Low Flow Fume Hood Project: Safety, Containment Requirements and Test Methods

Student #2 Assignment

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August 12, 1999
DOE – CSEE Summer Session

Overview

The history of fume hoods can be traced back to the days when Thomas Edison used his fireplace chimney to exhaust fumes from his laboratory. Fume hoods are ventilated, enclosed workspaces designed to capture, contain, and exhaust fumes, vapors and matter generated within. They control chemical fumes and aerosols within pharmaceutical, hospital, educational, and industrial laboratories, protecting the research and quality control technicians that work with chemical hazards.

In addition to being one of the most vital safety components in laboratories, fume hoods have a reputation for being among the most expensive. Typical hoods exhaust 1000 to 1500 cfm and most are run continuously. In terms of dollars, their operation can cost $4 to $5 per cfm per year. These cost are due to the expense of conditioning supply air to the laboratory, which results in significant energy usage. This has raised questions and debates as to whether there is a way to save energy and still maintain or improve worker safety levels using the fume hood.

At this moment the Environmental Technologies Division of the LBNL is working to answer that question. My mentors, Geoffrey Bell and Dale Sartor, along with others are involved in a history-making project: the design and construction of a second-generation prototype fume hood, the Low-Flow Fume Hood.

Several questions of great importance face any designer of the fume hood. These include:

- What are the various laws, regulations, standards, codes, and industry practices that apply to fume hoods, and what must be done to meet them?
- What testing procedures are necessary to prove containment within the hood?
- What changes are imminent in terms of industry standards for the hood?
- As far as the Environmental, Health, and Safety people in individual laboratories and institutions are concerned, how do we ensure that our hood will meet their standards in the years to come?

For the past ten weeks, I have had the opportunity to examine these questions and look for possible solutions. The following pages detail the results of my research.

Guidelines for Fume Hood Face Velocity and Testing Methods

Hood regulating authorities are hard to define. Quite simply, there are more standards, methods, and recommendations then there are regulations and laws. The majority of these organizations, including ASHRAE have no binding on U.S. businesses.

Nevertheless, the following is a compiled a list of the most widely accepted committees in the fume hood industry. It is a brief synopsis of each organization's purpose and/or goals as well as the current and future standings that are commonly accepted in industry today.

Accepted Standards Authorities in the Fume Hood Industry

ASHRAE. The American Society of Heating, Refrigerating and Air-conditioning Engineers is an international organization that writes standards that set uniform methods of testing and rating equipment and establishes accepted practices for the HVAC&R industry worldwide, such as the design of energy efficient buildings. The ASHRAE 110 test is the most widely accepted method for testing and evaluating fume hoods.

SEFA. The Scientific Equipment and Furniture Association is a voluntary national trade association representing members of the laboratory furniture, casework, fume hood and related equipment industry. SEFA's recommended practices are designed to promote better understanding between manufacturers and purchasers and to assist the purchaser in selecting and specifying the proper product to meet the user's particular needs. SEFA 1.2 1996 supercedes SAMA LF10 1981.

OSHA. The Occupational Safety and Health Administration is a regulating body dedicated to saving lives, preventing injuries and protecting the health of America's workers. To accomplish this, federal and state governments must work in partnership with the more than 100 million working men and women and their six and a half million employers who are covered by the Occupational Safety and Health Act of 1970. OSHA issues rules and regulations for many facets of industry, including laboratory and fume hood technology.

Cal/OSHA. California's version of the Department of Labor's OSHA. Cal/OSHA has jurisdiction over all aspects of workplaces not governed by the federal OSHA. The mission of Cal/OSHA is to protect the health and safety of California's workers.

National Research Council's **Prudent Practices in the Laboratory, Handling and Disposal of Chemicals.** This is a report that was initially issued by the National Research Council in the early 1980s. The purpose of this report is to provide safety and waste management guidance to laboratory workers, managers, and policymakers. Since that time, several updates have been issued, the latest being 1995.

