# DOES THROUGH-THE-WALL SENSING MEASURE AVERAGE FACE VELOCITY?

APPLICATION NOTE LC-103

*A discussion of how through the wall sensing works and how it ensures measurement and control of average fume hood face velocity.*



## Introduction

Knowing that through the wall (TTW) fume hood sensors like those used by TSI Incorporated in EVERWATCH® and SUREFLOW™ instruments make their measurement at a single point on the fume hood wall sometimes creates the perception that point face velocity is being measured rather than average face velocity. However, if you understand exactly how the TTW sensor works, you'll find that it is inherently sensitive to the average face velocity in the hood, assuming that the sensor is installed in the proper location. This discussion explains how the TTW sensor works and summarizes previous research conducted to determine the optimum sensor location.

## Is the TTW sensor an air velocity sensor or a pressure sensor?

It's true that the TTW sensor incorporates an air velocity transducer, but since the velocity of air past that transducer is determined by the pressure differential between the inside and outside of the hood, the TTW sensor is actually a pressure sensor. Think of it as an innovative pressure sensor that utilizes an air velocity transducer, thereby allowing for very sensitive pressure measurements at very low pressure differentials. Similarly, conventional pressure sensors utilize a strain gage internally. The problem with conventional pressure sensors is that they generally cannot make accurate measurements at the very low pressure differentials (typically near 0.001 inches $H_2O$) present in a typical laboratory fume hood.

## How can a sensor at one point on the side wall measure average face velocity?

Once you recognize that the TTW sensor actually measures pressure differential, you can see that the pressure differential across the TTW sensor is similar to the pressure differential across the face of the hood. It has to be, because we are comparing the pressure difference between the same two areas; inside and outside the hood.

One way to prove this is to observe the performance of a TTW sensor type hood controller using a portable air velocity meter. With the sash about half open, measure several locations around the face to make sure the average is about 100 ft/min (or whatever setpoint is being used). Now have someone stand directly in front of the hood, blocking some of the flow as if someone were working there. Measure the face velocity in several places on either side of the person. You'll find that the controller has sensed the change and made the necessary adjustment so that the air velocity through the remaining open space is maintained at 100 ft/min. The TTW sensor has reacted to the change in average pressure differential (i.e. average face velocity) and the adjustment has been made to compensate.

Changing the sash position has the same effect. The controller does not know if the change in pressure differential is due to a person or the sash. All it knows is that the face velocity has changed and an adjustment is needed.

## Similar pressure differentials

Note that a previous paragraph stated that the pressure differential across the face and the differential across the sensor are "similar", rather than identical. In fact, there is some difference, and this is the reason that TTW sensors must be individually calibrated after installation. These differences are due to the geometry of the hood and the resulting airflow characteristics within the hood.

Since the pressure differential across the face and at various locations along the side wall are not the same, it is necessary to locate the TTW sensor in such a way as to minimize that difference. The TTW sensor must be located at a point where the pressure differential through the side wall varies in a way that accurately matches the pressure differential across the hood face as it changes due to varying sash position. It is not necessary for the two differentials to be identical because any consistent difference can be easily "calibrated out" after installation.

## Where should a TTW sensor be located?

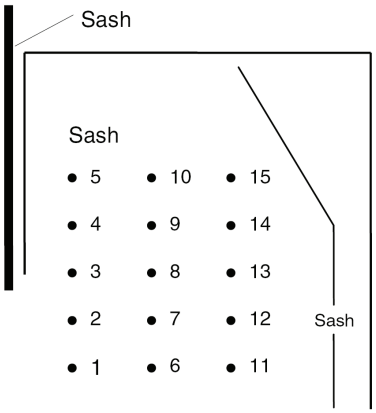


**Figure 1.**

| Differential Pressure Through Side Wall ($x10^{-2}$ mm Hg) | | | |
|---|---|---|---|
| **Sensor Location Index** | **Sash 33% Open** | **Sash 66% Open** | **Sash 100% Open** |
| 1 | 0.228 | 0.296 | 0.236 |
| 2 | 0.228 | 0.278 | 0.248 |
| 3 | 0.225 | 0.330 | 0.333 |
| 4 | 0.227 | 0.358 | 0.450 |
| 5 | 0.226 | 0.380 | 0.701 |
| 6 | 0.228 | 0.297 | 0.236 |
| 7 | 0.226 | 0.306 | 0.333 |
| 8 | 0.226 | 0.335 | 0.435 |
| 9 | 0.225 | 0.368 | 0.720 |
| 10 | 0.225 | 0.380 | 0.712 |
| 11 | 0.228 | 0.302 | 0.242 |
| 12 | 0.227 | 0.315 | 0.400 |
| 13 | 0.226 | 0.340 | 0.542 |
| 14 | 0.227 | 0.367 | 0.800 |
| 15 | 0.227 | 0.400 | 0.890 |
| Face velocity = 100 feet per minute for all sash openings | | | |

