

Fume Hood Sash Stickers Increases Laboratory Safety and Efficiency at Minimal Cost:

Success at two University of California Campuses

Fume hoods represent the first line of worker safety measures in a research laboratory. Providing supply and exhaust air to fume hoods is highly energy intensive. A typical six-foot hood exhausting air at 100 linear feet per minute (LFM) and open 18 inches exhausts almost 1.5 million cubic feet of conditioned air every day. As opportunities for energy and resource conservation are found in laboratories, the clarion call of “shut the sash” goes forth, yet still many researchers don’t hear the call or forget the message. It is not unusual to find unattended hoods opened beyond 18 inches and remain that way for weeks.

Fume Hood Sash Sticker Technology Overview

In response to this obvious waste of energy, elaborate campaigns achieve essentially 100% compliance to close fume hood sashes during initial publicity efforts and from a period of incentives. However, following this initial state of heightened worker awareness, some decay in their diligence follows within a month or two.

It is not surprising that researchers do not habitually close sashes. They are very focused on their research, not laboratory building performance and energy conservation. Even when instructions on sash use are given, they are often combined with many safety lessons. There is a mixed message of “the hood is certified safe when open” and “close the sash for energy savings” that can be further

Case Study at a Glance

Technology used at UC Davis and Santa Barbara

Installed colorful sash position stickers on fume hoods that:

1. Reminds workers to close the sash after use.
2. Maximizes VAV system efficiency and worker safety.
3. Increases sash closure persistence.
4. Builds professional work habits.

Savings Achieved at UC Davis

Project effort with student assistance

- Approximately 600 stickers were installed.

Per hood installation cost = \$5

Simple Payback at UC Davis

- Estimated, at \$7/CFM/yr = **-15 hours!**

Return on Investment (ROI) = **-599!**

confused by labels placed at 18 inches that say “Place Sash here for Maximum Safety.” The authors of these labels have confused “maximum” and “minimum”, not realizing that a hood is least safe when fully open.

A Basic Solution

To address the confusion at the University of California, a lab manager and a hood safety specialist designed a bold vinyl sticker to attach on the exterior sidewall of a fume hood (Figure 1). The sticker cleverly uses the ubiquitous traffic light color scheme, with a red zone above 18 inches, and a large arrow pointing down with the words, “More Safe, Less Energy” changing from yellow at the midpoint to green at the bottom when the sash is closed completely. Interestingly, a nearly identical sticker was designed without words and installed at the Danish

Technical University in Copenhagen, where utility companies give rebates for its placement. Since 2009, the design has been shared with many campuses from Denmark to Singapore. As a public service, UC Davis prints and can provide this copyrighted sticker. From this case study, it appears the sticker promotes safe and efficient operation of fume hoods.

Implementation

In summer 2009, about 600 stickers were deployed in ten buildings at UC Davis and about 200 stickers in seven buildings at UC Santa Barbara. UC Davis hoods were chosen with safety and energy priorities. To improve safety awareness, two UC Davis chemistry buildings were recipients of the stickers even though they predominantly had constant air volume (CAV) fume hood systems and, thus, would see negligible energy reductions compared to a variable air volume (VAV) fume hood system. For safety and energy savings, all buildings with VAV systems were “stickered.” At UC Santa Barbara, only VAV lab buildings were stickered.

Survey efforts

At UC Davis, visual surveys of sash-position status were conducted: before sticker deployment; about 2 months after sticker installations; and again in spring, 2011, to assess persistence. The survey method estimated sash status by benchmarks in approximate quartiles to streamline the survey effort. This also helped capture information on VAV-system response. These benchmarks were assigned values as follows:

- **24 inches:** anywhere above the 18 inch sash stop
- **18 inches:** at the sash stop
- **13.5 inches:** between 9 and 18 inches
- **4.5 inches:** between 0 and 9 inches
- **0 inches:** less than 2 inches.

These benchmarks were incorporated into energy savings calculations. Sash positions were averaged by floors at each sample time.

At UC Santa Barbara, surveys were conducted by collecting real-time sash position data provided by the campus' building monitoring system (BMS). Data were collected for 10-day periods prior to sticker installation for select fume hoods, and one, two, and three months following sticker installation. The average sash height for each hood was calculated for each 10-day period.

