<u>Fume Hood Study: Tufts University</u>

Available Fume Hood Technologies and University Survey

Scott Taylor
6/28/2004
Tufts Climate Initiative

TABLE OF CONTENTS

SUMMARY

Research laboratories, both academic and commercial, consume large amounts of energy under normal operation. This energy consumption exceeds residential and most types of commercial properties, and has recently become the focal point for various energy conservation programs, such as Labs21[1]. Researching, identifying and documenting the laboratory energy expenditures at Tufts University are part of a larger goal to reduce Tufts' greenhouse gas emissions. Tufts University is a medium sized academic institution with a significant number of laboratories used for both classroom instruction and research. New technologies and methodology provide a significant potential for Tufts to increase its future environmental performance in laboratories, as well as the possibility for significant monetary savings.

Fume hoods present one of the largest hurdles for energy efficiency. A hardware staple of research facilities, they must constantly provide protection against hazardous particles and gases. A large amount of energy is used to continuously operate exhaust fans and subsequently replenish the room with conditioned air. In a basic sense, they are a necessary but very energy intensive and costly expense.

Technologies exist to reduce the energy consumption of fume hoods, mainly through the reduction in exhausted air. This paper presents an overview of existing technologies, which ones currently exist on the Tufts campus, and what changes may present a significant opportunity. Low flow fume hoods, a relatively new technology, are assessed and compared to the existing systems at Tufts. Issues of safety and cost are also considered in the assessment. In addition, a university inventory of fume hoods is recorded. This report is only a first step in helping to define parameters for future design and construction of laboratory facilities.

<u>SOURCES</u>

Much of the material presented in this report is derived from testing done by LabCrafters Inc., a manufacturer of low flow fume hoods. While other manufacturers produce similar products, the information provided by LabCrafters was the most available and extensive. In addition, LabCrafters is possibly the "only manufacturer to advertise the ability to meet stringent containment requirements while operating at low-flow conditions." [6, pg1] The reports containing field-testing were done at Columbia University [2] and Oregon State University [1]. These field studies referenced were conducted by LabCrafters personnel, but were overseen by representatives from various independent contracting agencies.

[1] See appendix H

It should be noted that there are alternative low flow fume hoods produced by other manufacturers. One example is The Berkeley Hood, a high-efficiency fume hood developed by Lawrence Berkeley National Laboratories. It promises to deliver energy efficiency equal to or greater than LabCrafters Inc. while also providing superior levels of safety. There exists a large amount of information for the Berkeley hood, but it is not yet commercially available, and therefore not included in this report. For more information, refer to their web site:

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

FUME HOOD TYPES OVERVIEW

Constant Volume (CV)

Constant volume fume hoods exhaust a constant cubic feet per minute (CFM) of air regardless of the vertical sash (up-down) position. As the sash is lowered most manufacturers introduce additional bypass air in order to maintain face velocities that do not become too great. At very high face velocities back eddies result in hood contaminant spill and exposure of contaminants to lab workers. [3]

Variable Air Volume (VAV)

Variable air volume fume hoods employ a constant face velocity. They use little to no bypass air and the exhaust CFM is reduced as the sash is lowered while maintaining a fairly constant face velocity. Typically a Phoenix control valve is used to throttle or reduce the exhaust CFM as the sash is lowered. As the sash is raised the valve opens allowing for increased fume hood exhaust in conjunction with an increase in supply air. [3]

The above categories are general in description. There are multiple variations of each type and the reader is encouraged to further review current hood configurations.

LOW FLOW CONSTANT VOLUME FUME HOOD

LABCRAFTER'S AIR SENTRY - DESCRIPTION

The equipment under consideration in this report is constant volume fume hoods manufactured by LabCrafters Inc. Particular models introduced in this summary are the HBASC4 4' wide Air Sentry fume hood and the HBASC6 6'wide Air Sentry fume hood. Both models under consideration are equipped with factory installed variable face velocity (VFM) controls that automatically adjust the back baffle according to input from an airflow sensor mounted in the interior sidewall of the hood [1]. They are specified as Class A fume hoods. Class A hoods are suitable for "most operations requiring local exhaust ventilation to control the exposure of personnel to hazardous materials" [4]. The majority of fume hoods on the Tufts campus are designated as class A.

The physical appearance of the Air Sentry is similar to conventional hoods although there are a number of distinguishing operational characteristics. The hood itself has a vertical sash allowing a maximum opening of 27.5" [1]. Also present on some models are horizontal sashes that are not normally found on conventional hoods. They allow an operator to work comfortably within the hood while providing glass in front of the user to serve as a first layer of defense in case of an unanticipated event. The hood chamber is also significantly deeper than is normal and is based on sizing formulas contained in the product patent. Lastly, the baffles in the back of the hood automatically adjust in real time to provide higher levels of containment [3].

Figure 1: LabCrafters Air Sentry Standard Fume Hood [5]

COST

Preliminary information and discussion with industry representatives indicate that the Air Sentry has a higher initial cost compared other companies. In a report prepared for the University of Wisconsin by the state of Wisconsin's division of facilities development, LabCrafters Inc. and Fisher Hamilton submitted bids for a university fume hood replacement project. LabCrafters submitted a bid for $873,012, much higher than the $406,580 proposed by Fisher Hamilton [6]. The cost compared to outfitting a conventional hood with Phoenix Controls (discussed later) varies from project to project, but industry reps[2] have put the initial cost of an Air Sentry complete with installation below the overall cost required to incorporate and install Phoenix Controls.

Costs incurred over the useful life of the fume hood can justify a higher initial cost compared to conventional CV systems. Low flow fume hoods can use up to 50% less energy than a conventional CV fume hood and result in significant operation and maintenance (O&M) savings that may result in a lower life cycle cost. Cost benefits must be analyzed in detail for a particular facility, with actual savings depending on a variety of factors including climate, room size, desired temperature, peak usage requirements, and number of hoods.

SAFETY

[2] Private conversation with Jim Shiminski (DAC)

Economic savings provide good criteria when evaluating the performance of fume hoods, but foremost is safety. A fume hood's primary purpose is to protect the worker from breathing hazardous gases or particles. For safe fume hood operation, effective air circulation throughout the laboratory is essential [8]. One parameter often listed in conjunction with a measure of safety is face velocity, the average velocity of air at the opening of the hood while in operation.

Hood airflow face velocity through the sash was originally considered adequate at 50 feet-per-minute (fpm). However, this value increased over time to 150 to "improve" hood safety. Only when a research project, sponsored by the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), produced a procedure for establishing fume hood performance were face velocities reduced to the range of 60 to 100. This research—based on new information relevant to worker safety—formed the basis of ASHRAE Standard 110-1985, a standardized method for evaluating laboratory fume hood performance. [8]

Face velocity is not a direct indicator of degree of safety. "Contrary to common expectations, increasing face velocity does not improve containment. Instead, errant eddy currents and vortexes are induced around hood users as air flows into the hood, reducing containment effectiveness" [8]. OSHA requirements for laboratory safety recognize this and do not apply mandatory settings for face velocity [9]. The industry standard is to use the ASHRAE 110 testing procedure to ensure escaping gases do not exceed allowable amounts, typically in parts per million (ppm) [7].

TESTS AND RESULTS

ASHRAE 110 regulations can be summarized into three categories.

1. Face velocity measurement
2. Visual inspection of flow (smoke test)
3. Tracer gas containment

In reports prepared for Oregon State and Columbia University, the LabCrafters Air Sentry met or exceeded a ASHRAE 110 based tests. In some instances the tests were **modified** to further challenge the hood. The modifications included:

1. Lowering mannequin height to simulate a shorter hood operator.
2. Increasing the tracer gas release from the standard 4.0 liters per minute (lpm) to 8.0 lpm.

The following sections are the test procedures from both reports. The tests were either similar or identical, and the source files can be located by the reference numbers at the end of each section.

FACE VELOCITY
The opening of the hood was divided into equal area grids and the face velocity measurement was taken at the center of each grid, at the plane of the sash. The measurements were taken with a thermal anemometer. The average air velocity was recorded over 10/20 seconds at each grid location. All of the grid velocities were averaged to determine the average face velocity for that opening. [1,2]

SMOKE VISUALIZATION
The smoke visualization tests followed the guidelines of the ANSI/ASHRAE 110-1995 Standard. The large volume smoke visualization was performed using a theatrical smoke generator. The smoke generator was placed inside of the hood, and connected, via a flexible hose, to a cylindrical can ten inches (10") tall with a four-inch (4") diameter opening at the top. The can was placed in the center of the hood, six inches (6") back from the plane of the sash. The smoke generator was turned on and the smoke was ejected from the top of the can. The smoke flow patterns were observed and noted. The can was then moved to the left side and right side of the hood and the test was repeated. The can was then detached from the hose and the smoke was generated through the end of the hose. The smoke was ejected along the interior periphery of the hood opening, along the sidewalls and along the work surface. The smoke flow patterns were observed and noted. [1,2]

STATIC TRACER GAS TESTS
The Static tests followed the guidelines of the ANSI/ASHRAE 110-1995 Standard with the above modifications. The mannequin was placed in three positions: left position, center position, and right position as seen looking into the hood. In the left position, the ejector centerline was located twelve inches (12") from the left inside wall of the hood. In the center position, the ejector centerline was located equidistant from the interior sidewalls. In the right position, the ejector centerline was located twelve inches (12") from the right inside wall of the hood. The ejector body was positioned six inches (6") in from the hood face in all positions. The mannequin was positioned in front of the hood, centered on the ejector. The MIRAN 1A gas analyzer's detector probe was affixed to the mannequin's "breathing zone", the region of the nose and mouth of the mannequin. The nose of mannequin was nine inches (9") in front of the ejector (3" in front of sash). The sulfur hexafluoride (SF6) tracer gas was released from the gas ejector for a period of five minutes at a rate of eight *[four]* liters per minute. The concentration levels of the tracer gas that were detected at the mannequin's breathing zone by the MIRAN gas analyzer were recorded every second and logged on a laptop computer. At the conclusion of the five minutes, the average tracer gas exposure was calculated and is expressed as 8.0 *[4.0]* AI yyy, where yyy equals the average tracer gas concentration, in parts per million, over the five minute period. See Figure 2 for a diagram of the ASHRAE 110 tracer gas test setup. [1,2]

