage tank, as it's not useful in Europe to measure a boiler/hydronic heater without thermal storage. So the method is defined by the storage tank in that the beReal researchers took measurements with cordwood boilers and the method can then be recalculated for bigger and smaller storage tanks. Christoph noted that this is still in the research phase and it not as mature a method as the roomheater method(s). More work is required before it can be finalized.

- John Crouch noted that the current American method runs a heater at 4 distinct burn rates/outputs from hot to hot and each is separate test. John asked Christoph to confirm that the beReal method is one long test with refueling and batches. Christoph confirmed that was correct, as that's the usual way they are operate in Europe, in order to keep heat output constant. John Crouch noted that Americans were stuck with the old method and concerned that the process of reloading introduces additional variability. John asked Christoph how the beReal researchers minimized interlab variability during reloading. Christoph responded that several parameters are set by the manufacturer – the wood amount, pieces [length/shape], and how those pieces are placed in the stove. These must also be defined by the user's guide, including with photos in the guide. This guide makes it quite easy to reproduce results with that help/guidance regarding procedure. In addition, the infield measurements revealed that the end users all liked the quick user's guide (that is, the one page summary with photos). Christoph explained that each field test consisted of 3 days of measurements – on the first day, the end user/homeowner started the stove without any influence; on the second day the user used the quick user guide; and on the third day the team was instructing the end user/homeowner. The beReal researchers found that by just providing the user guide, the performance was getting better.

- Lisa Herschberger asked what it cost to do the online survey. Christoph noted that the online survey had two expensive components – first the development of the questionnaire (so it was clear, not too long, used understandable symbols, etc.). The next step regarding the implementation of the survey was quite cheap, as it just required software and the data is continually being stored on a server. The final analysis and calculation of results had some cost to it, as it required some person months. Christoph estimated that at least a few person months was required to develop the survey and then a few more person months was required to calculate the results. Lisa Rector noted that she could PDF the on-line survey and send it around to the workgroup, and also noted that one of the beReal survey developers offered to work with people in the US interested in conducting a survey here.

- Bob Ferguson asked how the beReal researchers identified people to take the survey. Christoph noted that manufacturers had databases of their customers and that the survey was sent out via industry to over 200,000 people. Christoph noted that low feedback results for surveys that require time but provide no pay, so it must be sent out to large numbers of people. Christoph further noted that the software is still running at his university, is available in 7 languages, and that he could provide the link. Lisa Hershberger confirmed that the survey was still up-and-running, as she checked it this morning. [Note: the beReal User Behavior Survey is available on-line here: http://www.bereal-project.eu/survey.html].

- Lisa Rector noted that it was 6:20pm in Austria and thanked Christoph for staying late at work to do this presentation and also thanked everyone for their attention and participation.

- John Crouch noted that the group would return to normal time next week (9 am Pacific Time, noon EST). John noted that they've keyed up a discussion/presentation regarding why specific gravity might be useful in addressing species differences. John noted that state people should

let the workgroup chairs know about other presentations/chunks that people want to learn about.

- Bob Ferguson noted that he has his 3rd ASTM presentation regarding low and medium burn rates. Bob noted that it was interesting to hear about beReal's calculation procedure on-line, as ASTM built that into the ASTM test method via a locked Excel spreadsheet, so it's a similar concept.

- John noted that half of the time of next week's meeting would be devoted to specific gravity and the other half given to finishing up Bob's ASTM presentation. Bob will post the third ASTM presentation to Basecamp.

- Lisa thanked everyone. Meeting adjourned

ATTACHMENTS

beReal Firewood Room Heater Measurement Cycle

beReal Pellet Room Heater Measurement Cycle

EPA Notes Operation and Fueling (O/F) Workgroup Meeting Notes from October 20, 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), Ann 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:

- The details of today's presentations are noted below in the meeting highlights as well as in Rick Curkeet's and Bob Ferguson's presentation slides posted to Basecamp. This is background material to educate the workgroup; no official conclusions have yet been drawn by the group.

To-Do List:

- The Workgroup should post their questions to Basecamp. State regulators are also encouraged to send their questions to Lisa Rector and Bob Lebens.

- The Workgroup should suggest ways to transition from these background educational meetings to working on the group's charge.

- Lisa Rector will work with Bob Ferguson to post testing data from the ASTM CTM development process to the Operation and Fueling Workgroup's Basecamp, as requested by Tom Morrissey.

Highlights from Meeting:

- John Crouch opened the meeting, noting the agenda was on the GoToMeeting screen including announcements and roll call, followed by a presentation by Rick Curkeet on wood density as a possible solution to the species question, and then the third-part of Bob Ferguson's presentation on ASTM's draft cordwood method. It was agreed that a brief overview regarding EPA's research efforts will be given by Adam Baumgart-Getz at the next meeting (November 3, 2016).

- Regarding upcoming presentations, John noted that the ASTM TG worked on the [cordwood/species] problem resulting from not being able to move cordwood freely around the country, unless it was fumigated or kiln-dried, both of which are counterproductive in terms of representing in-home use. Bob will then conclude the last third of the draft ASTM CTM presentation. John further noted that the next meeting will include an overview by Adam plus a few other presentations. John suggested that the states may want to caucus and develop questions that Bob Lebens or Lisa Rector collect for the group, noting it was hard to believe there are no questions. [Perhaps Lisa and Bob facilitating questions may bring forth more.]

- Lisa Rector noted that one of things she's struggling with is how to transition from these background educational topics to the workgroup's charge. Should they [the background presentations and beginning to do the work of the O/F group] happen concurrently or sequentially? John Crouch also asked for input from the group on how that transition should best happen.

Rick Curkeet's ASTM Presentation on Cordwood – Specification for Emissions Testing:

- Rick noted he would discuss 4 topics: common firewood species, species vs density, availability of firewood (related to "don't move firewood"), and his recommendations. Rick further noted that he is the chairman of the ASTM subcommittee and worked on this issue even before becoming the chairman.

- Rick explained that when one is discussing [cord]wood, one must speak of trees and tree species. The specific gravity/density of wood is an important parameter and the specific gravity is widely available in the literature for various species. Rick showed a slide entitled "Common Species & Specific Gravity" which contained a listing of the specific gravity for many different species. Rick noted that wood is divided into deciduous/hardwoods and conifers/softwoods, although the hardness varies a lot within each group.

- Softwoods have their highest value when used for construction lumber because they are light weight but have a high strength to weight ratio. Softwoods are also used for pulp/paper and utility poles, because they are straight and tall. When harvested commercially, the waste (called "slash") is of low value and is typically left behind to decompose, or is chipped up.

- Hardwoods are most valuable in the furniture industry, for veneers and decorative flooring, and are also used for railroad ties and landscape timbers. Typically only relatively clear straight grain portions of tree have a high value. The waste includes substantial portion (larger limbs and defects) that are good for firewood.

- Rick noted that there is a lot of information on the internet from various wood-burning groups on the most commonly available firewoods. Such information includes density (pounds/cubic foot), specific gravity, pounds per cord (green or dry), BTUs per cord, and even how good the "coaling" is (poor, fair, good, excellent) – that is, how good a coal bed forms when different species are burned.

- Rick showed a table of softwood and hardwood with specific densities, noted that the draft ASTM CTM's specified density range is 0.48-0.73 based on dry weight and volume, which is equivalent to 30 to 45.5 lb/ft^3.

- Rick noted that when looking at the specific gravity of common wood species, about 53% of species fit into the 0.48-0.73 range. Rick showed a bar chart showing specific gravity on x axis and the number of wood species at each specific gravity range on the y axis.

- Rick explained that one of the concerns about combustion emissions from one tree species versus another species is their chemical composition when heated and burned. For this, one can look at the chemical composition in a *proximate analysis*, which breaks down wood material into carbon, volatiles and ash by heating samples of wood in an oxygen free environment. Rick explained that it's a simple test to get carbon %, volatile %, and % ash content. Rick noted that most of this data comes from the wood/biofuels atlas compiled by the Renewable Energies lab in Colorado. Rick explained that an *ultimate analysis* can also be done, which looks at carbon, hydrogen, oxygen, nitrogen, and sulfur component. Rick noted that 99% of a tree's components falls into carbon, hydrogen and oxygen.

- Proximate analysis shows all common wood is about 84% volatiles and 16% fixed carbon. Particulate emissions are generated almost entirely from the volatile products of pyrolysis. Volatiles represent about 84% of the fuel dry mass and about 73% of the heating value. Rick averaged all values, breaking out hardwoods and softwoods, and did not find much of a difference between hardwoods and softwoods from proximate and ultimate analysis. There was lots of crossover with the averages within 1% of each other. Rick noted that this makes sense since chemically all common wood species are very similar.

- The biggest difference between hardwoods and softwoods tends to be their lignin content (which is higher in softwoods). This higher lignin content results is a somewhat higher heating value – about 4-5%. Hardwoods tend to be denser than softwoods, but there is considerable overlap. Density does directly relate to burn rate when burning conditions are equal (that is, coal bed heat, air supply, fuel size and configuration). Rick noted that the higher the density, the slower the burn rate. However, burn rate is equal to the heat release rate. So, <u>at equal burn rates</u> there is very little difference in terms of combustion zone temperatures, air to fuel ratio, heat output or efficiency.

- Regarding what consumers burn, Rick pointed to a 2008 paper by Houck which contained survey data, noting that the net result around the country is that 19% burn softwoods and 81% burn hardwoods. Rick noted that this came from census data, but the northwest was probably underrepresented. The conclusion is that hardwoods are the dominant tree type for heating.

- The wood density data available in the literature is based on averages of large sample sets, without an indication of variability. The density is actually quite variable within species from tree to tree and even from different parts of a single tree. The range is generally ± 10 to 20%. The Douglas fir density range seen in EPA testing has varied from 0.45 to 0.66 specific gravity (28 to 41 lb/ft^3). Specifying test fuel simply by species does not mean that the wood density will be uniform.

Consumers who heat with wood prefer higher density wood if available, because this provides more BTUs per cord. Most information resources regarding wood heating recommend hardwoods as the preferred fuel.

- Rick noted that 34 States have restrictions on the movement of untreated firewood. Most states limit the movement to within 50 miles and some to within 10 miles. The purpose of these restrictions is to slow the spread of invasive, destructive pests and diseases such as the Gypsy Moth, Emerald Ash Borer, 1000 Cankers Disease, Asian Longhorn Beatle and many others. Rick further noted that 38 million Ash trees are expected to be killed by the Emerald Ash Borer within 10 years.

- Restrictions apply in states where most labs and many manufacturers are located. The purchase of treated firewood is not a viable option, as treatment requires heating wood to a core temperature of 140 to 160 F (varies by state). This treatment is done in kilns and to make the process efficient kilns are run at 180 to 200 F. This results in drying wood unevenly and below normal firewood levels (<18% moisture content with shell moisture contents as low as 6-10% after treatment. In addition, treatment is expensive as is shipping cordwood long distances. Fortunately common species with densities in the most common range are broadly available locally (i.e., well within the 50 mile restricted range).

- Regarding species identification, Rick noted that it is typically quite difficult to determine the species of a piece of wood without specialized training and knowledge. While possible, the process generally requires fresh clean cuts to examine grain and cell structure and this usually requires 10 to 15X magnification. In addition, this requires references to a detailed data base and knowledge of wood cellular biological characteristics. In some cases differences between species are very difficult to detect. Rick further noted that firewood suppliers often mix species within a load making sorting very tedious and time consuming.

- Regarding how much species matters, Rick noted that the chemical process of burning is relatively the same for two [different] species with equivalent densities – suggesting that density matters more than species. Comparing softwoods to hardwoods, an OMNI study used 2 stoves (one with “high emissions” at 5.9 g/hr and one with “low emissions” at 2.1 g/hr) and tested with cold starts at low burn and hot starts for the high burn rates. Two replicate tests were run under each (i.e., 2 softwood tests and 2 hardwood tests at each burn rate, for a total of 8 runs). The results showed that the higher emissions stove had lower emissions when burning hardwood compared to softwoods, but the lower emissions stove had lower emissions when burning softwood compared to hardwoods. Rick noted therefore that these tests reveal that one can’t conclude how hardwood versus softwood affects emissions. (In response to a question from Lisa, Rick clarified that the bar chart at the bottom of this slide #16 was from a different study than the table at the top of the slide.)

- Regarding the bar chart at the bottom of slide#16, Rick noted that g/kg as a measure of completeness of combustion reveals something. Ignoring the fireplace bar, Rick explained that the testing on the non-catalytic woodstove resulted in white oak giving the highest emissions, while red maple gave the lowest emissions. Sugar Maple and Douglas fir results were similar for the non-

cat stove, while loblolly was slightly higher emitting (but not as high as white oak). In other words, the data shows no discernable trend in terms of softwoods versus hardwoods.

- Lisa Rector requested, for both the OMNI data and the second bar chart (on slide #16), if Rick could provide the g/hr and the burn rates. Lisa noted that hardwoods and softwoods have different burn rates. Rick replied that unfortunately the studies didn't provide the burn rates. Rick further explained that the stoves were run at same control settings, so it may well be that the hardwood was burning slower than the softwood. Rick noted that he would look for the burn rate data. Lisa asked if the different burn rates for hardwoods versus softwoods could be a reason for the variability. Rick replied that no, he thinks it's the burning of wood itself which introduces the variability, not the fuel.

- Regarding the next slide#17, Rick noted that they took data and put it through a corner score test to determine if there was an association between density and emissions. The corner score was +2 and Rick explained that anything less than 11 means there is little association between variables. In addition, the regression R^2 value was close to 0 (it was 0.0048). Rick concluded that this analysis showed that the density range used in EPA testing didn't directly relate to emissions.

- According to Rick, the EPA proficiency test program data clearly demonstrated high emissions rate variability even though the fuel used in all tests was from a single species and the fuel crib configuration was very reproducible. This leads to the conclusion that the fuel characteristics are not the likely source of the variability in results. Rick noted that in his view, we need to rethink and redefine what we mean by clean technology in wood burning. It should be an appliance that produces acceptable emissions even though it will be supplied with variable fuel in its intended use. Rick opined that, to properly evaluate these products, they should be tested with similarly variable fuel.

- Regarding Rick's recommendations, he noted that due to firewood movement restrictions laboratories need to be able to source cordwood fuel supplies locally. Since fuel must be well seasoned to meet Moisture Content limits, labs must be able to use what their local suppliers have available. There is no way to assure than adequate supplies of fuel of specific species or narrow density range will be obtainable. (Rick noted that it's not practical for the labs to store firewood for two years.) Rick asserted that there is no compelling evidence that species or density have a significant effect on results given roughly equal test load weights and burn rates.

- Rick noted that it is not difficult to determine density. It is relatively easy to determine and verify wood density and that it is within the range specified in the ASTM method. This need not be a precise measurement since the load weight and moisture content are quite tightly specified and accurately measured. Purchasing seasoned cordwood from a reputable local dealer should not be a problem and would be typical of normal consumer practice. Appliance designs will need to be able to perform well even though the fuel used in qualification [certification] tests may be as variable in the lab as it is in the real world. This is, in fact, the point of moving to a cordwood test method.

- Rick noted that the ASTM Draft Cordwood method has an adequate cordwood fuel specification, supported by a broad consensus. It has been vetted through a significant number of tests by experienced labs and manufacturers. It is similar to the fuel specifications in CSA B415.1 and ASTM E2618 for furnaces and hydronic heaters, which have demonstrated it is workable and does not result in unusual variability. The ASTM Method should be used as published so that the development of a database for tests with a well-defined cordwood fueling procedure can be begin in advance of any implementation of regulatory requirements. Rick noted this was the end of his presentation.

- Adam thanked Rick for his presentation, noting that it was obvious he'd done a lot of work on this topic. Adam noted that EPA and ASTM are coming up with slightly different angles on the same problems. EPA needs substantial evidence that species does not produce variability – the burden of proof is on showing that different species don't show variability, rather than showing that there is little variability. Adam noted that this is a subtly different angle. Rick replied that it sounds like Adam/EPA wants us to prove a negative, which we can't do. Adam clarified that, rather than look through a body of evidence [as Rick has done], it would require burning a bunch of wood to show that little variability results. Adam further noted that EPA is doing this and is not asking for Rick or industry to do this. Rick noted that he was skeptical of how that can be dealt with/accomplished, since we know there is a large variability in emissions even when the species and density is taken out of the equation, as it has for the last 30 years. Rick further noted that it's difficult when so many other variables exist, because multiple different parts of the process [burning wood in a wood heater] effect the end results. Adam agreed and noted that EPA is working on it. Adam clarified that we won't resolve the issue of the inherent variability of wood now. Adam concluded that his obligation is to show [or not] that no variability results from changing species.

- Adam asked, regarding the tests Rick referred to, if they were done with the same test method and similar stoves. Rick replied that the OMNI study [top of slide#16] was done with two different stoves with variations in burn rates. The chart [on bottom of slide#16] shows test results from same stoves [a cat and non-cat, plus a fireplace] tested with multiple fuels [in each stove]. Adam noted that there is data from the late 80's from testing done on an old Vermont Castings stove. Bob Ferguson is looking for that data. Adam asked if that data from the late 80's informed Rick's and ASTM's analysis as well. Rick replied that if there is more data, he/ASTM would love to see it. Adam noted that EPA once had this data (from the late 80's) but doesn't currently. Adam too would like to review that data.

- John asked if there were any other questions for Rick.

- Tom Morrissey noted that he had some questions for Rick and Bob Ferguson. Tom noted that reportedly the ASTM CTM has been vetted through a significant number of test labs and manufacturers. Tom would like to know who did the vetting and how many tests they performed. Bob replied that Mark Champion did most of the testing, but he is not sure of the exact number of tests. Tom asked if any of that data been released. Bob confirmed it had. Tom asked if the data included appliance temperature, gas compositions and emissions – Tom wanted to know if there was enough information in the data released from Mark's testing to determine reproducibility. Bob replied that yes, data was published in different chunks in various reports, but it's all on

ASTM's website and some has also been posted to Basecamp as well. [Note: this ASTM data is posted on the Steering Committee's Basecamp, not on the Operation & Fueling Workgroup's Basecamp.] Bob noted that there were other tests conducted by other labs, but he doesn't know the number of data points collected. Bob further noted that some manufacturers used the draft ASTM CTM – including Tom Morrissey as well as US Stove, Hearth & Home, Blaze King, and Ben Myron – and a number of these results were reported during the ASTM meetings.

- Tom Morrissey noted that the only accredited labs to have used the draft ASTM CTM were Ben Myron and Rick Curkeet. Tom pointed out that OMNI didn't use it, neither did Dirigo nor Polytests. So actual lab work/testing hasn't been done with the method, according to Tom. Rick Curkeet noted that the reason is because the draft ASTM CTM is not a standardized test. Tom replied that that's not relevant because both Rick and Bob have made the claim that the ASTM CTM has been extensively vetted, yet [Tom noted that] he's never seen spreadsheet with actual data. Bob noted that Tom has been on the distribution list and that information was provided through the distribution list.

- Lisa Rector asked Bob Ferguson if he could share the full test reports for the company's and labs that ran the full ASTM tests, not merely the supporting data, but rather the full lab reports from the multiple tests through their stoves. Tom Morrissey confirmed that is what he would like as well. Tom noted that one must essentially take it on faith that there is high variability and that the results are not reproducible, but Tom doesn't necessarily believe that.

- Lisa offered to check Basecamp's site for the ASTM data Bob posted and then send it to Bob to ensure it's the full list of data available. Then Lisa will post the data to the Operation & Fueling Workgroup's Basecamp site. Bob noted that the data is from the testing/work done by Mark Champion on 5 stoves during the course of development to exercise the method. Bob further noted that he did not use the word "vet" pertaining to this testing.

- Tom Morrissey clarified that there is no public knowledge about how many tests have been done, who did it, what the results were, and who paid. Tom noted that Mark Champion's data was summary data, but not test data. Tom asserted that if this method is to be discussed as a serious method, then actual spreadsheet data needs to be seen. Lisa Rector noted that she will touch base with Tom Morrissey after the meeting and see what there is to post to Basecamp, as the O/F workgroup will need to start digging into the weeds.

- John Crouch asked the group to post questions for Rick to Basecamp or, if a state regulator, to send any questions to Bob Lebens or Lisa Rector.

<u>Bob Ferguson's ASTM Cordwood Test Method Development Discussion (continued from 2 weeks ago)</u>:

- Bob started going through his slides entitled "A Discussion of the Development of the Proposed ASTM Cordwood Test Method for Room Heaters – Part 3". Bob noted that he would move quickly through the slides in an attempt to finish and would discuss: the medium and low fire test categories of the procedure, the test method outputs, the summary test report and the method's

annexes (including efficiency and heat output using CSA B415.1-10 and the method for single burn rate heaters). Note: Bob's presentation slides are posted to Basecamp.

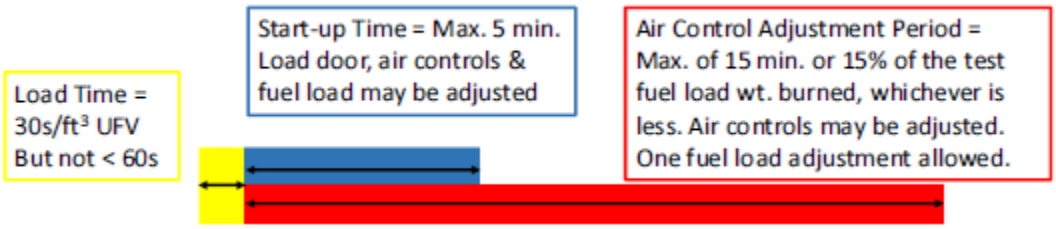
- Regarding the low and medium fire nominal test fuel load density (9.6.3), Bob noted that the test fuel load density evolved to 12 lb/ft^3 of UFV, as previously discussed. An exception is included consistent with the high fire exception discussed earlier. This exception to the load density requirement was added rather than adopting an unproven sliding scale to accommodate small or atypical fireboxes. (Bob added that sliding scales are difficult to vet.) The exception is: if it is physically impossible to achieve the minimum 12 lb/ft^3 (low end of the tolerance), despite exercising all of the piece size and other fueling flexibility allowed in the method, the stove must be operated with the actually achievable maximum load density. (Bob added that sometimes this much wood will simply not fit in the firebox due to a number of reasons including unusually shaped fireboxes, etc.) This exception must be fully documented and the load density that is achieved reported. This is recognition that for some fireboxes 12 lb/ft^3 won't be achievable, especially if the 10 lb/ft^3 requirement was not achieved for the high fire run. Bob noted that the 12 lb/ft^3 represents at 73% increase in load weight over EPA M28.

- Regarding the starting charcoal bed weight (9.6.4), Bob noted that this is defined as 10 – 20% of the test fuel load weight and is based on testing and observations by Mark Champion – that is, the appearance of the charcoal bed plus adequate space for the test fuel load. The low and medium fire load time (9.6.5) is based on 30 seconds per ft^3 UFV, but not less than 60 seconds. For the low and medium fire test run start-up time (9.6.6), the load door and air controls may be in any position as recommended in the manufacturer's written instructions for up to five minutes after the maximum allowed load time. Fuel adjustments may be made as needed to ensure ignition of the test fuel load.

- Regarding the low and medium fire air control adjustment period (9.6.7), Bob noted that up to 15 minutes after the maximum load time is allowed, or until 15% of the test fuel load weight is burned. Combustion air controls may be adjusted to ensure ignition of the test fuel. Bob noted that there was much discussion by the Task Group about this optional extra time. Without this option, it was observed that some test run fires simply died out. It takes more time to get the large mass of the test fuel load to ignite in a sustainable fashion.

- Regarding that test fuel pieces can be adjusted once during this period (9.6.8), Bob noted that this was described earlier in the high fire section. (Bob re-iterated that homeowners would likely adjust fuel if a wood piece fell on a glass door, for example.) The practice of fuel adjustment will be self-limiting because: wood consumption could be accelerated causing a failure to meet a low burn rate; fuel adjustments can increase PM since emissions controls (door, bypass, flow path) get interrupted (and stirring up fly ash during load adjustment); and emissions are sampled during this period, so no PM is being missed. Test fuel load may also be adjusted once during the test run but only after 60% of the test fuel load weight AND 10-minutes have lapsed with a measurable weight loss.

- The following diagram capture the allowable load times, controls adjustment and fuel adjustments:



- Regarding the medium and low fire test run start (9.6.9), Bob noted that emission and efficiency sampling begins immediately before the test fuel load is added. The test fuel load is added in accordance with the manufacturer's written instructions. The full test fuel load must be in the stove by the end of the fuel loading period.

- Regarding the medium and low fire test run completion (9.6.12), Bob noted that the primary criteria is that the test run ends when 100% of the test fuel load weight is consumed. However an exception was added that if the fire goes out, at least 90% of test fuel load weight has been consumed AND there has been no measurable weight loss for at least 30 minutes, then this alternatively marks test run completion. During testing, it was observed that combustion could cease before the full test fuel load weight was consumed, even when the charcoal/fuel bed was adjusted once as allowed in the method. Invalidation of the test run would result if 100% test fuel load consumption were the only requirement.

- Bob noted that further rationale for special test-end criteria include: the fact that cordwood burns very differently than spaced crib fuel and dead zones can occur late in the test run where combustion simply ceases; visually, the stoves were at the end of their burn cycle even though there was remaining test load weight; and the Task Group discussion was about what was reasonable and whether a test run should be invalidated only because all the fuel wasn't consumed. Regarding the last point, it was recognized that essentially 100% of the PM will be accounted for with a test run potentially stopped at or beyond 90% consumption. This 90% cut-off point was directly based on the data and observations. Bob further noted that most if not all of PM has been released by then, so this alternative/special test-end criteria results in shortening the test run and saving a perfectly valid run.

- Bob noted that of course, there are risks for the manufacturer if the stove stops burning before the full test fuel load weight is consumed. The burn duration or burn rate requirement may not have been achieved and the emission rate will be higher due to the shorter test duration. This risk was the trade-off for saving an otherwise perfectly valid and representative test. Bob noted that since fires can go out in the field before all the wood is burned, this is not an unrealistic end point.

- Regarding the low fire test category (9.7), the primary combustion air will be at the lowest setting at all times after the air control adjustment period has lapsed (9.7.1). Automatic controls allowed to operate as designed. The low fire test run duration must be at least 8 hours, reflective of an unattended overnight burn. However, the minimum burn rate achieved cannot exceed 1.5 kg/h

dry basis. This was in recognition of needing to limit the minimum burn rate for heaters with very large fireboxes.

- If a heater cannot achieve the 8-hour burn duration, a minimum burn rate ≤ 1.15 kg/h must be achieved. This was in recognition of needing a limit for heaters with small fireboxes where 8 hours is simply not possible or even intended. This section of the draft ASTM CTM was the result of significant discussion of various options. The key guiding principle was that an overnight burn is a key consumer demand. Once it was generally agreed that meant a minimum of 8 hours, the issues with larger and smaller stoves surfaced and lead to the additional requirements noted above.

- Regarding the medium fire test category (9.8), This section defines a methodology that ensures that the burn rate from medium fire test runs will be in the lower half of the overall burn rate range. Once the high fire burn rate and low fire burn rate have been determined, the mid-point can be calculated. The medium fire burn rate must be below that mid-point. It also includes the need for the air control actuator to be set in the lower half of the consumer controllable range (whether a lever, knob or otherwise). This makes the air control setting to achieve a medium heat output more logical from a visual perspective. Requiring the medium fire test run to fall in the lower half of the operating range is in recognition of the fact that consumers operate much of the time at lower heat outputs (burn rates).

- In the ASTM Task Group discussion, it was noted that by allowing a High Fire test run to continue to 100% fuel consumption, the resultant burn rate could meet the Medium Fire definition. In other words, a medium fire test run could be achieved with the air at the highest setting, just because of the long charcoal tail. Additional test runs were conducted to help inform the Task Group on this issue. It was agreed that achieving two different burn rate categories with the same air setting was not desirable and the requirement to set the air control no higher than the visual mid-point of the control range was added.

- Regarding other requirements common to low, medium and high fire tests (that is, applicable to all test categories) and pertaining to auxiliary equipment operation (primarily convective air fans), the auxiliary equipment should be operated in accordance with the manufacturer's written instructions. That is, automatic systems are allowed to operate as designed. Since the fan "on" condition has always been presumed to be the worst case from a PM emission perspective but is probably the best case for efficiency, defining the appropriate operating conditions for the test runs generated some protracted Task Group discussion. The conclusion reached by the Task Group was to require the convection air fan to be operated for all test runs if it is optional or included equipment. The consensus was that this represents the worst case for PM which has a passing grade -- whereas efficiency is simply measured and reported. To address the possible impact on efficiency, it was agreed that a statement should be required in the owner's manual indicating that overall efficiency may be lower without a fan installed or if the fan is installed but not used.

- Regarding overall efficiency measurements, for all test runs, including the high fire with cold start, the efficiency measurements are made on a hot-to-hot basis. This is consistent with the way the CSA B415.1 efficiency determination was designed and eliminates the need to insert a number of exceptions to the CSA efficiency spreadsheet. Direct comparisons were made for the same test run

including and excluding the cold start part of the high fire test. The efficiency differences observed were small enough to garner Task Group support to proceed using the CSA B415.1 procedure without modification or exceptions. (Bob noted that the hot-to-hot basis for the high fire efficiency determination means efficiency is being measured during a different time period than emissions are being measured.)

- Regarding test method outputs, Bob noted that the High Fire PM Emission Rate (g/h) and PM Factor (g/kg) includes kindling and start-up emissions, test duration and total fuel burned. The test run duration is from ignition of kindling to the end of the test run. The High Fire PM per MMBtu output applies the CSA B415.1 overall efficiency (hot-to-hot) to the total fuel burned (including kindling and start-up fuel) and the total emissions including the cold start. This is adjusted to a per million Btu output basis. The Low and Medium Fire PM Emission Rate (g/h) and PM Factor (g/kg) are based on total hot-to-hot emissions, test run duration and total fuel burned. The Low and Medium Fire PM per MMBtu output is based on the hot-to-hot CSA B415.1 Overall Efficiency, the total weight of test fuel burned over the test run, and the total PM emissions over the test run. This is also adjusted to a per million Btu output basis.

- The weighted average results apply a 40%-40%-20% (Low Fire-Medium Fire-High Fire) weighting to all relevant parameters (e.g., PM emission rate and overall efficiency). The 40-40-20 weighting is based on extensive analysis of PM results from EPA certified stove models. Bob noted that EPA's enhanced database represents a large number of certified stoves. ASTM utilized the original enhanced certified stove database. This was part of the method development process for ASTM E2780. Various alternative data weighting options were compared to the burn rate probability weighting that is part of EPA M28. The 40-40-20 weighting provided a good match with the advantage of simplifying the weighting. This simplification was supported by all Task Group members.

- Regarding the draft ASTM CTM's 40-40-20 average weighting scheme for emissions, Bob showed a number of slides (see slides 20 through 24 on Bob's Part 3 presentation on Basecamp) including:
    - A graph on slide 20 is entitled *40 - 40 - 20 Weighting vs. EPA M28 - All QC'd Cat & NC Data ≤ 4.5 g/hr M28, With Data Falling Within <1.15, 1.15 - 1.75 and Maximum Burn Rate Ranges*. Bob noted this line-fitting was from a group of 96 certified models comparing EPA weighting vs 40-40-20.
    - Regarding the datapoints that did not fall so neatly on the fitted line, Bob noted that ASTM analyzed those individual profiles. The graphs on slides 21 and 22 examine what caused those differences and reveal why some of this difference is occurring with these stoves. The graphs slides 21 and 22 are entitled *Selected Emission Profiles and 40-40-20 Weighting Results, Ave. Emissions = (0.4 X Ave. Low (<1.15 kg/hr) + 0.4 X Ave.Med (1.15-1.75 kg/hr) = 0.2 X Ave.High (>1.75 kg/hr)*.
    - Slide 23 is a table from January 2010 (updated May 2016) entitled *Comparison of M28 Weighted Average Emissions vs 40-40-20 Weighting for Fixed Burn Rate Ranges and Percentage Based on Burn Rate Ranges*. Bob noted that the last column of data in this table is no longer relevant.
    - Slide 24 is a bar chart entitled *EPA M28 Weighting When Grouped into ASTM E2780 <1.15, 1.15-1.75 and >1.75 Burn Rate Ranges*. Bob noted that good 40-40-20 averages result if

one takes the averages of all stoves, both those close and far away from the fitted line, and group M28 data into burn rate categories.

- The combined 80% weighting of the low and medium fire results satisfies the recognition that homeowners operate their stoves at lower burn rates (heat output) a significant portion of time. In light of the inclusion of the cold start to the high fire test run, the 20% weighting still seems appropriate and in-keeping with consumer practices. Weighted averages provide the consumer with a single number rating which simplifies the comparison of different stove models.

- Regarding the wood heater cordwood test summary, the concept of including a Summary Test Report was proposed as a means to help ensure standardization in the way the test laboratories report key information about the wood heater tests conducted using the cordwood test method. The summary report is in an interactive Excel spreadsheet format that: contains active cells where information and data are entered, contains locked cells where standardized calculations determine the various parametric results, ensures calculations and reporting are consistent, and that will be available from ASTM as an adjunct to the method. This test summary has received broad support within the ASTM Task Group. Bob further noted that the Task Group noticed that there is a variety of ways information is provided based on a bunch of different summaries from different EPA testing labs. The Task Group thought standardization would be helpful, especially now that test reports are published on websites. Hence the idea of the Excel spreadsheet.

- Bob walked through an example entry on the Excel spreadsheet (see slides 27 through 30 on Basecamp). Regarding slide 27, Bob noted that the spreadsheet requires general information plus lots of photos. These photos show how the stove was set up and also what the typical fuel load looked like. Bob emphasized that photos are required for each test run. Bob explained regarding slide 28 that anything in yellow is an input, anything not in yellow is calculated. The summary [based on its formulas/programming and calculations] realizes whether it's a low, medium or high fire test and knows, for example, where to put "NA". Regarding slide 29, Bob noted that the difference between the 2 trains is captured the in average. The spreadsheet will automatically recognize the # of columns and adjust the calculations accordingly. Slide 30 shows the calculated results.

- Regarding the Cordwood Test Method Annexes, Annex A1 is the WOOD HEATER THERMAL EFFICIENCY AND HEAT OUTPUT DETERMINATION. This provides the information for the application of the CSA B415.1-10 efficiency and heat output determination to the cordwood method. It adds the option for using weight average fuel property values (C-HO, HHV and Ash Content) for mixed species test fuel loads. (Bob noted that this is what Rick Curkeet discussed in his presentation regarding the Ultimate Analysis.) Annex A1 explains the need to subtract the weight of any unburned portion of the test fuel load from the fuel weight values input in to the calculation spreadsheet. Bob noted that it expects 0 weight, but if there's some fuel left this annex will tell you how to subtract that out.

- Regarding Annex A2. SINGLE BURN RATE HEATER FUELING AND OPERATION, Bob noted that since there are no user-operated controls (no changes in air settings), the procedure requires two test runs (no Medium Fire Test) based on a High Fire Protocol with Cold Start and a Low Fire Protocol

(hot-to-hot). The data from both test run categories are averaged to determine the overall average PM and CO emissions and overall efficiency.

- Bob concluded his presentation and thanked everyone for their patience.

- John Crouch reminded everyone that all 3 of Bob's presentations on the draft ASTM CTM were posted to Basecamp. John asked the group to please review and send lists of questions to Lisa and Bob Lebens or to post questions directly to Basecamp. Bob Ferguson also offered that it was fine for people to call him directly with questions, if they prefer that to posting questions. Rick Curkeet may also be called directly for questions on his presentation (which is also posted to Basecamp).

