

STATE OF CALIFORNIA  
DEPARTMENT OF INDUSTRIAL RELATIONS  
OCCUPATIONAL SAFETY AND HEALTH STANDARDS BOARD  
2520 Venture Oaks Way, Suite 350  
Sacramento, California 95833  
(916) 274-5721

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In the Matter of an Application for a )  
Permanent Variance by: )  
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University of California, Irvine, )  
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Applicant. )  
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OSHSB FILE No. 11-V-030

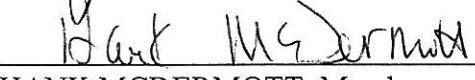
DECISION

The Occupational Safety and Health Standards Board hereby adopts the attached PROPOSED DECISION by David Beales, Hearing Officer.

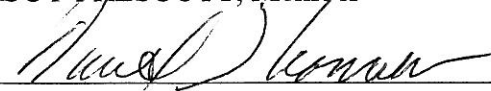
  
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JOHN D. MACLEOD, Chairman

  
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WILLIAM JACKSON, Member

  
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JOHN KASTORFF, Member

  
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HANK MCDERMOTT, Member

  
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GUY PRESCOTT, Member

  
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DAVID THOMAS, Member

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WILLIE WASHINGTON, Member

OCCUPATIONAL SAFETY AND HEALTH  
STANDARDS BOARD

Date of Adoption: March 15, 2012

THE FOREGOING VARIANCE DECISION WAS ADOPTED ON THE DATE INDICATED ABOVE. IF YOU ARE DISSATISFIED WITH THE DECISION, A PETITION FOR REHEARING MAY BE FILED BY ANY PARTY WITH THE STANDARDS BOARD WITHIN TWENTY (20) DAYS AFTER SERVICE OF THE DECISION. YOUR PETITION FOR REHEARING MUST FULLY COMPLY WITH THE REQUIREMENTS OF CALIFORNIA CODE OF REGULATIONS, TITLE 8, SECTIONS 427, 427.1 AND 427.2.

Note: A copy of this Decision must be posted for the Applicant's employees to read, or a copy thereof provided to the employees' Authorized Representative(s).

BEFORE THE OCCUPATIONAL SAFETY AND HEALTH STANDARDS BOARD  
DEPARTMENT OF INDUSTRIAL RELATIONS  
STATE OF CALIFORNIA

	)	OSHSB File No. 11-V-030
In the Matter of an Application for a	)	
Permanent Variance by:	)	<u>PROPOSED DECISION</u>
	)	
University of California, Irvine,	)	
Applicant.	)	
	)	

A. Procedural Matters

1. The University of California, Irvine (Applicant) applied for a permanent variance from provisions of Title 8 of the California Code of Regulations.
  2. This proceeding is conducted in accordance with Labor Code Section 143.
  3. The hearing in this matter was held on January 9, 2012 at Sacramento, California, before an Occupational Safety and Health Standards Board (Board) hearing panel consisting of Board Chair John MacLeod and Board Member Hank McDermott. David Beales was the hearing officer.
  4. At the hearing, Lisa Mahar, Erike Young and Marc Gomez (all Applicant personnel) and Tom Smith of Exposure Control Technologies represented the Applicant; Joan Lichterman and Lucy Joseph represented UPTC-CWA 9119\* ; Darius Sivin and Steve Yokich represented UAW Locals 2865 and 5810; Mike Horowitz and Steve Smith represented the Division of Occupational Safety and Health (Division), and Hans Boersma represented the Board staff. No appearance was made by AFSCME Local 3299. The employee organizations referred to in this Item A.4 all requested and were granted standing to participate in this proceeding.
  5. Oral and documentary evidence was received at the hearing. Official notice was taken of the Board's files, records, recordings and decisions in the following variance matters: OSHSB Files No. 01-V-013, 02-V-010, 04-V-042 and 09-V-141. This matter was submitted for decision at 12:30 p.m. on January 25, 2012 (at the close of the proceeding on January 9, 2012, the record was held open for the receipt of additional documentary evidence).
- B. Safety Order at Issue: California Code of Regulations, Title 8, Section 5154.1(c)(1), regarding the laboratory fume hood ventilation rates.

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\* Per California Code of Regulations, Title 8, Section 426.1(c), a clerical error has been corrected in this Item A.4 (the number "9119" has replaced the number "9199").

C. Findings of Fact

Based on the record of this proceeding, the Board makes the following findings of fact:

1. The Applicant proposes to install an unspecified number of low flow laboratory fume hoods that will be used in connection with a variety of substances at the following University of California, Irvine School of Engineering buildings: the Engineering Tower, the Engineering Gateway and the Engineering Hall.
2. California Code of Regulations, Title 8, Section 5154.1(c)(1) requires in part that laboratory fume hoods “provide an average face velocity of at least 100 feet per minute [fpm] with a minimum of 70 fpm at any point, except where more stringent special requirements are prescribed in other sections of the General Industry Safety Orders, such as Section 5209.” The Applicant proposes to use specific types of hoods and to operate these hoods with an average face velocity of at least 70 fpm at a sash height of 18 inches or less, with a minimum of 56 fpm at any given point.
3. Fume hoods are protective enclosures in which work involving potentially harmful substances may be performed. The person conducting the work is outside the hood; the potentially hazardous substance is under the hood. The average face velocity is, in essence, the rate at which air containing possibly harmful substances is withdrawn from the fume hood. The safety order at issue appears to assume that the higher the average face velocity, the greater the protection afforded, because greater force is being used to evacuate harmful substances from the fume hood. In fact, the performance of laboratory fume hoods is subject to a virtually incalculable number of variables. The actual flow of air under the hood, and thus, the hood’s ability to promote health and safety by retaining and evacuating hazardous substances, may be effected by such factors as cross drafts, the configuration of equipment inside the hood, the size and position of the person (if any) working at the hood and the hood’s design features—to name a few. A hood with a particular design operating at an 80 fpm average face velocity might well operate more effectively as a hood with another design operating at 100 fpm.
4. The sash is an adjustable barrier at the front of the hood that is intended to protect the person working at the hood by limiting the size of the opening where harmful substances could escape; the lower the sash, the smaller the open face area of the hood and thus the greater the protection afforded.
5. One of the two types of low flow fume hoods that the Applicant proposes to use is the Kewaunee Supreme Air LV six foot hood. This hood has a vertical sash with a sash stop set at 18 inches or less above the work surface. This device is to be used with a Phoenix Model 430 Hood Monitor (or equivalent) that includes a visual and an audible flow alarm for use with variable air volume ventilation systems and an Air Alert 600 (or equivalent) visual and audible flow alarm for use with constant air volume ventilation systems. This Kewaunee