Industrial Ventilation: A Manual of Recommended Practice. 23rd edition. This is a manual produced by the American Conference of Government Industrial Hygienists. The book provides information on the design, maintenance, and evaluation of industrial exhaust ventilation systems.

NFPA 45 (National Fire and Protection Agency). A document developed by the Technical Committee on Chemistry Laboratories, its purpose is to provide recommendations and guidelines regarding chemical laboratories, hazards, and protection. This compilation of standards codes, and recommended practices are developed through a consensus standards development process approved by the American National Standards Institute.

Fume Hood Face Velocity Standards

Face Velocity is a measure of the average velocity at which air is drawn through the face to the hood exhaust. It has been the cause of debates among standards committees. No regulating body can seem to agree on a specific number. For the most part, the accepted face velocity measure falls within 80 – 100 fpm. 60 or 50 fpm has been accepted only in perfect laboratory conditions.

ASHRAE-110

Current Standards

Although the ASHRAE 110 *Method of Testing Performance of Laboratory Fume Hoods* does require face velocity in the testing methods, there is no specific number given for face velocity.

Future Considerations

For the upcoming rewrite ASHRAE 110 will be considering the continued use of face velocity in the ASHRAE 110 test, since studies have shown that there is little or no correlation between face velocity and effective hood performance. Consideration will also be given to turbulence and dynamic fume hood testing procedures. At this time, no specifics are available on those issues as the committee in still in the preliminary stages.

Cal-OSHA

Current Standard

Face velocities of 80 to 100 fpm are adequate if the overall installation can be rated as good to excellent. (California Title 8- Paragraph 5154.1 requires 100 linear feet per minute with a minimum 70 fpm at any point, except for hoods used with carcinogens, which require 150 fpm and a minimum of 125 fpm)

Future Considerations

Cal-OSHA has two petitions before the committee with regard to the issue of face velocity. These are as follows:

Petition #377: On June 3, 1997, Richard Yardley of George Yardley Company requested the Board amend California Code of Regulations, Title 8, Section 5154.1 of the General Industry Safety Orders, to change the face velocities of a chemical fume hood to 100 linear feet per minute when an operator is present and to reduce the flow to 60 lfm when the hood is unattended.

The Board has considered the petition. Recommendations from the Division and Board staff have also been heard. The Petition has been GRANTED to the extent that the Division is requested to develop proposed revisions, if appropriate, to Section 5154.1 consistent with the Petitioner's request. The proposal will be submitted for the Board's consideration at a future Public Hearing.

Petition #395: On January 19, 1999, Mr. George Orff, President of DMG Corporation petitioned the Board to make recommended changes to Title 8, California Code of Regulations (CCR), Section 5154.1 (c) of the General Industry Safety Orders to replace the fume hood face velocity requirements with a performance test requirement.

The Board has considered the petition along with recommendations from the Division and Board Staff. The petition has been GRANTED to the extent that the Division is requested to convene a representative advisory committee to consider the Petitioner's recommended revision to Section 5154.1 (c).

There is no specific timeframe for these proposals. It could take anywhere from a year to several years before these petitions are fully considered and decided upon.

OSHA

Current Standard

Hood face velocity should be adequate (typically 60 – 100 fpm)
According to Lillie Clark, who has served on the committee for years, this is only a recommendation because it falls under Appendix A. Any and all information concerning laboratory fume hoods that fall under **Appendix A are recommendations**. The only **requirement is that fume hoods operate properly**.

Future Consideration

Clark intimated that there are no rewrites or changes planned in the near future.

Prudent Practices

Current Standard

The recommended face velocity is between 80 and 100 fpm. Face velocities between 100 and 120 fpm may be used for substances of very high toxicity or where outside influences adversely affect hood performance. However, energy costs to operate the fume hood are directly proportional to the face velocity. Face velocities approaching or exceeding 150 fpm should not be used, because they may cause turbulence around the periphery of the sash opening and actually reduce the capture efficiency of the fume hood.

Future Considerations

As of now, there is no plan to produce a rewrite of the Prudent Practices document anytime soon.

