CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

2019 Title 24 Codes & Standards Enhancement (CASE) Proposal

Laboratory Fume Hoods – Automatic Fume Hood Sash Closure Systems

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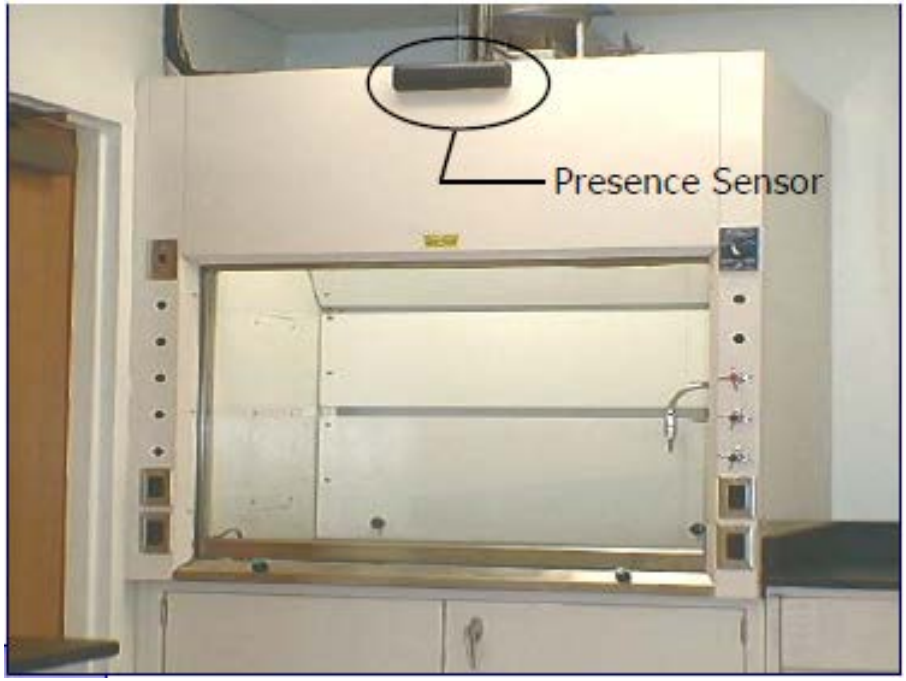
Proposed Code Change Overview

- Types of building impacted: Laboratory spaces
- Building system impacted:
  - Fume Hoods, HVAC
- This will be a new mandatory requirement for covered processes.
- Proposed measure would require automatic sash closure systems be installed with variable volume hood operation in new laboratory exhaust systems that meet certain design criteria.
  - Measure aims to reduce overall airflow through fume hoods that will result in energy savings associated with the fume hoods as well as with the HVAC system supplying conditioned air to the laboratory spaces in which the hoods are located.