hood claims to have such design features as the following that enhance its ability to function effectively:

- a. A patent-pending self-closing sash to 18 inches for less exhaust volume and maximum protection;
  - b. A patented Dynamic Barrier bypass that provides safe flow of clean air between experiment and user;
  - c. Interstitial, vertical slot baffles that promote turbulence-free air flow and minimal upper vortex roll;
  - d. A spoiler-shaped sash handle that directs air away from the user.
6. The other type of low flow hood that the Applicant proposes to use is the LabConco Protector XStream six foot hood. This hood also has a vertical sash with a sash stop set at 18 inches or less above the work surface and is to be used with a Phoenix Model 430 Hood Monitor (or equivalent) that includes a visual and an audible flow alarm for use with variable air volume ventilation systems. Instead of the Air Alert 600, however, this type of hood is to be used with a LabConco Guardian 1000 (or equivalent) visual and audible flow alarm for use with constant air volume ventilation systems. This LabConco hood claims to have such design features as the following that enhance its ability to function effectively:
- a. A containment-enhancing sash handle;
  - b. A rear downflow dual baffle system that directs horizontal streams of airflow to the rear slots of the primary baffle in a single pass, while the secondary baffle counteracts the upward air streams that create roll in traditional hoods;
  - c. A type of air foil that has a unique curve that allows air to sweep the work surface for maximum containment;
  - d. Upper dilution air supply that provides bypass air from above the work area that constantly bathes the sash interior with clean air and reduces chemical fumes along the sash plane, near the critical breathing area.
7. According to the Applicant's proposal, the minimum air flow alarm set point for these devices is to be 60 fpm.
8. Portions of the Board staff evaluation filed in this matter are attached hereto as Exhibit 1. That exhibit is incorporated herein by this reference, and the contents of that Exhibit 1 constitute findings of fact by the Board. The term "lpm" used in that Exhibit 1 and elsewhere in this Proposed Decision means liters per minute, and the term "lfm" used in that Exhibit 1 and elsewhere in this Proposed Decision means linear feet per minute.

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9. According to the Applicant, the low flow fume hoods it proposes to use are designed to operate safely and effectively at an average face velocity of 60 fpm, and the proposed average face velocity of 70 fpm is intended to provide a cushion of safety.
10. A bar graph presented by the Applicant summarizing its extensive test data indicates that, in terms of average tracer gas concentrations, with an 18 inch sash, the proposed low flow hoods operating with an average face velocity of 80 fpm performed in a manner equivalent to their performance at 100 fpm, but with an average face velocity of 60 fpm, the concentrations of tracer gas for the LabConco device, and possibly for the Kewaunee device, were higher than they were at 100 fpm. The graph does not contain information regarding the proposed 70 fpm average face velocity. This graph was presented twice by the Applicant: once in the initial application and again in Exhibit F, a document submitted by the Applicant at the hearing. Data found in Table 6 on page 21 of Attachment 8A to the application filed in this matter are consistent with the depiction presented in the bar graph.
11. The data referred to in Item C. 10 pertain to a low flow fume hood study conducted at the Applicant's Engineering Tower building. The study was initiated in June, 2008, and the written report of the study's results is dated April, 2009. In addition to studying the performance of Kewaunee and LabConco devices, the study tested two other types of low flow fume hoods and one traditional fume hood. The Applicant originally proposed to use all four types of low flow hoods, but later limited its proposal to the Kewaunee and LabConco devices—the devices that had the best overall test results.
12. The variances granted in OSHSB File Nos. 01-V-013 and 04-V-042 each require an average face velocity of at least 80 fpm. The variance granted in OSHSB File No. 01-V-013 requires full ANSI/ASHRAE 110-1995 testing at least annually, while the variance granted in OSHSB File No. 04-V-042 requires such testing annually for the first three years and triennially thereafter.
13. UAW and UPTE-CWA favor granting the variance subject to many conditions. Those conditions include the development of an industrial hygiene sampling plan, personal exposure monitoring, training, testing and more. Some of their conditions pertain to hoods not proposed to be covered by the variance. As to the low flow hoods to which the variance would pertain, UAW and UPTE-CWA urge that the minimum average face velocity be 80 fpm for reasons that mirror the statements made in Item C.10 of this Proposed Decision. They also urge that no variance be granted from the Section 5154.1(c)(1) requirement of a minimum of 70 fpm at any point.
14. The general practice regarding the alarm set point appears to be to make that point 80% of the average face velocity. If the average face velocity is 80 fpm, that set point would be 64 fpm (this "80%" method was urged by the UAW and UPTE-CWA and was utilized in OSHSB File No. 01-V-013).

