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AIR FLOW, TURBULENCE AND SMOKE YIELDS.
THE UNEXPECTED CONSEQUENCES OF MACHINE DESIGN

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Structure

- Introduction
- Experimental
- Results and discussion
- Conclusions
- Acknowledgements and references

INTRODUCTION

Defining air flow

- Governed by ISO 3308:2012
  - Referenced by Health Canada and WHO TobLabNet SOP1
- Annex A specifies velocities and mechanical enclosure
- Known to influence yields

Measuring Air flow

- Measured on axis
- Holders in place
- 40mm from the puff termination device
- Measurements made at extremes and centre for type B machine
- Value between 150mm/sec and 250mm/sec
- Uses an omni-directional anemometer
- In practice extraction is baffled for velocity and uniformity

Hidden problems

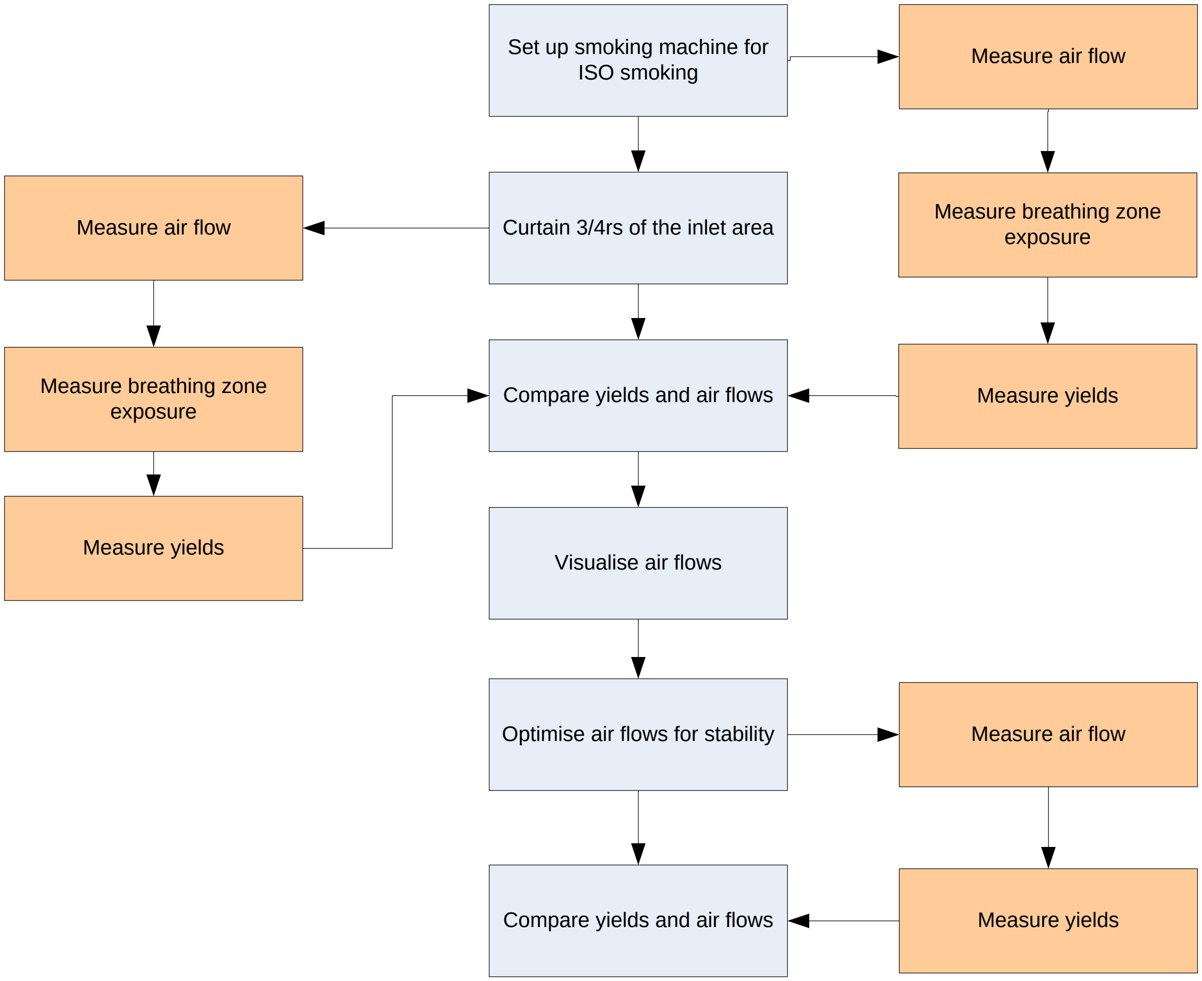
- The direction of air flow can impact yields
- The turbulence in the air flow impacts yields
- Gross effects are easy to spot e.g. abnormal CO yields
- Subtle effects less clear
  - Uniformity of yield within a single smoke machine?
  - Uniformity when dealing with non-standard constructions

Questions?

