DOCKETED	
Docket Number:	19-BSTD-03
Project Title:	2022 Energy Code Pre-Rulemaking
TN #:	235654
Document Title:	GE Appliances Comments in Response to Staff Workshop Presentation on Range Hoods
Description:	N/A
Filer:	System
Organization:	GE Appliances
Submitter Role:	Public
Submission Date:	11/17/2020 4:37:07 PM
Docketed Date:	11/17/2020

Comment Received From: GE Appliances
Submitted On: 11/17/2020
Docket Number: 19-BSTD-03

GE Appliances Comments in Response to Staff Workshop Presentation on Range Hoods

Additional submitted attachment is included below.

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November 17, 2020

Via Online Submission (Docket No. 19-BSTD-03)

Mr. Peter Strait
Supervisor, Building Standards Office
California Energy Commission
1516 Ninth Street
Sacramento, California 95814

Re: Comments in Response to the November 3, 2020 Staff Workshop Presentation on Range Hood Capture Efficiency

Dear Mr. Strait:

GE Appliances, a Haier company ("GEA"), respectfully submits the following comments in response to the November 3, 2020, Staff Workshop Presentation on Range Hood Capture Efficiency as a part of the 2022 Energy Code Pre-rulemaking Process, Docket No. 19-BSTD-10.

GEA is a leading, US manufacturer of home appliances. GEA offers a full suite of major and portable household appliances across seven brands, a full line of space conditioning products to the residential and commercial market, and a line of residential water heaters. GEA's products include a full line of range hoods and over-the-range microwaves that include range ventilation. GEA has been a participant in and contributor to federal and California state energy regulatory programs for over 40 years.

GEA supports the November 17, 2020, comments filed on this docket by the Association of Home Appliance Manufacturers (AHAM) and makes these further comments in response to the Staff Workshop. GEA further supports and incorporates by reference AHAM's comments regarding range hood ventilation from June 12, and July 29, 2020, copies of which are enclosed as Exhibit A. None of the many detailed issues raised in those comment letters were sufficiently addressed by the November 3, 2020, Staff Workshop Presentation nor do the proposals identified in the Staff Workshop Presentation account for the numerous concerns with scientific integrity raised in AHAM's comments on this matter to date.

In summary, GEA opposes the implementation of capture efficiency standards in the 2022 building code and opposes the proposed airflow requirements. GEA believes this is an important issue and looks forward to working further with the CEC to develop reliable measurements of airflow and capture efficiency so that meaningful, reliable standards for range hood performance can be properly included in future Energy Codes.

1. GEA Has Long Been a Supporter of Capture Efficiency Standards

GEA has long been a supporter of the development of an effective and reliable capture efficiency test procedure and corresponding standards. Capture efficiency (CE) has the potential to be a valuable metric for fairly comparing the performance of range hoods; providing valuable, practical consumer information; and establishing meaningful energy consumption metrics. GEA's history of work to develop a capture efficiency standard includes the following.

- GEA was the first and only chair of the HVI subcommittee tasked with the development of HVI 917, the HVI procedure intended to implement the ASTM E-3087-18 test procedure for capture efficiency.

- GEA performed, at its own expense, the first repeatability and reliability testing of HVI 917 at the only laboratory then or currently equipped to perform the HVI 917 test, the Riverside Energy Efficiency Laboratory (REEL).

- GEA is the only company of which it is aware to publicly release a summary of repeatability and reliability testing for HVI 917, which it did in February of 2019. These results showed substantial repeatability and reproducibility problems with HVI 917 and the underlying ASTM E-3087 test procedure. Information on these results in included with this comment letter as Exhibit B.

- GEA publicly released a summary of a second round of repeatability and reproducibility test results for HVI 917. After the poor repeatability and reproducibility of HVI 917, REEL made changes to lab conditions and re-ran the initial testing sponsored by GEA. Unfortunately, the second round of testing run by REEL showed worse repeatability and reproducibility. Information on these further test results in also included in Exhibit B.

As is evident from the above, GEA has long supported development of a capture efficiency test procedure and has devoted substantial resources in an effort to validate existing proposed procedures. Unfortunately, the result of GEA's work has been to show that the ASTM E-3087-18 test procedure, as implemented in HVI 917, lacks reproducibility and repeatability. This is the nature of science – not to confirm our hopes, but to provide data by which to make decisions.

2. No Capture Efficiency Test Procedure Proven to be Repeatable and Reproducible Exists

As set out above, GEA has devoted substantial resources in the hopes of validating the ASTM E-3087 test procedure as implemented in HVI 917. Unfortunately, that work has done the opposite – shown that the procedure lacks repeatability and reproducibility. Details on the repeatability and reproducibility testing performed by REEL were made public in presentations given by GEA at HVI conferences in February and October 2019. A copy of the presentation from October 2019 is enclosed as Exhibit B. As shown in Exhibit B, significant run-to-run variation existed between tests on identical units in the same lab tested on the same test fixture. In a second round of identical testing intended to determine if changes to the lab environment could improve repeatability, the run-to-run variation actually increased. In the 48 sets of testing run, 22 of the test pairs had 5% or greater variation in their results. GEA is aware that REEL continues to investigate potential lab-based solution to the issues with run to run variation on identical units in an identical lab. Indeed, GEA has participated in in-person efforts at REEL to address concerns with HVI 917. GEA is unaware of any other testing comparable to that run by GEA that demonstrates the issues with HVI 917 and the underlying ASTM E-3087-18 have been resolved.

3. No Reliable Regulatory Requirement Can Exist Without a Repeatable and Reproducible Test Procedure

Without a repeatable and reproducible test procedure, no reliable regulatory requirement can exist. Engineering based measurements of performance rely on the ability to test a unit at certifying lab and get the same results testing the same unit at another lab or at another time. No such test procedure exists for capture efficiency. Without a repeatable and reproducible test procedure, any alleged measurement of capture efficiency is unreliable. It cannot be used for regulatory enforcement as there can be no expectation of results consistent with the registered performance. Until this issue is resolved, no reliable capture efficiency metric can be set, and no capture efficiency metric should be set.

4. CEC's Proposed CFM Requirements Are Too High

The CFM requirements proposed by in the Staff Workshop have several problems. No reliable definition of Nominal Installed Flow has been developed. Establishing an airflow minimum without consideration of real-world installation and actual performance provides limited, if any, benefit to California residents. Further, the rates above 200 CFM proposed by CEC staff are not supported by reliable evidence nor justified based on the impact on available models and increased prices.

GEA appreciates the opportunity to provide these comments. Please do not hesitate to contact me with any questions or concerns.

Very truly yours,

John T. Schlafer

Exhibit A

AHAM
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June 8, 2020

Mr. Peter Strait
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via Email: peter.strait@energy.ca.gov
cc: info@title24stakeholders.com

Re: Proposed 2022 California Energy Code (Title 24, Part 6), Multifamily Indoor Air Quality - Kitchen Range Hood Capture Efficiency Requirement

Dear Mr. Strait,

The Association of Home Appliance Manufacturers (AHAM) respectfully submits the following comments to the proposed 2022 California Energy Code (Title 24, Part 6) Multifamily Indoor Air Quality - Kitchen Range Hood Capture Efficiency Requirement submitted by Codes and Standards Enhancement (CASE). The new requirement is defined as:

- All kitchen exhaust systems must either meet a minimum capture efficiency or minimum airflow. For both enclosed and non-enclosed kitchens, if a range hood is chosen, the range hood must either provide a minimum capture efficiency of 70 percent or provide airflow of at least 250 cfm at nominal installed airflow. Kitchen exhaust systems may also consist of a downdraft kitchen exhaust with a minimum airflow of at least 300 cfm at 0.1 inches w.c. (25 Pa) fan for both enclosed and non-enclosed kitchens, or a continuous exhaust system with a minimum airflow of at least 5 air changes per hour for enclosed kitchens only (Submeasure B, p. 14).

AHAM represents manufacturers of major, portable, and floor care home appliances, and suppliers to the industry. AHAM's membership includes over 150 companies throughout the world. In the U.S., AHAM members employ tens of thousands of people and produce more than 95% of the household appliances shipped for sale. The factory shipment value of these products is more than $30 billion annually. The home appliance industry, through its products and innovation, is essential to U.S. consumer lifestyle, health, safety and convenience. Through its technology, employees and productivity, the industry contributes significantly to U.S. jobs and economic security. Home appliances also are a success story in terms of energy efficiency and environmental protection. New appliances often represent the most effective choice a consumer can make to reduce home energy use and costs.

AHAM was approved by CEC in 2020 as an alternate range hood directory. We currently have 7 participants and have listed over 350 range hood models. AHAM appreciates CEC's efforts to pursue energy efficiency improvements and Indoor Air Quality Improvements (IAQ) for California residents and supports efforts to use national consensus methods like ASHRAE 62.2. IAQ has become even more important as so many people are at home due to the recent COVD-19 pandemic stay-at-home orders. AHAM supports the continued inclusion of range hood ratings in Title 24 as this assures the right product is installed in the home.

