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November 9, 2001

Jon Zboralski
Fisher Hamilton
1316 18th Street
PO Box 137
Two Rivers, WI 54241

Re: Pioneer Hood Testing
University of Wisconsin - Milwaukee
Project 346-004

Dear Mr. Zboralski:

At your request, Gerhard W. Knutson of Knutson Ventilation conducted ASHRAE performance tests on you Pioneer Hood. The tests were conducted at the request of Dan Motl, Division of Facilities Development, Sate of Wisconsin, and Jack Wunder, University of Wisconsin.

**SUMMARY**

1. The Pioneer Model 54L644PO, when tested with a modified ASHRAE 110 tests, performed adequately with a face velocity of 52 fpm and 63 fpm.

2. The face velocity measurements, made on a three by four grid, varied by less than 15 percent from the average.

3. Smoke visualization indicated adequate airflow patterns and minimal turbulence within the hood.

4. The tracer gas readings, during the performance tests, were at or below the minimum detection level of 0.01 ppm.

5. The hood was tested with cross drafts and boxes in the hood
   a. High cross draft, 75 fpm, parallel to the hood did not disrupt performance.
   b. The combination of boxes inside the hood and the cross draft did not disrupt the hood performance.
   c. The hood did not perform adequate with boxes in the hood and no cross draft.

6. Placing the boxes on wooden spacers appeared to eliminate the loss of performance.

## HOOD DESCRIPTION

We tested Fisher Hamilton, 5-foot, SafeAire Pioneer hood, Model 54L644PO. The hood had a single vertical sliding sash. Photo 1 shows an overview of the Pioneer hood set up in the Fisher Hamilton Test Laboratory.

Photo 1: Overview of the Pioneer Hood.

Vertical Sash

The Pioneer hood had a single vertical sash. Although the operator can open the sash to the full open position, the sash will not normally remain at that position. When the chemist releases the sash, a closure mechanism slowly reduces the sash height to about 18 inches above the work surface.

When the operator needs to open the sash for "start up" or for a procedure, that requires a larger opening, the hood had a sash stop which held open at a sash height of 27.5 inches.

When the operator releases the sash stop, (which can be achieved by opening the hood slightly or by manually removing the sash stop) the sash slowly closes to a height of about 18 inches. If the operator positions the sash with a height less than 18 inches, the sash remains in place.

A monitor, mounted in the side wall shows when the sash is in a set up mode and provides a short, periodic "beep" to remind the chemist that the sash is in the set up mode.

**Airfoil**

The Pioneer hood has a nearly flat airfoil. See Photo 2. Although the airfoil is nearly flat, proper operation of the hood requires the chemist to work inside the hood. Good work practices recommend working six inches inside the hood. The lip of the dished work surface is six inches inside the hood, to assist the chemists in proper location of apparatus.