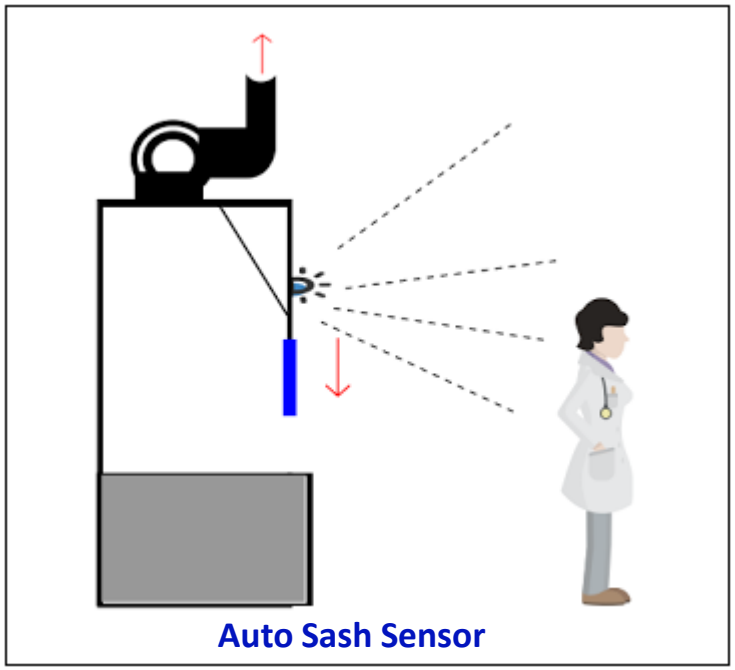
Proposed Code Change Overview

- Laboratory Fume Hood Definition from Title 8 (Industrial Regulations) of the California Code of Regulations:
  - Laboratory-Type Hood is a device enclosed except for necessary exhaust purposes on three sides and top and bottom, designed to draw air inward by means of mechanical ventilation, operated with insertion of only the hands and arms of the user, and used to control exposure to hazardous substances. These devices are also known as laboratory fume hoods.
- Components of an auto sash closing system:
  - Infrared occupancy sensor
  - Sash Drive Unit
  - User control panel – Adjustable unoccupied delay time, auto open function, manual override
  - Sash obstruction sensor (using a Safety Light Curtain)

Proposed Code Change Overview



PG&E. “Automatic Fume Hood Sash Closure – Demonstration and Test at: The University of California, Davis.” November 2007



http://www.nanofumehoods.com/2015/11/how-to-implement-greener-fume-hood.html

Proposed Code Change History

- Why are we proposing this measure?
  - Laboratory exhaust systems in California consume approximately 2,495 GWh/year and 18 trillion Btu/year, with a peak demand around 574 MW.
  - Fume hoods are one of the largest energy users in most lab facilities.
  - Multiple fume hoods in each laboratory facility often dictate airflow requirements for the entire space. As a result, labs often require larger HVAC systems than spaces without hoods.
  - Some fume hoods, especially those in larger facilities, operate 8760 hours/year, even if they are not in use 24/7.
  - Measure intends to reduce overall airflow through the hoods and strengthen existing California Code requirements.
  - Added benefit of increasing user safety.

Current Code Requirements

- Existing Title 24 Standard requires certain laboratory exhaust systems to be capable of reducing zone exhaust and makeup airflow rates to the minimum allowable levels.
- National Fire Protection Agency (NFPA) has the following standards that must be met regarding Fume/Chemical Exhaust Hoods:
  - NFPA Standard 45-6.8.3 Laboratory Hood Sash Closure: Laboratory hood sashes shall be kept closed whenever possible. When a fume hood is unattended, its sash shall remain fully closed.
  - NFPA Standard 45A 6.8.3 – Users should be instructed and periodically reminded not to open sashes rapidly and to allow hood sashes to be open only when needed and only as much as necessary.
- Cal/OSHA has approved automatic sash closure systems for use in CA provided that additional conditions are met (e.g. tracer gas testing as specified in ANSI/ASHRAE 110-1995).

Current Code Requirements

- ANSI/AIHA Z9.5-2003 American National Standards for Laboratory Ventilation, Section 3.1.1.4 specifies that the following conditions shall be met before using automatic sash closing devices:
  - Automatic sash positioning systems shall have obstruction sensing capable of stopping travel during sash closing operations without breaking glassware, etc.
  - Automatic sash positioning shall allow manual override of positioning with forces of no more than 10 lbs (45 N) mechanical both when powered and during fault modes during power failures.

Current Code Requirements

- Title 8 (Industrial Regulations) of the California Code of Regulations (CCR) includes Ventilation Requirements for Laboratory-Type Hood Operations that explicitly allow ventilation rates to be reduced if nobody is in the immediate area of the hood opening.
  - …The exhaust system shall provide an average face velocity of at least 100 feet per minute with a minimum of 70 fpm at any point…
  - When a laboratory-type hood is in use to contain airborne hazardous substances and no employee is in the immediate area of the hood opening, ventilation rate may be reduced from minimum average face velocity of at least 100 fpm to a minimum average face velocity of 60 fpm if specific conditions are met, including:
    - Reduction in face velocity is controlled by an automatic system which does not require manual intervention
    - Hood has been tested at reduced flow according to the tracer gas test
    - Maintain records of tracer gas test results and the “as used” test

