DOCKETED

Docket Number:	17-BSTD-01
Project Title:	2019 Building Energy Efficiency Standards PreRulemaking
TN #:	220554
Document Title:	Signage First Steps for Fume Hood Sash Behavior
Description:	N/A
Filer:	System
Organization:	UC Davis
Submitter Role:	Public Agency
Submission Date:	8/4/2017 12:42:51 PM
Docketed Date:	8/4/2017

Comment Received From: Allen Doyle
Submitted On: 8/4/2017
Docket Number: 17-BSTD-01

Signage First Steps for Fume Hood Sash Behavior

While the proposed measure 2019-NR-MECH4-D addresses the most fume hood-intensive rooms that could waste a lot of ventilation energy, it uses old data for compliance ("diversity"), does not distinguish between instructional laboratories with good compliance and research or testing laboratories with less predictable compliance. It does not account for maintenance costs, or modern decals and stickers which have persistent behavior for closing, and evolving air flow standards which reduce energy impacts. It imposes a complex and expensive device before requiring intuitive and compelling signage, which would be a first step, and proposed language is included.

Additional submitted attachment is included below.

To: the California Energy Commission
From: Allen Doyle, MS, CEM, LEED AP EB:OM University of California, Davis
Date: 2017, August 4
Subject: Title 24 2019 proposals relative to TN# 217908

Scope: The proposed changes are relevant to new construction and renovations of research laboratories with fume hoods, and the installation of automated sash closers. The presumption of this code is that users are not manually closing fume hoods and that an automated device can safely and efficiently conserve energy by closing the sash. Users are presumed to be ignoring or unaware of the existing regulations that encourage them to close sashes when unoccupied.

Summary of Response: From my experience as a laboratory manager, safety advocate and conservation specialist, and given the baseline conditions and availability of behavior policies, enforcement and education, this is a technology in search of a problem, and not justified in first cost and extended maintenance when education and signage already achieves near 100% closure, Cal OSHA code does not exist, and pairing of safety and conservation messaging solidifies their culture and buy-in. This proposed code does not address all fume hoods and misses some energy conservation opportunities. A simpler measure might read,

> "All fume Hoods shall be equipped with intuitive and compelling signage, decals or stickers that indicate the sash should be closed when unoccupied. This signage must be compatible with the manufacturer's design intent of the fume hood, and may be provided by the manufacturer or after market. Institutional policy must clearly state that unoccupied hoods should be closed."

Detailed Response

Closure Confusion: In the past, traditional decals and stickers have been confusing and poorly worded, indicating that users should leave sashes open for "maximum safety" or "adequate ventilation" rather than minimum-safety-beyond-which-is-not-safe (Figures 1a and 1b). These were common when some of the diversity studies in the CASE were conducted in 1993, for example.

Figures 1a & 1b. Fume hood inspection stickers which may lead to inappropriate operation.

Existing Behavioral Code: While "close the sash" campaigns have recently become the mantra of Green Lab programs in university and government laboratories, Cal OSHA makes no reference to best practices including closing fume hood sashes, manufacturers signs and decals are missing or misleading, and enforcement of this practice is just getting started. The 2012 ANSI z9.5 ventilation standard 3.1.5 includes a "good work practice"

to close fume hoods when unoccupied, yet this basic practice may not be emphasized in chemical hygiene plans (CHP) or a pro-active laboratory ventilation management programs (LVMP). Requiring sites with laboratory buildings to have firm and proactive policy towards best practices that align with safety would be a good first step before requiring complex and expensive mechanical devices.

Proven Compliance through Signage, Decals and Stickers: Manual closing of fume hoods is already considered safe and professional conduct in laboratories, and is improved with education and enforcement. Since 2009 many improved decals or stickers have been designed to intuitively instruct users to close the sashes, (Figures 2 a, b, c). A search on the internet reveals many more.

Figure 2 a, b, c. Fume hood sash closure stickers from the University of California, CU Boulder, and Massachusetts Institute of Technology. Over 15,000 vertical stripes (2a) have been sold by UC Davis domestically in 26 states and internationally to higher education, health care, government laboratories and private companies, yet manufacturers and distributors do not include intuitive and compelling stickers on every fume hood. Industrial Hygienists have welcomed these designs.

Figure 3. Sash sticker adapted by Purdue University from University of California sticker for horizontally closing sashes, which are not addressed by auto closers.

Target Laboratories: Not all laboratories have the same compliance with manual closure. Laboratories with consistent supervision over many years have good participation in hood closure, and thus different diversity values than the baseline conditions model. This includes teaching laboratories and government laboratories where occupied diversity should be low and unoccupied diversity is typically zero. In teaching laboratories active use is also much higher than the baseline example.

On the other hand, poor compliance has been observed in chemical research and testing laboratories that have very high hood abundance, so these settings might be candidates for mechanical closers if other

remedies are not successful. In unpublished data from UC Davis in 2011, hoods in the Chemistry Department with and without stickers showed dramatically different diversities with and without stickers, (Table 1)

Hood Sash Diversity	Without Stripe	With Stripe
Floor 1	100%	0%
Floor 2	100%	25%
Floor 3	42%	0%
Floor 4	52%	0%
Floor 6	0%	50%
Grand Total	80%	20%

Table 1. Fume hood diversities with and without reminder stripes on the jamb in a chemistry building at UC Davis, 2011.

