Challenges in Adopting ACGIH's TLV for Hexavalent Chromium

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Background

Hexavalent chromium has a long documented history as a material hazardous to human health. As such, it is governed by an OSHA PEL and a recommended TLV from ACGIH

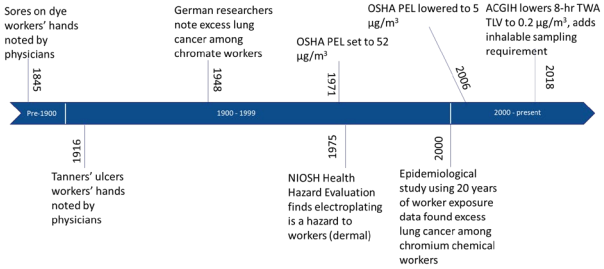


Figure 1. Timeline of key events in the history of hexavalent chromium and human exposure

ACGIH's recent adoption of a new hexavalent chromium TLV poses some challenges for an industrial hygienist, including the dramatic lowering of the exposure limit and additional requirement to sample for the inhalable fraction. In order to get sufficient mass on a filter to exceed a laboratory's LOD, it has been suggested that the IOM sampler (SKC Inc.) flowrate be increased.

The goal of this research was to determine if increasing the IOM sampler operating flowrate from 2 L/min to 6 L/min would result in a statistically significant difference in reported mass concentrations.

Methods

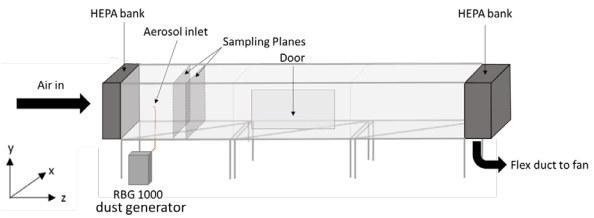


Figure 2. Aerosol exposure chamber for side-by-side IOM experiments

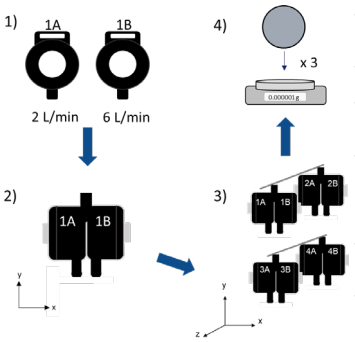


Figure 3. Experiment workflow

- Experiments took place in a previously characterized 21' x 3' x 3' aerosol exposure chamber (Figure 2).
- IOM capsules were pre-weighed in triplicate.
- Two IOMs were paired back-to-back. One was assigned a flow rate of 2 L/min and the other 6 L/min.
- For each run, four pairs of IOMs were exposed to Arizona Road Dust with a mass median aerodynamic diameter of 70 µm for 90 minutes. Ten runs were executed in total (Figure 3).
- Post-experiment: the samples were equilibrated and each capsule weighed in triplicate.
- The mass concentration per IOM was calculated and the difference in concentration between pairs compared.

Potential Sources of Systemic Bias

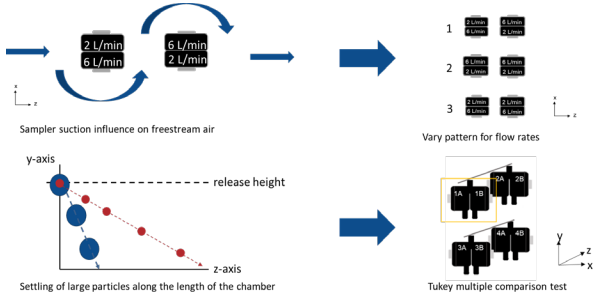


Figure 4. Two scenarios identified as potential sources of bias

The mass deposited on the filters was so small that it was imperative that sources of bias be controlled to ensure any differences detected were due to the operation of the IOM at a different flow rate from design (Figure 4).

Of primary concern was the effect of flow pattern on the overall free airstream and the effect of position on the sample apparatus.