Industrial Ventilation

Current Standard

There is no specifically recommended face velocity. Instead this source states, "The interaction of supply air distribution and hood face velocity makes any blanket specification of hood face velocity inappropriate."

Future Consideration

The next rewrite for Industrial Ventilation is scheduled to take place in 2001. At this time, there are no details on what the contents of this text concerning fume hood technology will be.

It would be best to write a letter to the Industrial Ventilation Committee to find out about the status of the upcoming rewrite.

NFPA 45

Current Standard

Laboratory hood face velocities and exhaust volumes shall be sufficient to contain contaminants generated within the hood and exhaust them outside of the laboratory building. The hood shall provide confinement of the possible hazards and protection for personnel at all times when chemicals are present in the hood. (Section 6-4.5)

The document further states:

> Laboratory fume hood containment can be evaluated using the procedures contained in the ASHRAE 110 *Method of Testing Performance of Laboratory Fume Hoods*. Face velocities of 0.4 m/sec to 0.6 m/sec (80 fpm to 120 fpm) generally provide containment if the hood location requirements and laboratory ventilation criteria of this standard are met.

According to committee member Ray Richards, the standard does not specifically address velocity flow rates, but leaves that up to other standards/codes.

Future Considerations

The new NFPA 45 standard will be issued early in 2000. A new code cycle will not begin until after that time, which is expected to be a 3 or 5-year cycle. A ROC (Report on

Comments) meeting is scheduled to take place in New Orleans on October 21-23, to finalize any proposal that have been processed. There is still time to send in proposals for change in the standard.

At this time, no information concerning imminent changes in the standard is available, since the committees work may originate from one individual or from within the NFPA committee.

ANSI/AIHA z9.5

Current Standard

"Each hood shall maintain a velocity an average velocity of 80-120 fpm with no face velocity measurement more than plus or minus 20% of the average."

Future Considerations

For its upcoming rewrite due at the end of this year, ANSI z9.5 has the following considerations:

- **European Fume Hood Standards**: A committee member considered looking into the possibility of implementing the standards of the German DIN and British Standards Institute. Although the committee will consider it, it is highly unlikely that any part of these standards will be adopted.
- **Face Velocity**: Due to the arguments about the reliability of face velocity as a measure of fume hood performance, the committee will re-evaluate their standing on face velocity.
- **Ductless Fume Hoods**
- **Recommended work practices for fume hoods**

SEFA 1.2 - 1996

Current Standard

"Face velocities of laboratory fume hoods may be established on the basis of the toxicity or hazard of the materials used or the operations conducted within the fume hood."

Future Considerations

According to Joan Powers, Executive Director, the committee is currently working on a rewrite for the coming year. The standards committee will meet in November. Powers indicated that SEFA's Laboratory Fume Hood Recommended Practices has not changed greatly over the past 6-8 years. However, if there are drastic changes in the rewrite, the document's number will appear as SEFA 1.3-1999. You can check for changes online within the first six months of the coming year. Web Address:
http://www.sefalabfurn.com/sefa-1.htm

Also, according to Powers, "any recommendations published by SEFA apply to standard fume hoods, not to the newer hoods on the market."

Performance Testing Standards

Testing is a necessary to ensure that fume hoods provide containment, which in turn means that workers are protected. In accordance with the following information, the most widely accepted method of testing Fume Hoods is the ASHRAE Standard 110 Method of Testing Performance of Laboratory Fume Hoods.

ASHRAE-110

"Fume Hood Performance Criteria. ASHRAE Standard 110, Method of Testing Performance of Laboratory Fume Hoods, describes a quantitative method of determining the containment performance of a fume hood. The method requires the use of tracer gas and instrumentation to measure the amount of tracer gas that enters the breathing zone of a mannequin, which stimulates the containment capability of the fume hood as a researcher conducts operations in the hood."

The ASHRAE-110 consists of three tests: (1) face velocity, (2) flow visualization test, and (3) tracer gas test.