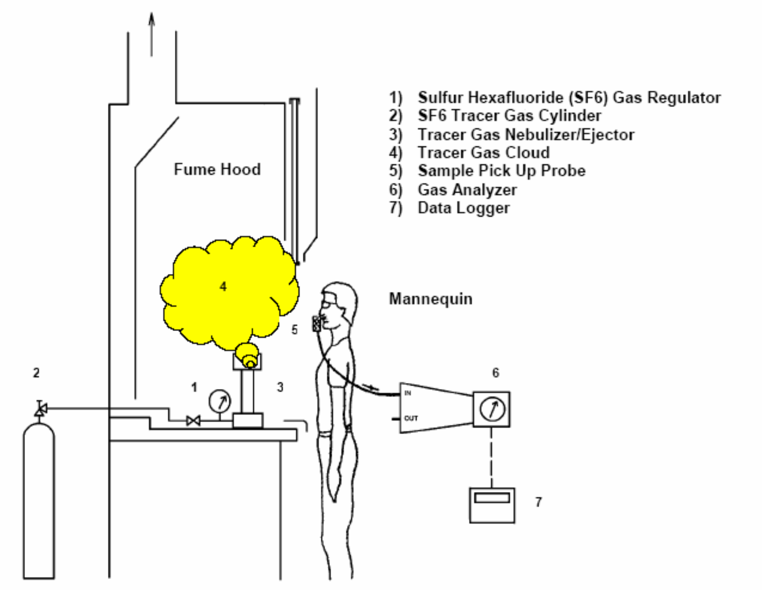


Figure 2: ANSI/ASHRAE 110 Tracer Gas Setup

DYNAMIC SASH MOVEMENT EFFECT TEST (SME)
The ANSI / ASHRAE 110-1995 outlines a sash movement effect (SME) procedure. After testing fume hood statically in the three positions and the results recorded. The mannequin was placed in the center position and the sash closed. The SF6 tracer gas was released, at a rate of eight *[four]* liters per minute, in the hood for a period of two minutes while the sash was closed. After two minutes, the sash was opened in a smooth motion at a velocity between 1.0 ft/s (0.3 m/s) and 1.5 ft/s (.05 m/s) while tracer gas was released and the tracer gas concentration was recorded. After the sash had been open for two minutes, the sash was closed at a rate between 1.0 ft/s (0.3 m/s) and 1.5 ft/s (0.5 m/s) while continuing to record the tracer gas concentration. The sash then again remained closed for a period of two minutes. The cycle was repeated three times. The sash movement effect (SME) is the average tracer gas concentration determined during the periods in which the sash is open in above test. The sash movement performance rating of the hood was recorded as 8.0 *[4.0]* SME-AI yyy, where yyy equals the average tracer gas concentration detected in ppm. [1,2]

HOOD LOADING
For one of the sash movement effect tests conducted on the HBASC4 Air Sentry fume hood (Test #2), the hood chamber was loaded with various objects, including briefcases, cardboard boxes and containers, to simulate as "As Used" condition. See Appendix C for photographs of the hood loaded with these objects. [1]

HOT PLATE TEST
This tracer gas test (Test #8) was run in the same manner as the STATIC TEST, outlined above. The mannequin and the tracer gas ejector were placed in the center position. A hot plate was placed to the immediate right of the tracer gas ejector. The hot plate was turned on to its highest setting. Unfortunately I had no means of measuring the temperature in the hood chamber or the heat produced by the hot plate. Once the hot plate reached its maximum temperature, the tracer gas was released at a rate of eight liters per minute. The static test was performed for a period of five minutes. At the conclusion of the five minutes, the sash was closed. After a period of 70 seconds, the sash was opened. After a period of 70 seconds, the tracer gas sensor was removed from the mannequin's breathing zone and was scanned across the top edge of the hood front panel for a period of 20 seconds. After this scan, the tracer gas was turned off and the test was concluded. The average tracer gas exposure was calculated and is expressed as 8.0 AI yyy, where yyy equals the average tracer gas concentration, in parts per million, over the entire test. This test was only performed on the HBASC4 Air Sentry fume hood. See Appendix C for photographs of this test, including the location of the hot plate and the scanning of the top of the hood front panel. [1]

TEST CONCLUSIONS

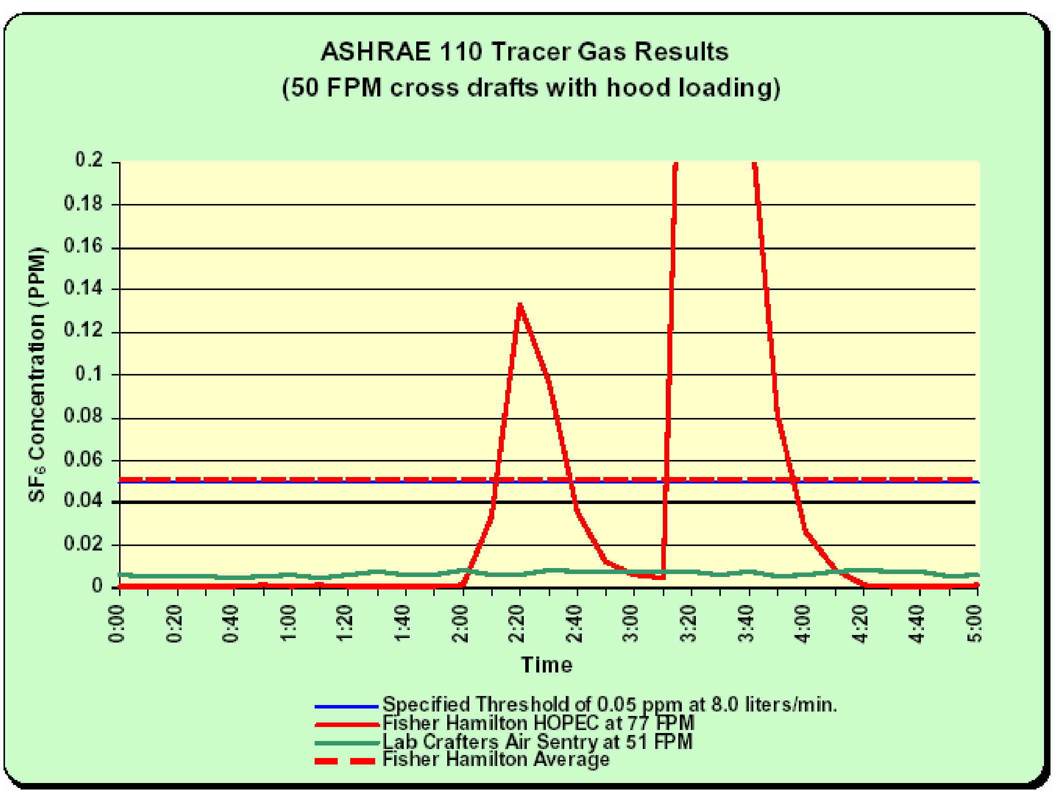
Pass/Fail

ASHRAE 110 standards do not provide pass/fail criteria; they are meant to serve as a method to test relative containment under predetermined conditions. ANSI/AIHA Z9.5-1992 Standard for Laboratory Ventilation outlines the acceptable performance ratings for "Class A" fume hoods. To qualify as Class A, the hood must achieve an ASHRAE 110 performance rating of 4.0 AM 0.05 and 4.0 AI 0.1. Both ratings correspond to a tracer gas release of 4.0 liters per minute. AM 0.05 indicates that when the hood manufacturer tests the hood in his own test facility, "As Manufactured" (AM), the tracer gas concentration at the mannequin's breathing zone cannot exceed an average of 0.05 parts per million. The second rating, AI 0.1, indicates that when the hood is tested in the field, "As Installed" (AI), the tracer gas concentration at the mannequin's breathing zone cannot exceed an average of 0.1 parts per million [1].

Results of Above Testing Procedure – Columbia University and Oregon State

The face velocity measurements for the Air Sentry showed consistent and uniform flow over the sash opening. With this test, average face velocity was approximately 60 fpm for a fully open sash. Smoke visualization tests also showed smooth flow with no apparent turbulence or undesired "dead spots".

Static and dynamic tracer gas results yielded results that exceeded specifications for a Class A



hood. For the procedures described above, tracer gas averages were always less than the 0.01 ppm requirement. Testing with hood loading, hot plate, and various other parameters to simulate actual use did not adversely affect hood containment [1]. Refer to the figure below for an example of the tracer gas results for the Air Sentry compared with that of a standard Fisher Hamilton fume hood. Additional selected data is included in Appendix C. Overall, the Air Sentry has been shown to provide exceptional and reliable safety to the fume hood operator.

Figure 3: Tracer Gas Results

COMPARISON

Similar tests have also been performed on conventional fume hoods, conducted by either independent contractors or a LabCrafter's test technician. Results vary, but in general the **Air Sentry outperforms conventional hoods in the desired areas of energy efficiency and operator safety.** Conventional hood models compared include models from Fisher Hamilton and Kewaunee Supreme Air. Please refer to reference section for further details.

CASE STUDY

University of Wisconsin Study

The following is referenced from "*Fume Hood Performance Test and Life Cycle Cost Analysis for University of Wisconsin Milwakee*, State of Wisconsin Adminstration Division of Facilities Development." [6]. It is meant to serve as an example of how life cycle costs can outweigh initial cost considerations.

In January of 2000, the Division of Facilities Development for the University of Wisconsin received bids from LabCrafters Inc. and Fisher Hamilton for an extensive fume hood replacement project. The bids totaled $873,012 and $406,580 respectively. The main objectives of the project were to improve laboratory safety conditions by replacing non-code complying fume hoods with new fume hoods and insure a safe operating ventilation system for the research laboratories.

Several alternatives had been evaluated during design to determine the most economic solution while maintaining safety as the utmost priority. During the research process, University of Wisconsin – Madison Environmental Health and Safety staff conducted an independent test of a Lab Crafters Air Sentry fume hood installed at the University of Illinois, Chicago. Their results confirmed safe operation and containment by this fume hood at an open sash face velocity of approximately 50 feet per minute (fpm) under challenging air current conditions that simulated a less than ideal laboratory setting [6].

Despite leaning toward the LabCrafter's Air Sentry due to preliminary research and life cycle analysis, Facilities Development felt that it was necessary to carefully review both products due to the great disparity between bid prices submitted by Fisher Hamilton [6]. They performed detailed life cycle cost analysis in conjunction with safety testing compliant to the AINSI/ASHRAE 110 industry standard. The results of both cost and safety analysis overwhelmingly favored the Air Sentry fume hood.

LIFE CYCLE COSTS

For the University of Wisconsin, the additional initial cost of a low flow fume hood was justified by the life cycle cost savings. Refer to Appendix A for a summary of the cost analysis over an estimated 20-year life. The present value cost of owning the Air Sentry was calculated to be over $400,000 less than the Fisher Hamilton alternative. While cost analyses will vary from project to project, the reduced energy consumption of a low flow hood will typically result in significant savings.

TUFTS UNIVERSITY

According to a list provided by Tuft's Environmental Health and Safety department, there are 598 fume hoods located on the three major Tufts campuses, Medford, Boston and Grafton. The Boston campus has the largest amount at 358, followed by the Medford campus with 187 hoods, and Grafton totals 57. The hoods are used for research purposes by a wide range of school departments including engineering, biology, chemistry, and medical school.

The pictures below are fume hoods at Tufts University. They show some of the many uses of fume hoods, some of which are not their intended function, such as the long term storage of chemicals. Fume hoods must not only provide a safe workspace for various short term experiments, but are may also house long term or permanent operations, exemplifying the need for fume hoods to provide continuous, reliable, and stable operation.

