
Comparison of a Conventional and a Berkeley Fume Hood

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Table of Contents

1 Executive Summary .................................................................1

2 Overview ......................................................................................1
    2.1 Testing Fume Hood Containment Performance ..................1
    2.2 Side-by-side hood evaluations ............................................2
    2.3 Summary of Results ..............................................................3

3 Test Procedure ............................................................................5
    3.1 Test Description .................................................................5
    3.2 Instrumentation .................................................................6
    3.3 Acceptability Level ..............................................................7
    3.4 Deviations from ASHRAE 110 Test Procedure ....................7

4 Side-by-side Setup .......................................................................7
    4.1 Conventional hood configuration .......................................7
    4.2 Berkeley hood configuration ..............................................8
    4.3 Mannequin Setup ................................................................8

5 Test Run Narrative ....................................................................13
    5.1 Flow Visualization test runs ..............................................13
    5.2 Face Velocity measurements .............................................13
    5.3 Static Tracer Gas test runs ................................................13
    5.4 Sash Movement Effect runs .............................................14
    5.5 Sash Periphery Traverse test runs .....................................14

6 Appendix A - Side-by-side Containment Test Runs .................15
Conducted at Lawrence Berkeley National Laboratory, Bldg. 63-103

1 Executive Summary

Lawrence Berkeley National Laboratory (LBNL) has developed and patented a high-performance fume hood, The Berkeley hood. The Berkeley hood’s main design feature uses a gentle flow of air, introduced at the sash perimeter, to direct fumes inside the hood away from the face of the hood, and therefore away from the user. This push-pull approach not only provides for improved containment and greater operator safety, but also allows for much lower exhaust volume – 50% lower in the tests reported herein – dramatically reducing the amount of conditioned air that must be continually supplied and exhausted to a laboratory.

The side-by-side fume hood testing compares two otherwise identical hoods – one conventional and one Berkeley hood – by measuring the escape of a tracer gas from each per the American Society of Heating Refrigeration and Air-conditioning Engineers (ASHRAE) 110-1995 Method (more below). Test results indicate that the Berkeley hood provides substantially better containment of potentially harmful fumes, and therefore greater operator safety, than a conventional fume hood. It outperformed the conventional hood in all tests.

2 Overview

2.1 Testing Fume Hood Containment Performance

The purpose of an enclosing or containment laboratory hood is to contain toxic materials generated within the hood in order to keep exposure to laboratory hood users below the relevant health hazard exposure guidelines (e.g. OSHA PEL’s or ACGIH TLV’s). It has long been recognized that many factors affect the hood’s ability to contain including face velocity, hood design, room airflow patterns and user activities. Prior to the 1980’s, face velocity and visual smoke observations were used as the major indicators of hood performance. Recent studies have indicated that face velocity alone may not be predictive of adequate hood performance.¹

2.1.1 ASHRAE 110-1995 Method

The American National Standards Institute and ASHRAE Standard, ANSI/ASHRAE 110-1995, Method of Testing Performance of Laboratory Fume Hoods, is the foremost protocol used when testing laboratory-type fume hood performance. The ASHRAE-110 “Method” is an elaborate, three-part test that involves face velocity testing, flow visualization, and a tracer gas test. However, the ASHRAE 110 standard specifies the test, not the performance standard.

¹ From correspondence by ANSI/AIHA Z9.5 Standards committee, June 2003.
2.1.2 ANSI/AIHA Performance Standard

Using the ASHRAE 110 tracer gas containment test, the American National Standards Institute (ANSI) and American Industrial Hygiene Association (AIHA) have established containment performance standards in ANSI/AIHA Z9.5-2003 for as manufactured (AM) as installed (AI), and as used (AU) fume hoods established by ASHRAE. In this case, “performance” refers to the level of confinement of possible hazards and protection of the employees for the work which is performed inside a laboratory-type hood.