ANSI/AIHA Z9.5

Both initial and periodic performance tests are required. ASHRAE 110-1995 is the recommended test for purchase specification and initial evaluation, but other equivalent tests are acceptable. Routine performance tests such as face velocity measurements and smoke visualization are required at least annually.

NFPA 45

This standard (Section 6-13.1) stipulates that fume hoods be inspected and tested upon installation and annually thereafter. The tests performed should consists of visual inspections of the hood's physical condition, flow monitor, face velocity, verification of inward airflow over the entire hood face, changes in work area conditions that might affect hood performance, as well as low airflow and loss-of-airflow alarms at each alarm location.

Section A-6-4.5 states:

Laboratory fume hood containment can be evaluated using the procedures contained in the ASHRAE 110 *Method of Testing Performance of Laboratory Fume Hoods*.

Table of Standards for Fume Hood Face Velocity and Performance Testing

Organization	Face Velocity	Testing
ASHRAE		ASHRAE 110
OSHA	60-100 fpm	
SEFA		
Cal-OSHA	100 fpm	ASHRAE 110
Prudent Practices	80-100 fpm	ASHRAE 110
Industrial Ventilation		
NFPA 45	80-120 fpm	ASHRAE 110
ANSI		ASHRAE 110

Fume Hood Testing Procedures

When we talk about fume hood performance testing, what we're looking for can be summed up in one word: **Containment.** In the simplest of terms, containment means that the hood works. Hazardous materials are kept within the fume hood and not allowed to leak or spill out into the breathing zone of the user.

Throughout the years, many methods have been employed to prove containment. Today's most recommended method is the ASHRAE-110 Method of Performance for Laboratory Fume Hoods. This is an elaborate three-part test that involves face velocity testing, flow visualization, and a tracer gas test. However, this test is so expensive and time-consuming that those who do use it only perform it on a one-time basis. In terms of annual testing, the tradition has been to use Face Velocity.

Face Velocity

As previously stated, face velocity is a measure of the average velocity at which air is drawn through the face to the hood exhaust. This test involves forming a grid pattern by equally dividing the design hood opening into vertical and horizontal dimensions. Velocity readings are taken with a calibrated anemometer fixed at the center of the grid spaces. An average of the readings is taken. If the hood meets a 100 fpm requirement, it passes. Although quick and inexpensive, this method may not be safe.

Is Face Velocity the Right Measurement?

- Statistics report that 30% - 50% of hoods leaking excessive levels of contaminants pass the traditional face velocity tests[3].

- In a recent study conducted performed by Dale Hitchings, 59% of the hoods passed face velocity criteria. Only 13% of those same hoods met tracer gas industry standards[1].

- Had the face velocity measurements alone been used to determine adequate containment, 46% of the hoods would have passed based on face velocity[2].

- In a separate study, one investigator found that in a properly designed laboratory, fume hoods with face velocities as low as 50 fpm provided protection factors 2,200 times greater than hoods with face velocities of 150 fpm[4].

- Another study indicated that with the exception of one particular type of hood operation, there was no difference in hood containment with face velocities between 59 and 138 fpm[5].

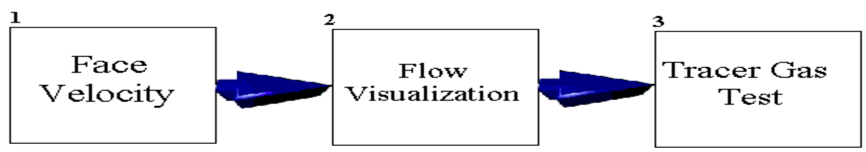
Obviously, face velocity is not an effective indication of good containment and fume hood performance. As these statistics indicate, there have been cases when hood passed the 100-fpm requirement and failed grossly to protect the worker. Then too, there have been cases where hoods operating far below the 100 fpm requirement have performed better than those meeting the standard. In short, there is one conclusion:

Face Velocity Does Not Equal Fume Hood Performance.

One solution being offered by experts in the field is to couple the face velocity test with ASHRAE 110. This would mean using the ASHRAE protocol once, and use face velocity on an annual basis. The following is a discussion of the ASHRAE 110 protocol.