Figure 4:
Large hood providing a containment area[3]

Figure 5:
Fume hood used for chemical storage

In order to quantify any future benefit of new hood types, it is necessary to properly survey existing equipment and determine any economic and environmental potential. *Scientific American*, an independent contractor, surveys every fume hood on campus once a year. However, the information gathered only pertains to the state of the hood to determine its ability to adequately protect users. The hood is checked for face velocity and visible signs of defects that pose a safety risk, such as cracked glass or a sash that does not operate properly. The hood is then given only a Pass/Fail mark. Those that fail are designated as Do Not Use (DNU) and must be repaired and re-tested before they are recommissioned for use. Typically less than 10 fume hoods per year are shut down due to failed testing or reports of malfunction from lab supervisors.

[3] All pictures taken by Scott Taylor

It should be noted that these face velocity measurements **are not** necessarily good indicators of safety performance, as explained previously.

For this report additional information was needed than provided by the *Scientific American* list. The physical size and type of the hood is necessary to estimate the amount of energy used. Partial information of this nature was gathered at the Medford and Boston campuses. Unfortunately, the data is limited due to access restrictions and time constraints. All data and calculations in the following sections are interpolated and therefore prone to relative amounts of error. Out of 598 hoods, 194 were surveyed on the Boston and Medford campuses during the spring semester of 2004. Measurements on the width, height, depth, and sash height were taken. In addition to physical measurements, the type of fume hood was noted, if readily apparent. The types found on campus are described below.

Tufts University possesses various types of constant volume and variable air volume fume hoods. The older constant volume hoods are for the most part energy inefficient. Many of the newest installed or renovated hoods are equipped with Phoenix controls, but not all. Out of the 194 hoods surveyed, 84 were equipped with Phoenix controls. However, drawing conclusions on the number of hoods with Phoenix controls based on a sample size is inaccurate, as they are often grouped in clusters and therefore harder to estimate.

PHOENIX CONTROLS

Phoenix controls reduce energy use by monitoring sash height and correspondingly regulating the amount of airflow into the hood. The goal is to attain a set face velocity, typically 100-fpm. Lower sash heights result in less air exhausted by the hood. This reduces the energy requirement of the hood itself as well as the building HVAC system that must supply conditioned make-up air to the room. In addition, some hoods equipped with Phoenix controls are equipped with a motion sensor. When there is no operator present, the exhaust air is further reduced.

While Phoenix controls amount to significant increases in energy efficiency, they are costly to install and maintain. Integration with environmental room controls is required, and the system can become out of balance without proper maintenance. In addition, sudden use fluctuations of several hoods at once (as is often the case with classroom lessons) can result in an uncomfortable room environment for a short period of time. This occurs when the building HVAC system must suddenly supply large amounts of make-up air into the room. If it does not have enough time to properly condition the air, the room climate may temporarily shift into uncomfortable zones, particularly if the outside air is extremely cold, hot, or humid.

ADDITIONAL CONSERVATION METHODS

One other energy saving feature present on some hoods is overhead supply air. With this feature, outside air is directly pumped overhead of the fume hood. The result is that a large portion of the air exhausted by the fume hood contains this outside air, instead of conditioned air supplied by the building's HVAC system. Although the energy savings of this feature are significant, complaints of user discomfort, particularly during extreme weather, have already halted any further expansion of these hoods on campus. It is difficult to determine how many of these hoods are on campus, but it is relatively small. A general estimate is around 5% of the total hoods on campus.

UNIVERSITY CALCULATIONS

Using the width and height measurements of the fume hoods surveyed, as well as a reasonable estimate of the face velocity for a general hood, the total cubic feet per minute (CFM) of air can be calculated. The average CFM for a single non-Phoenix control fume hood is between 547 and 671 CFM for the Boston campus and between 878 and 1010 CFM for the Medford campus. Both intervals are at 95% confidence. The discrepancy in averages seems to correspond with an average smaller sized hood on the Boston campus. The face velocity for these calculations was assumed to be 80 fpm for a hood at full open. This estimate may be low, but this was to account for any small inaccuracies in the measurements, which are prone to be overstated rather than understated. The calculations do not take into account some energy saving features such as the overhead air supplies mentioned above or a switch for variable fan speed. These types of features were not present on a large portion of the hoods. A more extensive evaluation must be done to more precisely depict the quantity and effect of these conservation measures.

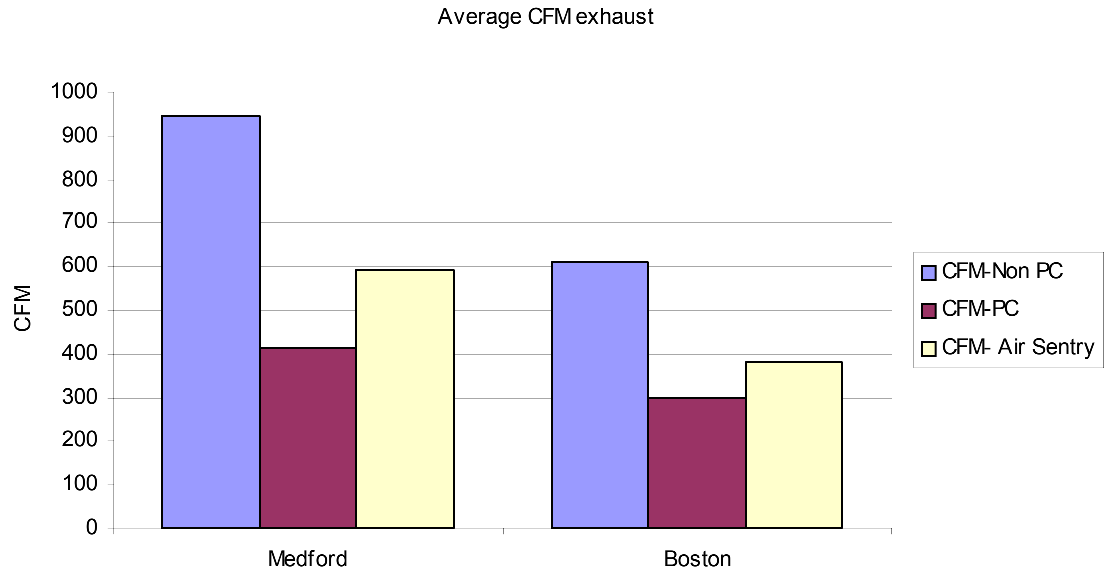


Figure 6: Average Exhaust/Hood in CFM

On hoods equipped with phoenix controls, the reduction in CFM was significant. Since the exhaust is dependent on sash height, the CFM was calculated using the height of the sash as it was found during the survey. This was meant to portray actualized savings during everyday use and not the total potential savings. On the Medford campus, the average CFM was between 313 and 509 CFM, while the Boston campus was between 247 and 351 CFM. Again, both are 95% confidence intervals. The face velocity was assumed to be 100 fpm, a typical setting for a hood equipped with Phoenix controls and in the range shown on hoods equipped with a face velocity meter. The difference between the averages on both campuses is attributed to the sash height. The average sash height was found to be 11.5” in Medford but only 7.5” in Boston. A lower sash height correctly corresponds to a reduction in CFM.

It is worth noting that the survey of the Boston campus was done during spring break. Many rooms appeared ‘shut down’ for the week, which would likely involve shutting fume hood sashes. This could explain the reduction in sash height. **Conversely, there are savings realized from Phoenix Controls sensors that were not accounted for.** Some hoods equipped with Phoenix Controls are also equipped with sensors that further reduce airflow when there are no operators present. While not particularly useful in a busy lab, they can result in large savings in unoccupied times, namely at night. The sensors were not taken into account due to the difficulty in estimating by how much they reduce flow, as well as hours they are effective since many labs are operated by students at irregular intervals and hours.

Using estimations described above, **the reduction in CFM due to Phoenix controls is approximately 60%**. The dollar value of these savings is related to the amount of energy used by the hood and the current cost of energy. The graph below shows the interpolated CFM exhausted as compared to the maximum CFM possible. The max CFM was calculated by adding the CFM of a Phoenix Control hood at full open to the CV exhaust.

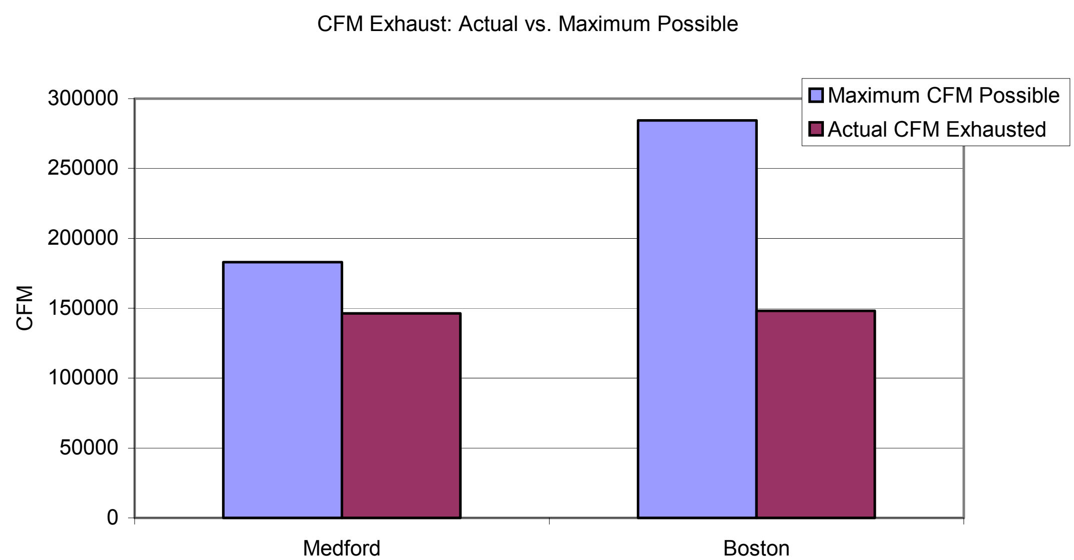


Figure 7: Total Exhaust in CFM

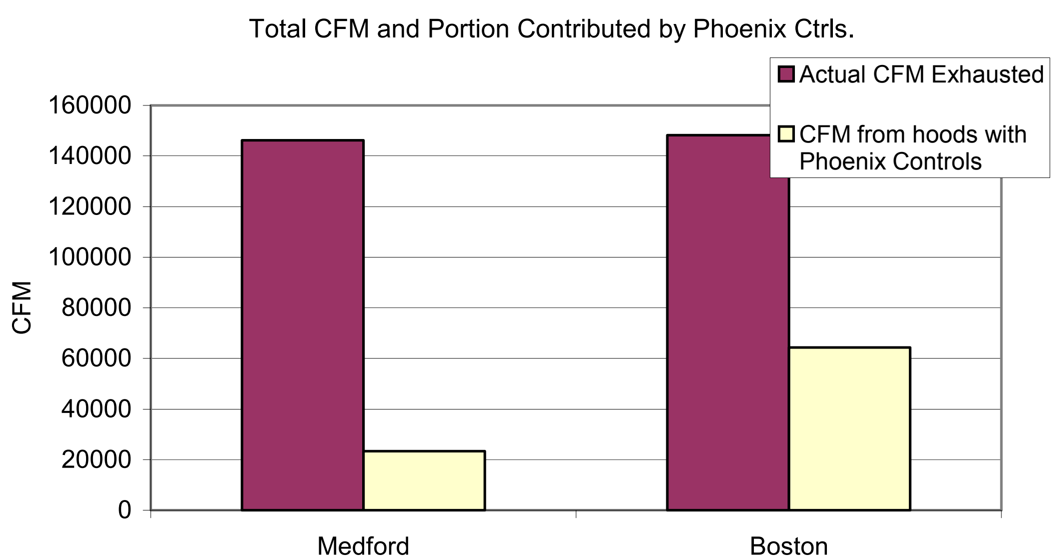


Figure 8: Total Exhaust and Portion Contributed by Phoenix Controls

The total dollar value of operational costs is determined by estimating the cost per CFM per year. One figure given by Jim Shiminski from DAC sales (industry representative for LabCrafters Inc.) is $6.68 per CFM/yr. This figure is higher than many other parts of the country in consideration of the extreme northeast climate. However, there is a paucity of available data at the moment to affirm that claim. A figure of $3.50 is a commonly used by industrial rate [10], and accounting for a more difficult climate can raise that figure to $5 per CFM/yr as given by Ray Ryan, president of Flow Sciences Inc. [11]. The two tables below shows some of the monetary expenditures of Tufts fume hoods as well as savings from Phoenix Controls.