An interpretation was solicited from the ANSI/AIHE Z9.5 committee to provide an interpretation of a section in the ANSI/AIHA Standard for Laboratory Ventilation, ANSI/AIHA Z9.5-2003, regarding an equivalent performance indicator for “traditional” face velocity. This interpretation would be used to evaluate laboratory-type hoods having design features that do not use traditional face velocity as their method of confinement.

2.1.3 ANSI/AIHA Performance Thresholds

The response from ANSI/AIHA to the solicitation, noted above, to an equivalent performance indicator for “traditional” face velocity with performance thresholds was provided:

“Therefore ANSI Z9.5 requires that some form of containment test using a challenge agent such as a tracer gas that can quantitatively measure hood “leakage” be used to determine if a hood’s containment is acceptable. The hood “user” or “owner” needs to define what containment is acceptable. At the current time ANSI Z9.5 recommends that ASHRAE 110-1995 be used as this containment test. For a 4 lpm challenge the recommended maximum acceptable “leakage” is 0.05 ppm at the breathing zone for hoods tested under controlled conditions and/or 0.1 ppm for hoods as installed in the laboratory.”

2.2 Side-by-side hood evaluations

2.2.1 Comparative Approach

In an effort to demonstrate equivalent or superior performance of a Berkeley fume hood compared to a conventional fume hood (see next section), the California Energy Commission (CEC) sponsored a series of so-called “side-by-side” comparative performance evaluations. An example of each hood type was installed and tested in the same room. The basic hoods were produced by the same manufacturer (Jamestown Metal Products) and are of the same nominal size. Testing method employed was the ASHRAE 110-1995 protocol. Containment performance threshold levels were obtained from the ANSI Z9.5-2003 Laboratory Ventilation Standard. This report provides the results for the side-by-side tests. A companion report provides results for an innovative human-as-mannequin (HAM) side-by-side test series.

2.2.2 An Innovative Laboratory-type hood

Researchers at Lawrence Berkeley National Laboratory (LBNL) are developing an innovative containment technology that reduces required airflow through laboratory fume hoods. This technology provides containment at 50 to 70 percent lower airflow than a

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2 From correspondence by ANSI/AIHA Z9.5 Standards committee, June 2003.
typical fume hood, based on total exhaust volume. It does not rely on face velocity, in the
traditional sense, to maintain fume containment within a hood.

The LBNL containment technology uses a “push-pull” displacement airflow approach to
contain fumes and move air through a hood. Displacement air “push” is introduced with
supply vents near the hood’s sash opening. Displacement air “pull” is provided by
simultaneously exhausting air from the hood. Thus, an “air divider” is created, between an
operator and a hood’s contents, that separates and distributes airflow at the sash opening.
This air divider technology is simple and increases operator protection.

2.3 Summary of Results

2.3.1 Successful Containment Performance

Table 1 presents the complete results from the ASHRAE 110-1995 Method, including
tracer gas containment performance per ANSI/AIHA thresholds. Note that both the
conventional and Berkeley hood “pass”, per ANSI Z9.5-2003.

Table 1: ASHRAE 110 Test results for Side-by-side Conventional and Berkeley hoods