- Where does the air used in smoking come from?
- Where does this air go?
- Where does the ETS go?
- How sensitive are yields to changes in air turbulence?

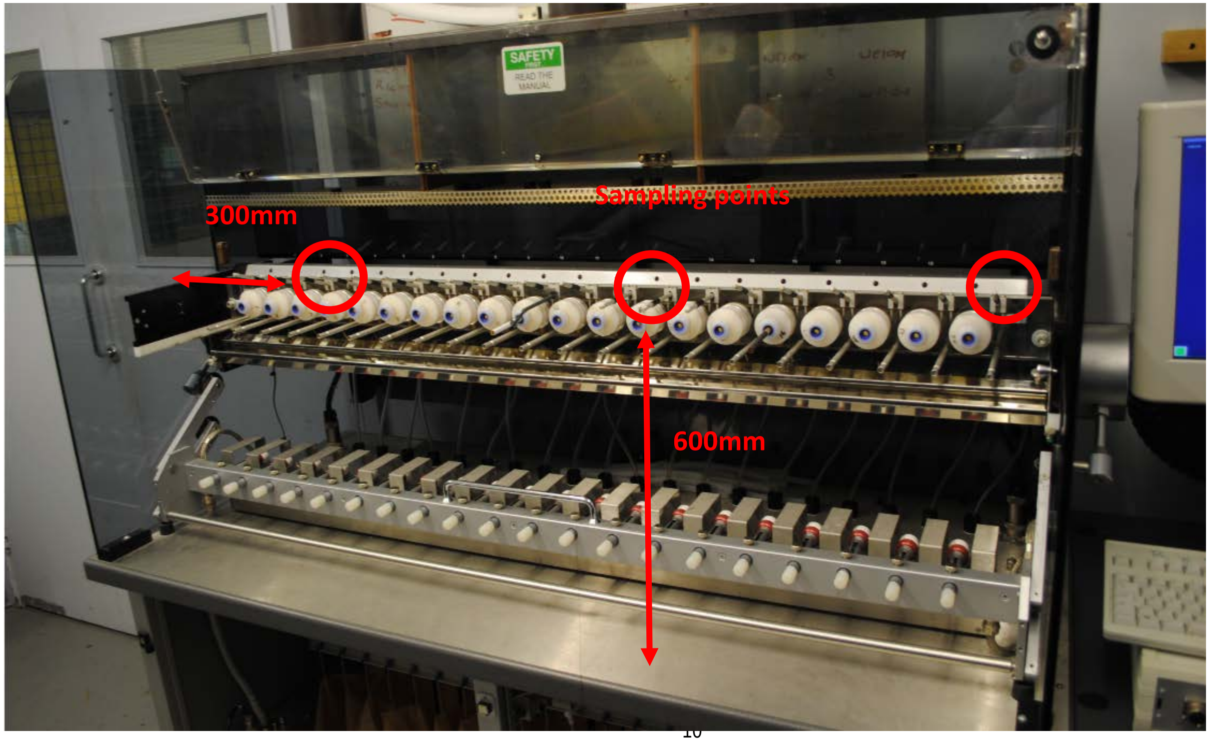
EXPERIMENTAL

Experimental plan



Operator exposure?