The ASHRAE 110 Protocol

The most widely accepted protocol in industry today and the only nationally recognized quantitative evaluation proposed by a U.S. organization, this three-part evaluation process consists of a face velocity test, flow visualization, and a tracer gas test.



The **face velocity** test proceeds as described above.

Flow Visualization is a two-fold process. It consists of a local or small-scale smoke test and a large scale smoke test.

The **tracer gas test** is a more elaborate set-up. A quantitative method, it involves placing a gas detector in a mannequin's mouth in front of the hood and injecting a tracer gas, sulfur hexaflouride (SF_6) into the hood. SF_6 is used for five specific reasons:

(1) It is non-toxic.
(2) It is non-flammable.
(3) It is not does not naturally occur in laboratories.
(4) It provides good electron capture for testing.
(5) It is easily accessible.

The standard makes allowances for other gases to be used in lieu of SF_6. However, no specifics are given. The standard only states that the gas must be similar to SF_6.

ASHRAE 110 ISSUES

Contrary to popular belief, the ASHRAE method is not a cure for all fume hood ills. There are particular issues within this test that must be dealt with. Consider the following:

- Although this method is recognized as the standard for fume hoods, **none of the standards are binding** on U.S. businesses.

- The standard **does not specify what is acceptable**. In fact the ASHRAE standard states[6]

This standard defines a reproducible method of testing laboratory fume hood. It does not define safe procedures.

The standard further states[7]

> The procedure is a performance test method and does not constitute a performance specification. It is analogous to a method of chemical analysis, which prescribes how to analyze for a chemical, constituent, not how much of that substance should be present. Another analogy would be a method for measuring airflow; it prescribes how the flow should be measured, not how much it should be.

- The procedure is both **time-consuming** and **expensive**. It requires **complicated** equipment such as **mannequins**, **purpose built tracer gas eje**ctors, and **electron capture instrumentation**. To use this test on an annual basis would be overkill for any organization. (Besides, who's going to carry a mannequin around to test 100 fume hoods?)

Therefore, people rely upon the face velocity and/or flow visualization as verification that the hood works on an annual basis. The forward of the ASHRAE 110 test does state[8]

> The flow visualization and face velocity tests can be conducted without the tracer gas as a combination of qualitative velocity measurement and a qualitative evaluation of hood performance. This portion of the standard could be used in the testing and balancing of new facilities and periodic tests of many hoods at a large facility.

- ASHRAE 110 **does not closely approximate the conditions of human hood use**. The manikin remains **static** throughout the testing procedure.

- One fume hood developer intimated that his company's laboratory found that the test makes **no allowances for manikin height.** As the height of the manikin is dropped, the test becomes more difficult to pass. If a leak is in the lower level of the hood, it tends not to drift to the breathing zone of a 5'7" manikin.

So what happens when a human operator is at the hood and he/she falls under the 5'7" range?

Alternative Test Methods for Laboratory Fume Hoods

From the aforementioned information, it is safe to conclude that face velocity is not a safe method for performance testing in fume hoods. On the other hand, ASHRAE 110 sounds good in theory, but the reality is that the test is too expensive and time-consuming. Consequently there is a need for alternative testing. The following is a brief explanation of tests that were given to me over the course of my research assignment.

User Tracer Gas Test[9]. The User Tracer Gas Test is actually a variation of the ASHRAE 110-tracer gas test using a human subject instead of the mannequin. In the original test procedure all facets of the ASHRAE-110 tests are followed. The results of the mannequin tests were compared to that of the user tracer gas test, which in turn were compared to the smoke tests.

This user tracer gas test was performed with a human subject standing in front of the hood making consistent, prescribed movements, such as extending both arms into the hood and pulling them back out in one motion every 30 seconds. A sampling line from the detector is attached to the shirt collar in the breathing zone of the human subject. The gas test is performed by releasing sulfur hexafluoride at 4 L/min inside the hood from a 46-cm by 15-cm (18 inches by 6 inches) rectangular diffuser. The concentration of the sulfur hexafluoride in the breathing zone is monitored for 5 minutes with an Ion Track Instrument Model 120 Leakmeter. The average and peak concentrations of sulfur hexafluoride during the 5-minute tests are recorded by a data logger and used to indicate hood leakage.