Typical Practices

- Common Practices
  - Bypass Constant Air Volume (CAV) Fume Hood and HVAC System
    - Utilizes constant speed fan and bypass damper
    - Allows air to be pulled through bypass opening as sash closes
    - Energy consumed remains constant regardless of sash position
    - Lower initial cost
  - Variable Air Volume (VAV) Fume Hood and HVAC System
    - Equipped with a variable speed fan or throttling valve on hood exhaust
    - Varies volume of room air exhausted while maintaining set face velocity
    - Can provide considerable energy savings by reducing total volume of conditioned air exhausted, if sash is properly closed
    - Higher initial cost
  - Studies suggest that sash is often left open.

Typical Practices

- Trends
  - Per PG&E's 2007 ET study, market penetration of fume hood automatic sash closure systems have been slow, especially in CA.
  - In 2014, PG&E administered the Laboratory Fume Hoods Program but requested program be closed in 2015 due to lack of participation.
  - At the International Institute for Sustainable Laboratories Conference, presentation results documented a shift in perception from apprehension that automatic sash would cause safety issues, to appreciation for the safety the auto sash provided.
  - Despite slow up-take in adoption, it is expected that automatic sash closure systems will become more common in existing labs and will be common practice in newly constructed labs by the time the new Standard takes effect.
- Do you agree with this description?

Market Overview and Analysis

- Current Market
  - LBNL Fume Hood Calculator states that CA has 85,000 fume hoods.
  - It is unclear the number of fume hoods installed in newly constructed laboratory facilities that could deploy automatic sash closure systems.
  - Market barriers are currently unknown.
- Approach to Market Analysis
  - CASE team will research and conduct outreach with stakeholders to estimate market size, market impact, market barriers and measure applicability using the following resources:
    - Utility incentive program participation
    - Published studies with market references (most current)
    - New construction projects (SMEs)
    - Measure End-users (e.g. University Labs)
- What market barriers are stakeholders seeing in industry?
- Other market information sources should we consider?

Incremental Cost Estimation

- PG&E's 2007 ET study found that automatic fume hood closure systems cost about $5,500 if purchased in small quantities, but the price was over $1,000 less when purchased in bulk (for labs with 80 hoods).
- We will collect costs of base case technology and proposed technology from the following sources
  - Interviews with manufacturers, distributors and/or contractors
    - Unit price for automatic sash closure controls are well established
    - Fume hood performance tests and gas tracer test costs are also well known
    - Multiple suppliers of this technology: fume hoods equipped with auto sash closure systems and auto sash closure systems that can be installed on new or existing fume hoods
  - Cost for ancillary equipment will be attained through suppliers, published cost catalogs, or other cost-estimating software
  - Prior projects and case studies
- What components of costs did we leave out?

Methodology for Savings Analysis

- Methodology for energy and demand Impacts
  - Challenges:
    - Understanding individual baselines and potential savings applicable to specific applications.
    - Every hood will have different savings potential based on hood usage and layout of laboratory space.
    - Assumptions will need to be made to estimate average energy use of all facilities throughout state.
  - Strategy for determining energy and demand impacts:
    - Hourly spreadsheet analysis will be used for multiple laboratory scenarios to determine energy and demand impacts.
    - Past projects and LBNL fume hood calculator will also be used to complement the spreadsheet results.