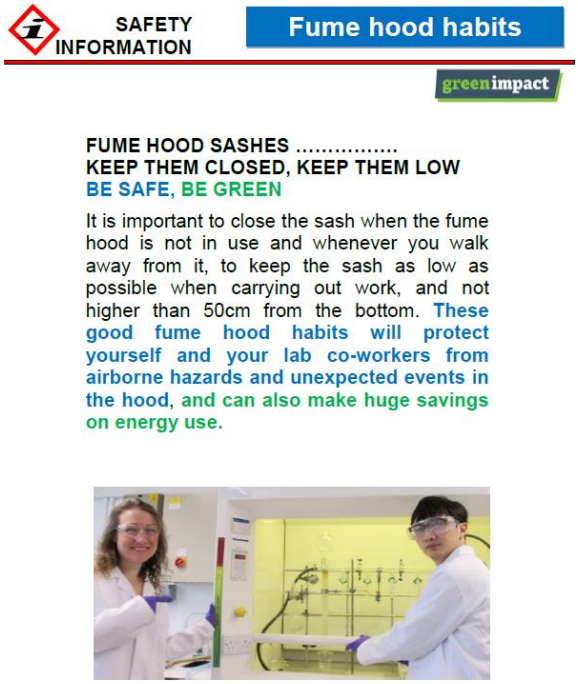

Figure 4. Sash Closure Poster from Oxford University, UK, including the sticker developed at the University of California.

Two studies on four campuses of the University of California have shown persistent reduction of sash positions in life science and chemistry laboratories[1],[2] for the cost of about $1 per hood. The initial diversity of many life science laboratories was much less than in the CASE, and was already close to zero, or negative (below 6"). For many laboratories diversity approached zero after the decals were installed or after closure initiatives. A vertical stripe has been distributed by UC Davis, and has sold over 15,000 copies in 26 states, the United Kingdom[3] and Australia, and it has been modified by other sites as well, including horizontal sliding sashes

[1] UC Santa Barbara and Davis: https://www1.eere.energy.gov/femp/pdfs/sash_stickers_cs.pdf
[2] UCLA and UC Berkeley: http://wcec.ucdavis.edu/wp-content/uploads/2014/06/Case-Study-SASH_Final.pdf
[3] Oxford University, Dr. Mimi Nguyen, Chemical Safety Advisor. 16 Parks Road, Oxford, OX1 3PH

(Figure 3), which auto sash closers do not address. Requiring intuitive and compelling decals or stickers on all fume hoods could dramatically reduce diversity.

Further, future laboratory fume hood installations should include position sensors, and controls operators can remind operators when sashes are habitually open. Design could also include loud alarms or strobes if sashes are left open when unoccupied, which would inhibit leaving them open.

Calculated Impact: As described in the June 2017 workshops, "zero diversity" describes hood sashes that are at 6" height or less. Hoods at 18" (1.5') are considered to be at 100% diversity. The base case indicates about 30-35% excess diversity above unoccupied or actively used hoods, so the goal is about 35% reduction in average diversity. Because fully closed (zero diversity) represents 33% air flow, getting a 30% diversity reduction is only 35% x (100-33%) = 23% reduction in average hood exhaust, or 200-250 average cfm per 6' hood. The calculated savings per hood over 15 years appear to be high for this partial air flow reduction, especially in the mild climates commonly found in California.

In closing, this device is not necessary when behavior campaigns can align energy conservation and safety for little mechanical cost or maintenance, with the additional benefits of improved occupant awareness and action towards safety.

"Diversity" Usage of this term is confusing and would be better replaced with "compliance", as it only refers to sash opening between design height (typically 18") and the point of minimum flow (typically 6"). In this present definition it is possible to have negative diversities below 6", which is not a helpful construct. With evolving standards in face velocity or interior flushing standards, "diversity" would better refer to relative air flow compared to 100% at the design height for standard operation, (18", not above the stop).

"Hood Driven" This term should be changed to "hood intensive" as it addresses rooms with very high abundance of hoods that far exceed general exhaust by a factor of 2 or 3. Because targets rooms highly abundant with fume hoods the use of "hood driven" is misleading.

First, the code proposal chooses an odd metric based on surface areas instead of relative air flows. "Fume hood driven" is generally considered to be the threshold when the cumulative maximum fume hood exhaust (Fex) may exceed the general exhaust (Gex) under design conditions, i.e. where Fex $\geq$ Gex. The ratio of work surface inside fume hoods to floor area is only indirectly related to air flow, and does not consider set-backs or occupancy for either hoods or general exhaust, and it is static relative to evolving standards. Note: Because there is a 100:1 ratio of face velocity to 1 CFM/SF floor ventilation, a quick guideline for "hood driven," where Fex > Gex, is when hood face area $\geq$ 1% floor area.

Second, the high threshold misses some rooms where fume hood exhaust may be wasteful. To see this, the exhaust ratio proposed in the code change needs to be deduced from common ventilation practices. Given typical 2016 air flows in laboratories (6 air changes per hour (ACH, or 1 cfm/sf), 100 linear feet per minute face velocity and 18" sash opening) the threshold of 1 SF working area per 35 SF floor area (WA/FA = 2.9%) translates to Fex = 3.2 x Gex, an excessive case of being hood driven. The importance of Fex control in rooms like this is very high, but overlooks intermediate hood driven rooms where energy conservation is important as well.