- John noted that on November 3rd there will be a presentation regarding 3 stoves tested to the beReal method and to EPA's method. John asked the group to let John and Lisa know if more presentations are needed (e.g., for CSA B415).

- **Meeting adjourned.**

EPA Notes Operation and Fueling (O/F) Workgroup Meeting Notes from November 3, 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:

- The November 17th meeting will be a primer on EPA Method 28 and attendance is optional. The upcoming O/F workgroup meetings are on November 17th, December 15th and January 5th.

- EPA is currently funding foundational research into the effect of species on burn rates and emissions. Mark Champion is measuring burn rates and sampling emissions in a pre-NSPS (essentially uncontrolled) stove burning crib wood from the following species: Douglas fir, Red Oak, White Pine, Red Maple, White Birch and Ash. After the crib testing, 1 to 3 of these species will be chosen to be tested as cordwood. One objective of this testing is to inform a data bridge from the Method 28 Douglas fir crib database to other species available in cordwood. Furthermore, NESCAUM has provided a TEOM being used during testing, so continuous minute data is being collected which provides a sense of when emissions are highest and lowest during the burn cycle. Adam Baumgart-Getz will present some of the data collected to-date from this species testing during the December 15th workgroup meeting.

- John Voorhees gave a slide presentation entitled "EPA vs EU 13240 Emission Results" which is available on Basecamp. In European wood stove testing, the weight of the fuel is based entirely on the rating (kW output) of the stove which is declared by the manufacturer, not on the dimensions of the firebox. (In Europe, the manufacturer can classify the stove as "intermittent" or "continuous", depending on the length of the burn in the stove.) European testing is performed with the wood stove set at nominal air settings and there is no set minimum burn requirement. The minimum burn is determined by the stove and manufacturer, rather than by the method. The Din+ is a partial cycle sampling method (testing occurs during the optimal part of the burn, but not

during the full cycle) while EPA sampling is full cycle sampling. Another key difference is that the Din+ uses a heated filter which results in a big difference in the amount of condensables captured/measured. In EPA's M28, the filter temperature can't exceed 90 degrees F in the dilution tunnel, whereas the temperature of the filter in the European method is 180 degrees Celsius because it's a heated filter line and filter.

- Another European Union program called Ecodesign is set to be implemented across Europe in 2022. Ecodesign sets limits for CO_2, NOx, CO and efficiency [in addition to PM] and is more restrictive than EN 13240, although it uses EN 13240/16510 test methods.

To-Do List:

- John Voorhees will identify the third wood species allowed under the European EN 13240 testing (in addition to Birch and Beech) and will e-mail the group regarding the permissible species. John (with assistance from Rick Curkeet) will also provide the workgroup test results from his presentation in g/hr at each burn rate, as well as results for other parameters measured, including CO and organics. Finally, John will share with the group information about the European Union program called Ecodesign, set to be implemented across Europe in 2022.

- Lisa Rector will identify and distribute any information/data from the 2009 NESCAUM study in which OMNI tested a European stove using M28 and EN 13240 with hot filters instead of a dilution tunnel.

- Lisa Rector will clarify the intended use of the beReal method when she is in Europe for the conference in January and will inform the O/F workgroup of what she learns. Lisa will also find Christoph's results from when beReal ran a dilution tunnel and a hot filter. Finally, Lisa will find and post to Basecamp a paper on this subject by Thomas Nitzbaumer.

- The O/F Workgroup should think about what pieces from today's discussion would be useful in the US/EPA test method (e.g., loading weights, testing based on a stove's rating as intermittent versus continuous, appropriate filter temperature during testing, should the test method essentially design the stove or should the method be flexible enough to allow for different stove designs/ratings/settings).

Highlights from Meeting:

- Lisa Rector noted that the following people were in attendance at the beginning of the meeting: Amanda Aldridge, George Allen, Jack (from Minnesota), Adam Baumgart-Getz, Bob Lebens, Gaetan Piedalue, Gregg Achman, Cindy Heil, John Barnes, John Crouch, John Voorhees, Kelli O'Brien, Lisa Herschberger, Randy Orr, Rick Curkeet, Bob Ferguson, Rod Tinnemore, Tom Butcher, Tom Morrissey, Rebecca Trojanowski, Mike Toney, John Wakefield, and possibly others on the phone who did not announce themselves.

- John Crouch opened the meeting, noting the agenda on the screen including an update on future meetings, an EPA Research Update, and an EPA vs EN Emission Results presentation by John Voorhees. Regarding the update on future meetings, John noted there's no O/F meeting next

Thursday, but a Steering Committee meeting on November 14th to discuss PM Measurement recommendations. Lisa noted that the next OF meeting is November 17th.

- Lisa understands that industry will be travelling on November 17th. Therefore, the plan for that day is to do a Method 28 discussion/primer regarding the differences with other methods. This will provide regulators with a basic understanding of M28. Industry folks may not need to participate, so participation on 11/17/16 is optional. Lisa noted that on December 1st almost all regulators will be absent due to a NESCAUM meeting in Albany, therefore the December 1st meeting should be moved. [It was later decided that instead of December 1st, the next meeting after November 17th would be December 15th.]

- John asked Adam to brief the group regarding the woodstove testing EPA was involved in.

- Adam Baumgart-Getz gave a brief update, noting that EPA is currently doing foundational work regarding how fuel species impacts emissions. In the draft ASTM, a range of densities is allowed – that is, any species within that density range may be used as the test fuel and it's a fairly generous range. This [allowable density range] gave EPA pause in terms of how such a wide range might contribute to test method variability. Therefore, EPA put together a contract to examine the impact of species. Currently crib wood testing is being done using Douglas fir, Red Oak, White Pine, Red Maple, White Birch and Ash. These are the species that the labs indicated they thought they could obtain as cordwood [except for the Douglas fir]. Adam explained that the testing is first examining how they burn as crib wood, then 1 to 3 species [from that list of 6 species] will be identified to examine how these 1 to 3 species burn as cordwood.

- Adam further explained that this testing is meant to inform a data bridge to take us from the Method 28 Douglas fir crib database to other species available in cordwood. The testing currently consists of 5 burns per species using crib wood. Adam noted that the testing will therefore not provide a robust/large database, but will provide a sense of which direction to head. Some results from Mark Champion's testing [under this contract] are in and these results will be shared with everyone after the Quality Assurance Project Plan (QAPP) is reviewed and approved. EPA is reviewing the QAPP now and hopes to approve it by next week, although it may take longer. Grossly summarized, the results so far indicate that burn rates vary with these species. The specific gravity of each tested species will also be measured and how density affects burn rate will also be examined, in addition to species. The goal is to identify 1 to 3 cordwood species to move forward with further testing. Adam noted that EPA hoped to start sharing the testing results during the next few weeks.

- John Crouch asked if the testing was being performed on a conventional stove. Adam replied that there is no perfect solution as to what kind of stove to perform the testing in, whether catalytic or non-catalytic. One goal of the test design was to eliminate stove technology's effect/interference on emissions [to be able to compare emissions from various species under a simple/raw burn, thereby eliminating a potential variability factor]. Therefore, testing is being performed in a refurbished pre-1988 stove with minimal control technology. There are some flaws and downsides to this decision – for example, the stove is not designed to burn at low burn rates. However, EPA determined that removing control technology [as much as possible] as a variable was important.

- Adam also pointed out that NESCAUM provided a TEOM to be used during testing, so continuous minute data is being collected during the test which provides a sense of when emissions are highest and lowest. The R-squared value of the filter vs TEOM data is 0.99 – so the data between the two measurement techniques is a very good match. Adam noted that EPA is not going to require a TEOM in certification testing. The TEOM is being used in this testing to determine where emissions are occurring [e.g., at what point of the burn cycle] and to inform answers to other questions such as where to cut off the test for certain burn rates, etc. Adam asked the group to please bring up questions in the next teleconference or feel free to contact Adam directly, with more pressing questions. Adam noted that the group could have a more detailed discussion about this testing in the next couple of weeks.

- Lisa Rector and John Crouch decided that the next teleconference would be on December 15th, during which Adam would present EPA's species testing in more detail. Adam and Mike Toney agreed the QAPP should be approved before then. John requested that the EPA testing data be posted to Basecamp a day or two before the December 15th presentation, so group members can review the data and formulate their questions for Adam.

- John noted that a longer meeting on December 15th makes sense – for Adam's presentation for to discuss any issues that the state regulators have raised so far with Lisa and Bob Lebens. It was agreed that November 17th would be the Method 28 review meeting and December 15th would be a longer teleconference to discuss priority topics and EPA's testing work so far. It was further agreed that there would be no meeting on December 29th, so only one meeting would occur in December on the 15th. John noted that after that the next teleconference would be on January 5, 2017. Lisa noted that she would change the Outlook invites and also send out e-mail invitations, as some people have issues with Outlook.

- Prior to John Voorhees beginning his presentation, Lisa clarified that John's presentation would regard the EN certification test results, not the beReal protocol results. Lisa had previously sent out the draft beReal protocol to the group and further noted that she would confirm with Christoph Schmidl regarding the plans for beReal's method. Lisa noted that there is some confusion about beReal because we have heard both that beReal is merely a concept and that beReal will be used for an incentive and labeling program in 2017 with an aim to be used for certification in 2020. It's not clear how finalized these plans are. But for today's meeting, Lisa wanted to clarify that John Voorhees is not talking about beReal, but rather about the EN certification method. John Crouch noted that HPBA will be speaking to German trade organization to clarify with them as well, while Lisa clarifies the nature of the beReal effort with her contacts. Lisa noted that she will discuss beReal with the Europeans in the January conference and will clarify this with the O/F workgroup in February.

- John Voorhees agreed, noting that things are not clear regarding the future of certification in Europe. John explained that EN 13240 is being used but is in the process of being phased out with EN 16510 taking its place. EN 16510 is currently being vetted. Also, the beReal protocol is not a requirement, it's more of a labelling option. BeReal is not vetted through the TC295 group in Europe that authorizes test protocols and therefore it's a bit of a quagmire regarding how beReal

will be used. John further noted that EN 16510 hasn't been promulgated yet to take over EN 13240, due to technical difficulties with labeling and other issues. John explained that the European group is attempting to get the entire European Union to agree, which is complicated. John clarified again that what he will present today has nothing to do with beReal.

John Voorhee's Presentation on EPA versus EU 13240 Emission Results:

- In response to a request from John Crouch that John Voorhees introduce himself again to the O/F workgroup, John noted that he has worked in the hearth industry for 18 years. He worked in labs for 15 years, including with Intertek, and was involved in hearth products and testing for all those 15 years. Since 2014, John has been the director of product development at U.S. Stove Company.

- John Voorhees began his presentation entitled "EPA vs EU 13240". These slides are posted to Basecamp. John noted that all testing results he will be showing were performed by ISO accredited /notified body labs. Furthermore, all the stoves were certified to EPA's standard before being tested in EU/UK Labs. The Din+ Method comprises 3 runs which are averaged. PD 6434 comprises 5 runs on high that are averaged and 5 runs on low that are averaged.

- John noted that Birch or Beech is burned in the UK and Europe, although everything he saw used for fuel was Beech. John showed a slide with a photo of Beech showing half of the bark off. John noted that most cord wood used in Europe has bark still attached because Birch and Beech wood tend to keep bark. All tests [discussed in his presentation] used wood with bark still on.

- Regarding a slide entitled fuel weight comparison, John noted that it shows the different fuel weights used for the emission testing under EPA, EU and ASTM, as well as the volumes used. Three models are shown – A, B, C – and John noted that the B and C models are the same firebox with merely exterior cosmetic differences. John explained that the European testing Din+ uses a [fuel weight] figure related to how the manufacturer decides to rate the stove in kilowatts and has nothing to do with the actual size of the firebox. John further explained that the two ASTM numbers shown (6.59/7.91 kg) are different because one is for the high burn and the other one is for the medium and low burn. Regarding the European fuel weight, John again noted that because the manufacturer can declare what the heat output of the stove is, the weights for models B (2.23 kg) and C (1.32 kg) are different. The European testing can use different weights of fuel in the same firebox, because they may be rated at different kilowatts.

- Regarding the test results slide, John noted that he didn't know the formula for conversion, but the results are in g/hr under EPA testing and in mg/m^3 under the EU Din+ testing. The UK method results are in g/hr with two different emission results – one g/hr result for high burn and one g/hr for low burn. Rick Curkeet noted he had looked at the numbers and converted them, but needed to know the burn rate and efficiency and what standard was used for the oxygen in the flue gas (13%) for the 2 kg/hr burn rate. Rick estimated that the converted results were 0.48, 0.51 and 0.86 g/hr under Din+.

- Regarding the Highlights of EU Testing slide, John noted that 8", 10" or 12" long pieces were used depending on the size of firebox – that is, sometimes longer pieces are used in longer fireboxes. However, the weight of the fuel is based entirely on the rating (kW output) of the stove, not on the dimensions of the firebox. John noted that all the testing is done at "nominal" air settings and there is no minimum burn requirement under European testing. For example, one stove can burn at 1.5 kg/hr while another stove may only go down to 2 kg/hr. John further noted that under the UK method, the minimum burn rate must be set at whatever the manufacturer requires.

- Lisa noted that for the British/UK method, while there is no requirement to burn at x kg/hr burn rate, testing must be performed at the lowest burn rate the manufacturer plans to sell the stove at. John agreed this was correct, noting that consumers can't set the stove lower and this prevents smoldering.

- John continued, noting that the moisture content of the EU fuel must be 16% ± 4% vs. EPA crib fuel must have a moisture content in the range of 19-25%. The moisture content for the ASTM Cordwood Method is 19-25%. All the testing John witnessed used Beech as the fuel species, although they can also use Birch and possibly a third species. Beech is readily available. The Din+ is a partial cycle sampling method (they sample during the optimal part of the burn, but not during the full cycle) while EPA sampling is full cycle sampling.

- Regarding the Highlights of UK testing, 10 tests are performed (5 high burn and 5 low burn tests). Sampling is with an electrostatic particle precipitator in the exhaust stream at the exit from the chimney. No minimum burn rate is required. Fuel moisture is the same as Din+. John noted that most of the fuel was in the 12-14% moisture content (dry basis) range.

- John concluded his presentation, noting that it was short and sweet, but he wanted people to have a general sense of the differences between the methods.

- John Crouch noted that the UK does not use a dilution tunnel, but is rather just dealing with the exhaust stream as-is. The Norwegians, however, do use a dilution tunnel. John Voorhees agreed this was the case, noting that the fueling protocol is similar to USA's crib method except that the manufacturer can declare the minimum burn rate for their stove. John explained that there are 2 different steps regarding the minimum burn rate, which can go down to 1.15 kg/hr.

- John Crouch noted that there is also a difference in terms of fuel length and asked John Voorhees to explain for the group what it would be here [in the US]. John Voorhees noted that for the [US] crib method, 5/6th the length of firebox is the optimally prescribed fuel length and 7 lb/cubic ft. Therefore, John noted, it's customized to the stove in the US. In Europe, the fuel length is based on the manufacturer's recommendations. John explained that in Europe, the manufacturer can classify the stove as "intermittent" or "continuous", depending on the length of the burn in the stove. For a continuous rating, the stove must burn more than 4 hours on one fuel load. However, John noted that 95% of stoves that he has seen are rated as intermittent. Intermittent stoves must burn at least 45 minutes on one fuel load, although most burn for an hour or 1.5 hours at a nominal setting.

- Lisa Rector asked who decides what species is used in the certification test. John Voorhees replied that EN 13240 specifies the testing fuel as either Birch, Beech or maybe a third species (which John will look up). Among those 2 or 3 choices, John noted that the lab chooses the species based on what the lab has available to burn. John noted that he would send out an e-mail confirming what the third permissible species is for certification testing under EN 13240.

- Lisa Herschberger asked if organics are collected/measured or just dust [particulate]. John Voorhees replied that organics and NOx are collected/reported but not regulated. CO, CO_2, and OGC (as a general organics percentage) are reported, but not broken down further [according to specific organics]. Lisa Rector noted that some countries do regulate those different pollutants, but that's a patchwork. John Voorhees agreed it was a large, widely-varying patchwork [regarding European regulations]. Different [European] countries require different pollutants [to be regulated and reported], different efficiencies, and different CO [allowances]. Lisa asked John if he could provide numbers for all pollutants listed on the test results and provide g/hr at each burn rate. John said he could and would speak with Rick Curkeet to obtain those numbers. Lisa asked if John could provide the other parameters measured and John said he would, that there were no secrets. John noted that he can provide the CO numbers, will look for data on organics and will provide whatever values he has.

- Lisa Herschberger asked if these were the only stoves he had data on and John confirmed that these were the only stoves that the manufacturers provided John data for. John noted that it's possible that he may be able to obtain information from other manufacturers. He had reached out to two [originally], but he could reach out to others. John also clarified that he didn't look at stoves tested with the Australian method for this analysis. The Australian method uses wood logs [i.e., it's a cordwood method] and Australia recently updated standards on hearth products, according to John. John noted that therefore the O/F group may want to look at the Australian method as well and further noted that he would love to involve additional manufacturers.

- Lisa Rector noted that in 2009 NESCAUM funded a study that did the converse of the study John Voorhees was presenting – that is, NESCAUM sent a European stove to OMNI and they tested it using EPA M28 and EN 13240 with hot filters, not a dilution tunnel. The results did not come out as expected. John Voorhees noted that too much information was left out of that study (e.g., did they use the correct weight of fuel and were the stoves tested at nominal setting). Lisa Rector offered to dig into the test reports and pull out the information.

- Lisa Rector further noted that she'd like to understand how Europeans regulate – Lisa's understanding is that there isn't a single passing grade, but rather classes. John noted that he has a sheet from the labs showing the specific requirements for each country, including what the passing grade is for that country. However, John further noted that these standards/passing grades are always under discussion regarding what the future requirements will be. Lisa Rector noted that she thought there were different levels of certification for some of the northern European countries.

- John Voorhees noted that there's another European Union program called Ecodesign set to be implemented across Europe in 2022 that does set limitations for CO_2, NOx, CO and efficiency. Ecodesign is more restrictive than EN 13240 and it will be mandated, using EN 13240/16510 test methods, but with stricter requirements. John noted that he would share that information too. John noted that therefore there's beReal and Ecodesign and that he thinks Ecodesign is country-specific (although is not sure).

- Lisa Rector asked if there were any major changes between EN 13240 and EN 16510. John Voorhees replied that EN 16510 harmonizes EN 13229 and EN 13240 with another couple of standards into one standard. There will be EN 16510-1 and 16510-2, etc. John explained that there will likely be some improvements to the methods which will be vetted through the European TC groups. However, John concluded that he is not aware of any huge changes between EN 13240 and EN 16510.

- John Crouch noted that John Voorhees had alluded to a heated filter train. John Voorhees explained that there is no filter train in the UK method, because it's electrostatic. But Din+ uses a heated filter. John further explained that in EPA's M28 the filter temperature can't exceed 90 degrees F in the dilution tunnel, whereas the temperature of the filter in the European method is 180 degrees Celsius because it's a heated filter line and filter. This results in a big difference with regards to condensables. John concluded that the major difference is that the filter temperature can't exceed 90 degrees F in the EPA testing.

- Regarding why the dilution tunnel can't exceed 90 F, Mike Toney noted that it is related to how EPA defines particulate. Mike noted that Stef Johnson had sent out in an e-mail awhile back that there was some discussion of going to 110 degrees, but that was put down. Mike noted that Rick Curkeet says more studies should be done before changing the filter temperature requirement. Mike further noted that John Kinsey has also explained that EPA's definition of particulate is a policy decision [reflected in the filter temperature requirement]. Stef explained that EPA has chosen 85 F as the cutpoint for ambient PM. Therefore, once the stack gas cools to 85 F, the primary particulate [by definition] is formed.

- John Crouch thanked John, Mike and Stef for calling attention to this difference and noted that European stoves have a hard time with EPA M28, as it's more restrictive regarding filter temperature and the minimum burn rate requirement. John opined that the filter temperature [requirement] is a fundamental disconnect. Rick Curkeet noted that it's complicated.

- Lisa Rector noted that the condensable fraction changes with the specific combustion characteristics of each stove [model]. Rick agreed with Lisa, noting that the condensable fraction is related to the temperature and efficiency of the stove, which is why the results are so variable. Rick explained that almost all is condensable with very little as solid. Therefore, as the temperature cools down, liquid droplets start forming that collect in the filter. Rick noted that he was involved in a brief study looking at going to 100 degrees and that the condensation problem disappears completely at 100 F. Rick explained that the study looked at filters run at different temperatures, which were put in the oven and dried to a constant weight to see how much mass was lost.

Approximately 2 to 10% of mass with a boiling point in the 100-degree F range was lost consistently. Rick noted that if the filter was heated to 350F/180C [like European method], huge differences would have been seen.

- Lisa Rector noted that the condensable fraction from larger boilers tested with Methods 201 and 202 is typically 10 to 35%. Lisa further noted that the general rule is: the cleaner the device, the lower the condensable fraction.

- Lisa Rector noted that George Allen from NESCAUM has a TEOM running [during Mark Champion's testing for EPA] and the filter temperature can be changed on that easily to observe differences with different filter temperatures. Lisa explained that George can run a pair of TEOMS – one at 80 C and one at 100 C – and the difference will be seen.

- Lisa Rector further noted that many recognize the shortcomings of the EN 13240 test method, but it's interesting to consider in terms of policy. That is, rather than have the rule set the design parameters, instead the manufacturer declares the stove as intermittent or continuous. John Voorhees agreed, noting it's a marketing decision rather than a technical/design decision. For example, some stoves burn overnight and some don't and this is not dictated by the manufacturer doing something to stove.

- Lisa Rector continued, noting that the question is: do we want a test method to set the design parameters (as the EPA method currently does). Lisa noted that the complementary question is, if this group wants to move away from that, what does EPA think of this change. John Voorhees opined that it would be a plus [to move away from the method setting the design parameters] as it would prevent the consumer from loading a stove with fuel with a high moisture content and letting it smolder. John explained that in Europe the stove cannot be turned down that low, so neither can consumers turn the stove down low there [and allow it to smolder]. John further noted that Europeans also wonder why the EPA test method requires overloading of the stove.

- Regarding what EPA would be open to, Adam noted that it's essentially Stef's decision, in that EPA is open to whatever the data suggests is a good direction. But EPA needs to see data [to support any change]. As an aside, Adam noted that he has been involved in wood burning in Germany and Americans load stoves much higher than Germans do.

- Regarding the test load slide, John Crouch noted that the ASTM level of loading is even higher than M28. In response to a question from John Voorhees, Bob Ferguson clarified that under the ASTM method the lower loading density is for the high burn rate and the higher loading density is for the low and medium burn rates. Bob explained that the rationale for the higher density loading at the lower burn rates is that the low burn rates is to represent an overnight burn. Bob noted that there are different philosophies regarding how stoves are operated in different parts of the world. John Crouch agreed, noting that he just wanted to make it clear that the proposed ASTM method envisions three times as much fuel as the EU method.

- In response to a question from Lisa Herschberger regarding the choice of the manufacturer, John Voorhees explained that in the European method the amount of fuel is dictated by expected efficiency and a lower calorific value of fuel. However, the fuel amount is based on a formula which is dictated by how the manufacturer chooses to rate that stove (e.g., if the manufacturer rates their stove at 5 kilowatts, that rating will drive the fuel calculations in the European method). That rating also plays into [the measured and marketed] efficiency – so it's a double-edged sword, John noted. The test results are different, based on the manufacturer's rating – so the manufacturer chooses the optimal rating and then that dictates the fuel.

- John Barnes (from New York) noted that presumably the user can do whatever they want, however. John Voorhees agreed. John Barnes asked for confirmation that the European method doesn't really monitor what the user does. John Voorhees confirmed that was correct, noting that there are user manual indications about what is optimal and the European standard does dictate that the manufacturer must specify and reveal to the consumer regarding how to operate the stove optimally. This is very clearly called out. John Voorhees thanked everyone for their attention.

- Lisa Rector noted it was a great discussion regarding thinking about pieces that are interesting and would be useful in the US/EPA test method (e.g., loading weight, the stove rating as intermittent versus continuous). These pieces should be captured for future discussions. Lisa noted that the other important point to consider is does/should the test method design the stove or not. John Crouch noted that filter temperature is another aspect the O/F group needs to think about. John noted that the first-time people witness the European method, they invariably mention the heated filters. John further noted that the stakeholders have lived with this filter temperature limit for 30 years, so it boggles the mind to see these hotter filter temperatures.

- Lisa Rector noted that the PM Measurement Workgroup does have a recommendation as to filter temperature, but perhaps it'd be helpful to determine what this O/F Workgroup would specify regarding filter temperature. Lisa noted that she can see the issue in terms of comparing test results, to get results equivalent to dilution tunnel results, noting that it is unknown if the conversion is correct. John Crouch agreed this was the bottom line.

- Lisa Rector noted that it may be helpful to review Christoph's results from where they ran a dilution tunnel and a hot filter. Lisa further noted that there's also a good paper on this by Thomas Nitzbaumer (spelling?) that Lisa can post to Basecamp regarding temperature and PM. John Crouch agreed that it was a good idea to post the paper and asked if anyone had any last questions.

- Lisa Herschberger asked if anyone wanted to share the rationale for using an older stove to compare emissions from different species [under the current EPA-funded testing]. Specifically, Lisa wondered how the data from the older stove would transfer to newer catalytic and non-catalytic stoves. Stef noted that it was not possible to make assumptions about how the data would translate under different control technologies. Lisa asked if EPA went to a pre-NSPS stove to capture differences in emissions, as if from a campfire, without other variables [such as control technology] affecting the emissions too much. Stef confirmed this was the rationale – that is, the

goal of the experimental design was to avoid the control technology changing/impacting the species testing/emissions.

- John Crouch noted that the EPA testing sounds like original baseline work and he noted he was glad EPA was doing it. The funds weren't available in the 80s to do such baseline work in support of the Oregon method, according to John.

- Stef noted that there isn't a "magic bullet species" that exists everywhere [and is allowed to be shipped to labs across the country]. Therefore, the effect of species [on emissions and burn rates] needs to be determined.

- John Crouch and Lisa noted that there will be an optional tutorial on M28 during the next meeting of the O/F Workgroup on November 17th. Then there will be a full/mandatory meeting on December 15th with hard recent data to look at on that date. John noted that several people will gather on December 1st in Albany and lab or industry people can contact John Crouch with questions.

- Lisa thanked everyone for participating, noting it was a good call today.

- **Meeting adjourned.**

EPA Notes 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.**

EPA Notes Operation and Fueling (O/F) Workgroup Meeting Notes from December 15, 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:

- Lisa Rector gave an overview of the survey results which asked workgroup members to rank list operation and fueling topics for discussion by the group. It was noted that all respondents from labs, industry and consultants wanted to discuss fueling protocols first, while the majority of SLT and federal regulator/agency personnel wanted to discuss operational procedures first. Nonetheless, it was agreed that the topics are inter-related and circling back between operational and fueling issues will likely be necessary.

- Mark Champion gave an overview of his testing for EPA into the effect of wood species on primarily PM emissions and burn rate. Crib testing on 6 different species – Douglas Fir, Red Oak, White Pine, White Birch, Red Maple and Ash – has been performed in a pre-NSPS stove (with little to no control technology) at both low and high burn rates. PM factor (g/kg) is a function of burn rate (kg/hr) and a linear regression appears to correlate very well for PM factor versus burn rate for the species testing, while PM rate (g/hr) versus burn rate is likely to be fit best with a curve rather than linearly. Cordwood testing on several of the 6 species tested as crib wood will likely begin in January. Definitive conclusions have not yet been drawn from the data, although workgroup member expressed interest in understanding the big picture conclusions that may be drawn from this species testing.

- Regarding results from Mark's/EPA's testing, it was noted that it would be helpful for the data to show the length of the burn (due to the importance of the charcoal tail in determining the g/hr PM emission metric). It was also noted that it would be helpful for narrative portions of the results' write-up to discuss why Mark and EPA made the choices that they did for the experimental design.

- Bob Ferguson presented a condensed chronology regarding the wood stove testing Mark Champion performed for the ASTM Task Group (TG) in 2014 and 2015. This testing was meant to inform ASTM's cordwood method development and allow the TG to move past discussion to actual data and observations. Bob's summary memo follows these notes and is also posted to Basecamp.

To-Do List:

- Lisa Rector or Mark Champion will post Mark's data from EPA's crib species testing to Basecamp, once Mark has finished his QA review. George Allen will post his TEOM data to Basecamp taken during Mark's EPA species testing.
- Workgroup members should review George's TEOM data along with Mark's spreadsheet data and write down any questions. Workgroup members are also encouraged to slice and dice the data in different ways and suggest their own analysis to the group.
- Workgroup members should review the ASTM graphs posted to Basecamp along with Bob's memo and write down questions for the next January meeting.
- Lisa Rector will confirm with workgroup members via e-mail that January 12th and 26th work for January O/F workgroup meeting dates.

Highlights from Meeting:

- Lisa Rector opened the meeting noting that Adam Baumgart-Getz and Amanda Aldridge could not join today's call, and Stef Johnson and Mike Toney may not be able to join either. John Crouch noted that Gregg Achman could also not join.

- Lisa Rector noted that the following people were in attendance: Bob Lebens, Mark Champion, John Voorhees, Lisa Herschberger, Randy Orr, Rick Curkeet, Rod Tinnemore, George Allen, John Barnes, Bob Ferguson, John Wakefield, Dan Henry, Ben Myron, Cindy Heil, Rebecca Trojanowski and Tom Morrissey, as well as others who did not announce themselves.

- Regarding the agenda, Lisa noted that this is the only call for December and the next currently-scheduled call is during a NESCAUM Board of Directors meeting on Thursday January 5th. (Note that alternative meeting dates of January 12th and 26th were discussed later in the meeting, as summarized at the end of the notes.) Lisa noted that today's meeting will be a review of survey results and then Mark Champion will present data from his testing done as part of an EPA research effort into wood species.

- John Crouch announced that during today's meeting Bob Ferguson will also walk the group through Mark Champion's work for HPBA over the course of 10 months, as agreed upon in Albany. Bob prepared a summary that is posted to Basecamp (memorandum regarding "Testing conducted to support ASTM cordwood test method development") and Bob will present it today, after Mark's presentation. Bob Ferguson noted that he will post all 5 original ASTM cordwood reports to Basecamp. Lisa Hershberger mentioned that there are 5 summary reports posted to Basecamp. Lisa Rector will put them in the correct folder.

Lisa Rector's review of Survey Results from Rank Listing of Operation and Fueling Topics:

- Lisa thanked everyone for completing the Survey Monkey she sent around regarding listing and ranking the fueling and operational topics the O/F workgroup needs to discuss.

- Lisa noted that Question #1 (Q1) asked the group: should we discuss fuel or operational procedures first? Lisa explained that slightly more respondents wanted to discuss fueling issues/protocols before operational procedures. However, when Lisa looked behind the data to see what group answered how, she noted that all respondents from labs, industry and consultants wanted to discuss fueling protocols first, while the majority of SLT and federal regulator/agency personnel wanted to discuss operational procedures first. Lisa noted that it might be helpful to understand why the two groups had differing perspectives. Lisa offered that she voted for operational protocol first because she thought a lot of fuel questions would follow operational protocol. For example, if it's decided that the operational protocol involve high, low and steady state phased on an existing coal bed (like M28's protocol) then discussing fuel first makes sense. But if, on the other hand, the workgroup is thinking about an integrated run as in the ASTM or beReal protocols, then that would require a different thought process on fuel. Lisa continued that therefore, the operational protocol would guide the fuel discussion in some ways, in order to ensure the fuel could accomplish that operational protocol. But Lisa noted that this is a chicken or egg question in some ways.

- John Crouch asked labs to chime in. Bob Ferguson said the fueling and operational topics are intertwined and the workgroup will have to circle around more than once, no matter which topics the group starts with. Bob noted that he personally does not have an issue with starting the discussion with operational topics. However, Bob further noted that dealing with and managing fuel is such a big part of what testers have to deal with on a daily basis, that it makes sense [to labs and industry] to deal with fueling first.

- Cindy Heil explained that she voted for operational issues to be discussed first because we haven't gotten EPA results from species testing yet. Therefore, it seemed most efficient timing-wise, in Cindy's opinion, to move forward on operational issues while and until the species results come in. Rod Tinnemore agreed with Cindy, noting that he'd like to see the EPA/Champion species results. However, Rod noted that he too is fine with starting on either topic first.

- Lisa Rector suggested that she go through the survey results with the workgroup and then come back to these questions after Mark and Bob give their presentations, noting that people may feel differently after seeing some results of EPA's work.

- Regarding Q2 on the survey "Please order the fueling elements to determine which items we should develop recommendations", the following order of importance was given by respondents: fuel species, fuel characteristics, fuel load weight and fuel loading protocol. Lisa noted that Q2 responses did not have an obvious split between lab/industry and regulatory/agency respondents, as Q1 had had.

- Regarding other fueling issues, respondents commented that:
    - The test should not prescribe a generally clean/low emission species. It should be either a higher emissions species, or both a high and low, with shorter tests and more repetitions.
    - Fuel load volume is related to fuel load weight. Some folks have reported issues getting the load to fit in the stove using the draft ASTM cordwood method.
    - Compare with the ASTM cordwood fueling protocol to see if we are missing something important.
    - You will have to discuss fueling first because what you decide to do in terms of fueling will then determine how the stove will be operated.
    - Three additional issues: species versus specific gravity, practicality, lab costs

- Lisa noted that the research items in the list are useful. Bob Ferguson had given Lisa a long list to incorporate and Lisa thanked Bob for that list. Bob noted he would like to speak with Lisa about the list before it's shared more widely [as it's in draft form].

- Regarding Q4 "Please order the operational elements to determine which items we should develop recommendations", survey results revealed the order to be as follows:
    - What is the test run cycle;
    - Appliance adjustments;
    - Appliance requirements.

  Lisa noted that Q4 responses did not have an obvious split between lab/industry and regulatory/agency respondents.

- Other operational issues noted include:
    - I think the group/process should make every effort to significantly shorten the testing time for individual tests so that more repetitions can be performed.
    - Explore the application of the procedure to the many emerging designs, e.g., automated stoves, twin-chamber stoves, new designs.
    - End of test marker.
    - Efficiency testing.

- Lisa noted that she wanted the workgroup to think about the fueling and operational issues not as an either or, but rather discuss [for example] what the test run would look like and then go to fuel and volume and then flip back into operational questions. Lisa further noted that she agrees with Bob Ferguson that the two items are linked and so separating them may not make sense. Rather, Lisa suggests that trying to understand what issues flow into each other may be a better approach.

Mark Champion's Presentation regarding EPA species testing:

- Mark Champion began giving his presentation regarding his testing for EPA's initial species characterization in a pre-NSPS stove. Regarding discussion of data, Mark clarified for John Crouch that the QA/QC plan is in place and Jill Mozier confirmed that the QAPP is signed.

- Mark noted he's finishing up the first phase of burning 6 species of crib wood in a 1979 pre-NSPS Vermont Castings stove. Mark explained that the stove is 3 cubic feet and is very old technology which is geared towards efficiency not emissions; so there is very little emissions control in this stove. John Crouch pointed out that this stove (the Vigilant) was used nationwide all the way to Alaska and all over north America.