Technology Safety Benefits

A fume hood's primary purpose is to contain hazards including fumes and eruptive events. It is clear that a closed-sash hood is the safest hood, and for these reasons alone sash closure needs to be a professional standard in all laboratories. The personnel safety savings from one contained event are precious, and will not be assigned a monetary value here. The sash stickers reinforce this training and remind workers of both the safety and the energy implications of inattentive sash management procedures.

Implementation Assessment at UC Davis and UC Santa Barbara

Assessment of implementing the sticker installation project was provided through a number of surveys. At UC Davis, the time of the survey of low-use hoods was not controlled because occupancy was low regardless of time. For high-use hoods, surveys were conducted during the middle of the research day, and before 9 am when occupancy was very light. At UC Santa Barbara, surveys were provided continuously by the BMS.

Energy saving persistence

Surveys at UC Davis of ten research laboratories, with a low-density number of fume hoods, showed 90-100% compliance 22 months after installation with no additional reinforcement of closure. Figure 2 shows typical response before, 2 months after, and 22 months after installation. Averages less than 2.4 inches open indicate essentially 100% compliance. Similarly, sticker installation had a strong impact on sash closure persistence in a building at UC Davis with a high fume hood density, especially overnight.

At UC Santa Barbara, compliance results were similar. In Figure 3, pre-installation average night-time sash positions were 15 inches in the ESB lab and 7.35 inches in the CNSI lab. Following the sticker installation, 23 months later, these night-time sash positions decreased to 9.38 inches and 4.8 inches, respectively. More importantly, hourly sash position data for individual hoods trended in the building control system highlight the wide differences between compliant and non-compliant laboratories, and provide impetus for strategically targeted outreach efforts. The data also provides highly quantitative visual evidence of the problem, which is one of the best ways to motivate behavior change among scientists.

Estimating savings performance

Energy savings estimates based solely on sash position are not straightforward. To understand savings performance, consider that a lab may have either a high-density fume hood count or a low-density fume hood count, based on the number of hoods per unit of floor area. In a high-density situation, the volume of lab exhaust air is dominated by fume hood requirements. In a low-density situation, the volume of lab exhaust air is determined by a required ventilation rate that is provided in combination with a general exhaust. It is clear that sash position in a fume-hood-dominated lab will significantly impact energy use and much less in a low-density fume hood lab.

Fume Hood Density

A simple rule-of-thumb indicates when a lab may be fume-hood-dominated. Many laboratory designs use ventilation guidelines that set minimum airflow at 6 air changes per hour (ACH) with a 10 foot high ceiling, or 1 CFM/SF. Therefore, in a medium size lab of 1,000 SF, the total exhaust would be 1,000 CFM. Interestingly, this is nearly equivalent to the exhaust flow rate of one CAV six-foot hood, calculated as follows: with sash fully raised, the open area is approximately 6 feet x 2 feet face area, or 12 SF; fume hood face velocity rate is



Figure 1: Fumes Hood Sticker.

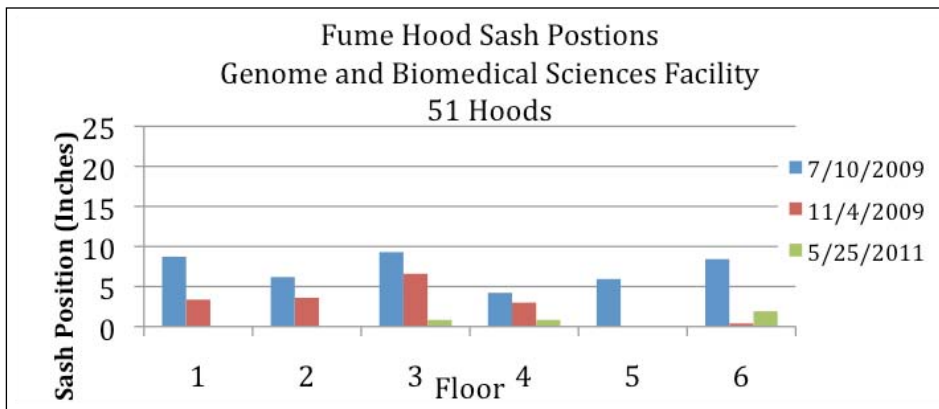


Figure 2: Sash Closing Persistence at UC Davis, Genome and Biomedical Facility.