AHAM opposes, however, CEC incorporating by reference a non-consensus standard and by-passing the ASHRAE 62.2 committee efforts on improving range hood metrics. Additionally, CEC should ensure any method specified can be effectively and fairly implemented by all directories. Numerous places through the CASE report state "HVI listed", "HVI or AHAM listed", or "HVI listed or other methods." The CASE report and the updates to Title 24 should consistently call out "HVI or AHAM listed."

AHAM supports the objectives of the CASE Proposal for Multifamily Indoor Air Quality - Kitchen Range Hood Capture Efficiency Requirement proposal. AHAM agrees with these points made in the CASE Proposal:

- AHAM supports the Indoor Air Quality strategies defined by the EPA[1] and AHAM agrees that ventilation is an important part of that strategy. AHAM supports ASHRAE 62.2 efforts for Indoor Air Quality and ventilation to define these non-energy related performance methods.
- AHAM agrees that a meaningful way to measure range hood performance is needed.
- AHAM greatly appreciates that the CASE team has listened to input and has developed an alternate path(s).

Although ASHRAE has not yet published any improvements to 62.2, there was a working group on changes in the area of range hood metrics. As the work had been suspended by the Working Group Chair, AHAM recently asked the Standing Standard Project Committee (SSPC) 62.2 chair to restart this working group. The HVI proposal in HVI 920-2020 came from "cherry-picking" what the ASHRAE working group initiated. The HVI proposal was not brought back through the working group, the ASHRAE systems sub-committee or the full SSPC. There were significant concerns and remaining gaps with the Nominal Installed Flow (NIF) proposal from the working group where they had identified further changes or clarifications that would be needed.

The ASHRAE working group needs to develop repeatable and reproducible methods, resolve issues with all range hood products, gain consensus, and then have the change approved through review of the full committee. In place of ASHRAE standards, CASE proposes to use HVI procedures, which are not appropriate for the following reasons:

- HVI's standards development process does not take broad input into the development of the standard and does not require the resolution of objections or provide supporting data

[1] https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-quality

prior to issuance. The capture efficiency procedure that HVI has developed has not been shown to be repeatable, which was a significant objection raised by multiple members.

- The exception that CEC added to Title 24-2019 in clause 150.0(o) and 120.1(b)2 to allow working speed per HVI 916 was not accepted by ASHRAE SSPC 62.2 when that CEC exception was proposed to ASHRAE 62.2 because the SSPC felt the HVI allowances were too broad and would allow airflow and sound requirements to move in the wrong direction. This shows that with CEC working directly with HVI, the previous change was not being fully vetted before CEC adopted it.
- The proposed reference to HVI 920-020 and HVI 917 (unreleased at this time) also have not been vetted by a consensus body and they select testing points at unrealistic pressures resulting in artificially high performance.
    - AHAM has asked for a draft version of the HVI 917 specification since April 2019 but HVI has not shared it with AHAM. AHAM even asked to enter an MOU with HVI to jointly work on this effort, but HVI refused. How can CEC adopt this requirement under these circumstances?

Previously, CEC has chosen to adopt non-consensus standards. However, the past method of using HVI standards in your exceptions in the 2019 Title 24 change makes it harder to advance CEC's larger objectives. Incorporating non-consensus standards and unique, virtually proprietary methods cause confusion and create possibilities for unreviewable poor behavior because the referenced standard has not been properly developed and approved. AHAM recommends that CEC only reference published versions of ASHRAE 62.2.

AHAM wants to highlight these issues in the CASE proposal:

- Capture Efficiency (CE) and Nominal Installed Flow (NIF) are concepts that have not been defined in a manner that makes them repeatable and reproducible. Rather than rushing concepts into the Title 24 code, the right work should be done to build consensus and get them accepted by ASHRAE SSPC 62.2.
- The main changes in the CASE proposal are establishing performance requirements that can only be met if the multi-family housing occupant turns on the range hood <u>and</u> sets it at the proper speed.
- The 250 CFM is chosen arbitrarily and the data does not precisely define that it is the right set point for minimum air flow. If 250 CFM is the wrong set point, it may allow range hoods that are not as effective as needed at an even higher RPM or may prevent range hoods that are effective at a lower RPM from being used to improve IAQ in the multi-housing market.

AHAM has expanded our input on these issues and where we think the presented logic is faulty.

<u>Capture Efficiency</u>

1. The CASE proposal references the American Society of Testing and Materials (ASTM) document titled "Standard Test Method for Measuring Capture Efficiency of Domestic Range Hoods," 2018 (ASTM E3087-18). The ASTM E3087 has

repeatability and reproducibility issues along with many characteristics that are not defined. Please note that to achieve its original approval, the standard has the following note:

Section 11 (Precision and Bias),

> 11.1 The test method has not yet been subject to long-term or standardized precision and bias testing. The precision and bias estimates of this section are considered preliminary.

The standard has also not established how to assess over-the-range microwaves (OTR's) or down draft range hoods and may need to be adjusted to properly address various room sizes and styles. Additionally, AHAM has the following concerns: Temperature requirements for gas operation versus electric; mounting specifications; two burners versus more burners in operation; and the method for make-up air.

The standard is a good start, and AHAM recommends working to address these R&R issues in parallel with looking at the IEC International efforts on capture efficiency so that one harmonized standard is useable around the world for the same issue. This will allow the improvements in range hoods to be realized by consumers and multi-family housing occupants globally.

- A new future amendment of IEC 61591 is planned for Captured Efficiency (CE), but more investigation is needed on the different proposals that have been announced. The designated Maintenance Team, MT 3 of SC59K, is in charge for the aforementioned publication. This work will determine a method to be used for measuring the CE of range hoods both in exhaust and recirculation mode. There are currently four proposals under revision, one of which is based on ASHRAE 62.2, considering a nominal pressure representative for typical installations of household domestic hoods. Other methods include digital evaluations based on optical sensors and tracer gases.

2. There is flawed thinking on the use of Capture Efficiency as CASE has defined it and represents it:

- Appendix J: the testing completed was in one lab. The results appear to be from a single run.
  - The Lesson Learned from the implementation of the Title 24-2019 requirements is that more than one lab must be available for testing.
  - Basing the work on an equation derived from testing of one run does not speak to the variation in the testing and that the equation is not based on the mean of multiple tests.
  - Two OTR's were tested but only one OTR is included in the graphing of Figure 16.

- CE % has yet to be measured at nominal installed flow. Appendix J states (p. 246) – "Results also show that products that exhibit high capture efficiency at low static pressures, do not necessarily produce higher capture efficiency at higher static pressures.
  - But the CASE report notes the qualitative finding (increased capture efficiency with increased airflow) will hold [or the relationship will be maintained](section 2.2.2.5, p. 51).
    - The statement may be partially true but without more data how do you know if the variance is too high and that the results follow the previous statement of not producing higher capture efficiency at higher static pressures? Code requirements that drive this much effort need some confidence level attached to them.

Based on the variances in CFM between vertical and horizontal duct configurations (up to 60 CFM), CASE did not propose separate CE % rates tied to the duct configuration. Only 46 % of the products comply in the horizontal configuration (Table 7, section 3.2.2.3, p. 87). This shows establishing one number may not be as easy as it would seem as that percent will likely go lower with NIF (see below). Most products offer alternate exhaust options, meaning that the product would be compliant in some installations and not others. Vertical discharge requires that the exhaust consume space above the range hood, which is often used for additional storage cabinets and therefore a tradeoff decision is required by the builder.

Establishing a CE rate for Range Hoods with a broad brush regulation that does not reflect all of the variances that exist in multi-family or residential kitchens is getting the "cart before the horse." AHAM proposes that CASE join the ASHRAE working group on Range Hood Metrics so they can participate in the updates to ASHRAE 62.2 for Capture Efficiency and base their recommendation on the working group efforts and not preliminary half-developed concepts. Alternatively, CASE can get updates from Jeff Miller (CEC) who was a member of the first working group. Additionally, AHAM recommends that CASE consider engagement in the international effort on range hood CE through IEC's MT-3 for SC59K.

Nominal Installed Flow (NIF)

Nominal Installed Flow was a term created by the ASHRAE 62.2 working group on range hood metrics. The term should be used for the flow rate that is expected to be achieved in a "typical" duct system. The "nominal installed flow" should be determined by the intersection of the hood's fan curve and the system curve.

1. NIF has not been accepted by ASHRAE 62.2. As previously noted, there was a sub-working group on the task that has stopped activity. The HVI proposal in HVI 920-2020 came from cherry-picking what the ASHRAE working group was working on. It was not brought back through the working group nor the whole SSPC.

2. HVI took the ASHRAE working group efforts as their own and incorporated them into HVI 920-2020 without allowing AHAM or our member's input into the final HVI document. It intentionally excluded AHAM in the development or review apparently to build competitive advantage for HVI. HVI 920 (2015 or 2020) is not a consensus standard. It has not had the required scrutiny or proper vetting in a public forum that is required for ASHRAE 62.2 approval. Without the public scrutiny, HVI920-2020 should not be deemed as acceptable for use within CEC Title 24.