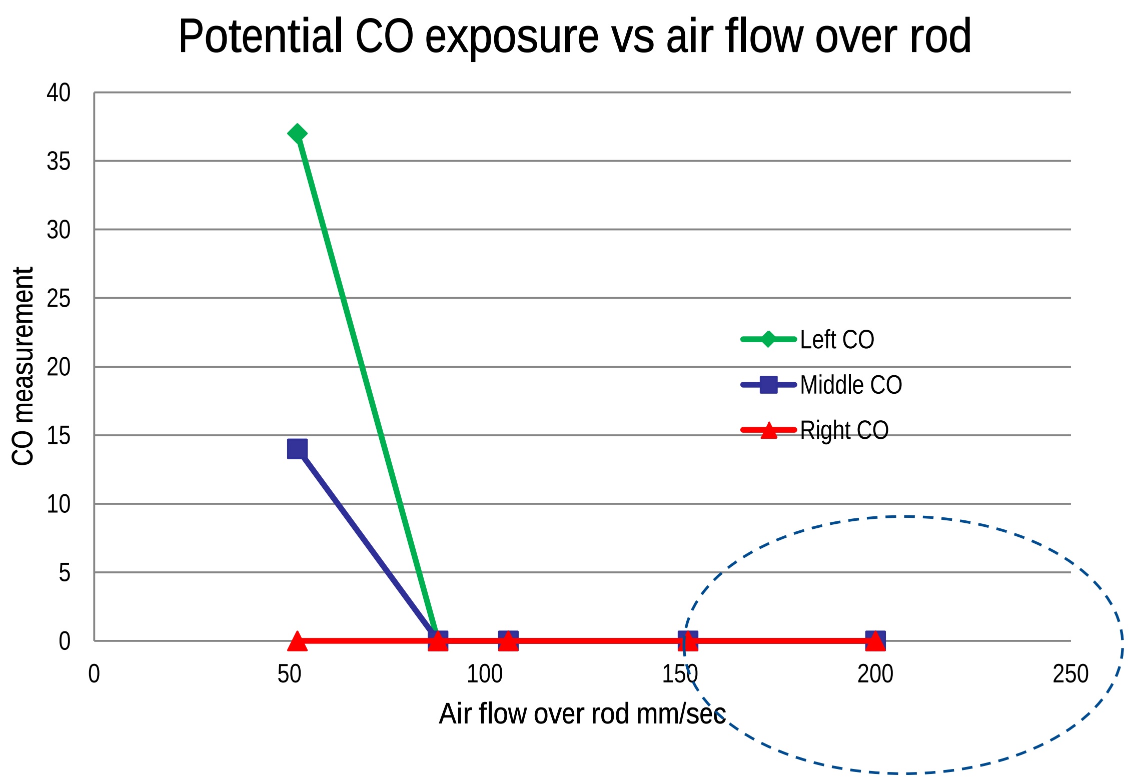
- Where does the smoke go?
  - Throughout the changes monitoring of CO outside of the smoking hood
  - Measured CO at <<OSHA TLV during experiment
  - Mapped CO yield in the "breathing zone" for different smoke extraction rates