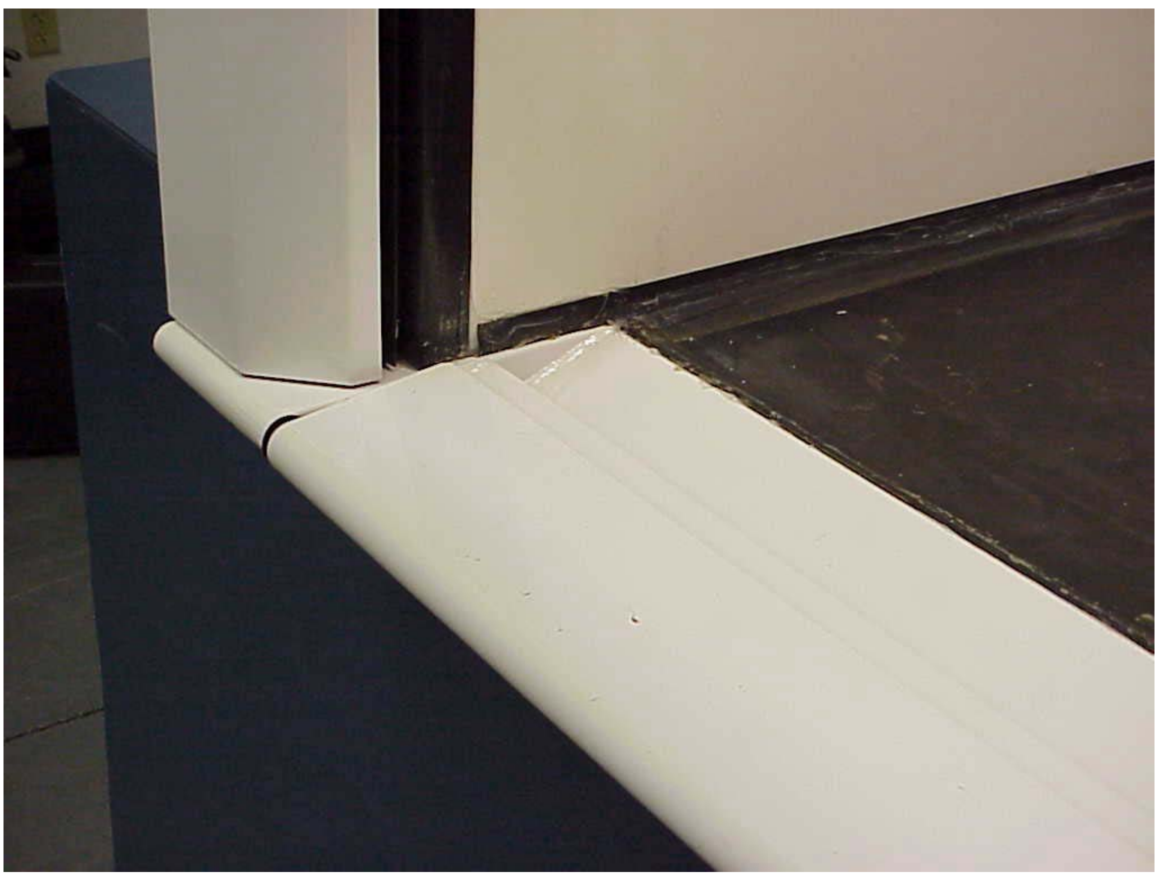


Photo 2: Pioneer Airfoil

Baffle Construction

The back baffle consists of two fixed panels. The bottom panel has a slot about 3.5 inches above the dished work surface. Three brackets, about 1.75 inch wide, break the slot into two parts.

The top panel overlaps the bottom panel.

The slot between the hood interior and the top baffle is about one inch.

**Air Curtain**

The front of the hood has an "air curtain". A separate fan, mounted behind the front panel, discharges room air through a plenum at the front of the hood. The width of the discharge plenum is less than the width of the opening (36 inches verses 50.5 inches).


Photo 3: Front of the hood showing the Air Curtain plenum

The hood has a switch that turns off the air curtain fan when the sash lowers below 19 inches. As the chemist raises the sash above 19 inches, the fan energizes and provides the required flow. Because the sash-lowering device keeps the sash below the point where the air curtain fan energizes, the air curtain operates only while the sash is at the sash stop or moving.

The volumetric flow though the air curtain was about 70 cfm.

## HOOD TESTING

The test procedures followed the ASHRAE 110 Standard, with two exceptions. First, at the request of Fisher Hamilton, the release rate was eight liters per minute (compared with the standard 4 lpm). Second, the breathing zone of the mannequin was 18 inches above the work surface, rather than the specified 26 inches above the work surface.

### Ventilation Measurements

The investigator used a calibrated TSI air velocity transducer, Model 8455-06, to measure the face velocity for each hood condition. He divided the hood face opening into equal twelve equal rectangular areas. The test results are shown in Table 1 and Table 2.

**TABLE 1**
**FACE VELOCITY MEASUREMENTS**
**NOMINAL 60 FPM FACE VELOCITY**

| | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **A** | 57 fpm | 61 fpm | 62 fpm | 70 fpm |
| **B** | 63 fpm | 56 fpm | 58 fpm | 63 fpm |
| **C** | 73 fpm | 61 fpm | 64 fpm | 63 fpm |

| | |
|---|---|
| Average | 63 fpm |
| Maximum | 73 fpm (117 %) |
| Minimum | 56 fpm ( 90 %) |

**TABLE 2**
**FACE VELOCITY MEASUREMENTS**
**NOMINAL 50 FPM FACE VELOCITY**

| | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **A** | 53 fpm | 50 fpm | 53 fpm | 59 fpm |
| **B** | 47 fpm | 51 fpm | 47 fpm | 52 fpm |
| **C** | 58 fpm | 60 fpm | 58 fpm | 61 fpm |

| | |
|---|---|
| Average | 54 fpm |
| Maximum | 61 fpm (113 %) |
| Minimum | 47 fpm ( 86 %) |

## SMOKE TESTS

The small-scale smoke visualization methods used Regin™ smoke bottles to generate a visible aerosol within the hood. The investigators released the smoke at several locations at each hood. In addition, the investigator used theatrical fog, from a Rosco 1600 fog generator, to visualize a large smoke challenge to the hood.