- Lisa Rector ensured that everyone understood the rationale of using a pre-NSPS stove [to avoid control technology introducing another variable and potentially complicating the effect of species]. Lisa noted that in terms of trying to characterize the impact of moving from one species to another, the research didn't want to introduce the variable of how well the stove controlled emissions. It was deemed important that the stove not interfere [or interfere as little as possible with the results]. Lisa also pointed out that the results are not looking at the g/hr values for PM, but rather the results are looking for percentage differences [in PM emissions] from species to species. Mark noted that this research is not intended to evaluate the stove, but rather to compare the species. The stove is just a vessel to burn wood. To clarify, Lisa noted that they could have used a campfire for this species research, were that deemed safe enough by EPA.

- Mark presented a table showing the specific gravity results. For each species, samples were cut from dimensional 4x4 crib stock and all block samples were from the same tree for each species. Mark calculated the average specific gravity for each species based on 4 measurements. The average measured specific gravity for the species were as follows:
    - Douglas fir: 0.47
    - Red Oak: 0.69
    - White Pine: 0.33
    - Red Maple: 0.50
    - White Birch: 0.52
    - Ash: 0.58

  Mark noted that the specific gravity for Maple, Birch and Douglas fir were all around 0.5. Mark showed a photo of the 4x4s blocks used for taking specific gravity measurements (4 blocks for each species), noting that he first ensured they were all down to the proper moisture content.

- Mark showed a photo of the cordwood and dimensional lumber, noting that the moisture content goal was 20% and that was achieved for all samples. Mark also noted that for Maple, Birch and Ash the cordwood came from the same tree as the dimensional lumber.

- Mark showed a photo of a typical crib load, noting that it was Method 28-inspired but not M28-compliant, due to stove dimension limitations. Mark noted that this crib was placed on a coal bed formed per M28 using 2x4s of the same species. Some modifications to M28 were used because the Vigilant stove was not designed to burn per M28 and therefore run-away fires could have resulted, and on the other hand some fires went out.

- Lisa Herschberger asked if testing was done on cordwood in addition to crib. Mark explained that only crib testing had been done to-date, that he may do a few repeat tests or gap fillers on crib, and then cordwood burning/testing is next. Mark noted that Adam invites comments and

suggestions from the O/F workgroup. All data will be available in a spreadsheet. Lisa Rector further clarified that there will be cordwood testing, but testing had to start with crib since the current test method is based on crib. Therefore, the idea was to first see species changes in crib and then move onto cordwood. Lisa noted that Stef Johnson had recommended moving in this way with the testing. Mark agreed that cordwood testing would proceed soon.

- Mark showed the following spreadsheet which includes the 5 tests on crib from each of the 6 species (although there were 7 tests on Douglas fir to tune the method and to vary and examine the crib piece length of the wood load). Mark noted that for all other species there were 2 low and 3 high fire/burn tests and that real-time data was collected for numerous parameters including PM, CO, burn rate, stack gas, draft, temperature and load weight.

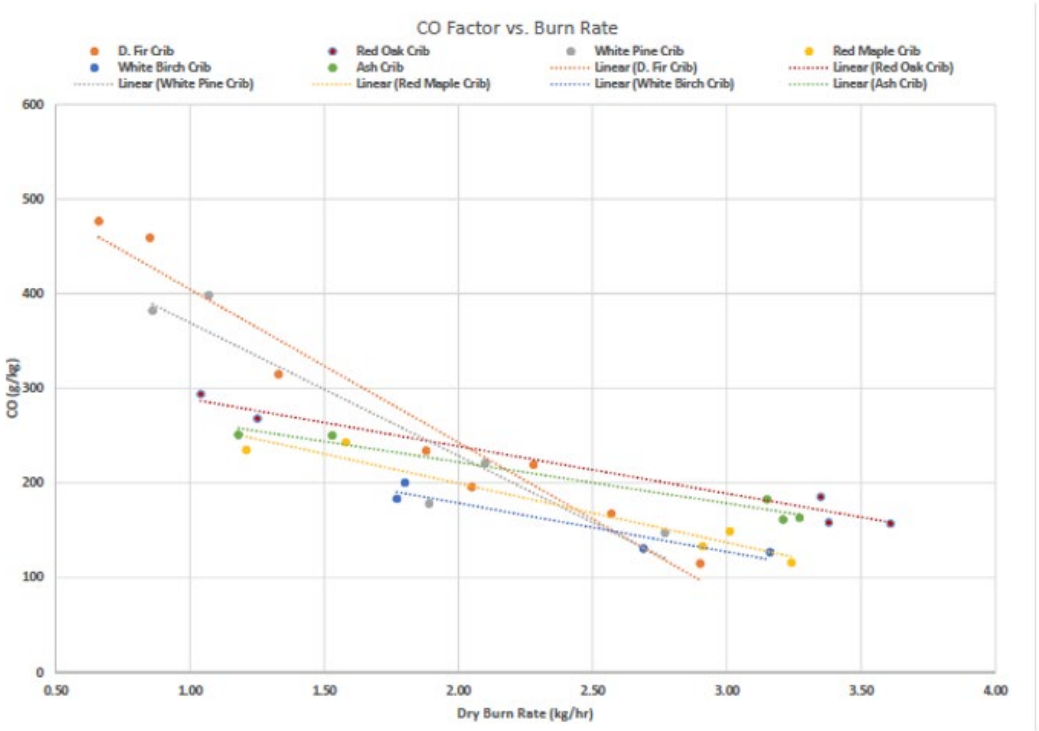
File	Fuel	Test Setting	PM, g/hr	PM, g/kg	CO, g/kg	Burn Rate, dry kg/hr	Train 1 time 0 front catch, mg	Train 2 time 0 front catch, mg	Final PM Precision, %
Vig1608161	D. fir crib	high	27.7	13.5	196	2.05			
Vig1608211	D. fir crib	high	33.4	17.8	234	1.88	54.1	53.9	1.4
Vig1608231	D. fir crib	high	29.5	11.5	168	2.57	34.1	34.2	0.3
Vig1608251	D. fir crib	high	35.1	15.4	220	2.28	33.8	34.8	1.9
Vig1608271	D. fir crib	Low	24.4	28.6	459	0.85	54.4	56.6	0.0
VigOak1608311	Red oak crib	high	37.4	11.2	186	3.35	29.0	28.2	2.6
VigOak1609011	Red oak crib	high	30.1	8.4	158	3.61	21.1	21.0	0.1
Vig1609031	D. fir crib	low	38.1	28.6	315	1.33	66.8	63.4	3.8
Vig1609101	D. fir crib	high	21.0	7.3	115	2.90	17.2	17.5	0.4
Vig1609201	D. fir crib	low	20.6	31.3	477	0.66	44.3	44.2	3.4
VigOak1609211	Red oak crib	high	28.3	8.4	159	3.38	21.3	21.6	1.9
VigOak1609221	Red oak crib	low	36.0	34.5	294	1.04	68.6	67.9	3.7
VigOak1609271	Red oak crib	low	46.5	37.2	268	1.25	106.5	104.4	0.7
VigWPine1610151	White Pine crib	high	32.2	11.6	148	2.77	17.1	17.1	3.0
VigWPine1610152	White Pine crib	high	43.8	20.9	222	2.10	34.3	32.9	0.9
VigWPine1610161	White Pine crib	low	47.1	54.6	382	0.86	92.2	90.4	0.8
VigWPine1610181	White Pine crib	low	58.7	54.8	399	1.07	88.5	86.8	0.8
VigWPine1610211	White Pine crib	high	29.8	15.8	179	1.89	25.0	23.9	2.8
VigMaple1610301	Red Maple Crib	high	34.7	11.6	149	3.01	26.4	25.9	0.1
VigMaple1610302	Red Maple Crib	high	24.2	7.5	116	3.24	16.6	16.2	1.2
VigMaple1610311	Red Maple Crib	low	52.1	43.1	235	1.21	99.6	98.1	0.3
VigWBirch1611031	White Birch Crib	high	36.5	13.6	131	2.69	32.9	31.7	0.4
VigWBirch1611051	White Birch Crib	low	55.1	30.7	201	1.80	78.3	73.3	3.7
VigMaple1611061	Red Maple Crib	low	61.9	39.3	243	1.58	91.8	91.8	0.4
VigWBirch1611071	White Birch Crib	high	23.0	7.3	127	3.16	15.5	15.6	1.4
VigMaple1611151	Red Maple Crib	high	18.8	6.4	134	2.91	13.6	13.6	2.5
VigAsh1611161	Ash Crib	high	27.7	8.6	162	3.21	21.7	21.5	2.8
VigAsh1611171	Ash Crib	high	26.0	8.3	183	3.15	19.8	20.1	0.5
VigAsh1611191	Ash Crib	low	59.5	38.9	251	1.53	106.1	108.6	1.4
VigWBirch1611201	White Birch Crib	low	42.4	23.9	184	1.77	56.2	56.8	0.7
VigWBirch1611221	White Birch Crib	high	19.6	6.3	113	3.08	14.5	14.3	0.4
VigAsh1611261	Ash Crib	low	49.5	41.8	252	1.18	106.2	106.7	0.4
VigAsh1611301	Ash Crib	high	19.8	6.1	164	3.27	14.6	14.8	0.4

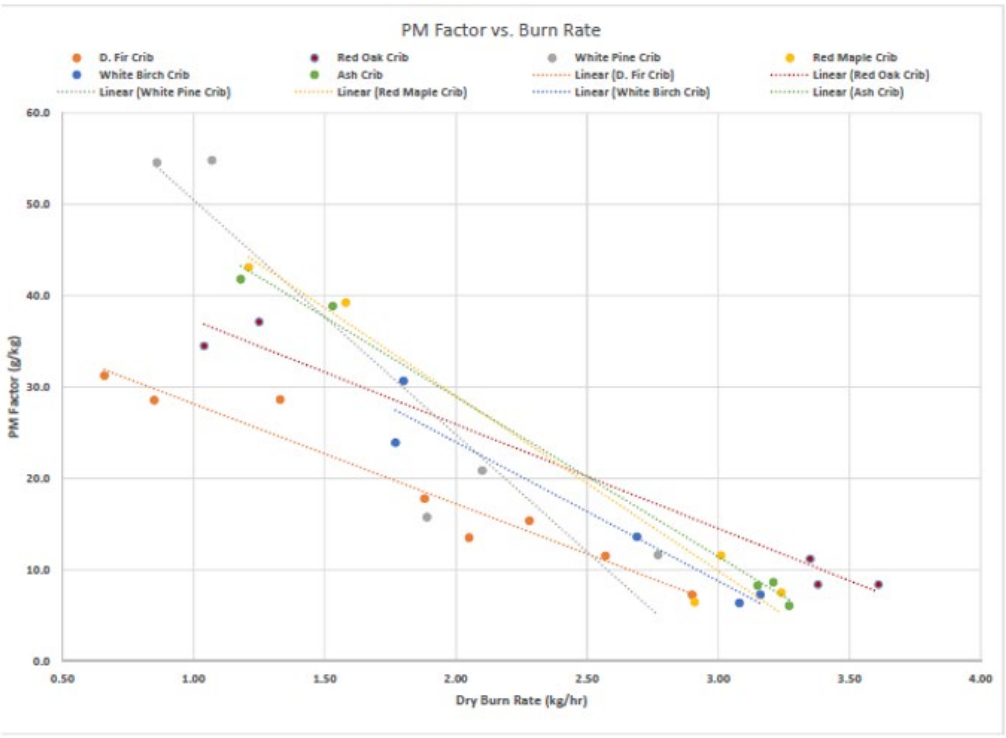
- Mark then displayed several graphs/plots of the data (shown below) for: CO Factor (g/kg) versus Dry Burn Rate (kg/hr); PM Factor (g/kg) versus Dry Burn Rate; PM Factor versus Normalized Load Mass or Normalized Dry Burn Rate (kg/hr); and PM Rate (g/hr) versus Dry Burn Rate.

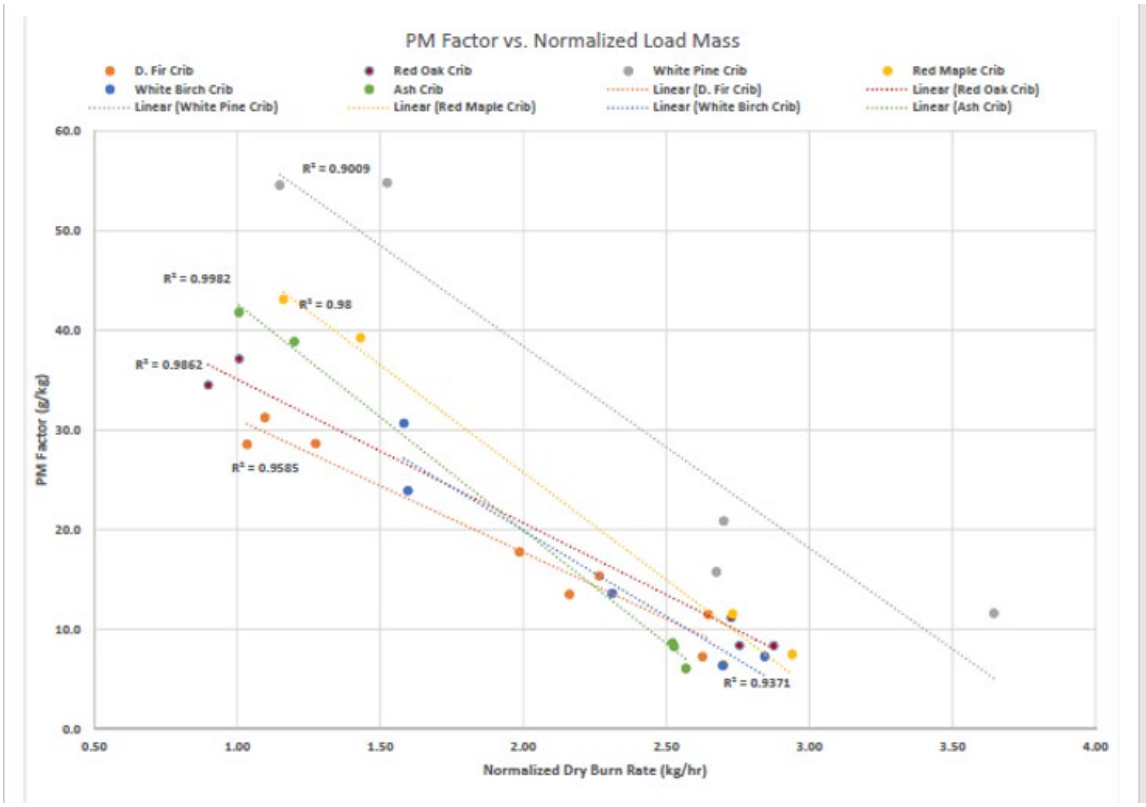
- Mark explained that to the left of the 2 kg/hr dry burn rate was essentially the fixed low burn setting and to the right of 2 kg/hr was the fixed high burn setting. Mark pointed out that the graphs underscore there was a range of burn rates even at the same setting of the stove. Reproducibility appeared to vary as well – for example, Mark noted that the graph suggests that Ash has reproducible burn rates but the burn rates on Douglas fir were not so reproducible.

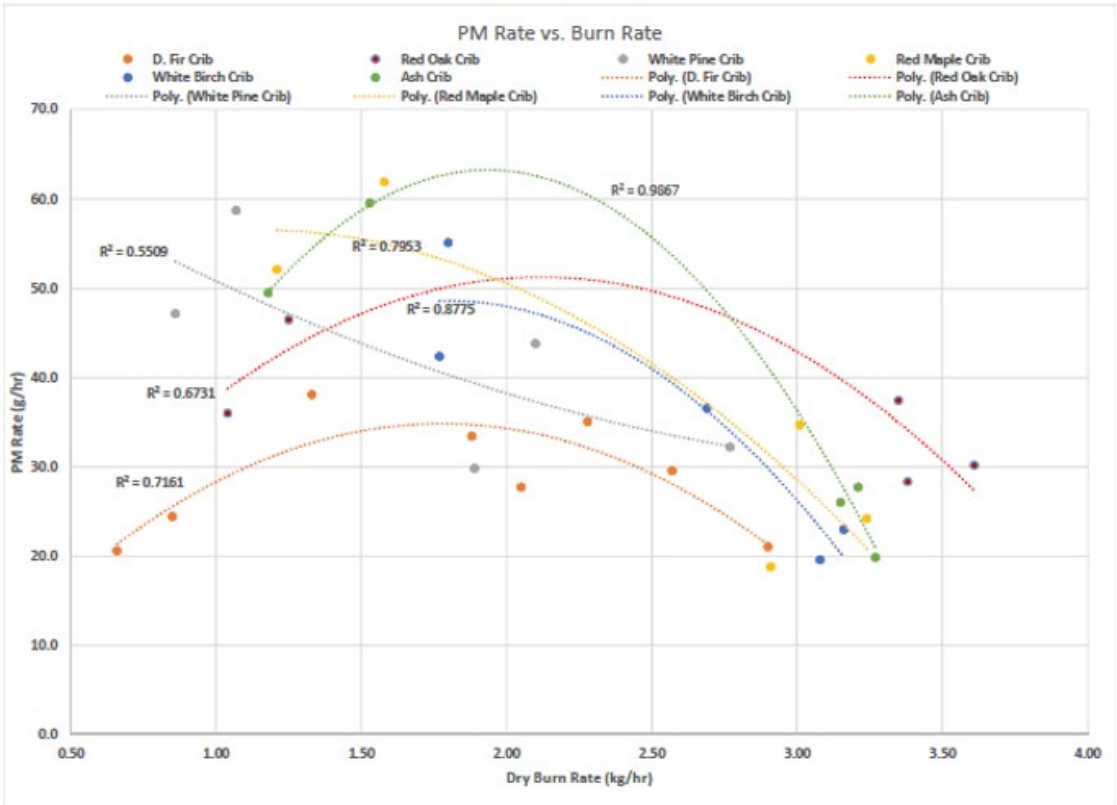
- Regarding PM factor versus burn rate (with regression lines drawn), Mark noted there was pretty good correlation. However, there was variation of burn rates even at the same high setting. Mark therefore attempted to normalize each load to the weight of a Douglas fir load. Mark explained

that, due to the higher density of Red Oak for example, there is 60% more wood in the same volume load [when comparing Red Oak to less dense species like Douglas fir]. Therefore, with this extra wood, a higher burn rate is expected. Normalizing to the weight of a Douglas fir load was meant to account somewhat for the variation in load weight/density, although Mark noted that he's not certain the normalization is entirely appropriate or helpful.






PM Factor vs. Normalized Load Mass
D. Fir Crib
Red Oak Crib
White Pine Crib
Red Maple Crib
White Birch Crib
Ash Crib
Linear (D. Fir Crib)
Linear (Red Oak Crib)
Linear (White Pine Crib)
Linear (Red Maple Crib)
Linear (White Birch Crib)
Linear (Ash Crib)
R² = 0.9009
R² = 0.9982
R² = 0.98
R² = 0.9862
R² = 0.9585
R² = 0.9371
PM Factor (g/kg)
Normalized Dry Burn Rate (kg/hr)


PM Rate vs. Burn Rate
D. Fir Crib
Red Oak Crib
White Pine Crib
Red Maple Crib
White Birch Crib
Ash Crib
Poly. (D. Fir Crib)
Poly. (Red Oak Crib)
Poly. (White Pine Crib)
Poly. (Red Maple Crib)
Poly. (White Birch Crib)
Poly. (Ash Crib)
R² = 0.9867
R² = 0.5509
R² = 0.7953
R² = 0.8775
R² = 0.6731
R² = 0.7161
PM Rate (g/hr)
Dry Burn Rate (kg/hr)

- Lisa Herschberger asked Mark to explain more how the data was normalized. Mark explained that he took the 4.5 kg load of a Douglas fir load and divided that by the actual load [for each and every test run] and then multiplied by burn rate. This effectively adjusted the burn rate for graphical reasons. Mark noted that, in effect, the higher density fuels get burn rates adjusted down and the lower density fuels get burn rates adjusted upwards.

- John Crouch noted that [this normalization] allows comparison of the crib woods by accounting for the fact that more energy is going into the stove with Red Oak with the same volume compared to Douglas fir. John further noted that he likes the effort to normalize to account for different amounts of energy. Mark clarified that one rationale is to give credit to those higher density fuels for giving more heat with time. On other hand, Mark noted that some homeowners may turn the stove down to lower the heat output [from higher density wood fuels]. Mark concluded that the normalization is primarily another angle to view the species question from.

- Regarding the PM rate versus Burn rate graph, Mark noted that he added the curves and that [the data regression] gets messy here. Mark explained that the PM rate graphs look very different than the PM factor graph since PM factor is a function of burn rate, while PM rate is related to the stove/appliance. Mark noted that these curves are not proven and further noted that the experimental design group is discussing possibly filling in middle data points, which may help prove or disprove the characterization [curves] as shown here.

- Mark concluded his presentation, noting that he needs to do a final run-through of the data. For example, Mark had instituted a self-imposed QA trigger for precision and for 3 test runs Mark needs to further QA the results to ensure the results are good.

- John Barnes asked why the curve for White Pine is concave [on the PM rate vs Burn rate graph, while all the other species appear to have convex curves]? Mark replied that the White Pine burned erratically with a poor coal bed, noting that it can't be explained beyond noting that White Pine was not a nice fuel to burn on high or low. Mark concluded that this could be caused by the variation in the coal bed, but the reason(s) can't be known with certainty.

- Lisa Rector asked why [the PM rate vs burn rate] graph uses curves rather than straight line regressions. Mark replied that there's better correlation with the curve than with a linear fit. Mark also noted that he sees it [the curve] in the data and further noted that one can argue that g/hr should go to 0 as burn rate goes to 0. Bob Ferguson remarked that part of the problem is that time [hours] is in both variables [both burn rate and PM rate]. Bob noted that this is reminiscent of Oregon presenting data 30 years ago using curves; there is no reason to expect any straight lines. The g/kg had good R^2 but one stove had a good emission profile at low burns but not at high burns. There are a variety of factors that can explain what was going on in any given stove. The g/hr [PM rate] versus kg/hr [burn rate] have often been represented by curves.

- Mark noted that he could come up with physics that drive the curve(s) in this old [Vigilant] stove. In new stoves, the technology would drive those curves. Mark further noted that while this stove is not a campfire, there is very little technology.

- George Allen noted that it was striking on the lower left portion [of the PM rate graph] that the two Douglas fir low burn rates are some of the cleanest overall, even regardless of burn rates. George noted that he hasn't burned wood before, but he was surprised to see that Douglas fir in g/hr burns as clean at the low burn rate as on the high burn rate. George asked if this was surprising to anyone else. Mark noted that the result is not a surprise but it is a hard to explain mechanism. Mark further noted that those two data points actually line up on the g/kg chart. Bob Ferguson explained that the rate is affected by the device itself and how wood is burning. If the wood is burning slow and the draft goes away, this results in a low g/hr even though the g/kg [may not be as low]. Mark confirmed that the low burn rate data points occurred with very long tails. Bob Ferguson explained that therefore the emissions get cut in half, since time [hour] is a variable in both [the PM rate and burn rate]. John Crouch suggested that in those cases the fire just didn't go out and was burning for a long time [long tail]. John noted that this means the denominator in hours goes up, which drives down the g/hr [PM rate] metric. Mark agreed.

- Lisa Rector noted that it would be helpful to see total burn time in the table. Mark said he could show that. Lisa pointed out for the workgroup that the definition of the end of the test for Mark's EPA testing was burning 95% of the wood load (not 100%) or no scale change for 15 minutes. Mark confirmed this was the definition of the end of the test used and noted that only 2 or 3 test runs stopped because the fire went out or the weight loss criteria was met.

- Bob Ferguson noted that these results emphasize the need to look at data in a g/kg basis. Bob noted that one needs to understand what's happening on g/kg basis before adding in the additional variable of test length. Very different conclusions might be drawn by looking at g/hr versus g/kg. Lisa Rector replied to Bob that she agrees that looking at g/kg is important, but the current metric is g/hr – therefore, both g/kg and g/hr information are needed. Lisa noted that each crib had a different weight and this needs to be look at/considered as well as burn time, since the g/hr is directly affected by the charcoal tail. Mark cautioned care, as some of these results are specific to this stove. Mark noted that he agreed with Bob and that one needs to look at the nature of the wood burning [in g/kg] as that reveals more in this stove.

- Rod Tinnemore asked what was the big picture that this data reveals and asked Mark for his conclusions. Mark replied that he hadn't come to any conclusions, that this data is being generated for EPA, but no conclusions have been drawn yet. Rod noted that the data seems to be confirming some of the variability inherent to solid fuel, but it's hard to see definitive conclusions.

- Rick Curkeet remarked that, if he understands this correctly, it's an experiment on the effect of species on emission rate, with the null hypothesis being that species doesn't matter. Rick noted therefore that the question is, does this prove the null hypothesis incorrect? Rick said the good thing is that the g/kg looks linear for all species – that is, that the emission factors are directly related to burn rate for all species. Furthermore, the slopes are similar – there is not a big difference and the White Pine outlier may be a true outlier, depending on statistical testing.

- Lisa Rector noted that she wanted to remind the workgroup that this data is only based on crib wood testing. Testing hasn't proceeded yet to cordwood.

- Rod Tinnemore noted that he wanted to get to the big picture/conclusions, since not everyone has the capacity to look at big tables of data and interpret them [correctly].

- John Crouch remarked that Rod is segueing the discussion to older data that is cordwood. John further noted that this is good to normalize crib and get this in record for all time.

- Bob Lebens remarked that this information is useful, noting to Mark that it would be helpful to understand why Mark [and EPA] made the choices that they did [for the experimental design] in the narrative portions of the result's write-up. Mark noted that could be done and again noted to the workgroup that Adam is welcoming discussion and comments and these suggestions should be made to Adam.

- Lisa Rector asked if a report will be written up. Mark noted that there would be a report about the results, although he is not sure if it will include analysis. Mark noted that he is not in a position to do analysis, that it is up to larger groups to analyze and conclude. Mark noted that he is shying away from analysis. Lisa noted that she primarily wanted to temper expectations – that is, that a report is not being prepared which will provide analysis. Lisa concluded that this might be a question to ask Adam when he's on the line.

- Mark explained that the reason for linear regression is that PM factor (g/kg) is a function of burn rate and the linear regression correlates very well for PM factor. The data demonstrates the clear linear relationship, although it needs to be statistically validated still.

- Lisa Rector noted that she looks forward to seeing Mark's data posted to Basecamp. Lisa noted that another question for Adam is what's the time frame for asking questions and finding out what other information/data people would like to see. Lisa suggested that people perhaps comment on Mark's data by the next meeting in January. Mark noted he needed to do a final quality review, which would just take a few days, and then he thought the data could be posted to Basecamp. Lisa noted that the workgroup should review the data before January 5th [which may be changed to January 12th, as noted below] or before the second January call.

- Mark noted that he will do more burning/testing, but the moisture content must be within range before proceeding with the cordwood burning. Mark noted that he is currently discussing with EPA doing a few more crib tests to fill-in middle burn rates and do some repeat burns – nothing has yet been decided, but it's being discussed. After any additional crib tests, corwood testing would happen next. Mark noted that how the cordwood testing should be done is being discussed – that is, should the same nominal mass be used, or the same volume, how should the coalbed be prepared, does the cordwood bed need to be the same as crib coalbed, etc. Mark noted that his guess is that cordwood burning will happen in January.

- Lisa Herschberger asked if the moisture content was recorded in the data. Mark replied that yes, the moisture content is recorded for all tests in the data, just not in the summary page.

- John Crouch noted that it was time to transition to Bob Ferguson's presentation. John noted that after workgroup members have looked at Mark's spreadsheet of data, it may be useful for Mark to walk people through the data again with Stef and Adam on the call.

Bob Ferguson's Presentation regarding Chronology of ASTM testing by Mark Champion:

- Bob Ferguson noted that workgroup members asked for a short version [of the chronology of ASTM testing]. Because no additional ground was being gained by discussion, it was decided to start testing a draft of the ASTM method; the ASTM Task Group (TG) members realized that we needed to burn fuel to proceed. So, Mark Champion was contracted to provide supportive testing for the TG. The main reports [produced from the testing] are informal as the process was done dynamically – that is the TG looked at the data, discussed how to modify the approach and then try again before moving onto the next issue. This kind of testing was done on 5 certified stoves that differed in volume, material of construction, whether catalytic or non-catalytic. Therefore, although the sample was small, it was a somewhat representative sample of stove differences.

- Bob noted that the memo he posted to Basecamp [entitled "**Memo regarding ASTM Cordwood Method Development Testing 13.Dec.16**"] is extracted from larger reports to make them read in chronological order. John Crouch noted that Bob's memo was posted to Basecamp yesterday. Bob reviewed his memo for the workgroup, which is attached following these meeting notes. Bob explained that the memo is the summary of the summaries and tracks directly to reports as they are numbered [in the attached memo]. In most cases conclusions and observations were brought back to TG regarding whatever topic was being discussed/examined.

- Bob noted, for example, that the TG tried tying back to M28 where we could, but the loading density from low to high changed with charcoal amount. There was too much leftover start-up fuel. The 10 cubic ft loading density worked for some stoves, but not for smaller firebox sizes. The TG was also interested in the end of the test – that is, when does the test run end. Long charcoal tails were possible on especially big stoves, and on high fire tests, artificially low heat output would result. Therefore, in his testing, Mark looked at visual cues like flaming and what the fuel looked like and Mark brought his observations back to the TG.

- Cold start testing continued with the recognition that the higher loading density resulted in too much charcoal. The recommendation therefore was to lower that high load density. Bob noted that the idea was to get something that would work and then worry about stoves that might be adversely impacted. There's a report that focusses on the end of test. Regarding the "dreaded charcoal tail", Bob noted that the rate of heat output is affected by the long tail, and the g/hr results are also affected by the long tail (making the emission results lower). Therefore, the TG based some decisions on observations, since [for example] homeowners don't have a scale. [Rather than basing things on weight or other parameters the homeowner would not be privy to] the TG just based such decisions as when to re-load on how it [the fuel and fire] looks to the homeowner.

- Bob noted that he was now on page 3 of his memo now. Regarding #4 on page 3 that a different determinant of max heating capability involving the peak burn rate over a prescribed time interval (one or two hours) could be extracted from the high fire test data, Bob noted that this didn't get traction from anyone.

- Bob continued, that how much kindling and start-up fuel to place in the stove also had to be decided. For the high fire, a load density of 10 lb/cubic ft worked okay for most stoves (except the smallest). Maple was used in the testing, which is in the middle of the allowable range [for ASTM's specific gravity range]. For the coalbed, Mark burned down to 10 or 15% of the test load fuel weight and then put the test fuel on. The TG came up with alternative end of 90% of fuel being burned. This 90% point appeared to coincide with place where visually the stove was ready for reloading and the flames were down as well, with the burn rate beginning a rapid decline.

- Regarding the low fire after high fire, Mark and the TG noted that the residual coal bed after the cold-start/high fire burn cycle provided an excellent coalbed for the low fire/burn load and the prescribed loading density of 12 lb/cubic ft worked for all stoves (although it was a tight fit in smallest stoves). Bob noted that EPA M28 has a Delta T (temperature) requirement. ASTM originally had a Delta Q (energy) requirement rather than Delta T requirement, reflecting the fact that small stoves have much different Delta T than large stoves. However, Bob explained that neither the Delta T nor the Delta Q limits appeared to be a problem (related to the stove being hot when it was loaded for the low burn cycle). The TG determined that the end of the test and when to refuel were more important issues.

- Bob noted that he was now on page of his memo. Bob pointed out that it was difficult to define a medium burn rate, but Mark noticed an interesting phenomenon – that is, the stove could achieve a medium burn rate without Mark/the operator having to do anything (see bottom of page 5 onto page 6 of Bob's memo). Mark provided graphical representation of what that looked like, which was helpful to the TG.
- Bob noted that other interesting observations (page 6 item 5 of memo) included that the burn rate at the medium setting was actually above the burn rate at the high fire setting. The reason for this goes back to what Mark said about the mass of wood in the firebox – that is, the fact that the load was 10 lb/cubic ft for the high fire burns but 12 lb/cubic ft for the low and medium fire burns.

- Bob noted that when the TG finally settled on the definition of test runs, then additional work was needed to look at [define] the end of test and how tests can meet medium burn rate requirements. Bob further noted that what would happen if a stove couldn't meet the medium burn rate also needed to be considered, but it was very unlikely that this [failure to achieve a medium burn] would happen with a pre-conceived medium burn rate setting.

- Bob noted that from the fall through the end of 2014 and then in the spring and summer of 2015, little ASTM work/testing was done because that's when everyone was focused on the new NSPS.

- Bob offered that anyone could contact him regarding the graphs and that he's happy to be the ASTM historian and recreate the timeline and discussions. John Crouch suggested that an excellent piece of homework would be for the workgroup members to look at the graphs along with Bob's memo and write down questions.

- Bob concluded that the big takeaway from this [the ASTM experience] is that these questions are brought up hypothetically or based on test data. Therefore, the group must be prepared to come up with their best shot at what will work and ultimately "the proof is in the pudding". Bob explained that the initial values were in some cases not too bad, but were not so great in other cases. The only way to refine test methods was to have data that would address answering a specific question. For processes where the TG wasn't sure, testing was used to try to generate data for how to move forward.

- Ben Myron commented that all of this data has/had great impact on what ASTM did, but it assumes that stoves are not going to change much to burn cordwood cleanly. Ben asserted that's an assumption that needs to be questioned, because Ben's experience says otherwise. Bob replied that ASTM was not trying to stifle innovation in any way. Not stifling innovation was one of ASTM's goals. Bob noted that the other goal was to get something out there. That something [method] was not perfect, it still had lumps, but the method needed to get out there and get people to burn [with it]. Ben agreed but noted that some of this is based on Phase 2 stoves. Ben asserted that, as stoves are designed to burn cordwood cleanly, some of those things will disappear. Bob agreed and again noted that ASTM didn't want to box anyone in. Ben again agreed and concluded that his point is that stoves designed to burn cordwood cleanly will change dramatically.

- John Crouch noted that most people in the industry agree with Ben – that is, once a cordwood test is settled on, the stoves produced will act differently and be more in-line with how stoves burn in the real world [in homes]. John noted the he would like to call attention to the fact that the ASTM group spent a lot of time on the end of test criteria. John further noted that currently [the industry] is stuck with a metric that includes time and it is frustrating for the labs and industry to watch [a long] charcoal tail with no PM emissions. The PM emission part is over [during this tail]. John explained that this is why, as we [the ASTM group] looked at a cordwood method, it wrestled a lot with a reasonable way to define the end of test. In [the current] artificial end of test criteria, we [industry] recognizes that [the method] does something different than what consumers would do. John concluded that consumers would operate their stoves differently.

- Lisa Rector noted that NESCAUM has a TEOM running with Mark Champion's filter data [during his EPA-funded testing]. Lisa explained that the TEOM provides real-time PM measurement and is doing a good job tracking with the filter data. The goal is to gather data to track when the test can be stopped and how much fuel is left at that point. Lisa noted that this will need to be converted back to long tail tests. Lisa offered that George Allen could present some of that TEOM data [during a future meeting].

- Lisa Rector and John Crouch discussed when NESCAUM was available in January for O/F teleconferences and Lisa concluded that January 12th and 26th would work for NESCAUM. Lisa will

e-mail workgroup members including EPA to determine if those January dates will work for everyone.

- John Crouch noted that these January dates give workgroup members more time to create questions for Bob, which is homework for everyone. John suggested that just before George presents his TEOM data, perhaps Mark can go through his data and the O/F workgroup members can ask Mark any questions.

- Lisa Rector noted that workgroup members may wish to look at the data and slice and dice it in different ways. Lisa invited people to give their take on data. George Allen agreed, noting that they were looking for people to analyze the data. George noted that he could probably post the TEOM data to Basecamp next week.