	MEDFORD	**BOSTON**
Total CFM Exhausted/Yr.	146271	148251
Operation Cost @ $5/yr-CFM	$731,355	$741,255

Table 1: CFM Cost

	MEDFORD	**BOSTON**
Average Percent CFM savings from Phoenix Controls Compared to Conventional Hood (per hood)	61%	68%
Estimated Percent Savings in CFM with Air Sentry (per hood)	~40-45%	~40-45%

Table 2: % Savings with Phoenix Controls and Air Sentry

In contrast to Phoenix controls, the energy savings realized through the use of low flow fume hoods is estimated at about 40%, assuming an average face velocity of 50 fpm when fully open. This is about 20% less than Phoenix controls. However, there are several advantages when evaluating a decision to switch to low flow fume hoods over Phoenix controls.

1. **The energy savings are not dependent on the state of use of the hood**. This means that the savings are constant, and do not decrease as the hood sash is left open. This eliminates the problem of actively trying to keep the sashes closed when not in use. As evidenced by the questionnaire results and notes from personal conversations [see below], most students do not realize the door should be shut when finished with the hood. The large numbers of students that use a facility also make it hard to enforce any rule to do so.

2. **Integration with room environmental controls is not necessary**. Once the hoods are installed, the system is set at according to the number of hoods present in the room. This is particularly beneficial in a room with many hoods, as sudden changes in use will not disrupt

comfort levels.

3. **Maintenance is reduced**. The numerous throttle valves used by Phoenix controls require added maintenance to function properly. The maintenance of a low flow fume hood requires no special maintenance. These cost savings thru reduced maintenance labor cost may be significant.

4. **HVAC systems in new buildings can be reduced since the max power load will not be as high.** This can lead to lower initial construction costs. This also applies to existing buildings undergoing renovation. The current HVAC system may not require upgrading with additional low flow hoods whereas it would with traditional fume hood additions.

These advantages over Phoenix Controls show a great opportunity in retrofitting rooms with older hoods. Unlike Phoenix Controls, the hoods can be replaced without the spatial requirements for additional ductwork and large throttle valves that are present with Phoenix controls. There is also no need to calibrate the new hoods with HVAC or Johnson controls. These features, along with a high level of user safety, may offer the viability of retrofitting old rooms on the basis of energy savings alone; should the long term savings warrant such an action. This would not commonly be possible with Phoenix Controls, as the cost of additional room renovations could far outweigh the energy savings

The final cost implications of low flow fume hoods compared to Phoenix controls must be determined on a case by case basis. When a construction project is undertaken it would be beneficial to consider low flow hoods as a viable alternative to conventional as well as Phoenix Controls hoods. A detailed life cycle cost analysis should be undertaken to determine the true cost of ownership.

USER OPERATION

Student Survey

Phoenix Controls provide savings when the sash is **shut.** When the sash is left open, the hood is in full operation and the economic and environmental savings are lost. Many students do not realize this, as evidenced by personal interviews and questionnaires given to some laboratory users. Several questionnaires are in the appendix of this report. The number of students and supervisors interviewed is small – on the order of 20 to 30. Therefore the following should be considered in the context of subjective interpretation based on a limited number of surveys, and not fact.

Most students are unaware of the large demand fume hoods place on utilities, and even less cognizant of fume hood technologies. When asked whether they shut their fume hood door after use, many replied that they did, although interviews with lab supervisors yielded a different answer. For those that did shut the sash, they were still unaware that shutting the sash saves enormous amounts of energy. Informing them of this fact received several promises to be more diligent in shutting the fume hood sash after use, as they are happy to do perform such a small task for the environment, as are most students.

But just as simple tasks such as turning off room lights and computers when unoccupied has become well known doctrine, in practice the results are often far from expectations. Conversations with a couple of lab supervisors yielded one who was extremely concerned with laboratory energy waste, and frustrated with the amount of time spent properly shutting all hoods, as well as turning off lights, etc. He indicated that despite his frequent instructions, they often went unheeded, most commonly by undergraduate students who may use the labs only infrequently.

Formal training on fume hood use is limited. It deals with safe fume hood operation, and occurs yearly, at most. Incorporating instructions on the importance of shutting down properly after use may provide a greater realization of savings potential by making students aware of the environmental costs of operating fume hoods. Additionally, hiring a student to visit each room daily and shut the sashes could provide economic savings that would cover the cost of their salary and then some.

The opportunity to save energy in existing labs is limited to the measures listed above. It is not as large as correct and careful designs for new facilities can yield. However, the savings from simple conservation measures can still be significant and are worth the effort in implementing.

FINAL DISCUSSION

This paper is meant to serve as a source of information for future projects concerning laboratory energy consumption. Fume hoods and the respective technologies used to render them more efficient are a matter worthy of consideration when designing or renovating a laboratory facility. The calculations done for Tufts University will hopefully provide a base from which further research may yield progress towards environmental sustainability.

Progress in this area will be the result of collaboration between the many departments at Tufts. Energy conservation as a project goal should become a priority in the development of a laboratory. Using available resources such as Labs21 can provide methods, research tools, and networking that may prove beneficial. Steps such as seeking out engineering and architectural firms with experience in environmental sustainability are also important. There are obviously many hurdles to overcome in implementing these ideals, including cost, time, and administrative hierarchy. Unfortunately, construction projects are often largely under control by the individual department benefiting rather than a centralized group. This makes communication between various groups more difficult to facilitate, hampering goals such as environmental sustainability that require the cooperation of various departments within a construction project.

Despite these hurdles, significant savings are possible with the implementation of low flow and other reduced flow fume hoods. The monetary savings combined with improved environmental performance make these fume hoods an attractive option for new or renovated laboratories. The best option for each project must be carefully considered based on the competing factors of cost, life cycle maintenance, and laboratory performance. It is hoped that the information in this paper results in careful consideration of low flow fume hoods as a future alternative.

References

[1] DeLuca, Robert. *LabCrafters Inc. Fume Hood Test Report Prepared for Oregon State University*

[2] DeLuca, Robert. *Fume Hood Test Report Prepared for Columbia University.* LabCrafters Inc. & The Morgan Contracting Corporation

[3] Di Giacomo, Stephen M. *Short Primer Project Summary.* February 4th, 2002. Energy Management Associates

[4] http://web.princeton.edu/sites/ehs/hazardcommguide/4.htm

[5] *Labcrafterhood.pdf.* Provided by LabCrafter Inc. & Flow Safe Inc.

[6] *Performance Test and Life Cycle Cost Analysis for University of Wisconsin Milwaukee – Chemistry Building Fume Hood Replacement Project.* Prepared by State of Wisconsin Department of Adminsitration Division of Facilities Development. February 21st, 2000.

[7] *ANSI/ASHRAE 110-1995 Method of Testing Performance of Laboratory Fume Hoods.* American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. 1995.

[8] Bell, Geoffrey, Dale Santor & Evan Mills. *The Berkeley Hood. Development and Commercialization of an Innovative High-Performance Laboratory Fume Hood.* Lawrence Berkeley National Laboratories. 2002.

[9] http://www.osha.gov/pls/oshaweb/

[10] http://www.newtechtm.com/html/aspsenergy.htm

[11] http://www.flowsciences.com/images/Articles/VentedContain.htm

[12] http://www.phoenixcontrols.com/images/UBCsystem.gif

Contacts and Acknowledgements

The following people have been valuable in the production of this report

Beaudoin, Daniel
Manager of Operations, Energy and Utilities
Harvard School of Public Health

Creighton, Sarah Hammond
Project Manager
Tufts Climate Initiative

Di Giacomo, Stephen M.
Principal
Energy Management Associates

Isenstein, Betsy
Energy Manager
Tufts University

Kollmuss, Anja
Outreach Coordinator
Tufts Climate Initiative
Tufts University

Magliano, Nick
Environmental Health and Safety Manager
Environmental Health and Safety
Tufts University

Miller, Elliott
Manager: Maintenance Planning & Engineering
Facilities
Tufts University

Nowak, Peter
Industrial Hygiene Tech
Environmental Health and Safety
Tufts University

Saya, Wayne
Facilities Manager
Facilities
Tufts Boston Medical School

Shiminski, Jim
DAC
Sales

APPENDIX A: University of Wisconsin Case Study

Life Cycle Cost Analysis Summary
University of Wisconsin- Milwaukee [6, pg 16]

All figures are in present value (PV) cost

UW MILWAUKEE CHEMISTRY PHASE 2 COST BREAKDOWN - ALTERNATIVE 1

LAB CRAFTERS FUME HOODS

TOTAL PV OF INITIAL COST =	1,879,930
TOTAL PV OF REPLACEMENT COST =	9,725
TOTAL PV OF ANNUAL RECURRING COSTS =	178,102
TOTAL PV OF ENERGY COSTS =	559,229
TOTAL LIFE CYCLE COST =	**2,626,986**

UW MILWAUKEE CHEMISTRY PHASE 2 COST BREAKDOWN - ALTERNATIVE 2

FISHER HAMILTON FUME HOODS

TOTAL PV OF INITIAL COST =	1,568,737
TOTAL PV OF ANNUAL RECURRING COSTS =	233,758
TOTAL PV OF ENERGY COSTS =	1,252,685
TOTAL LIFE CYCLE COST =	**3,055,181**

UW MILWAUKEE CHEMISTRY PHASE 2 COST BREAKDOWN - ALTERNATIVE 1
LAB CRAFTERS FUME HOODS

Lab Crafters Fume Hoods	$	873,012.00		
General Construction	$	383,000.00		
Plumbing	$	78,990.00		
HVAC	$	228,400.00		
Electrical	$	182,500.00		
Asbestos Abatement	$	49,680.00		
DDC Control Work	$	65,000.00		
Testing and Balancing	$	32,200.00		
ASHRAE 110 Fume Hood Testing	$	27,600.00		
Construction Cost Subtotal			**$**	**1,920,382.00**
Construction Contingency			**$**	**57,611.46**
DFD Supervision	$	79,119.74		
A/E Fees	$	155,000.00		
Code Plan Review	$	5,000.00		
Fume Hood Performance Testing	$	15,000.00		
Design and Supervision Subtotal			**$**	**254,119.74**
TOTAL PROJECT COST			$	2,232,113.20