### Work Surface

The slot in the bottom baffle swept the smoke released along the work surface toward the back of the hood without significant turbulence or reverse flow. Smoke released within one inch of the recessed lip of the work surface lingered near the lip, with minor reverse flow, before the exhaust at the bottom slot captured the smoke.

### Air Foil

Smoke released under the under the airfoil is drawn smoothly into the hood. Occasionally, the smoke exhibited turbulence at the back edge of the airfoil lip. In addition, as smoke entered the hood at the corners, it demonstrated slight turbulence and reverse flow. The reverse flow did not exit the pane of the hood.

Smoke released on the top of the airfoil, but outside the hood was lazy. It frequently remained on the airfoil briefly before the inward airflow drew it into the hood. With the mannequin in the plane of the hood, the reverse flow on the airfoil was exacerbated. However, the reverse flow did not appear to draw air from the interior of the hood (smoke released inside of the dished work surface).

The lazy air reinforces the need to use good work practices while operating the hood. In particular, the airfoil is outside the hood. It should not be used as an extension of the hood.

### Sidewall Jambs

The air flowed cleanly and smoothly around the sidewall jamb and entered the hood.

### Sidewall

Smoke released six inches into the hood was drawn smoothly toward the back of the hood. However, when we released smoke within four inches on the bracket above the open window, the air demonstrated some turbulence and reverse flow. The reverse flow moved toward the bottom of the sash but did not pass the plane of the sash. The triangular segments were installed to break up the reverse flow along the sidewall. When smoke was released an inch or two below the triangular block, the air reversed and moved toward the front of the hood. However, it did not break the plane of the hood.

Smoke released along the sidewall, about two inches behind the sash track, rose and occasionally moved forward, about six to ten inches above the smoke generation. The smoke was visible along the black plastic strip along the sash track; however, it did not break the plane of the sash.

Smoke released along the sidewall, six inches into the hood, generally flowed toward the back. In the lowed third of the hood, the smoke dropped to the lower slot. In the upper two thirds of the hood, the smoke flowed toward the top slot and some entered the roll in the top of the hood.

Bottom of the sash

Smoke released outside the hood, about three inches above the bottom of the sash, was influenced by the air from the "air curtain" which washed the smoke into the hood in a smooth manner. The visible smoke followed with the "air curtain" discharge about three inches below the opening before the hood inflow drew the air into the hood.

Smoke released along the clear vision panel followed the roll down toward the sash. As the smoke passed the bottom of the header panel, it moved forward toward the sash. It then followed the sash down until it moved forward toward the lip on the sash. However, it did not break the plane of the sash.

Smoke released above triangular section followed the section into the hood the curled back toward the sash. However, the smoke did not break the plane of the sash.

Back Baffle

Smoke released along the bottom baffle panel split. Below 18 inches, it fell toward the bottom sash. Above 18 inches, it rose to the middle or top slots. Some of the smoke bypassed both slots and formed a minor roll in the top of the hood.

"Air Curtain"

Smoke released under the "air curtain" bonnet flowed smoothly toward the hood opening. Because the width of the plenum is less than the width of the opening (36 inches verses 50.5 inches) there was some turbulence in the corners, above the sash opening. However, the turbulence dissipated before the air reached the sash opening. In addition, the air released between the air curtain plenum and the sash minimizes this effect.

The "air curtain" had the advantage of providing a buffer of room air between the operator and the hood. The "air curtain" pushes any instability, which may form at the hood, past the breathing zone of the operator and prevents reverse air from flowing up the chest of the mannequin. This is particularly important since the most likely instability form directly in front of the operator.