RESULTS AND DISCUSSION

Exposure

- Using CO as a marker for potential operator exposure
- Change extraction flow

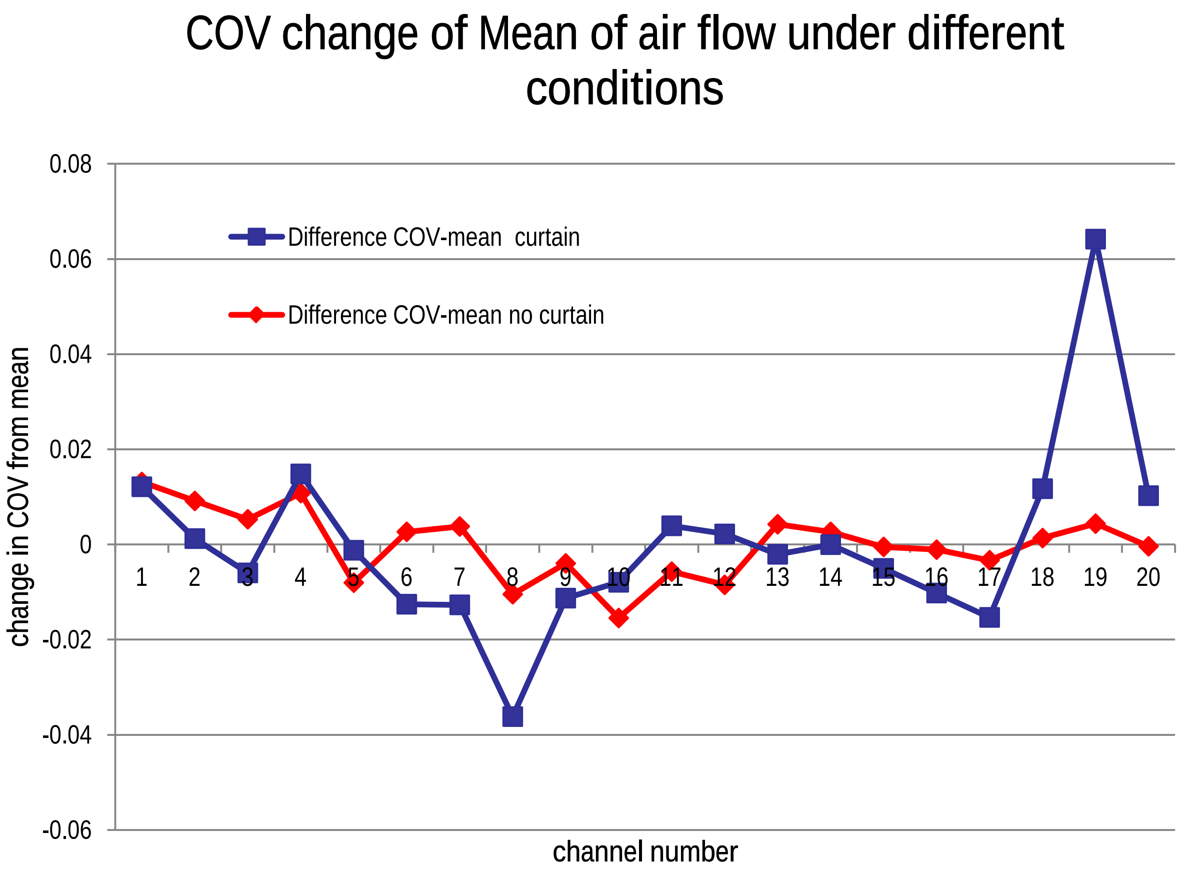


Exposure 2

- Adding a ¾ length curtain to eliminate air movements from operators

	Max CO measured PPM		
	curtain in place	No curtain in place	flow rate mm/s
full extraction	0ppm	0ppm	204
75% extraction	0ppm	1ppm	156
50% extraction	4ppm	1ppm	107
25% extraction	174ppm	56ppm	56

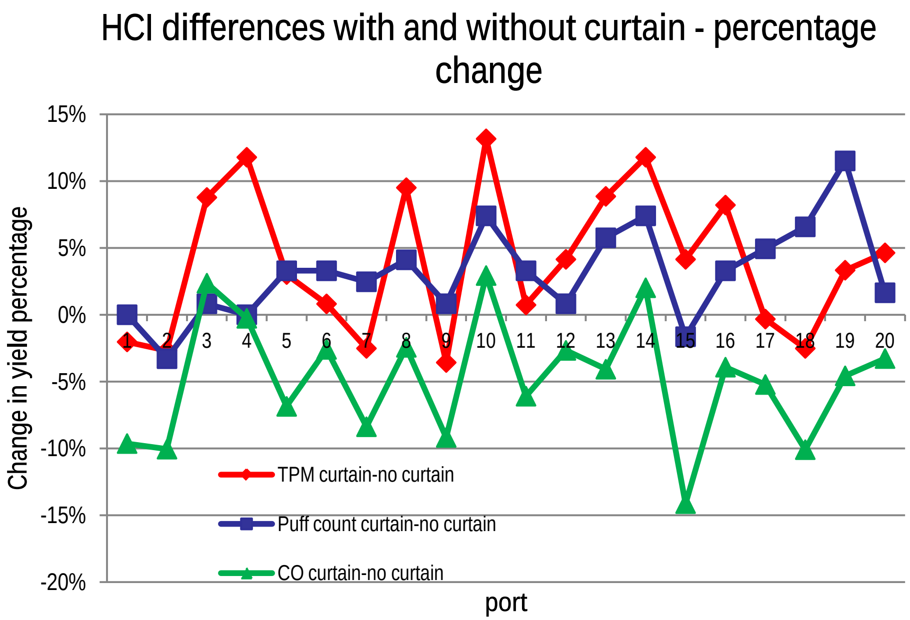
Flow stability – is this effected



Yield change and air stability

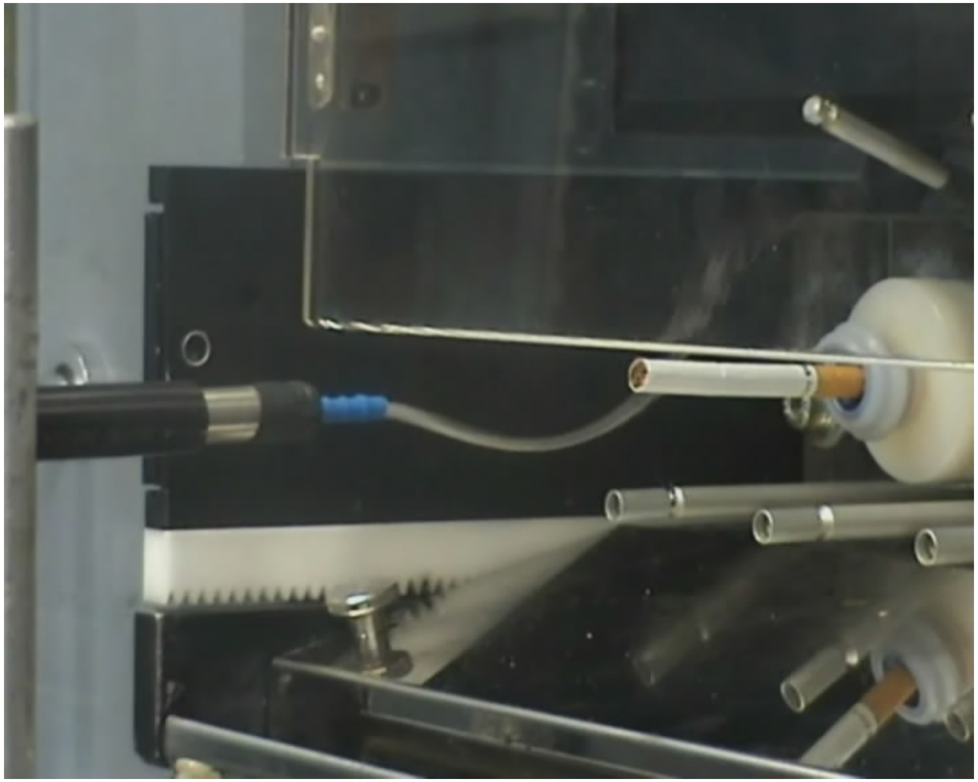
- CO yield is the most sensitive to instantaneous air flow stability – COV and in absolute yield