15. The Division opposes granting this variance, based mainly on many alleged shortcomings that the Division finds with the Applicant's test data and methodology.
16. The Division granted the Applicant an experimental variance for the purpose of testing the Kewaunee and LabConco devices from September 28, 2009 through January 28, 2010 at average face velocity "rates at both 80 fpm and 70 fpm (plus or minus 5 fpm) while chemical research experiments are conducted inside the hoods." The Division's evaluation in this matter mentions this experimental variance but does not discuss it, thereby providing no information as whether the experiment disclosed data that would augur for or against granting this variance.
17. The Board staff urges that the variance be granted, subject to conditions stated in the Board staff's evaluation.
18. Safety is enhanced by the conditions set forth in the Decision and Order.

D. Reasons for the Decision

The procedural matters, legal authority and findings of fact stated above lead to the following conclusions:

1. The Applicant has complied with the statutory and regulatory requirements that must be met before an application for a permanent variance may be granted.
2. A preponderance of the evidence establishes that the Applicant's proposal, combined with the conditions set forth in the Decision and Order, will provide employment and a place of employment that are as safe and healthful as those that would prevail if the Applicant complied with the safety orders at issue. The conditions set forth in the Decision and Order are based in large part on the Board staff's recommendations.
3. The variance granted and the conditions imposed have been drafted with these considerations in mind:
  - a. As provided in Labor Code Section 143, this variance must be granted if the Applicant establishes that its proposal results in a level of safety and health at least equivalent to the level of safety and health that would be achieved if the Applicant complied with the safety order at issue.
  - b. The safety order at issue, Section 5154.1(c)(1), does not require the use of any particular laboratory fume hood, nor does it require that the fume hood used meet any particular safety or health criterion. Instead, it merely requires that whatever fume hood is chosen operate at a minimum average face velocity of 100 fpm.

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- c. If the Applicant shows that a particular device performs as effectively at a lower average face velocity as it does at 100 fpm, the Applicant has established a factual basis for a variance from the portion of Section 5154.1(c)(1) at issue.
- d. The test data in the present matter establish that the devices the Applicant proposes to use operate as effectively at an average face velocity of 80 fpm as they do at 100 fpm. The data do not establish that the devices operate as effectively at 60 fpm as they do at 100 fpm, and there is no data sufficient to establish that the devices operate as effectively at 70 fpm as they do at 100 fpm. Thus, the Applicant has established the requisite factual basis for a variance to operate these Kewaunee and LabConco hoods at 80 fpm, but not at a lower rate.
- e. The Division's criticisms of the Applicant's tests are not persuasive. With so many variables to consider, any test will be arbitrary to some extent, but a reasonable test may be based on reasonable assumptions, and the totality of the record establishes that the Applicant's tests were conducted in a reasonable manner. The use of a mannequin to represent a person working at the hood is an example of a test condition established in order to mirror conditions that are likely to exist when the hood is in use. If the Division's reasoning were followed, the 100 fpm standard, an imperfect indicator of safety or health, would be applied invariably, because no test would ever be perfect enough to warrant varying from that standard.
- f. Nonetheless, the Division forcefully makes an important point that contributes to the resolution of this matter. The Division demonstrated in great detail many flaws or potential flaws in the Applicant's tests. Since any test procedure of this sort must necessarily limit the number of variables considered and must be based on assumptions that are unlikely to mirror real-world conditions with complete accuracy, the real value of the test data is the overall direction in which it points rather than its numeric detail. Excessive deference to the numeric test results actually could be misleading in a quest for real-world safety and health. Thus, the bar graph referred to in Item C.10 of this Proposed Decision provides better guidance than the mountain of data submitted by Applicant, and the bar graph should be read conservatively, which leads to the Board's conclusion that 80 fpm, and not 70 fpm, is the appropriate average face velocity that this variance should permit.
- g. The continued testing required by the conditions set forth in the Decision and Order is a prudent means of ensuring that the devices used in accordance with the variance will continue to operate, and thus promote safety and health, in the manner intended. The Board believes that requiring full ANSI/ASHRAE 110 testing based on the model provided by the OSHSB File No. 04-V-042 variance (annually for the first three years and triennially thereafter) better safeguards safety and health than the regimen proposed by the Applicant and endorsed by the Board staff (initially and when certain triggering events occur, but never as part of the regular annual testing).

- h. The portion of Section 5141.1(c)(1) that requires “a minimum of 70 fpm at any point” may be viewed as an absolute limitation, but it also may be viewed as an allowable percentage downward deviation from the average face velocity. Thus, “70 fpm at any point” is another way of saying that, at any point, a downward deviation of 30% from the 100 fpm average is permitted. In asking for a 56 fpm “any point” minimum in conjunction with a 70 fpm average, the Applicant is asking for a maximum 20% downward deviation. Using simple arithmetic interpolation between a 30% allowable deviation at 100 fpm and a 20 % allowable deviation at 70 fpm, the allowable downward deviation from a 90 fpm average would be 26.67%, and the allowable downward deviation from an 80 fpm average would be 23.33%. Rounded to the nearest whole number, 23.33% of 80 fpm is 19 fpm, which leads to an “any point” minimum of 61 fpm. Sixty one fpm is within the parameters of the testing done by the Applicant, and in light of the test results, the Board believes that single point readings of 61 fpm tied to an 80 fpm average would afford a level of safety and health equivalent to the level afforded by compliance with the safety order at issue.
- i. The conditions urged by UAW and UPTE-CWA regarding training of Union members to conduct tests, personal exposure monitoring, an industrial hygiene sampling plan, the availability of test equipment to any employee who asks for it and requirements for hoods not covered by this variance are more appropriate as topics for interaction between the Unions and the Applicant than as variance conditions. If the Applicant operated the proposed devices at an average face velocity of 100 fpm, there would be no requirements for such things, and the test data indicate that, at 80 fpm, the devices operate in essentially the same fashion as they do at 100 fpm. Other conditions urged by the UAW and UPTE-CWA are reflected in the conditions imposed in the Decision and Order.
- j. The Applicant should note that variances may be modified. For instance, if the Applicant comes to have test data regarding the operation of the Kewaunee and/or LabConco devices at a 70 fpm average and at a 56 fpm “any point” minimum, and those data show persuasively that the devices perform on a par with their performance at a 100 fpm average and a 70 fpm “any point” minimum, the Applicant might consider filing an application to modify this variance to allow operation at the 70 fpm average and 56 fpm “any point” minimum.
- k. An argument could be made for the proposition that the Kewaunee and LabConco devices should be subject to different requirements, since they performed differently in the Applicant’s tests. In presenting its case, however, the Applicant sought to have the same requirements applied to both and presented its case accordingly. If the Applicant chooses to seek less stringent requirements for the possibly better-performing Kewaunee device, that matter also could be the subject of a variance modification application.