**Figure 2.**

Zhang and Agarwal studied the pressure differentials along the side wall of typical fume hoods at various sash positions. Their data, shown in Figures 1 and 2, was taken at 15 different locations on the side wall while the face velocity was maintained at a steady average of 100 feet per minute. Position number 2, (4 inches in from the sash and 4 inches down from the sash's full open position) was determined to provide the best performance because the pressure differential remained nearly constant at all sash positions. Figure 3 shows how a TTW sensor in position 2 performs at various sash positions.

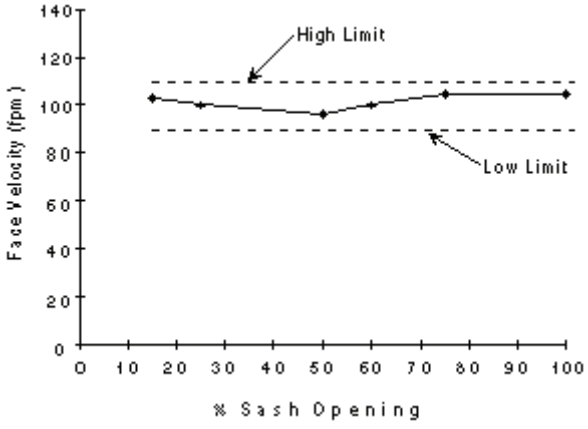


**Figure 3.**

## Calibrating a TTW sensor to measure average face velocity

As mentioned earlier, TTW fume hood sensors must be calibrated after installation to "calibrate out" the offset between the pressure differential across the face and the pressure differential across the sensor. This is done by measuring the actual face velocity and adjusting the controller to read the same value.

Average face velocity should be measured using ASHRAE Standard 110-1985 as a guide. Divide the hood face into imaginary rectangles approximately one foot square (see Figure 4) and measure the velocity at the center of each square using a portable air velocity meter. Sum the readings and divide by the number of squares to compute the average face velocity. TSI recommends that calibration be performed with the sash 60% open.

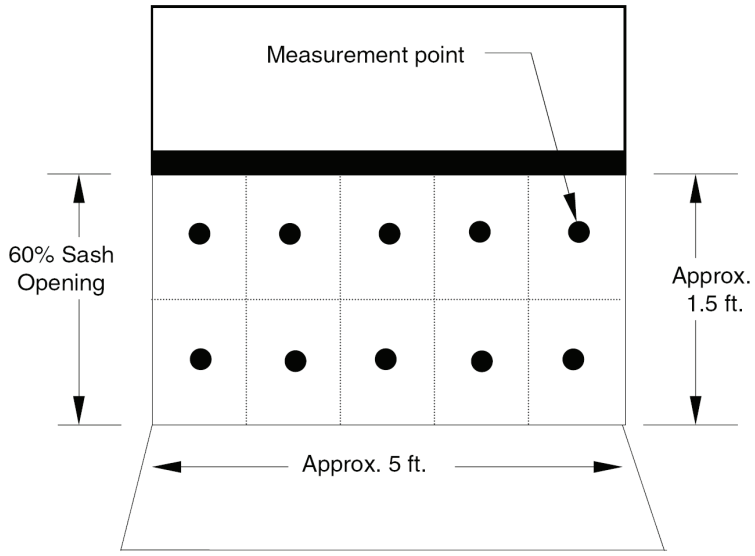


**Figure 4.**

## Summary

Through the wall (TTW) fume hood sensors like those used by TSI Incorporated in EVERWATCH® and SUREFLOW™ instruments are sensitive to average face velocity because they are actually pressure sensors. The pressure differential that drives the air across the hood face also drives air across the TTW sensor. When properly installed, the pressure differential across the TTW sensor matches the pressure differential across the face with an offset that is constant at any sash position. Precise measurement of face velocity is accomplished by "calibrating out" the constant offset after installation.

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