

# Dosimetric Analysis of Aerosol Generated by a Vitrocell® VC10® Smoking Robot – Investigations on Dose Dependency and Consistency of Application

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## Abstract

Quartz Crystal Microbalances (QCMs) were used to assess the suitability of the Vitrocell® VC10® exposure system. The main objective of the study was to deliver smoke aerosol in a consistent and dose dependent manner across a range of module formats. Dose resolving power, uniformity of deposition within the module, and repeatability across experiments were all assessed by the application of the 3R4F aerosol after dilution with clean air at flow rates of 10, 8, 4 and 1 SLPM (n=3). Twelve 3R4F were smoked per experiment according to the HCI Smoking regimen (Health Canada Test method T-115). Exposure duration in the system was 66 minutes. Vitrocell® Ames 4, 6/4, 12/4 and 24/4 exposure modules were assessed.

The ability to resolve statistically significant differences between the 8, 4 and 1 SLPM dilution levels was observed across all modules in the test, however none of the module formats were able to detect a significant difference between dilution rates between 10 and 8 SLPM.

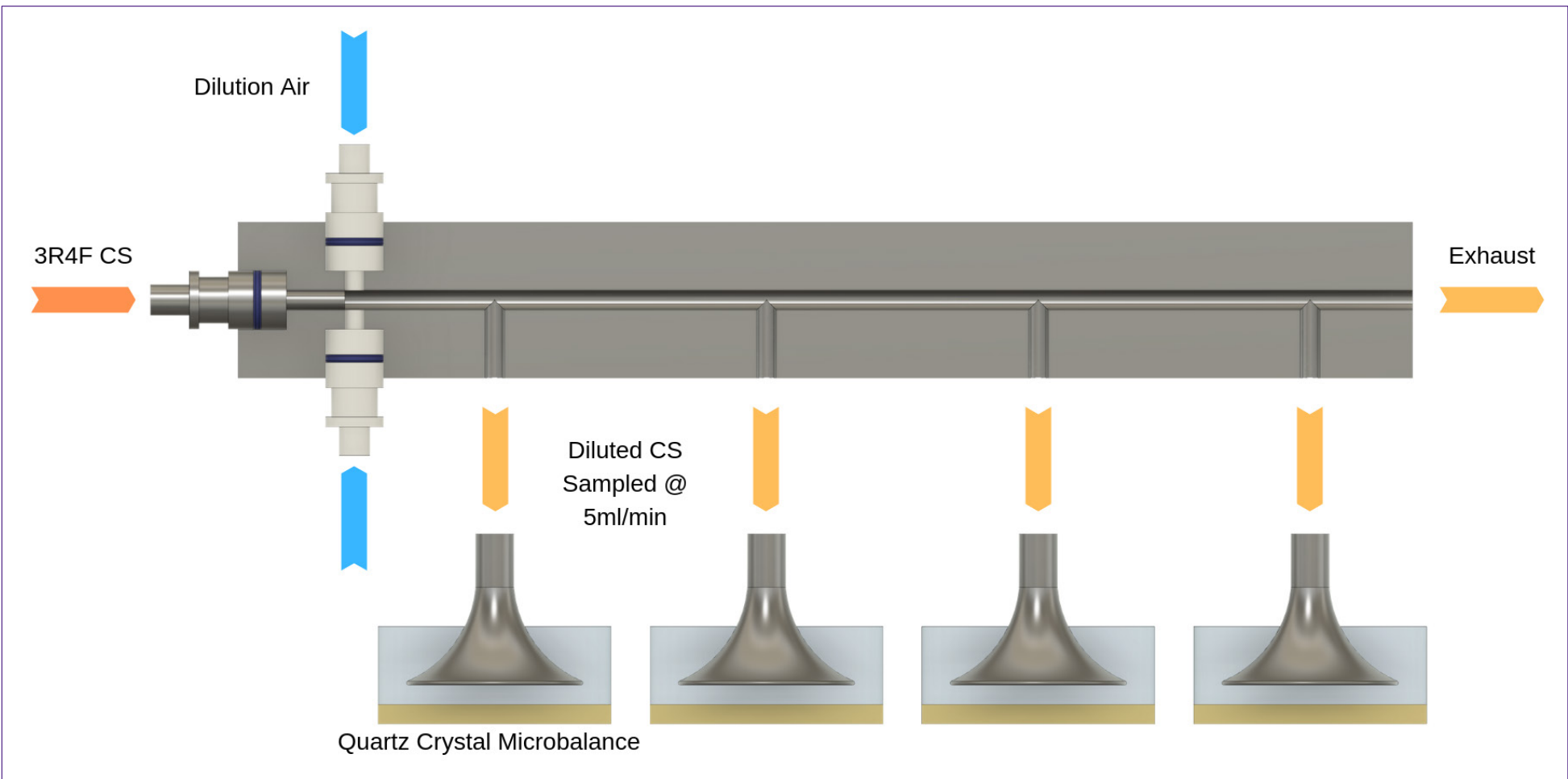
Uniformity of deposition within the module was assessed on a per experiment basis and found to have no significant differences and high reproducibility (adjusted P >0.98) in all module formats tested and across the full range of airflows.