E. Decision and Order

The application that is the subject of this proceeding is GRANTED to the extent that, upon the Board's adoption of this Proposed Decision, the University of California, Irvine shall have a permanent variance from California Code of Regulations, Title 8, Section 5154.1(c)(1) (only to the extent Section 5154.1(c)(1) states that laboratory fume hoods' exhaust systems "shall provide an average face velocity of at least 100 feet per minute with a minimum of 70 fpm at any point"), with respect to laboratory fume hoods located at the following University of California, Irvine School of Engineering buildings: the Engineering Tower, the Engineering Gateway, and the Engineering Hall. The variance is subject to the following conditions:

1. The hoods covered by this variance shall operate with an average face velocity of at least 80 fpm with a minimum of 61 fpm at any point and with a maximum sash height of 18 inches. Nothing in this variance authorizes the Applicant to diverge from the requirements of any Title 8 safety order or any other provision of the law that impacts the Applicant's operations, other than the portion of Section 5154.1(c)(1) that requires that laboratory hoods "provide an average face velocity of at least 100 feet per minute with a minimum of 70 fpm at any point."
2. The hoods operated under this variance shall be either:
  - a. Kewaunee Supreme Air LV six foot hoods (used with a Phoenix Model 430 Hood Monitor (or equivalent) that includes a visual and an audible flow alarm for use with variable air volume ventilation systems and an Air Alert 600 (or equivalent) visual and audible flow alarm for use with constant air volume ventilation systems), or
  - b. LabConco Protector XStream six foot hoods (used with a Phoenix Model 430 Hood Monitor (or equivalent) that includes a visual and an audible flow alarm for use with variable air volume ventilation systems; instead of the Air Alert 600, however, this type of hood is to be used with a LabConco Guardian 1000 (or equivalent) visual and audible flow alarm for use with constant air volume ventilation systems).
3. The hoods shall be tested pursuant to ANSI/ASHRAE 110-1995 test methods with the following requirements:
  - a. The testing shall be conducted at the average face velocity of 80 fpm.
  - b. The sash height shall be 18 inches.
  - c. The Applicant shall use a mannequin during tracer gas testing.
  - d. The tracer gas source rate shall be at 4 lpm when using Sulfur Hexafluoride.

4. The hoods shall meet the following criteria:
  - a. Face Velocity Testing; an average face velocity of at least 80 fpm with a minimum of 61 fpm at any point.
  - b. Smoke Visualization Testing; no visible smoke shall escape from the hood.
  - c. Tracer Gas Testing; the hoods shall achieve a performance rating of 4-AI-0.05 ppm or better, and the maximum 30 second rolling average of 0.1 ppm or less, during any 5 minute tracer gas test (Peak Tracer Gas Value).
5. The fume hood testing frequency shall be as follows:
  - a. Face velocity and smoke visualization testing shall be performed annually (except when supplanted by full ANSI/ASHRAE 110 testing in accordance with Condition No. 4.b.v.).
  - b. Full ANSI/ASHRAE 110 testing, including face velocity tests, smoke visualization tests, and tracer gas tests, shall be performed as follows;
    - i. When the hood is first installed, prior to use.
    - ii. When changes have been made to the hood that may impact the hood's performance.
    - iii. After the hood has been taken out of service per Condition No. 6.
    - iv. When changes have been made to the laboratory, its building, and/or the mechanical systems that may impact the hood's performance.
    - v. At least once a year for the first three years, in lieu of the annual test required by Condition No. 5.a., and thereafter, at least once every three years, in lieu of the annual test required by Condition No. 5.a.
6. When a hood fails the required annual testing, even after repair or adjustments, the hood shall be taken out of service. The hood shall not be returned to service until necessary corrections are made, and the hood successfully meets the full ANSI/ASHRAE 110 testing requirements per Conditions No. 3 and 4.
7. The hoods shall be equipped with a continuous air flow monitoring system that shall at a minimum provide a visual and audible cue to the hood operator. The monitoring system (alarm) shall be set to activate when the air flow drops below 64 fpm at the hood opening.

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8. The monitoring system shall be calibrated and the alarm tested during the commissioning process and checked annually. The results of this calibration, testing and checking shall be supplied to the Division if and when the Division requests this information.
9. Should an alarm condition occur, Applicant shall investigate the alarm and its cause, and document the occurrence, the reason the alarm sounded, and any action taken to resolve the cause of the alarm.
10. Records shall be kept of the tracer gas tests, smoke visualizations, and face velocity verifications performed and of any alarm conditions from the hoods covered by this variance, and those records shall be maintained for five years.
11. Each hood covered by this variance shall have a legible and durable label indicating the date of the most current testing and the date the next test is due.
12. The laboratory workers shall be trained in hood operation and in the ventilation systems. The training shall include, but not be limited to, instructions regarding:
  - a. The hood's monitoring and alarm system,
  - b. Causes for the alarm system to sound,
  - c. Actions to be taken during alarm conditions.
13. Nothing in this variance precludes the Applicant from utilizing the variance granted OSHSB File No. 09-V-141 regarding the tracer gas that may be used when the Applicant performs ANSI/ASHRAE testing. In the event that the Applicant uses the alternative tracer gas (nitrous oxide) permitted by the variance granted OSHSB File No. 09-V-141, the tracer gas source rate per Condition No. 3 of the present variance shall be 5.5 lpm.
14. The Applicant shall notify its employees or their authorized representative(s), or both, of this order in the same way that it notified them of the application for permanent variance.
15. This Decision and Order shall remain in effect unless modified or revoked upon application by the Applicant, affected employees(s), the Division of Occupational Safety and Health, or by the Board on its own motion, in the manner prescribed for its issuance.