## TRACER GAS TESTS

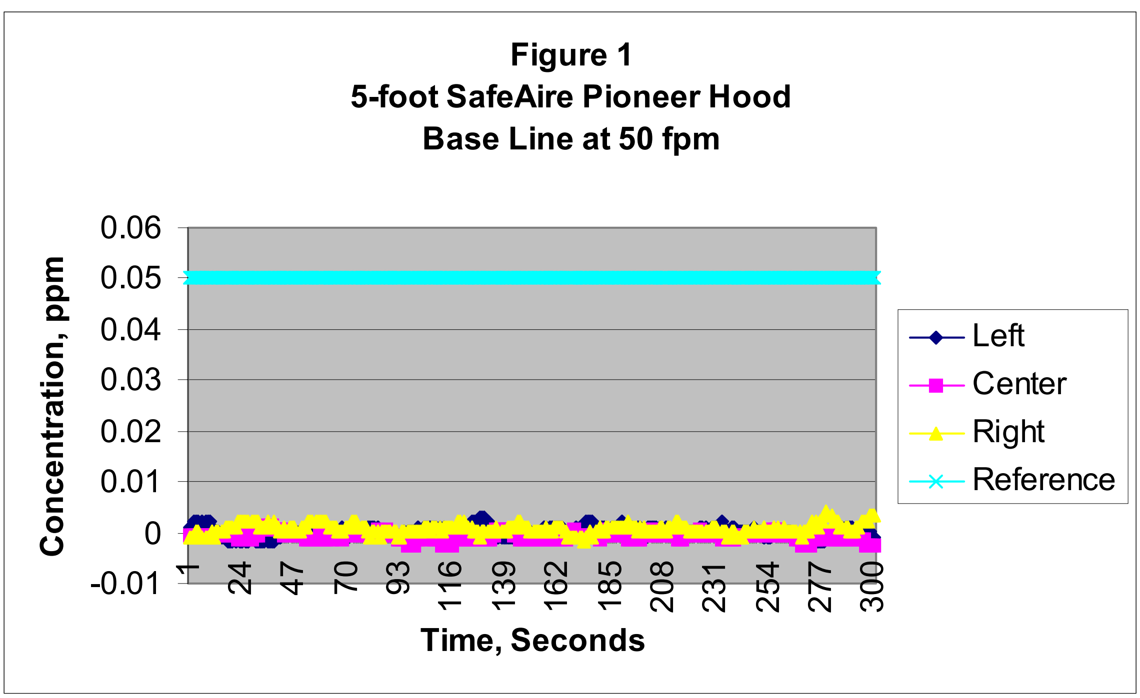
Although not specifically requested by Mr. Motl, we conducted baseline testing at with a nominal face velocity of 50 fpm and 60 fpm. The results of the tracer gas tests are summarized in Table 3 and Figures 1 and 2.

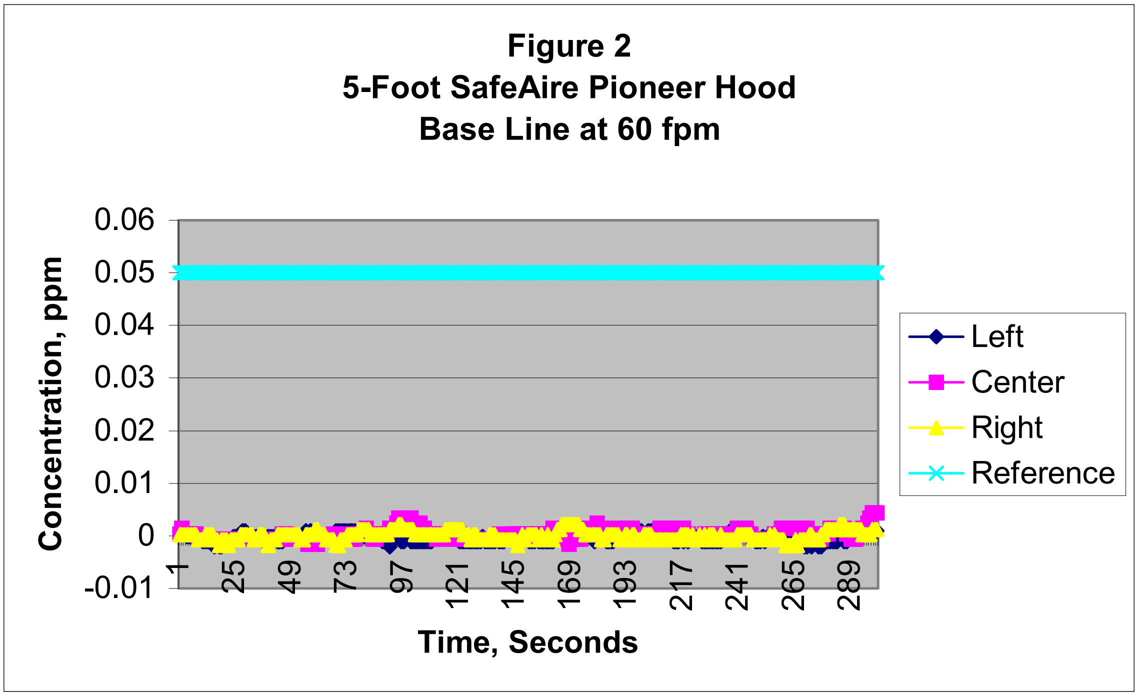
**TABLE 3**
**TRACER GAS TESTS**
**5-FOOT SAFEAIRE PIONEER HOOD**