Repeatability was assessed per airflow over three experiments and showed no significant difference at airflows of 10, 8 and 4 SLPM, however a significant difference between experiments was found in 9 out of 12 cases at 1 SLPM airflow.

Our assessments show that the Vitrocell® VC10® is capable of delivering cigarette aerosol in consistent and dose dependent manner. However, it was found that resolution of small differences in dose (particularly at higher dilution rates) is critical and therefore at low dilution rates variability of deposition should be expected on a per experiment basis.

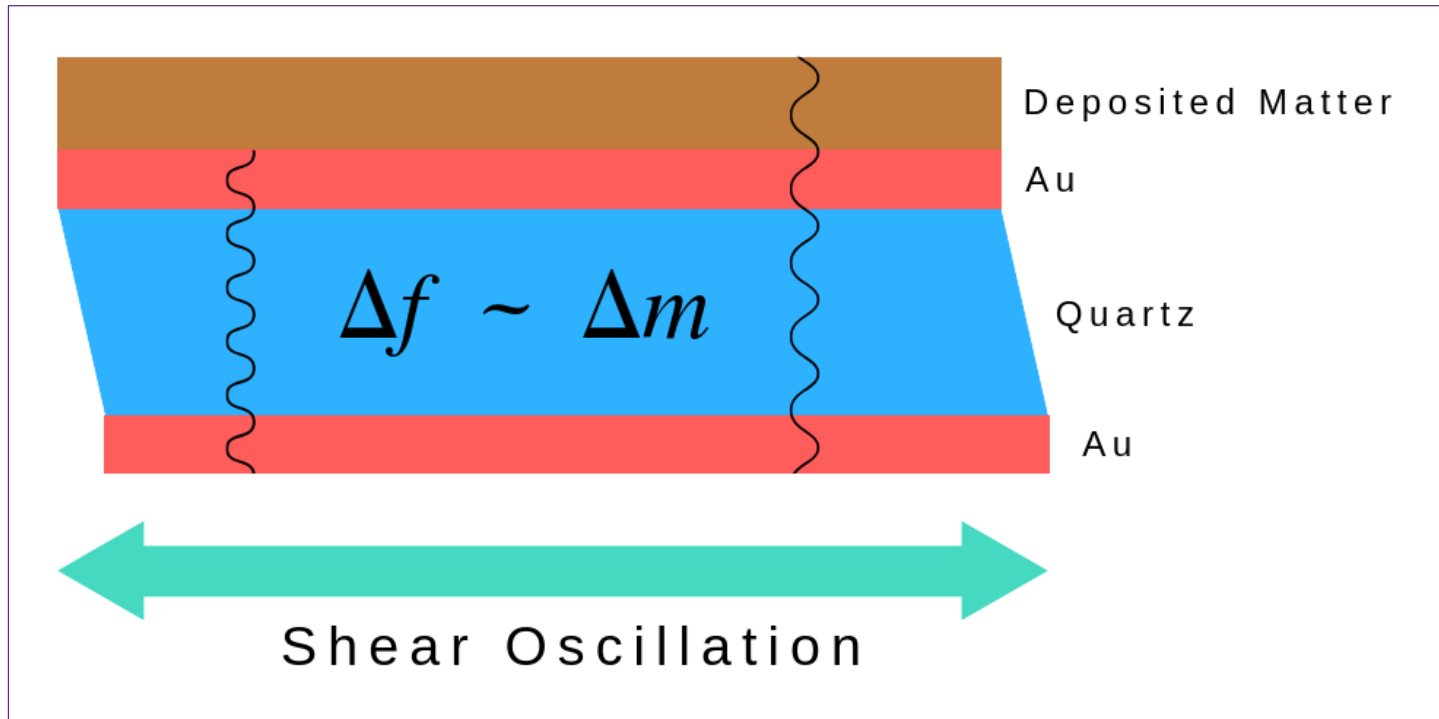
## Experimental Setup

Mainstream smoke generated from 3R4F cigarettes under the Health Canada Intense (HCI) puffing regimen was diluted at a range of airflows to achieve four concentrations of cigarette smoke (CS). Diluted CS was then sampled at four points via a constant vacuum at 5ml/min and passed over QCMs to quantify the rate and quantity of particulate deposition. A single airflow was performed per experiment (n=3) and three module types were assessed. Each exposure consisted of 132 puffs from 12 cigarettes and had a duration of 66 minutes. A total of 36 experiments were performed.