   NIF per HVI 920 has just been released as a public document (Feb. 28, 2020). There are significant issues that need to be resolved within ASHRAE 62.2 range hood metrics rating working group:

   - The Escatel study used by HVI only included a select number for 4 and 6 inch termination devices, and its conclusions are limited to airflow above 300 CFM.
   - The extrapolation of the curve to 100 CFM has not been demonstrated to be valid.
   - There is a difference in the formulas for determining the hydraulic diameter of a rectangular duct in HVI 916, Appendix I Clause 2.1.3.1 compared to ASHRAE 62.2 Table 5.3 footnote a). It is a significant difference.
   - There were numerous issues that did not achieve consensus of the working group on how to define them in a standard such as exterior terminations, internal dampers, and static pressure reporting.

   In the report, CASE says (section 2.2.1, p. 47), "Once the system is published, industry should use that nominal installed airflow for consistency." AHAM agrees with this statement. However, it is not proper for CASE to follow HVI 920-2020 now and create intentional inconsistency when a different standard is published. A CEC promulgation of a preliminary draft standard creates precedent that if found to not be proper, would require all the testing to be redone and increase costs and confuse the consumer. Ultimately, this inconsistency delays IAQ improvements to multi-family occupants and consumers.

3. Also, CASE makes this statement in the report (Section 2.2.2.6, p.55), "Because of the additional static pressure in the field, and the resulting decrease in capture efficiency and air flow, range hood products that comply with the proposed requirements will likely provide less than 70 percent capture efficiency and 250 cfm airflow as installed, so may not maintain PM2.5 and NO_2 concentrations at acceptable values. Future code proposals should consider adjusting the proposed requirement to address the higher static pressure of installed conditions". This is clear acknowledgement that the CE and CFM limits are arbitrary and that they will not yield the expected performance in the field. Figure 10 shows this that at the 0.1 in. w.c. flow is 300 CFM but the NIF for a 6 in. duct is 180 CFM (HVI 920 rounding rules applied). Note also that the CFM at NIF for different ducting will yield a different CFM number.

Thus, AHAM recommends waiting for approval of the CE & NIF proposals as a consensus standard and then revisiting the assumptions of 70 % CE and 250 CFM at NIF on all possible ducting considerations used for multi-family housing.

User Dependent

In 3.2.3.4 (p. 91), the report states, "This measure will provide improved IAQ to occupants." The assumption here is that the hood is being used as intended and recommended, which includes starting the hood prior to the cooking process to generate air flow and possibly even continue the 'run-on' time of the hood for up to 10 minutes after cooking to continue clearing the air. This assumption is not consistent with what occurs in the home. There is no data provided showing that the changes will increase usage of range hoods and provide any measured improvements in IAQ.

The 2012 study done by LBNL[2,3] listed factors that cannot be controlled by the range hood such as temperature, food surface area, and tidiness of cooking appliance. These could have a larger impact on IAQ than the selection of speed setting. This proposal does not offer any communication to occupants to educate them on these factors. Based on the LBNL study in 2012, the CEC should publish guidelines to consumers with factors that they can control to protect their health. Those factors would include cooking methods, use of a range hood, opening a window, ceiling fan, operating a portable air cleaner, and kitchen configuration set-up. AHAM would be eager to partner with you on this program.

The whole premise of the proposal is that the range hood is turned on (user actuated). Per the CASE report, occupants use range hoods for only approximately 29 % of cooking events. The first step needs to be education so owners turn on the range hood more frequently. The survey shown in Figure 9 (p. 54) shows 39 % feel that they do not need to run the range hood. There is no information in the CASE report that states how they will change behavior in 39 % of the population to get them to turn the hood on and at a setting that will provide a 70 % capture efficiency level/250 CFM.

The logic the CASE report uses for a time weighted event is wrong. The CASE report claims that occupants used their range hoods for 42 % of cooking events when weighting times for duration of cooking (section 2.2.2.5, p. 53). However, at best, this 42 % was partial usage where the hood was turned on for a portion of the cooking process. The full range usage over that 42 % value was only 11 %. The final column of Table 4 (p. 53) indicates that occupants rarely use their range hood for the full duration of the cooking

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[2] Delp WW and Singer BC. 2012. Performance assessment of U.S. residential cooking exhaust hoods. *Environmental Science & Technology* 46(11): 6167-6173. DOI: 10.1021/es3001079. LBNL-5545E.

[3] Singer BC, Delp WW, Apte MG, Price PN. 2012. Performance of installed cooking exhaust devices. *Indoor Air* 22: 224-234. DOI: 10.1111/j.1600-0668.2011.00756. LBNL-5265E.

event. This again highlights the education potential. If people who use the range hood 60 % more of the time on long cooking events than shorter events, then with education there could be a real increase in usage and a corresponding improvement in IAQ.

AHAM does not see any documentation in the report that there will be any change in user behavior. Changes to Title 24 which set new requirements should be based on a cost-benefit analysis on improving indoor air quality.

The 250 CFM volume target has been chosen arbitrarily.

The data on Figure 16-18 in the report and slides 64, 66 and 68 in the March 25, 2020 presentation were not based on NIF. Therefore, it is questionable whether 250 CFM is the right value.

On Figure 17 (slide 66), these measurements are not at the NIF that is proposed. The yellow dotted box outlines products that would be compliant under the proposed requirement of having a minimum airflow of 250 CFM at 0.1 in. w.c. or higher. It is noted (section 3.2.2.3, p. 89), "As shown in the below figures, the proposed minimum requirement of 250 cfm for range hoods would cause several products that currently comply with the 2019 Title 24, Part 6 requirement of at least 100 cfm to no longer comply, but most would." There are no products on the chart that would meet 250 CFM and 3 sones as shown by the red box below. (Note - As a reminder, the CEC acceptance of working speed for sound measurements was not accepted by ASHRAE SSPC 62.2). Therefore, 250 CFM was not chosen based on a balance of performance and sound for a given speed setting.

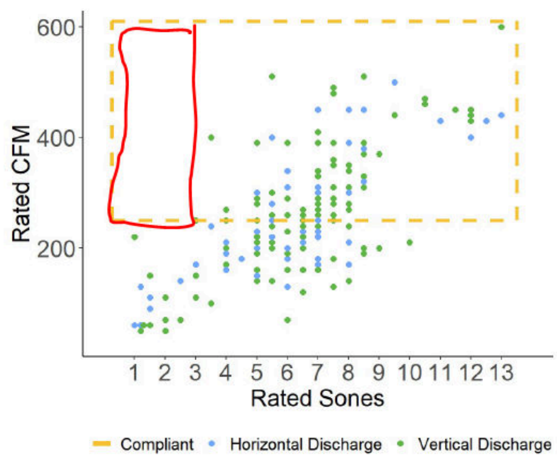

Figure 17(slide 66)

On Figure 16 (slide 68), the ROUGHLY 70 % CE value shown on the line is more like 65 %. It is clear that CASE does not feel confident in the current proposal as the chart says ROUGHLY highlighted by the capital letters. From the graph, the CE is below the 70% horizontal grid line at 250 cfm. This highlights the 250 CFM value was chosen arbitrarily. The data on Figure 16 does show the shift due to different backpressures (note - neither point is at NIF). If NIF is higher than 0.25 in. w.c., the flow may be much lower depending on the duct. This chart also shows that the slope of the airflow as a function of pressure based on the two data points, varies significantly between individual products. The two products that are on the line (Undercabinet 1 & 2), while having the same slope, have significantly different airflows from 0.1 to 0.25. This data does not support the use of the current HVI rating condition (0.1 in. w.c.) as indicative of field performance.

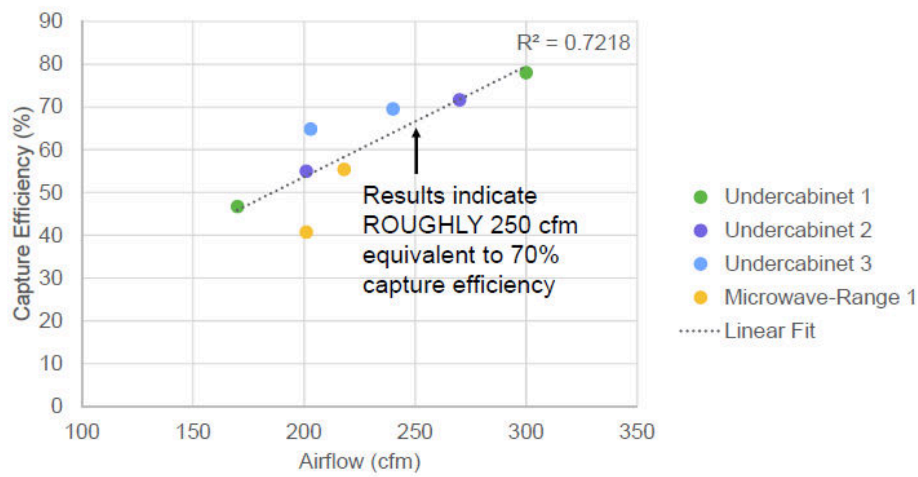

Figure 16 (slide 68)

In discussion on Figure 16 (slide 68), the CASE reports states (section 3.2.2.2, p. 85), "the higher static pressure (0.25 in. w.c.) is a more accurate representation of installed conditions," yet the CE & CFM data in Figure 16 show no units at this pressure meet the CE/CFM requirements.