<table>
<thead>
<tr>
<th>Run</th>
<th>Test Procedure</th>
<th>Detection Medium</th>
<th>Test Conditions</th>
<th>Conventional Hood Containment AI (as installed)</th>
<th>Conventional Hood Containment AM (as m³/g)</th>
<th>Berkeley Hood Containment AI (as installed)</th>
<th>Berkeley Hood Containment AM (as m³/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Local Flow Visualization</td>
<td>Small volume Smoke tube</td>
<td>Visual observation</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>2</td>
<td>Large-volume Flow Visualization</td>
<td>Large volume Smoke</td>
<td>Visual observation; no mannequin</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Face Velocity Static Mannequin</td>
<td>N/A</td>
<td>Velocity meter Ejector Center position; Sash full open</td>
<td>Pass</td>
<td>Pass</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>Static Mannequin</td>
<td>Tracer gas</td>
<td>Ejector Center position; Sash full open</td>
<td>Pass(^a)</td>
<td>Pass(^a)</td>
<td>Pass(^a)</td>
<td>Pass(^a)</td>
</tr>
<tr>
<td>5</td>
<td>Static Mannequin</td>
<td>Tracer gas</td>
<td>Ejector Left position; Sash full open</td>
<td>Pass(^a)</td>
<td>Pass(^a)</td>
<td>Pass(^a)</td>
<td>Pass(^a)</td>
</tr>
<tr>
<td>6</td>
<td>Static Mannequin</td>
<td>Tracer gas</td>
<td>Ejector Right position Sash full open</td>
<td>Pass(^a)</td>
<td>Pass(^a)</td>
<td>Pass(^a)</td>
<td>Pass(^a)</td>
</tr>
<tr>
<td>7</td>
<td>Sash Movement Effect (SME)</td>
<td>Tracer gas</td>
<td>Ejector Center position Sash operated</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
</tr>
<tr>
<td>8</td>
<td>Sash Movement Effect (SME)</td>
<td>Tracer gas</td>
<td>Ejector Left position Sash operated</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
</tr>
<tr>
<td>9</td>
<td>Sash Movement Effect (SME)</td>
<td>Tracer gas</td>
<td>Ejector Right position Sash operated</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
</tr>
<tr>
<td>10</td>
<td>Periphery Traverse</td>
<td>Tracer gas</td>
<td>Ejector Center position; Sash full open; no mannequin</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
<td>Pass(^b)</td>
</tr>
</tbody>
</table>

\(^a\) Tracer gas Pass/Fail criterion per ANSI Z9.5 2003.

\(^b\) No specified Tracer gas Pass/Fail criterion per ANSI Z9.5 2003; however, compared to static mannequin
guidelines and an averaged value during the test, a pass rating was achieved.
2.3.2 Superior Containment Performance

Examining quantitative data, in Table 2, shows that the Berkeley hood provides superior containment performance, per ANSI Z9.5-2003, to the conventional hood.

Table 2: ASHRAE 110 Test results for Side-by-side Conventional and Berkeley hoods

<table>
<thead>
<tr>
<th>Tracer Gas Test Position/Type</th>
<th>Conventional (Aver PPM for 5 Min.)</th>
<th>Berkeley (Aver PPM for 5 Min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center</td>
<td>0.008</td>
<td>0.002</td>
</tr>
<tr>
<td>Left</td>
<td>0.009</td>
<td>0.007&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Right</td>
<td>0.006</td>
<td>0.001</td>
</tr>
<tr>
<td>SME Center</td>
<td>0.025</td>
<td>0.001</td>
</tr>
<tr>
<td>SME Left</td>
<td>0.021</td>
<td>0.002</td>
</tr>
<tr>
<td>SME Right</td>
<td>0.012</td>
<td>0.001&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Periphery Traverse</td>
<td>0.022</td>
<td>0.001</td>
</tr>
</tbody>
</table>

<sup>a</sup>) Includes unscheduled AI door opening and closing during test run.<br>
<sup>b</sup>) Corrected for increasing level of background SF6 tracer gas (0.006 without correction).

2.3.3 Containment Performance Comparison

Chart 1 presents comparative results for the ASHRAE 110 tracer gas containment tests averaged over a 5-minute interval. Note that both the conventional hood and the Berkeley hood performed very well by providing containment far below the ANSI Z9.5 2003 threshold for an as-installed (AI) hood of < 0.10 PPM. Importantly, the ANSI containment threshold for the more stringent as-manufactured limit of <0.05 PPM was also achieved by both hoods.
3 Test Procedure

