The Low Constant Volume Cupboard: How Low Is Safe?

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Approximately one year ago, St Charles published research on a newly configured low constant volume fume cupboard with a significantly reduced extract volume and improved containment.

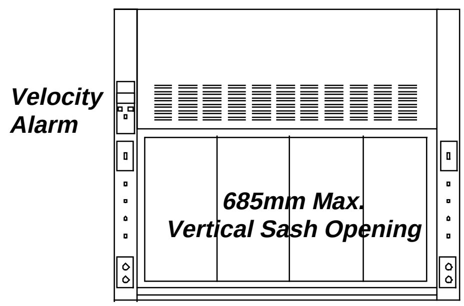
The low constant volume (LCV) fume cupboard is an approach to fume extraction involving a constant extract volume through a reduced sash opening (figure 1). On the Aero 2000 LCV, this reduced sash opening can either be achieved by Opening the special combination sash vertically up to 38Omrn or by sliding the horizontal panels open up to 850mm on a 2,000mm fume cupboard.

At these sash positions (approximately 50% open) one can reduce extract volume by 50% over a fully open fume cupboard and still have O.5Om/s face velocity.

Reduced extract volume can substantially reduce building energy costs[2] and can also be advantageous if additional fume cupboards need to be added to an existing floor plan without expensive expansion of the room make-up air system.

The containment of an 1800 mm fume cupboard tested in the earlier study (Phase 1) was surprisingly good, even when the sash was vertically opened 100% to 685mm with a resultant face velocity of .25 m/s. Based on this successful test, we decided to undertake "additional studies testing the "lower limits" of exhaust under which this particular design will produce containment under all reasonable challenges".[1]

Figure 1



Extract Volume

	At 0.50 M/S	At 0.40 M/S
Standard 2000mm Fume Cupboard	700 L/S	560 L/S
Prototype (Open 50%)	307 L/S	246 L/S

Figure 2

Placement of Diffuser & Manikin ASHRAE 110 1985 Test

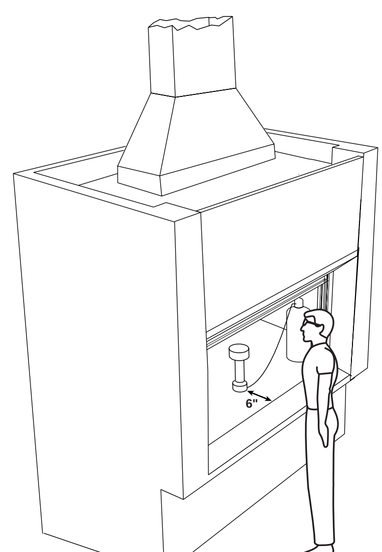
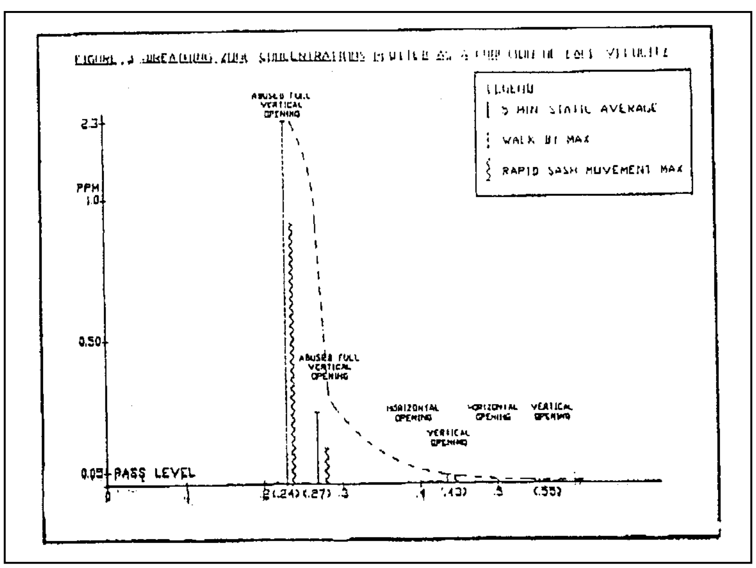