- John Crouch asked the workgroup to look at the TEOM data while looking at Mark Champion's spreadsheet.

- John noted that the group would tentatively meet on January 12th unless that date doesn't work for many people, in which case the workgroup would meet on January 5th without NESCAUM.

- Happy Holidays and Happy New Year to everyone. **Meeting adjourned.**

ATTACHMENT – MEMORANDUM

To: Cordwood Operation and Fueling Group
From: Bob Ferguson
Date: December 13, 2016
Re: Testing conducted to support ASTM cordwood test method development

The purpose of this memorandum is to provide a chronological accounting of the testing, test results, conclusion and recommendations as they emerged from the testing conducted by Mark Champion of Hearthlab Solutions during 2014 and 2015. More complete reports were provide to the ASTM Task Group prior to meetings and those reports have also been made available to all interested parties and have been posted on the OFG Base Camp site. It is important to remember that the testing specifics evolved over time based on on-going test results and after discussion during ASTM Task Group calls and meetings. This testing was conducted using five individual stove models that bracketed size, materials and technology. All models were EPA certified.

There was considerable discussion about the various fuel and operational parameters for many months prior to the recognition that actual testing was needed to fairly evaluate the proposed test conditions within the draft method. The evolution of the test method to the point when the initial test runs began was memorialized in numerous call reports and will not be included here.

Most of what is included here is extracted from the larger reports. Those reports included graphs, charts and photos in various combinations so you will see references to those even though the graphics are missing. As previously mentioned, the full reports were posted to Base Camp for those that want more detail.

The main takeaway from this is that testing was conducted to help inform the ASTM Task Group as they worked through testing details that were proposed for the draft cordwood method. Issues that were uncovered during the testing we given consideration and procedural modifications proposed. Additional testing confirmed whether the issues had been satisfactorily addressed in the method. The latest draft reflects the information learned during this testing program.

It was also fully recognized by the ASTM Task Group that other substantive procedural issues could be anticipated once the method was more widely in use. It was simply not possible to predict if some parts of the procedure would prove problematic for stove models that are less typical in their individual designs. This is just a fact in test method development and the ASTM process allows the consideration of method improvements or corrections at any time. It was the intent to get the best possible initial method completed and out in use so that data could be generated and the method refined as justified by supporting evidence.

Report 1: Nov. 17, 2014

Observations, Conclusions, Recommendations

1. The currently proposed residual start-up fuel weight range at the conclusion of the cold start portion of the high fire test run is 15 to 25% of the test fuel load weight. It appears that range could be lowered to 10 – 20% or even 10 – 15% and provide a realistic fuel loading condition with more available headroom in the firebox for the fitting in the test fuel load.
2. The proposed nominal 10 lb/ft^3 loading density is workable across the range of stoves tested but may result in a very tight load for smaller firebox volume stoves with the wood load very close proximity to the firebox ceiling.
3. The test ending criterion may need more attention. At least with the wood used for this study, long charcoal tails are possible (particularly on the larger stoves). This will reduce output ratings. We are collecting data and looking at alternatives to the current scale driven test end definition. These include visual cues, stove temperature, presence of flaming, etc.

Report 2: Dec. 9, 2014

Additional cold start testing has been conducted since the last conference call. Based on previous test runs, it was decided that adding the high fire test fuel load after the kindling and start-up fuel burned down to 10% of the test fuel load weight represented a realistic loading point based on the visual appearance of the fire. The range in the current draft is 15 - 25% of the test load weight. This range was carried over from previous drafts where the high fire test nominal loading density was 7 lb/ft^3 so the resultant range of residual fuel is would be ~40% greater (10/7's) based on the current 10 lb/ft^3 loading density.

Conclusions Regarding the Residual Start-up Fuel Weight Range

1. Lowering the residual start-up fuel weight range appears to make sense based on the limited testing that has been conducted so far. The currently proposed 25% upper limit (and probably even a 20% upper limit) could result in start-up conditions at the point the test fuel load is added that are not very representative of conditions when a homeowner might actually add the first fuel load after a cold start. There is also some thought that loading at the high end of the currently proposed range could contribute to increased variability of results.

2. Lowering the range to 10 – 15% may be warranted however it should be cautioned that we have a very limited experience base and some stove models may be adversely impacted once this protocol has been more extensively used.

Defining the End of Test for the High Fire Test Run

1. The current draft defines the end of the high fire test run as the point where the full weight of the high fire test fuel load has been consumed. In other words, the point where the scale weight returns to the weight at the time the test fuel load was added to the stove (residual start-up fuel weight).

2. During the recent test runs, it has been observed that the cordwood fuel test runs tend to have long tails, even on the maximum air settings for the high fire tests. These tails have two impacts on the test results that should be fully considered before the test method development can proceed toward completion.

3. The first is that the high fire test burn rate can be significantly reduced if the test run includes a long tail. Test length is the denominator in the calculation. Secondly, the g/h emission rates are also dependent on the test length. Artificially long tails affect the emission rate.

4. It has been observed during the test runs that waiting for the consumption of the charcoal at the end of the high fire test run can add dramatically to the length of the test run, in some cases doubling the test length. This charcoal tail occurs after all volatiles in the test fuel have been consumed (all yellow flaming has ceased) and when PM emissions are almost always negligible. The charcoal is generally in a somewhat compact configuration with the bottom of the pile not engaged to any great degree in the combustion process. This significantly slows the rate of combustion and extends the test time.

5. Several observers of the test runs have opined that a typical homeowner will rake the coal bed and add more fuel well before the weight-based end of test as currently proposed.

<u>Possible Options for Defining the End of the High Fire Test Run</u>

1. Keep the current definition of the end of test where 100% of the test fuel load weight must be consumed. Determine whether the 15% residual start-up fuel weight will adequately reduce the tailing without other adverse impacts to the test procedure or without increasing variability or decreasing comparability of test results.

2. End the high fire test run before the full test fuel load weight is consumed. This may better simulate homeowner operation where fresh fuel is likely to be added once yellow flaming has ceased and there is substantial charcoal bed remaining. There would be deminimus impact on the PM emission capture and the test run would be substantially shorter. A range of 90 to 95% of the test fuel load weight might be reasonable to consider. This might also result in a better estimation of the high fire burn rate and heat output capability of the model. It has been determined that the impact on the CSA B415.1-10 efficiency calculation will be extremely small.

3. Use a visual cue, average surface temperature cue or flue gas cue (or some combination) to determine the end point for the high fire test. It would have to be determined whether this concept will be biased for different stove models and whether it will introduce additional variability to the test results.

4. A different determinant of maximum heating capability might also be considered where the peak burn rate over a prescribed time interval (one or two hours, for example) could be extracted from the high fire test data. This would at least insure consistency in the way rated heat output is determined and would provide comparative information for consumers. At the moment, manufacturers often employ differing procedures for determining their advertised heating capability.

Report 3: Jan. 7, 2015

Thus far, five stove models covering a range of firebox size, construction and technology have been tested using the draft ASTM cordwood test method. Cold-Start/High Burn testing was the main focus however a preliminary examination of Low Burn cycles was accomplished by loading the low burn fuel loads onto the residual coals of the High Burn cycle. Of particular interest during all the testing were issues of load density, reloading points, resulting burn rate measurements (and consequent heat output determination) and test end criteria, all with the intent of mimicking realistic practices likely to occur in field use. While PM measurements were made for all test cycles, these were of less importance for the current work since the results are dependent on the fueling method and that method was changing throughout the course of this testing. A wide range of emissions results was encountered and these are not reported here.

<u>Significant Findings and Adaptions</u>
Cold Start/High Burn:
1. A kindling and start-up fuel mass consisting of 50% of the High Burn mass appears to provide an adequate residual coalbed for the high burn cycle.

2. Load density of 10 lb/ ft^3. physically worked in all stoves but was a tight fit in the smallest stove of the study. (fire wood s.g. average of 0.60, middle of the allowable range).

3. The range of start-up residual fuel (15 to 25% of HB) seemed unrealistically high with both too much unburned fuel and active flaming. Work included examining a lower
bottom boundary of 10% which worked well in four stoves but was not tested in the 2.5 ft^3. Non-cat.

4. Residual fuel conditions (mass, flaming, breakup of coals) can significantly affect the burn rate and emissions results of the High Burn test cycle.

5. Very long coalbed tails can result using the cordwood procedures which impact both heat output and emissions determinations significantly.

6. An alternate High Burn test end criterion of "90%" consumption appears to consistently be a place where visually the stove is ready for reloading, flames are nearly out and the burn rate begins a rapid decline.

Low Burn Cycle:
1. The residual coal bed of a Cold-Start/High Burn cycle provides an excellent starting coalbed for a Low Burn load.

2. Generally, a coalbed range of 10-20% appears realistic and works well.

3. If the High Burn test ends at the 90% consumption point, there can be 40 to 180 minutes of continued burning before reaching the low end of a Low Burn charcoal bed range.

4. The loading density of 12 lb/ft^3 (s.g. =~ 0.60) worked in all stoves but was a tight fit in the smallest of the stoves.

5. Long charcoal tails can result with cordwood fueling. Laboratory instrumentation was automated and unmanned during these tests so opportunities for stirring were not taken. Resulting burn rates, emissions, Delta T and Delta Q measurements must consider this.

6. Given the unmanned, long tails encountered and the fact that Low Burn cycles were started on the residual coals of a stove on its highest setting (i.e., Loaded on a hot stove), Delta T and Delta Q values do not appear to be a significant problem.

7. More attention to the tail end of the Low Burn cycle is needed to determine the need and effect of stirring, possible alternate end points, etc.

Report 4: June 30, 2015

This report provides the preliminary and unaudited results of the continued cordwood testing in Vermont that resumed after the suspension of regular ASTM Task Group meetings (due to resource and time constraints) during the final months of the NSPS process that resulted in the current rules.

There were two primary goals of this testing. The first was to provide data showing the relative emissions of one-hour, start-up only and main load periods during the cold-start/High Fire phase of the ASTM draft method. The second was to explore the starting and ending points of the proposed Medium Fire test cycle and provide burn rate and emissions results for two test- end scenarios (ie. 90% consumption and 100% consumption). Results are reported graphically and can't be easily summarized without looking at the charts.

Report 5: Aug. 5, 2015

A continued analysis of burn rate data generated during the cordwood testing in Vermont was presented. The effort was to look for further Medium Fire definition possibilities in relation to the burn rates achieved on High and Low fire tests. One concern that was voiced during discussions was that it was felt to be important that a physical air control adjustment must be made to a medium air setting achieve the medium burn rate category requirement. Otherwise, some stoves could achieve a medium burn rate by simply setting the air control at maximum and burning 100% of the test fuel load due to a long charcoal tail. It was felt that this was not consistent with user practices. If they want a medium heat output, they will move the control to a medium air setting and that setting must result in less air going to the stove.

Graphs depicting fuel consumption in real time compare the High, Medium and Low fire cycles for each of the four stoves were provided. Two graphs were given for each stove model. The first (% Load Remaining vs. Elapsed Time) can be thought of as the net load weight with the Y-axis normalized to the fuel mass for each firing cycle. The second graph (Calculated Dry Burn Rate vs. % Consumed) shows the burn rate that would be calculated at any given load consumption over the course of each burn cycle. Of particular interest were the relative calculated burn rates at the 90% consumption point for the three firing cycles. These graphs do not include the cold start portion of the High Fire test but only the main fuel load.

Some interesting effects from the graphs were highlighted:
1. Only one of the four stoves (Large Steel Non-cat) exhibited a medium burn cycle which we might expect (until now) with a medium air setting. The medium burn rate, and presumably the heat output, falls right between the High and Low Fire test results for the entirety of the test cycle.

2. The Iron Non-cat stove had a Medium Fire burn rate profile which closely matched the High Fire burn rate until over 80% of the load had been consumed. At that point, the charcoal phase extended the burn time thus reduced the calculated burn rate.

3. The last two stoves (Stone NC and Iron Cat) had Medium Fire burn rates which exceeded that of the High Fire test until 80 or 90% of the medium load had been consumed. In other words, the heat output is presumed higher than the High Fire output until reaching the charcoal phase.

4. Despite the above anomalies, all of the Medium Fire cycles met the current draft definition of "The primary air control(s) for the medium fire test run shall be set so that a dry basis
burn rate that is equal to or less than the mid-point between the dry burn rates for the low fire and high fire test runs is achieved."

5. When looking at these graphs and considering the anomalies above, a few factors may be important. The nominal loading density of the High Fire test was 10 lb/ft^3 while the Medium

and Low Fire loading density was 12 lb/ft^3. This partially explains how the Medium Fire burn rate can exceed the High Fire burn rate for much of a firing cycle. Results are given for a single Medium Fire cycle run at a "best guess" medium setting and may differ considerably with slight setting changes. The data was presented in order of stove firebox volume (largest to smallest) and coincidentally, more "erratic" or "unexpected" behavior occurred as the firebox size decreased. This is clearly unproven but possibly is a factor in a stoves response to reduced air settings.

Additional Data

1. Four additional test runs were performed to provide more insight into the current draft medium burn rate category definition. Past tests have shown the possibility for very long charcoal "tails" when burning the cordwood used in this study (mostly maple, s.g. about 0.6). Of interest was the resulting burn rate when a 12 lb/ft^3 wood load was placed on the required coalbed for Medium and Low fire tests (i.e., the resulting coalbed of a cold-start, High Fire test) and the stove run at its maximum air setting until 100% of the fuel load was consumed. Would the resulting burn rate meet the current Medium Fire definition because of the long charcoal tail? How likely would it be that the Medium Fire definition is missed (i.e., a burn rate above the midpoint of the High and Low measured burn rates) resulting in a test that does not fit any defined category?

Some observations of the data were given:

1. In all but one stove, the iron catalytic, the resulting burn rate of the 12 lb/ft3 high air setting test fell within the current Medium Fire definition (i.e., below the mid-point).

2. In all but one stove, the iron non-catalytic, burn times were appreciably shorter and burn rates were appreciably higher than those measured during the previous Medium Fire tests using throttled air settings.

3. In the case of the iron non-catalytic stove, the high air setting hot-to-hot test had a lower burn rate than the previous Medium Fire test.

One concern expressed regarding the medium burn rate category definition was that a test run might miss the category by having too high of a burn rate despite having a significantly lower air setting. What happened to that run? These test results show that it is unlikely a Medium Fire test would be missed because the burn rate was too high. The definition of the Medium Fire category also includes factors of being a hot-to-hot test cycle, having a higher loading density and running until 100% fuel consumption. These further differentiate the Medium Fire test from the High Fire test and make it highly likely that the required burn rate cap will not be exceeded once manufacturers define an appropriate medium air setting.

Operation and Fueling (O/F) Workgroup Meeting Notes from January 12, 2017 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:

- Lisa Rector and John Crouch discussed the option of having an O/F workgroup (WG) meeting at the HPBA Expo in Atlanta, GA (March 1-4, 2017).

- EPA's wood species testing by Mark Champion is continuing and is moving from burning crib wood to burning cordwood. EPA will post Mark's spreadsheet data after adding explanatory metadata to the spreadsheet to aid in data understanding/interpretation. Meanwhile, Lisa Rector has posted George Allen's real-time TEOM data to Basecamp and has provided graphs to the WG via e-mail. Any questions about the TEOM data should be directed to George Allen via e-mail, with Lisa Rector cc'd.

- The WG discussed the causes of emission spikes (as seen in the TEOM plots) including stirring/poking the fire, the natural release of organics from the wood, late pyrolysis from unburned wood catching and baking, how wood falls in the firebox, and [for lower fire burns] the lack of enough heat later in the burn to optimize the emission reduction system (whether thermal or catalytic). WG members from industry and lab explained that such spikes late in the low burn cycle can happen with any technology stove and are unpredictable.

- It was noted that going from a high fire to a medium fire is 2/3rds of the way to an integrated test run. As such, the ASTM method serves as a road map for a large portion of an integrated protocol. A fully integrated test run method would also go from medium to low fire. If a fully integrated test method was developed, the next goal might be designing the test to be achievable in one day, so that three days of testing would result in an N of 3 for each burn rate. Basing certification on an N of 3 instead of an N of 1 is important to regulators.

- WG members discussed the advantages and challenges of shortening the test by re-defining the end of a category burn and developing a formula to link back to a full burn's Method 28 emissions. Advantages include shortening the test enough to get 3 data points (N of 3) for each burn rate, rather than the current single (N of 1) data point and developing a test that is more reproducible and reflective of actual stove operation. Challenges include the fact that efficiency calculations using CSA B415 assume a full burn down to 0 fuel load weight. Related to this, WG members opined that cutting-off the high fire test at 90% is not a problem, but shortening the low and medium fire burns is problematic and needs more research. It was also generally noted that, since stoves are designed to pass the certification test method, the implication of shortening (cutting-off) the test method on stove design needs to be understood, as the new test method must not negatively impact real-world performance.

- WG members discussed the possibility of defining a shortened end of the test for PM emissions, but define another end of test for efficiency calculations and/or calculating efficiency differently.

- Regarding efficiency, Bob Ferguson offered (when he has time) to run ASTM's and/or EPA's current stack gas data through the B415 algorithms and perform sensitivity analyses to determine the impact of shortening/cutting-off the test at various points.

- It was emphasized that in terms of determining compliance and a passing grade, any new values from a re-designed (shortened, integrated) test method would have to be correlated with the 4-burn steady state crib run values. The results of the new method would not have to meet [as-is] the NSPS's limit without the use of a formula to relate/translate the values.

- It was noted that a shortened test would require smaller fuel loads than used currently (e.g., in ASTM's draft cordwood method).

- It was noted that firebox size is another variable to consider when designing a new test method because larger fireboxes require longer tests. It was suggested that instead of time, the % of fuel weight consumed be the metric used to shorten the test – that is, that an integrated test run be based on fuel weight conditions. Nonetheless, it was agreed that the impact of different firebox sizes should be researched.

- The WG began discussing how to define burn categories (e.g., low burn defined as 30% of high burn) and it was decided to continue this aspect of the discussion on the next call in January. Bob Ferguson offered (when he has time) to review ASTM data regarding fixed burn rates versus burn rates defined by percentages.

To-Do List:

- WG members should e-mail Lisa Rector if attending the HPBA Expo and are interested in having a face-to-face O/F WG meeting. In the e-mail, indicate what days would work best for that meeting.

- John Crouch will send the HPBA Expo agenda to Lisa Rector, who will distribute to the States.

Highlights from Meeting:

- Lisa Rector opened the meeting and noted that the following people were in attendance: John Crouch, Bob Lebens, Mark Champion, George Allen, Gregg Achman, Cindy Heil, John Barnes, John Steinart, Gaetan Piedalue, Randy Orr, Rick Curkeet, Robert Ferguson, John Wakefield, Ben Myron, Stef Johnson, Lisa Herschberger, Tom Morrissey and Adam Baumgart-Getz, as well as others who did not announce themselves.

- Lisa noted that the meeting's agenda includes reviewing the schedule for today's call, meeting updates/questions (regarding the IEA [European] Task Force meeting and the HPBA meeting), an update on Mark Champion's testing for EPA and a discussion of data analysis.

- Lisa noted that she and John Crouch had shifted the scheduled February and March calls and left April as it was. The Fueling and Operation Work Group (WG) should be getting an invite to IEA task force occurring in Graz, Austria. Lisa can be e-mailed questions while there, as she's attending. Lisa will send an agenda for that meeting to everyone and reminded the WG that it's a 6-hour difference from the East Coast and a 9-hour difference from the West Coast.

- Lisa asked how many people would be attending the HPBA Expo [in Atlanta, see http://hpbexpo.com/]. Lisa noted that this year there's no ASTM meeting before the Expo and wondered how many people from OF WG were attending the Expos, as it may make sense to have a face-to-face meeting there. WG members should please e-mail Lisa if attending the Expo and interested in having a face-to-face O/F meeting and indicate what days would work best. Lisa noted that John Crouch secured a meeting space on Tuesday that could be used; and on Wednesday, the group could meet in the evening or at EPA Region 4 offices.

- John Crouch clarified that the EPA regional office might be obtained for Wednesday, for the entire day, and then Thursday morning the group could tour outdoor wood burning. John further noted that on Friday morning there will be a short presentation aimed at retailers and what they need to know about options in cordwood testing. John asked the WG to please plan for several days if possible. John agreed to give the HPBA Expo agenda to Lisa this afternoon, so that Lisa can send it out to the states. John further clarified that last year in New Orleans and previously in Nashville the HPBA had meetings [prior to the start of the Expo]. But given that people are coming from different time zones and given that the ASTM method is essentially complete, nothing will be planned for Tuesday afternoon.

- Lisa noted that during the December call the O/F WG had gone through Bob Ferguson's ASTM review and Mark Champion's EPA species testing, which is ongoing. Lisa asked if there were any updates from Adam or Mark.

- Adam Baumgart-Getz noted that, regarding a quick overview, the work is continuing. [Mark Champion's testing is] close to being done with crib wood work and the cord wood species burning is starting. Adam further noted that EPA will share data with the WG, as it can be shared. In response to a question from Lisa regarding whether the old data sets were posted to Basecamp, Adam explained that the spreadsheets will be updated with metadata and that EPA

hopes to get that metadata soon and then will post [the updated spreadsheets to Basecamp]. Adam explained that not all the columns in the current data spreadsheets are intuitive, so adding metadata will help with that. Lisa wondered if there would be misinterpretation of the data without metadata added. Adam replied that there could be, which is why EPA wants that metadata added before posting it to Basecamp.

- Lisa explained that real time TEOM data is on Basecamp, although [Mark Champion's] filter pull data is not yet posted. Lisa clarified that the study involves looking at TEOM data in addition to species [differences], to help determine how to define the end of test. Lisa suggested that the WG refer to the e-mail she sent with TEOM data in PDF, including a slide of [the TEOM's] correlation with the filter pull data. Lisa noted that there are also plots of different species by burn rate (although Lisa did not include the white pine data in those plots, as that data is too weird/different from the rest). Lisa explained that these are 15-second averages, glued to 2-minute running averages and they [especially Lisa and George Allen of NESCAUM] are looking for patterns from the TEOM data.

- Lisa noted that many have suggested that the test could end when 90% of the fuel is burned. The TEOM data shows that most of the emissions occur during the first 30 minutes of the burn.

- Lisa noted that it's important to think about an operational protocol to get at the data EPA needs to ensure compliance with the standard, but it's also important to move the test to an integrated test run. Lisa further noted that George plotted the different species information (with the exception of white pine) for high burns, medium burns and low burns.

- Rod Tinnemore asked if the peak at minute 160 is a reload situation. Lisa replied that it wasn't a re-load and that's why metadata is important. Rather, the fire may have been stirred/poked at this point. George Allen agreed that stirring/poking did indeed change the test. Lisa noted that she would like metadata added to the data to elucidate whether or not the two spikes on the low burn data are from stirring/poking. This would allow the impact of stirring to be shown. Lisa opined that it'd also be important to know the weight of the fuel charge at 110 minutes on the low burn, where the emissions are tailing off prior to stirring/poking.

- Ben Myron explained that organics come out of the wood in waves and are not evenly distributed over time. The wood alcohol peak comes, then there's a dip [in emissions], then a peak, then another dip, then finally the pyrolysis peak, followed by a dip and charcoal tail. Ben further explained that these peaks [in the TEOM data] could occur because some of the wood didn't get burned in the back of the firebox. This wood caught later but there was not enough heat in the firebox [at this later point] to fully burn, so these spikes occurred. George clarified that this is crib wood data. Ben noted that this can still happen with crib, not as often as with cordwood, due to the spacing; but [these peaks] could happen even with crib wood. Ben concluded that peaks don't surprise him and are well within the normal scatter of data that wood burners regularly see.

- Lisa asked if her following understanding was correct: Towards the end of the burn, the emissions are not so much a reflection of the efficacy of the stove to control emissions, but are rather more indicative of how the end of the fuel charge is burning. Ben replied that it's a combination of both: If the stove can't handle the emissions [emission spikes might occur], but in addition, as more and more of the fuel is consumed, there is less fuel to sustain the emission reduction system, whether it's thermal or catalytic. Ben further explained that there may not be enough heat in the system to do the job, so a spike may occur. In this way, Ben explained that the later part of the burn can overwhelm the early part of the burn; a spike at the end can cause the loss of [an otherwise] compliant run and nothing can be done to control this.

- George explained that the spike occurring on the black Douglas fir curve at 200 minutes was caused by stirring/poking. Ben noted that if all the fuel was charcoal, then that spike wouldn't occur. Ben explained that pyrolysis (yellow flames) started and then that piece baked out and the firebox went back to charcoal. Mark Champion clarified that only 2 early burns were poked/stirred on Douglas fir. After that, the test end criteria were developed and poking was no longer required. Mark further clarified that these spikes are possibly caused by the 4x4's collapsing. The rise in CO_2, the drop in air-to-fuel ratio and the rise in burn rate indicate a rise in wood ignition and this was probably the 4x4s falling. Mark noted that there's real time stack gas analysis; so these spikes could be explained with the data.

- Lisa noted that the stove being used [in Mark Champion's EPA testing] is a pre-NSPS stove. Lisa asked how often unburned wood is left at the end of a compliance test using an NSPS-certified stove – that is, is it common or rare to have wood left in an EPA-certified stove? Lisa also asked if this issue is more common with certain burn rates, like lower and middle burn rates, or with all types of burn rates. Ben replied that any stove would be more prone to have this on the lower burn rates, because the stove temperature is low. On the high burn rate, Ben explained that there's a high enough temperature for the organics to come out of the wood. Regarding how often wood is left unburned at the end of a compliance test for an NSPS-certified stove, Ben notes this was a more difficult question to answer.

- Bob Ferguson noted that [labs and industry] call that a "chunky end". Bob noted that sometimes a 4x4 end remains and this would be a fair amount of the leftover weight, compared to ash and charcoal. So, you do see chunky leftover pieces, according to Bob. Ben agreed, but noted that there's not a stove out there that that couldn't happen to – this happens to all stoves. Bob agreed that spiking is not predictable at all and could happen on any stove. Regarding the pre-NSPS Vigilant stove in particular, Bob was somewhat familiar with it and noted that it can leave wood on the left end versus the right end and is known for that tendency.

- Lisa noted that she had something for the regulatory people to consider – that is, that burning down to 0 doesn't necessarily mean burning down to no fuel, so when thinking of a new test protocol to accurately represent stove and real world burns, consider whether it is important to go to 0. EPA may need to backtrack to the emission standard, but for a new test method, the goal is to characterize the performance of the stove, not how the burning wood falls within the firebox (for example). Looking at high and low burns hopefully allows for a way to end the test

earlier and develop a formula to link back to a full burn's emissions. Lisa noted that this is important since the standard uses a g/hr metric – that is, time matters. Lisa noted that the WG needs to think about a definition for the end of a category burn, and develop a formula to get to 0 weight, so that the result is more reproducible and reflective of stove operation than a 0-weight end might be.

- Rick Curkeet reminded everyone that this test is being used to determine efficiency too, and the input is determined by the higher heating value of raw wood that's assumed to be fully burned in the test. Rick explained that the WG must consider this in deciding to cut the test off early. Rick noted that the efficiency determination assumes the stove burns back to starting conditions. Bob Ferguson agreed, noting there would be a difference in cutting test off before the charcoal phase, which may occur long before 90%. Bob noted that cutting off the test before all the volatiles are consumed could account for PM emissions, but looking at only parts of the burn cycle may increase the air band by quite a bit. Bob explained that the weighted average is based on the rate of fuel consumption and other parts of the algorithms. Bob concluded that it might be tricky if the test is cut off too soon.

- Ben Myron noted that the stove design itself is another aspect. For Method 28, all the test fuel must be burned. So, the stove must be designed to burn all the fuel. If the test is cut short, then the design will focus on [the new] test and that may or may not be a good thing for real-world performance. Ben emphasized that the WG needs to consider that implication. Lisa asked Ben what kind of test he would design, if he were to design a test to better reflect how the stove behaves in the real world. Would the test look like the ASTM test? Ben replied that he doesn't have a problem with cutting high burn at 90%, but the medium and low burns ought to go all the way to the end of the fuel load. Ben explained that, for stoves with asymmetrical air flow, if the test is cut off when the burning starts to release organics, that will be missed in the test results. Ben noted that one wouldn't want to cut that off. This happens in asymmetrical stove designs and the data is skewed from what the stove will do in the real world. It was suggested that the medium and low burns be run all the way to the end, until there is enough data to confirm that the test can be shortened.

- Lisa agreed that any changes [to the test method] shouldn't be made arbitrarily. These are research ideas. Lisa noted that she keeps circling back to an integrated test run – for example, going to a medium fire run after the high fire run is 2/3rd the way to an integrated run. Lisa wondered however how to go from a medium fire run to a low fire run. Lisa pointed out that if that third piece can be achieved, the goal then becomes how to achieve one test in one day and then repeat that test 3 times, because one data point at one burn rate is not enough. Lisa opined that it would be better to run that test 3 times. If the test doesn't go well at first, then there are 2 more days of testing.

- Lisa noted that an N of 3 instead of an N of 1 is important especially to regulatory people. Lisa asked if there is interest in heading in the direction of an integrated run. Ben Myron replied that he is willing to talk about [an integrated run], but the WG needs to be aware of the pitfalls. Lisa Herschberger noted that an N of 3 is much more valuable than an N of 1. She understands that

there may be a problem with efficiency. Lisa Herschberger further noted that a test run of 2 hours may be sufficient. Lisa Rector noted that the WG is here to figure out if there is a way to understand the tradeoffs of going that route.

- Ben Myron asked how issues will be taken into account when determining compliance and a passing grade. Lisa Rector replied that since the [test] end wouldn't be what it currently is, the new value will have to be correlated with the 4-burn steady state crib runs. Lisa clarified that in no way is anyone thinking that the results of the new method would have to meet [as-is] the NSPS/standard's limit; a formula is needed to relate/translate the two values.

- John Barnes wondered if the end of the test can be defined one way for emissions and [another] way for efficiency. Lisa Rector replied that she has seen that; there's an integrated run that measures different burn rates and cuts off PM sampling but keeps the burn going for efficiency measurements. Lisa noted that that might be a way to approach it, as Bob Ferguson was getting to. It would require research and testing regarding how the efficiency number on an integrated run correlates to the CSA B415 number and associated error bands.

- Ben Myron noted that, if going out on a limb, overall efficiency could definitely be calculated in a different way. Bob Ferguson noted that the thinking could conceivably be altered to look at a representative period of time instead of looking at the full time, in order to calculate efficiency. Bob noted that this is not impossible; it's an interesting challenge but it's not impossible. Bob further noted that CSA B415 has its downsides – for example, the method doesn't deal well with excess air during the long tail, so it's not perfect. Bob suggested that a separate group of people who have knowledge of B415 algorithms is needed.

- Rick Curkeet suggested to keep in mind that B415 is a stack loss basic traditional type method, developed from first principles. As such, there are no correlation factors or fudge factors. Rick further noted that wood burning is unlike other fuel burning because the fuel changes so dramatically during the burn cycle –consequently, the incremental calculations are never really accurate. Therefore, getting an average at the end that is a good/reasonable number relies on the expectation that errors cancel each other out during the course of the burn cycle. Rick explained that this means if a chunk of the series is left out, then some of these internal corrections are also left out. Rick opined that one wouldn't know how to compensate for leaving a period out, without doing a lot of research to determine how to adjust for the omission.

- Bob Ferguson noted that the group has tons of CSA B415 data with which a sensitivity analysis could be performed. The data could be analyzed to determine where there is a divergence. Bob explained that existing data could be used to look at where cut off could occur – for example, use the data to determine what happens [to the efficiency value] when the data/test is cut off at 60%, 75%, etc. Ben Myron noted that they have looked at that [already] and it matters more in some wood stoves than others. Ben explained that this is a difficult issue for stoves with active air controls, as there's a much bigger impact to [the calculated efficiency value] on such stoves [when data is truncated]. Bob explained that they had looked at what happened when the data was cut off at 90% and those impacts were small and so ASTM went with that [for its draft

cordwood method]. However, the group didn't look at what kind of impact an 80% cut-off would have and it might be good to look at Mark's ASTM datasets and see what happens in general. Ben noted that he agreed and was not trying to sound negative, but rather just underscore that it needs to be investigated. Ben noted that the idea seems to work okay and makes sense with integrated runs on pellet stoves, using the B415 algorithms. Bob noted that he could perform a few sensitivity analyses with the current data – that he may try to take that on, although he couldn't take it on currently [due to his work load].

- Lisa asked if it would be useful if hash marks were added to the TEOM data at 50%, 75%, etc. Bob noted that he doesn't have ASTM data run through CSA B415, so if EPA wants to share stack gas, then Bob could run it through B415. Bob noted that while he can do this, it's not a trivial effort. Bob suggested speaking with Adam and Mark to see if they want to release that data. Lisa clarified with Mark and Adam that all the data would be released. Mark confirmed it would be and that all data is available in his spreadsheet, but currently it's not necessarily clear what all the columns mean. Therefore, the data needs to be cleaned up [with column headers and units added, etc]. Adam agreed and told Bob that the data would be available soon, but he was not sure exactly when. Bob noted that he has worked before with Mark's data and so could crunch the numbers for B415 once Adam and Mark are ready. Adam replied, sounds great.

- Regarding the idea of ending up with a one day test, Bob noted that even if all problems are solved and any part of the test is shortened, if the ASTM loading densities are used, it would be difficult to finish the test in one day. Bob further noted that this would be true even if the test were cut-off at 50%, because low fire tests go for a very long time. Bob suggested therefore that the WG needs to think about smaller fuel loads [in addition to] cutting-off the test time. Bob noted that all aspects will need to be considered, so that the test can be accomplished in a reasonable test day. Bob further noted that the WG would have to be creative regarding how to shorten up the test, if the goal is to accomplish all 3 burn rates in one fell swoop/one day. Bob clarified that a test day can be longer than 8 hours, but if 3 runs is the goal, then the goal should be not to exceed what a current run takes, so as not to increase costs.

- Lisa asked the labs what a reasonable length day would be. Rick Curkeet replied that the low and medium fire tests are a long day, with 12 to 16 hour days common. Rick noted that outdoor boilers may take 40 hours, which is expensive given the labor. Therefore, Rick explained that labs like being able to complete a test run in 8 to 12 hours. However, the reality is that if a run lasts 6 to 8 hours, there are also hours before and after the run. Therefore, even short test days are always longer than 8 hours.

- Ben Myron noted that, even for a high burn test day, it's an 8-hour day. Ben explained that the amount of time needed depends partly on firebox size – large fireboxes take longer (e.g., Blazeking's 4.5 cubic foot firebox takes a long time to test). The test time needs to be prorated by firebox size, therefore. Ben noted that a 1.5 cubic foot firebox is very different than a 4.5 cubic foot firebox [in terms of test time]. Ben concluded that firebox size is a huge variable that should be prorated by.

- Lisa thanked Ben for his input and reiterated that firebox volume is one variable. Lisa asked if the general design of the stove is another variable – that is, tube stove vs catalytic stove. Ben replied that tube versus catalytic design was not really a variable, as both stove types are approached the same [for testing]; testers get both stoves hot.

- Bob Ferguson noted that the TEOM data collected derives from one stove, but that a different stove would provide different TEOM data. Bob clarified that he was suggesting using the % of fuel weight consumed rather than time as the metric. Using the % of fuel weight consumed will allow for more similar conditions in each stove, rather than an arbitrary time pick. Bob noted that the question is: Do they end up in same place in terms of chemistry when the same amount of fuel is burned? Bob again noted that the times will be different for different fireboxes [as Ben had explained as well].

