Fact Sheet No. 5

An Improved Laboratory Fume Hood Performance Test: Beyond Instantaneous Face Velocity

Traditional fume hood testing methods which employ the use of a handheld anemometer may yield incorrect and non-repeatable results. This new method of fume hood testing gives more accurate and repeatable results with less investigator-induced error. It also yields statistical data to measure fume hood turbulence.

FACTS:

Periodic performance evaluation of laboratory fume hoods is required by the OSHA lab standard. Most frequently, the performance evaluation test method chosen is a face velocity traverse using a handheld anemometer and the recording of instantaneous or short term (1-5 sec) average velocity readings at each traverse point. The mean of all these readings (the average face velocity) is then compared to the user's specifications and a determination of acceptable or unacceptable is made. Some advanced users also compute the standard deviation of the traverse readings to get an idea of the variation in the face velocity profile and compare this number to some threshold to determine acceptability or unacceptability. This calculation of standard deviation gives a representation of the variability of the face velocity from traverse point to traverse point but yields no information about the variability of the face velocity over time at each traverse point.

The ability of the laboratory fume hood to capture and contain hazardous fumes and vapors is often equated to its face velocity. Although average face velocity and containment efficiency are related under ideal conditions, *they are not the same.* Many fume hoods which meet a simple face velocity specification described above may be allowing worker exposure to the hazards used in them. These instantaneous tests ignore transient effects on the face velocity such as turbulence and interference from external sources such as supply air diffusers, doors and traffic on the hood. Is there a better test? Certainly, personal air sampling and analysis will yield the most accurate results, but it is extremely expensive and time consuming to sample each person at each hood for each possible species of chemical and is therefor impractical. ANSI Z9.5 American National Standard For Laboratory Ventilation[1] recommends ASHRAE-110 tracer gas containment testing for all fume hoods. This is excellent (and necessary) for a one time check to use after fume hood installation or modification, and to get a containment vs. face velocity baseline, but is probably overkill for annual use. This Fact Sheet describes an improved face velocity test and analysis method that gives more accurate results and more valuable information than the traditional instantaneous multi-point face velocity traverse does.

The improved test described here involves real-time data acquisition of velocity data at each traverse point and the use of statistical process control techniques to give more accurate picture of fume hood performance through the use of modified control charts and upper and lower velocity control limits. ❑

LIMITATIONS:

There are three problems inherent in the traditional instantaneous multi-point face velocity traverse. The first is investigator induced error caused by improper location, orientation or movement of the velocity probe during the traverse. The second is instrument reading error caused by having to guess at the mean velocity when using an analog instrument and watching the needle bounce back and forth, or choosing the wrong reading to sample or record from the changing display when using a digital instrument. The third is lack of velocity versus time data for each traverse point from which to draw a more complete picture of the variation related performance of the hood. ❑

A BETTER WAY:

The improved test is performed using a hot-wire type velocity transducer that produces an analog signal proportional to the air velocity at the probe. This signal is used as the input to a data acquisition system which performs signal conditioning and analog to digital conversion. This digital data is then scaled and offset to produce velocity data in engineering units and then collected using a computer for analysis.

Investigator induced error caused by improper location, orientation or movement of the velocity probe during the traverse is reduced or eliminated by clamping the velocity transducer to a ring stand or other stationary device that can be accurately positioned in the plane of the sash opening of the hood. Instrument reading error is eliminated by having the computer read the output of the instrument. The problem of lack of velocity versus time data is eliminated by programming the system to accumulate velocity readings over a reasonable time period of 30-60 seconds per traverse point.

The velocity probe is positioned at the desired traverse point in the plane of the hood opening and data is accumulated. The probe is then moved to another location until the entire sash opening has been surveyed. It is recommended that the sash opening be divided into a grid of approximately one foot (30 cm) dimensions and the probe placed in the center of each grid box. Smaller grids will produce a more accurate average but this is more time consuming. Hoods with poor velocity profiles (i.e., large deviations of the mean velocity across the sash opening) may require a smaller grid (additional traverse points) to accurately describe the hood performance. ❑

STATISTICS:

There are three standard deviation calculations that describe fume hood velocity data.