- The one OTR that is on the chart is below the best-fit line and below 250 CFM so the tested OTR is not compliant to the proposed limits. OTR's were also not equally represented in the data (1 of 4 units charted even though 2 OTR's were tested). Additional testing of OTR's is needed to show that the level being set does not intentionally eliminate OTR's for use in multi-housing units. It was also previously noted that the ASTM specification does not have requirements for OTR's so this may explain some of the issues with these data points.
- Two of the eight points are above 250 CFM or above 70 %. This would show a 40 % compliance rate based on the samples tested (2 of 5). However, the points shown are clearly high speed or boost speed settings and 0.1 in. w.c., which will likely have high noise levels and will likely not be used by consumers without significant education and reluctance.

The chart clearly highlights the value is based on a small sample size. A 0.72 R^2 value says that only 72 % of the variation is captured by the analysis of CE vs. CFM. However, the R^2 in the CASE report is 0.6945 (section 3.2.2.2, p. 86). This value needs to be higher to create a non-arbitrary value. The R^2 increased to 0.87 when the OTR was removed but that is more likely tied to the fact that 3 of the 4 points in the graph were not OTR's and thus one point does not statistically represent all OTR's and may be part of a different population.

250 CFM is arbitrary and could easily be 200 CFM or 300 CFM based on variation and a different set of backpressures. One CFM level is going to be hard to justify under all conditions. Thus, if the wrong condition is used to define the 250 CFM target it will yield unimproved IAQ results in multi-family housing. This risk highlights that there is no data to show that a range hood capable of 250 CFM at 0.1 in. w.c. when installed in real multi-family housing will have improved any IAQ metrics.

The choice of using 0.1 w.c. on the 250 CFM measurement because that data exists sets a terrible precedent rather than specifying the right CFM at NIF. Too much work will be created to show the speed setting that provides 250 CFM at 0.1 w.c. when that won't be seen in a real installation. The right answer is to get the right data and make the right decision on the CFM target.

AHAM recommends that testing be repeated once the ASTM specification is properly updated for repeatability and reproducibility and the definition of NIF is agreed to in ASHRAE 62.2 to establish the proper CFM at NIF.

Summary

AHAM supports the objectives that the CASE proposal seeks to address setting new requirements. However, the requirements lack the needed technical detail, the required R^2confidence levels, and the measurements systems are still in flux. A more immediate impact on improving Indoor Air Quality would be gained by better educating consumers on what different speed settings deliver on current range hoods available to multi-family housing.

AHAM finds the CASE proposal to be arbitrary and capricious in nature. The conclusion of the CASE team in regards to barriers and solutions is flawed as noted above. The CASE proposal moves too quickly in some areas and ignores known repeatability and reproducibility issues. AHAM recommends developing solutions to reduce variability and recommends CEC align its proposed regulation in regard to Capture Efficiency with the ASHRAE 62.2 when that standard is published. We appreciate the opportunity to comment on the proposed amendments to the CEC Title 24 regulations and look forward to discussing these matters further.

Sincerely,

Kevin Messner	Randy Cooper
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July 29, 2020

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cc: info@title24stakeholders.com

Re: Proposed 2022 California Energy Code (Title 24, Part 6), Multifamily Indoor Air Quality - Kitchen Range Hood Capture Efficiency Requirement – including CASE's response & comments from July 13 & 20, 2020

Dear Ms Goebes,

The Association of Home Appliance Manufacturers (AHAM) respectfully submits the following comments to the proposed 2022 California Energy Code (Title 24, Part 6) Multifamily Indoor Air Quality - Kitchen Range Hood Capture Efficiency Requirement submitted by Codes and Standards Enhancement (CASE). The updates communicated in CASE's July 13th responses are underlined. The updated requirement from our July 20 conversation are in *italics*:

- All kitchen exhaust systems must either meet a minimum capture efficiency or minimum airflow. For both enclosed and non-enclosed kitchens, if a range hood is chosen, the range hood must either provide a minimum capture efficiency of *60 % (over electric models) or 70 % (over gas models)* at nominal installed airflow <u>on at least one speed setting</u> or provide airflow of at least *225 cfm (over electric models) or 270 cfm (over gas models)* at 0.<u>1 inches w.c. (25 Pa) on at least one speed setting</u>. Kitchen exhaust systems may also consist of a downdraft kitchen exhaust with a minimum airflow of at least 300 cfm at 0.1 inches w.c. (25 Pa) fan for both enclosed and non-enclosed kitchens, or a continuous exhaust system with a minimum airflow of at least 5 air changes per hour for enclosed kitchens only. *Kitchen exhaust fans must be rated at a maximum of 2.0 sone at one or more airflow settings greater than or equal to 100 cfm.* (Submeasure B, p. 14 plus July 2020 communications).

AHAM represents manufacturers of major, portable, and floor care home appliances, and suppliers to the industry. AHAM's membership includes over 150 companies throughout the world. In the U.S., AHAM members employ tens of thousands of people and produce more than 95% of the household appliances shipped for sale. The factory shipment value of these products is more than $30 billion annually. The home appliance industry, through its products and innovation, is essential to U.S. consumer lifestyle, health, safety and convenience. Through its technology, employees and productivity, the industry contributes significantly to U.S. jobs and economic security. Home appliances also are a success story in terms of energy efficiency and environmental protection. New appliances often represent the most effective choice a consumer can make to reduce home energy use and costs.

AHAM was approved by CEC in 2020 as an alternate range hood directory. We currently have 7 participants and have listed over 530 range hood models. AHAM appreciates CEC's efforts to pursue energy efficiency improvements and Indoor Air Quality Improvements (IAQ) for California residents and supports efforts to use national consensus methods like ASHRAE 62.2. IAQ has become even more important as so many people are at home due to the recent COVD-19 pandemic stay-at-home orders. AHAM supports the continued inclusion of range hood ratings in Title 24 as this assures the right product is installed in the home.

AHAM appreciates the opportunity to provide additional comments to CASE based on the CASE response to AHAM (July 13h) and verbal discussion with a CASE representative (July 20).

First, thank you for addressing the AHAM reference with your revision in the final CASE report that AHAM will be referenced explicitly for the range hood database listings: "HVI or AHAM listings." AHAM also appreciates the following is being added to the CASE report for clarification: "The capture efficiency testing was conducted once for undercabinet range hoods, and repeated (run twice) for the OTRs. This is because one of the OTRs had a different relationship between airflow and CE than the other range hoods (i.e., had the greatest deviation from the curve-fit regression line). Results deviated little between the duplicate runs for each OTR: 1 to 3.6% in absolute capture efficiency."

However, AHAM wants to highlight the issues below that still exist in the latest version of the CASE proposal:

1. Nominal Installed Flow (NIF) is still a concept that has not been defined in a manner that makes it repeatable and reproducible. It needs to be delayed to the 2025 code cycle.
2. Capture Efficiency levels need to be initially established at the appropriate level since it is not being delayed to 2025.
3. The minimum CFM requirement is still arbitrary since it is based on a single test of 4 units. The values need to have a better correlation to the corresponding CE levels and reflect greater than 50 % of the range hood market. Consumer education should also be taken into account on the values.
4. Sounds level limits that were just proposed need to be postponed to 2025.

AHAM has expanded our input on these issues and provided the logic for our recommended resolution to these issues.

1. Delay NIF to 2025

AHAM asks CASE to delay any use of NIF until the 2025 code cycle. CASE stated in their latest response noting, "HVI 920 is a published standard. It is important to align the proposal with the general direction that the industry is headed, which is towards nominal installed flow."

AHAM is not questioning the direction towards Nominal Installed Flow but is highlighting the reality that it is premature to require this in ratings by January 1, 2023. AHAM notes that HVI 920 -2020 is a published standard but it is not a consensus standard. AHAM has provided input to HVI directly and this input has yet to been addressed. Additionally, ASHRAE has just sent the HVI proposal to the systems subcommittee and this should be resolved over time but not in adequate time to redesign product for the 2023 requirement date. The details of the NIF methodology are not expected to be defined by this fall. Since a 3 year effectivity date is needed for product revisions from when the requirements are published, it is imperative that the ASHRAE SSPC 62.2 get this resolved in their current revision cycle and CASE should not be setting possibly conflicting requirements ahead of this effort.

The execution of NIF is built into the attached roadmap (Appendix A) and AHAM sees that 2025 is the time to appropriately bring this requirement to the codes. By 2025, the consensus approach to the static pressure requirements will be through ASHRAE and thus will have been developed and published. The NIF data for the products will have been generated by 2025. The NIF static pressure point will require retesting and AHAM recommends staying at 0.1 inches w.c. (25 Pa) for now just so there is no wasted effort on testing something with NIF while it is still in final development.

