

# Lawrence Berkeley National Laboratory

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High-Performance fume hood

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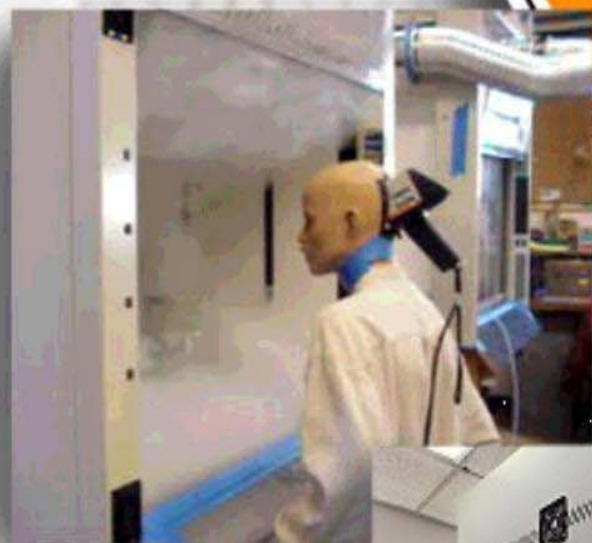
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**Publication Date**

2002-10-01

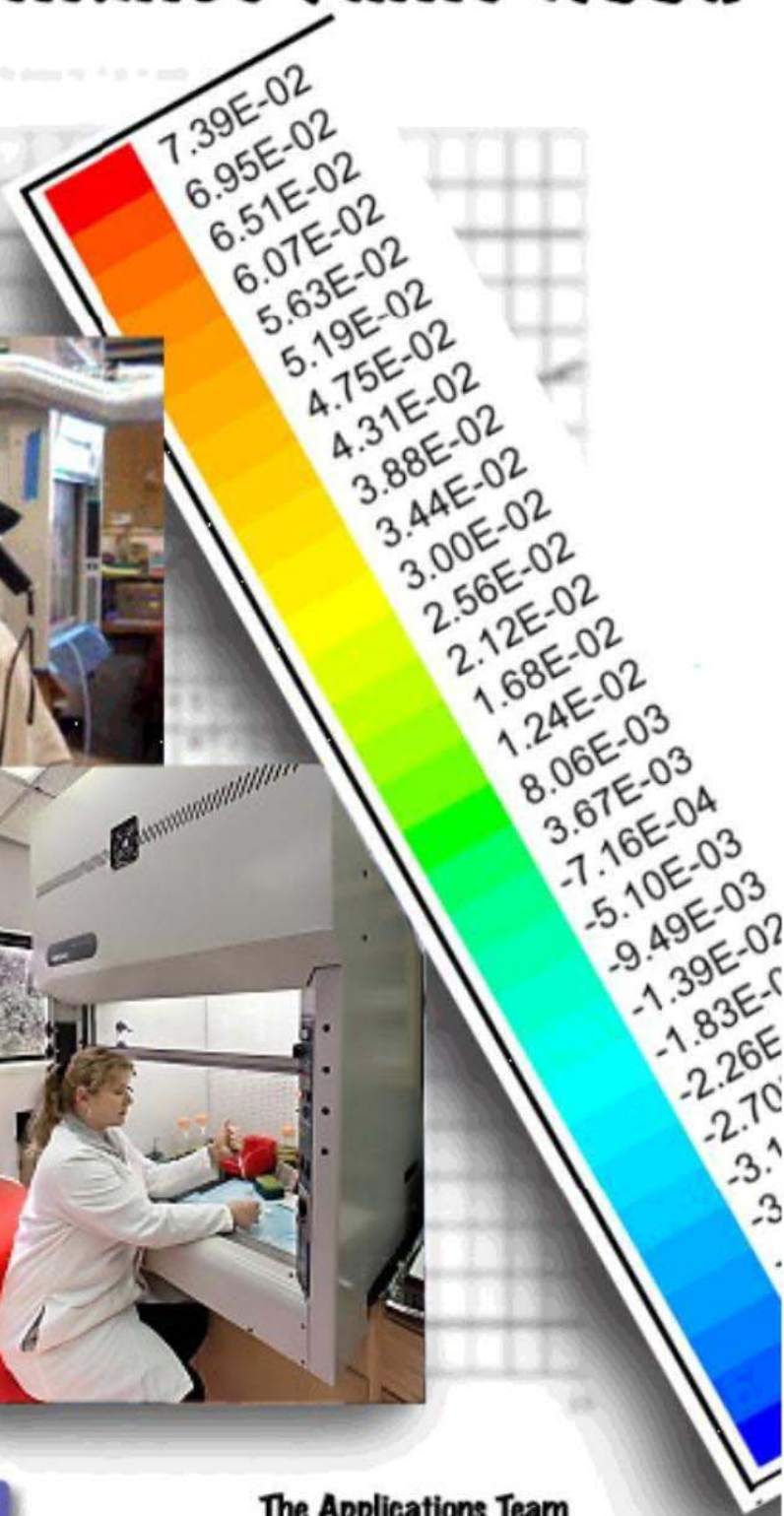
# High-Performance Fume Hood



High-Performance Technology  
Developed by the

## A-Team

The Applications Team  
Lawrence Berkeley National Lab



# EXHAUST HOODS—CRITICAL BUT COSTLY

Exhaust hoods protect operators from breathing harmful fumes by capturing, containing, and exhausting hazardous gases created in laboratory experiments or industrial processes. These box-like structures, often mounted at tabletop level, offer users protection with a movable, window-like front “face” called a sash. Fans draw fumes out the tops of the hoods. (See Fig. 1)