		%COV ISO		%COV HCI	
		Standard	Curtained	Standard	Curtained
High yield product	TPM	2.9	5.7	4.7	3.5
	Puff count	3.4	3.7	2.6	3.2
	CO	5.6	7.6	3.3	4.1
Low yield product	TPM	8.0	7.2	6.2	5.5
	Puff count	3.2	3.5	3.6	3.8
	CO	9.5	12.9	5.0	6.9



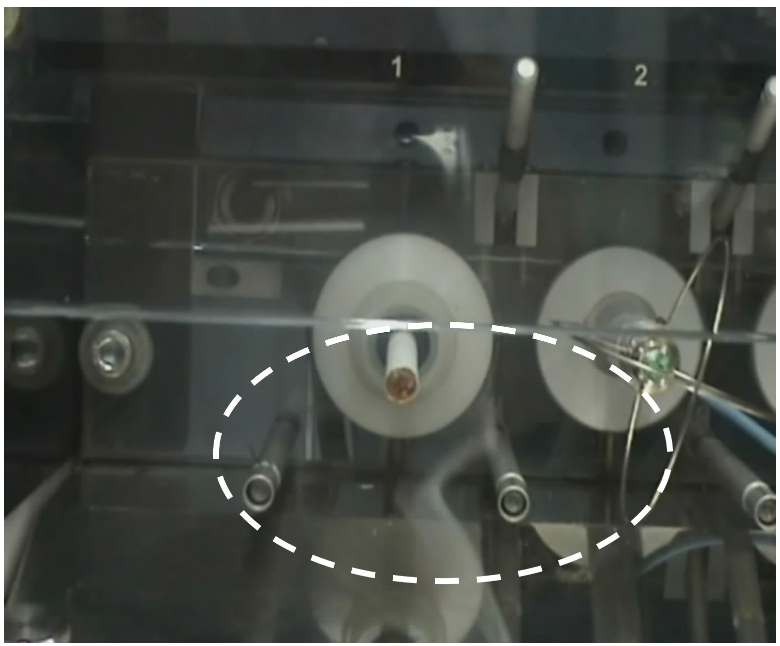
Visualising flow

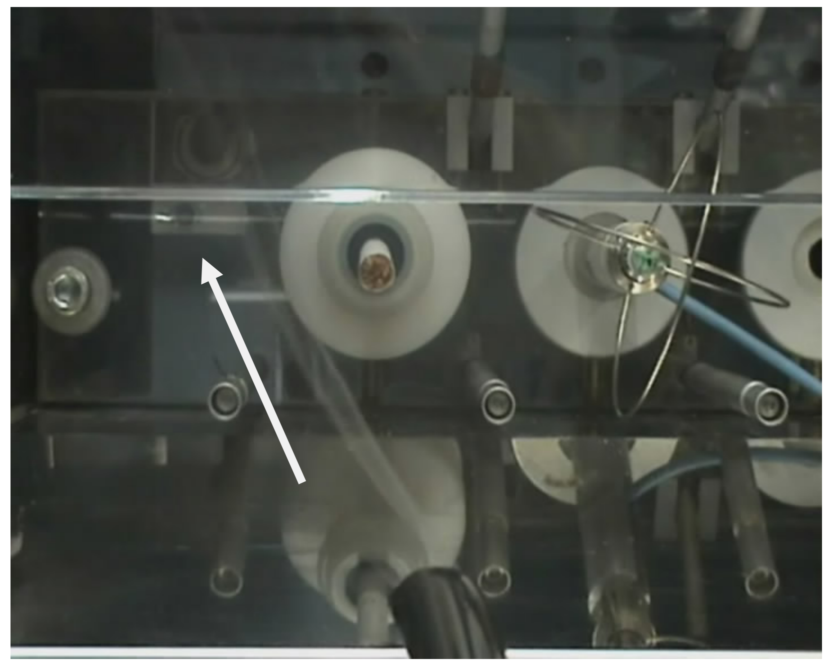
- Using glycerine and water vapour and a video camera flow patterns can be made visible