This test may be a good indicator of fume hood performance, since it simulates a real work environment physically, unlike the manikin in the ASHRAE test. Further research is needed.

Air Monitoring Test. The Air Monitoring test is very simple. The downside is that it may take a few days. The procedure is as follows: Allow someone to wear an air-monitoring device in the breathing zone while performing work in the hood. Evaluate the contamination levels at various velocities.

In-Use Testing Procedure[10]. This test is similar to the above user-tracer gas test. SF_6 was used in the original study, but other vapors and detectors could be It was designed to assess fume hood performance during normal work activities. substituted.It uses a hollow rectangle as a challenge gas diffuser to enclose the work area and flood the live operator's hands and apparatus with tracer gas. The operator conducts usual work activities. Escape of the challenge gas is measured in the operator's breathing zone by a direct reading instrument. The perimeter of the opening should be scanned to indicate the presence of leaks and to identify practical solutions.

This method is practical for three reasons:

(1) the technique is easier and faster
(2) results are interpretative as a quantitative measure of protection, and
(3) it allows use of an identical test method for establishing hood criteria for rating hoods while engaged in routine operations

Dioctylphthalate (DOP) Test[11]. DOP is a part of the NSF 49 test for Biological Safety Cabinets used to stimulate particles of less than 3 microns in size. A recent research study suggests that a more quantitative approach using the NSF 49 procedure might lead to a better understanding of fume hood limitations and the evaluation of exposure potentials to not only the fume hood worker but those sharing the laboratory as well.

The test proceeds in the following manner: A DOP aerosol generator operated at 20 psi is connected to a metal canister 7 inches in diameter. The canister's open top is covered with 1 inch thick open cell foam to allow a relatively even discharge of aerosol in the geometric center of the fume hood work zone, approximating an aerosol emitting from a large beaker in the hood where the outer edge of the vessel was 10 inches behind the sash. DOP is released at 150 L/min. An aerosol photometer is employed to detect aerosol escape from the face of the hood. At the fume hood's face opening, the photometer probe is passed from left to right across the plane of the face, one inch in front of the opening in 1 inch wide rows from top to bottom and readings are recorded. At the face opening a concentration reference point is recorded 4 inches deep in the work zone in the center of the face opening. (See Appendix B-8)

Dry-Ice Test. The Dry- Ice test is relatively simple. All that is required is a bucket of water and dry ice. After placing a bucket of water in the fume hood, you drop in the ice. CO_2 evolves and spills out of the container and onto the work pane. You can see physically if the hood captures well. There is a drawback, however. Although the test is simple, it is not very convenient to carry buckets of water to each hood. There are also burn hazards involved due to the freezing temperature of the dry ice

NIOSH Method 1500[12]**.** This is a test that was recommended by Mr. Coaimhin Connell of CIH, Inc. The test calls for air sampling pumps (e.g. SKC Model, Gillian, MSA Personnel Pump), human subject, and NIOSH Method 1300 equipment. The test proceeds as follows:

Draw steady air stream for several hours. Place a pump on the back of the human subject. A NIOSH charcoal tube extending from the pump should be attached to the subject's shirt collar. Air should be drawn through the tube while the person is working with an appropriate solvent and analyzing it. Another pump should be placed at the exhaust and measurements should be taken. A third pump in the lab as a blank. Measure the evacutory volume of the fume hood. Measure the concentration of contaminants in the exhaust air stream. Calculate the total mass balance of the fume hood and personnel sampler on the collar. Calculate the protection factor.

According to Connell, this test is effective because it answers two questions: 1) Is the employee protected? 2) Does the hood work effectively? Both questions are answered because the amount of contaminants released in the subject-breathing zone is measured as well the air stream emitted from the exhaust fume.

Unfortunately, this test too seems time consuming and a bit complicated for my taste, personally.