2. CASE needs to establish capture efficiency levels at the appropriate level since it is not being delayed.

In your response, CASE states, "the Statewide CASE Team strongly recommends that the Energy Commission include an optional compliance option based on capture efficiency in the 2022 version of Title 24, and we are planning to move forward with referencing ASTM E3087-18 for capture efficiency for the following reasons". Additionally, AHAM was communicated to verbally on July 20 that 60 % CE was being considered for electric (for $PM_{2.5}$) and 70 % CE was being considered for gas models (for NOx).

AHAM supports the latest CASE levels by fuel based on the LBNL simulation work[1]. However, AHAM is still concerned about the test method and therefore requests the minimum CE levels be adjusted downwards. AHAM would like CASE to consider revising the target for CE to 55 % (electric) / 60 % (gas) for 2022 and look at 60 % and 70 %, respectively, for 2025. The LBNL report recommends a 60 to 70 % range and notes that slightly lower CEs could be acceptable if users could be relied upon to operate the range hood for an extra 10 minutes after cooking. AHAM would like to use new consumer education to allow the lower CE levels for 2022. By 2025, the products can be redesigned

[1] https://eta.lbl.gov/publications/simulations-short-term-exposure-no2

and setting that target to not require user involvement and extra operation time is acceptable.. In 2025, with performance as noted in the roadmap continued consumer education will only improve IAQ further.

AHAM believes a parallel path where either a Capture Efficiency target or a minimum CFM target can be used for compliance is appropriate both initially and also long term. The cost of the CE test is very burdensome and the ability to defer to a lower cost CFM test is absolutely required. Since the testing is burdensome, ventilation manufacturers would like to be able to use any past testing while Nominal Installed Flow methodology is established. Allowing the use of a minimum of 0.1 in w.c. for the CE test is the least burdensome way to transition to this new performance requirement (CE) for 2022.

AHAM appreciates CASE comments on the proposed IEC standard, "The Statewide CASE Team would be interested in referencing the IEC 61591 amendment once developed. But based on communications with IEC, this amendment is in its initial stages of development (roughly 18 months from resolution) so will not be ready to incorporate into Title 24-2022 (the requirements of which must be drafted by this fall). The capture efficiency standard in the IEC 61591 amendment could be considered for the Title 24-2025 standard development, as an alternative method to ASTM E3087-18 (if deemed equivalent) or instead of ASTM E3087-18 (if deemed superior)." AHAM concurs with this assessment and has built the ASTM/IEC alignment into the roadmap (Appendix A) and we show 2025 as the target for convergence of the ASTM and IEC methods.

3. The minimum CFM levels are still arbitrary & not correlated to CE.

In your response, CASE stated, **"**While 70 percent corresponds to approximately 270 cfm, the Statewide CASE Team proposes a minimum airflow of 250 cfm, to ensure that at least 50 percent of products comply and to ease burden for industry compliance." Additionally, CASES stated on July 20th that the proposal will be adjusted with two different speeds to address $PM_{2.5}$ and NOx. On that date, CASE communicated the new targets are 225 cfm for electric models and 270 cfm for gas models.

AHAM appreciates the clarification and confirms it is appropriate to have different CFM levels for gas and electric as the cooking pollutants can be different. For 2022, AHAM recommends that 200 cfm (for electric models) and 220 cfm (for gas models) be used. AHAM chose these target values based on the commentary from the LBNL report and also based on our assessment of the field data. For 2025, the CFM level will need to be determined based on the correlation between Capture Efficiency and CFM at the NIF static pressure point. This is in the roadmap for 2025.

Please see Appendix B, for the following tables showing the compliance based on the directory data:

a. Note that 250 cfm does not provide 50 % of the models in either directory (Figure B-1). 270 cfm does not even cover 30 % of the current market (Figure B-2).
b. A level of 220 cfm is needed to get more than 50 % of the models in the directory for both vertical and horizontal installations. It should be noted that this percentage is

going to be conservative since a lot of the information are derivatives of the same model which skews the percent to be higher than what would be seen by consumers or builders when they are shopping various brands. The only way to address this and assure 50 % of the market is to go to a lower CFM that covers more products. This is why AHAM is recommending 200 cfm as the airflow for electric models for 2022.

The LBNL report referenced above does show their modeling is assuming a range hood airflow rate of 200 cfm, which appears to be needed by many currently available range hoods to achieve these levels of CE when cooking occurs on rear cooktop burners. On that note, burner location while cooking is going to be handled in the consumer education that AHAM will be doing. Lastly, the 220 cfm target for gas models correlates to the 60 % capture efficiency from the data CASE provided.

4. Sounds limit changes need to be postponed to 2025.

On July 20th, CASE communicated to AHAM that they are considering reducing the sound requirement to match the ENERGY STAR level of less than or equal to 2.0 sones. Although this is a marketplace metric that is already in place, AHAM disagrees with including this in the CASE proposal.

First, ESTAR saturation of range hoods is non-existent and in the latest ESTAR shipment report it shows NA for fans[2]. The view of the directories show only a few units that would be ESTAR complaint. There would only be a handful of units that currently meet 2.0 sones for working speed AND meet the CFM requirement you propose. This does not meet the CEC requirements for a proposal. This is also not in alignment with the 2025 roadmap where AHAM is recommending that the sound target be established for a range hood that meets the Capture Efficiency target at Nominal Installed Flow in 2025.

Second, the sound level at working speed isn't the most relevant for consumers and doesn't necessarily make the range hood quieter at a higher CFM or higher static pressure. Setting this target lower does match ESTAR but there is no proof that it will be quieter in the installation and thus it is not providing any value with lowering the target. Additionally, CEC would have to adjust the allowable CFM at working speed down to 90 cfm to align with ESTAR's allowances for 2 sones. The ASHRAE sub working group will be working to develop an industry accepted sound measurement that is relevant to consumers and will replace the working speed requirement.

Summary

AHAM supports the objectives that the original CASE proposal and the updates that the proposal seeks to address. However, many of the requirements lack the needed technical detail, are based on non-consensus standards, or have methods that need to be fully defined. As AHAM has stated previously, a more immediate impact on improving Indoor Air Quality would be gained

[2] EPA ENERGY STAR Shipment report (2018) https://www.energystar.gov/sites/default/files/asset/document/2018%20Unit%20Shipment%20Data%20Summary%20Report%20.pdf

by better educating consumers on what different speed settings deliver on current range hoods available to multi-family housing. We recommend the scope for the 2022 update be listed as follows:

> All kitchen exhaust systems must either meet a minimum capture efficiency or minimum airflow. For both enclosed and non-enclosed kitchens, if a range hood is chosen, the range hood must either provide a minimum capture efficiency of 55 % (over electric models) or 60 % (over gas models) at 0.1 inches w.c. (25 Pa) on at least one speed setting or provide airflow of at least 200 cfm (over electric models) or 220 cfm (over gas models) at 0.1 inches w.c. (25 Pa) on at least one speed setting. Kitchen exhaust systems may also consist of a downdraft kitchen exhaust with a minimum airflow of at least 300 cfm at 0.1 inches w.c. (25 Pa) fan for both enclosed and non-enclosed kitchens, or a continuous exhaust system with a minimum airflow of at least 5 air changes per hour for enclosed kitchens only.

AHAM has also provided a 2025 roadmap in Appendix A so that the issues that CASE was wanting to see implemented for 2022 will get the focus and attention to deliver them for 2025. AHAM recommends following this roadmap to allow developing solutions that reduce variability. As noted in the roadmap, AHAM recommends CASE and CEC align its proposed regulation in regard to Capture Efficiency with the consensus standards (ASTM and/or IEC) for this metric. We appreciate the opportunity to comment on the proposed amendments to the CEC Title 24 regulations and look forward to discussing these matters further.