## Principal of Operation

QCMs are piezoelectric devices that measure a change in mass per unit area by monitoring the resonant frequency of a quartz crystal. The frequency at which the crystal resonates is dependent on crystal thickness, temperature, pressure and bending stress. Through careful control of temperature and stresses acting upon the crystal extremely accurate changes in relative thickness can be measured. This relative change in thickness directly corresponds with the deposited mass and is calculated by Sauerbrey's equation.



## Dose Resolution

Dose resolution was compared via Tukey's multiple comparison of each airflow - 95% CI.

Vitrocell 12/4				
Airflow (SLPM)	10	8	4	1
10	x	0.9732	0.0097	<0.0001
8	0.9732	x	0.0262	<0.0001
4	0.0097	0.0262	x	<0.0001
1	<0.0001	<0.0001	<0.0001	x

Vitrocell 6/4				
Airflow (SLPM)	10	8	4	1
10	x	>0.9999	0.0304	<0.0001
8	>0.9999	x	0.0293	<0.0001
4	0.0304	0.0293	x	<0.0001
1	<0.0001	<0.0001	<0.0001	x

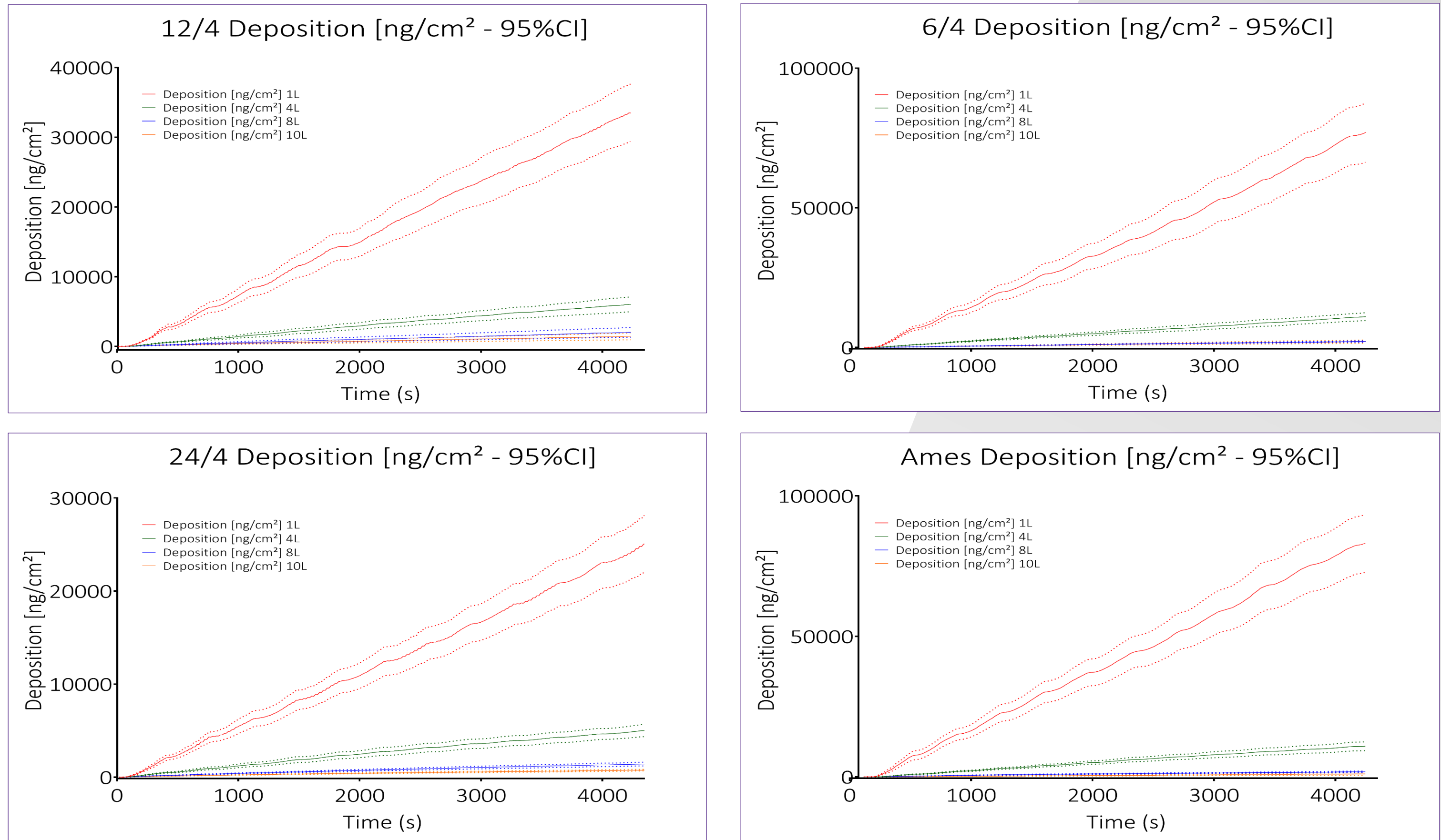
Vitrocell 24/4				
Airflow (SLPM)	10	8	4	1
10	x	0.8361	<0.0001	<0.0001
8	0.8361	x	0.0006	<0.0001
4	<0.0001	0.0006	x	<0.0001
1	<0.0001	<0.0001	<0.0001	x