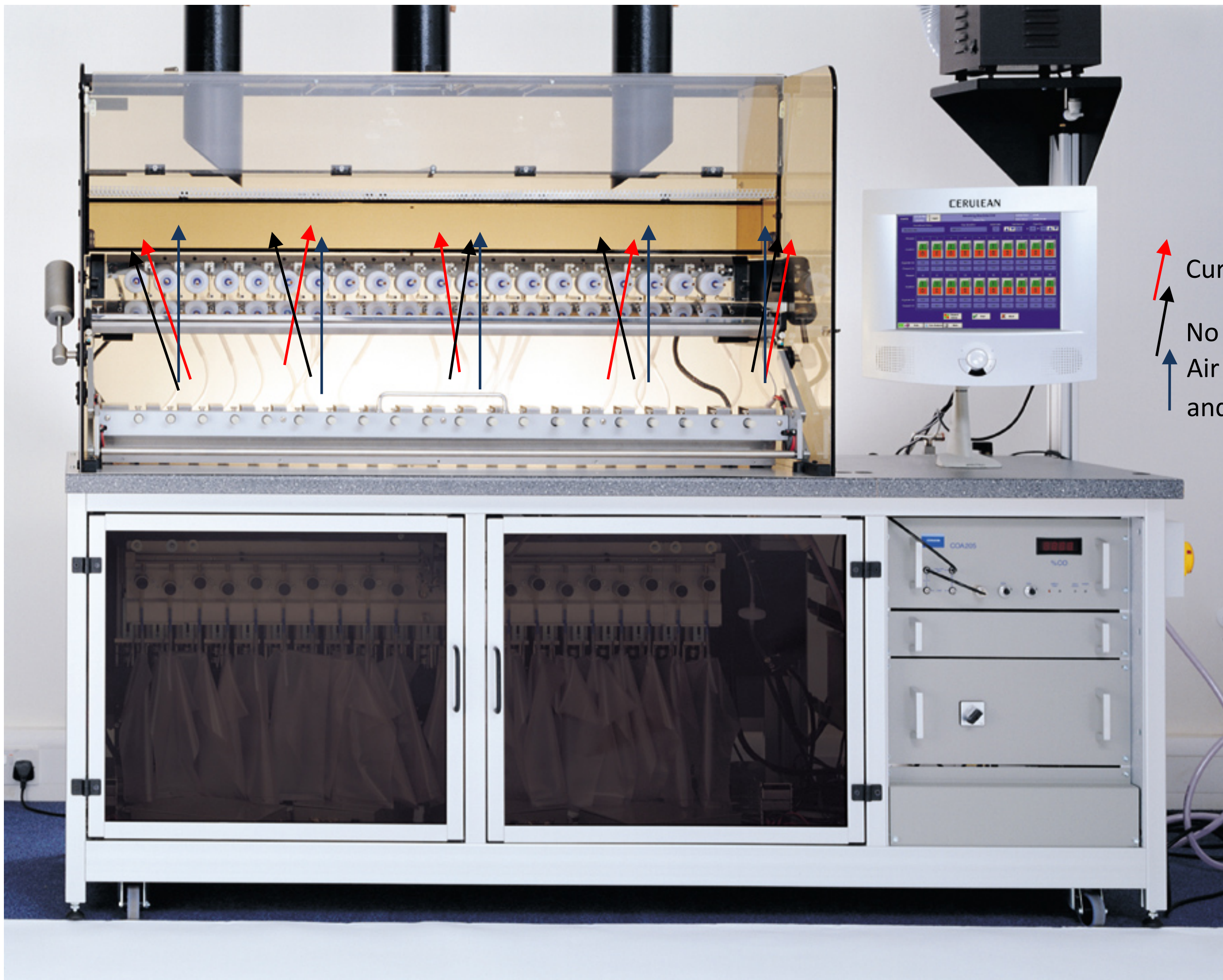
Visualising air flows

- Turbulence and lateral flow evident





Overall picture



Curtained