Table I. Phase II Test Results for 2,000 mm Aero 2000 LCV Fume Cupboard									
Test #	***Vertical Sash Position***	***Horizontal Sash Position***	***Manikin Position***	***Face Velocity***	***Extract Volume***	***5 Min ASHRAE Avg.***	***5 Min ASHRAE Max***	***Walk-by Max***	***Sash Movement Max***
A1	Closed	Left	Left	0 .50m/s	307l/s	0.000ppm	0.001ppm	0.000ppm	0.000ppm
A2	Closed	Middle	Middle	0.50m/s	307l/s	0.000ppm	0.000ppm	0.010ppm	0.000ppm
A3	Closed	Right	Right	0.50m/s	307l/s	0.000ppm	0.006ppm	0.000ppm	0.000ppm
A4	343mm	Closed	Left	0.55m/s	307l/s	0.002ppm	0.003ppm	0.008ppm	0.000ppm
A5	343mm	Closed	Middle	0.55m/s	307l/s	0.000ppm	0.001ppm	0.000ppm	0.000ppm
A6	343mm	Closed	Right	0.55rn/s	307l/s	0.001ppm	0.017ppm	0.020ppm	0.009ppm
A7	685mm	Closed	Left	0.27m/s	307l/s	0.003ppm	0.007ppm	0.390ppm	0.015ppm
A8	686mm	Closed	Middle	0.27m/s	307l/s	0.000ppm	0.004ppm	0.003ppm	0.001ppm
A9	685mm	Closed	Right	0.27l/s	307l/s	0.000ppm	0.008ppm	0.120ppm	0.230ppm
B1	Closed	Left	Left	0.40m/s	246l/ s	0.000ppm	0.003ppm	0.000ppm	0.010ppm
B2	Closed	Middle	Middle	0.40m/s	246l/s	0.000ppm	0.004ppm	0.010ppm	0.005ppm
B3	Closed	Right	Right	0.40m/s	246l/ s	0.000ppm	0.008ppm	0.005ppm	0.015ppm
B4	343mm	Closed	Left	0.43m/s	246l/s	0.00ppm	0.003ppm	0.000ppm	0.000ppm
B5	343mm	Closed	Middle	0.43m/s	246l/s	0.000ppm	0.005ppm	0.010ppm	0.030ppm
B6	343mm	Closed	Right	0.43m/s	246l/s	0.000ppm	0.006ppm	0.045ppm	0.003ppm
B7	685mm	Closed	Left	0.24m/s	246l/s	0.000ppm	0.007ppm	2.298ppm	0.000ppm
B8	685mm	Closed	Left	0.24m/s	246l/s	0.000ppm	0.000ppm	2.294ppm	2.100ppm
B9	685mm	Closed	Left	0.24m/s	246l/s	0.000ppm	0.009ppm	2.300ppm	0.700ppm

In early September, 1994 St Charles began this additional containment testing of a slightly larger 2,000mm fume cupboard. This larger size was selected for Phase II testing because our research on other projects showed a 2,000mm width fume cupboard posed more aerodynamic design challenges than the narrower 1,800 mm width.

Phase l of our LCV fume cupboard testing was run at a face velocity of 0.50m/s at 50% open. Phase II repeated all Phase I tests with the wider 2,000mm model. In addition, a second series of tests was run at O.4Om/s face velocity. Using these additional data, we hoped to gain an insight into how much face velocity could be lowered and still achieve an acceptable margin of safety.

The test method used in both Phase I and Phase II is ANSI/ ASHRAE 110-1985.[4] This test places a manikin in the plane of the fume cupboard frame with an air analyzer in the breathing zone (Figure 2). For the purposes of this study, a diffuser releasing four liters per minute of pure sulfur hexafluoride gas was placed 150rnm behind the sash plane. The air analyzer used was a Miran 1A infrared spectrophotometer set at a wavelength of 10.68 microns. Total test time was eight minutes.