Assumptions for Energy Impacts Analysis

- Prototype Laboratories
  - Laboratory spaces with varying space area, hood quantity, etc.
  - Applicable HVAC Types
    - Single zone constant volume
    - Single duct constant volume with reheat
    - Single duct variable volume with reheat
    - Dual duct constant volume
    - Dual duct variable volume
    - Dedicated outside air system
  - Applicable Fume Hood Type
    - Vertical and horizontal sliding sash hoods
    - Fume hood size (Hood Width TBD)

Assumptions for Energy Impacts Analysis

- Key assumptions
  - Operating hours: May vary depending on facility lab space
  - Baseline fume hood type: TBD depending on ISP; will dictate max flow (CFM) and min. face velocity (fpm)
  - HVAC system type: TBD depending on fume hood type
  - Air Distribution System type: TBD depending on fume hood type
  - Baseline fume hood usage schedule: % time sash fully open
- Data sources
  - TMY3 weather files
  - LBNL and other laboratory fume hood energy models
  - Collected field monitoring from pilot projects, previously conducted studies on the measure, laboratory best practice guidelines
  - Stakeholder input to further support key baseline assumptions

Incremental Cost Savings

- Approach
  - Incremental cost savings are calculated based on TDV cost savings associated with energy savings over the entire period of analysis.
  - Present TDV cost multiplier ($/TDV kBTU)

Preliminary Energy Savings Estimates

- Several sources present HVAC system savings estimates for automatic sash closure systems:
  - DOE: 40-50%
  - LBNL's Laboratory Fume Hood Energy Model: 50%*
  - PG&E Fact Sheet on Sash Closures: 38%**

* Based on existing CAV and a 6 foot hood

** HVAC cost savings

Table 1. Fume hood energy use and savings potential.*

	United States*	California
PER-HOOD VALUES		
Electricity Use (kWh/year)	34,871	29,326
Peak electricity demand (kW)	6.74	6.74
Fuel use (GJ/year)	272	223
Annual energy cost per hood ($)		
Total	5,624	6,031
$/CFM	4.50	4.83
MACRO-SCALE BASELINE ENERGY USE		
Number of Hoods	750,000	85,000
Total Electricity (GWh/year)	26,153	2,493
Total Peak Power (MW)	5,057	573
Total Natural Gas (10^{15}J, PJ/year)	204	19
Total Energy Cost ($ Million/year)	4,218	513
MACRO-SCALE ENERGY SAVINGS		
Per-hood energy savings**	50%	50%
Maximum potential market penetration	75%	75%

LBNL. "Energy Use and Savings Potential for Laboratory Fume Hoods." April 2006. LBNL-55400.

Preliminary Cost Effectiveness Estimates

- Total incremental cost and TDV cost savings over period of analysis and Benefit/Cost ratio have yet to be determined.
- Cost effectiveness analysis will include any acceptance tests and tracer gas testing, as deemed necessary for the measure.
- Several sources provide initial simple pay back estimates for automatic sash closure systems.
- Existing studies show that this measure typically involves pay back periods within 2.0 years.

Compliance and Enforcement- Market Actors

- Who would be involved in implementing this measure?
  - Laboratory HVAC Designer
  - Fume Hood Manufacturer/Supplier
  - Fume Hood Controls Manufacturer/Supplier
  - Fume Hood/Controls Installer
  - Fume Hood End User
  - Facility Manager
  - Building Owner
  - Acceptance Test Technician?

- Are there any stakeholders missing from the above list?

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Laboratory HVAC Designer	- Design new laboratories to meet mandatory code.	- Do this within current work tasks
Fume Hood Manufacturer/Supplier	- Advise Designer or End User of code so correct product is selected. - Manufacture/Supply products that meet code or work with Controls Manufacturer/Supplier to deliver code compliant systems.	- Do this within current work tasks - Do this cost effectively
Fume Hood Controls Manufacturer/Supplier	- Work with Fume Hood Manufacturer, Supplier or End User to integrate required auto sash closure systems on applicable VAV hoods.	- Do this within current work tasks
Fume Hood/Controls Installer	- Install, commission, and test the new installation of fume hoods and/or fume hood controls.	- Do this within current work tasks

What are we not capturing?

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Fume Hood End User	- Operate fume hood as intended by code.	- Do this without impacting fume hood use.
Facility Manager Building Owner	- Incorporate new code into chemical hygiene plan. - Identify when maintenance and/or testing is required.	- Do this within current work tasks. - Do this cost effectively.
Acceptance Test Technician	- Verify that new automatic sash closing systems meet the acceptance requirements for code compliance.	- Do this without ambiguity in acceptance requirements. - Do this with minimal paperwork.