| Face Velocity | Tracer gas results | | | Hood Rating | Notes |
|---|---|---|---|---|---|
| | Left | Center | Right | | |
| 50 fpm | < 0.01 | < 0.01 | < 0.01 | AM < 0.01 | 1 and 2 |
| 60 fpm | < 0.01 | < 0.01 | < 0.01 | AM < 0.01 | 1 and 2 |

Notes

1. The release rate was 8 lpm while the ASHRAE Standard 110 requires 4 lpm.
2. The mannequin height was 18 inches above the work surface






Sash movement effect tests were conducted at both face velocities. In both tests, the movement of the sash did not have a measurable effect.

**UW-M Requested Tests**

Mr. Motl requested several special tests with clutter in the hood (the tests used boxes) and cross drafts (the test used a filter box).

*Boxes for Clutter*

To provide a challenge by adding clutter to the hood, we placed eight cardboard boxes in the hood. The boxes were approximately 8" deep by 10" wide by 11.5" high. We stacked the boxes two high and four wide. The boxes were five inches from sidewalls and had a 1.5-inch spacing. They were placed about 2 inches in front of the baffle.

*Cross Draft*

To provide cross draft, we used a fan discharging into a wooden box. The front of the box consisted of two sets of 2-inch filters. The fan box was placed in the plane of the right sidewall of the hood, 15 inches from the plane of the front of the hood. The cross drafts were measured with the TSI transducer. The probe was placed 60 inches above the floor, 21 inches from the sash, and at the centerline of the mannequin. See Figure 4 for the arrangement.