I hereby certify that the above Proposed Decision is the decision of the Hearing Panel, and the Hearing Panel recommends its adoption by the Occupational Safety and Health Standards Board as the Board's decision in this proceeding. In light of the correction of Item A.4, this version of the Proposed Decision supersedes any prior version.

DATED: March 12, 2012


  
David Beales, Hearing Officer

Exhibit 1

FUME HOOD PERFORMANCE TEST METHODS

Face Velocity Test Method

The face velocity test method uses an anemometer to read air velocity in a grid pattern or sections across the hood face. The grid pattern is formed by dividing the hood face opening into a number of equally sized sections. The velocity readings are then taken with the anemometer at the center of each section and are then averaged to establish the mean or average face velocity of the hood....

Air Flow Visualization Method

Air flow visualization requires the generation of smoke streams at designated points within a fume hood. It provides a visual understanding of the air flow currents that exist within the hood. This test will show loss of containment as smoke escapes into the laboratory from the fume hood....

Tracer Gas Methods

The tracer gas testing involves releasing a large volume of tracer gas delivered at prescribed locations within the fume hood and the monitoring of the air outside the fume hood for the presence of escaped tracer gas. The tracer gas air monitoring process uses monitoring equipment affixed at the breathing zone of a mannequin positioned in front of the hood that measures tracer gas in parts per million (ppm)....

The ASHRAE 110 Test Methods

The ASHRAE 110 test is a three part test that includes measurements of face velocity, air-flow visualization, and tracer gas containment testing discussed above and indicates the level of containment in terms of the amount of escaped tracer gas in the breathing zone of the mannequin. Board staff notes that the application and scope of the ASHRAE 110 test methods do accommodate the evaluation of fume hood performance by comparing its performance during the different operational variables described above.

Board staff feels that the ASHRAE 110 test methods go beyond face velocity and air flow visualization measurements by testing the fume hood's ability to contain tracer gas under the prescribed conditions. The ASHRAE 110 testing offers a method of directly measuring a fume hood's ability to contain the tracer as generated inside the fume hood. The ASHRAE test method enables employers to quantify and compare fume hood performance as well as evaluate the relative safety that the hood provides. The test method can also show inherent flaws in fume hoods, HVAC systems, and the laboratory designs that the face velocity test methods do not.

The Applicant's study clearly showed the usefulness of the ASHRAE test method for comparing the relative performance of different hoods under specific conditions and to determine the effect of operating conditions on a hood's ability to contain tracer gas. For example, the "as installed" tracer gas test helps to better evaluate whether such challenges as cross drafts at the face of a hood could cause contaminants to escape from the hood. Board staff notes that the ASHRAE test is not conducted under real life operating conditions with an operator using the hood during actual chemical processes and does not account for all of the variables that can affect a hood's performance during actual real world operations. The ANSI/ASHRAE 110-1995 states, "the performance test does not give a direct correlation between testing with a tracer gas and actual operator exposure of fumes during actual use of the hood, however it does give a relative and quantitative measure of the efficiency of the hood containment under a set of specific, although arbitrary conditions."

#### Variance from Section 5154.1 Face Velocity Requirements

Board staff opines that in order for the Applicant's variance request to be found to provide equivalent or superior safety to the standards from which the variance is sought, the Applicant's fume hoods must be in compliance with an alternative test procedure that is an equal or better measure of fume hood performance than the current face velocity requirements in terms of the ability to contain airborne contaminants.

Since the promulgation of these face velocity requirements in Section 5154.1(c) numerous studies<sup>1,2,3,4,5</sup> have indicated that fume hood performance solely based on face velocity cannot guarantee exposure control from the fumes generated inside the hood. As the result of this information and research efforts during the 1980's, the ANSI/ASHRAE 100 test methods were developed and are now used as an industry standard for evaluating hood performance.

The ANSI/AIHA Z9.5-2003 American National Standard for Laboratory Ventilation (Z9.5) recommends specific acceptance values for fume hood performance including that the ASHRAE 110-1995 be used to insure that fume hoods initially installed (as commissioned) and being used (as installed) in the laboratory, provide containment of tracer gas emitted at a rate of 4

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<sup>1</sup> Kevin T. Fox, Geoffrey Bell, Chemical Fume Hood Safety, Protecting the Health of Laboratory Workers, United States Department of Energy, Lawrence Berkeley National Laboratory

<sup>2</sup> Volin, C.E., Joao, R.V.; Rieman, J.S.; Party E.; Gershey, E.L. "Fume Hood Performance: Face Velocity Variability Inconsistent Air Volume Systems." Applied Occupational and Environmental Hygiene. Vol. 13(9): pp. 656-662, 1998.

<sup>3</sup> Maupins, Karen. Hitchings. Dale T. "Reducing Employee Exposure Potential Using the ANSI/ASHRAE 110 Method of Testing Performance of Laboratory Fume Hoods as a Diagnostic Tool." AIHA Journal: Vol. 59, No. 2., pp. 133-138. Feb 1998.

<sup>4</sup> DiBerdinis, L., First, M., Ivany, R. "Field Results of an In-Place, Quantitative Performance Test for Laboratory Fume Hoods." Applied Occupational and Environmental Hygiene, Vol. 6(3): pp. 227. March 1991.