Fume hoods typically exhaust large volumes of air at great expense. The energy to filter, move, cool or heat, and in some cases scrub (clean) this air is one of the largest loads in most lab facilities. A six-foot-wide hood typically exhausts 1200 cubic feet per minute (cfm), 24 hours per day, and consumes three-times more energy than an average house. The annual operating cost of U.S. fume hoods is approximately \$3.2 billion, with a corresponding peak electrical demand of 5,000 megawatts. This equates to the electrical output of about 20 electric power plants (at 250 megawatts each), plus nearly 200 trillion cubic feet of natural gas burned each year, for the associated cooling and heating of outside make-up air. Consequently, greenhouse-gas emission caused by operating this typical hood is equivalent to six automobiles.

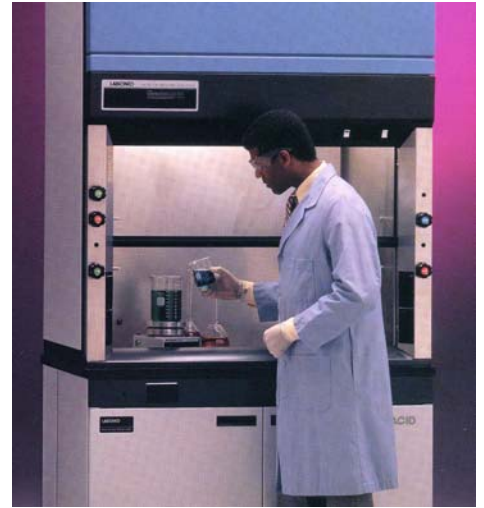


Figure 1: Standard fume hood in use.  
*Courtesy of Labconco Corp.*

## STANDARD HOODS

### *Design Characteristics Dictate High Exhaust Rates*

Fume hood exhaust induces airflow through the fume hood’s “face.” The generally accepted “face velocity” is 100 feet/minute; a high airflow rate causing large exhaust flows. Interestingly, increasing face velocity does not necessarily improve containment (See Fig. 2). Instead, errant eddy currents and vortexes can be induced around hood users as air flows into the hood, reducing containment effectiveness.

Fume hoods frequently operate 24 hours/day. Since many laboratories have multiple hoods, they typically dictate a lab’s required airflow and thus the supply and exhaust systems’ capacity. The result is larger fans, chillers, boilers, and ducts compared to systems having less exhaust. Consequently, fume hoods are a major factor in making a typical laboratory four to five times more energy intensive than a typical commercial space.

### *State-Of-The-Art System Limitations*

Most state-of-the-art, energy-efficient fume hood systems require several interactive features and diligent users. Sophisticated controls, for each hood and for supply and exhaust air streams, communicate with a variable air volume (VAV) system to provide a constant face velocity and a pressure differential between the laboratory and adjacent space. These controls add significantly to the system’s first cost and complexity.

In a VAV system, energy savings occur only if a hood’s sash is less than fully open, which reduces exhaust flow while maintaining a constant face velocity. Each hood user must operate the sash properly to ensure that the system achieves full energy savings potential. Also, when sizing air distribution and conditioning equipment, many designers assume worst-case conditions—all sashes fully open—requiring larger ducts, fans, and central plants than if assuming some sashes are partly closed.

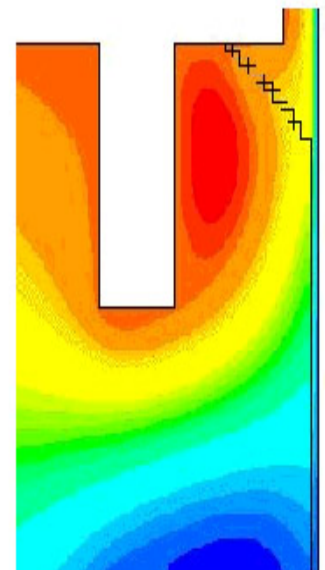


Figure 2: Computer model of airflow through a standard fume hood. Shading indicates air speed, with darker colors being faster. Upper & lower vortexes (dark areas) trap air and tend to spill.

# THE INVENTION

## *The Berkeley Hood: a High-Performance Fume Hood*

Lawrence Berkeley National Laboratory has developed a promising new technology, a High-Performance Fume Hood, referred to as the Berkeley Hood in this document. The Berkeley hood reduces airflow requirements by 50 to 70 percent while maintaining, or enhancing, worker safety. Airflow reduction cuts energy costs about \$2,100 per year per hood installation, on average.