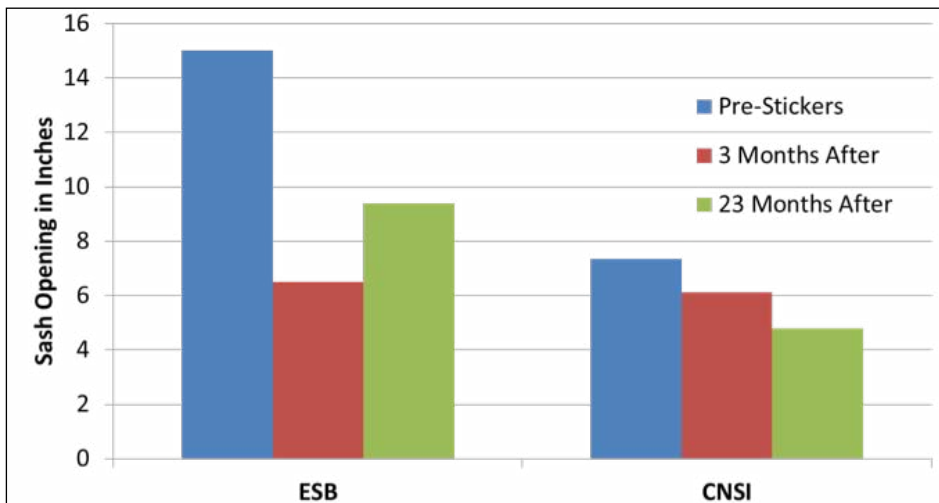


Figure 3: Sash Closing Persistence at UC Santa Barbara.

typically set at 100 LFM. Therefore, the open face area times flow rate = $12 \times 100 = \sim 1,200$ CFM. Thus, in this generalized scenario, a lab with only one six-foot wide hood in a 1,000 SF lab the airflow volume will not be appreciably affected by sash position.

VAV Energy Saving Benefits

A laboratory fume hood system is usually CAV or VAV. Airflow volume in CAV laboratory buildings will not change appreciably relative to sash position, and thus have negligible energy savings from sash closure. Whereas, in a VAV laboratory building, airflow volume should vary significantly depending on the number of fume hood sashes that are open. Also in a VAV lab space, if fume hood exhaust is less than laboratory air change rate, then fully closing sash(es) will have negligible impact on energy use, such as in the low-density spaces described above. Therefore, not every closed fume

hood saves a guaranteed, fixed amount of money. However, at UC Santa Barbara in a lab building with a high fume-hood density, an average reduction of 185 CFM was verified that equates to \$1,300 savings annually per fume hood, using the airflow costs presented in the next section.

Airflow Cost

Savings will result by reducing fume hood exhaust that is greater than needed to achieve a required ventilation rate in a lab room. A common metric (in 2011) for the value of conditioned air is \$7 per CFM per year assuming 100% once-through outside air. Note that this value would increase with very hot, cold or humid climates. Thus annually, using a 6-foot VAV fume hood at 10% full open for experiment set up, 25% at 18 inch working opening and keeping the sash closed 65% of the time would save approximately \$6,000 every year compared to constant fully open hood.

Technology Results

Data collected at UC Santa Barbara by their BMS provides a view into how users interface with their fume hoods and manage sash positions. Figure 4 presents hourly BMS trending of sash positions over two 7-day periods; before and after sticker installation. Non-compliance is indicated by high horizontal lines at night in the uppermost plots. Targeted outreach to improve sash management was implied. Beneficially, BMS trending supports follow-up outreach to be focused in problem labs.

Improvement in night-time sash closure and frequent daytime openings, as well as an apparent increase in day-time use, is fairly evident. The upper plot of averaged values (red lines) indicates that without sash stickers (uppermost plot for each building), the opening remained large without much daily variation. Conversely, with sash stickers, the averaged plot (blue lines, bottom plots) shows a generally smaller opening that changed greatly between occupied and unoccupied periods.