Sincerely,

Randy Cooper
VP, Technical Operations and Standards

Appendix A – AHAM Presented Roadmap

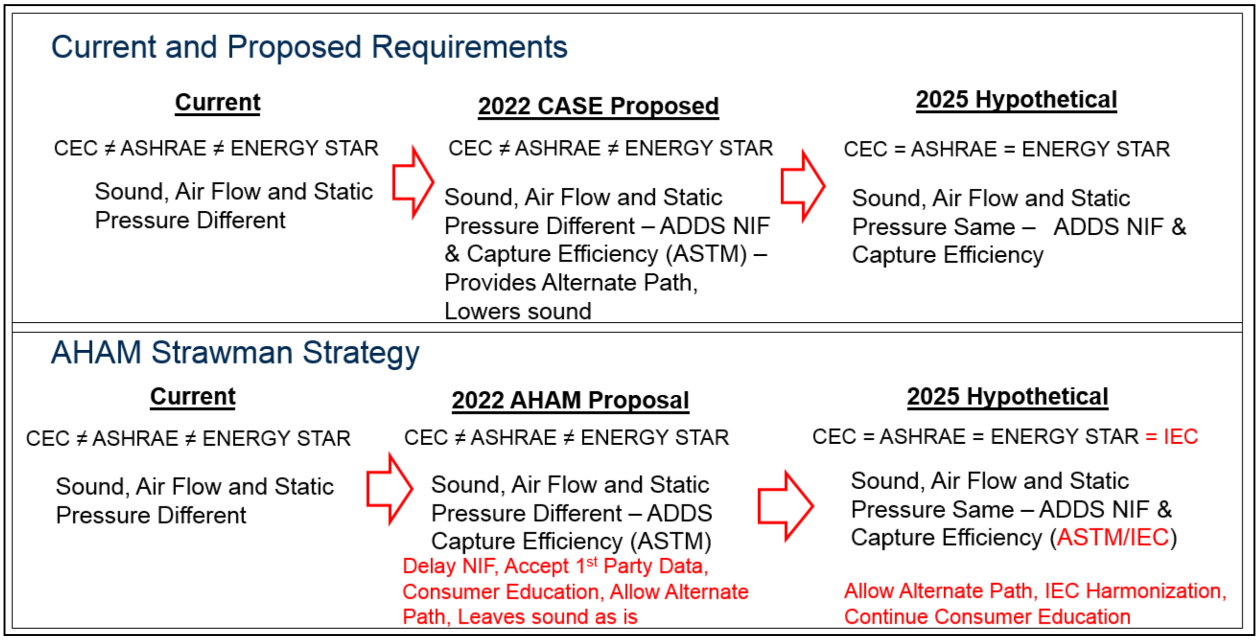


Figure A-1 – High Level View of Roadmap

Current

metic	level	static pressure
sound	< 3.0 Sones	WS
CFM	100 CFM	0.1 in. w.g.

CEC ≠ ASHRAE ≠ ENERGY STAR

2022 CASE Proposed

metic	level	static pressure	where
sound	< 3.0 Sones	WS	Non-MFH
sound	< 2.0 Sones	WS	MFH
Min CFM	100 CFM on at least one speed setting	0.1 in. w.g.	Non-MFH
CFM = CE	225 CFM on at least one speed setting on electric models	0.1 in. w.g.	MFH
CFM = CE	270 CFM on at least one speed setting on gas models	0.1 in. w.g.	MFH
Capture Efficiency	NA	NA	Non-MFH
Capture Efficiency	60% for electric models	NIF	MFH
Capture Efficiency	70% for gas models	NIF	MFH

Note - Alternate paths – CE or CFM
ASTM E3087 for CE

CEC ≠ ASHRAE ≠ ENERGY STAR

2025 Hypothetical

metic	level	static pressure	where
sound	< TBD Sones	TBD	All
sound @ CE	< TBD Sones	TBD CFM @ NIF	
Min CFM	100 CFM on at least one speed setting	NIF	All
CFM = CE	TBD CFM on at least one speed setting	NIF	All
Capture Efficiency	On at least one speed setting, 60 % for electric and 70% for gas models	NIF	All

Note - Alternate paths – CE or CFM

CEC = ASHRAE = ENERGY STAR

Figure A-2 – Details of the Current state and Future Proposals

Current

metic	level	static pressure
sound	< 3.0 Sones	WS
CFM	100 CFM	0.1 in. w.g.

CEC ≠ ASHRAE ≠ ENERGY STAR

2022 AHAM Strawman

metic	level	static pressure	where
sound	< 3.0 Sones	WS	Non-MFH
sound	< 3.0 Sones	WS	MFH
Min CFM	100 CFM on at least one speed setting	0.1 in. w.g.	Non-MFH
CFM = CE	200 CFM on at least one speed setting on electric models	0.1 in. w.g.	MFH
CFM = CE	220 CFM on at least one speed setting on gas models	0.1 in. w.g.	MFH
Capture Efficiency	NA	NA	Non-MFH
Capture Efficiency	55% on at least one speed setting on electric models	0.1 in. w.g. or higher	MFH
Capture Efficiency	60% on at least one speed setting on gas models	0.1 in. w.g. or higher	MFH

Note - Alternate paths – CE or CFM
ASTM E3087 for CE

Delay NIF, Certified Performance Data (ASHRAE) + Consumer Education

CEC ≠ ASHRAE ≠ ENERGY STAR

2025 Hypothetical

metic	level	static pressure	where
sound	< TBD Sones	TBD	All
sound @ CE	< TBD Sones	TBD CFM @ NIF	
Min CFM	100 CFM on at least one speed setting	NIF	All
CFM = CE	TBD CFM on at least one speed setting	NIF	All
Capture Efficiency	On at least one speed setting, 60 % for electric and 70% for gas models	NIF	All

Note - Alternate paths – CE or CFM

NIF defined, Sound at NIF & at CE, IEC Harmonization

CEC = ASHRAE = ENERGY STAR = IEC

Figure A-3 Details of the AHAM Multi-Step Proposal

Appendix B – Directory search of available models by CFM

- 250 CFM does not provide 50 % of the market. It is closer to 40 % for both AHAM and HVI.
- 220 CFM or lower is needed to get above 50 % including OTR, Horizontal.

AHAM Directory

HS only, w/o downdraft	Count	percentage	% compliant	
Total	548			
Total ≥ 250	223	41%	40%	net compliant that don't require make-up air
Total ≥ 220	345	63%	62%	
Total ≥ 200	449	82%	81%	
Total ≥ 400	6	1%		require make-up air
MHC, HS only	**Count**	**percentage**	**% compliant**	
Total	538			
Total ≥ 250	213	40%	40%	net compliant that don't require make-up air
Total ≥ 220	335	62%	62%	
Total ≥ 200	439	82%	82%	
Total ≥ 400	0	0%		require make-up air
MHC, Horiz., HS only	**Count**	**percentage**	**% compliant**	
Total	268			
Total ≥ 250	62	23%	23%	net compliant that don't require make-up air
Total ≥ 220	145	54%	54%	
Total ≥ 200	201	75%	75%	
Total ≥ 400	0	0%		require make-up air
MHC, Vert., HS Only	**Count**	**percentage**	**% compliant**	
Total	270			
Total ≥ 250	151	56%	56%	net compliant that don't require make-up air
Total ≥ 220	190	70%	70%	
Total ≥ 200	238	88%	88%	
Total ≥ 400	0	0%		require make-up air

HVI Directory

HS only, w/o downdraft	Count	percentage	% compliant	
Total	3101			
Total ≥ 250	1989	64%	43%	net compliant that don't require make-up air
Total ≥ 220	2435	79%	58%	
Total ≥ 200	2757	89%	68%	
Total ≥ 400	651	21%		require make-up air
MHC, HS only	**Count**	**percentage**	**% compliant**	
Total	670			
Total ≥ 250	267	40%	39%	net compliant that don't require make-up air
Total ≥ 220	461	69%	68%	
Total ≥ 200	570	85%	84%	
Total ≥ 400	5	1%		require make-up air
MHC, Horiz., HS only	**Count**	**percentage**	**% compliant**	
Total	331			
Total ≥ 250	49	15%	15%	net compliant that don't require make-up air
Total ≥ 220	201	61%	61%	
Total ≥ 200	246	74%	74%	
Total ≥ 400	0	0%		require make-up air
MHC, Vert., HS Only	**Count**	**percentage**	**% compliant**	
Total	339			
Total ≥ 250	218	64%	63%	net compliant that don't require make-up air
Total ≥ 220	260	77%	75%	
Total ≥ 200	324	96%	94%	
Total ≥ 400	5	1%		require make-up air

Figure B-1 percent available models for a given CFM

AHAM Directory

270 CFM

HS only, w/o downdraft			
548	Total		
151	Total ≥ 270	28%	meet min CFM
6	Total ≥ 400	1%	require makeup
145		**26%**	**compliant**
MHC			
538	Total		
141	Total ≥ 270	26%	meet min CFM
0	Total ≥ 400	0%	require makeup
141		**26%**	**compliant**
MHC, horizontal			
268	Total		
39	Total ≥ 270	15%	meet min CFM
0	Total ≥ 400	0%	require makeup
39		**15%**	**compliant**
MHC, vertical			
270	Total		
102	Total ≥ 270	38%	meet min CFM
0	Total ≥ 400	0%	require makeup
102		**38%**	**compliant**

HVI Directory

270 CFM

HS only, w/o downdraft			
3101	Total		
1606	Total ≥ 270	52%	meet min CFM
651	Total ≥ 400	21%	require makeup
955		**31%**	**compliant**
MHC			
670	Total		
159	Total ≥ 270	24%	meet min CFM
5	Total ≥ 400	1%	require makeup
154		**23%**	**compliant**
MHC, horizontal			
331	Total		
13	Total ≥ 270	4%	meet min CFM
0	Total ≥ 400	0%	require makeup
13		**4%**	**compliant**
MHC, vertical			
339	Total		
146	Total ≥ 270	43%	meet min CFM
5	Total ≥ 400	1%	require makeup
141		**42%**	**compliant**

Figure B-2 Percent available products that meet 270 cfm

Exhibit B

Presented at HVI Annual Meeting – October 2019

RETEST OF RANGE HOOD CAPTURE EFFICIENCY

- Earlier this year, GEA tested a mix of units for RHCE at REEL. The testing showed unacceptable repeatability. GEA presented the findings at the HVI 2019 Spring Meeting. In response, REEL retested the same units with some changes to the setup at its own expense.