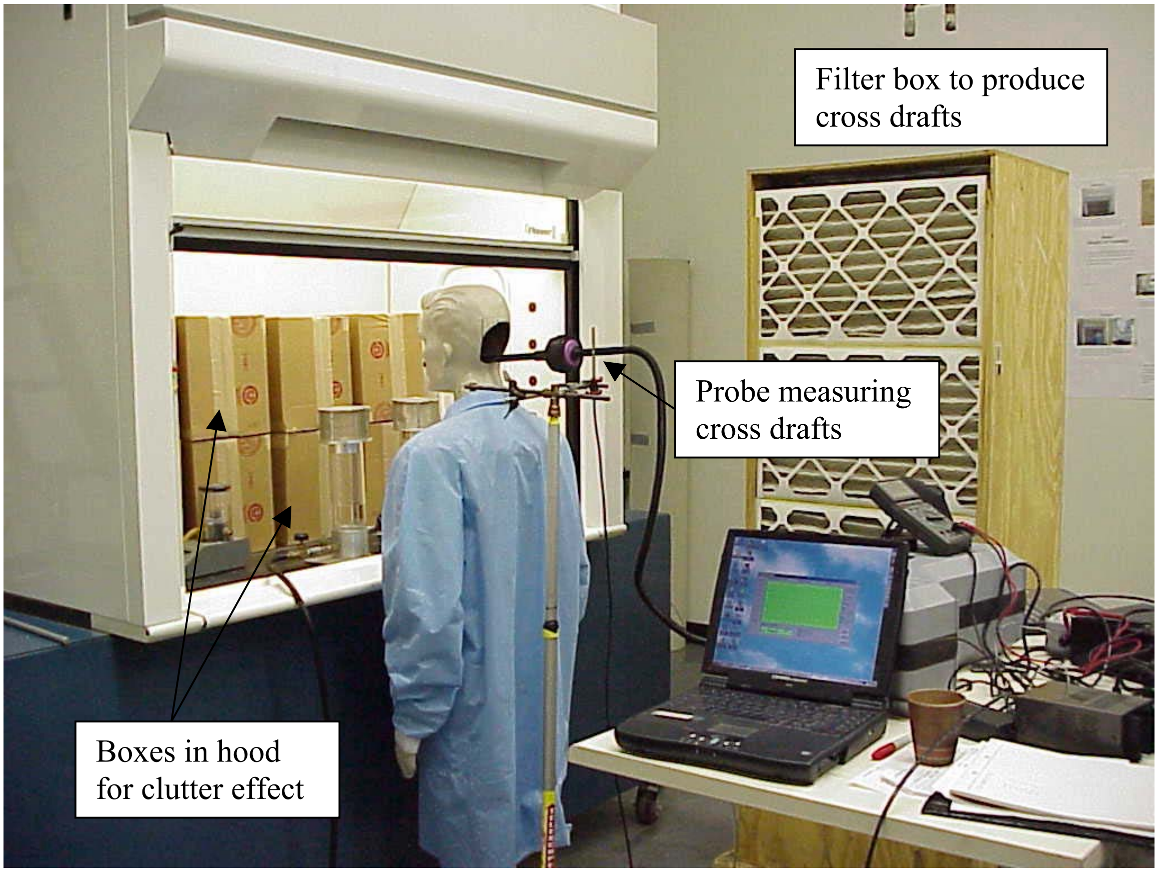



Photo 4: Cross drafts and boxes in hood

**Test Results**

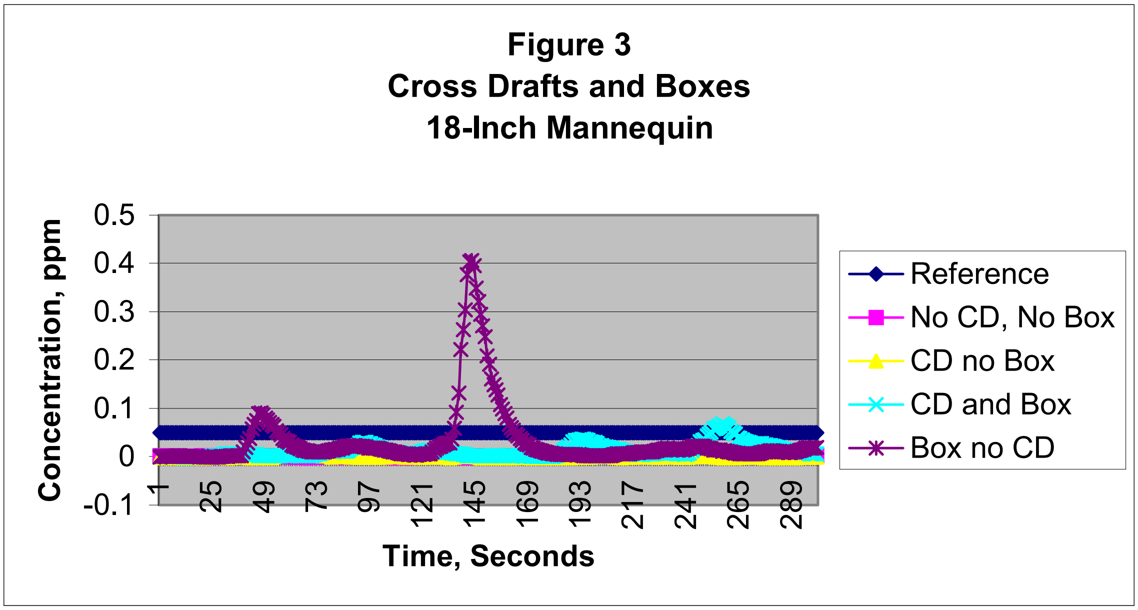
The cross draft fan was adjusted to provide a cross draft with a nominal velocity of 75 fpm. Table 4 shows the test results. Most tests were non-detectable. The only exception was the tests with boxes in the hood but no cross draft. The investigator conducted the tests three times (see Figure 3). Smoke visualization tests demonstrated the boxes effectively obstructed the airflow. However, smoke did not provide an explanation of the non-detectable results when the release rate was changed to 4 lpm.