3.1 Test Description

All tests followed ASHRAE’s 110-1995 test methods for flow visualization and tracer gas tests, Section 6.1 and Section 7, respectively. Face velocity tests were performed on each hood; however, the Berkeley hood face velocity tests were performed without the hood’s supply fans in operation. Refer to ANSI/ASHRAE 110-1995 for specific information regarding its Purpose (Section 1), Scope (Section 2), Definitions (Section 3), Instrumentation and Equipment (Section 4), and Test Conditions (Section 5). The tests, referenced below, used the ASHRAE 110 method’s Section 6.1, Flow Visualization and Section 7 (7.1 through 7.10), Tracer Gas Testing Procedure to evaluate containment performance. A general overview of these tests is provided:

1) Flow visualization tests can be performed with various smoke-generating substances. Theatrical smoke, superheated glycol, smoke “sticks”, titanium tetrachloride, and dry ice, solid-phase CO₂, are examples of smoke sources. A qualitative understanding of containment is gained from conducting smoke tests. A rating system has been devised for “poor-to-good” patterns of smoke containment by Tom Smith³. However,

³ Tom Smith, President of Exposure Control Technologies, Inc. 231-C East Johnson St. Cary, NC 27513 ph: 919.319.4290
these tests are only used as indicators of containment. When satisfactory results are observed, they should be followed by tracer gas testing. Both small and large volume smoke tests were performed on each hood with full containment of all smoke clearly moving towards the rear of the hood without any “reverse return” flow noted.

2) Face velocity measurements are performed by using a “hot wire” velocity meter with its probe held fast in a stand. This removes any variability that a person may introduce into the data. An imaginary grid of one-foot squares provide the location for the meter’s probe, which is centrally located in each square foot area. For the side-by-side tests, each hood’s grid had three rows and five columns, yielding fifteen readings that were averaged. Each hood’s averaged reading compared well to the exhaust volume, as determined by a calibrated pitot tube in its exhaust stack.

3) Tracer gas testing is the most reliable test for determining a fume hood’s containment performance. A highly generalized overview of the test is provided. The gas typically used is sulfur hexafluoride, or SF$_6$. This gas flows into a fume hood being tested through a specially constructed “ejector.” The ASHRAE 110 guideline includes engineering drawings to fabricate this ejector. SF$_6$ flow rate is set at four liters per minute (LPM). A mannequin is placed in front of the hood being tested to simulate an operator. An inlet port to a detector device is placed at the “breathing zone” (the nose) of the mannequin. This breathing zone is set a height of 26 inches above the hood’s work surface. Tracer gas is allowed to flow for five minutes and spillage levels are recorded by the detector. The mannequin and the tracer gas ejector are located in three positions: center, left, and right to determine containment. Ratings can be provided for a hood at three levels of hood installation:

- "As manufactured" (AM) — initial test of performance of a hood in a highly controlled/idealized setting at the manufacturer’s facility.
- "As installed" (AI) — hood testing is completed in the actual, fully operating facility, potentially more difficult conditions than the manufacturers' facility.
- "As used" (AU) — hood testing is performed by adding a hood operator’s experimental equipment, a.k.a., “clutter”, to the “as installed” hood, making the test conditions even more difficult.

3.2 Instrumentation

3.2.1 Total Exhaust Flow Measurement

Total exhaust flow was verified by measuring pressure readings from a pitot tube located in a straight run of each hood’s exhaust stack. The volumetric flow was verified with a calibrated flow meter with an accuracy of better than ±3 percent for each hood’s pitot tube and a calibration curve was generated using a least squares second-order method. Each hood’s calibration curve was plotted and attached to the hood for easy reference during hood setup.

3.2.2 Face Velocity Meter

Face velocities were tested with a TSI velocity meter, model 8360. Readings were averaged with fifteen points. Volumetric flow, from pitot tube readings, correlated well with face velocity readings measured in each hood. However, face velocity readings indicated some level of turbulence not quantified in this study. This is a typical situation for most
conventional hoods and is being addressed by many hood manufacturers with advanced
design methods and construction enhancements. In the case of the Berkeley hood, the
air divider technique addresses this situation by gently pushing air into the hood with low
turbulence intensity.