<sup>5</sup> Woodrow, Lisa Michele. *An Evaluation of Four Quantitative Laboratory Fume Hood Performance Test Methods*. U.S. Govt. Printing Office: 1987-0-573-034/ 80,000, pp. 103. Nov 1987.

liters per minute (lpm), below an average of 0.1 ppm measured for five minutes in the breathing zone of a stationary mannequin. Fume hoods tested during the manufacturing process must meet the more stringent ANSI/ASHRAE "as manufactured" recommended control level rating of 0.05 ppm with a tracer gas emitted at 4 lpm.

#### 100 fpm Face Velocity Equivalency

Board staff notes that during the December 4, 2002 variance hearing to consider a similar variance application OSHSB File # 02-V-010, the hearing panel requested that the Applicant, Board staff and Division staff contact a national consensus body such as the ANSI, and solicit an opinion on what would constitute equivalent safety to the 100 fpm face velocity requirement in Section 5154.1(c). In reply to an opinion request, J. Lindsay Cook, Chair, Accredited Standards Committee, American Industrial Hygiene Association, replied by stating the following:

*"The tracer gas portion of ASHRAE 110 with an "as installed" performance of 4 liters per minute at 0.10 ppm is a superior test of fume hood safety and containment than simply verifying the fume hood as having 100 feet per minute of average face velocity."*

With regard to meaning of the word "capture" in the draft ANSI Z9.5-2002 Standard, in Section 3.3.1 as to whether the fume hood's ability to "capture" fumes would include the ability to "re-entrain" or "recapture" fumes once these have escaped into the laboratory, J. Lindsay Cook replied:

*"The laboratory hood is an enclosing or containment hood and not a capture or exterior hood therefore it is not designed to "capture" any contaminant generated outside the face of the hood."*

In summary, J. Lindsay Cook noted the following:

*"It seems that your specific design of your hood (the Berkeley Hood) may not lend itself well to evaluation solely by face velocity tests. It is for this very reason that Section 3.3 was written from a performance-based aspect. The current document indicates that containment, and not face velocity is the primary performance criteria."*

#### Federal OSHA Fume Hood Standards

Federal OSHA does not have a laboratory hood ventilation standard that specifies a minimum face velocity. The comparable Federal OSHA standard in 29 CFR 910.1450(e)(3)(iii) is performance based and mandates a chemical hygiene plan that requires fume hoods to function properly and that specific measures must be implemented to ensure proper and adequate performance of such equipment.

Additionally, the non-mandatory laboratory standard in 29 CFR1910.1450 Appendix A states in Section (g);

*“General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas; airflow into and within the hood should not be excessively turbulent; hood face velocity should be adequate (typically 60-100 linear feet per minute (lfm)).”*

OSHA specifically discussed the issue of specifying a minimum average face velocity in the Federal Register January 31, 1990 when publishing the current version of 29 CFR Part 1910.

OSHA wrote (page 3318),

*“As in the proposed standard, the final standard does not specify face velocities for fume hoods. OSHA's rationale for this approach was explained in the preamble to the proposed standard (see 51 FR at 26671). In brief, the preamble stated that OSHA recognized that there was considerable debate over what optimum velocities should be in light of differences in hood design and methods requiring specific face velocities was not consistent with the performance orientation of the standard.”*

In response to comments in favor of specifying a minimum average face velocity, OSHA wrote the following:

*“These comments offered little or no substantive information to persuade OSHA to abandon the performance approach which allows the employer to determine the appropriate face velocities on the basis of design, use patterns and other factors which influence the effectiveness and proper functioning of the fume hood.”*

The federal OSHA Carcinogen standard, like its counterpart in Section 5209, requires hoods to have an average face velocity of at least 150 fpm when used for any of the thirteen regulated carcinogens covered by the standard. The Applicant has not requested a variance from Section 5209.

#### The Applicant's Variance Proposal

The following relevant facts were compiled from information submitted with the variance application and provided by the Applicant's representative during the site visit and during subsequent submittals and telephone conversations:

- 1) In June 2008 the Applicant initiated a study to evaluate whether new low flow fume hoods could provide equivalent protection to that provided by traditional fume hoods.
- 2) In the hood evaluation study the Applicant compared the performance of low flow fume hoods from four different manufacturers and one traditional fume hood at different face velocities.

- 3) A temporary variance from the Applicant to perform chemical exposure testing was granted by the Division to enable the Applicant to evaluate hood performance at face velocities below the mandated 100 fpm.
- 4) The Applicant relied on independent third parties, i.e. Exposure Control Technologies, Inc. and Indoor Air Professionals, Inc. to conduct an extensive series of performance tests on the fume hoods.
- 5) The "leakage" of each hood was quantitatively measured using the ANSI Z9.5 recommended ANSI/ASHRAE 110 test method at 100 fpm, 80 fpm and 60 fpm face velocities.
- 6) The ANSI/ASHRAE 110 testing was carried out with the fume hoods' sash fully open and at an 18" height.
- 7) In addition to the standard ANSI/ASHRAE 110 testing, the study included modified ANSI/ASHRAE 110 testing to determine how the selected fume hoods would perform under real life fume hood operating conditions and challenges.
- 8) The modified ANSI/ASHRAE 110 testing incorporated the following elements:
  - a) Dynamic "Human as Mannequin"<sup>6</sup> (HAM) tests, where instead of a static mannequin, a person, simulating routine motions, is used.
  - b) Hoods were loaded with obstructions to simulate the presence of experimental apparatus, and
  - c) Hoods were challenged by external air currents at velocities simulating pedestrian walk-by and cross draft challenges.
- 9) During baseline tracer gas testing with the sash fully open and operated at or above 60 fpm, the Kewaunee Supreme Air LV and LabConco Protector XStream fume hoods, showed an average leakage into the laboratory of less than 0.05 ppm, which is equivalent or better than the more stringent ANSI/ASHRAE "as manufactured" recommended control level rating.
- 10) During the modified tracer gas testing with the sash fully open and operated at or above a face velocity of 60 fpm, the Kewaunee Supreme Air LV and LabConco Protector XStream fume hoods showed control levels similar or better than traditional fume hoods operated at 100 fpm.
- 11) During baseline and modified tracer gas testing with the sash opening reduced to 18 inches the Kewaunee Supreme Air LV and LabConco Protector XStream fume hoods showed leakage into the laboratory at an average of 0.01 ppm or less at 100 fpm, 80 fpm and 60 fpm face velocities.
- 12) During baseline and modified tracer gas testing the Kewaunee Supreme Air LV and LabConco Protector XStream fume hoods when operated at 60 fpm with the sash fully open showed excessive peaks in a few of the tracer gas readings (Peak Tracer Gas Values).
- 13) The Kewaunee Supreme Air LV and LabConco Protector XStream fume hoods will be equipped with an airflow monitor and a low flow alarm to provide the hood user with a warning in the event the hood fails to provide adequate face velocity.
- 14) Once installed and commissioned, using the ASHRAE 110 test methods, the Kewaunee Supreme Air LV and LabConco Protector XStream fume hoods would be incorporated in the