The first, *standard deviation of the traverse point means* (S_{MEANS}), describes the variation of the velocity profile across the face of the hood. This number may be calculated using the data from both the traditional and the improved methods and can be used to quantify changes made in the baffles, equipment placement in the hood, duct arrangement (for multiple takeoff hoods), etc. Optimization of the hood should include modifications or changes designed to reduce this number that will improve or even out the velocity profile of the hood.

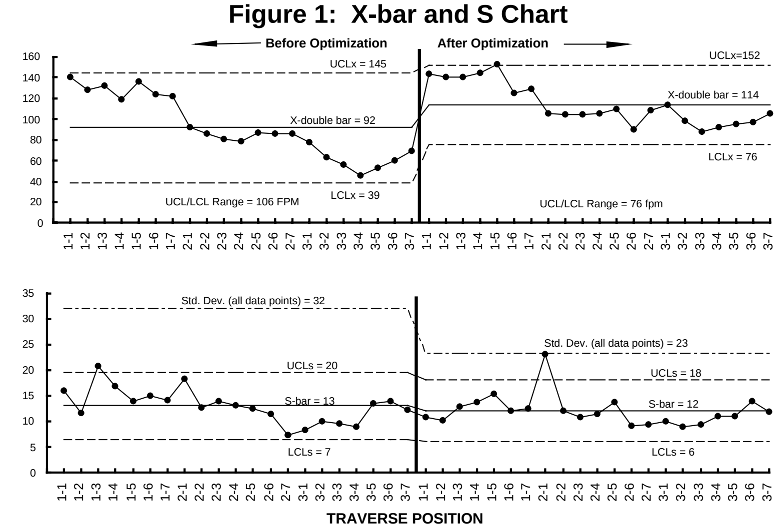
The second, *mean of the standard deviations of the traverse points* (S_{POINT} or S in Figure 1), can only be calculated using the velocity/time data available from the improved method. It describes the variability of the face velocity over time and can be interpreted as a measure of the turbulence of the hood. Optimization of the hood should include modifications or changes designed to reduce this number that will improve the performance of the hood by producing a more laminar flow into the hood face.

The third standard deviation number, the *standard deviation of all velocity data* (S_{ALL}), likewise can only be calculated using the velocity/time data available from the improved method. It describes the aggregate variability of the fume hood face velocity and represents both variability from position to position and velocity variation over time. It can be used to compute upper and lower control limits for this "process" as shown in Figure 1. ❑

CONTROL CHARTING:

Applying statistical process control techniques to fume hoods is similar to applying them to other processes except that traditional control charts use time as the X-axis variable and a fume hood control chart uses the traverse point positions on the X-axis. Traditional control charts track process performance over time while a fume hood control chart shows a snapshot of the fume hood performance at the time the fume hood evaluation was performed, therefore the standard guidelines for interpreting the results of these control charts and determining whether a hood is in or out of statistical control cannot be used here. The results of two or more evaluations, however, may be displayed on the same control chart as in Figure 1. to show a before and after picture of a hood that was optimized or modified. A detailed description of the control charting method is beyond the scope of this fact sheet but may be found in any standard TQM or SPC textbook. Other methods of graphical representation of fume hood data are also possible. Contact H-A for details. ❑

Figure 1: X-bar and S Chart



CONCLUSION:

Traditional face velocity testing using handheld anemometers frequently yields incorrect results due to investigator induced errors. Face velocity testing and maintaining a specific face velocity does not assure fume hood containment. ASHRAE 110 testing should be performed on all new and existing fume hoods and hoods and fume hood exhaust systems that have been modified. This assures industry standard containment and leakage rates and established a relationship between containment and face velocity. Periodic fume hood testing should then be done using a method, like the one described herein, which yields accurate, repeatable, and statistically significant results. Hitchings Associates can provide complete fume hood testing, reporting, documentation and training services to meet your needs.

REFERENCES:

[1]American Industrial Hygiene Association. 1992. ANSI/AIHA Z9.5-1992: *American National Standard for Laboratory Ventilation.* Fairfax VA: American Industrial Hygiene Association.

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