3.2.3 Tracer Gas Ejector

A standard ASHRAE 110 ejector, manufactured by Air Flow Tech Products, Inc., was
used during the test runs. A BIOS Dry-Cal DC-1 Flow calibrator was used to verify SF₆
volumetric flow at 4 LPM. A pressure gauge attached to the ejector was monitored during
the flow calibration sequence at 23.5 psig and maintained throughout the test runs.

3.2.4 Tracer Gas Detector

Test instrument used to detect SF₆ was an ITI-Qualitek Leakmeter 120. Inlet tube was
located at nose of mannequin. Calibration was verified frequently with known
concentrations of SF₆ in "cal bags." Analog output readings (voltage) from the ITI-Qualitek
Leakmeter were recorded with an A-to-D converter (a voltage-ohm-meter, VOM) and
stored on a personal computer. Later these data were graphed with Microsoft Excel™ for
presentation.

3.3 Acceptability Level

The LBNL test/fabrication laboratory is not a highly controlled/idealized setting as would be
found in a manufacturer's facility. Therefore, due to the environment where the hoods
were installed, test criterion for the "as installed" (AI) designation was used from
ANSI/AIHA Standard Z9.5 (2003). The acceptability level required for AI designation is
0.10 PPM, or less, averaged over five minutes. However, the acceptability level required
for AM designation, which is 0.05 PPM, or less, for five minute average, was not exceed
by either hood during testing. It is noteworthy that both hoods met the more stringent AM
threshold even though the test site was less than an ideal environment.

3.4 Deviations from ASHRAE 110 Test Procedure

None.

4 Side-by-side Setup

4.1 Conventional hood configuration

The conventional hood is produced by Jamestown Metal Products. It is a nominal six-foot
wide hood. The hood was installed with a dedicated exhaust fan and operates in a
conventional manner.

The depth of the nominal six-foot-wide hood is 32.5 inches from the sash to the rear baffle.
The fully open sash dimensions are 61.75 inches wide by 26.5 inches high, for a total
open area of 11.36 square feet. Testing was conducted with total exhaust flow of 1136
CFM. This corresponds to a 100 FPM face velocity.
4.2 Berkeley hood configuration

The nominal six-foot-wide version of the Berkeley hood is 30.5 inches from the sash to the rear baffle. The fully open sash dimensions are 61.75 inches wide by 30 inches high, for a total open area of 12.87 square feet. Testing was conducted with total exhaust flow of 643 CFM. This corresponds to 50 percent flow in a standard hood operating at a 100 FPM face velocity, respectively.

4.2.1 Push/Pull System

This six-foot version of the Berkeley hood uses four fans to push room air into the hood's cabinet. The "top" plenum fan pushes air from behind the top of the sash towards the rear baffle. The "front" plenum fan blows air from the top of the face area down (and across the front of the sash when it is closed). The "lower" plenum fans (two) push air from behind the lower airfoil towards the rear of the cabinet. All three plena have individual rheostats to manually adjust fan speed. These fans produce a vectored airflow (push) that provides containment at lower than normal exhaust airflow (pull). The push air is introduced at or inside the sash (face) that creates an “air divider.” Consequently, face velocity measurements are irrelevant.

4.2.2 Supply Airflow Rate

Each supply grill/screen was measured with a hot wire anemometer with the results provided in Table 3. The velocity of the Front and Top plena was recorded in a vertical orientation at intervals of every two inches. The velocity of the Bottom plenum was recorded in a horizontal orientation every inch. Conversion from velocity to volumetric flows from the supply outlets is approximate.

Table 3: Configuration of CEC Six-foot Berkeley hood at LBNL.