- Lisa noted that she liked thinking about an integrated run being based on fuel weight conditions – that is, looking at scale weight data. Research wise, Lisa noted that different firebox sizes should be looked at.

- Rick Curkeet noted that it's very important to recognize that this Vigilant is not controlled. Real-time TEOM data for current stoves would show much lower peaks and those peaks would last a much shorter time. Rick noted that, within the first 10 minutes, the smoke is gone and the unit has low emissions for the duration of the burn. Rick further opined that if the g/hr metric is used and the actual burn cycle is not used, the differentiation of good versus not so good stoves could be lost.

- Lisa agreed that it's important to remember it's a g/hr metric and that something may have to be given up for everything gained [with a new test method]. Lisa noted that TEOM data has been run on a certified stove and the high fire looked similar to the Vigilant pattern (not quantitively, but similar pattern). Lisa concluded that the patterns look similar, but more research would be needed to determine if the pattern held up. Rick agreed that the pattern may look similar on a clean stove, except that emissions will be 10% of this scale.

- Regarding the TEOM data and this concept, Lisa asked if anybody else had comments and also asked if the discussion [so far] raised any red flags for EPA.

- Adam replied that [the discussion] is a reminder that this work is foundational and valuable, but more work on current stoves will need to be done before going forward.

- Lisa noted that the goal is to get in the lab and try to do research on newer technologies with other funding. But good feedback has been received on how to look at an integrated run as an option for a cordwood test method. Lisa further noted that the ASTM method went a long way and serves as a road map for a good portion of that integrated protocol.

- Bob Ferguson noted that fuel loads will need to be considered, as well as fuel consumption (rather than time). Using fuel consumed would keep the status quo in terms of shorter test days

for small stoves and longer test days for larger stoves. Bob clarified that that's how it is now and basing the new test on % of fuel consumed will keep that status quo. Bob opined that it is probably not possible to get away from longer test days for larger stoves.

- Rick Curkeet noted that right-sizing of stoves is an option and that what homeowners do would be consistent with that. However, Rick noted that forcing a big stove down to a low burn rate is not real world.

- Bob agreed and noted that forcing low burn rates on every product is different than allowing a stove to operate where it's supposed to operate.

- Rick suggested that the duration of the test would be the same if burn categories were defined based on the stove itself – for example, the low burn being defined as 30% of the high burn, etc.

- Lisa suggested that defining burn categories would be a great spot to dig into on the next call.

- Bob noted that ASTM had looked at finite fixed rates and this data is available. CSA cutoffs were used, but in the end these CSA cutoffs were taken out. Bob explained that there was support to keep them, but also a firm belief that we needed to keep the low burn rate in. Therefore the ASTM work group eliminated the percentage option. However, Bob opined that it was worth talking about again in detail.

- Lisa noted that she wanted to talk about different options and then circle around something this group could support, assuming EPA would be comfortable with connecting back to previous Method 28 burn categories.

- Bob noted that he could help bridge that gap, as the ASTM work group did analyses relevant to a fixed versus percentage defined burn rates. Bob explained that this work was done in 2010 and he can provide that data. Bob offered to look into the 30% cutoff data versus the finite burn rate data and provide it to the WG. Lisa replied, great.

- Lisa suggest that the WG discuss burn categories for the second January call.

- In response to a question from Ben Myron, Lisa noted that the [TEOM] graphs were posted to Basecamp and provided via e-mail. George Allen suggested that anyone who had questions about the graphs e-mail him and cc Lisa.

- Lisa noted that she would send an e-mail to everyone regarding the HPBA Expos and would talk again with everyone in 2 weeks [at the next teleconference meeting of the WG].

- Thank you to all. Meeting adjourned.

EPA Notes Operation and Fueling (O/F) Workgroup Meeting Notes from January 26, 2017 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:

- The O/F Workgroup (WG) began discussing the 3 primary choices for defining burn rates:
    - Method 28's (M28's) four specified/fixed burn rate categories;
    - Defining burn rates as a percentage of the maximum burn rate. For example, Canadian Standard Association's (CSA's) option of defining burn rates as follows: CSA's Category 1 is < 35% of the max burn rate; Category 2 is ≥ 35% and <53%; Category 3 is 53% to 76% of max burn rate; and Category 4 is the max burn rate. It was noted that using a low burn rate defined as 35% of the max burn rate matches EPA's M28 low burn category well.
    - ASTM's method using 3 burn rate categories instead of 4, which was first used in the 2010 version of ASTM E2780. ASTM uses low, medium and high burn rates, with high burn ("high fire") being the max burn rate the stove can achieve and low burn ("low fire") being defined as follows in ASTM's method: Low Fire = minimum 8 hours burn duration but with a burn rate not to exceed 1.5 kg/h. If the model can't meet the 8 hour burn duration, the minimum burn rate must be ≤ 1.15 kg/h. So, no Low Fire Burn rate can exceed 1.5 kg/h and small stoves that can't make the 8 hours must have a Low Fire burn rate at 1.15 kg/h or less. For ASTM's low fire, the air settings have to be at their lowest setting (which is the same as in M28, except that in M28 the stove must not exceed a burn rate of 1 kg/hr). In addition, it was noted that ASTM's 40/40/20 weighting scheme for the 3 burn rates largely agrees with EPA's 4 burn rate weighting in M28.

- If the WG decides to move from 4 to 3 burn rate categories, it is important to determine what data EPA needs to bridge the gap to enable compliance determination.

- The key question the decision on burn rates hinges on is: should the test method set design parameters or should the test method challenge the unit to burn cleanly, as designed.

- There was general consensus among the WG to discuss the topic of burn rates further on the next call in February and seek to come to a decision regarding which of the 3 burn rate options (bulleted above) the proposed cordwood test method should use.

To-Do List:

- Lisa Rector will determine via e-mail with WG members if a face-to-face meeting is possible at HPBA's Expo (as an alternative to the previously discussed Tuesday meeting, which is not possible).
- WG members interested in providing suggestions for NESCAUM's proposed sampling protocol for upcoming testing by Mark Champion, regarding different operation protocols, should e-mail Lisa Rector.
- Bob Ferguson will post additional information/data to Basecamp regarding looking at the EPA database from the perspective of CSA's burn rate percentages.
- The WG should frame any remaining questions regarding burn rates in writing and post the questions to Basecamp, so that others can see and look for responses.

Highlights from Meeting:

- Lisa Rector opened the meeting and noted that the following people were in attendance: George Allen, Gregg Achman, Bob Lebens, Cindy Heil, John Voorhees, Kelli O'Brien, Gaetan Piedalue, Randy Orr, Rick Curkeet (note: Rick announced he has retired from Intertek; Rick said Lisa should reach out to Intertek if the O/F work group wants a representative from Intertek), Robert Ferguson, John Wakefield, Amanda Aldridge, Rod Tinnemore, Lisa Herschberger, as well as others who did not announce themselves.

- Lisa opened the meeting noting that the agenda for today's call includes administrative updates, a recap of the operational protocol discussion, and a discussion regarding burn rates. It will likely be a short call today. Regarding administrative updates for people attending HPBA's Expo in Atlanta, Lisa noted that the proposed meeting on Tuesday will not work, as not enough people can attend. It is not clear how many people from the States can attend the Expo, but Lisa may have a better sense of that next week. If a face-to-face meeting happens at the Expo, Lisa noted that it may happen on Thursday or Friday. Lisa will nail this down via e-mail. There were no further questions on the Expo or administrative updates.

- Lisa began recapping the operational protocol discussion from the last meeting. The O/F work group (WG) had talked about the idea of moving into integrated/composite runs rather than the hot-to-hot run in Method 28. Lisa noted that they were contemplating NESCAUM having funding to support testing at Mark Champion's lab to examine different operational protocols. Lisa is in the process of preparing a sample work plan for this, including running multiple loads at the

same burn rate and also varying operations within a single test run. Lisa asked that anyone interested in providing feedback on the sample test plan to please e-mail her with their suggestions regarding drafting the sampling protocol.

- Lisa launched the discussion regarding burn rates, that had begun during the last WG call. Lisa noted that ASTM has moved away from [Method 28's] previous definition of burn rates. Lisa put the following CSA B415 burn rates on the screen, noting that CSA 8.2.3 is the same as Method 28. **Note**: *Rick Curkeet later clarified that the following CSA slide refers to year 2000 definitions [and CSA section locations] of burn categories, not the most recent 2010. In the 2010 version, there is no "5.3 or less" caveat [and these burn rate categories are located in CSA Section 7.1.4.2]. Rick further clarified that the default burn rate categories under the 2010 CSA B415 are [located in Section 7.1.3] as follows: Category 1 is < 35% of the max burn rate; Category 2 is ≥ 35% and <53%; Category 3 is 53% to 76% of max burn rate; and Category 4 is the max burn rate*. Amanda confirmed that as well. Lisa apologized for her outdated slides.

CSA B415 Burn Rates

8.2.3

For appliances having a maximum burn rate at or below 5.3 kg/h, one emission test run is required in each of the following burn-rate categories (rates in kg/h dry basis):

Category 1	Category 2	Category 3	Category 4
<0.80	0.80 to 1.25	1.26 to 1.90	Maximum rate 5.3 or less

8.2.4

For appliances having a maximum burn rate above 5.3 kg/h, one emission test run is required in each of the following burn-rate categories:

Category 1	Category 2	Category 3	Category 4
<15% of maximum	15% to 24% of maximum	24 to 36% of maximum rate	Maximum rate

- Lisa noted that while [the above] are the published burn categories, Method 28's Category 1 is often below 1.0 kg/hr [rather than below 0.80 kg/hr as listed] because that's allowed as an alternative [if below 0.80 is not achievable on the stove].

- Bob Ferguson noted that origin of the 4 burn rates goes to Oregon Method 7, developed by OMNI 35 years ago, for Oregon DEQ. Bob explained that the concern then was that most people were operating their stoves at very low air settings; hence the emphasis on low burn rates. The Oregon DEQ took off followed by Colorado and that database became the basis for the original NSPS which was a regulatory-negotiation (or "reg-neg"). Bob noted that CSA B415 was just the Canadian version of M28. In 2010, CSA added central heaters (mainly warm-air furnaces) including the CSA B415 option that uses percentages of max burn rates. Bob explained that it was identified that having a prescribed fixed low burn rate pushed the designs in ways that were

only there to meet testing requirements. CSA had a different idea –that is, that the low burn rate could be a fraction of high burn rate rather than a fixed number.

- Bob continued that, the reason the >5.3 kg/hr was in the CSA regulation, was to be consistent with hydronic heater regulations. When ASTM looked into redoing M28 in 2009, there was a lot of discussion about whether 4 burn rates were necessary. ASTM ultimately determined that 3 burn rates were adequate to define performance across the range and [going to 3 burn rates] cut out an unnecessary test to reduce cost and allow an extra run. Bob noted that he has put a lot of that historical data up on Basecamp, which shows what happens when using 3 burn rates.

- Bob subsequently clarified (via e-mail to Jill Mozier) that moving from 4 to 3 burn rates happened in the 2010 version of ASTM E2780 (the updating of EPA M28) and ASTM did a lot of analysis to understand the impact of eliminating one burn rate. There was full support for moving to 3 burn rates, including from EPA at the time, according to Bob, because the extensive data analysis was quite convincing. Bob further noted that the move to 3 burn rates was tied directly to a change in the way the data is weighted. It is the combination of the two that makes it all work

- Bob continued that, in addition to getting to 3 burn rates, the ASTM method allows the use of a percentage of the max burn rate – e.g., ASTM uses 35% of high burn rate to define the low burn rate and thereby allows getting over 1 kg/hr at this low end. Bob explained that ASTM's low burn category recognizes that for a large unit, sized right, the low burn rate will be higher than 1 kg/hr. Bob noted however that even though EPA was accepting of [this] low burn rate, the Agency was still tied into [their defined] low burn rates. Bob pointed to a paper by Dr. Houck that looked at that disconnect, and ASTM ultimately increased its minimum burn rate from 1 to 1.5 kg/hr. EPA has still been requiring a burn rate under 1 kg/hr on crib, however.

- Regarding a cordwood method, Bob noted that ASTM started thinking differently of test runs. Bob noted that he had located the mini reports from ASTM on this topic and can probably post them to Basecamp. Bob opined that it's great that the O/F WG is looking into how to define burn rate categories again. Bob noted that ASTM's idea for a low minimum burn rate was to allow for/represent an overnight burn rate. ASTM defined the overnight burn rate as an 8-hr burn rate – and for most stoves, that aren't small, this is not a problem. Bob clarified that the 8-hr burn means large stoves can get an 8-hr burn with something above 1, up to 1.5 kg/hr. But ASTM recognized that some small stoves cannot meet/achieve an 8-hr burn and therefore these stoves still are required to meet a minimum of 1.15 kg/hr. Bob explained that ASTM formulated it this way because ASTM wanted to define separate definable burn rates and take away the arbitrary fixed minimum burn rate. Bob pointed out that this was sort of what CSA was doing when they used a % of the max burn rate. ASTM tried to do this as well and then took it a step further by redefining these burn rates.

- Bob subsequently clarified (via e-mail to Jill Mozier) that CSA based the burn rate categories on % of maximum burn rate without other conditions. For stoves, the minimum burn rate must be 35% or less of the maximum. So, minimum burn rates start to climb above 1.0 kg/h (the current

M28 requirement) when the maximum burn rate is above 2.86 kg/h. If the maximum burn rate is 4.0 kg/h, the model must only achieve a minimum burn rate of 1.4 kg/h or less. This does level the playing field by recognizing that larger stoves are intended to heat larger spaces and the need to force a burn rate of 1 kg/h or less is not a fair requirement. ASTM backed off the % based burn rate definitions when it was obvious that there was not consensus (at that time, at least) to move in that direction.

- Bob continued that ASTM calls it a "low fire" test and there's a time requirement (8 hours). If the stove (e.g., some small stoves) can't meet/achieve the time requirement of 8 hours, then there's a burn rate limit (of 1.15 kg/hr) that must be achieved. Bob noted that the cap is 1.5 kg/hr for a stove that can burn for 8-hours; and if the stove that can't meet the 8-hour time requirement, then the burn rate may not exceed 1.15 kg/hr for ASTM's low fire test.

- Bob noted that there was an evolution ASTM went through – going from 4 to 3 burn rates was based on crib data and on EPA's certified database. ASTM then moved to cordwood and redefined burn rates, but still require stoves to be tested at the maximum and minimum air settings and also at a medium burn rate – which ASTM defined as in between the max and min, but in the lower half of that range.

- To aid the discussion, Lisa put the following slides on the screen during Bob's explanation –

ASTM High Fire

9.5 *High Fire Test Category*

9.5.1 *Start-up Conditions* – Appliance operation for the high fire test category employs a cold start. The average heater surface temperature per 9.2.2 and flue-gas temperature per 9.2.4 at the start of the test run shall be less than 10°F, (5°C) above ambient.

9.5.2 *High Fire Test Primary Combustion Air Control Setting* – The primary combustion air control(s) shall be at the highest setting(s) at all times during the high fire test run.

9.5.3 Other manual air control(s) shall be set at the position(s) in accordance with the manufacturer's written instructions. Automatically operated controls shall be allowed to operate as designed.

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ASTM Draft – Low Fire

9.7 *Low Fire Test Category*

9.7.1 *Low Fire Test Combustion Air Control Setting* – For the low fire test run, the combustion air control(s) shall be set at the lowest airflow position and must result in a burn duration of at least 8 hours or a minimum burn rate less than or equal to 2.54 lb/h (1.15 kg/h) dry basis. The duration of the test is defined as the period of time from the beginning of the load time per 9.6.5 to the test run completion defined by 9.6.12. When the 8 h minimum burn duration criterion is used, the minimum burn rate shall not exceed 3.31 lb/h (1.5 kg/h) dry basis.

9.7.1.1 The primary combustion air control(s) shall be at the lowest setting(s) at all times during the low fire test run except as allowed by 9.6.5, 9.6.6 and 9.6.7.

9.7.1.2 Other manual air control(s) shall be set at the positon(s) in accordance with the manufacturer's written instructions. Automatically operated controls shall be allowed to operate as designed.

- Regarding the above low fire slide, Bob noted that the low fire definition is close to final, but is missing one sentence from the final version. Bob clarified that ASTM's Low Fire = minimum 8 hours burn duration but with a burn rate not to exceed 1.5 kg/h. If the model can't meet the 8 hour burn duration, the minimum burn rate must be ≤ 1.15 kg/h. So, in other words, no Low Fire Burn rate can exceed 1.5 kg/h and small stoves that can't make the 8 hours must have a Low Fire burn rate at 1.15 kg/h or less. Bob noted that the air settings have to be at their lowest setting (which is the same as in M28, except that in M28 the stove must not exceed a burn rate of 1 kg/hr). Bob further noted that some stoves have secondary air controls and the ASTM method allows those to be set as the manufacturer recommends; automatic controls are also allowed to operate as recommended.

- Bob noted that ASTM had a wide variety of people and opinions on this topic and realized that they had to try to link back [any changes] to the existing database. As such, ASTM didn't want to take giant steps away from the Oregon database and what EPA was comfortable with. Therefore, Bob explained that ASTM took smaller steps along the way rather than one big step at once, because ASTM couldn't garner support of all stakeholders and of the EPA if large steps were taken.

- Lisa Rector noted that the O/F WG needs to make a decision ASAP regarding these two very different approaches [to burn rates]. In M28, the burn rates are specified/fixed. In ASTM, the high burn rate is the high air setting, the low burn rate is the low air setting, and then the medium burn rate falls in between of low and high. Bob Ferguson added that ASTM still put conditions on those general categories – that is, if the stove can't meet the 8-hr burn (with the not-to-exceed burn rate cap of 1.5 kg/hr), then the stove must not exceed a 1.15 kg/hr burn rate. In this way, it's a bridge backwards [to the existing database] too, Bob explained.

- Lisa Rector underscored, however, that the ASTM method moves from 4 to 3 burn rates and specifies test parameters rather than design parameters. So, it's a change in philosophy. Lisa noted that the WG needs to understand where the state regulators are on this philosophical discussion. Lisa observed that industry and labs are behind the ASTM method; but the WG needs to know how many states are also comfortable [with ASTM's approach] so the work can proceed. Lisa emphasized that this decision is critical in order to proceed. Lisa noted that EPA is still fairly wed to 4 burn categories. If this group recommends 3 burn rates then it's important to understand what research EPA needs, that it doesn't have already, in order for the Agency to become comfortable with 3 burn rates. Lisa asks if there was anyone in the WG who wants to stick with 4 burn rates.

- Randy Orr replied that how [the stove] tamps down needs to be captured, noting that start-up has the highest emissions and 3 burn rates might be fine. However, perhaps the dampers should be closed, not open.

- Bob Ferguson noted that the burn rate categories and the way emissions are averaged are inextricably linked. Therefore, ASTM also looked at weighting schemes and moved away from EPA's probabilistic weighting scheme, which is complicated. ASTM looked at how to weight the burn rates in its method. Bob explained that ASTM's weighting puts 80% toward the lower end of burns and that's very similar to EPA's certified stove data. ASTM's 40/40/20 weighting scheme for the 3 burn rates has a lot of agreement with EPA's 4 burn rates. Bob noted that it's important to look at the weighting of burn rates to determine how it compares to EPA's current M28 weighting. Bob reiterated that burn rates and weighting are linked. Randy Orr replied that he would think about it further.

- Lisa Rector remarked, regarding the low burn rate, the air setting should be at low air flow. Lisa noted that there's start up and then high emissions over a long time due to less than ideal burn conditions, in order to get to an 8-hour burn. Lisa further noted that moving to 3 burn categories seems to make sense and explained that NESCAUM mined [burn rate] categories 2 and 3 and found the closest alignment in those two categories. Lisa commented that something will have to be given up, but it's difficult to provide sufficient information to EPA to determine compliance. Lisa explained that EPA must be given a dataset that shows that moving from 4 to 3 burn categories is enough to determine compliance. ASTM has probably done a lot, but Lisa noted that the WG will need to speak with Stef Johnson and Mike Toney to figure out what EPA needs to be more comfortable [with 3 burn rates instead of 4].

- Bob Ferguson explained that ASTM looked at Category 1 plus 2 and Category 1 and 4 together, and all of that information/analysis is posted. The correlation between M28 and the 3 burn rates can be examined. Bob noted that this work was done 7 years ago, in conjunction with going from M28 to E2780, which was ASTM's crib method with a cordwood annex. Bob further noted that Gil [Wood of EPA] was very involved. There's a good track record and the information is there, if someone wants to re-analyze the data. Bob noted that he had already analyzed data from 100 or so stoves and, in those results, one can see that there are some differences when

you have stoves with unusual emission profiles – that is, stoves with big changes from burn rate to burn rate, a radical slope up or down. Bob explained that, for those stoves with emission profiles that are more level (less changing/radical), the weighting scheme becomes much less sensitive. Out of 140 stoves, those with changing/radical slopes from burn rate to burn rate were farthest away from equivalent numbers; but there were a whole bunch of stoves which were nearly identical. Bob concluded that the weighting doesn't matter at all for stoves with flatter emission profiles.

- Rick Curkeet noted that the CSA B415 fuel section allows for either cordwood (with specifications similar to ASTM specifications) or crib wood as an option. Rick explained that CSA B415 allows a test to be run using M28 burn rates and crib wood fuel crib, so it's compatible with the existing EPA requirements; but it also has other options using cordwood for stoves certifying only to CSA.

- Lisa Rector pointed out that there are essentially 3 choices: burn rates based on a % [of the max burn]; using 3 burn rates [as ASTM uses]; and using the 4 M28 burn rates. Rick agreed that was correct and explained that the reason 35% was chosen is that if you calculate actual percentages from EPA's database regarding what percentage low is of high, 90% of the stoves in the database have low burn rates that are between 30 and 35% of their max burn rate and the average is 31%. So, Rick concluded, using 35% of max burn rate [for the low burn rate] would match the EPA categories.

- Lisa Rector noted that she had to leave the call shortly and asked how people in the WG wanted to move forward with deciding these burn rate categories. Lisa asked if people needed more technical data to decide or if they had enough data already.

- Bob Lebens remarked that WESTAR had advocated for a low burn rate requirement in their NSPS comments, so maybe more information is needed. Bob noted that, as we try to make the test method more reflective of how units are operated, maybe we need to look again at the low burn rate. Bob wondered if it is a heat load issue and opined that these units do need to be challenged at low burn rates because that's where they are dirtiest and the controls are least effective.

- John Voorhees noted that the reason [stoves] have low burn rates is because it's required [in M28]. John wondered therefore if a stove needs to be turned down that low. John asked: If a stove can only be turned down to 1.5 [kg/hr burn rate], why does it have to be tested lower than that?

- John Wakefield pointed out that that [burn rate] may be the lowest a stove can go on a full load of wood, but it could go lower with a partial load. John asked however, why a manufacturer is forced to go lower on a full load.

- Bob Lebens noted that he was mindful of time and that this topic probably needs to be discussed in more depth, as there are a number of ways to look at this problem.

- John Voorhees agreed, noting to Lisa Rector that it should be an action item for the next call. Lisa agreed that was a great idea, noting that this issue is a key question – that is, should the test method [essentially] be setting design parameters or should the test method be challenging the unit to burn cleanly as designed. John Voorhees replied "Exactly."

- Rod Tinnemore noted that he agreed the test method needs to move beyond the constraints that were put on. Rod further noted that he is not sure why EPA went that route but maybe stoves were highly adjustable back then. Now, however, Rod opined that stoves should not be pushed to run/burn where they can't run/burn. Rod noted he would like the WG to discuss this issue.

- Cindy Heil also commented that she would like to talk about this topic [on the next call] as well.

- Lisa Rector asked the WG if it needed more information or if members had enough on Basecamp already to review and be prepared for the next call. Lisa asked the WG if it could discuss and decide this issue on the next call.

- John Voorhees replied that the WG should aim for both a discussion and decision on next call.

- Lisa Rector noted that she and John Crouch could outline the 3 approaches discussed on the call today and point folks where to get more information. WG members should bring their thoughts and [on the next call] a pulse of the room will be taken to see if we have consensus and can move forward.

- Bob Ferguson noted that he had additional information that is not posted to Basecamp, including looking at the EPA database from the perspective of CSA's percentages. Bob offered to post this to Basecamp.

- Lisa Rector noted that she had to leave the call, but this discussion could continue on the WG's next call in February.

- John Crouch noted that the WG needs to frame any remaining questions in writing. As homework over the next 7 days, John asked that WG members frame questions and post them to Basecamp in writing so that others can see and look for responses.

- Bob Ferguson noted that he could point people in the right direction, if there are very specific things that people need to see and can't find them on Basecamp. John Crouch agreed and encouraged people to ask Bob Ferguson for specific information, as there has been an avalanche of material on this topic since 2009. So, WG members may need a guide through the material.

- Bob Lebens agreed that more discussion on this topic is needed, noting that consensus may not be reached, but it's worth talking about more.

- John Crouch agreed to have further discussion on the topic and noted that nothing more is left on the agenda for today's call. The WG will meet in 2 weeks at noon to discuss this topic.

- Thank you to all. Meeting adjourned.

EPA Notes Operation and Fueling (O/F) Workgroup Meeting Notes from February 9, 2017 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), **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:

- The workgroup (WG) discussed ASTM's hybrid approach to defining low, high and medium burn rates along with capped minimum burn rate(s) and burn duration requirement; the idea of basing burn rates on how the individual stove being tested was designed; the continued need (or not) for a specified minimum burn rate (as in EPA's Method 28); the importance of heat output to the consumer and the consumers' tendency to burn at low settings; the problem of a stove's low air setting being designed to meet M28's low burn requirement on crib and then burning cordwood in the field (in-homes); the value of moving toward a test method that better reflects in-home use; and the value of labeling the tested burn rates and achievable burn duration of each stove for the consumer (while allowing stoves to be tested based on their individual design).

- The WG voting members present on the call voted on which of the following 3 concepts to move forward with as a basis for burn rates in a cordwood test method. Seven (7) of the voting members present voted for #1 below, while 1 member voted for #2, with 4 votes TBD:

    1. Let the manufacturers design the stove and test according to that design (i.e., the low burn rate is whatever the lowest setting and burn rate is for that specific stove, the highest burn rate is at the max air setting for that stove and the medium is in between), aka "definitional burn rates";
    2. Specify burn rates with fixed numbers regardless of the individual stove being tested (i.e., define burn rates as M28 does); or
    3. Specify burn rates as a percentage of the maximum burn rate for that stove.

- The O/F WG voting members voted as follows:
    - Gregg Achman – #1
    - John Crouch – #1
    - John Voorhees – #1
    - Rod Tinnemore – #1
    - Cindy Heil – #1
    - Randy Orr – #1, but with the caveat that the burn rates and burn times must be expressly indicated on the label
    - Bob Lebens – #2
    - Lisa Rector – #1, with labeling requirement
    - Ben Myren – not present, Lisa will contact and obtain his vote;
    - Tom Morrissey – not present, Lisa will contact and obtain his vote;
    - Tom Butcher – not present, Lisa will reach out to and obtain his vote;
    - Lisa Herschberger – not present, Lisa will contact and obtain her vote.

- The WG agreed to discuss refinements to the definitional burn rate approach on February 23rd using the draft ASTM cordwood method as a starting point – for example, should ASTM's 8-hour burn duration be required with capped minimum burn rates or should these requirements be dropped in favor of strict labeling requirements.

To-Do List:

- Lisa Rector, John Crouch and Bob Ferguson may put a chronological summary together regarding ASTM's process in developing the approach taken in the ASTM draft cordwood method.

- Lisa Rector will obtain the votes of the 4 WG voting members not present.

- John Voorhees will prepare a short summary (~3 sentences) of the refinement being contemplated (ASTM's refinement versus John Voorhees' market-driven labeling idea) and e-mail it to Lisa Rector and John Crouch for editing. Lisa Rector will post the refinement summary to Basecamp so WG members could review it prior to the next meeting on February 23rd.

- Bob Ferguson will send Lisa Rector the current ASTM draft cordwood method and Lisa will post it to Basecamp for everyone.

Highlights from Meeting:

- Lisa Rector opened the workgroup (WG) meeting, noting that the meeting was being recorded since meeting note-taker, Jill Mozier, could not be present on the call.

- Lisa noted that the following people were in attendance: John Crouch, George Allen, Gregg Achman, Amanda Aldridge, Bob Lebens, Cindy Heil, Mark Champion, Gaetan Piedalue, John Vorhees, Kelli O'Brien, Randy Orr, Bob Ferguson, Rod Tinnemore, Mike Toney, John Wakefield and others who may have joined the meeting after roll-call.

- Lisa noted that on last week's call the WG left it that burn rates would be discussed today and that a vote would be taken regarding where the group is going with burn rates. Lisa further noted that since some voting members are missing today, the floor would be opened up for discussion on different ways to define burn rates within the test method and the pros and cons of each of these ways would be discussed. When the end of that discussion is reached, Lisa noted that she would like to take a vote to see where the group is on this issue. Lisa noted that 4 voting members were not present on the call but, according to the rules agreed upon for the WG, these voting members could vote subsequent to the meeting.

- Lisa reminded the WG that the following people are voting members: Cindy Heil, Tom Butcher (not present), John Crouch, Gregg Achman, Lisa Herschberger (not present), Ben Myron (not present), Randy Orr, John Voorhees, Rod Tinnemore, Bob Lebens and Tom Morrissey (not present). Note: Lisa Rector is also a voting member.

- John Crouch noted he thought this [how to handle burn rates in the cordwood test method] is a fundamental question that the states need to decide. John explained that industry has some consensus about this issue already, as determined by the ASTM process. So, John noted that he hoped states/regulators could reach some consensus.

- Lisa asked Bob Ferguson to summarize for state regulators where ASTM is [on the burn rate issue] and why the ASTM group came to the conclusion they did.

- Bob Ferguson noted that he had hoped to provide cliff notes on burn rates to the WG, but he'd been unavailable/too busy recently. Bob had pulled together 25 separate meeting reports and documents all of which contain some information on burn rates, starting back in 2013 when ASTM initiated the cordwood test method (CTM) process. Prior to 2013, the CTM was an annex to the crib method (i.e., in ASTM E2780). In 2013, ASTM moved to develop a standalone method for cordwood. Bob noted that burn rate categories are a big part of that CTM effort and many approaches were proposed. Lisa Rector, John Crouch and Bob Ferguson will see if they can put a chronological summary together.

- Bob continued that one big change from having very specific burn rates defined in kg/hr was ASTM's move away from that to redefining the low burn specifically as representing an un-tended fire or overnight burn, with a minimum burn duration of 8 hours. ASTM's proposed CTM also recognizes that an 8-hour burn may not be possible for all stoves. Bob noted this was discussed over many meetings and it was concluded that an 8-hour burn would be the primary criterion, but that smaller stoves [not able to burn for 8 hours] would still have to meet a 1.15 kg/hr burn rate. Bob noted that ASTM also put an upper limit [of 1.5 kg/hr] on [the 8-hour burn] as well, because there was some concern that big stoves could have too high of a burn rate. All decisions were reached by discussion until consensus was achieved among ASTM's large diverse group.

- Bob noted that these ASTM discussions led to the minimum burn rate definition being tied into loading density (lbs/cubic ft) and also what the test load looked like, for the low fire test. ASTM was able to get some testing done in 2014 by Mark Champion and this testing was helpful in looking at all burn rate categories. Bob explained that, for a long while, burn rates had been looked at in the context of hot-to-hot tests (that is, starting and ending on a hot coal bed) such as in M28 and the current ASTM (E2780). But a paradigm shift occurred at the end of July 2014 when ASTM moved to introduce the cold start. This had an impact on how burn rates would be defined. So, Bob noted that he tends to consider [wood heater testing history] in terms of a pre-cold-start era and then a post-cold-start era.

- Regarding ASTM's high, low and medium fires: Bob explained that the high fire burn rate is straightforward: from a cold-start, the max air setting is used followed by slightly lower load of wood that's allowed to run until 90% of the fuel is burned. The low fire burn is a hot-start at a higher loading density at 12 lb/cubic feet and the low burn rate definition requires an 8-hour burn [not to exceed 1.5 kg/hr] or meeting a minimum burn rate [of 1.15 kg/hr]. The medium fire is defined to be less than 50% the difference between the high and low fire [burn rates], which puts the medium fire burn rate in the bottom half of the operating range. So, Bob concluded that those are the 3 [ASTM] burn rates.

- Bob had intended to create a summary from the 25 documents looked at, but he ran out of time, as it was not as straightforward as he hoped. Bob noted that ASTM's task group asked complicated questions about what they were really doing. When stuck, ASTM's prime directive was how to best simulate what people would do in their homes. A secondary consideration was guarding against creating too much variability in the method when deciding to take one course of action versus another. Bob pointed to the example of dividing a load into 3 sections and adding it in parts to simulate someone who wants a medium fire before bed, by putting logs in every 1 to 2 hours. Bob noted that all of this was addressed and discussed, but ASTM needed a means to judge if the task group was moving in the right direction. The information from Mark Champion's testing was used to assess whether or not the task group's proposals passed the reasonable test.

- Bob concluded that that's the quickest summary, but answering questions the WG has may be more informative. Bob again summarized that ASTM's CTM does assess using individual test runs, including a cold-start high fire, a low fire, and then a medium fire in the lower half of the operating range. So, Bob noted, ASTM's CTM does focus the weighting on the lower half of the operating range and, in conjunction with weighting, puts 80% [of test] in lowest two categories, where stoves are more sensitive to issues.

- Lisa thanked Bob for his summary and asked Bob if, for the ASTM method, the stove is tested at the lowest air setting for the low burn rate. Bob confirmed that was correct and clarified that the stove is tested at the lowest setting consumers can push the stove [controls] to. Lisa noted that this means essentially the manufacturer/stove model determines what the lowest air setting is [for ASTM's low fire test].

- John Crouch reminded the WG what Bob said regarding the ASTM task group wrestling with this issue – that is, how to avoid the manufacturer setting low at 50,000 BTUs, an absurd setting. To avoid this, the caveat in the method requires that, because of the higher load of cordwood (higher than the crib load), the stove needs to have a target of an 8-hour burn, since consumers expect this. John pointed out that this is an important caveat because, although the lowest setting is determined by the manufacturer/stove, the ASTM task group put some effort into bounding that low setting, so that it's consumer-friendly. Even with a big stove, the burn rate can't exceed 1.5 kg/hr at the low setting, at least as it's defined today. So, the stove must burn for 8 hours and not more than 1.5 kg/hr, or it has to burn at less than or equal to 1.15 kg/hr. In other words, there are still tight constraints on what that low burn rate can be.

- For clarification, Bob Lebens asked what "not higher than 1.5 kg/hr" meant. Bob Ferguson explained that a large stove that holds a lot of wood, with high BTU output or a high burn rate, can easily achieve an 8-hour burn that may have a 2.5 kg/hr burn rate at even the lowest air setting. Therefore, the ASTM task group recognized the need for a limit/cap on how high the low burn rate could be. The ASTM task group recognized, for example, that for a 4.5 cubic foot stove it should not be permissible to call 2.5 kg/hr that stove's low burn rate just because the stove was at the lowest air setting. The task group agreed that was too high a burn rate, even if the stove met the 8-hour primary criterion. Therefore, the task group included a reasonable not-to-exceed low burn rate of 1.5 g/hr; otherwise the stove would overheat people in their homes.