UW MILWAUKEE CHEMISTRY PHASE 2 COST BREAKDOWN - ALTERNATIVE 2
FISHER HAMILTON FUME HOODS

Fisher Hamilton Fume Hoods	$	406,580.17		
General Construction	$	383,000.00		
Plumbing	$	78,990.00		
HVAC	$	228,400.00		
* Additional HVAC Costs HV-9	$	96,500.00		
Electrical	$	182,500.00		
Asbestos Abatement	$	49,680.00		
DDC Control Work	$	65,000.00		
Additional DDC Costs for HV-9	$	25,000.00		
Testing and Balancing	$	32,200.00		
ASHRAE 110 Fume Hood Testing	$	27,600.00		
Construction Cost Subtotal			**$**	**1,575,450.17**
Construction Contingency			**$**	**47,263.51**
DFD Supervision	$	64,908.55		
A/E Fees	$	155,000.00		
Code Plan Review	$	5,000.00		
Fume Hood Performance Testing	$	15,000.00		
Design and Supervision Subtotal			**$**	**239,908.55**
TOTAL PROJECT COST			$	1,862,622.22

* Additional HVAC Costs to convert HV-9 to Air Conditioning System		
Extension of chilled water piping to penthouse for HV-9	$	29,000.00
Cooling coil and reheat in HV-9	$	64,000.00
HV-9 filtration system upgrade	$	10,000.00
HV-9 supply air distribution in labs	$	58,500.00
Credit for not doing work on AC-6	$	(65,000.00)
Total	$	96,500.00

T L C C WORKSHEET (revised 12/97) **State of Wisconsin, Division of Facilities Development**

PROJECT:	UW MILWAUKEE CHEMISTRY PHASE 2	BY:	d. motl
	FUME HOOD REPLACEMENT	DATE:	Feb-00

ECON FAC (%)		TIME FAC(YRs)		ALT NO:	1
GEN INFLA:	3	BASE PT:	0	SCOPE:	
DISC RATE:	4	STUDY PD:	25	Fume Hood Replacement	
BOND RATE:	5	BOND PD:	20	Air Sentry at 50 fpm	

INITIAL COSTS:	YEAR(n)	BPV FAC	PV FAC	COST	PV
1 Project Construction Cost	0	0.8422	1.0000	2,232,113	1,879,930
2	0	0.8422	1.0000	0	0
3	0	0.8422	1.0000	0	0
4	0	0.8422	1.0000	0	0
5	0	0.8422	1.0000	0	0
6	0	0.8422	1.0000	0	0
TOTAL PV OF INITIAL COST (+) =				2,232,113	1,879,930

REPLACEMENTS COSTS:	YEAR(n)	BPV FAC	PV FAC	COST	PV
1 VFV Belimo Motor Replacement	20	0.8422	0.4564	25,300	9,725
2	0	0.8422	1.0000	0	0
3	0	0.8422	1.0000	0	0
TOTAL PV OF REPLACEMENT COST (+) =				25,300	9,725

ANNUAL COSTS:	ESCAL(%)	SPV FAC	PV FAC	COST/YR1	PV
1 Fume Hood Maintenance	5	18.5523	1.0000	4,600	85,340
2. Air Handling Unit Maintenance	5	18.5523	1.0000	5,000	92,761
3.	0	11.5287	1.0000	0	0
TOTAL PV OF ANNUAL RECURRING COSTS (+/-) =				9,600	178,102

NON-ANNUAL COSTS:	YEAR(n)	PV FAC	COST	PV
1	10	0.6756	0	0
2	15	0.5553	0	0
3	20	0.4564	0	0
4	0	1.0000	0	0
TOTAL PV OF NON-ANNUAL COSTS (+/-) =			0	0

ANNUAL ENERGY COSTS:	ESCAL(%)	SPV FAC	PV FAC	COST/YR1	PV
1 NATURAL GAS	2.8	14.8767	1.0000	0	0
2 LIGHT OIL	3.2	15.4654	1.0000	0	0
3 COAL	1.9	13.6627	1.0000	0	0
4 ELECTRICITY	2.3	14.1842	1.0000	21,895	310,564
5 STEAM	2.8	14.8767	1.0000	9,404	139,901
6 CHILLED WATER	2.3	14.1842	1.0000	7,668	108,765
7 OTHER	0	11.5287	1.0000	0	0
TOTAL PV OF ENERGY COSTS (+/-) =				38,967	559,229

RESIDUAL VALUE:	YEAR INSTALLED	USEFUL LIFE	RPV FAC	PV FAC	COST	PV
1.	0	40	0.2107	1.0000	0	0
2.	25	25	1.0000	0.3751	0	0
3.	15	15	0.2705	0.5553	0	0
TOTAL PV OF RESIDUAL VALUE (-) =					0	0

TOTAL LIFE CYCLE COST = SUM OF PV'S = 2,626,986

TOTAL ANNUAL WORTH = T.L.C.C. X (A/P i, n) = 168,159

NOTES:

1. Initial Costs are based on actual bid prices for project.
2. Replacement cost of VFV motor are based on Belimio life cycle testing and calculations. See appendix
3. Mainenance costs are based on $50/yr/fume hood plus $5000/year/single hvac system serving the fume hoods.
4. Energy costs are based on ventilation load and fan motor energy. Reference energy calculations in this report.

T L C C WORKSHEET (revised 12/97) **State of Wisconsin, Division of Facilities Development**

PROJECT:	UW MILWAUKEE CHEMISTRY PHASE 2	BY:	**d. motl**
	FUME HOOD REPLACEMENT	DATE:	Feb-00

ECON FAC (%)		TIME FAC(YRs)		ALT NO:	2
GEN INFLA:	3	BASE PT:	0	SCOPE:	
DISC RATE:	4	STUDY PD:	25	Fume Hood Replacement	
BOND RATE:	5	BOND PD:	20	HOPEC Hood at 90 FPM	

INITIAL COSTS:		YEAR(n)	BPV FAC	PV FAC	COST	PV
1	Project Construction Cost	0	0.8422	1.0000	1,862,622	1,568,737
2		0	0.8422	1.0000	0	0
3		0	0.8422	1.0000	0	0
4		0	0.8422	1.0000	0	0
5		0	0.8422	1.0000	0	0
6		0	0.8422	1.0000	0	0
	TOTAL PV OF INITIAL COST (+) =				1,862,622	1,568,737

REPLACEMENTS COSTS:		YEAR(n)	BPV FAC	PV FAC	COST	PV
1		15	0.8422	0.5553	0	0
2		0	0.8422	1.0000	0	0
3		0	0.8422	1.0000	0	0
	TOTAL PV OF REPLACEMENT COST (+) =				0	0

ANNUAL COSTS:		ESCAL(%)	SPV FAC	PV FAC	COST/YR1	PV
1	Fume Hood Maintenance	5	18.5523	1.0000	4,600	85,340
2.	Air Handling Unit Maintenance	5	18.5523	1.0000	8,000	148,418
3.		0	11.5287	1.0000	0	0
	TOTAL PV OF ANNUAL RECURRING COSTS (+/-) =				12,600	233,758

NON-ANNUAL COSTS:		YEAR(n)	PV FAC	COST	PV
1		10	0.6756	0	0
2		15	0.5553	0	0
3		20	0.4564	0	0
4		0	1.0000	0	0
	TOTAL PV OF NON-ANNUAL COSTS (+/-) =			0	0

ANNUAL ENERGY COSTS:		ESCAL(%)	SPV FAC	PV FAC	COST/YR1	PV
1	NATURAL GAS	2.8	14.8767	1.0000	0	0
2	LIGHT OIL	3.2	15.4654	1.0000	0	0
3	COAL	1.9	13.6627	1.0000	0	0
4	ELECTRICITY	2.3	14.1842	1.0000	35,140	498,434
5	STEAM	2.8	14.8767	1.0000	38,965	579,672
6	CHILLED WATER	2.3	14.1842	1.0000	12,308	174,580
7	OTHER	0	11.5287	1.0000	0	0
	TOTAL PV OF ENERGY COSTS (+/-) =				86,413	1,252,685

RESIDUAL VALUE:	YEAR INSTALLED	USEFUL LIFE	RPV FAC	PV FAC	COST	PV
1.	0	40	0.2107	1.0000	0	0
2.	25	25	1.0000	0.3751	0	0
3.	15	15	0.2705	0.5553	0	0
TOTAL PV OF RESIDUAL VALUE (-) =					0	0

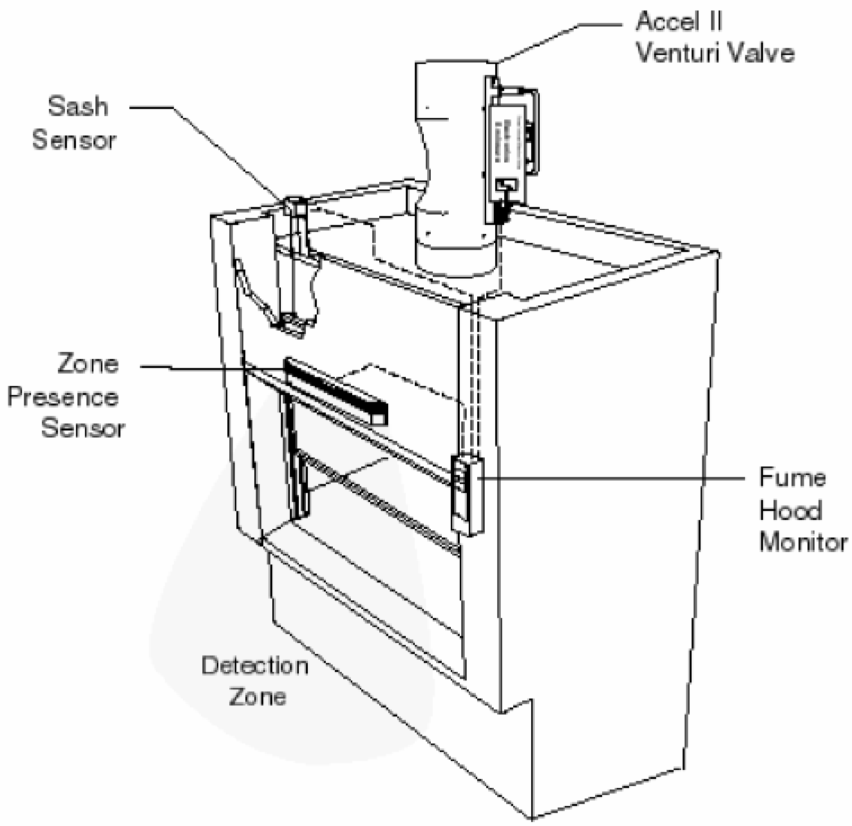
TOTAL LIFE CYCLE COST = SUM OF PV'S = 3,055,181