Berkeley Lab's hood design uses a "push-pull" approach to contain fumes and exhaust them from

the hood. Small supply fans located at the top and bottom of the hood's sash, or "face," gently push air into the hood (see Figure 3). These low-velocity airflows create an "air divider" that separates the fume hood's interior from the exterior (unlike an air curtain approach that uses high-velocity airflow).

Berkeley Lab's air-divider approach of separating and distributing air (See Fig. 4) leads to greater containment and exhaust efficiency. The result is an extremely effective and energy-efficient unit.

## *Revolutionary Design Delivers Numerous Benefits*

Beyond the 50–70 percent ventilation reduction and associated energy savings, the Berkeley Hood offers design features that deliver a range of benefits, including:

- ◆ Simpler design than the state-of-the-art VAV fume hood systems offers easier and less expensive installations.
- ◆ Constant volume operation ensures that energy efficiency is not dependent on the operator.
- ◆ Clean room-air flowing into the operator's breathing zone reduces potential hazard from fumes.
- ◆ Supply airflow patterns reduce dangerous eddy currents and vortices, improving containment and exhaust performance.

In new construction projects, designers will be able to specify the Berkeley Hood and easily achieve energy cost savings. The Berkeley Hood is expected to have a cost premium over a current standard hood. However, this cost premium can be offset with savings from installing smaller ducts, fans, and central plants, as well as simpler control systems. Combined, these features yield a lower overall first cost than standard hood systems.

In retrofit projects, Berkeley Hood users will realize critical benefits beyond energy savings. Typically, laboratories are "starved" for air as their need for additional hoods has grown. In some cases, low airflows cause inadequate exhaust and increased potential for hood spillage. Since increasing airflow is very costly in most cases, many laboratories cannot add new hoods. By replacing existing hoods with Berkeley Hoods, users can increase the number of hoods or improve exhaust performance.

Based on conservative assumptions, researchers estimate the new Berkeley Hood could save the U.S. over 8,000 GWh/year (assuming 75 percent market penetration). This amounts to over \$1.2 billion in energy savings annually.

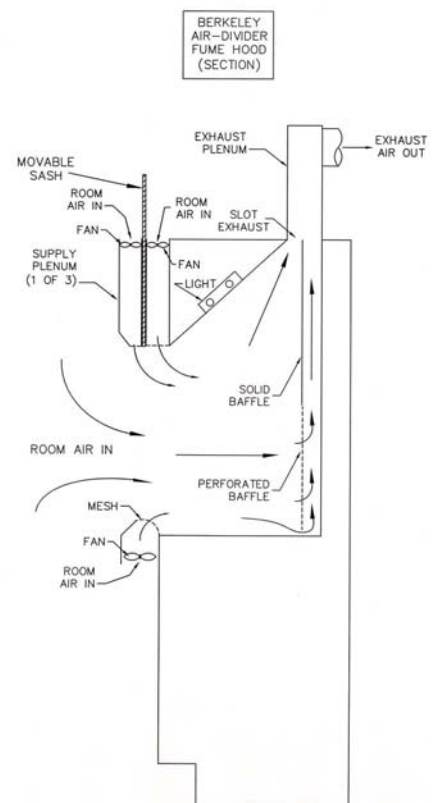


Figure 3: Schematic of the Berkeley Hood; side view shows airflow patterns.



# BRINGING LABORATORY RESEARCH TO MARKET

## *Major Achievements*

- ✓ Established high-performance containment design concept.
- ✓ Conducted CFD modeling to speed design optimization.
- ✓ Completed schlieren visualization testing to confirm capture and containment.
- ✓ U.S. Patent 6,089,970 issued for the basic concept; U.S. Patent 6,428,408 issued for the advanced “air divider” technique and other features (see Fig. 4).
- ✓ Conducted ASHRAE Standard 110-1995 test and achieved containment with 70 percent flow reduction using alpha prototype.
- ✓ Established partnerships with laboratory hood and controls manufacturers to develop and test alpha units.
- ✓ Signed intellectual property agreement for product development in the microelectronics field.
- ✓ Conducting new field tests in 2002 with larger version; started additional field test in 2001; completed two field tests in 2001.
- ✓ Designed new lighting systems that reduce lighting energy by 47 percent, improve lighting quality and reliability while reducing maintenance.



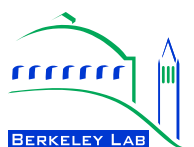
Figure 4: Prototype unit demonstrating the air divider.

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<http://ateam.lbl.gov/hightech/fumehood/fhood.html>



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The High-Performance Fume Hood work is supported by:

- U.S. Department of Energy under contract number DE-AC03-76SF00098
- California Energy Commission
- California Institute of Energy Efficiency
- Pacific Gas and Electric Company
- San Diego Gas and Electric Company
- Montana State University

PUB-842 Rev. G

October 2002