- Bob Ferguson further noted that another way to explain this was a graph he had previously prepared (that he could send out) to show this issue. If one does the math, it becomes clear that at a certain size firebox – and with a 12 lb/cubic ft load divided by 8 hours – a 2.5 kg/hr low burn rate can easily result. For small stoves, 2.5 kg/hr may be their max burn rate. Therefore, Bob explained, the ASTM Committee at the time didn't want to get away from the recognition that people often operate their stoves at lower burn rates and own stoves that, even if properly sized, would not be able to get down to the lower end of the burn rate range. Such a stove could achieve perhaps a 12 or 16 hour burn and meet the 1.5 kg/hr burn rate requirement. But, the ASTM Committee didn't want the minimum setting to be too high, just because the stove was large and could be loaded with a lot of wood.

- Lisa noted that the ASTM language requires both an 8-hour burn and that the device be set at the lowest burn setting. Lisa asked for confirmation that there's therefore no wiggle room for the manufacturer to set it higher than the lowest air setting. Bob Ferguson confirmed that was correct and noted that ASTM wanted it to be at a setting equivalent to what the consumer would do and so the requirement is to put the device at the lowest setting. Bob clarified that it's not appropriate to, for example, set the device at 1 inch open [for the low fire test] with a device that can go lower than that – as emissions would in that case not be measured as low as the device could go – even if that device could meet ASTM's burn rate criteria. Bob noted that this was discussed quite a bit [by the ASTM committee].

- Bob Ferguson further noted that the current M28 has an interesting "out" that hardly ever gets used. Bob explained that M28's low burn rate definition is less than 0.8 kg/hr, but any runs less

than 0.6 kg/hr don't have to be counted. According to Bob, this recognizes that if the device can meet 0.8 with its air controls, then the requirement has been met, even if the air controls can go lower. But Bob noted that this "out" has hardly ever been used to his knowledge, and it's confusing in the test method and regulatory language. So, ASTM's requirement, on the other hand, is simply to turn the stove to its lowest air setting and that [by definition] is low. How much air that represents is up to the manufacturer but it does represent where the stove's air is at its lowest setting from the consumer's perspective. Bob noted that some of this discussion and resulting language is coming up on its 3rd or 4th year of existence and ASTM has moved onto other issues. But, Bob pointed out, ASTM was more closely tied into maintaining some connection to M28 and its burn rate definitions by not straying too far afield. For example, Bob explained that ASTM was never really at the point in the conversation then of proposing that low is whatever the manufacturer says it is; if the stove can only burn for 4 hours then the consumer will hate it and the stove won't last long in the marketplace. Rather, ASTM recognized then a need to maintain some semblance of a defined low burn rate in the method.

- Lisa noted that describes ASTM's low fire requirement and asked for confirmation that ASTM's high fire requires the device to be on the highest air setting. Bob Ferguson confirmed that was correct, noting that high is the opposite end of the spectrum. The combustion air control must be at the max setting for the high fire.

- In response to Lisa asking Bob Ferguson to explain the medium burn rate more, Bob replied that the medium burn rate was an interesting problem and the reason ASTM ended up where it did was specifically because of the testing that Mark Champion did. Bob explained that ASTM proposed that the air control had to be at the point visually halfway or lower of the distance between the high and low air settings. Thus, ASTM proposed that the medium fire air setting would be a visual reference, with the air control placed in the middle of the operating range. Bob noted that many stoves at high typically operate at wide open and other categories all occur in bottom half or below of visual [halfway point in] range of controls. Bob explained what drove the definition [of medium fire]. When Mark Champion ran the high fire tests (from cold starts), the tests were cut-off at 90% because the long tails were doubling the length of the high fire test. Bob noted that in some cases there were 6-hour high fire tests because of this long tail. So, half of that time was burning the last 10% of the fuel. Bob explained that, interestingly enough, Mark Champion's [and Ben Myren's] analysis of the data showed that cutting-off the test at 90% fuel consumption will provide an appropriate high fire test and, by burning the remaining 10% at the exact same air setting, the stove happens to fall into ASTM's definition of a medium burn rate.

- However, Bob explained that ASTM did some conceptual development to ensure that the medium runs would be run with the air control setting in the position of medium heat output, rather than merely meeting the burn rate criteria of being less than half the burn rate between high and low. Bob explained that ASTM wanted to avoid the medium burn rate being merely an artifact of a test method and rather be based on a physical action on the stove, to cause the stove to burn slower. Bob noted that there's quite a bit of discussion in the ASTM reports regarding this. Mark Champion's data was helpful in underscoring the need for specificity about

how the medium fire is defined to ensure an air control setting is made and that the actual burn rate is achieved because that air setting was turned down. ASTM was trying to get the medium fire to be in the lower half of the operating range in recognition of the fact that people operate their stoves more often in the lower half than the upper half of the range.

- Bob noted there exists a no man's land where a medium test could be run and not make the burn rate criteria as defined, but rather end up too high, somewhere between what ASTM calls medium and high fire (that is, a "no man's land"). Bob explained that those tests have to be repeated with the air control set lower to ensure they meet the medium point. [Note that ASTM's 1-3-2017 draft CTM states the following regarding the *Medium Fire Test Combustion Air Control Settings –The primary combustion air control(s) shall be set at a position no greater than half-way between the lowest and highest primary air control settings as measured on the control actuator (lever, knob, etc.). The half-way setting may be a linear or angular position depending on the air control actuator. If the resultant dry burn rate is greater than the mid-point between the dry burn rates for the low fire and high fire test runs, the primary combustion air control shall be set to a lower position and the test run repeated*.] Bob further noted that ASTM's definition did accomplish the objective of ensuring that 2 out of the 3 burn rates were in the lower half of the appliance's burn capabilities – that is, one burn rate is the lowest and second is in the lower half of the burn rate capabilities of the appliance.

- Bob Ferguson opined that anything the O/F WG proposes will need to be confirmed by testing because of the possibility of unintended consequences, especially if the test runs will be ended prior to 100% of fuel consumption or have other definitions for the end of the test. The end of test definitions will all impact the category definitions. So, for instance, Bob noted, if all tests are going to be cut-off at 90% [of fuel consumed], then the 8-hour burn may have to be rethought, because a stove that could otherwise burn for 8-hours may not be able to do so if the test is cut-off at 90%. Bob noted that it's important to understand how elements of the test method are intertwined. The ASTM protocol as defined was exercised to the point where no unintended consequences were ensured. An example of this was the medium burn rate work [explained by Bob above], where the ASTM task group realized there could be an unintended consequence, depending on how the medium burn rate was defined and what was required in the test. Hence, the requirement of a physical change in the air control setting to a medium or lower position.

- Lisa noted that, based on John Crouch's introduction, it sounds like the industry is solidly behind this definition of burn rates. Lisa further noted that industry folks on the phone who disagree should feel free to contradict that claim. Lisa wondered what the regulators think – e.g., whether or not regulators have concerns about the ASTM method, or support a different burn rate definition/test method such as the two alternatives discussed last week. Lisa reminded the WG that the two burn rate definitions discussed last week are (1) burn rates being defined as a percentage of maximum burn rate, which is not a definition used with stoves to-date, but which has been used by CSA for central heaters; or (2) the burn rate definitions currently used in CSA as well as in M28 for the crib test.

- John Voorhees, calling at 1:30 in the morning from China, noted that he appreciated Lisa's effort. John commented, regarding whether or not industry is fully behind the current definition of burn rates [in ASTM's draft CTM], that he's not sure if the answer is yes or no. John opined that, regarding the low burn rate, industry felt that some kind of [specified] minimum low burn rate was needed because of EPA's perceived feelings and history behind M28. John noted therefore that it may be worth asking industry on the next call whether or not industry feels like they need to be saddled with a minimum burn rate. John noted that he's bringing this up in light of the knowledge he's gaining regarding European testing, where there is no specified minimum burn rate number. Rather, the minimum burn rate is determined by the lowest air setting on that particular stove. John reiterated that industry has been saddled with a minimum burn rate for over 30 years and perhaps it's time to consider whether the market should determine what the minimum burn rate is, rather than a technicality forcing the stove to burn at possibly an unrealistic number and produce more emissions.

- Bob Ferguson explained that ASTM uses a consensus process, so the end result was a compromise among all parties – that is, everybody got to the point where they could live with the end result, although it may not have been anyone's first choice. Bob explained that the end result was an interaction from different perspectives. Regarding the percentage approach to burn rates that Lisa Rector mentioned, Bob noted that ASTM put that into its original crib method, ASTM E2780, with the understanding that at that point in time EPA would not allow it [as a certification test method]. When ASTM moved onto the draft CTM, ASTM discussed it again in detail and got the same feeling from EPA – therefore, ASTM moved off it. Bob clarified that people are not unsupportive of the percentage idea. However, the current draft CTM [that does not include the percentage approach] resulted from a consensus process, in which common ground was sought.

- Lisa thanked Bob for that history and noted that, one of things that John Voorhees raised, is that the low setting requirement in the ASTM method includes a caveat. So, with respect to the ASTM method, there might be a question of whether that 8-hour burn rate time should remain. Lisa asked John if she was understanding him correctly – that is, she understands John to be supportive of testing at the lowest setting, but not supportive of also requiring an 8-hour burn.

- John Voorhees replied that perhaps neither a specific burn time or burn rate should be required. Thinking outside the box, John noted that he's wondering why parameters have to be put on the minimum burn rate. Rather, let the market decide that. John noted that, if a particular model of stove has a lowest air setting and that lowest air setting is used for the testing, perhaps it should not matter what that lowest burn rate time or burn rate is.

- Bob Lebens gave a different view. Bob Leben's general thinking is that the appliance needs to be tested in the range in which will be operated. In addition, Bob noted that what consumers are interested in are the BTU's delivered to the room. Bob Lebens further noted that the minimum burn rate limit of 1.5 kg/hour [explained by Bob Ferguson as ASTM's low burn rate cap] would seem to produce a fairly high level of BTU's, given the distribution of heat demand that people are looking for. Bob Lebens opined that, given that these are space heaters or essentially room

heaters, that minimum setting [of 1.5 kg/hr], that heat demand/output, will drive people out of the room.

- In response, Bob Ferguson explained that those numbers are stove size related and that [1.5 kg/hr] was for a large stove. That stove would have had to meet the 8-hour burn, but just couldn't go above the 1.5 kg/hr cap. Bob reiterated that that [large] stove would have made an 8- hour burn duration or longer, but couldn't go above 1.5 kg/hr. The 1.15 g/hr minimum burn rate cap is still in effect if a [smaller] stove can't make the 8-hour burn. Bob Ferguson noted that this is all about ensuring the stoves are properly sized to the size they're attempting to heat. Bob further noted that there are larger spaces being heated by a single stove and their heat demand is different than a small space heated by a small stove.

- Bob Lebens responded that he understood that and noted that, probably more important than the size question, is the fact that the most prevalent technology in use for certified appliances is non-catalytic technology that relies on secondary combustion air. Bob noted that, because of that, he understands it's a real challenge to produce clean burning stoves at the burn rate currently required by the NSPS. But, Bob Lebens further noted that he thinks there's good reason for that, honestly, because people do shut the stove down to produce the desired heat demand as well as to get an overnight burn. Bob Lebens opined that appliances really need to be challenged at those low burn rates, because it's difficult with lower combustion temperatures for those stoves not to produce a smoldering condition, at those low heat demands. Bob stated that he would challenge the industry folks that, because this is a performance-based standard and the technology currently [predominantly] adopted [non-catalytic] is really challenged in this area, the appliances really ought to be tested in a rigorous method, as they will be used in the homes, at low heat demands. Bob opined that he thinks there's good reason for the current low burn rate requirement. According to Bob, there's a distribution of heat demands out there that suggests that people will use the appliances at such low heat outputs. Bob noted that he knows it's a real challenge to get these appliances to burn clean at these low burn rates and so that challenge should be met by everyone cleaning up the appliances in that range in which they're used for heating.

- John Crouch responded that he didn't think anyone was suggesting they didn't want clean appliances. John noted that he didn't know how to respond because the implication of Bob Leben's comment is that industry doesn't want the appliances to be clean, or doesn't want to challenge them [with the test method]. But what Bob Ferguson went through is how industry – along with EPA and some states - after a lot of discussion came up with several things [in ASTM's method] which are much more relevant to how consumers use their stove than [what's required by] M28. First and foremost, John noted [that ASTM's method uses] a much heavier load of fuel, much heavier. The ASTM committee decided that when people burn their stoves overnight, they really pack it, so that load needed to be more. John noted next, regarding the assumption that people will always turn the stove down to their lowest setting, no one is arguing that it shouldn't burn cleanly at the lowest setting. John pointed out that ASTM set boundaries at what the lowest setting could be, so a manufacturer couldn't claim an absurdly

high lowest setting (such as 50,000 BTUs). So, John concluded that no one disagrees with Bob Leben's fundamental concept.

- Bob Lebens replied that people seem to have a problem with the current testing requirement of 1 kg/hr, since in this [ASTM] proposal it's 1.15 kg/hr and 1.5 kg/hr.

- Lisa clarified that right now, under M28's current burn rate, the minimum burn rate must be less than 1 kg/hr. However, Lisa asked for confirmation that, under M28, that might not be the lowest air setting. Bob Ferguson clarified that [at 1 kg/hr] it is the stove's lowest air setting and two runs are required. Bob noted that, that is the kick-out there, because the real burn rate is 0.8 kg/hour unless the stove can't meet 0.8 and then two Category 2 burns must be run. This is similar to what happens with hydronic heaters. So, Bob further clarified that 1 kg/hr is the defacto cut-off, but if that is the case, then the air setting has to be at the lowest setting.

- Bob Ferguson noted that he doesn't disagree with what Bob Lebens is saying. But, Bob Ferguson pointed out that an amazing shift is occurring going from crib loaded at 7 lb/cubic feet to cordwood loaded, in ASTM's method, at either 10 lb/cubic feet for high fire or 12 lb/cubic feet for low fire. Therefore, Bob noted that the burn rates that are relevant from EPA's M28 are totally irrelevant and the air settings are also totally irrelevant. Based on Bob's experience, there's a 50-50 chance that the stove's fire will go out when a stove that burns crib wood at a 1 kg/hr burn rate is loaded instead with 12 lb/cubic feet of cordwood at the same air setting. Such a load will require a completely different primary air setting to get the same burn rate. Therefore, Bob explained, anything the WG comes up with for the cordwood method has to be confirmed through testing, as it can't be assumed that what's relevant for crib applies to cordwood for certification.

- Bob Lebens responded that he can appreciate there will be these differences, but it's all about BTUs, as that's what the consumer is interested in. Therefore, Bob noted, that's an important comparison to look at.

- Bob Ferguson noted that he doesn't disagree and that ASTM did essentially look at ensuring that 2 of ASTM's 3 runs were in the lower half of the stove's operating range. And further that stoves have to be ~2.4 cubic feet before the 1.5 kg/hr cap would kick in. So, Bob explained, stoves smaller than 2.4 cubic feet are going to be living with [a low burn rate specification of] 1.15 kg/hr, whereas with M28 burning crib they'd have to meet 1 kg/hr. But, Bob again explained, it's an apples-to-oranges comparison based on what the testing revealed. Bob noted that his testing revealed (which Ben Myron would also confirm) that there are radical differences in what the stove's air settings will look like compared to today.

- Bob Lebens replied that while this may be the case, burn rate is burn rate; given the same efficiency that's going to be equivalent heat output. Going back to Lisa's question, Bob Lebens noted that if a stove can burn at lower than 1 kg/hr, then that's the minimum. Bob remarked that Bob Ferguson has noted in the past that manufacturers will mark the point at which the

stove burns at 1 kg/hr and that's where the stove's stop will be. However, if the stove tests below 0.8 kg/hr, [the lowest setting] doesn't have to be at that stop.

- Lisa Rector noted that she heard John Voorhees saying if someone wants to design a stove with a minimum burn rate that delivers 50,000 BTUs, then the manufacturer should be allowed to do that, that [the test method] shouldn't be putting these artificial constraints on the manufacturer. Lisa noted that she understands Bob Leben's concern to be if a stove like that were sold, then the unit shouldn't be able to be operated below 50,000 BTUs, to use an extreme example. Lisa asked Bob Lebens if he was concerned that the homeowner would do something to modify the stove, in such case, to get a lower burn rate. Bob Lebens replied that yes, he was absolutely concerned about that.

- Lisa concluded that that's the crux of the issue that Bob Lebens is having. It's not that Bob is necessarily opposed to the philosophical idea of letting the manufacturer design. Rather, it's the practical concern regarding what the homeowner will do to get the stove to deliver a lower heat load – that consumers will modify the stove to get there anyway. Therefore, Lisa explained, the minimum burn rate should reflect this because, even if the stove is not designed to get to such a low burn rate, the homeowner will make the stove get there.

- Bob Lebens noted that this concern is still relevant. Bob also noted that there's lots of different variables to consider in the various test methods and that he's open to being persuaded that the minimum [burn rate] level ought to be different than it is. But, as Bob Ferguson pointed out, now we're dealing with cordwood not crib wood; so there are different elements of the test method that factor in regarding what an appropriate burn rate is/should be.

- Bob Ferguson noted that part of the problem, when comparing field performance to lab performance, is that the air setting used to achieve the 1 kg/hr burn rate based on crib wood burning becomes the permanent low air setting. This air setting may deliver emissions that are below the limit. But, as soon as cordwood is burned in this stove in the field at this low crib setting, that's where smoke/dirty burns happen. Bob explained that all of these stoves have a sweet spot where it doesn't matter if the stove is burning crib or cordwood. But, the low air setting is being defined based on burning crib wood at 1kg/hr. Then, when different fuel (cordwood) is used in the field compared to what was used in the lab, everyone's surprised that the same performance is not achieved in the field as in the lab.

- Bob Lebens responded that he can appreciate that, but he's not sure revising the minimum burn rate requirement slightly upward will solve that problem necessarily. Bob Ferguson responded that it may not solve the problem, but it's moving in the right direction from the perspective of making it more difficult for a homeowner to make a stove burn with crappy performance. Bob Ferguson noted that he can take both sides of this argument but concluded that the goal is to develop a more representative method that produces less surprises when moving from the lab to the field [in-home use]. Bob Lebens agreed, noting that's why it's good having these discussions regarding moving to cordwood.

- Lisa Rector noted it's important to hear from other state people and asked Cindy Heil, John Wakefield, Rod Tinnemore or Randy Orr to comment. John Crouch noted that he would like to put Rod Tinnemore on the spot, as Rod watched cordwood burn in and EPA-certified stove at the low burn setting (using a single-story stack, as typically used for testing in the lab) and Rod saw what happens with all that secondary air. John noted that Rod is one of few [state] people who saw what Bob Ferguson is referring to – that is, the amount of secondary air that the minimum burn rate on cribs requires and how that negatively affects cordwood burning.

- Rod Tinnemore replied that yes, without a doubt, a slightly higher air setting is needed in order to work with cordwood. Period; end of discussion. Rod noted that this is old news that he's tired of rehashing.

- Lisa asked Rod if he is comfortable with how ASTM has defined the burn rates and air settings. Rod replied yes, although he would also be comfortable with what John Voorhees is talking about it – that is, sticking with the lowest setting that a device is designed to achieve. Rod noted that he is still struggling with balancing the need of having a defined low burn rate setting as a bridge back to M28 versus the look to the future – that is, to have the burn settings follow the devices. Rod further noted that he didn't see the relevance of worrying about cheating when the device is tested at the lowest setting a consumer can use. Unless [the consumer does] something very unusual like adding a damper in the flue, [the consumer] will not be modifying that low burn rate on the device, because it can't go any lower.

- Lisa Rector noted that that's where I'm at too, noting she understands Bob Leben's concern [regarding consumer tampering], but [a consumer] could do that now – for example, take a stove with a 1 kg/hr minimum burn rate and make it burn at 0.5 kg/hr. There's a lot that can't be controlled once the device gets out in field. Rod agreed, noting that's less a practice now than it used to be.

- Cindy Heil noted that she too was leaning more toward what Rod Tinnemore just expressed.

- John Voorhees noted that he understands Bob Lebens' concerns, but it's pretty clear in the current [NSPS] requirements that you can't alter the damper or flue; it's not legal. John also pointed out that the argument flies in the face of single burn rate stoves, in which the burn rate is not adjustable and it's set where it's set. John opined that, based on what he's seen in Europe, the market should determine this, but the labeling needs to be clear (e.g., that the stove burns between here and there, based on the test setting or test load). Lisa Rector asked John to confirm if he was suggesting testing at the lowest air setting, but also have test requirement that allows consumers to see how long the burn time is for that lowest air setting. John Voorhees clarified that it should be reported. John proposed that it should be made clear to the consumer; the consumer shouldn't be deceived. The appliance should be required to be set at the lowest setting, but that lowest setting should be whatever the manufacturer decides/designs for that stove.

- Bob Ferguson noted that industry has always anticipated finally a common basis for labeling, regarding heat output and efficiency. Whatever labeling requirements are, Bob noted that minimum overnight burn duration is important and something consumers can understand. Consumers may not be familiar with g/hr ratings, but consumers would understand a 4-hour burn duration versus a 10-hour burn duration. John Voorhees heartily agreed.

- Randy Orr noted that this made sense, pointing to the US having gone through a history of automobiles being tested one way but having totally different results [in the field]. Randy noted that he thinks Bob Lebens is saying that the wood heater stakeholders don't want a wink, wink, nudge, nudge as has happened in the auto industry. But, Randy opined, if there's a lowest setting to the stove and it's posted on the tag, that should be fine – and the lowest level should be the level the stove is tested at.

- Bob Lebens noted that, when comparing labels, it's relative and under lab conditions. So, the labels would publish relative [lab-based] differences. But, Bob pointed out, there's very big differences based on in-home installation. The burn rates will differ a lot and so, for example, one of these stoves may have a published [lab-based] minimum burn rate on the tag that is quite different from how that stove will actually perform under in-home installation, because of draft conditions, etc. Therefore, Bob noted, the appliance should be put in, for example, a low draft situation to ensure clean burning in that situation, if at all possible.

- Lisa asked the WG if it was ready to take a vote, or if other items needed to be discussed first.

- Cindy Heil remarked that unfortunately she had to leave the call, but that she is leaning towards what Rod Tinnemore said. Cindy noted that the [cordwood method effort] is in a transitional period and that perfection can't be reached; but it's a start and the process is moving in the right direction. Cindy left the call at this point.

- John Crouch suggested clarifying the question regarding which options were being decided upon. Bob Ferguson noted that, for now, the WG could answer the question conceptually and getting that concept into workable language is important, especially regarding how to make any decision work without unintended consequences. For now, the question is what burn rate concept does the WG want to proceed with.

- Lisa agreed that only the concept was being decided today and listed the following 3 options:

    1. Let the manufacturers design the stove and test according to that design (i.e., the low burn rate is whatever the lowest setting and burn rate is for that specific stove, the highest burn rate is at the max air setting for that stove and the medium is in between);

    2. Specify burn rates with fixed numbers regardless of the individual stove being tested (i.e., define burn rates as M28 does); or

    3. Specify burn rates as a percentage of the maximum burn rate for that stove.

Lisa noted that these are the 3 conceptual frameworks and once the WG knows where it wants to go conceptually, there will be details that will require further refinement. Lisa asked the WG voting members to voice their decision.

- Bob Ferguson clarified that ASTM's method uses a hybrid approach. Lisa agreed, noting that's why she didn't call it the ASTM approach, although the WG may later refine it and decide on whether or not, for example, ASTM's 8-hour burn idea should be used. But, for now, Lisa merely wanted to get a sense of where people are conceptually.

- The O/F WG voting members responded as follows:

    - Gregg Achman – let the stove define the burn rates;
    - John Crouch – seconded Gregg Achman;
    - John Voorhees – agreed stove should define the burn rates (#1 of Lisa's options);
    - Rod Tinnemore – also #1 of the options;
    - Cindy Heil – had indicated she agrees with Rod, so #1 of the options;
    - Randy Orr – also #1, but with the caveat that the burn rates and burn times must be expressly indicated on the label so the consumer understands and so that it will be blatantly obvious if "they're tricking it out on the burn rate". John Voorhees also agreed with this labeling requirement. Gregg Achman agreed 100% regarding labeling being important (both g/hr and burn duration) so consumers know what they're getting, similar to the city and highway mpg's being listed on an auto label.
    - Bob Lebens – there needs to be a minimum burn rate requirement [presumably #2 on Lisa's above list]. Bob explained that on their NSPS public comments, WESTAR was in support of what EPA ultimately established, but he realizes he's an outlier here.
    - Lisa Rector – agrees with Randy – so #1 on the list, but Lisa agrees that burn time and other information have to be provided to the consumer on the label.
    - Ben Myren – not present, Lisa will contact and obtain his vote;
    - Tom Morrissey – not present, Lisa will contact and obtain his vote;
    - Tom Butcher – not present, Lisa will reach out to and obtain his vote;
    - Lisa Herschberger – not present, Lisa will contact and obtain her vote.

- Lisa Rector noted that, in terms of process, there are 7 folks who want to move forward based on the design-based definition concept, while Bob Lebens wants a minimum burn rate, and 4 people are not present and haven't voted yet. Lisa noted that there is a majority in a certain direction, but need to hear from 4 more voting members. The process previously laid out is that the WG moves forward with the majority decision, but the minority position can be captured for presentation to EPA when the majority decision is presented to EPA. Lisa noted that therefore, there won't be a final vote until the remaining 4 voting members vote. The decision so far is to move forward with the burn rate definitions being based on the design of the stove.

- Lisa asked the group if it was ready to move forward with a discussion about ASTM's hybrid approach – that is, requiring the 8-hour burn or not requiring an 8-hour burn but instead

requiring clear labeling. Lisa noted that there might be some third alternative, but those are the 2 refinements she has heard so far.

- Rod Tinnemore suggested tabling the refinement discussion for a future call. Gregg Achman seconded that. Lisa agreed to table that discussion.

- Lisa asked the WG if they wanted to have the next call on February 23rd, as scheduled, or since it's close to the start of the Expo, if the WG would rather reconvene on March 6th.

- Bob Ferguson noted that there are a few manufacturers who have a big responsibility about getting new products to show. Lisa agreed, noting she's cognizant of that and didn't want to divert from important activities that are underway for the Expo.

- John and Gregg noted that they were fine with either having the call on the 23rd or waiting until March 6th.

- Amanda Aldridge noted that she would hate to go a whole month without a call and suggested that the call on the 23rd be for one hour and focused on refinement. Amanda suggested that someone can summarize quickly and then focus the WG on refinement. Bob Ferguson opined that a 1-hour call is a good compromise and John Crouch agreed.

- Lisa noted that she liked the idea of 1 hour to focus on refinements. Lisa noted that one refinement to be discussed would be John Voorhees idea of removing the burn rate and time component versus leaving the requirement in. The refinements to the "definitional burn rates" – that is defining burn rates by stove design rather than by specified burn rates – will be discussed on the next call. Lisa further noted that she welcomes other ideas for a short-hand name, other than "definitional burn rates".

- Amanda wondered if perhaps John Voorhees could put the refinement down in writing, so people could read it before the call on the 23rd – perhaps just 3 sentences or so. John Voorhees agreed to write up 3 sentences. Lisa suggesting that John write up his proposal versus ASTM's, as the two options currently on the table for refinements.

- Bob Ferguson agreed that it'd be good to use ASTM as a starting point, rather than starting from a blank piece of paper. Bob Ferguson will send Lisa the current ASTM method as soon as he gets off the call. Amanda noted it would be good for everyone to see. Lisa Rector agreed to post ASTM's current method for everyone.

- John Voorhees will send his 3 sentences to Lisa Rector and John Crouch, in case they want to edit. Lisa will then post both to Basecamp.

- The WG will meet again in two weeks, on February 23rd.

- Thank you to all. Meeting adjourned.

EPA Notes Operation and Fueling (O/F) Workgroup Meeting Notes from February 23, 2017 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), **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:

- The workgroup (WG) discussed two approaches for allowing a stove's design to dictate the low and high burn rates, rather than M28's specified burn rate categories: (1) ASTM's hybrid approach of allowing a stove's design to dictate the low and high burn rates, but also including a specified low burn rate duration with a low burn rate cap; versus (2) John Voorhee's approach of not requiring any specified low burn rate duration or cap, but merely requiring clear labeling regarding a stove's low burn duration, efficiency, emissions, etc.

- The WG discussed their intent that the labeling would be required within the cordwood test method (CTM) itself, which they expected/hoped would be promulgated by EPA as a federal reference method (FRM) to be incorporated by the wood heater NSPS.

- It was clarified that ASTM's terminology "primary air controls" refers to any and all controls that cause a stove to burn at its lowest and highest. For clarity, it was suggested that the modifier "primary" be dropped so that the CTM refer merely to "air controls" to avoid any possibility that a stove could be turned lower (or higher) that the CTM requires.

- The WG members expressed concern about making a firm decision regarding whether or not a low burn rate duration and/or low burn rate cap need to be specified by the CTM when the other aspects of the CTM test cycle were not yet decided (e.g., end of test definition, if the test will be cut-off prior to 100% of fuel consumption, if the test will be hot-to-hot or cold-to-hot).

- Although the WG was not ready to make a firm decision regarding using or dropping low burn duration and low burn rate cap requirements in the CTM (e.g., as required in ASTM's CTM), the WG was comfortable leaving the issue on the table for further consideration. The WG unanimously decided that requiring (or not) a specific low burn rate duration or cap in the CTM – as a concept – could be entertained further. That is, John Voorhee's proposed approach of allowing the stove's specific design to dictate the low and high burn rates – without requiring a low burn duration or low burn rate cap – need not be rejected at this point.

To-Do List:

- Lisa Rector and John Crouch will discuss next steps for the March 9th call and Lisa will send out an agenda for this call.

Highlights from Meeting:

- Lisa Rector opened the workgroup (WG) meeting, noting that the agenda for today's call included recapping the last call's conclusions (from February 9th) and discussing refinements to the voted-upon burn rate approach.

- The following WG participants were present on the call: John Crouch, Lisa Rector, Gregg Achman, John Barnes, John Voorhees, Stef Johnson, Lisa Herschberger, Randy Orr, Rick Curkeet, Bob Ferguson, Bob Lebens, John Wakefield, Amanda Aldridge, Cindy Heil, Phil Swartzendruber, Jill Mozier plus others who joined later or did not identify themselves.

- Lisa recapped that the WG had made its first decision regarding burn rates. A vote was taken during the February 9th call and all present concurred that the recommendation for a future cordwood test method (CTM) is to define what low, medium and high categories are by stove design, rather than by specified burn rates and rather than stoves being tested at a percentage of their max burn rate. Lisa noted that, from that discussion, the WG looked at John Voorhees' proposal (that the CTM burn rates be based strictly on the individual stove design) versus ASTM's hybrid approach (which is based on design but also includes minimum burn rate parameters such as kg/hr caps on the min burn and a burn duration requirement). Lisa thanked John and Bob for pulling together the draft of these approaches that Lisa had e-mailed out to the WG and posted to Basecamp.

- Lisa noted that the WG needs to further flesh-out what burn rate by design means. Lisa also noted that she has some questions about whether only the primary air settings are set to low and high, or all air settings are set that way. Lisa asked John Voorhees and Bob Ferguson to give a brief overview on the two approaches.

- John Voorhees noted that his proposal is spelled out clearly in the document [that Lisa e-mailed out to the WG and posted to Basecamp, *Burn Rate Options 2 23 2017 call.docx*]. John explained that the low burn rate ["low fire"] would be determined by an appliance tested at the lowest setting the appliance can be set at, while the high fire is the opposite with the appliance set at the maximum air setting that the appliance can be set at. Regarding Lisa's question of whether only the primary air controls or all air controls were set, John explained that basically any air

setting that would allow the appliance to burn at the highest or lowest burn rate should be set accordingly. Then medium burn rate would be determined by bracketing between the high and low burn rates – whether at the midway/50% point between high and low or at lower than that can be determined later. John noted that the only difference between what he's proposing and what's in ASTM's draft CTM is that there wouldn't be a minimum burn requirement [kg/hr cap] or burn duration requirement. In addition, John noted that there would also be a labeling requirement at the point-of-sale regarding appliance performance information such as emissions, max burn time during testing, etc. The exact contents of the labeling requirement is up for discussion, but John noted there is agreement that informing the end consumer is pivotal.

- Lisa Herschberger asked about implementation, regarding how consumer would know what they're getting. Lisa noted that she's curious what EPA would say, given that the current NSPS is in place. Lisa wondered how these labeling ideas could be implemented given the current regulation. John Voorhees replied that any standard usually has a part for markings and labeling - whether CSA, UL standards, etc. The labeling requirement could be clearly stated in the standard and then the manufacturer would be required to meet it. Lisa Herschberger wondered however, how such a labeling requirement in a CTM would be implemented within the context of the existing NSPS. John noted that the goal of this effort by the WG was developing a federal reference method [FRM] which will be presented to EPA.

- Lisa Rector clarified that John Voorhees was saying the labeling requirement would become part of the test method. Lisa explained that EPA will have to do a rulemaking to incorporate this new CTM into the NSPS, but EPA was not reopening the NSPS itself. Rather, this new test method was being pulled into the NSPS. [No comment was offered by the EPA either in agreement or disagreement.] Lisa Rector noted that she will also advocate that a new column showing each stove's burn time be added to EPA's certified stove list.

- Bob Ferguson noted that whatever tool is used, whether the ASTM method or another method, this will be a case where all sides are in agreement that the information provided to the consumer must be in a simple-to-understand format on hang tags and other places. Bob pointed out that, wherever it's decided that this information is needed [in terms of labeling], there will be universal support for it. John Voorhees agreed that everyone is in agreement that more education for the consumer is better and also mentioned that perhaps such information could be provided on the carton that the appliance is boxed in.

- John Crouch opined that it's worthwhile to remember that in the past consumers have unintentionally been given misinformation. John pointed out that the information provided to consumers [in the past and currently] is based on the high burn rate using crib wood and, in addition, the consumer is not told how much crib wood was burned or how long it burned. Therefore, John noted, the information provided often gave consumers an erroneous understanding. John agrees that the more information that can be given to the consumer based on cordwood, the better, and the more accurate the sizing of the stove will be.

- Lisa Herschberger asked if there was any way to address the issues and concerns that Bob Lebens had raised [on the February 9th call] regarding stoves being modified to burn outside this range.

- John Voorhees noted that modifying/ tampering with appliances is possible now, but it's clearly stated in the manual and in the NSPS that any modifications to the appliances are against the law. John noted that yes, people break the law. But if people modify the appliance it would nullify the warranty and the safety listing of the appliance. So, if there were a fire or other mishap, such modification would also probably nullify the insurance. John Voorhees clarified that on stoves his company manufactures, they clearly state that any modification nullifies the warranty. John noted that the wording [his company uses], which may be right out of the NSPS standard, is very strong and notes that any modifications can cause fire and even death. John concluded, in response to Lisa Herschberger's question, that there is no way to prevent [people illegally modifying their stove], but it's clear that if they choose to modify the stove, there are serious consequences.

- Gregg Achman opined that there may be less inclination to modify stoves [with this proposed labeling] perhaps, since the consumer will know [better] how it will perform.

- Lisa Herschberger wondered if all this information [being proposed for the label] would be provided to the consumer in big print, so people really see and understand it, or buried [somewhere in the product literature] so people don't really see it. In general, Lisa wanted to know how clear the information will be to the consumers so they understand the implications of modifying their stoves. John Voorhees noted that he didn't recall exactly (without the literature in front of him) where it's stated currently, but it is stated in a couple places in his company's manuals.