Photo Ionization Detector Test (PID). PIDs are used to monitor the amount or concentration of toxic gas. Many industrial applications as well as for utility companies, fire fighters, and environmental applications. Environmental consultants use PIDs to detect small traces of toxic gas, inspect leaking underground storage tanks, monitor hazardous waste, personnel monitoring, confined space entry and as a survey instrument.

How A PID Works[13]: A PID recognizes concentrations of gases by using ultraviolet light to ionize the gas sample (temporarily break apart the electrons from the molecule). A sensor then determines the concentration of the gas. Although all elements and chemical compounds can be ionized, they differ in the amount of energy required. Some materials lose electrons, or are ionized, relatively easily while others are not. The amount of energy required to displace an electron is called the ionization potential (IP), and is measured in electron volts (eV). Each element and chemical compound has its own IP; the lower the IP, the lower the amount of energy required to ionize the material.

Epibenzene, Xylene, or similar gases could be released in the fume hood. Use the PID to measure for leakage across the face and other probable places of the hood.

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CO_2 Test. The CO_2 test is very simple. A palm-sized CO_2 packet is placed inside the fume hood. As the CO_2 is emitted, an air monitoring device or wand is used to capture and record the amount of spillage.

This test is ideal in terms of expense, time, and probability. This makes the test seem a very promising choice. However, the drawback to using CO_2 is the chance of producing erroneous values due to human contact. More research will have to be done in this area.

(**Note**: There is a CO_2 Fogger on the market currently used in cleanrooms. See Appendix B-9.)

Other Test Methods. "An Evaluation of Four Quantitative Laboratory Fume Hood Performance Test Methods" by Lisa Woodrow, evaluates other testing methods that were once in use. These tests are:

(1) EPA Uranine Dye Test Method

(2) ASHRAE Freon Test (the predecessor to SF_6. Freon can no longer be used because of environmental issues),

(3) EPA SF_6 Test

(4) A modified EPA SF_6 test.

Conclusion………and the Next Steps

Fume Hood Technology is a **continuous** study and more research will have to be performed, specifically in terms of performance testing. However, I believe that the following conclusions are evident.

Performance Specifications. Organizations responsible for standards and regulations must provide a clearer set of performance specifications and requirements for fume hoods.

Face Velocity. Face Velocity is not a good indicator of fume hood containment.

Uniform Standards. Agreement on fume hood practices, testing, and common operations is needed between standards committees.

Less expensive, Less Elaborate Testing. Simple test procedures that effectively prove containment in an inexpensive and less time consuming fashion are needed. Apparently, face velocity is not the answer.

In terms of the **LBNL hood**, more research must be performed in the following areas:

CO_2 Testing. More research is needed in this area. The test seems viable in terms of attainability, time, and expense. The only problem is the human factor. Many of the people that I've talked with have felt that human contact would have too great an effect on the test results. Continued communication with testing experts is needed. Get their opinions on the CO_2 idea and any alternative gases that they consider feasible.

PID Testing. This would be another good test direction to look into, since the concept is similar to that of CO_2 testing. (See Appendix B-13)

Helium Testing. In a telephone conversation, Lou DiBerardinus suggested Helium instead of CO_2. Consider this area. There is a Helium Leak Test Method for Industrial Applications. (See Appendix B-12)

Cal-OSHA. At this time, there is no time period available as to when the petitions will be considered and decided upon. Therefore, someone should stay in regular contact with Steve Smith, chief hygienist, and Bruce Wallace, Standards Unit.
(**Note**: A copy of all contact information has been provided as well as a copy of both petitions (See Appendix A-7 and A-8))

ASHRAE. Someone should also stay in regular contact with members of the ASHRAE as they will be having a rewrite in the near future. From what I have been told, they will be considering face velocity, turbulence testing, and dynamic testing, among other things. Gary Knutson will chair this committee.

Industrial Ventilation: A Manual of Recommended Practice. A letter should be written to the Industrial Ventilation Committee to find out about the status of the upcoming rewrite due in 2001.

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