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<sup>6</sup> Dale Hitchings, PE, CIH, Montana State University, Task Order NIST 2001-06, Testing of Prototype Energy Efficient Fume Hoods, Report Date August 31, 2001, Report Number 2001-00SA, page II, Section 1.5.5 Person-as Mannequin Test. "Most experts on laboratory fume hood performance testing agree that the ASHRAE mannequin does not adequately simulate all meaningful aspects of a real person. Convection currents produced by a warm body and movement of the subject cannot be modeled using the room-temperature static mannequin."



Applicant's fume hood inspection program that includes annual face velocity and smoke visualization testing, and full ANSI/ASHRAE 110 testing when the hoods are recommissioned or when significant changes have occurred in the fume hoods or its performance.

15) The laboratory in which the tests were performed is equipped with a constant air volume HVAC system. The majority of the laboratories subject to this variance would be equipped with variable air volume HVAC systems that automatically provides for proper make-up and return air and therefore a superior environment to operate the subject fume hoods.

16) Employees and students required to use fume hoods undergo specific training to ensure the employee or student is familiar with proper and safe operation of the hood.

17) The Applicant has installed the Kewaunee Supreme Air LV and LabConco Protector XStream fume hoods used in the study, in the School of Engineering Buildings currently operate at a face velocity of 100 fpm, however these hoods would be operated under this variance if granted by the Board.

18) The Applicant has no immediate plans to add new fume hoods at the campus. However, when new fume hoods are needed the Applicant seeks the option of installing the high performance/low flow Kewaunee Supreme Air LV and LabConco Protector XStream fume hoods at a face velocity of 70 fpm and at an alarm set point of 60 fpm.

19) The recommendation made at the conclusion of the hood evaluation study report was that the Kewaunee Supreme Air LV and LabConco Protector XStream fume hoods be operated at a face velocity of 80 fpm when the sash is fully open and at a face velocity of 60 fpm when the sash height is 18 inches.

#### Peak Tracer Gas Values

Board staff notes that the UCI Study results indicate the subject fume hoods operated at the 18" sash height do meet the more protective "as manufactured" control level requirements of 0.05 ppm (of escaped tracer gas) at a tracer gas release rate of 4 lpm (4-AM-0.05). However, both the baseline ASHRAE 110 testing method and the dynamic ASHRAE testing recorded significant peak leakage values when the subject hoods were operated at 60 fpm with the sash fully open. The UCI study showed that hoods with excessive high peak values when subjected to the standard ASHRAE 110 test also showed a significant number of readings that failed to meet "as installed" control level of 0.1 ppm at a tracer gas release rate of 4 lpm (4-AI-0.1) during the modified dynamic ASHRAE 110 test. Therefore, Board staff feels that excessive peak tracer gas values produced during the standard or baseline ASHRAE 110 testing are a good indication that the fume hood would not effectively contain fumes, gasses and vapors at the tested face velocity. Board staff notes that although the ASHRAE 110 test method and the ANSI/AIHAZ9.5 do not provide recommendations for maximum allowable peak values, it is generally recommended that the employer determine the acceptable peak value. Board staff opines that for the purpose of this variance, it is important to include a requirement for a maximum allowable peak value since the UCI study showed that excessive high peak values attained during the standard ASHRAE 110 test of a hood would clearly predict failure of the hood in excess of the "as installed" or "as used" maximum control level of 0.10 ppm during the dynamic ASHRAE 110 test.

### Sash Height Limits During Fume Hood Operations

The Applicant proposes to operate the subject fume hoods with a sash height of 18." The UCI Study's baseline ASHRAE 110 test results demonstrate that the hood meets the "as manufactured" 4-AM- 0.05 ppm performance rating by producing control levels of 0.02 ppm or less, when the hood was operated at a 60 fpm face velocity with an 18" sash height. The UCI Study's baseline ASHRAE 110 test results demonstrated that the hood meets the 4-AM-0.05 ppm performance rating by producing control levels of 0.04 ppm or less, when the hood was operated at a 60 fpm face velocity and with the sash fully open. But because the peak tracer gas value at that sash height and face velocity were found to be as high as 1.35 ppm, the data indicates that the hood performance was insufficient at that face velocity with the sash fully open. Board staff therefore agrees with the Division that the UCI study established that the fume hoods performed optimally when operating at 60 fpm with a maximum 18" sash height, and when operated at 80 fpm with the sash fully open. Therefore any variance from the 100 fpm face velocity requirements in Section 5154.1(c) should include a variance condition that mandates a maximum sash height when employees operate the subject fume hoods at 60 fpm....