During the first five minutes, no motion was present near the test cupboard. During the sixth minute, four complete side by side walk-bys were undertaken by the researcher directly behind the manikin at a walking speed of 1.25 m/s. During the seventh minute, the sash was closed. At the beginning of minute eight the sash was reopened to its original position in less than one second.

A total of eighteen tests were run using two different extract volumes, nine different sash orientations and three different manikin locations. Actual data are summarized in Table 1.

Table I highlights in bold type all test data revealing unsatisfactory containment. The researcher took 0.05ppm of sulfur hexafluoride in the manikin breathing zone as a threshold value for containment failure.

The reader will note all tracer gas concentrations in the manikin breathing zone to be low with the

TABLE I LCV SASH ABUSE CONSEQUENCES

OPERATING CONDITION	*Containment under operating conditions			Containment under sash abuse		
	5 min avg.	Walk by	Rapid sash Movement	5 min avg.	Walk-by	Rapid sash Movement
1) .5O M/S AT 50% OPEN	P	P	P	P	F	F
2) .40 M/S AT 50% OPEN	P	P	P	P	F	F

* P=Pass, or ≤ 0.05ppm sulfur hexafluoride in manikin breathing zone in all trials
F=Fail , or ≥ 0.05ppm sulfur hexafluoride in manikin breathing zone in any trials

exception of rapid sash movement and walk-bys for the fully opened fume cupboard sash at correspondingly low face velocities.

The eighteen sets of data set forth in Table 1 are further condensed in Table II. No difference in performance exists on this table between .5Om/s face velocity performance and .40m/s performance. In both' cases excellent containment is achieved when the fume cupboard sash is properly set and unacceptable results are obtained when the sash is opened completely and rapid walk-bys or sash movement takes place.

One final condensation of the data in Table I is offered to further clarify the results of this Phase II study. In Figure 3, data for containment of each type of sash opening is plotted versus face velocity.

Each data line records either five minute average breathing zone concentration, walk by max, or rapid sash movement max for a particular sash type at the indicated face velocity.

The precipitous decline in containment performance between .4m/s and .27m/s face velocity is highly demonstrative of the fact that face velocity appears to be the defining behavioral variable for this type of fume cupboard's performance, at least at face velocities of .50m/s and lower.

These data can now be applied to the original research purpose of seeking a minimum face velocity at which reasonable fume containment can occur:

1. A face velocity of .4m/s appears to offer the same containment performance as .5m/s on the Aero 2000 LCV fume cupboard.
2. On this design of LCV fume cupboard, a certain amount of sash abuse appears to be tolerable. Average containment under static conditions is retained, even at a face velocity of 0 .24m/s.
3. The same types of movement around tile fume hood face, rapid sash movement and walk-bys, cause loss of containment under sash abuse conditions whether the fume cupboard is set at .50m/s or .40m/s half open.
4. Given the data as displayed in Figure 3, face velocity appears to be the variable most closely linked to fume cupboard containment. The data reconfirms that lower face velocities produce containment loss in the presence of kinetic disturbances.
5. The data strongly support some "means of preventing sash position abuse, particularly in the presence of movement of the sash or lab personnel.

A velocity alarm designed to alert the user whenever fume cupboard face velocity drops below 0.4m/s can be used to accomplish this end.

While additional research may provide further insights into safe fume cupboard face velocities, additional reductions below .4rn/s at 50% sash opening appear unlikely to yield safe operating conditions. Reducing the permitted opening size lower than 50% generally makes the fume cupboard difficult to use and this study demonstrates unreliable containment at any sash configuration setup that yields face velocities below 0.27m/s when the sash is fully opened.

REFERENCES

1. Haugen, R.: "The Low Constant Volume Fume Cupboard: Evaluating a New Prototype", *International Labmate*, December, 1993.

2. Lynch, J. R.: "Study Shows How to Select Lab Floods to Cut Cooling Costs", *Heating Piping and Air Conditioning*, January, 1967.

3. Andrews' R.: "Researchers are Breathing Easier, *The Scientist*, July 8, 1991.

4. American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. "Method of Testing Performance of Laboratory Fume Hoods; ANSI/ASHRAE 110-1985", 1985.