Lessons Learned

Good worker safety practices, including carefully monitoring sash position, will become increasingly important as laboratory ventilation designs are reduced to minimize operating costs. Some laboratories are already designed or retrofitted with setback ventilation or demand control ventilation making the position of fume hood sashes a critical element of both safety and efficient operation. Data from this case study shows that design diversity factors (number of closed hoods) may be increased substantially, reducing laboratory building cost.

Reinforcement Needed

The case study indicated that persistence in closing the sash was not absolute and may be influenced by fume hood density and type of scientific research. Some decrease in sash closure rates was observed over time at both UC Davis and UC Santa Barbara, highlighting the need for some level of continuous reinforcement of the sticker message. In one facility, there was low compliance

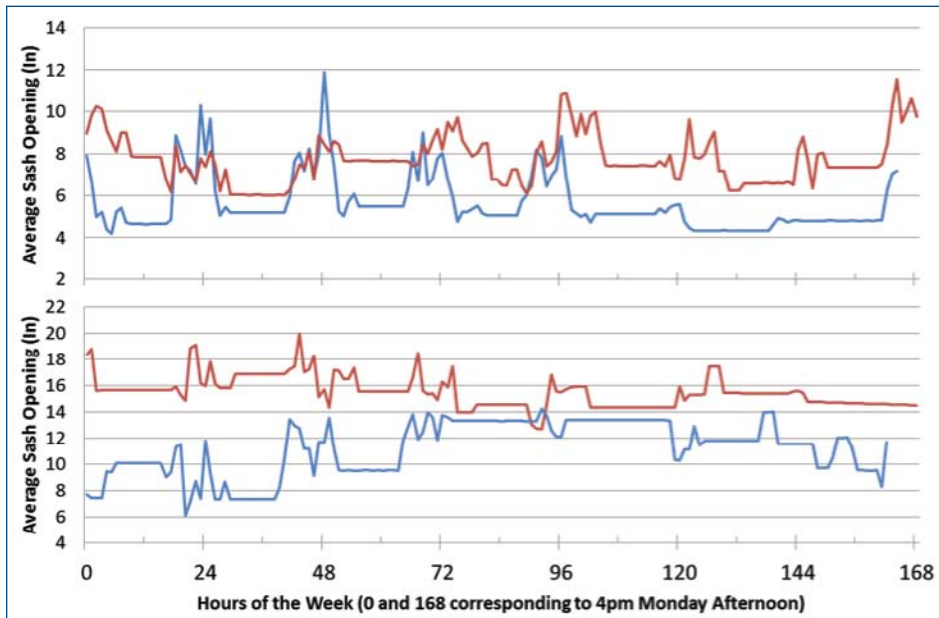


Figure 4: Average sash position before and after sticker installation at two UCSB buildings.

in high-density, high-use hoods regardless of time of day, indicating that additional reinforcement of sash closure behavior is needed. An extra measure of reinforcement is especially important in laboratories that are fume-hood-dominated. Therefore, issues that center on fume hood dominance in a lab will need particular attention during worker training exercises relating the importance to safety and energy savings, with this sticker reinforcing those lessons.

CAV versus VAV

The complexity of CAV versus VAV fume hood system designs need not confuse a hood user during training. From the worker's perspective, all hoods look the same and need to be treated with the same habit: Close the hood sash unless your arms are working inside the hood. The importance of this simple message cannot be stressed enough.

BMS Enhances Compliance

Buildings equipped with BMSs can have alarm tools designed to alert maintenance staff of problems within the buildings.

These tools can also be used with minimal effort to provide real-time feedback to fume hood users. Staff can periodically review sash behavior and address problem labs individually, or the system can be set up to send automatic e-mail alerts to laboratory managers or occupants when sashes have been left open overnight. In either case, having real data to present to users illustrating their behavior can be eye-opening; many users close their sashes much less reliably than they think they do.

Next Steps

The energy savings realized from this project exceeded all expectations. The trivial cost to install the sash stickers is dwarfed by the operating cost reductions due to the decrease in airflow in VAV fume hood systems. The safety benefits gained by good sash operating procedures are realized in both CAV and VAV laboratories. Therefore, since the benefits of installing the sash stickers are so dramatic, we believe that this type of sticker should be installed on every fume hood in the U.S.

Acknowledgements

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