### Tracer Gas Release Rates

ASHRAE 110 test method uses the 4 lpm release rate in the testing of the fume hoods as a standard. As stated above, the ASHRAE 110 testing provides a consistent methodology to enable uniform performance evaluations. To clarify the relative quantity of tracer gas released inside the hood the American Conference of Government Industrial Hygienists (ACGIH) explains in the "Industrial Ventilation, A Manual of Recommended Practices," that an 8 lpm gas release rate "approximates violently boiling water on a 500 watt hot plate," and a 1 lpm release rate "approximates pouring volatile solvents back and forth from one beaker to another". The ACGIH lists the ASHRAE 110 recommended release rate of 4 lpm as "an intermediate rate between 1 and 8 lpm".

The Division variance evaluation report recommends a release rate of 8 lpm for the testing of any hoods installed under this variance. However, Board staff notes that despite the 8 lpm tracer gas release rate recommendations for similar variances, the Board granted previous variances to the release rate of 4 lpm. Board staff feels that the subject fume hoods are highly efficient and when operating within the hood's design face velocity range that the average tracer gas readings during the baseline ASHRAE 110 testing are either "non-detect" or near to zero as shown on tables, 10 and 12 of the UCI study report, and that the hoods' test failures primarily depended on the tracer gas peak values. Therefore increasing the release rate to 8 lpm would not result in a significantly higher performance standard while adding significantly to the cost of the test. Other objections expressed by some of the parties to previous variance applications were that the tracer gas used (Sulfur Hexafluoride) is one of the most potent greenhouse gases known to men, and therefore unnecessarily increasing tracer gas emissions was environmentally inadvisable. Additionally, Board staff points out that a variance was granted to the University of California, applying to all UC campuses, that permits the Applicant

to use Nitrous Oxide (N<sub>2</sub>O) instead of the mandated Sulfur Hexafluoride as a tracer gas. The UC variance was granted pursuant to 12 variance conditions including a N<sub>2</sub>O release rate of 5.5 lpm based on equivalency to the 4 lpm of Sulfur Hexafluoride. Furthermore, Board staff notes that when the Applicant conducts tracer gas testing under the University of California variance file No. 09-V-141, the Applicant must comply with all the variance file No. 09-V-141 conditions including the tracer gas (N<sub>2</sub>O) release rate of 5.5 lpm.

#### Fume Hood Testing Frequency

The Applicant indicated that the subject fume hoods would be incorporated into the Applicant's fume hood inspection program that includes the following:

- 1) Full ANSI/ASHRAE 110 testing,
  - a) when the hoods are first installed (commissioning)
  - b) when the fume hood has experienced significant damage or structural changes, or
  - c) when the periodic face velocity and smoke visualization required standards cannot be met, even after adjustment and/ or repair.
- 2) Annual face velocity and smoke visualization testing....

#### Similar Variances Considered By the Board

Board staff notes that three similar variances from Section 5154.1(c) have been granted to Genentech, Inc., 01-V-013, San Diego State University (Biology Dept.), 02-V-010, and the National Food Laboratory, Inc., 04-V-042. The variance conditions to which these variances were granted differed according to the type of fume hood, the performance history and the application and use of the fume hoods. For example, the Genentech variance application proposed to operate 12-foot Lab Crafter low flow hoods at a face velocity of 80 fpm for the purpose of conducting synthetic chemistry research and development, able to contain air contaminants that included carcinogens and listed agents classified as "highly toxic" or immediately dangerous to health. The conditions included yearly ASHRAE testing to ensure effective protection of employees working with the highly toxic chemicals. San Diego State University and National Food Laboratory, Inc. variance applications proposed to operate 6-foot Berkeley Fume Hoods at 80 fpm. The variance conditions included ASHRAE testing at a performance rating of 4-AI-0.05 during commissioning and every three years at a performance rating of 4-AU-0.1. The condition required an ASHRAE test for the 2<sup>nd</sup> year of hood operation at a performance rating of 4-AU-0.1. Board staff notes that all three previous variances were granted without the benefit of the extensive UCI study and performance testing carried out by the Applicant.

Board staff opines that the ASHRAE test method with the coordinated tracer gas, face velocity and smoke visualization testing is a more effective fume hood performance test method than the face velocity requirement in Section 5154.1. Board staff feels that the ASHRAE test parameters and resulting performance data enable the establishment of variance conditions

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that insure superior hood performance that in turn will result in better employee protection than that provided under Section 5154.1(c).

Because the Applicant's hoods are similar to the Lab Crafter hoods used by Genentech, Board staff agrees with the Division that in the event this variance application is granted by the Board, the variance conditions should include the relevant variance conditions to which the Genentech variance file No. 01-V-013 was granted.



DECLARATION OF SERVICE BY MAIL

I, Rebecca Estrella, declare as follows:

I am a citizen of the United States, over the age of 18 years and not a party to the within action. My place of employment is the Occupational Safety and Health Standards Board (OSHSB), and my business address is 2520 Venture Oaks Way, Suite 350, Sacramento, California 95833.

On March 16, 2012, I served the attached Decision with respect to OSHSB File No. 11-V-030 as follows: I placed true copies thereof in envelopes addressed to the persons or entities named below at the addresses set out immediately below the respective names; I sealed said envelopes and placed them for collection by and deposit with the United States Postal Service at 2520 Venture Oaks Way, Sacramento, California 95833. I am familiar with OSHSB's practice for processing items for mailing via the United States Postal Service, and in the ordinary course of business, such items are deposited with the United States Postal Service with first class postage thereon fully prepaid on the same day they are placed for United States Postal Service collection and deposit.

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I declare under penalty of perjury that the foregoing is true and correct.  
Executed on March 16, 2012, at Sacramento, California.

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Rebecca Estrella