- The retesting at REEL did not improve the repeatability and is not achieving the level of repeatability or uncertainty from LBNL-1004365 (Walker) pg. 38, which states tests are repeatable within +/- 0.5% CE and have an uncertainty of less than 2% CE.

- Some tests that had huge run to run variation in the first testing have less in the second testing, and others that previously looked like they might be acceptable are now unacceptable.

- There is no clear pattern to the variation, which indicates potential issues with the test procedure itself.

- No root cause has been determined by REEL or HVI for the variability issues.

Test Plan

Model	Exhaust	Install Height	Speed	Test 1	Test 2
Model A	Horizontal rectangular	24	HS = 250 CFM		
Model A	Horizontal rectangular	30	HS = 250 CFM		
Model A	Horizontal rectangular	24	WS = 110 CFM		
Model A	Horizontal rectangular	30	WS = 110 CFM		

Tested each configuration 2x –
Test 1 & Test2 for any configuration
Was not ran consecutively (each were
Uninstalled and later reinstalled)

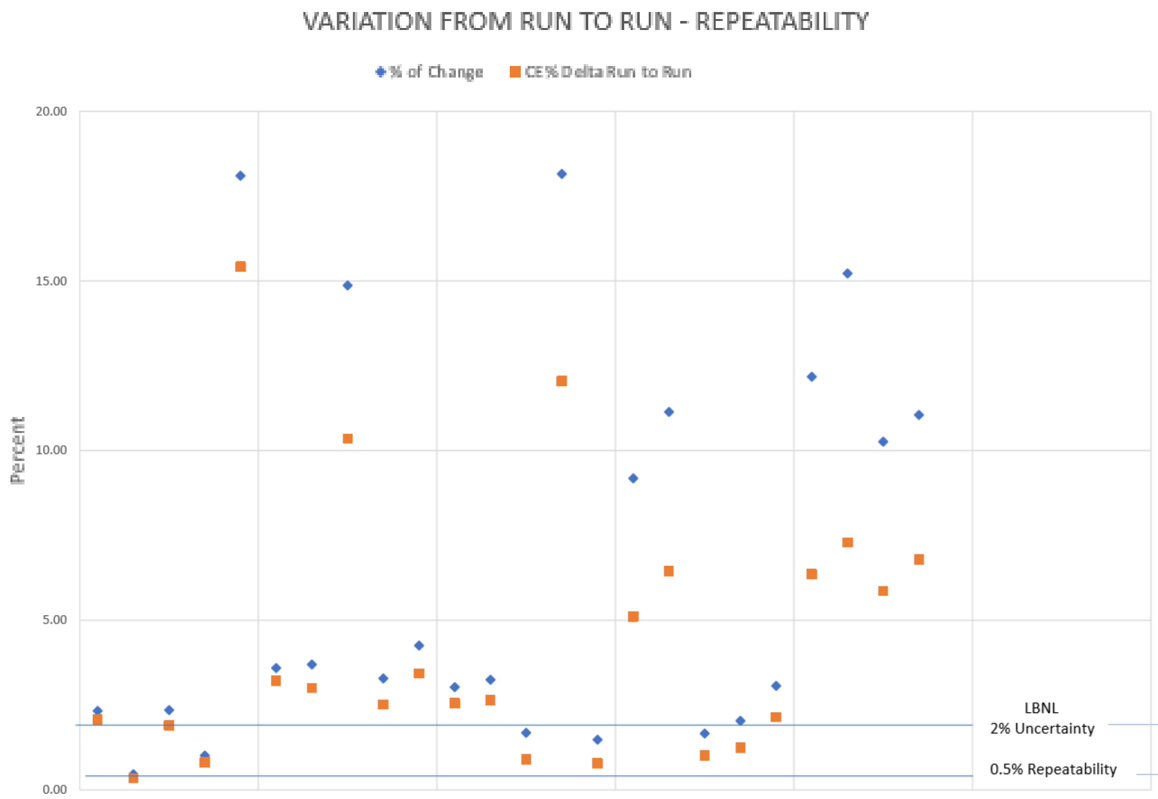
- 6 models tested, models A thru F
  - Vertical and horizontal exhaust directions
  - Round and rectangular dampers
- 2 speeds run on each model at 2 different heights
- Total tests: 24 configurations tested and then uninstalled and reinstalled and tested again for **48 total tests**

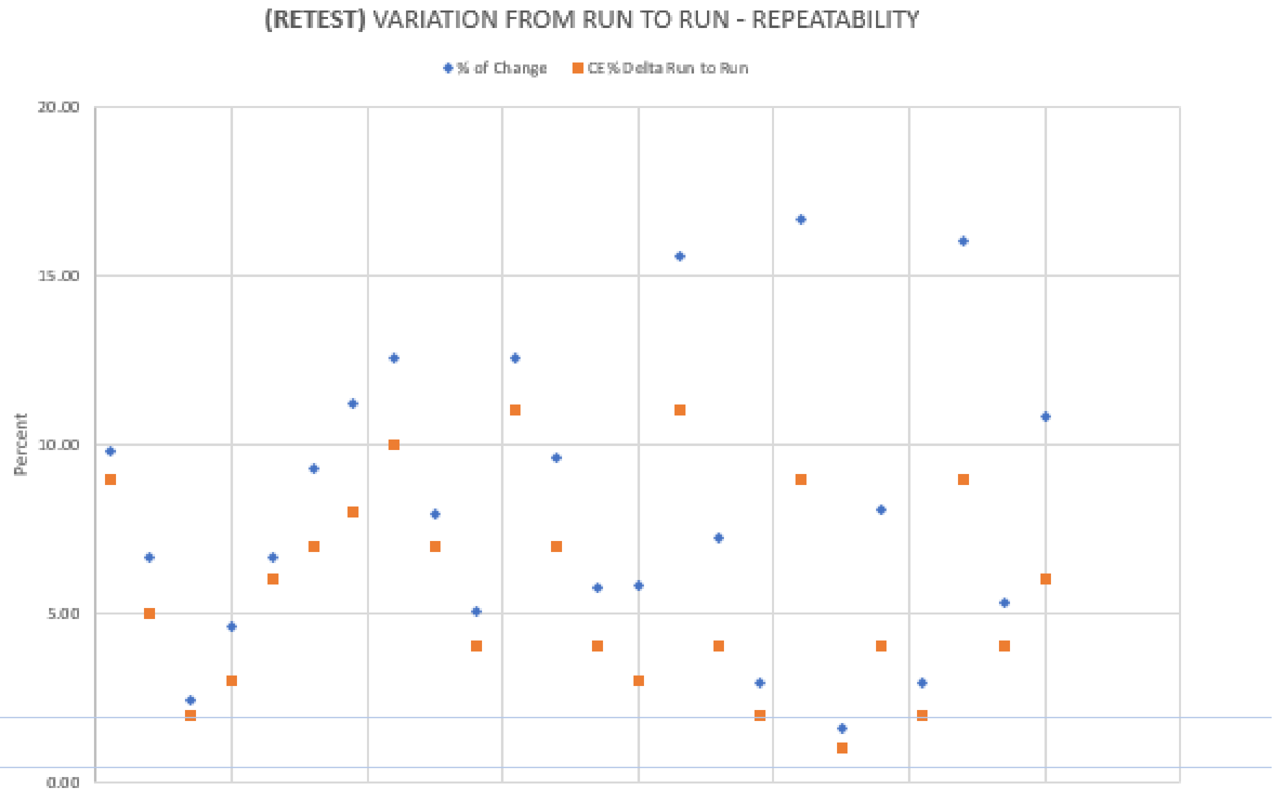
- Original testing presented at HVI Spring Meeting 2019
- Retested by REEL after making changes in effort to improve the setup

TESTING PARAMETERS

- High speeds: 250 CFM to 350 CFM
- Working speeds: 110 CFM to 160 CFM
- Exhausts: Vertical and Horizontal
- Mounting: Wall Mount and Under the Cabinet (UTC)
- All testing done at REEL, including original testing and retesting