Results

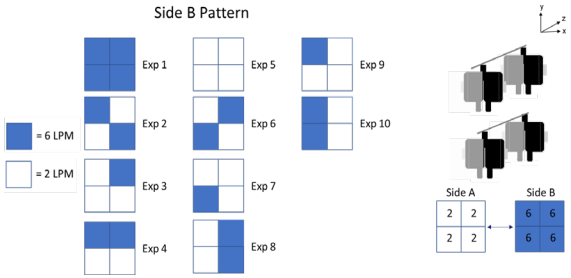


Figure 5. Flow patterns for 10 experiments to avoid bias from sampler suction on the free airstream

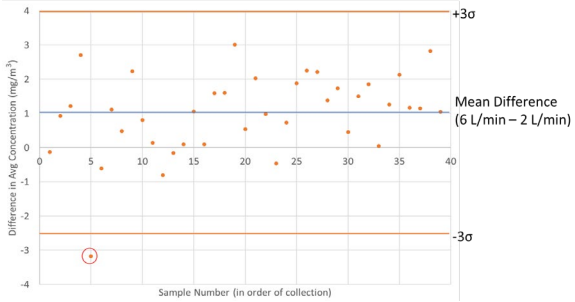
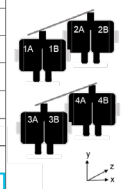


Figure 6. Control chart for the difference between each pair of IOMs.

The flow pattern for the IOMs were varied for each experiment (Figure 5). When the differences between paired samples were plotted, no correlation or trend was observed, suggesting that flow pattern did not influence the results.

Results (continued)

	1A	1B	2A	2B	3A	3B	4A	4B
1A		0.285	0.900	0.789	0.001*	0.001*	0.175	0.064
1B			0.764	0.900	0.479	0.310	0.900	0.900
2A				0.900	0.013*	0.005*	0.626	0.358
2B					0.071	0.033*	0.900	0.730
3A						0.900	0.560	0.812
3B							0.383	0.643
4A								0.900
4B								



*show p-values that indicate a significant difference exists

Figure 7. Tukey multiple comparison test of position in test apparatus

When the ANOVA indicated a significant difference in one of the positions, the Tukey test was conducted to determine if the difference was among pairs (i.e., 1A vs 1B) (Figure 7). The result showed no differences in paired locations, so a one-tailed paired t-test was conducted.

	6 LPM	*2 LPM*
Mean	2.586	1.476
Variance	0.934	0.525
Median	2.472	1.389
Geometric Mean	2.417	1.294
Geometric Standard Deviation	1.457	1.722
Observations	38.000	38.000
Pearson Correlation	0.370	
Hypothesized Mean Difference	0.670	
df	37.000	
t Stat	2.794	
P(T<=t) one-tail	0.004	
t Critical one-tail	1.687	
P(T<=t) two-tail	0.008	
t Critical two-tail	2.026	

Figure 8. Tukey multiple comparison test of position in test apparatus

The t-test revealed a 30% positive bias for the 6 L/min mass concentrations compared to their 2 L/min counterpart.

Conclusions

When using a polydisperse aerosol, IOM samplers operating at 6 L/min reported mass concentrations 30% higher than their 2 L/min counter parts.

This positive bias may increase Type II error in an industrial hygienist's analysis which may, in turn, drive unnecessary PPE requirements.

This high-flow technique has potential as a screening tool for workplaces were it is desirable to demonstrate no hexavalent chromium is present in the observed process.

Future Work

- Repeat the study under a greater range of freestream air velocity to encompass more types of workplaces.
- Conduct experiments with monodisperse aerosols to determine where the departure from the inhalable convention occurs.

Selected References

- Steward, J., Sleeth, D. K., Handy, R. G., Pahler, L. F., Anthony, T. R., Volckens, J. *Assessment of increased sampling pump flow rates in a disposable, inhalable aerosol sampler.* J Occup Environ Hyg. 14(3), pp 207-213. (2017).
- Steele, M. Aerosol Test Chamber Characterization. AFIT-ENV-MS-20-M-242. (2020).
- Zhou, Y., Cheng, Y.S. *Evaluation of IOM Personal Sampler at Different Flow Rates.* J. Occup. Environ. Hyg. 7(2), pp 88 – 93. (2009)