What are we not capturing?

Compliance and Enforcement—Resources

Market Actor	Resource(s)
Laboratory Designer	- EnergyCodeAce 10.7 Laboratory Exhaust, OSHA Code of Federal Regulations Volume 29 Part 1910.1450, ANSI/AIHA Z9.5, SEFA Recommended Practices for Laboratory Fume Hoods, ASHRAE Laboratory Design Guide, CBECC-Com
Fume Hood Manufacturer/Supplier	- EnergyCodeAce 10.7 Laboratory Exhaust, OSHA Code of Federal Regulations Volume 29 Part 1910.1450, ANSI/AIHA Z9.5, ANSI/ASHRAE 110-1995
Fume Hood Controls Manufacturer/Supplier	- EnergyCodeAce 10.7 Laboratory Exhaust, OSHA Code of Federal Regulations Volume 29 Part 1910.1450, ANSI/AIHA Z9.5, ANSI/ASHRAE 110-1995
Fume Hood/Controls Installer	- EnergyCodeAce 10.7 Laboratory Exhaust, OSHA Code of Federal Regulations Volume 29 Part 1910.1450, ANSI/AIHA Z9.5, ANSI/ASHRAE 110-1995, SEFA Recommended Practices for Laboratory Fume Hoods

What resources or tools are typically used for compliance?

Compliance and Enforcement—Resources

Market Actor	Resource(s)
Fume Hood End User	- EnergyCodeAce 10.7 Laboratory Exhaust
Facility Manager Building Owner	- EnergyCodeAce 10.7 Laboratory Exhaust
Acceptance Test Technician	- Title 24 Nonresidential Appendix NA7

What resources or tools are typically used for compliance?

Strawman Code Change Language

Title 24 Standards

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

(h) Mandatory Requirements for Fume Hoods

1. Fume hoods over x linear feet [or alternate size threshold] shall be variable air volume and have an automatic sash closure system that complies with the following:
   a) Have an accessible manual override of positioning with forces of no more than 10 lbs (45 N) mechanical, as specified by ANSI/AIHA Z9.5-2003, 3.1.1.4 (perhaps with a time limitation on the duration of the override);
   b) [TBD define types of sensors that can be used to detect use or occupancy];
   c) Automatically close the sash after 30 seconds [or other time threshold] of inactivity:
   d) Have obstruction sensing capabilities that stop travel during sash closing operations, as specified by ANSI/AIHA Z9.5-2003, 3.1.1.4;
   e) Automatically adjust exhaust air flow to maintain the minimum allowable constant face velocity requirements as defined in Title 24, Part 8 Section 5154.1 as the sash opening changes.
2. Acceptance for fume hoods: before an occupancy permit is granted for fume hoods subject to 120.6(h), the following equipment and systems shall be certified as meeting the Acceptance Requirement for Code Compliance, as specified by the Reference Nonresidential Appendix NA7. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements specified in NA7.16.

Strawman Code Change Language

- Title Appendices (JA, RA, or NA)
  - CASE team will need to investigate whether an Acceptance Test will be appropriate and proposed code will necessitate addition to Appendix NA7 – Installation and Acceptance Requirements for Non-Residential Buildings and Covered Processes
- Alternative Compliance Method (ACM) Reference Manual
  - Proposed measure will not require changes to be made within the ACM Reference Manual

Feedback Request from Stakeholders

- General thoughts on the proposed measure.
- What are current market barriers for implementing the proposed measure?
- What design criteria is most appropriate and feasible for the proposed measure as it relates to the impacted buildings?
- What fume hood systems are considered current market practice?
- Should there be any exceptions to the proposed measure (e.g. specific situations in which an auto sash closure may cause a safety issue)?
- Additional resources for market analysis?
- Any cost components that were omitted from IMC considerations?

- Please email Briana Rogers with any feedback.

Thank you.

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