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CONTAINMENT TESTING OF INSTALLED LABORATORY FUME HOODS

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ABSTRACT

54 fume hoods in three laboratory buildings in Norway were tested for containment using two tracer methods based on European and American standards, in addition to face velocity measurements. In the first method, an abridged version of Nordtest VVS 095, tracer gas was measured at one point in the sash opening, in front of a mannequin placed at the fume hood with a sash height of 30 cm. In the second method, based on ASHRAE 110-1995, tracer was measured in the breathing zone of the mannequin for a 67 cm sash height. The results demonstrated that fume hoods with low face velocities (< 0.3 m/s) have a high probability of exhibiting poor containment of tracer gas, while those with high face velocities (≥ 0.5 m/s) generally exhibit good containment. Fume hoods with face velocities in the range 0.3 – 0.49 m/s yielded a roughly even mixture of good and poor containment values. In this velocity range, which included more than half of the fume hoods tested, face velocity cannot be used as an indicator of containment performance, as measured by the tracer tests.

KEYWORDS

Fume Hood, Tracer Testing, Laboratory Safety

INTRODUCTION

Numerous studies have shown that face velocity testing alone is a poor indicator of containment in installed laboratory fume hoods. Recent examples are Maupings and Hitchings (1998) and Greenley et. al. (1999). Fume hoods with low face velocities can often exhibit better containment of tracer gas than hoods with higher face velocities. Face velocity testing is, however, fast and economical and is subsequently, in many countries, the only routine method of assessing fume hood performance. A more realistic measure of containment (from tracer testing, for example) is obviously important from a safety standpoint, but also has value economically. Fume hoods are expensive to own and operate and decisions regarding their use and/or replacement should optimally be based on an accurate measure of performance. Though tracer testing of containment has been reported in the literature for over twenty years, routine use of this technique, with a few notable exceptions, has not caught on. This is probably due in large measure to the prohibitive cost and complexity of procuring the equipment and carrying out a tracer containment test on each and every fume hood in use in a laboratory.

This study presents results from containment testing of 54 fume hoods in three laboratory buildings in Norway. The goal of the study was to develop a fast and economical tracer test suitable for routine fume hood evaluation and to investigate the dependence of the result on the way in which the containment testing is performed. The fume hoods were evaluated using two abridged tracer methods based on European and American standards, in addition to face velocity measurements.

TEST PROCEDURES

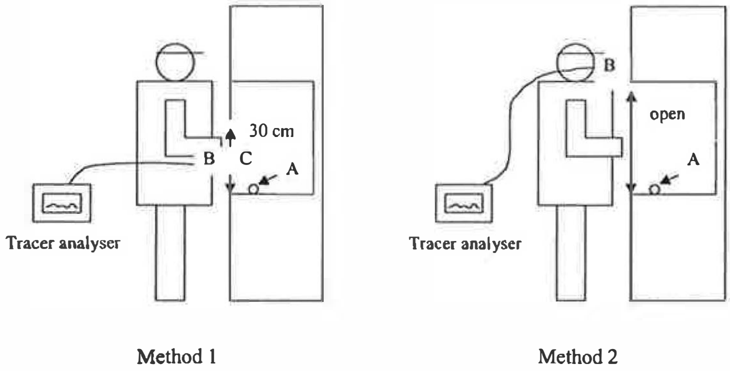

Figure 1 – Schematic of test set-up for the two containment test methods used in this study. Tracer gas was released at point A and measured at point B. Face velocity was measured at point C for both methods (sash height 30 cm and without mannequin in front of hood).

A schematic of the set-up for the two test methods is shown in Figure 1.

Tracer concentrations were measured with an URAS-3G infrared gas analyser with nitrous oxide (N_2O) as the tracer gas. The instrument has a reported detection limit < 0.15 ppm and a response time of 3 seconds. In practice, we found that the detection limit for this type of testing 0.25 ppm. Face velocities were measured with a Disa 54N50 low velocity transducer with a measurement accuracy of 0.05 m/s. All face velocities were measured at a height of 15 cm above the fume hood bench with a 30 cm sash height.

In all trials, nitrous oxide was released at a constant rate of 160 l/h through a perforated spreader placed on the fume hood bench 150 mm from the hood face. Tracer was released for one minute before, and then during a 6-minute measurement period in which the maximum observed tracer concentration was recorded. The tracer release was then shut off until the next test.