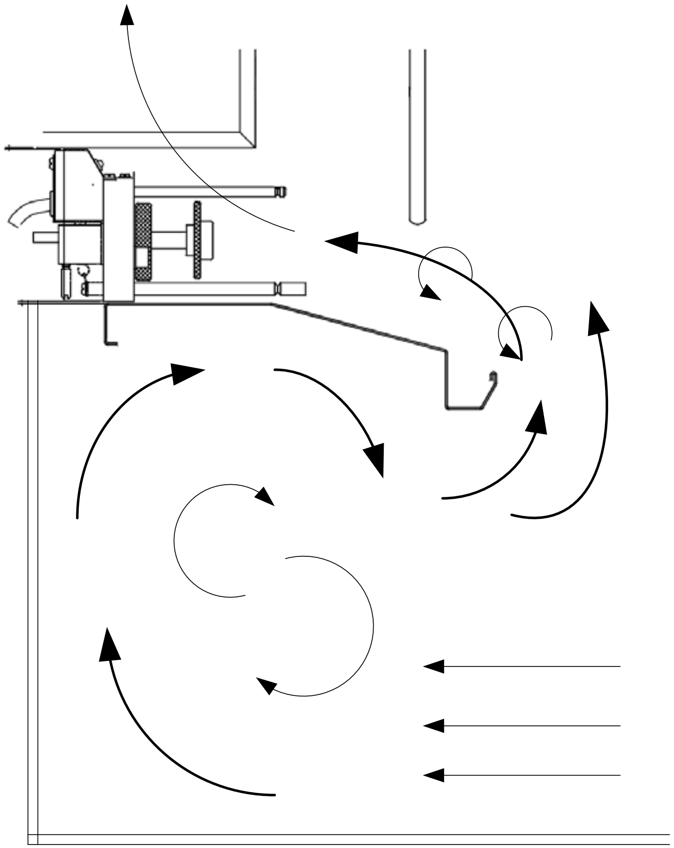
No Curtain

Air scoop

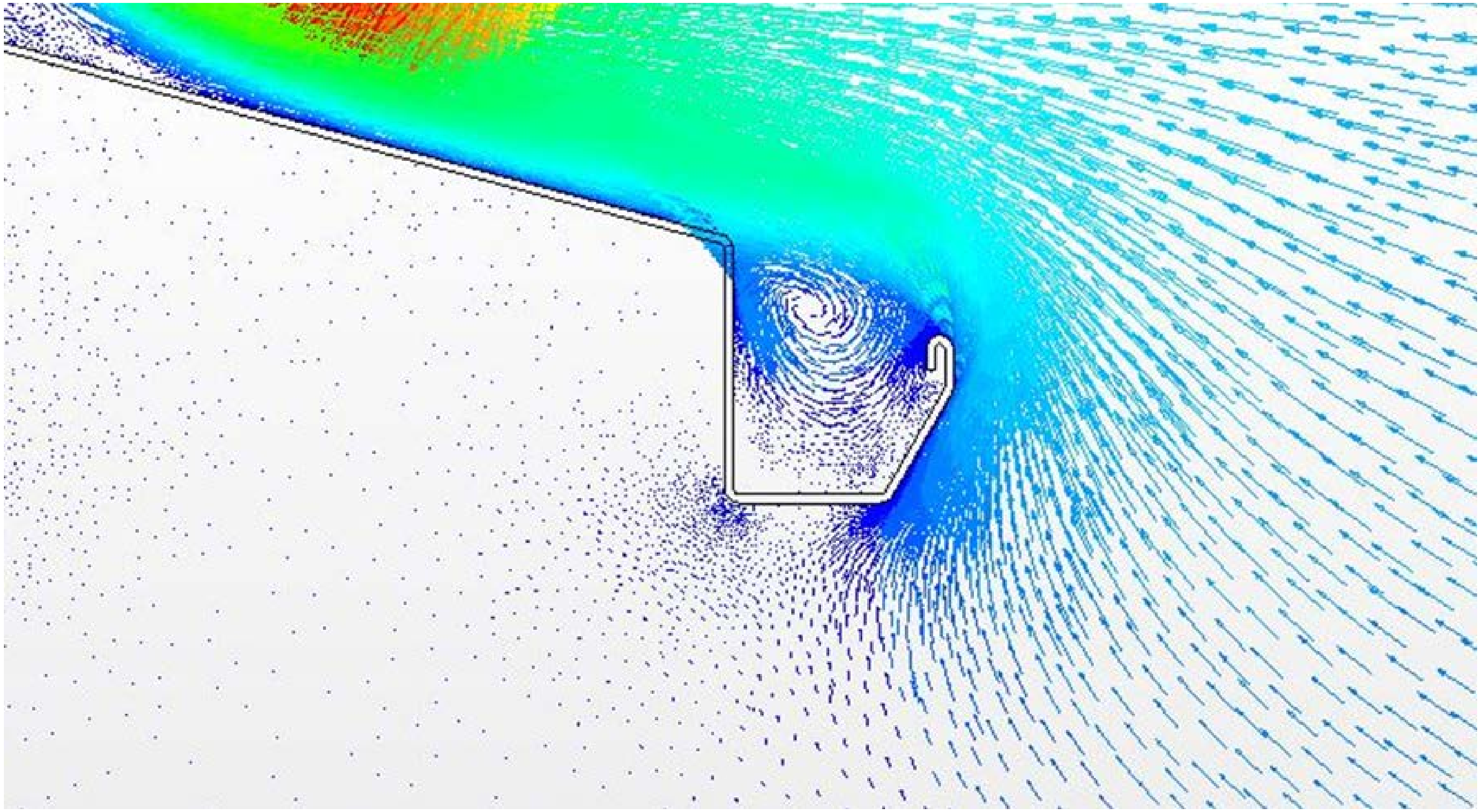
and fins

Visualisation 2