TOTAL ANNUAL WORTH = T.L.C.C. X (A/P i, n) = 195,568

NOTES:

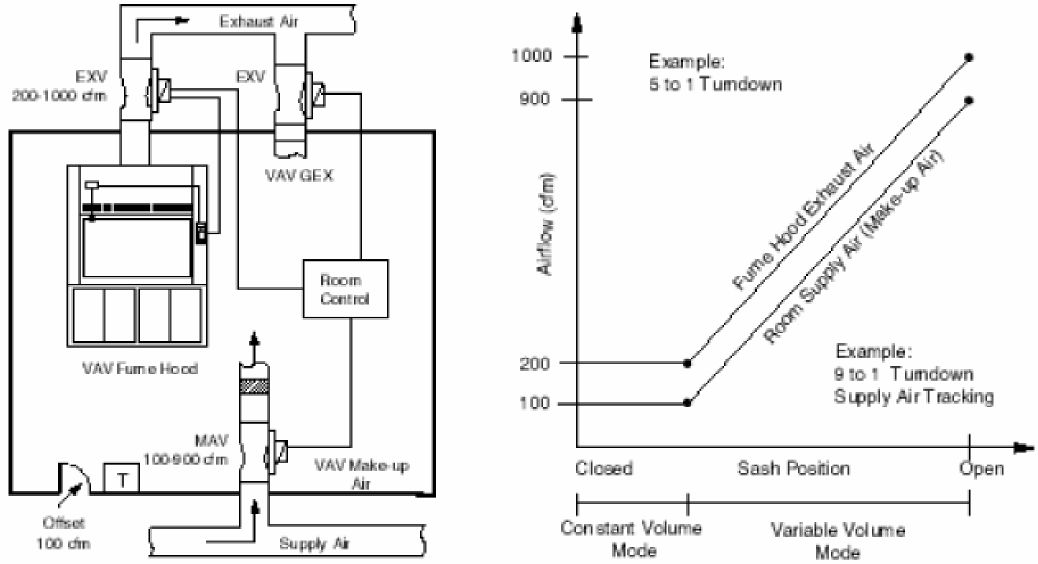
1. Initial Costs are based on actual bid prices for project.
2. This alternative assumes no replacement costs for fume hood components.
3. Mainenance costs are based on $50/yr/fume hood plus $8000/year/two hvac system serving the fume hoods.
4. Energy costs are based on ventilation load and fan motor energy. Reference energy calculations in this report.

Appendix B: Schematical Drawings



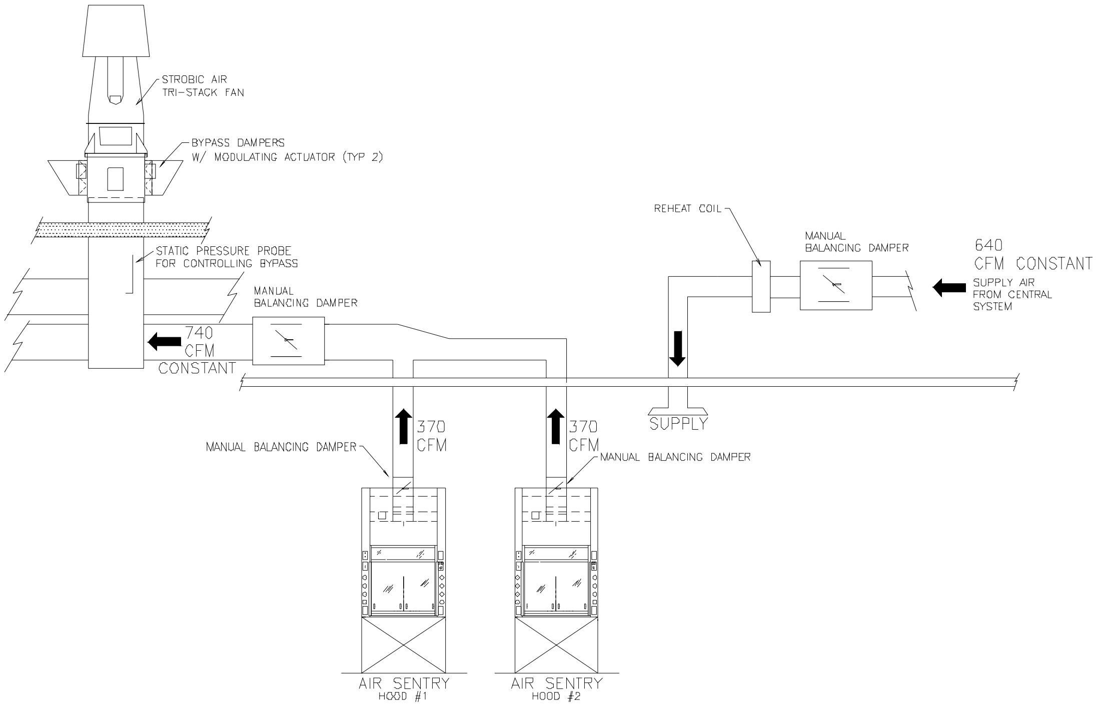
Usage Based Controls system. The system determines usage by sensing the presence of a person in a well-defined detection zone in front of the hood. When no one is present, the system sets the airflow face velocity to a safe "standby" level—typically 60 fpm. When the operator enters the detection zone, the system instantaneously (within one second) increases the face velocity to a higher level—typically 100 fpm.

Phoenix Controls – Occupancy Sensor Operation [12]

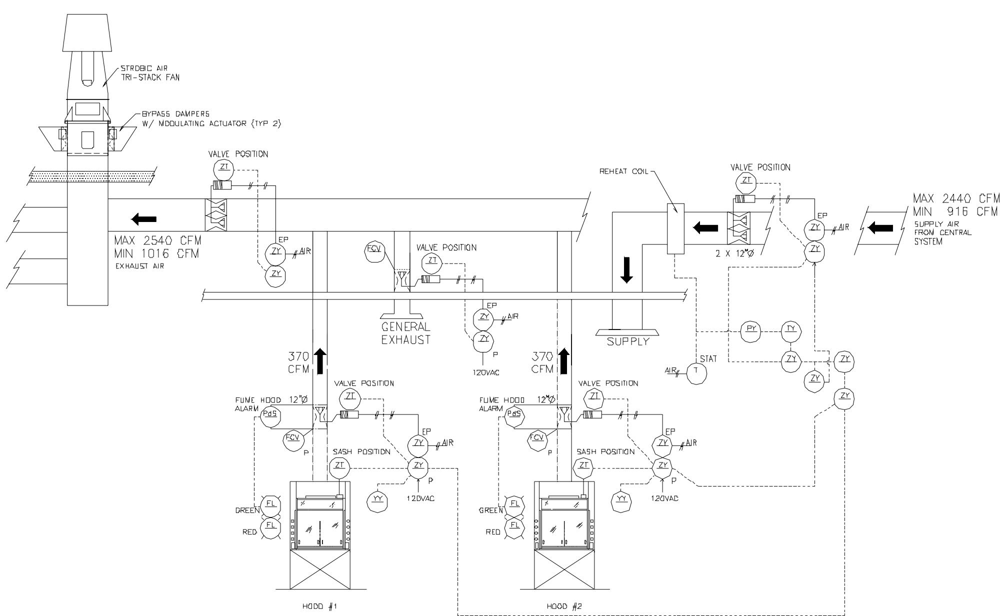


VAV application with Phoenix Controls. Pressure independent air valves maintain proper flows over the entire range of command. The sash opening determines flow requirements through the hood while the room make-up air adjusts to maintain pressurization. If additional air is needed due to thermal or ventilation requirements, the general exhaust and make-up air valves adjust accordingly. The fume hood monitor (FHM) provides continuous monitoring, meeting regulatory requirements.

Phoenix Controls room schematic [12]