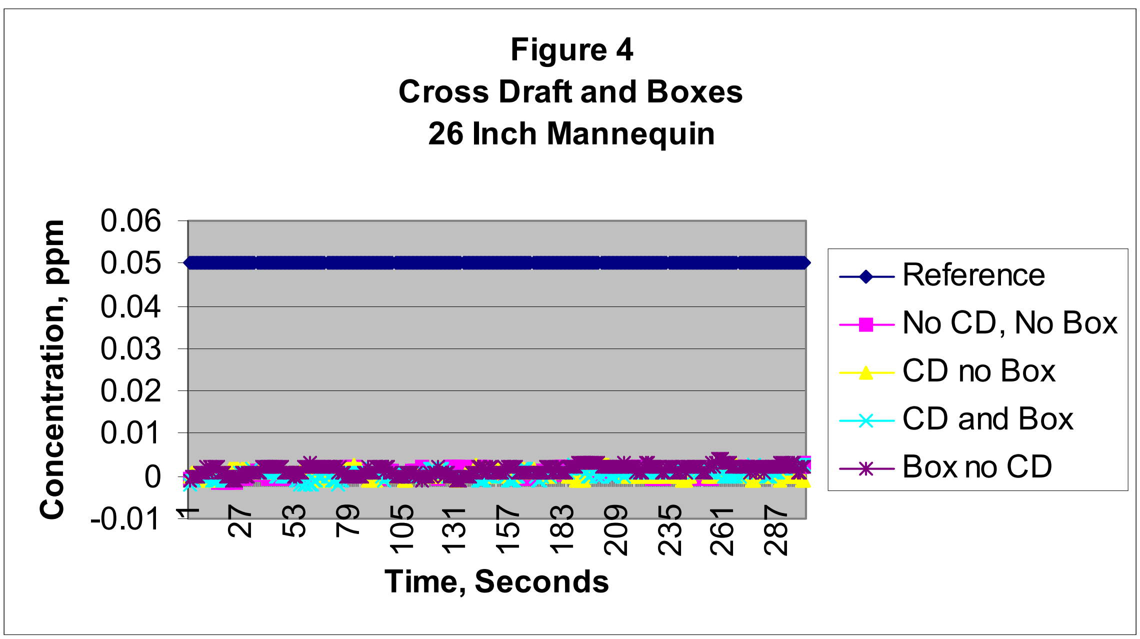
Figure 4 shows the test results for a 26-inch mannequin. All the tests were below the minimum detection level. Because the 26-inch high mannequin's head was in air flowing the air-curtain plenum, the air-curtain likely contributed to the low tracer gas measurements.

**TABLE 4**
**Special Tests for UW-M**

| Item | UWM No | Cross Draft | Boxes | Sash Height | Mannequin Height | Average ppm | Peak ppm | Notes |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | No | No | 27.5 inches | 18 inches | < 0.01 | 0.09 | 1 |
| 2 | 1 | No | No | 27.5 inches | 26 inches | < 0.01 | < 0.01 | |
| 3 | 2 | No | No | 27.5 inches | 18 inches | < 0.01 | < 0.01 | 2 |
| 4 | 4 | 75 fpm | No | 27.5 inches | 18 inches | < 0.01 | < 0.01 | |
| 5 | 8 | 75 fpm | Yes | 27.5 inches | 18 inches | 0.01 | 0.07 | |
| 6 | 6 | No | Yes | 27.5 inches | 18 inches | 0.03 | 0.41 | |
| 7 | 6 | No | Yes | 27.5 inches | 18 inches | 0.15 | 1.12 | 3 |
| 8 | 7 | 75 fpm | Yes | 27.5 inches | 26 inches | < 0.01 | < 0.01 | |
| 9 | 5 | No | Yes | 27.5 inches | 26 inches | < 0.01 | < 0.01 | |
| 10 | 6 | No | Yes | 27.5 inches | 18 inches | 1.10 | 8.97 | 4 |
| 11 | 9 | No | No | SME | 18 inches | < 0.01 | 0.01 | |
| 12 | 10 | No | No | 27.5 inches | 18 inches | < 0.01 | < 0.01 | |
| 13 | N/A | No | No | 18 inches | 18 inches | < 0.01 | < 0.01 | |
| 14 | 3 | 75 fpm | No | 27.5 inches | 26 inches | < 0.01 | < 0.01 | |
| 15 | N/A | No | Yes | 18 inches | 18 inches | < 0.01 | < 0.01 | 5 |
| 16 | N/A | No | Yes | 27.5 inches | 18 inches | 0.01 | 0.09 | 6 |
| 17 | N/A | No | Yes | 27.5 inches | 18 inches | < 0.01 | 0.02 | 6 |
| 18 | N/A | No | Yes | 27.5 inches | 18 inches | < 0.01 | < 0.01 | 7 |
| 19 | N/A | No | Yes | 27.5 inches | 18 inches | < 0.01 | < 0.01 | 7 |