The mannequin used in the tests is described in detail in Nordtest VVS095. The mannequin is motorised and moves its arms back and forth horizontally over the spreader to simulate a technician working at the fume hood.

Method 1 was based on Nordtest VVS095, a Scandinavian standard developed for type testing of fume hoods. Nordtest VVS095 prescribes tracer measurements at nine points in the plane of the hood sash with the tracer release at various heights in the hood and for different sash heights. For simplicity, tracer concentrations in this study were measured at one position, at a height of 15 cm in the plane of the sash in front of the mannequin, with a sash height of 30 cm.

Method 2 was loosely based on ASHRAE 110-1995. Tracer concentrations were also measured at one point, in the breathing zone of the mannequin, with the detector probe 75 mm from the front of the sash. The sash height was raised to 67 cm to represent maximum design height for the method 2 measurements.

RESULTS AND DISCUSSION

Plots of maximum tracer concentration vs. face velocity for method 1 and method 2 are shown in Figures 2 & 3 respectively. Tracer concentrations are represented on a logarithmic scale to facilitate viewing of the data. Results from the two figures are summarised in Table 1, where the fume hoods are divided into three groups based on the face velocity measurements. The table lists the number of fume hoods in each of the three velocity groupings and the number in which the maximum tracer concentration exceeded 1 ppm for both method 1 and method 2. 1 ppm is used here as an example of a control value for a fume hood in a containment test (Neither VVS095 nor ASHRAE 110-1995 define control values for containment). For fume hoods with the lowest face velocities (< 0.3 m/s), maximum tracer concentrations are almost uniformly over 1 ppm. Conversely, maximum concentrations are generally under 1 ppm for fume hoods with the highest face velocities (≥0.5 m/s). From Figures 2 and 3 it is clear that fume hoods with face velocities in the range 0.3 – 0.49 m/s exhibit a considerable spread in containment performance.

Maximum tracer concentrations with method 1 vs. method 2 are shown in Figure 4. Again, by defining a control value of 1 ppm in a tracer containment test, Figure 4 can be used to examine to what degree the two methods give a similar result in evaluating a fume hood's performance. The figure is divided into four regions by the 1 ppm line on the two graph axes (denoted by '3' on the log (1000 * concentration) scales. Data points in region I in the figure represent fume hoods that pass in both tests. Conversely, points in region III represent hoods that fail in both containment tests. Data points in regions II and IV represent fume hoods that pass in one of the tracer containment tests and fail in the other. Figure 4 reveals that for many of the fume hoods in the study, the choice of test method could be important for deciding whether the hood passes or does not pass a containment test. Point A in region IV is an example. For this fume hood, the highest concentration measured with method 1 was 0.25 ppm while method 2 yielded a maximum tracer concentration of 15 ppm. This is not necessarily surprising considering the two tests employ different sash heights.