<table>
<thead>
<tr>
<th>Supply</th>
<th>Approx. Outlet Area Sq. ft.</th>
<th>Average Velocity FPM</th>
<th>Estimated Volume CFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>1.6</td>
<td>57.8</td>
<td>92.5</td>
</tr>
<tr>
<td>Top</td>
<td>2.64</td>
<td>35.6</td>
<td>94.0</td>
</tr>
<tr>
<td>Bottom</td>
<td>0.65</td>
<td>71.0</td>
<td>45.9</td>
</tr>
<tr>
<td>Total</td>
<td>5.89</td>
<td></td>
<td>232</td>
</tr>
</tbody>
</table>

4.3 Mannequin Setup

In the following, Figures 1 & 2 show the typical mannequin positioned in front of the conventional hood prior to installing the tracer gas ejector and the ITI detector. Figures 3, 4, and 5 (center, left, and right positions) show the mannequin positioned in front of the Berkeley hood with both the tracer gas ejector and ITI detector installed.
Fig. 1 – Right view of mannequin position for standard Center ASHRAE 110 SF6 test; 26 inches above work surface, conventional hood.
Fig. 2 – Left view of mannequin position for standard Center ASHRAE 110 SF6 test; 26 inches above work surface, conventional hood.
Fig. 3 - Mannequin in position for standard Center ASHRAE 110 SF6 test; 26 inches above work surface with ejector and detector, Berkeley hood.

Fig. 4 - Mannequin in position for standard Left ASHRAE 110 SF6 test; 26 inches above work surface with ejector and detector, Berkeley hood.
Fig. 5 - Mannequin in position for standard Right ASHRAE 110 SF6 test; 26 inches above work surface with ejector and detector, Berkeley hood.
5 Test Run Narrative

5.1 Flow Visualization test runs

Test Runs #1 and #2 (refer to Table 1, above) are the results for the ASHRAE’s 110 protocol, Section 6.1 – Flow Visualization. Specifically, Sections 6.1.1 Local (small) Challenge and 6.1.2 Large-Volume Challenge were performed with passing ratings, per ANSI Z9.5-2003, with no visible escape beyond the plane of either hood’s sash.

5.2 Face Velocity measurements

The ASHRAE 110-1995 protocol includes a measurement of the tested fume hood’s face velocity. Face velocity is measured in the plane of the sash while fully open or with the sash in its “design position.” To simulate a worst-case situation, all measurements were gathered with each hood’s sash fully open. This is NOT the recommended position for the sash to be during operator use. The sash should always be lowered to yield the smallest opening that allows the operator to manipulate objects/experiments within the hood’s cavity safely. This is true for all fume hoods.

Test Run #3 presents results of ASHRAE’s 110 protocol, Section 6.2 – Face Velocity Measurements (refer to Table 1, above). As noted above per the ASHRAE 110-1995 protocol, an imaginary grid of areas of one square foot provided the pattern for measuring the conventional hood’s face velocity. The dedicated fan providing airflow into the conventional hood was adjusted until an average face velocity of 100 FPM was attained with no measured point below 70 FPM. This was confirmed by checking the total exhaust volume with a pitot tube device, as noted above.

With the Berkeley hood design, primary contaminant control is provided by the directed laminar to near-laminar air streams, not by the air flowing around the operator. This Hood design does not use the expected high face velocities of conventional fume hoods to achieve containment. Therefore, testing that measures face velocity, rather than containment, does not accurately describe the increased performance and containment achieved by the Berkeley Hood design. With a push/pull hood, much of the supply air is introduced at or inside of the face, so the resulting face velocity is reduced. To verify the Berkeley hood’s lower total exhaust airflow, both face velocity and total flow volume were measured and compared with supply fans turned off. An average value of 50 FPM is provided by its dedicated exhaust fan.