Notes
1. Significant activity in the room during the test
2. Repeat of test 1
3. Repeat of run 6
4. Repeat of run 6 after adjusting boxes
5. Sash at 18 inches
6. Release rate 4 lpm
7. Boxes on blocks




After the representatives of the University of Wisconsin left, the investigator used smoke to investigate the higher tracer gas measurements with boxes and no cross draft. The smoke patterns suggested the boxes were an excessive obstruction to the airflow. By applying good work practices, the boxes were lifted off the work surface. Specifically, 1" by 1" by 7" long spacers were placed under the boxes (see photo 5).

With the boxes elevated and the release rate at 8 lpm, the test with boxes and no cross draft were repeated.  The test results were very good:

| Test run | Max | Min | Average | Reported result | Peak |
|---|---|---|---|---|---|
| 18 | 27 | 21 | 24 | < 0.01 ppm | < 0.01 |
| 19 | 38 | 25 | 29 | 0.01 ppm | 0.01 |


Photo 5:  Boxes on wood blocks

When the boxes were elevated, the rear exhaust slot drew the smoke under the boxes resulting in significantly less turbulence in front of the boxes and less reverse flow toward the mannequin.  Photo 6 shows the smoke sweeping under the boxes.

When the boxes were on the work surface, the smoke had a hard time to work its way around the boxes.  As shown in Photo 7, the smoke tended to billow out toward the mannequin.  The smoke indicated a way for the tracer gas to spill from the hood.

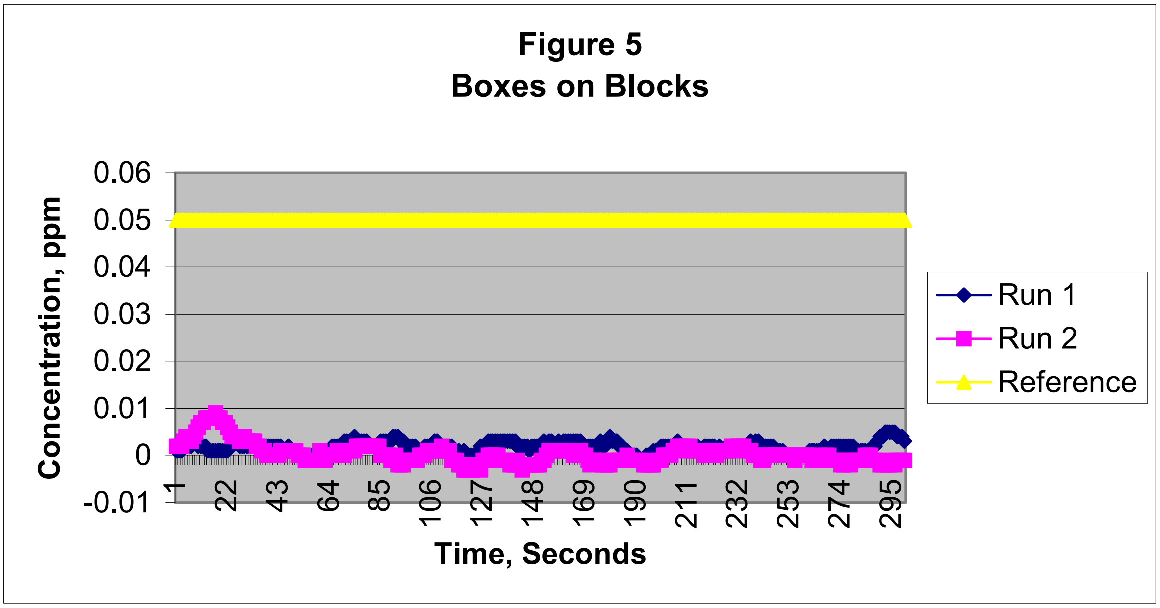



Photo 6: Smoke with the boxes on blocks

Photo 7: Smoke with the boxes on the work surface

These preliminary tests indicate the solid wall of the boxes pose a substantial blockage of the airflow. Just elevating the boxes appear to significantly change the results. Although the results are interesting, it does not explain the difference between the results with 4 lpm and 8 lpm. Possibly Fisher Hamilton can investigate this difference.

If you have any questions on these observations, please contact us.

Sincerely,

Gerhard W. Knutson, Ph.D., CIH
President