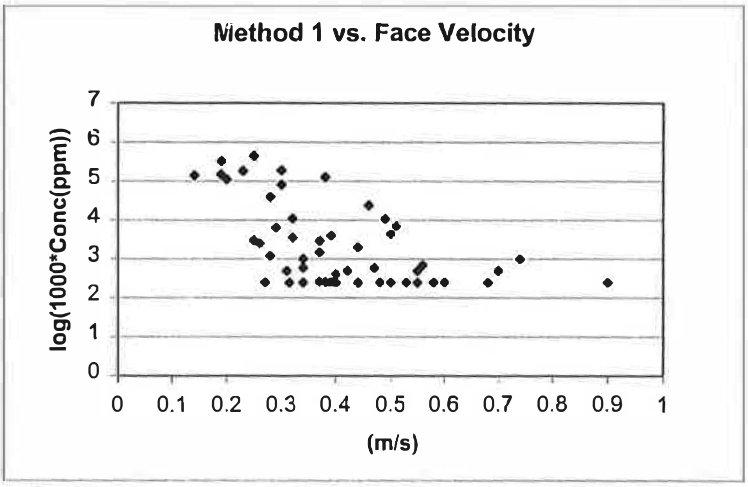

Figure 2 – Method 1 maximum tracer concentration vs. face velocity

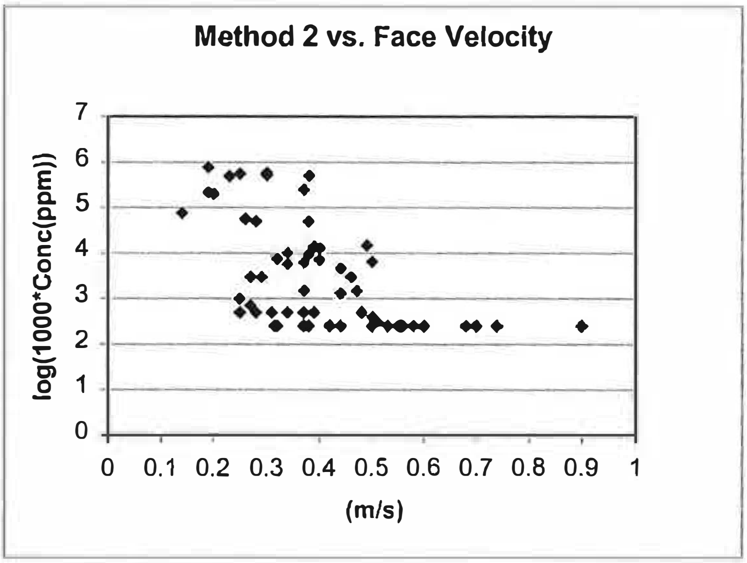

Figure 3 – Method 2 maximum tracer concentration vs. face velocity.

TABLE 1
FACE VELOCITY AND TRACER CONCENTRATION DISTRIBUTION OF FUME HOODS TESTED IN STUDY

Face velocity	Number of hoods	Number with concentration > 1 ppm Method 1	Method 2
<0.3 m/s	12	11	11
0.3 – 0.49 m/s	27	12	17
≥0.5 m/s	15	3	1

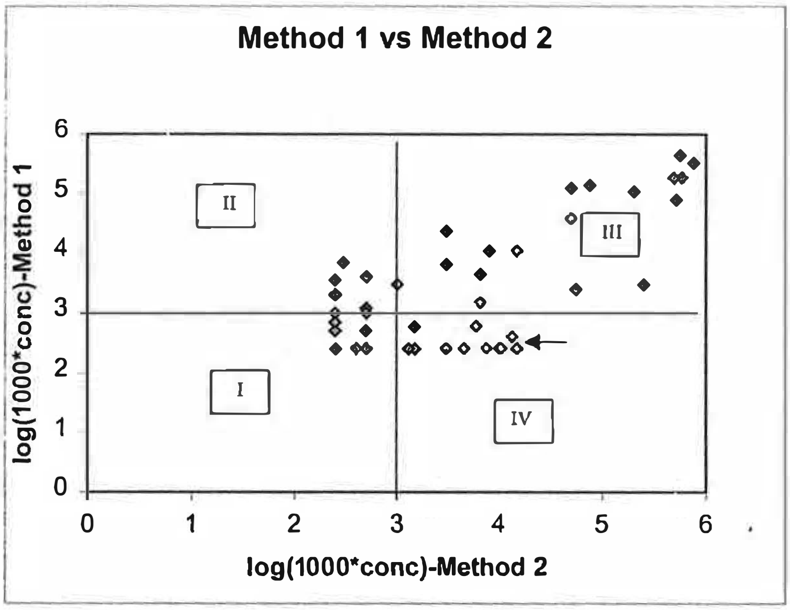

Figure 4 – Comparison of maximum tracer concentrations measured in fume hoods with method 1 and method 2.

CONCLUSIONS

The results from this study demonstrate that fume hoods with low face velocities (< 0.3 m/s) have a high probability of exhibiting poor containment of tracer gas, while those with high face velocities (≥ 0.5 m/s) generally exhibit good containment. Fume hoods with face velocities in the range 0.3 m/s – 0.49 m/s yielded a roughly even mixture of good and poor containment values. In this velocity range, which included more than half of the fume hoods tested, face velocity cannot be used as an indicator of containment performance, as measured by the tracer tests. Choice of test method can also be an important factor when evaluating containment performance. It is therefore advisable to employ a testing method that most closely simulates the actual working conditions in the hood.

An interesting point here is that the limited results of the study support the notion that face velocities ≥ 0.5 m/s can in most cases be equated with good containment. However, the majority of the installed fume hoods tested in the study had face velocities less than 0.5 m/s (with a 30 cm sash height) and the industrial hygienists in the test-buildings were aware of this, but the hoods were in regular use anyway out of necessity. It is here in particular that routine tracer containment testing could have great value, both for exposing fume hoods that really should be taken out of service and for identifying hoods that exhibit good containment despite lower-than-recommended face velocities.

ACKNOWLEDGEMENTS

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