- Lisa Herschberger asked if there was a way to include it [any proposed clear labeling] in with the testing revision [that is, the new CTM to-be-proposed]. John Voorhees responded sure, that it's not uncommon to require that a standard must be a certain size font. Gregg Achman noted that such labeling would follow ANSI Z535 and its requirements for wording, color and other labeling instructions for safety warnings. [Note: See for example http://www.appliedsafety.com/wp-content/uploads/2011/08/ansi_z535dot6_article.pdf.]

- Bob Ferguson noted that he fully agreed [that the labeling information and warnings not to modify] should be in an obvious place to be seen by consumers and installers. Bob further noted however that the safety standards organizations do not want everything to be a caution or a warning, as different things merit more importance and if everything is emphasized as a danger, then nothing ends up being emphasized/perceived as a danger. However, Bob noted that something like this [modifying the stove], since it is a violation of federal law and since the warranty and safety listing are voided, will probably rise to a high level in terms of the safety listing [and how it's displayed]. Bob opined that EPA can deal with this when adopting the new standard, regarding what must be done to be in compliance. Bob explained that not all test methods have labeling requirements. Safety tests generally do have labeling requirements, but

performance standards often do not, as performance standards generally feed into other laws/standards which put forth the labeling requirements. Nonetheless, Bob noted, this can be dealt with by just determining what the appropriate vehicle is to address anti-tampering.

- Lisa Rector asked Bob Ferguson to give a brief summary of the ASTM process.

- Bob Ferguson noted that the ASTM balloting for the draft CTM closed recently with no substantive negatives. There was one negative ballot from a "very ASTM-oriented person" who suggested some editorial tweaks. Therefore, the draft CTM is in process of its very final version, including edits by balloters. Next the CTM is sent to the editors and ASTM standards board. Bob noted that he expects to see the published CTM standard within 2 months. Bob explained that the interesting thing about ASTM is that if everyone is on board with for example, the burn rate changes being discussed by the O/F WG, then ASTM's CTM standard can be reopened, so that the burn rates may be redefined. Bob noted that this can be done at any time, that one need not wait for x years to reopen it. The ASTM process is an open process. So, if the WG can come to agreement and if the agreed changes pass muster with the ASTM balloting process, then these changes can be incorporated into a revised ASTM CTM at any time.

- Bob explained that the ASTM burn rates [in the ASTM draft CTM] were an attempt to bridge the gap of M28 cribs and ASTM 2780. ASTM 2780 was done years ago and there was still lots of discussion about maintaining some control over the burn rates. So high, low, and medium burn rates are defined. ASTM reconsidered the critical low fire and considered burn duration as the critical criterion, rather than burn rate. Therefore, the stove must meet an 8-hour burn duration [at a burn rate not to exceed 1.5 kg/hr]. If the stove cannot meet that burn duration because it's too small to hold enough fuel, ASTM implemented a fixed low burn rate requirement of ≤ 1.15 kg/hr. Bob explained that, based on ASTM task group discussions, there was a concern that a large stove could have a minimum burn rate, meet the 8-hour burn duration with no problem, but meet it with a relatively high burn rate. Therefore, ASTM added another requirement – that is, that the minimum burn rate can be no higher than 1.5 kg/hr, regardless of burn duration (even if 8 hours or more).

- Bob noted that ASTM's formulation bridges the gap from burn rates in place since the 1980's on cribs. ASTM kept some of the elements (e.g., finite numbers are included in the low burn rate definition) yet ASTM's method allows more flexibility in that the primary criterion is defined as an 8-hour burn. Bob noted however that lots of discussion has been happening in the last year that wasn't happening previously. Nonetheless, that's how ASTM arrived at its draft CTM as a method "somewhere in between", with more flexibility for stove design but with some burn rate criteria still bracketed. ASTM's high fire is the maximum burn rate. Bob clarified that if the air is affecting burn rate, then those controls should be at the highest [for the high fire] or the lowest [for the low fire]. Bob explained that many stoves are down to 1 or 2 controls and some is secondary air that may not impact the burn rate. Regardless, Bob clarified, the controls should be set to be truly maximum or truly minimum.

- For the medium burn rate, Bob explained that ASTM wanted the definition to set the medium burn rate in the lower half between the high and low burn rates, in recognition of the fact that consumers burn there. ASTM also wanted to ensure that the definition of the medium burn rate wasn't merely an artifact of the test method (e.g., burning last 10% of high fire fuel happened to land the burn rate in the medium category). Therefore, ASTM's draft CTM requires a physical air setting to be changed. Literally, the consumer will set air at the medium setting: at about halfway on the air control whether it be a knob, lever or slide. Bob reiterated that the tester needs to physically make a change on the appliance for the medium fire test.

- Lisa Rector note that the O/F WG decision regarding defining burn rates based on stove design was decided on the last call. However, there are 2 subsets within that definition: (a) let manufacturers design what they want and merely require labeling that includes the maximum burn time (this is a drastic change from M28); or (b) ASTM's draft CTM approach which, as Bob Ferguson explained, is a middle ground that requires a burn time and includes a low burn rate cap. Lisa asked Bob Ferguson to explain why the ASTM method uses the nomenclature "primary air controls", noting she was a little concerned about that [given there could be more air controls than primary air controls].

- Bob Ferguson explained that "primary air" is defined [in the ASTM method] as air that impacts the burn rate. Therefore, if it impacts the burn rate, it's primary air, even if the stove manufacturer calls it secondary air in the stove design. Bob explained that air that enters from tubes at the top is generally secondary air that's needed to complete combustion of volatiles. Catalytic stoves provide additional air in front of the catalyst, but usually that is separated from the combustion that's going on in the firebox. Other [non-catalytic] designs also have secondary air that's separated from the combustion firebox. Bob noted that it's complicated, but for the most part, there is a control on every stove that is the determinant on how fast the fire will burn. Other controls may control secondary air and some are automatic controls. But usually there is one control that is the primary determinant of how fast or slow the stove's fire will burn. Bob noted that any method should not give people the opportunity to game that. Bob opined that he thinks ASTM's language works [as written], but ASTM can look at it again to see if the definition of primary air is clear enough. The intent was that primary air is any air that controls the burn rate.

- Lisa Herschberger noted that it's important not to allow people to move around that requirement [in the method regarding setting all air controls to lowest]. Randy Orr agreed and noted that if the secondary air control changes the burn rate, then the method needs to control for that.

- Lisa Rector asked the WG if setting the minimum burn time/duration is important or if John Voorhees' concept is acceptable, which allows the manufacturer to decide.

- Randy Orr replied that the manufacturer should be allowed to decide and if their stove only achieves a 6-hour burn time, then they will face low sales. Lisa asked the WG then if it was more in line with John Voorhees' approach.

- Bob Ferguson replied yes and noted that Voorhees' approach really only changes a few words in an ASTM section, while the rest of ASTM's draft CTM wording works well. Bob explained that the one section that defines the 8-hour duration and low burn rate cap would come out of the ASTM method and John Voorhees' language would replace it. Bob concluded therefore that it'd be pretty easy to get to the end line.

- Regarding the ASTM section on air controls, Lisa Rector noted that if the WG decides to move ahead without a required burn time/duration, then perhaps ASTM can remove the word "primary" as an adjective of "air controls". Lisa suggested calling it merely "combustion air controls" instead of "primary air controls."

- Bob Ferguson noted that for high fire there's no issue, as some secondary air is needed. For low fire, the secondary air controller would also be in the appropriate place. Therefore, Bob noted that he doesn't have a problem changing this wording if it makes people uncomfortable. ASTM can come up with a definition that everyone is comfortable with. All air controls should be in position that results in lowest burn rate for low fire. Bob noted that, if secondary air controls are affecting the burn rate, then he's all for including that in the method's instructions. All air settings should be placed to ensure the lowest burn rate – that was ASTM's intent, but maybe it's not clear enough. Bob noted that he is open to making improvements to make what the method requires meet the intent. Bob opined that all are on same page regarding the intent.

- Lisa Rector asked WG members to weigh in regarding whether or not there should be a minimum burn duration and low burn rate cap.

- Bob Lebens noted that the WG hasn't decided yet on what the test cycle will look like and that may have a bearing [on what's decided regarding the burn duration and low burn rate cap]. For example, Bob noted that if the test cycle is cut off at 90% [of fuel consumed rather than 100%], then that will have a bearing on the question. Or, if the cycle is hot-to-hot versus cold-to-hot, that too would have a bearing on this. Lisa Rector agreed with Bob Lebens' point, as they pertain to a composite run. Bob Lebens clarified that he was speaking about the question of minimum burn times/durations.

- Lisa Rector explained that she was asking a high-level question – that is, does the test method need to set a requirement regarding burn duration – for example but not necessarily, an 8-hour burn duration. The high-level question regards whether or not the burn duration requirement need to be there, not what the specific number of hours needs to be, at this point.

- Bob Ferguson noted that Bob Lebens raises a good point. When ASTM looked at this, the cold-to-hot fire was stopped at 90% because the long tails were skewing the heat output rate as well as the g/hr emission rate. But, Bob noted, Bob Lebens is right. At the low fire, ASTM's intent is to burn 100% of the fuel load, but at a minimum 90% of the load must be burned. If the fire goes out or if the test is cut off early, the 8-hour duration may not be met. Bob Ferguson explained that it's on the manufacturer to meet the 8-hour burn duration. Not meeting [the 8-hour burn

duration] errs on the side of higher emission values in terms of g/hr or in not meeting the duration requirement – therefore, all the risk is on the manufacturer, Bob pointed out.

- Randy Orr noted that the endpoint of the test needs to be defined and put on the tag/labeling.

- Bob Ferguson explained that ASTM's end-of-test definition was based on test results. The low fire going to 100% made the most sense for the low fire. But for the high fire, the data indicated that stopping at 90% was okay. Bob noted that if the WG essentially decides to let the market decide, then all of this is off-the-table [and doesn't need to be defined]. But if finite numbers are used to define a burn rate cap of minimum burn duration, then the WG needs to think about the test cycle in order to avoid an overdetermined system [too many constraints].

- Lisa Rector wondered what should be asked, or if perhaps it cannot be answered now. Lisa noted that the WG has a general idea of where it wants to move with burn rate. Lisa therefore wondered if the WG should move onto operational questions, or if the finite burn times question needed to be answered first.

- Bob Lebens opined that ultimately it depends on what the test cycle looks like and the WG hasn't yet discussed the test cycle. Bob noted that perhaps the emission testing cycle of these appliances isn't directly related to how they are operated in the home. If so, Bob wondered how to match these up.

- Bob Ferguson noted that the testing cycle is also tied to the fuel loading density. ASTM currently calls for a 12 lb/cubic ft loading density for the low and medium fires. The burn duration requirement and the fuel loading density are tied together. It's unclear what burn duration can be required under a lower loading density. Bob pointed out that there are lots of moving parts tied together.

- Lisa Herschberger wondered if it would make sense for people to put forth proposals that include fuel load, a cut-off for the low burn/fire test, whether there needs to be low burn rate cap or minimum low burn duration, etc. Perhaps these elements could be put in a proposal and then the WG could find something that fits for all people.

- Regarding ASTM's approach, Bob Ferguson noted that the hot-to-hot test cycle and fuel loading density were part of the discussion when the 8-hour minimum burn was set. Bob noted that these are all tied up in a knot together. If fuel loading density or something else is changed, then the process would need to go back around the loop to see what's able to be achieved, so that it's not an overdetermined system. Bob noted that one needs to ensure all components work together.

- John Voorhees explained that he's proposing using everything in the ASTM standard, except taking out a sentence or two in order to remove the 8-hour minimum burn time (with the 1.5 kg/hr cap) and to remove the alternative 1.15 kg/hr minimum burn rate cap.

- Gregg Achman noted that it's a paradigm shift to even consider whether these things are needed or not. Lots of things are intertwined, but fundamentally the question is whether or not a fixed low burn rate is needed to move forward. This is a fundamental question "at the top of funnel" and, in order to keep going down the funnel [progressing in developing a CTM], the fundamental question of whether or not a minimum burn rate is needed needs to be decided.

- Lisa Herschberger agreed that whether or not to have a low burn rate cap or minimum burn duration is a threshold question.

- Bob Ferguson noted that the burn duration requirement is less restrictive than the low burn rate [cap] requirement; a fixed low burn rate for all stoves regardless of size is most restrictive. ASTM's CTM is something in the middle that includes a [finite] number of hours for the burn duration [plus a finite low burn rate cap] versus the least restrictive which is no burn rate or burn duration requirement (that is, John Voorhee's proposal of leaving burn rates up to the design).

- Lisa Rector noted that she wanted to check-in to see where WG members are regarding their thoughts on minimum burn rate and minimum burn time/duration. Lisa asked if WG members need more time or more information.

- Randy Orr noted that, for a test method that burns 100% of the fuel, coals should still remain [because consumers need coals in the morning]. Bob Ferguson clarified that the ASTM method ends back where it started, with the starting fuel. Therefore, the coals are still there.

- Lisa Rector noted that she wanted to go back to a higher level, to the fundamental question at the top of the funnel – that is, are minimum burn times and specified burn rates needed in the test method or is that a design function?

- Randy Orr noted that he did not care how long the stoves burn [for the test method], but he just wants the end of the burn to look a certain way.

- Lisa Rector noted that she's been thinking of integrated and composite runs that move far away from the ASTM and M28 methods. Those are examples of thinking out-of-the-box that the WG hasn't even gotten to. But, Lisa noted that for this step, she is trying to put some frame around how far folks are willing to go. Lisa further noted that, if the WG is not willing to give up much of the [current] test method – for example, hot-to-hot or steady state – that's important to know. Or do folks want to think about something very different [than the current test method]?

- Randy Orr opined that consumers will want to know how long a stove will burn. Consumers want to know, for example, whether there will be coals in the morning after going all night [without loading or tending].

- John Voorhees clarified that what is being asked is whether the WG is comfortable with the concept [not the actuality]. That is, rather than having to decide now that the minimum burn

rate requirements should be thrown out, the WG is being asked merely to entertain the concept. The question is: does anyone have problem with the idea of throwing out the minimum burn time/duration [and low burn rate cap]? John pointed out that questions such as how the test ends, what exactly the burn duration should be, etc are further down the funnel. So, John asked, is everyone okay with the concept of not having [these finite requirements], rather than having them?

- Lisa Rector agreed that this was the question on the table – that she liked John's explanation of this being about whether or not the WG is open to the concept. John Voorhees noted that he had never heard of the concept of not having a [finite] low burn rate and would like the WG to consider what it is needed for. John further noted that [the current method] is forcing some appliances to burn below where they should. John opined that rather, let the market decide.

- Lisa Herschberger noted that that was what she was saying as well, regarding what the [specific] set of conditions would be. Lisa replied that she is okay having an open mind, but would want to see the set of conditions to capture all emissions, inform consumers and [at the same time] not constrain the design.

- Tom Morrissey [who noted he was on the call but could not join the webcast because it says the webcast is oversubscribed] opined that there is going to be a low burn rate test, that's clear. The only question, according to Tom, is how [that low burn rate] is defined – whether the lowest setting, 1 kg/hr, 1.5 kg/hr, or something else. Tom further opined that there will be something in this method so that, when an appliance is turned down low, the method provides the resulting [emissions] profile – there is no question there. Tom noted that when he reads or hears "let's let the market decide/determine it" his BS detectors go off, because the market doesn't determine this. Tom explained that manufacturers have been disingenuous when they inform consumers what their appliances do. Therefore, the test must show real world emissions on high and low – unquestionably, in Tom's opinion.

- Lisa Rector agreed and noted that's conceptually where the WG is at – that the stove must be tested at the highest and the lowest.

- Tom Morrissey noted that all manufacturers promise overnight burns [of at least 8 hours], even on small stoves. Now there are manufacturers promising everything up to 40 hours.

- John Voorhees replied that that's a marketing thing that the WG will eliminate by the test itself defining it. John noted that he is proposing that the test method safeguard against such false claims.

- Tom Morrissey pointed out however that there is no prohibition against marketing material claiming that the test results don't mean anything and instead claiming that the manufacturer's own lab results are more relevant. John Voorhees pointed out that the WG is moving toward a cordwood method. Tom replied that that does not prohibit bogus claims and there will be bogus claims.

- John Barnes noted that EPA will be certifying and assumed EPA would monitor marketing claims.

- Tom Morrissey replied that no, EPA never has [monitored marketing claims] and never will because EPA doesn't have the staffing to handle such monitoring.

- Amanda Aldridge noted that she [as the EPA oversight person] did monitor marketing claims in the voluntary [hydronic heater] program. But, the work load is admittedly overwhelming now and she hasn't had the time [recently, with respect to the NSPS].

- Tom Morrissey noted that, if one wants to see complete and utter BS, then look at the stoves for sale at Home Depot and read the tags. Then, look up the EPA testing [on these same stoves]. The claims are all over the place, according to Tom.

- John Crouch noted that that's why stakeholders are moving to a cordwood test, with high and low burn times tested and then reported to the consumer. John opined that the current results [based on M28] give consumers a distorted view, because M28 is not representative of how the stove would be operated in the real world and because consumers don't understand [this disconnect and what it means].

- Tom Morrissey noted that the method should try to move beyond human nature.

- John Crouch replied that the method standardizes that; [the proposed method being discussed by the WG] takes such claims out of marketing and puts them in the engineering world [where they belong]. The proposed method will define efficiency, burn time etc. John noted that the first NSPS didn't anticipate all this and used a whacky fuel load.

- Tom Morrissey replied that he found John's statements unpersuasive. Tom opined that EPA wants to know and the consumer wants to know what happens [what's emitted and for how long] when the stove is turned down to its lowest setting.

- John Crouch replied that that's what the WG and John Voorhees is proposing. John Voorhees agreed that is what he's suggesting.

- Tom Morrissey opined however that "letting the market decide" is a nonstarter and should be thrown in the trash.

- Lisa Rector noted to Tom Morrissey that, if the WG decides to go down this route, there will have to be clear labeling requirements in the test method, which not all test methods have. Lisa noted that folks basically agree that consumers need to know how long a stove will burn [especially on low] and how much pollution it produces.

- Tom Morrissey noted that, in addition, the data needs to be comparable.

- Regarding this issue that Tom raised, Lisa Rector noted that one of the tradeoffs [in going from M28 to a new CTM approach] may be standardization and comparability, as what is low in one stove is not low in another.

- John Crouch agreed that the consumer needs to know how much heat is put off on low, how long it burns on low and what the stove's emissions are. The same things need to be conveyed for the high burn rate. John noted that there is not any disagreement on that. John pointed out that he [and John Voorhees] are not advocating for the current system [under M28], but rather for how the system should work.

- Lisa Rector clarified that the minimum burn rate is not the low burn rate [that is being discussed]. The current minimum is 1 kg/hr, while the low burn rate being discussed for testing under a proposed CTM is the burn rate when the stove is set at its lowest burn setting. Lisa noted that the question is: should a stove be required to burn at 1 kg/hr?

- Rick Curkeet noted that he is a big proponent of test methods being performance measurements and not being prescriptive. The test method should measure performance parameters like heat output, emissions, burn time, etc. The test method should determine all this and report on it. There should be standardization, but the method shouldn't be prescriptive. Regulators determine what is the maximum allowable emissions and the minimum allowable efficiency, Rick noted. But, as long as everyone uses a standard method, then the marketplace will indeed determine what is adequate, Rick opined.

- Lisa Rector noted that the call had gone over the scheduled one-hour time slot, but that she was at a loss regarding how to proceed. Lisa noted that she's sensing that folks are comfortable with exploring this. Lisa asked if there are any WG members for whom the concept is totally distasteful, even to explore. Lisa further noted that, even if no one has an issue with it conceptually, there are concerns voiced about what happens in practice. So, Lisa pointed out, that the WG is not ready to make a firm decision yet.

- Phil Swartzendruber agreed that how Lisa described the decision-to-be-made/situation makes sense and the WG should retain on the table the question – that is, is it reasonable to maintain a kg/hr burn rate requirement?

- Lisa Rector asked if there was any opposition to keeping it on the table. No one voiced opposition. Therefore, Lisa noted that the question is still on the table, still in play. The WG will move forward with that. John Crouch and Lisa will discuss about where to go next.

- Lisa noted that she would send out an agenda for the March 9th call. Lisa further noted that she will try to address the webcast access issues and apologized that some people couldn't join the webcast today. Lisa concluded that she looks forward to seeing those in Atlanta who will be there and she will join the rest of the WG participants on the next call, March 9th.

- Thank you to all. Meeting adjourned.

EPA Notes from Operation and Fueling (O/F) Workgroup Meeting Notes from March 23, 2017 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), **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), Roger Purinton (Jotul), Jill Mozier (EPA contractor, meeting note taker)

Primary Conclusions from Meeting:

- Assuming the new meeting day and time works for everyone, the workgroup (WG) meetings will likely be switched to every-other-Friday at 1 pm. This decision is not yet final.

- The EPA-funded species testing by Mark Champion has finished and results will be forthcoming as soon as the data spreadsheet is finalized.

- The draft 1-day integrated run testing protocol (a.k.a. "ASTM-in-a-day") was presented to the WG. Testing under a more finalized version of this protocol will be performed by Mark Champion under a project managed by Lisa Rector. The 1-day protocol compresses all 4 phases of ASTM's test into a single day's run and includes Start-up, followed by the High Fire phase, followed by the Medium Fire phase and ending with the Low Fire phase. Equivalency factors would be applied to correlate the 1-day test results back to the compliance standard in place under the NSPS.

- Trial loading densities used for each phase were 1 lb/ft for kindling, 3 lb/ft for start-up, 5 lb/ft for high fire, 5 lb/ft for medium fire, and as much fuel will fit in the firebox for the low fire. It was noted that the loading densities for the start-up and perhaps the kindling phases may be too low/small.

- Regarding piece size, WG members seemed to agree that it was reasonable for the protocol to call for small pieces for the High Fire load, medium to large pieces for the Medium Fire load and

a jigsaw size mixture of small, medium and large pieces for the Low Fire load (i.e., as much as would fit in the firebox for the Low Fire).

- Air settings were set fully open for start-up and the high fire phase, at medium open for the medium phase and at the lowest air settings for the low-fire phase. It was noted that, when burning cordwood, the low air settings on a stove designed to crib wood may be too low, as cordwood burns at a lower burn rate at a given air setting (compared to crib wood) and therefore more air may be required at the low burn for cordwood.

- The end of the low fire test is tentatively defined as 90% fuel consumption or no weight change after 30 minutes. WG members expressed support for defining the end of ASTM-in-a-day's high and medium fire phases in terms of percentage of coal bed burned down, instead of in rigid timeframes (e.g., 1- and 2-hour burn requirements), in order that the protocol be as flexible as possible to work for a wide range of stoves without requiring exceptions or allowing loopholes.

To-Do List:

- Lisa Rector will e-mail everyone about upcoming meeting days and times.

- Lisa will post to Basecamp PDFs and eventually a spreadsheet of data from EPA's crib and cordwood species testing performed by Mark Champion. WG members should review the data and provide input to Lisa and to EPA.

- Lisa will post to Basecamp her slides regarding the 1-day integrated run "ASTM-in-a-day" protocol she's working on via testing by Mark Champion and will also eventually post photos.

Highlights from Meeting:

- Lisa Rector opened the workgroup (WG) meeting, noting that John Crouch, Bob Lebens, Adam Baumgart-Getz, Amanda Aldridge and Cindy Heil couldn't join the call. Lisa also noted that many lab folks appeared to be missing from the call. The following WG participants were present on the call: Lisa Rector, Kelli O'Brien, Gregg Achman, John Barnes, Stef Johnson, Lisa Herschberger, Randy Orr, Rick Curkeet, Bob Ferguson, Rod Tinnemore, John Wakefield, Roger Purinton, Tom Butcher, Jill Mozier plus others who joined later or did not identify themselves.

- Lisa's webinar slide showed the agenda for the day to be: the [upcoming] call schedule; a brief overview of EPA's work; and a review discussion of the 1-day protocol.

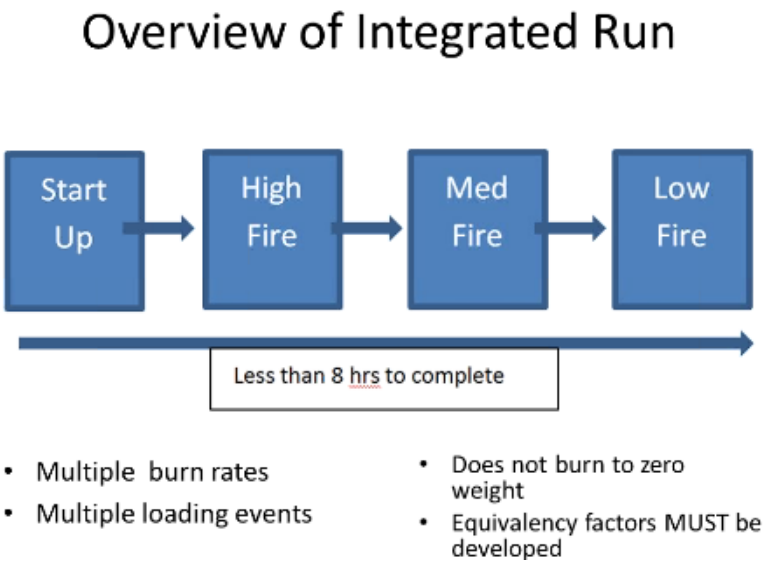
- Regarding scheduling of future meetings, Lisa noted that neither she nor John Crouch are available for the two regular April meetings and that Thursdays in general were problematic. Lisa therefore suggested Fridays at 1 pm and asked if anyone had problems with that day and time. Lisa Herschberger replied she will have problems some of time with Fridays at 1pm. Lisa Rector and Lisa Herschberger will talk one-on-one regarding a work-around.

- Lisa Rector noted that she has not yet posted data from the EPA-funded species testing that Mark Champion did. Mark has finished that testing and Lisa will post PDFs of the White Birch, Red Maple and Red Oak runs to Basecamp. Mark is currently cleaning-up and finalizing his Excel

spreadsheet of data and other testing information and that too will be posted, once cleaned up. Lisa asked WG members to review the postings on the species testing. Lisa noted that EPA welcomes WG members' input after they dig into the data. Lisa also noted that, probably on the next call, EPA will present some of that information.

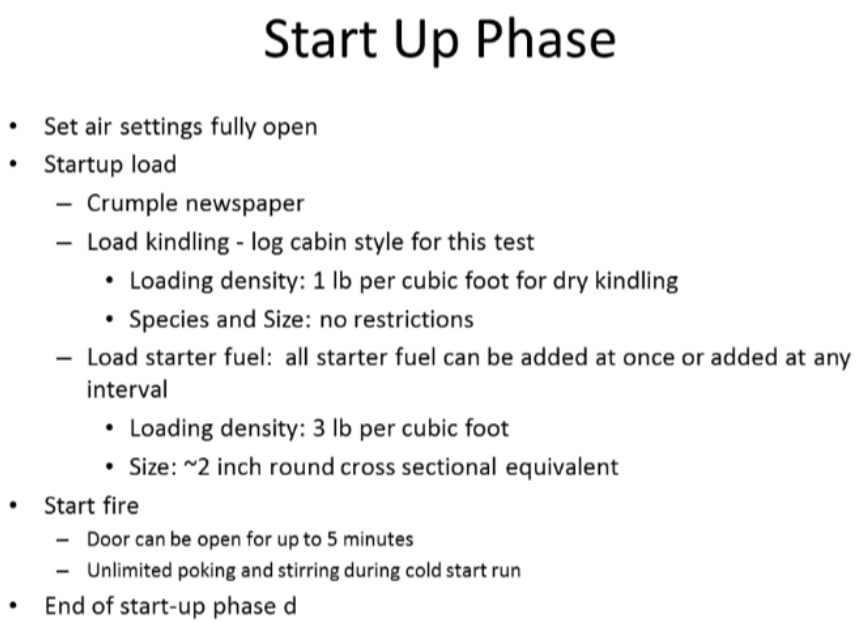
- Lisa recapped that the WG was starting to get into the definition of burn rates [on the last call]. Lisa suggested that laying out what an alternative protocol may look like could aid the discussion. To that end, Lisa noted that during today's meeting, she will go over the testing work she's doing with Mark Champion, in order to show the WG what one alternative protocol looks like. Lisa asked if there were any other items for discussion, but the group had none.

- Regarding the 1-day protocol, Lisa explained that she [NESCAUM] is trying to develop an integrated run, which builds on the ASTM method as well as the TEOM data being collected in a multitude of labs. **The 1-day protocol compresses all 4 phases of ASTM's test into a single day's run** (i.e., **"ASTM-in-a-day"**). The run consists of multiple burn rates and loading weights and doesn't burn the fuel charge down to 0 weight. Lisa clarified that the NSPS's 2 g/hr (cordwood limit) or 2.5 g/hr (crib limit) would not apply directly to the results of this 1-day test, but rather equivalency factors would be applied to correlate the 1-day test results back to the compliance standard in place under the NSPS. Rod Tinnemore asked the meaning of the 2 and 2.5 g/hr and Lisa replied that 2 g/hr refers to the NSPS' Step 2 [2020 limit] using crib and 2.5 g/hr refers to the Step 2 [2020 limit] using cordwood. Below is an overview of the integrated run:



- Lisa noted that she was at Mark Champion's lab yesterday, testing to determine what aspects of the protocol are doable and not doable. Lisa noted that she has questions about some parts of her draft protocol, but would like to run through it first for the WG and then come back to seek input and answer questions.

- Lisa noted that the first piece is the **Start-up Phase**. Mark had Lisa build a fire like she would have at home and then translated those loads into loading densities. Air settings were fully open. Lisa used 6 pieces of crumpled newspaper then loaded small, dry kindling on top of that. Lisa used the same species for kindling as used in the load. The kindling load resulted in a loading density of 1 lb/cubic foot. The starter load fuel was placed on top of the kindling. Lisa noted that they started with 2 lb/cubic foot but, about 15 minutes into the burn, Lisa noted that she wanted to add more fuel. Therefore, Lisa and Mark decided to increase the density to 3 lb/cubic foot, whether all at once or at any interval during the startup phase. Regarding the parameters for the door and poking/stirring, the door can be open for 5 minutes and poking/stirring is unlimited during startup (the cold start run). Lisa noted that the end of the start-up phase is currently defined as when the coal bed reaches 15% of the high fire fuel charge. [Note: this is cut-off in the below screenshot.]



- Next, is the **High Fire Phase**. Below is a photo of the load used for the high fire phase. Because the load is not being burned down to 0 in this protocol, half of ASTM's 10 lb/cubic foot was used (5 lb/cubic foot). Lisa explained that another load would not fit in the stove, if 10 lb/cubic foot had been used as the starting load, since it is only being burned down to 50%. For the high fire phase, Lisa and Mark used 3 pieces of wood and closed the door immediately. No stirring or poking is allowed during the 1-hour high fire. Lisa requested feedback on whether small or large wood pieces should be used and how the high fire should be defined.

- Lisa noted that the proposed protocol is high fire for only 1 hour. Part of the reasoning for the 1-hour burn is that TEOM data (showing real-time PM) reveals that 90% of the PM is captured in the first 45 minutes. Therefore, sampling really only needs to be performed for 1 hour, according to Lisa. Lisa underscored however that an equivalency factor will need to be figured out to translate back to burning down to 0%, as done in Method 28.

High Fire Phase

- Open door and load high fire load
  - Loading density: 5lb per cubic ft
  - Size: TBD
    - Questions - small or large pieces
- Door closed immediately
- No stirring or poking
- Test ends at after one hour from loading

- Next, is the **Medium Fire Phase**. Lisa noted that, for the medium fire phase, the wood is loaded in the firebox at 5 lb/cubic foot. This is the same density as the high fire, so the resulting volume is little less than 10 lb/cubic foot, because wood from the high fire is left in the firebox in addition. Lisa explained that, even though a lot burned during the high fire phase, all of the wood did not go down into coals; there are still chunks. Lisa also noted that she had questions for the WG about the proper piece sizes for the medium fire. Below is Lisa's slide for the Medium Fire Phase.

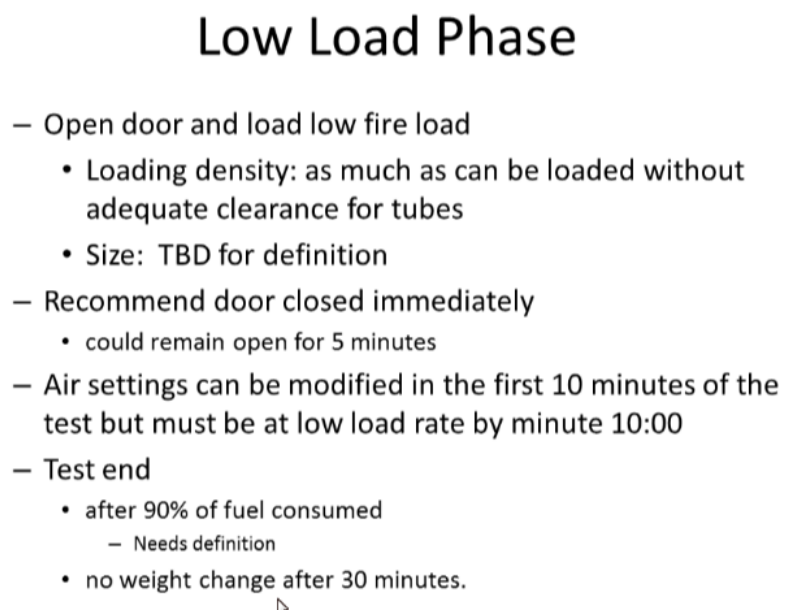
Medium Fire Phase

- Open door and load medium fire load
  - Loading density: 5lb per cubic ft
  - Size: TBD for definition
    - Piece size recommendations?
- Door closed immediately
- Set air settings to medium position
- One stirring and poking event can occur when there is no visible flame
- Test ends at after two hours from loading
  - Stove should be able to burn at medium setting for 2 hours. Thoughts on this recommendations?

- Lisa explained that the doors are closed immediately for the medium fire. However, Lisa had to open the doors to stir and poke the fire, as there were no flames. The fire re-lit after this. Lisa explained that the medium fire is currently defined as 2 hours from time of loading, but that Lisa

would like WG feedback on this. She defined the end of the medium fire as 2 hours after loading because it seems reasonable that the unit could be at medium for 2 hours. Lisa noted however that perhaps the end point could be based on 50% of the fuel charge being consumed. Lisa further noted that she is still trying to figure out what the end of test definition should be.

- Next and last, is the **Low Fire Phase**, which is summarized in the below screenshot of Lisa's slide. Lisa noted, that after 2 hours, the coal bed was a little less than 15% [of the 5 lb/cubic foot loading density weight]. For the low fire, the prescribed loading density is essentially to load the firebox with as much wood as it'll take. Lisa allowed room for the tube and noted that she and Mark had used birch for this initial test run.



- Lisa noted, that after closing the door, she had the air settings at high [open fully] for 5 minutes before closing them down to the low air setting. The end of the test was defined as when 90% of the fuel is consumed (which, Lisa noted, still needs to be defined further) or no weight change after 30 minutes. Lisa further noted that they were still deciding how to define the end of the low fire test and were looking at TEOM data to determine how long to sample to ensure all of the PM was captured. Lisa explained that they may allow one of the low fire runs to proceed all the way to the end (100% fuel consumption) in order to standardize the burn time, but PM measurements wouldn't necessarily have to be taken the entire time. Lisa noted that they were "still at the top of the funnel" in terms of determining the protocol and that this was the first attempt at the "ASTM-in-a-day" protocol. Lisa asked the WG if there were any questions.