Vitrocell Ames				
Airflow (SLPM)	10	8	4	1
10	x	0.992	0.0039	<0.0001
8	0.992	x	0.0078	<0.0001
4	0.0039	0.0078	x	<0.0001
1	<0.0001	<0.0001	<0.0001	x

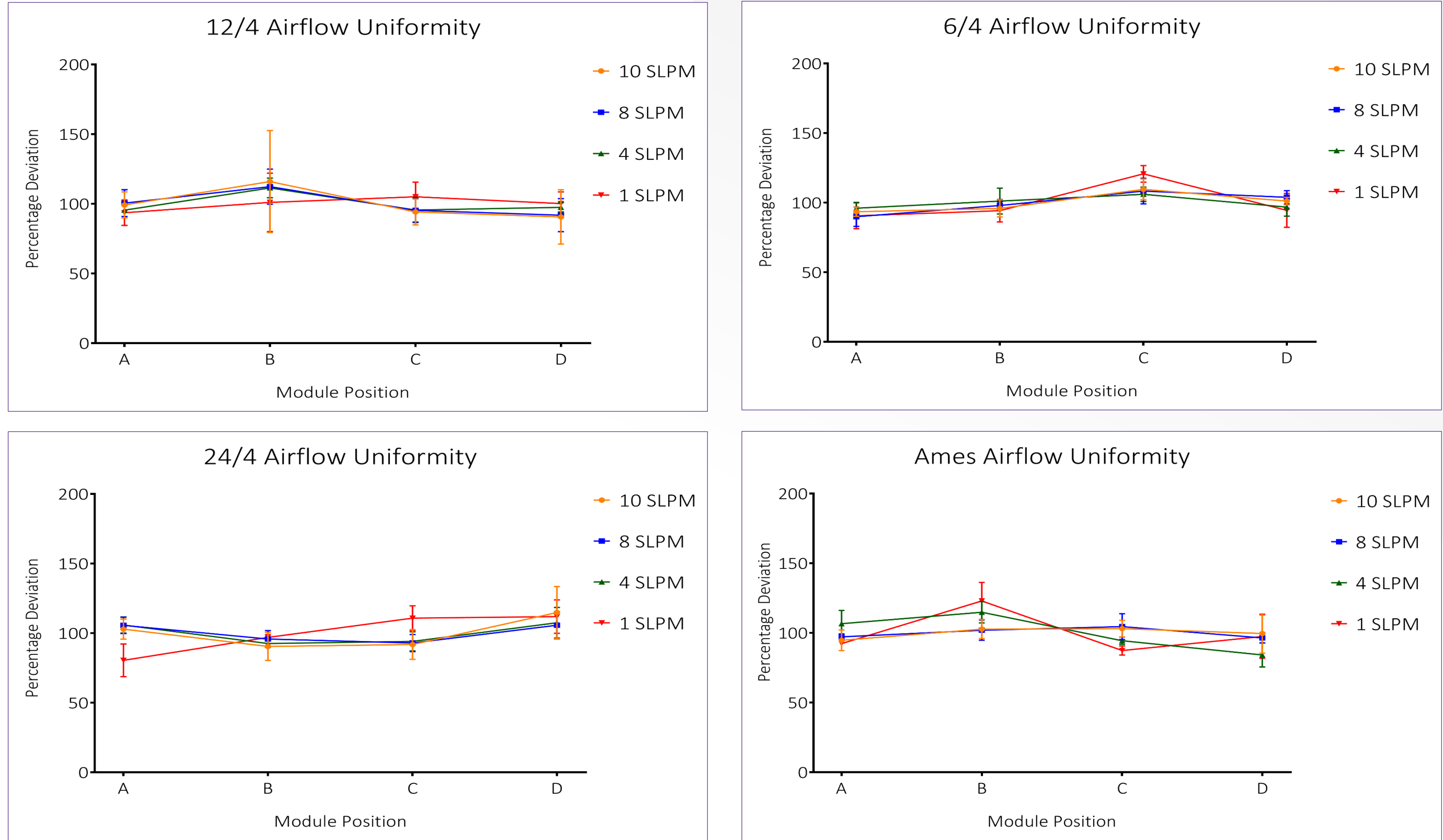
## Dose Repeatability

	12/4		24/4		6/4		Ames	
	Significant Difference	Adjusted P	Significant Difference	Adjusted P	Significant Difference	Adjusted P	Significant Difference	Adjusted P
Airflow 10 SLPM								
Experiment 1 vs. Experiment 2	No	0.7972	No	0.9877	No	0.9426	No	0.9976
Experiment 1 vs. Experiment 3	No	0.6467	No	0.9529	No	0.7438	No	0.9213
Experiment 2 vs. Experiment 3	No	0.9652	No	0.9883	No	0.9119	No	0.8941
Airflow 8 SLPM								
Experiment 1 vs. Experiment 2	No	0.9662	No	0.9623	No	0.9993	No	0.9995
Experiment 1 vs. Experiment 3	No	0.4411	No	0.7212	No	0.9691	No	0.9664
Experiment 2 vs. Experiment 3	No	0.5891	No	0.8665	No	0.9594	No	0.9575
Airflow 4 SLPM								
Experiment 1 vs. Experiment 2	No	0.9963	No	0.7473	No	0.9994	No	0.5759
Experiment 1 vs. Experiment 3	No	0.1885	No	0.0721	No	0.3111	No	0.5454
Experiment 2 vs. Experiment 3	No	0.2167	No	0.2698	No	0.326	No	0.9986
Airflow 1 SLPM								
Experiment 1 vs. Experiment 2	No	0.685	Yes	<0.0001	Yes	0.0006	Yes	<0.0001
Experiment 1 vs. Experiment 3	Yes	<0.0001	Yes	<0.0001	Yes	<0.0001	No	0.1728
Experiment 2 vs. Experiment 3	Yes	0.0003	No	0.1258	Yes	0.0003	Yes	0.0098

## Deposition Plotted over Time - 95% CI



## Dose Uniformity



## Summary

QCMs were used to assess the deposition of cigarette aerosol from a Vitrocell® VC10® in Vitrocell® Ames, 6/4, 12/4 and 24/4 exposure modules. The power to resolve difference between 8 and 1 SLPM is statistically significant in all module types assessed. Uniformity within each module was confirmed (P >0.98) in all module types, at all airflows. Repeatability was assessed and found to be consistent (no significant difference) in all module types at airflows of 10, 8 and 4 SLPM, however, at 1 SLPM a significant difference was noted in 9 out of 12 experiments – likely an artifact of high deposition. These results show that exposures utilizing the Vitrocell® VC10® and associated modules are robust; but indicate the necessity of dosimetry measures to aid in the quantification of delivered dose.