RUN TO RUN VARIATION





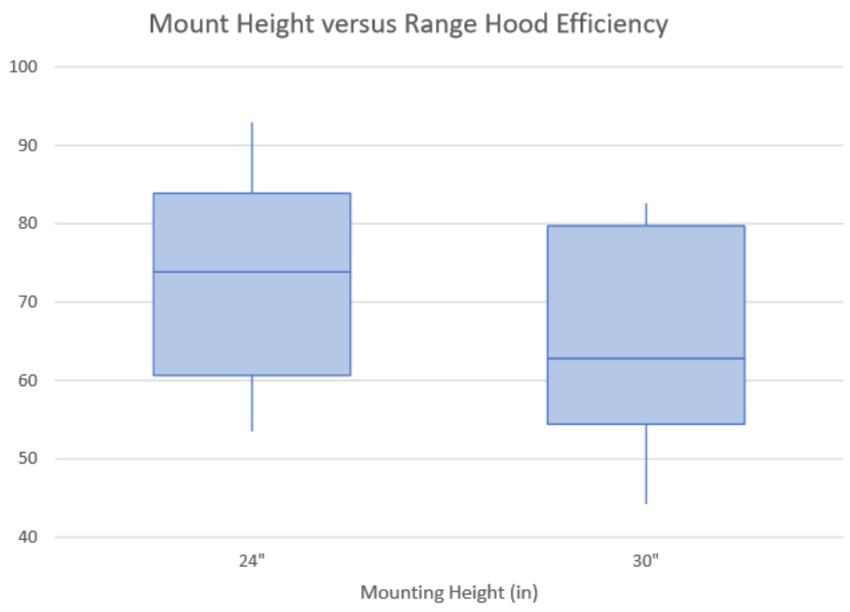
- The chart on the left was presented at the HVI conference, and the chart on the right is the data from retesting.
- The orange squares show the difference in CE between runs of the same model/configuration. (e.g. run1 = 60%, run2 = 50%, then CE Delta is 60-50 = 10%)
  - Some tests that previously had huge variation now have less, and others that previously looked like they might be acceptable are now unacceptable. There isn't a clear pattern to the variability, which indicates potential issues with the test procedure.
- The blue dots show the percentage of change in CE between the runs. (e.g. run1 = 60%, run2 = 50%, then % of Change = (60-50)/50 = 20%)
  - The blue dots are an attempt to see if the repeatability is tied to the CE level being measured. Unfortunately, it does not matter if the measured CE is low or high, the repeatability does not follow a pattern.

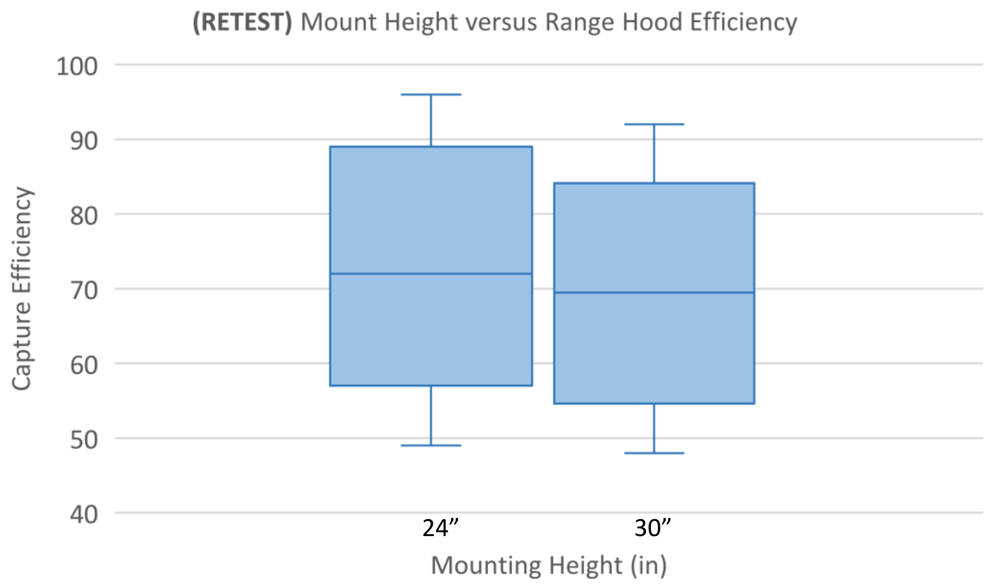
VARIATION BY MODEL

Model	Original Testing – CE Delta, Run to Run	Retest - CE Delta, Run to Run
A	2.07	9
A	0.35	5
A	1.91	2
A	0.82	3
B	15.52	6
B	3.22	7
B	3	8
B	10.35	10
C	2.52	7
C	3.43	4
C	2.56	11
C	2.65	7
D	0.91	4
D	12.05	3
D	0.79	11
D	5.11	4
E	6.45	2
E	1.01	9
E	1.25	1
E	2.15	4
F	6.36	2
F	7.29	9
F	5.86	4
F	6.8	6

- Each model was run and then re-installed and run again with the difference in capture efficiency shown. After the original testing REEL retested the models after making changes to the setup at the lab. CE% was reported as whole numbers for the retest.
- 15 out of 24 configurations showed increased variation during retest.

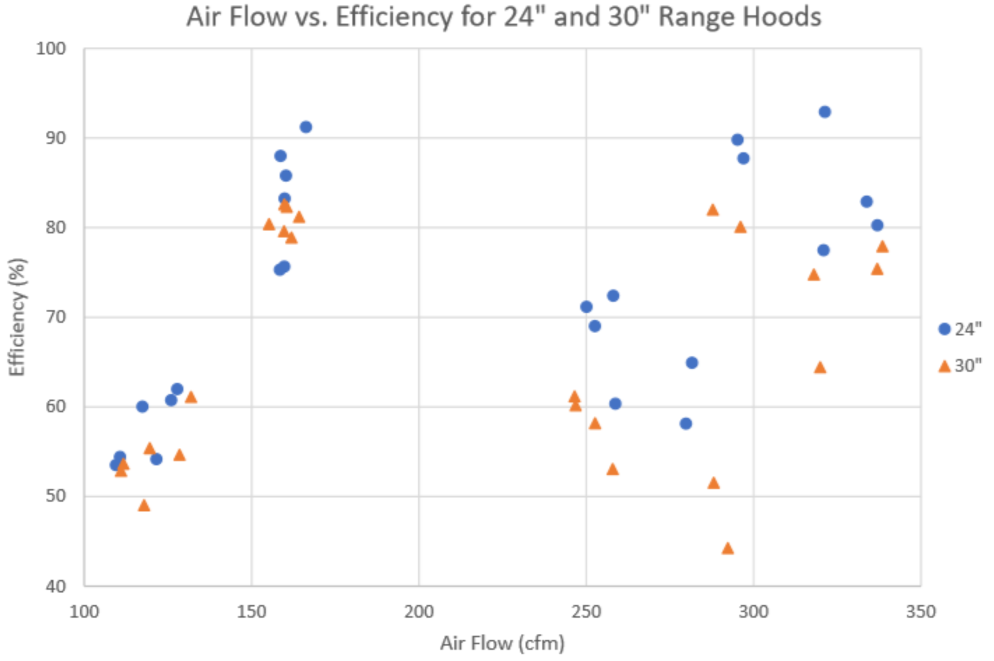
MOUNTING HEIGHT EFFECTS

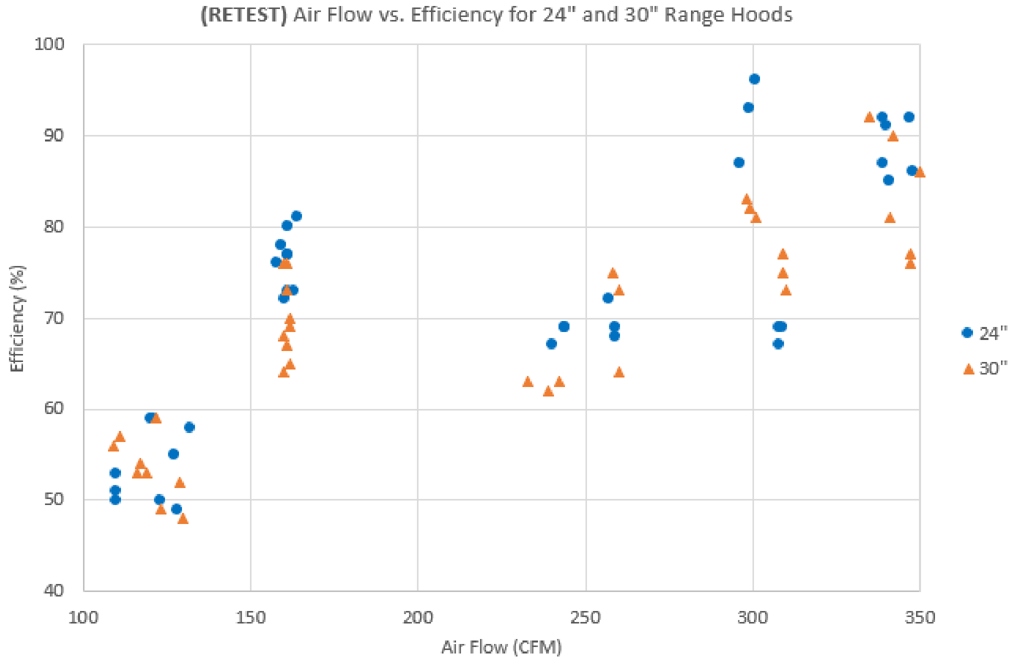




- The Mount Height vs Range Hood Efficiency whisker bar graphs show measurement is not sensitive to mounting height with a significant amount of overlap.
- Any changes to address variation must consider both low and high mounting heights.

AIRFLOW AND MOUNTING HEIGHT EFFECTS





- Air Flow vs. Efficiency shows that the variation is not correlating with the amount of airflow.
- Any changes to address variation must consider the variation across the entire airflow range.