- John Barnes (from New York) asked if loading as much wood as possible for the low burn rate was to simulate an overnight burn. Lisa replied yes, that was the purpose, but clarified that she and Mark had not taken filter measurements yet. So far, they have just been trying to see if the protocol is reasonable. To that end, they simply laid out 10 lb/cf worth of fuel charge on the ground and then subtracted out the pieces that did not fit (one piece). Lisa noted that she, as the novice did the loading, in an effort to simulate what the homeowner would do [in the "real world"].

- In response to a question from John Barnes regarding the ratio of [time] at the high burn rate versus the middle burn rate, Lisa explained that she didn't have time to parse the data yet and it was done as one integrated run. John clarified that he wanted to understand why 1 hour was selected for the high burn and 2 hours was chosen for the medium burn. Lisa explained that those duration choices were about the amount of fuel in the stove and how people generally operate stoves. Lisa noted that the stove couldn't burn for 2 hours on 5 lb/cf [for the high burn rate test] without going to nothing [no fuel left]. The idea behind the 2 hours for the medium burn is that this seems a reasonable time that people would burn at a medium setting. That is, a stove could sustain a medium fire for 2 hours and, furthermore, this 2-hour medium burn also provides good conditions to go to the low fire load/test. Lisa noted that they could have ended the medium burn test at 1 hour, but then the fire would need to keep burning before going into the low fire load/test.

- John Barnes wondered if perhaps the manufacturer would/should specify a load based on their design. Lisa replied that they were still in the process of determining the appropriate protocol.

- Lisa noted that one of the things she is grappling with, having the luxury of seeing EPA's [species] data [based on both crib and cordwood], is whether or not cordwood generally burns at a lower burn rate than crib wood at the same air settings, everything else being equal. Lisa further noted that EPA's species testing seems to indicate this, at least based on the pre-NSPS stove that EPA used for its species testing. Lisa would like to know if that would also hold true for a cleaner, NSPS-certified stove.

- Bob Ferguson replied that, based on the testing done [by himself and for ASTM, for example] this is true even with very modern stoves – that is, at the same air settings, cordwood burns at a lower burn rate than crib wood. Bob noted that this general experience/fact is based on using [the relatively high] ASTM loading densities. Bob explained that there's not enough air spacing [in the firebox when loaded with cordwood] and more air would be required in the stove than the cordwood load allows, in order to get to the higher crib-based burn rates.

- Lisa noted that a high fire [open, high air settings] with cordwood could be similar [in burn rate] to a medium fire [medium air settings] on crib. Therefore, as Lisa and Mark do cordwood testing and develop a cordwood protocol on an NSPS-certified stove that was tested for cribs, Lisa wondered if that should be determined/accounted for in some way.

- Bob Ferguson explained that [this differential in burn rates on cordwood versus crib wood] shows up most at the lower burn rates, that is, when stoves are set to the lowest air/burn settings. Bob noted that it probably occurs less on high because, as the fire gets going, there is less fuel weight with cordwood, depending on when the test is ended. If the test doesn't end until 100% of fuel consumption, then the charcoal tail is impactful. Bob noted that the long tail is much more of a problem with cordwood than with crib. On cordwood, the long tails is doubling the length of the test. Bob explained that it takes approximately the same amount of time to burn the last 10% of cordwood as it takes to burn the first 90% of the fuel (on high fire). It's not a linear process, but low fire shows the most difference, according to Bob. Lisa noted that this

was the same phenomenon that occurred during EPA's species testing on the pre-NSPS Vigilant stove.

- Lisa noted that one question that she and Mark had at end of the first trial day of testing was whether the stove's air setting designed for the lowest burn using crib wood should be used when burning cordwood. Or, should she and Mark adjust the air settings to achieve a similar low burn rate on cordwood that was achieved using crib [which would require that the air settings be opened some amount to allow in more air than the lowest setting, as cordwood would require more air to burn at the same burn rate as cribs]. Lisa clarified that it was a ridiculously low burn rate [using cordwood and the lowest crib settings].

- Bob Ferguson replied that, in his experience, fires burning cordwood at less than 1 kg/hr went out and so that air setting may have to be adjusted. Bob noted that ASTM handled that by requiring an 8-hour burn, but of course an 8-hour burn is to be avoided in an integrated run. Bob noted that there are many stoves where the fire will go out when burning cordwood on the lowest air setting designed for crib wood [certification test]. Bob concluded that he didn't have an answer for Lisa, but there is a big difference [in burn rates between crib and cordwood].

- Stef Johnson noted that Lisa would not find a prescriptive one-size fits all [for the cordwood protocol]. Therefore, Stef suggested that it may be better to be descriptive and look for a performance basis for defining the load rather than being prescriptive.

- Lisa noted that this meant playing with the stove [that is, adjusting the lowest air setting]. Moving forward, if a stove is designed to burn cordwood, it wouldn't be designed as stove designed to burn crib. Lisa wondered therefore how to design a protocol for a cordwood stove while using a stove designed for crib wood.

- Stef replied that he understood the conundrum and that an additional challenge is that there will exist many different stove designs. Therefore, the test method probably cannot be hard coded, since there is no one size fits all. Rather than defining the burn rates, Stef suggested considering defining the conditions that the test has to meet – for example, describe the operating criteria.

- Bob Ferguson noted that ASTM had looked into this on a particular stove and determined that the air setting that delivered a 1 kg/hr burn rate while burning a 12 lb/cf cordwood load, would have delivered about twice that burn rate (2 kg/hr) if burning crib wood. Bob noted that this was approximate and was based on one stove. Bob further noted that he agreed with Stef that there will be differences [among stoves]. Bob suggested considering that the protocol require burning X% of fuel or no more than X% of fuel, in order to allow some flexibility to accommodate stove-to-stove variation, but at the same time provide some basic performance description. Bob concluded that this is especially difficult to define after only one day of testing.

- Lisa replied that she and Mark will go back to the drawing board, regarding the cordwood protocol. Lisa suggested that the WG go back to the beginning, the first slide, to see if anyone had any questions on the proposed start-up.

- Lisa noted that Bob Ferguson had noticed that Lisa and Mark were using a lot less kindling in their draft cordwood ASTM-in-a-day protocol than ASTM's method does. Lisa asked if they were using about half of what the ASTM method calls for. Bob Ferguson confirmed that Lisa and Mark used about half of ASTM's start-up load. Bob noted that Lisa's and Mark's stove did look a little thin at start-up and the stove may have been happier with more kindling. Bob further noted that 1 lb/cf of kindling will look thin in some stoves, depending on the size of the hearth. Lisa agreed and noted that the amount used wasn't determined scientifically. Lisa further noted that she would use more starter fuel on the next run/step and may ultimately decide to go to more kindling, perhaps ending up in same the place as ASTM.

- Bob Ferguson noted that Lisa's and Mark's kindling density in their draft protocol was close to what ASTM requires. Bob explained that ASTM's requirement is based on fuel weight. Therefore, a 20% [of fuel load weight] metric for the kindling results in a loading density of 2 lb/cf for kindling and then 3 lb/cf for the start-up fuel. Bob suggested that Lisa start obtaining photo documentation so that people can see what the loads look like. Bob noted that the stove should maintain relatively clean glass and that the load could be seen this way and also with the door open. This way, Bob noted, people can see if the volume passes the reasonable test. Lisa noted that she had photos but wanted to clear those photos with Mark before showing. Bob suggested that Lisa decide where to take photos to avoid having too many photos, but that visual cues are helpful to stimulate discussion among the group.

- Since there were no questions from the WG on the start-up phase, Lisa went on to see if the WG had any questions regarding the high fire phase. Lisa noted that, for the high fire, she and Mark lowered the loading density to 5 lb/cf and wondered if they should go back to 7 lb/cf, in order to be closer to what Method 28R calls for. Lisa noted that she was agnostic about this decision. Lisa also asked the WG if they should be using small or large pieces in the high fire phase, or perhaps a mix of both.

- John Barnes asked in response what the homeowner/consumer would most likely do.

- Lisa explained that she and Mark used pieces that were twice the size of the starter fuel, but not the biggest pieces, with the rationale that the coal bed is not yet established when going to a high fire right after start up. Therefore, a homeowner wouldn't use the big pieces yet and Lisa decided to use small and medium size pieces, with not specific size definition. Lisa noted that her recommendation would be for the pieces to be on the smaller size for the high fire phase.

- Regarding the medium fire, Lisa again displayed the medium fire slide for the WG, and noted that she recommended larger pieces for this phase, because there is a better-established coal bed at this point. Therefore, the homeowner/consumer is more likely to use bigger pieces.

- Rod Tinnemore asked for confirmation that Lisa doesn't yet have a way of defining piece size. Lisa confirmed that she did not yet, but would have to determine a definition.

- Lisa noted that, for the low fire phase, she and Mark used a mix of piece size to get as many pieces into the firebox as would fit.

- Rod noted that the smaller loading density [used in Lisa's and Mark's draft protocol] does provide more flexibility for the smaller firebox sizes, since there are smaller stoves out there on the market. So, as stated, the protocol is not running the risk of the load not being able to fit into the firebox, whereas that's not a risk going upwards in firebox size. Lisa noted that was a good point and further noted that they were using a medium firebox for testing currently, but would need to go to smaller and larger fireboxes.

- Randy Orr noted that it's reasonable for the protocol to call for small pieces for the High Fire load, medium to large pieces for the Medium Fire load and a jigsaw size mixture of small, medium and large pieces for the Low Fire load.

- Lisa noted that she would post the "ASTM-in-a-day" (i.e., multiple burn rates and load weights in one consolidated/integrated run) protocol to Basecamp and asked WG members for feedback regarding variables or directions that Lisa and Mark may not have yet considered.

- Rod Tinnemore commented, regarding the 2-hour medium burn, that it's difficult/problematic to have an external factor [static requirement] applied to all stoves. Rod noted that other factors need to be examined to determine something other than a rigid timeframe. Lisa agreed and noted that she and Mark had discussed whether setting a rigid timeframe was providing loopholes for some stoves and hurdles for other stoves. Rod noted that he'd like not to build in [a need for] exceptions, but rather make the protocol as flexible as possible to work for a wide range of stoves.

- Lisa noted that, as an alternative [to a rigid time requirement], she is considering instead that the protocol call for burning down the coal bed to a percentage of the fuel load. Stef Johnson noted that he thinks that's a good metric. Lisa clarified that she's thinking about the protocol calling for burning down the coal bed by 50% from the High Fire to the Medium Fire and then by 25% from the Medium Fire to the Low Fire. However, Lisa noted that she's trying to balance those percentages so that the test doesn't go too long.

- There were no further comments or questions. Lisa noted that she and John Crouch would get back to the WG after reviewing their schedules. Lisa will post this presentation to Basecamp along with photos (with Mark's permission). Lisa will also post PDFs of EPA's species testing to Basecamp.

- Meeting adjourned

EPA Notes from Operation and Fueling (O/F) Workgroup Meeting Notes May 4, 2017 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), **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), Roger Purinton (Jotul), Jill Mozier (EPA contractor, meeting note taker)

Primary Conclusions from Meeting:

- Adam Baumgart-Getz from EPA provided a brief overview of the species testing which took place at Mark Champion's lab. The study examined PM emissions and burn rates from different species including Douglas Fir crib, White Pine crib, Red Oak crib and cordwood, Red Maple crib and cordwood, White Birch crib and cordwood, and Ash crib and cordwood. CO emissions were also measured. Study results seem to indicate that species does matter in terms of PM emissions, at least on the pre-1988 stove used in the species study (which had minimal emission control technology). Results also seem to indicate that there is not a big distinction within each species between crib and cordwood. In other words, preliminary review of results suggests that the emission differences between crib and cordwood is minimal within a species, especially compared to differences across/between species. Going forward, EPA is hoping to narrow in on 2 to 3 species and then work on the cordwood-based protocol. EPA hopes the workgroup (WG) will work with the WESTAR and NESCAUM groups on that effort before proposal, in order to inform EPA's proposal.

- It was noted that ASTM also recognized that differences between species in a wide range of specific gravity were potentially large. Therefore, ASTM prescribed a narrow specific gravity range in its cordwood method. Note: ASTM is taking final action on the current ASTM cordwood method. The method should be published within the next 6 weeks.

- It was suggested that the WG needs a face-to-face meeting to make recommendations on where to go directionally with the cordwood method. Conclusions from a core group of people experienced in data review will be presented to the larger WG after a July face-to-face meeting. Albany NY was suggested as the meeting place, with meeting space reserved in NYSERDA, 5

minutes from the airport. The suggested dates for the meeting are: to begin the afternoon of July 19th, followed by a full day on July 20th and finishing up on the morning of July 21st.

- Regarding other ongoing testing, NESCAUM received funding from Washington State a couple years ago and Lisa Rector has been overseeing running ASTM-in-a-day at Mark Champion's lab. The startup, high fire, medium and low fire draft protocol was reviewed in the March WG call. [See March notes.] TEOM results are of specific interest in current testing. Currently, 90% of the fuel is being consumed in this testing, but emissions are dropping off at 85% of the fuel load consumed. Next week (in mid-May) several people will observe the protocol in action at Mark's lab and comments will be collected. NESCAUM, via Mark's testing, is attempting to determine if the ASTM-in-a-day protocol is feasible and has merit with respect to the goals and objectives. Results of the testing to-date will be presented on the June 1st WG call.

- Other trips this summer may be feasible to view the ASTM-in-a-day protocol testing at Mark's lab, for both people experienced with lab testing and wood stove design and for people not as familiar with wood stove design and testing, although separate trips will likely be planned for these two groups.

To-Do List:

- WG members should provide comment and questions on EPA's species testing as well as NESCAUM's ASTM-in-a-day protocol and come prepared for the June 1st meeting by having reviewed data shared to-date.

- Lisa Rector will e-mail people regarding their availability and interest in attending the face-to-face meeting in Albany in July, as well as in visiting Mark Champion's lab to witness wood stove testing under the draft ASTM-in-a-day protocol.

- Lisa Rector will cancel current GoToMeetings and reschedule the WG calls as webinars, in order to allow more people on each call.

Highlights from Meeting:

- Before the meeting, Lisa Rector e-mailed four Oak and Ash PM Rate and PM Factor graphs to the workgroup (WG). John Crouch opened the WG meeting, asking everyone to look at the graphs before the meeting started.

- Lisa listed the name of the following people who were on the call, in attendance: Mark Champion, Gaetan Piedalue, Jane Gilbert, John Barnes, Gregg Achman, John Voorhees, Kelli O'Brien, Lisa Herschberger, Randy Orr, Rick Curkeet, Bob Ferguson, Sebastion Button, John Wakefield, George Allen, Rebecca Trojanowski, Tom Morrissey, Adam Baumgart-Getz, Phil Swartzendruber, Cindy Heil, Mike Toney and Jill Mozier.

- Lisa noted that it had been 6 weeks since the WG last met and that she was planning on this meeting being an update call. EPA will provide a brief overview, based on the [Oak and Ash] slides circulated, regarding the species testing at Mark Champion's lab. Lisa noted that she will

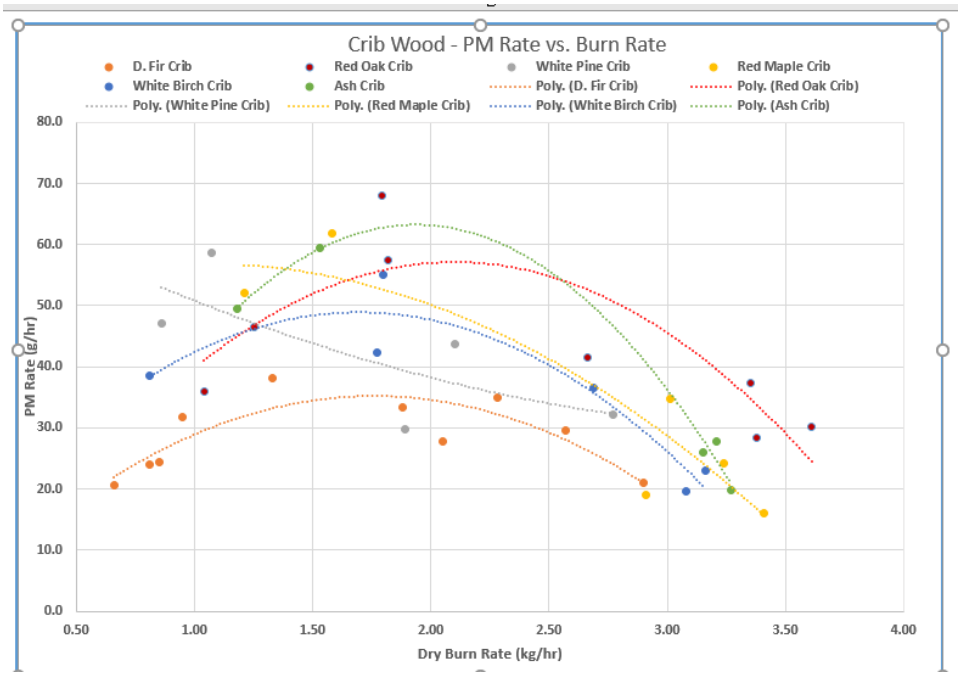
provide a brief overview of ASTM-in-a-day being funded by Washington State and also occurring at Mark Champion's lab. Lisa further noted that she will discuss upcoming meetings, including the structure and frequency of calls for the WG. Lisa asked Adam to provide EPA's update of the species testing.

Discussion regarding EPA's Species Testing at Mark Champion's Lab:

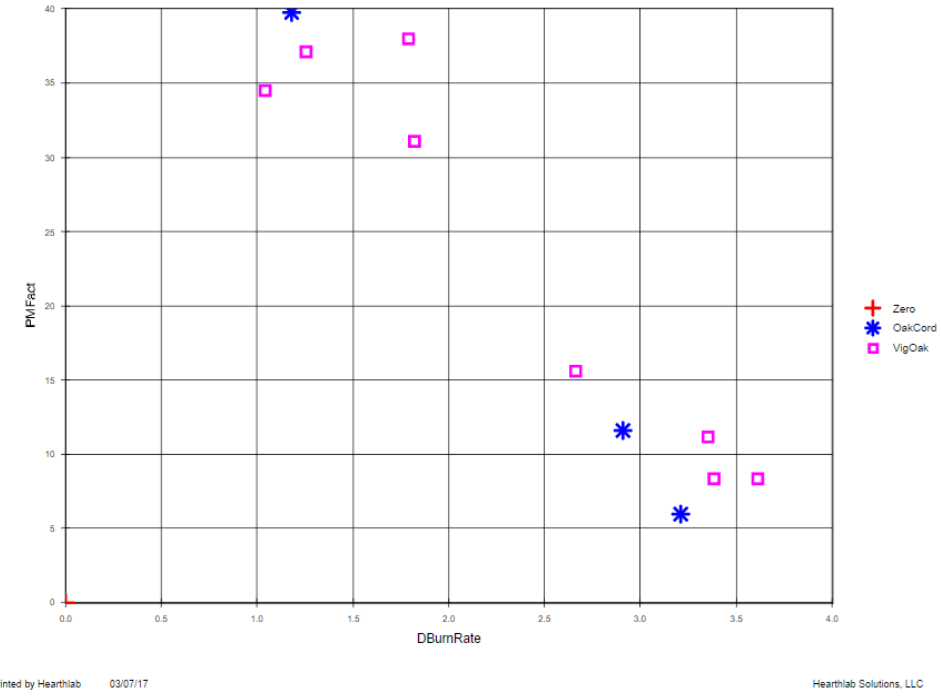
- Adam Baumgart-Getz ensured everyone had the Oak and Ash graphs, which had been e-mailed prior to the meeting. Starting with the Ash PM Factor graph, Adam noted that he hoped everyone had a chance to review the spreadsheet that Mark had sent out. Lisa put an image of the spreadsheet on the webcast screen. Adam noted that the study examined [PM emissions and burn rates from] different species [including Douglas Fir crib, White Pine crib, Red Oak crib and cordwood, Red Maple crib and cordwood, White Birch crib and cordwood, and Ash crib and cordwood]. CO emissions were also measured. Adam explained that the group [Hearthlab Solutions, SC&A (formerly EC/R) and EPA] are now doing final QA/QC on the spreadsheet of results. Adam apologized that the process has taken so long.

- Adam explained that the study began by burning crib wood first, since crib wood is used in the current standard. Adam noted that the study produced small data sets, based on a limited number of runs. Nonetheless the study found there were distinct patterns based on species. Some species' results were closer to other species' results, while some were distinct. But, Adam noted that the big take home message from the study is that species <u>does</u> matter … at least on crib wood on an old Vigilant stove.

- Adam noted that the graph being shown to the teleconference attendees shows the PM g/hr ["PM Rate"] on different species. Adam explained that the graphs reveal a distinct pattern across species. [An example based on crib wood is shown below.]



- The next graph shows crib plus cordwood data together [the PM Factor (g/kg) versus burn rate (kg/hr) for Red Oak], which was one of PDFs sent to the WG prior to the call. In the graph being displayed for the teleconference [shown below for Red Oak], the blue stars are based on cordwood burns/runs and the pink squares on crib runs. Adam concluded that, at least on this pre-1988 Vigilant stove, there is a pattern according to species, but there is not a big distinction within each species between crib and cordwood. The emission difference between crib and cordwood is minimal within a species, especially compared to difference across/between species. Adam suggested that people look at other graphs at leisure.



- Adam explained that the Vigilant was chosen in an attempt to test "raw emissions" from a "campfire in a box" as much as possible. Adam noted that the study wasn't interested in how a modern stove with different control technologies would handle emissions from various species. The goal was to determine what the raw profile for different species is and also to compare crib versus cordwood. Adam explained that EPA, through this study, is trying to build a data bridge from the crib wood standard to a cordwood test.

- Adam noted that EPA knows that not all labs can use Douglas fir cord wood [because it's not legal to import non-native species in most states]. EPA appreciates the ASTM work, but the Agency had some indication from forestry folks that species would impact emissions. Hence EPA undertook this study, Adam explained.

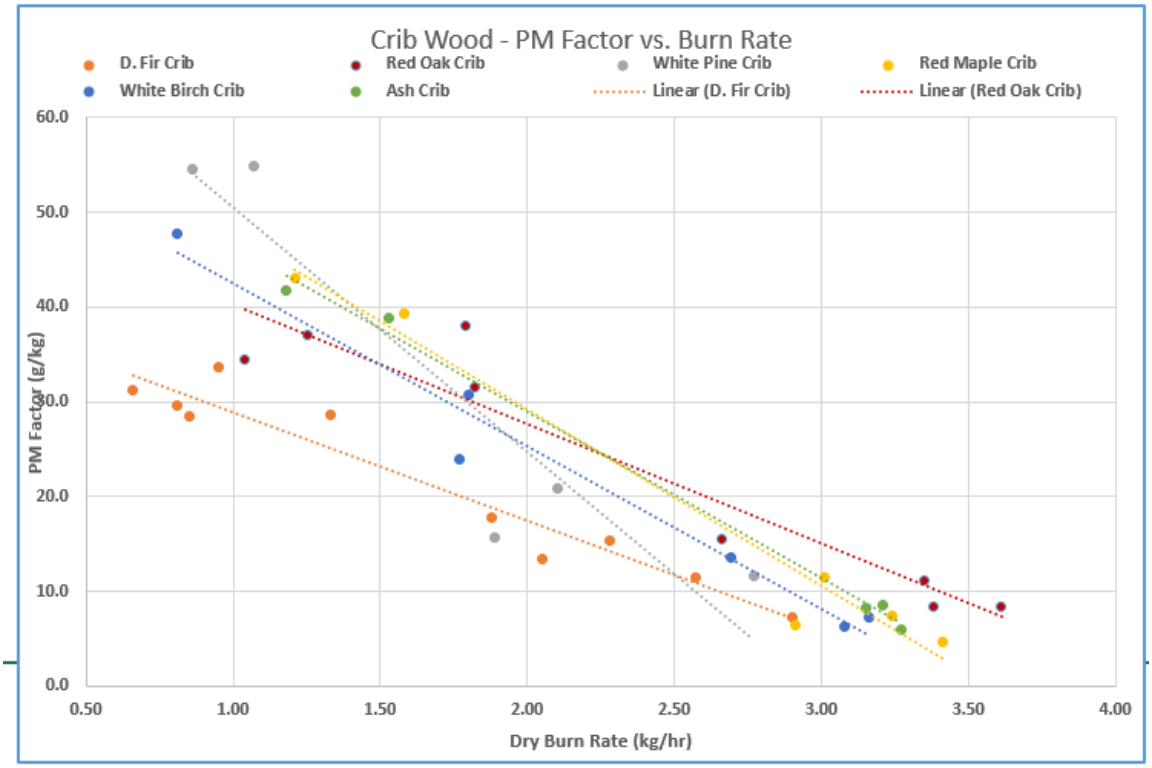
- Adam explain that, at this point, EPA is hoping to narrow in on 2 to 3 species and then work on the cordwood-based protocol. Adam noted that EPA is hoping people will work with the WESTAR and NESCAUM groups on that effort before proposal. Adam explained that, once EPA

enters the proposal phase, it's very difficult for EPA to work with stakeholder decisions and recommendations directly, as the proposal work occurs behind the veil of EPA.

- Bob Ferguson pointed out that ASTM's premise was not that there is no difference [in emissions] between different species, but rather that there wouldn't be a difference under the very narrow specific gravity range [that ASTM stipulated]. Bob noted that ASTM expected similar results for that narrow range only and emissions on average were the same for two groups of woods. Adam thanked Bob for the clarification and apologized for misspeaking [about ASTM's contentions].

- Adam noted that EPA's species study at Mark Champions' lab did include the specific gravity of wood burned. Adam further noted that White Pine was thrown in there to see what a softwood would look like, but EPA didn't seriously expect White Pine to make it through the process. Adam explained that the species study looked at different species' profiles and everything else was within the range. But the most striking finding was that Douglas Fir was the outlier / most different. Adam noted however that more data needs to be collected on this.

- In response to a question from Bob regarding the g/kg [PM Factor] slide shown below, Adam noted, that there is a lot of similarity but the Douglas fir seems to be different. Adam further noted that the final numbers are on a different tab, which EPA will distribute after final QA/QC.



- Lisa Rector noted that once this spreadsheet is available, it will be posted. George Allen and Lisa will be looking at the spreadsheet closer once they receive a final dataset. Lisa noted to the WG, that she and George would love to get input on other ways to look at the data, to tease other

information from it. Lisa further noted that they would also welcome other datasets. Adam agreed, noting that EPA and HearthLab Solutions have generated this data not as a definitive answer, but as part of a conversation.

- John Crouch noted that he needs to know more what these data points mean, but it's very interesting.

- Mark Champion noted that, based on data provided in the final report, the loading densities can be determined. Mark also pointed out that the specific gravity of each species of wood is listed on the Wood Data tab. [Note: this tab indicates the following average specific gravity measured for each species: Douglas fir = 0.47; Red Oak = 0.69; White Pine = 0.33; Red Maple = 0.50; White Birch = 0.52 and Ash = 0.58].

- Adam noted that Bob Ferguson had made an excellent point about White Pine [being outside the range of specific gravity ASTM recommended] and Adam reiterated that EPA never considered having a White Pine standard. Bob added that ASTM was always concerned about the range of specific gravity. ASTM recognized that differences between species in a wide range of specific gravity were potentially large.

- In response to a question, Mark Champion replied that the damper was closed for the test batches. Bob Ferguson noted that therefore the Vigilant was not close to a campfire, because when the damper is closed, there's a convoluted flow path out to exhaust. Mark agreed, noting that this will be clarified in the final report, so that it's well understood; the test burns in the Vigilant were not that close to a campfire.

- John Crouch asked if the cribs Mark Champion made for the species testing were like those called for by Method 28. Mark replied that they were "M28-like", although were not exact because the loading density was reduced by half. Mark explained that reducing the loading density by half was done to hopefully reduce the effect of boundary conditions, in too large of a fire. Mark explained that there were two 2x4's and two 4x4's in the crib. For the cordwood tests, Mark noted that the study matched volume – that is, the wood took up the same volume with cordwood as the crib occupied in the firebox.

- John Crouch asked if the surface area of the loads was measured. Mark explained that the surface area was not measured, but he took a photo at the end of the load with a ruler, so a reviewer of the data could go back and calculate/estimate the surface area.

- Bob Ferguson reported to the WG that ASTM is taking final action on the current ASTM cordwood method. The method will be off to editors and final formalities at ASTM, so it should be published within the next 6 weeks.

- Bob further noted that the specific density [range] is the same as in the Canadian Standards Association [CSA] method and asked Rick to confirm. Rick Curkeet noted that he would look at the CSA method to be sure, as he thinks that's correct, but he may be wrong.

- Later in the meeting, Bob Ferguson noted that the specific gravity range that ASTM started with (0.6 to 0.73) covered some Oaks and Pine and even Longleaf Pine. Bob noted that some species used by Mark Champion in EPA's species testing is slightly outside of that range. Bob explained that ASTM's range comes from the Forest Service database, and are based on oven-dried wood, which may be different than how Mark determined his specific gravities. Bob noted that the ASTM range originally came from CSA's B415 method, updated for warm air furnaces. Bob concluded that ASTM's range is a narrow range of 0.13 sg.

- Lisa Rector asked people to provide input regarding the species testing results. John Crouch noted he looked forward to a final report as soon as possible.

Discussion regarding proposed face-to-face WG meeting in July in Albany:

- John Crouch discussed the possibility for a July face-to-face WG meeting with a deep data dive, noting that this idea came out of discussion in Albany in December. John noted that he will be in the East in July around the Northeast HPBA affiliate in Albany. John proposed one full day and two half-days of face-to-face WG meetings in Albany in July: that is, the afternoon of July 19th with a full day on the 20th and then finishing up on the morning of July 21st. John explained that the purpose of these meetings is to spread out and look at all the data accumulated to this point, with the expectation that a face-to-face meeting will provide for more intense brainstorming work. John noted that this is how an ASTM subcommittee meeting often works, with lots of in-person robust discussion.

- Lisa Rector noted that she does have meeting space reserved in NYSERDA, which is 5 minutes from the airport, and she also has hotel rooms blocked. Therefore, Lisa requested that people let her know if interested in attending. Lisa noted that, for regulatory folks, this will tack onto something on the Washington State work. People may want to get over to Mark Champion's lab to see some testing. During the next couple weeks Lisa and John will come up with an agenda. Lisa noted that she will provide the WG with a travel agenda soon, which will not be final, but will be final for travel purposes.

- John Crouch noted that the genesis of this meeting is an opportunity to get together and look at data. On the industry side, we are inviting people used to looking at and reviewing data. Likewise, John asked regulatory folks to invite data-oriented people to these July meetings.

- Lisa Rector noted, to put a finer point on it, the WG needs a face-to-face meeting to make recommendations on where to go directionally. The WG needs a sense regarding where the test method should be going, from a core group of folks. Then the conclusions of this core group will be presented to the larger WG after that July meeting. Lisa noted that she and John are hoping it will generate a more robust discussion. John agreed with Lisa's comments.

Discussion regarding ASTM-in-a-day testing at Mark Champion's lab:

- Lisa Rector announced that she wanted to update the WG regarding the status of the Washington State project that NESCAUM is working on. Lisa noted that NESCAUM received

funding from Washington State a couple years ago and have been running ASTM-in-a-day in Mark Champion's lab. Lisa reminded the group that, during the last call in March, she walked through the protocol, including startup and high fire with some modifications and then moving right into the medium and low fires. Lisa noted that the process at Mark's lab included that the first few runs was with different species in a medium box stove then in a larger box stove. The protocol was refined based on those runs and now Mark is performing replicate runs based on 2 different wood species.

- Lisa displayed a mock-up of the chart showing PM emission peaks of startup, high fire, medium and low fires, which also included burn rates, times, amount of wood burned, and type (species) of wood. Lisa explained that the blue line is wood burned. The red line is percent of total PM over the course of the run. Lisa noted that the study is currently at "the top of the funnel" regarding how to perform a one day protocol, that can be run multiple times in order to provide replicate runs. The final dataset, once complete, will be shared with the WG.

- Lisa noted that next week a few folks have been invited to Mark's lab to see this protocol in action during several days of testing. Comments on the protocol are being collected. Lisa noted that they are still trying to understand if this protocol has legs, that is, has merit with respect to the goals/objectves.

- Lisa explained that at this point they are keeping groups small. Lisa noted that Mark Champion will be kept busy for the next year, so that when EPA is looking to move forward with its rulemaking, the data will be available to them. Lisa noted that Mark can allow some folks in lab with advance notice. Later this summer and into the fall, Lisa explained that Mark will be burning under a different funding source and have the ability to bring other folks in to see this protocol.

- Lisa asked the WG if there is interest in early June to dig in and see the results from different runs, how to translate ASTM-in-a-day, and how to correlate back to M28. Phil Swartzendruber noted that he would be interested. Lisa asked if such a discussion should occur as an O/F WG call, noting that the discussion will require the full time available in a meeting call, once the runs are complete. Lisa explained that Mark ran M28-like tests on the stove as well as these ASTM-in-a-day protocols. Mark noted that it was about 20 runs. Lisa reiterated that, once we go through the data and discuss how to modify the protocol, the discussion will take the full time allotment.

- John Crouch opined that such a discussion should happen within this WG, rather than in a side group. The discussion will regard the snapshot of data at that point.

- Lisa noted that she and Mark would be through their QA/QC this week. Lisa further clarified that the black line is realtime PM Lisa is really most interested in the TEOM data. Lisa explained that Mark is burning to 90% [of fuel consumed], but emissions are dropping off at 85% of the fuel load consumed, at least for this stove. Lisa noted that it would be interesting to see data from the medium versus large firebox stove testing overlaid. Lisa requested that WG participants let her know what kind of data they'd like to see.

Discussion regarding upcoming WG meetings in June and July and potential lab visit:

- Lisa noted that she will plan on sharing these results during the first WG call in June, which is the first Thursday in June, June 1st. There was some discussion about having a call on May 18th as well, Lisa noted, and asked the WG if there was interest in the additional call, or if they should wait until June 1st.

- John Crouch replied that one advantage to June 1st is that the WG will be more likely to see final EPA data prior to that date, than prior to May 18th. Therefore, John suggested not having a May 18th meeting, but just having the next call on June 1st. Lisa agreed and noted that the next call is June 1st. Cindy Heil agreed as well.

- John Crouch noted that June 1st will be a data-intensive call and so the WG may want to study up beforehand. Cindy Heil noted that she wasn't able to get into GoToMeeting and would like to see data on that date.

- Lisa noted that she will change to a Webinar format instead of this GoToMeeting format, in order to alleviate the issue of people not being able to join the webcast. Lisa noted that she will therefore cancel and revise invites for joining webcast.

- Lisa noted that she and Mark Champion should touch base, given the timing of the July meeting, to see if people can come to the lab to see the test protocol being run. Mark agreed that he and Lisa should talk, as some things were still up in the air.

- Lisa requested that folks who can travel to Vermont and are interested in Mark's lab let Lisa know, so she and Mark can get a sense of how many people are interested. Mark agreed that judging interest is a good first step.

- John Crouch noted that this visit would be a lab 101 for people who don't have access to a lab and would presumably take place on that Tuesday in July. Lisa agreed, noted that if there are enough beginners, it may be best to combine those people, versus people who are expert in stove design and familiar with labs, etc. John Crouch agreed that the focus should be on people who are not knee-deep in stove design. Lisa agreed that was best for the July meeting, although on another occasion, people who are knee-deep in stove design may wish to visit Mark's lab.

- Lisa will follow-up with an e-mail to which people can answer a few questions, in order to determine who can travel to Albany in July, and also who is interested in heading to Mark's lab to witness some testing.

- Lisa thanked everyone for their attendance and noted that the WG would reconvene on June 1st.

- Meeting adjourned