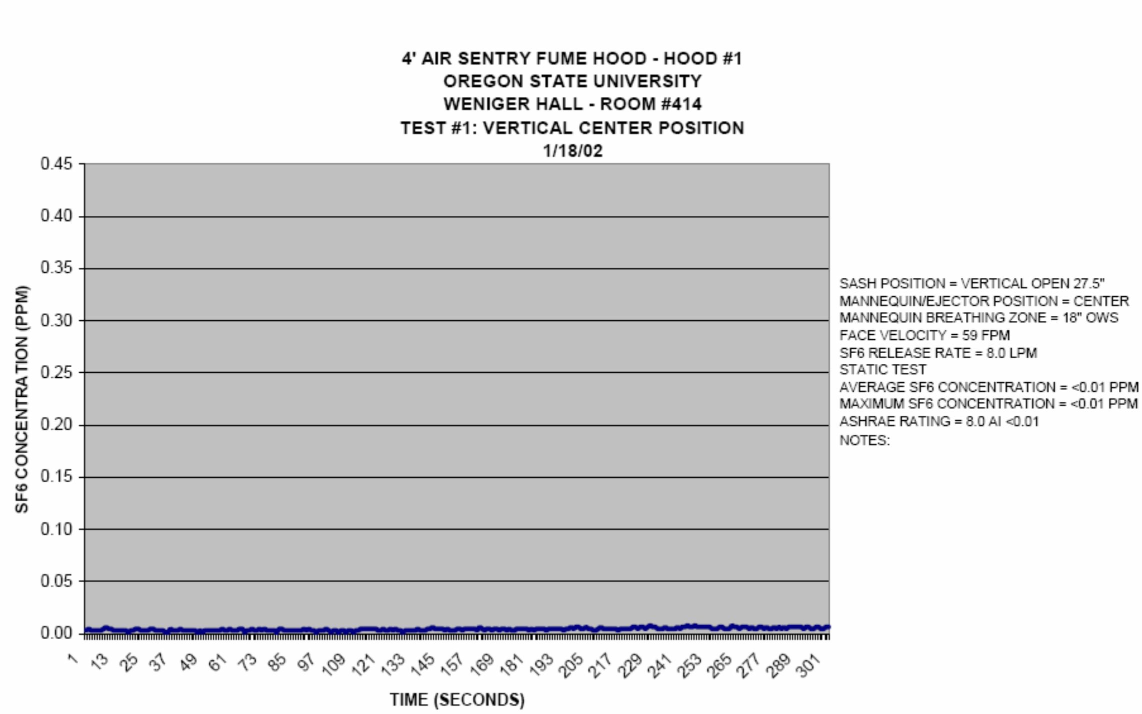


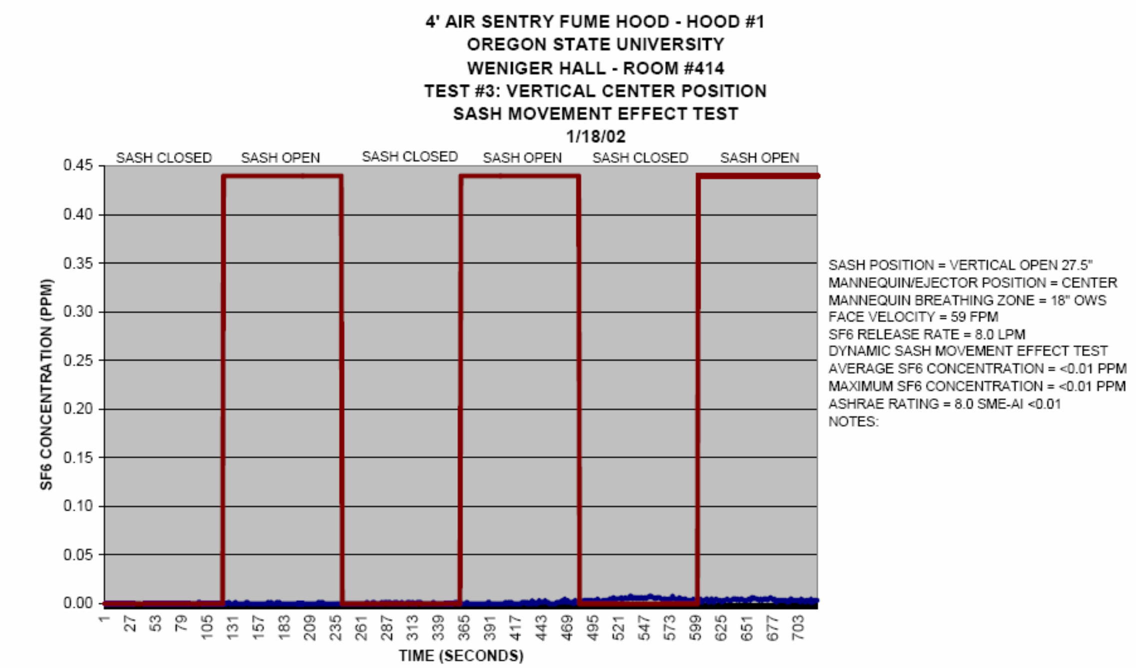
Low flow fume hood room integration schematic [12]

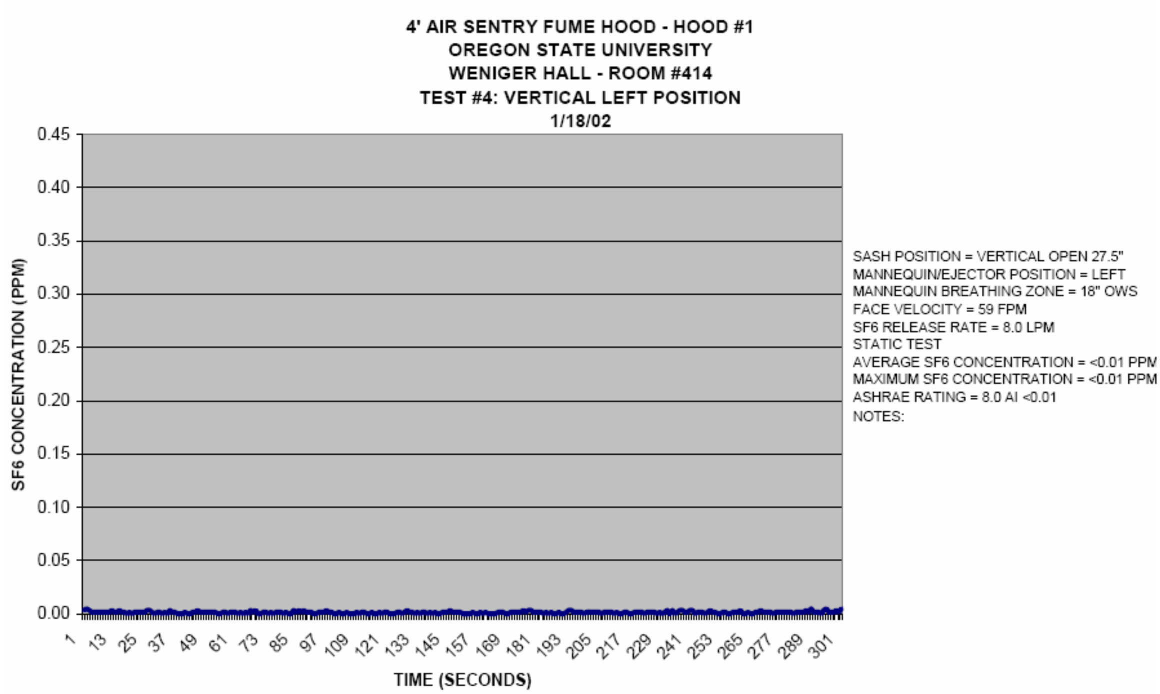


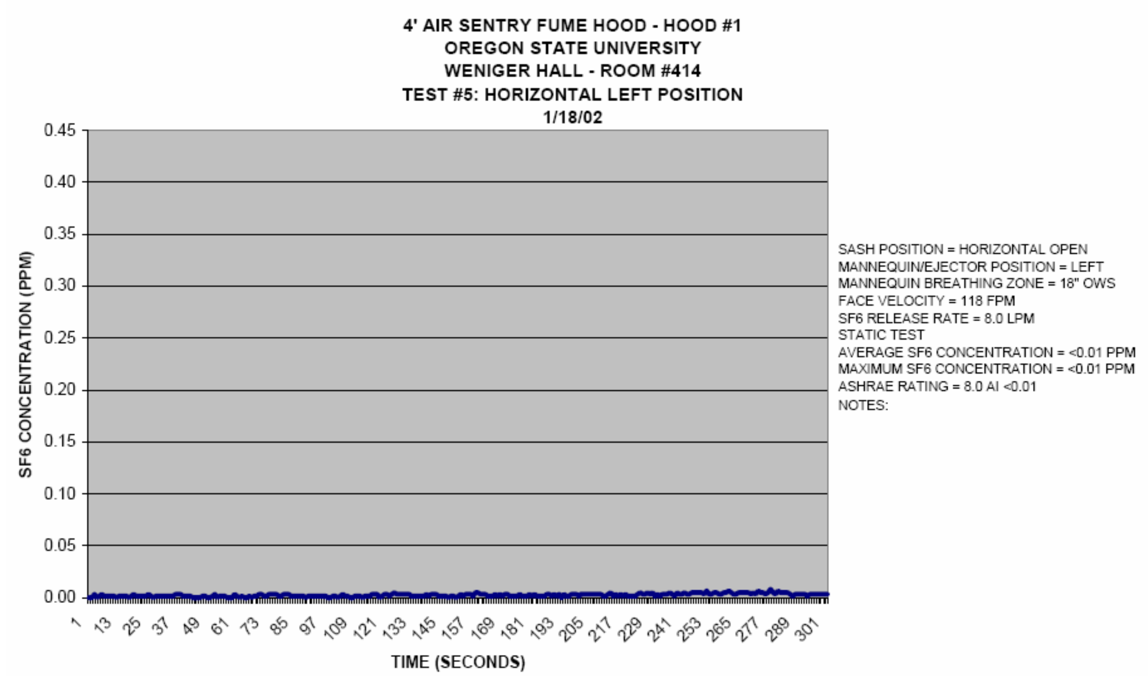
Phoenix Controls room integration schematic [12]

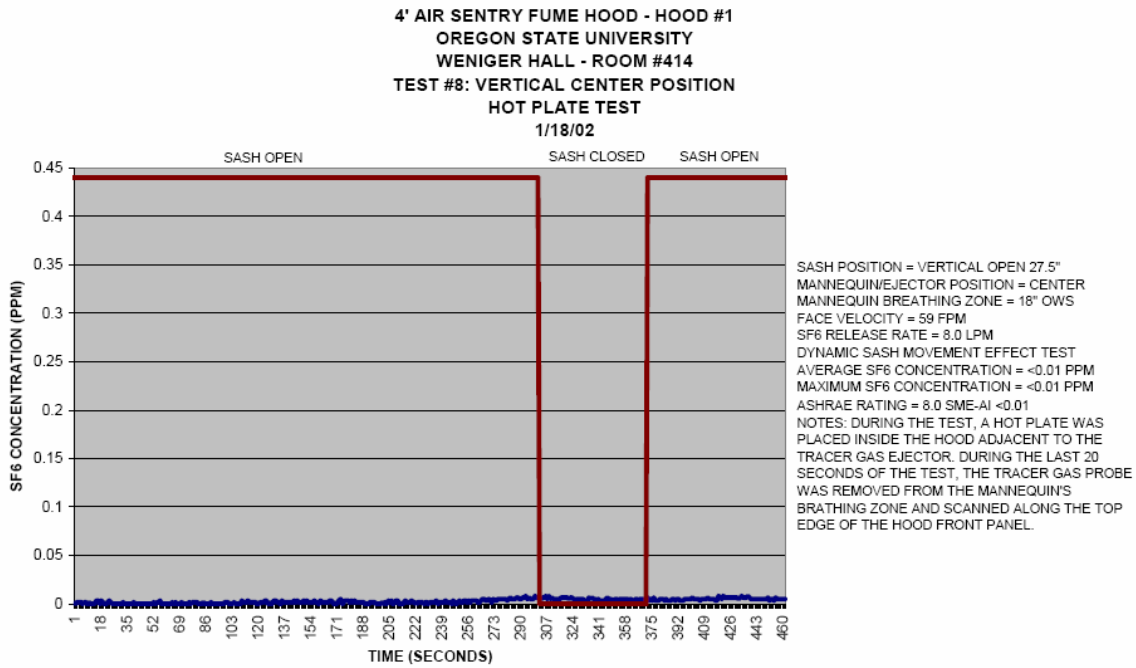
Appendix C: Selected Results from Oregon and Columbia Studies


4' AIR SENTRY FUME HOOD - HOOD #1
OREGON STATE UNIVERSITY
WENIGER HALL - ROOM #414
TEST #1: VERTICAL CENTER POSITION
1/18/02
SF6 CONCENTRATION (PPM)
TIME (SECONDS)
SASH POSITION = VERTICAL OPEN 27.5"
MANNEQUIN/EJECTOR POSITION = CENTER
MANNEQUIN BREATHING ZONE = 18" OWS
FACE VELOCITY = 59 FPM
SF6 RELEASE RATE = 8.0 LPM
STATIC TEST
AVERAGE SF6 CONCENTRATION = <0.01 PPM
MAXIMUM SF6 CONCENTRATION = <0.01 PPM
ASHRAE RATING = 8.0 AI <0.01
NOTES:


4' AIR SENTRY FUME HOOD - HOOD #1
OREGON STATE UNIVERSITY
WENIGER HALL - ROOM #414
TEST #3: VERTICAL CENTER POSITION
SASH MOVEMENT EFFECT TEST
1/18/02
SASH CLOSED
SASH OPEN
SASH CLOSED
SASH OPEN
SASH CLOSED
SASH OPEN
SF6 CONCENTRATION (PPM)
TIME (SECONDS)
SASH POSITION = VERTICAL OPEN 27.5"
MANNEQUIN/EJECTOR POSITION = CENTER
MANNEQUIN BREATHING ZONE = 18" OWS
FACE VELOCITY = 59 FPM
SF6 RELEASE RATE = 8.0 LPM
DYNAMIC SASH MOVEMENT EFFECT TEST
AVERAGE SF6 CONCENTRATION = <0.01 PPM
MAXIMUM SF6 CONCENTRATION = <0.01 PPM
ASHRAE RATING = 8.0 SME-AI <0.01
NOTES:


4' AIR SENTRY FUME HOOD - HOOD #1
OREGON STATE UNIVERSITY
WENIGER HALL - ROOM #414
TEST #4: VERTICAL LEFT POSITION
1/18/02
SF6 CONCENTRATION (PPM)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1 13 25 37 49 61 73 85 97 109 121 133 145 157 169 181 193 205 217 229 241 253 265 277 289 301
TIME (SECONDS)
SASH POSITION = VERTICAL OPEN 27.5"
MANNEQUIN/EJECTOR POSITION = LEFT
MANNEQUIN BREATHING ZONE = 18" OWS
FACE VELOCITY = 59 FPM
SF6 RELEASE RATE = 8.0 LPM
STATIC TEST
AVERAGE SF6 CONCENTRATION = <0.01 PPM
MAXIMUM SF6 CONCENTRATION = <0.01 PPM
ASHRAE RATING = 8.0 AI <0.01
NOTES:

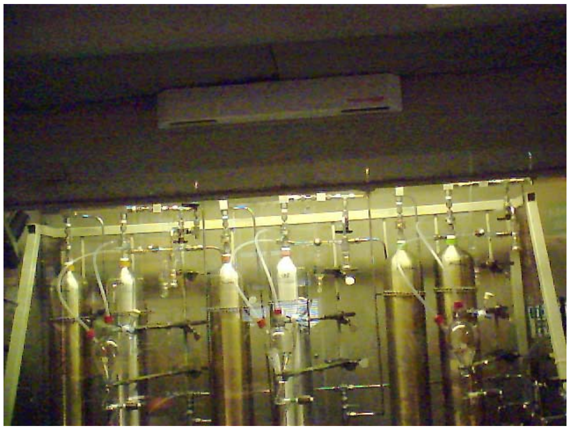

4' AIR SENTRY FUME HOOD - HOOD #1
OREGON STATE UNIVERSITY
WENIGER HALL - ROOM #414
TEST #5: HORIZONTAL LEFT POSITION
1/18/02
SF6 CONCENTRATION (PPM)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1 13 25 37 49 61 73 85 97 109 121 133 145 157 169 181 193 205 217 229 241 253 265 277 289 301
TIME (SECONDS)
SASH POSITION = HORIZONTAL OPEN
MANNEQUIN/EJECTOR POSITION = LEFT
MANNEQUIN BREATHING ZONE = 18" OWS
FACE VELOCITY = 118 FPM
SF6 RELEASE RATE = 8.0 LPM
STATIC TEST
AVERAGE SF6 CONCENTRATION = <0.01 PPM
MAXIMUM SF6 CONCENTRATION = <0.01 PPM
ASHRAE RATING = 8.0 AI <0.01
NOTES:



Tracer gas test being performed on the Air Sentry fume hood

Appendix D: Sample User Questionnaires

Appendix E: Tufts University Fume Hood Pictures





Appendix F: Meeting Notes with Elliot Miller and Betsy Isenstein

Summary of notes

Energy

Tufts contracts its energy use from 4 companies in 3 areas, electricity, gas and oil. The energy department is required to report the amount of gas and oil that are consumed by Tufts. Electricity is monitored, but is not reportable to any agency. The department also oversees the utility budget, contracting from energy companies and when spare time permits, attempts certain projects aimed at improving energy use.

New Construction

The process of building a new laboratory is not uniform from project to project. Each school on the Tufts campus has certain budgets, and funding for a new project can come from several areas, changing the administrative hierarchy from project to project. However, any large project will fall under the Trustees approval. Renovations can also receive money from deferred maintenance funds and will therefore involve facilities.

Pushing for a green design is not a general Tufts policy. There is no dedicated group that researches various technologies for efficient design. Promoting energy efficient measures for a new or renovated laboratory will often fall on the energy and facilities departments, and they do not have the manpower or time to research, evaluate and fight for green design. At the present state, energy efficient design is the result of cost to the university, and not directly related to any conservation mindset. An example would be the implementation of Phoenix controls as a way to reduce energy costs in operation of fume hoods, and not as a direct way to curb laboratory consumption. They work better when also equipped with an occupancy sensor, but even then the first cost causes hesitation, and the added cost of a sensor is a difficult hurdle. Although there have been case studies where the savings of these systems outweighed initial cost, there are no such calculations for the Tufts campus.

[In addition, utility companies often have government grant money to give out as a ‘prize’ for choosing energy efficient components when installing new equipment. This refund is often well worth the initial investment, as in the long term it provides significant savings.]

Typically, the energy and facilities departments will only become aware of a new project when it is well in the design process, if at all. The opportunity to implement energy efficient methods in the design is therefore somewhat limited. In addition, when they push for certain measures in the design of a laboratory, it limits the ability to effectively evaluate other areas of interest. For example, the push to obtain Phoenix controls for the Pearson laboratory when it was renovated drew attention away from other matters such as chillers and heating coils that also have significant impacts on energy usage. It would be more effective to have these departments work with the architects and administrators in the early stages of design, but there is no central process that mandates this, nor would it always be effective, since large projects can sometimes take up to 10 years before they get underway. However, in general there is a lack of communication between various groups that should have a hand in reviewing the design of a laboratory.

Some things to consider that may be of benefit:

LEED certification: LEED certification for laboratories is difficult to define due to the intrinsic differences between laboratory uses. However, it can be a good promotional tool to encourage steps towards energy efficiency, as it was shown to do for the Capen street faculty apartments.

Fume hood inventory: An extensive survey of the number of fume hoods, the type of fume hood, the physical measurements of each fume hood and sash height at time of survey could serve as a useful tool. Rough energy use figures could be calculated, and used as a method to promote energy saving features such as Phoenix controls

Health and Safety regulations: Tufts follows industry standards for the design of its laboratories. However, the Harvard School of Public Health has designed a few laboratories that do not meet these regulations. They relied on studies that indicated a sufficient level of safety was reached with other parameters, and as a result were able to implement low flow fume hoods with a lower first cost than Phoenix controls (and similar systems) yet realize the same energy savings over time. Looking into studies on relaxing AINSI standards in the design of certain laboratories could be effective

Proper User Training and monitoring: With Phoenix controls, the hoods must be closed to obtain any benefit from the system. Users may be unaware or impartial to this fact and as a result many fume hoods are left open. Proper user training on the function of fume hoods as well as periodic checks can help create energy savings.

Technological Awareness: It is also important to know what new things are out, how well they function, and where they can be implemented.

<u>Appendix G: Notes From Meeting with EH&S</u>

Nick and Peter: EH&S

What minimum environmental regulations are there on the use of fume hoods in laboratories?
ANSI standards for laboratory safety are followed- industry standard.

What processes does EHS control in the design of new laboratories?
Responsible for overseeing that safety standards are met. Not responsible for overseeing 'operation' of any of the labs (~400 labs on the 3 campuses)

How does Tufts University EH&S department oversee regulations?
Fume hoods are tested once a year by an independent contractor for safety regulations/proper operation. Any 'down' hood is reported to EH&S. Typically less than 10 fume hoods go down a year. In addition, when a fume hood is reported inoperational by a department, facilities is called and EH&S is notified. The contractor will test repaired hood. EH&S relies on line supervisors or 'principles' or users to report a broken hood.

Are additional or more stringent regulations imposed by EHS than is required by law?
No

Phoenix Controls are used to preserve energy consumption. What is the current status of these controls in terms of policy for new hoods, reports of controls being overridden, etc?
All new fume hoods are equipped with Phoenix Controls. The newest ones CANNOT be manually overridden. Some of the older equipment is not compatible with Phoenix Controls.

What kind of proper lab use training is given to users and who is in charge of this?
Lab training is done by lab supervisors although EH&S is available as a resource. Lab handbook is typically the usual way to transfer proper usage of fume hoods, etc. to users.

Appendix H: Labs21: EPC Background notes

Labs 21 EPC Introduction

Laboratories present a unique challenge for sustainable design and energy efficiency with their complex systems, health and safety requirements, flexibility and adaptability needs, and energy intensity. A typical laboratory is five times more energy intensive than a typical office building, and costs three times as much per unit area.

The Labs 21 Environmental Performance Criteria (EPC) is a rating system for laboratory projects to asses their environmental performance; similar in nature to the US Green Building Council's LEED system. In fact, it is based on LEED version 2.0, with modifications and enhancements to account for the complexity of laboratory buildings.

LEED and EPC

The US Green Building Council's LEED rating system is the standard in recognition of sustainable design. Its purpose is to:

- define "green building" by establishing a common standard of measurement
- promote integrated, whole-building design practices
- recognize environmental leadership in the building industry
- stimulate green competition
- raise consumer awareness of green building benefits
- transform the building market

Completely voluntarily based, LEED recognizes and supports achievements in green building through a comprehensive certification process, professional accreditation, training and practical resources.

LEED is currently the primary tool used in the evaluation of laboratory buildings, but lacks essential attributes in many areas due to the inherent and unique environmental challenges of laboratory facilities. In order to promote effective sustainable design for these facilities, Labs21 has created EPC. Through working groups consisting of engineers, architects, health and safety personnel, consulting experts, and facilities personnel, Labs21 constructed EPC in the spirit of the LEED system. It leverages LEED 2.0 towards laboratory facilities by making appropriate modifications and additions to the requirements for project certification. The end of this document contains references to the EPC changes and modifications of LEED 2.0.

Labs21 EPC is completely voluntary based, but unlike LEED does not provide a certification process or offer professional accreditation. Its effectiveness is therefore very limited. Without official recognition, the use of EPC can be assumed to appeal only to a very small group of dedicated and concerned developers or institutions with the available resources to apply towards meeting the EPC credits. Fortunately, the USGBC is in the process of developing an Application Guide for Laboratories. This would be used when trying to get a laboratory building certified with the LEED-NC (New Construction) program. At the moment, new members are currently being elected to the USGBC Labs committee.

Laboratories and Tufts University

LEED certification essentially only provides 'bragging rights' and possibly some limited utility rebates. Its utilization has become widespread and well known despite the added financial burden it imposes and the lack of any significant tangible reward. LEED certification is at its core only a form of recognition for conscientious design and development. Unfortunately, Tufts University does not implement LEED or EPC in the construction or renovation of its laboratory facilities. The absence of applicable performance criteria can (and does) result in poorly performing systems at Tufts. With widespread educational and research needs, the economic and environmental benefit of superior laboratory facilities is significant.

The most significant recommendation for the future would be to make performance criteria an integral part of the requirements for new development. Not only would it embody a spirit of environmental responsibility customary from an institute of higher education, but could also provide long term financial benefits in the form of reduced energy consumption. It is becoming more evident with each new study that the additional expenditure associated with implementing green design can be offset and even profitable in the form of lower upfront construction costs and life cycle energy savings.