5.3 Static Tracer Gas test runs

The ASHRAE 110-1995 protocol includes an evaluation of the tested fume hood’s ability to contain a tracer gas. Tracer gas containment is normally measured with the sash in its “design position”, which is typically in a position of 18 inches open. To simulate a worst-case situation, all tracer gas tests were performed with each hood’s sash fully open. This is NOT the recommended position for the sash to be during operator use. The sash should always be lowered to yield the smallest opening that allows the operator to manipulate objects/experiments within the hood’s cavity safely. This is true for all fume hoods.

Test Runs #4 through #6 presents results of ASHRAE’s 110 protocol, Section 7 – Tracer Gas Test Procedures (refer to Table 1, above). Specifically, Sections 7.1 through 7.10
were performed with passing ratings, per ANSI Z9.5-2003, for both "as-manufactured" and "as-installed" conditions. The total exhaust airflow for the Berkeley hood was 643 CFM. This exhaust flow equates to 50 percent of the volume when compared to the hood flowing with a face velocity of 100 FPM. For each hood, tracer gas test runs were performed with the ejector in center, left, and right positions. The SF₆ gas detector, an Ion Tracker Instruments (ITI) Leakmeter 120, was checked with calibrated bags of SF₆ tracer gas just prior to each test, thus ensuring accurate results. Refer to charts in Appendix B.

5.4 Sash Movement Effect runs

Test Runs #7 through #9 presents results of a Sash Movement Effect (SME) test per ASHRAE 110 Section 7.12 (refer to Table 1, above). Per the protocol with the mannequin present in each case, this challenge involves closing and opening the sash to fully three times for each ejector position; center, left, and right. Refer to charts in Appendix B.

5.5 Sash Periphery Traverse test runs

Test Run #10 presents results of ASHRAE's 110 protocol, Section 7 – Tracer Gas Test Procedures, Section 7.11 Sash Periphery Traverse test (refer to Table 1, above). This test was performed twice in each hood. Average containment ratings better than ANSI Z9.5-2003, for both "as-manufactured" and "as-installed" conditions were provided with the Berkeley hood. Excursions were noted with the conventional hood, although time-averaged values can be seen as "passing." All test runs were performed with the ejector in the hood center position. Refer to charts in Appendix B.
Appendix A - Side-by-side Containment Test Runs

Conventional-Ejector-Center

Time

PPM

BKGRND

AM

AI

0.00

0.01

0.02

0.03

0.04

0.05

0.06

0.07

0.08

0.09

0.10

03:41:00pm
03:41:11pm
03:41:22pm
03:41:33pm
03:41:44pm
03:41:55pm
03:42:06pm
03:42:17pm
03:42:28pm
03:42:39pm
03:42:50pm
03:43:01pm
03:43:12pm
03:43:23pm
03:43:34pm
03:43:45pm
03:43:56pm
03:44:07pm
03:44:18pm
03:44:29pm
03:44:40pm
03:44:51pm
03:45:02pm
03:45:13pm
03:45:24pm
03:45:35pm
03:45:46pm
03:45:57pm

PPM

BKGRND

PLOT

PLOT

15
Conventional-SME - Right

Time

PPM

AM

AI

Close-Start

Close-Finish

Open-Start

Open-Finish

Close-Finish

Open-Start

Close-Finish

Open-Start

Open-Finish

PPM

BKGRND

0.10

0.09

0.08

0.07

0.06

0.05

0.04

0.03

0.02

0.01

0.00

04:20:01pm

04:20:10pm

04:20:19pm

04:20:28pm

04:20:37pm

04:20:46pm

04:20:55pm

04:21:04pm

04:21:13pm

04:21:22pm

04:21:31pm

04:21:40pm

04:21:49pm

04:22:07pm

04:22:16pm

04:22:25pm

04:22:34pm

04:22:43pm

04:22:52pm

04:23:01pm

04:23:10pm

04:23:19pm

04:23:28pm

04:23:37pm

04:23:46pm

04:23:55pm

04:24:04pm

04:24:13pm
Berrkeley-Periphery Traverse

Note: Hood passes containment test if average concentration below limits shown for five minutes.