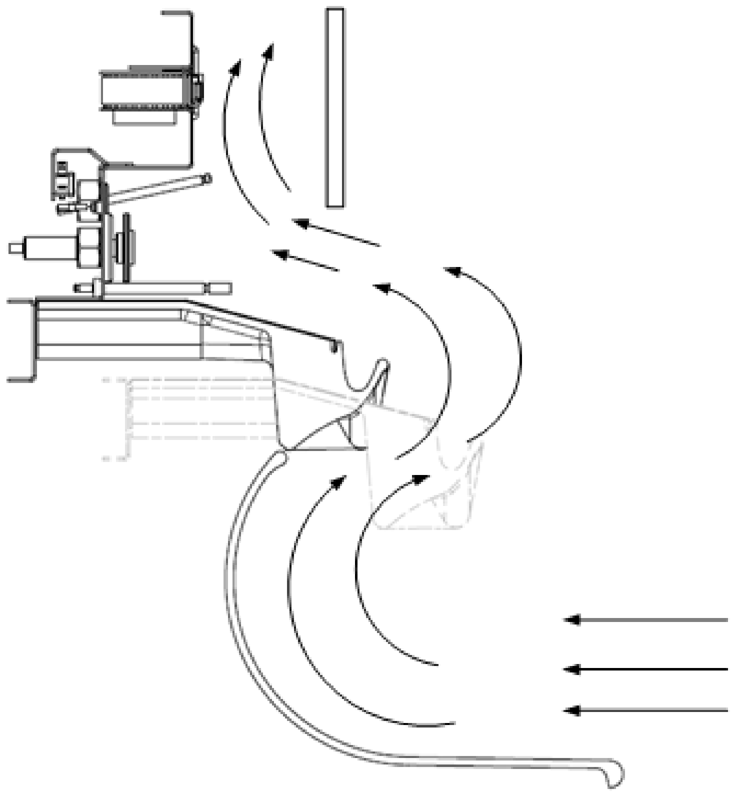
Schematic representation of a SM450



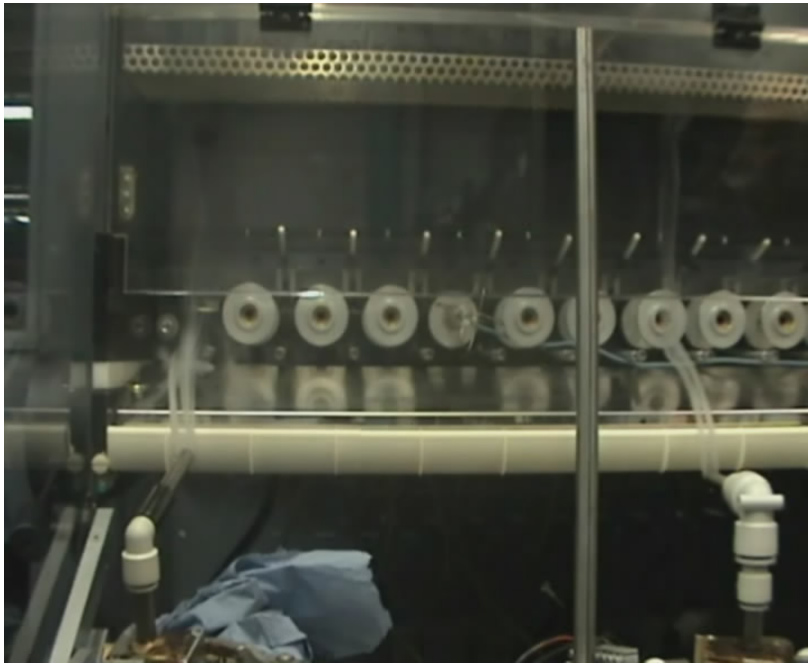
Modelled air flow



Modifying air flow

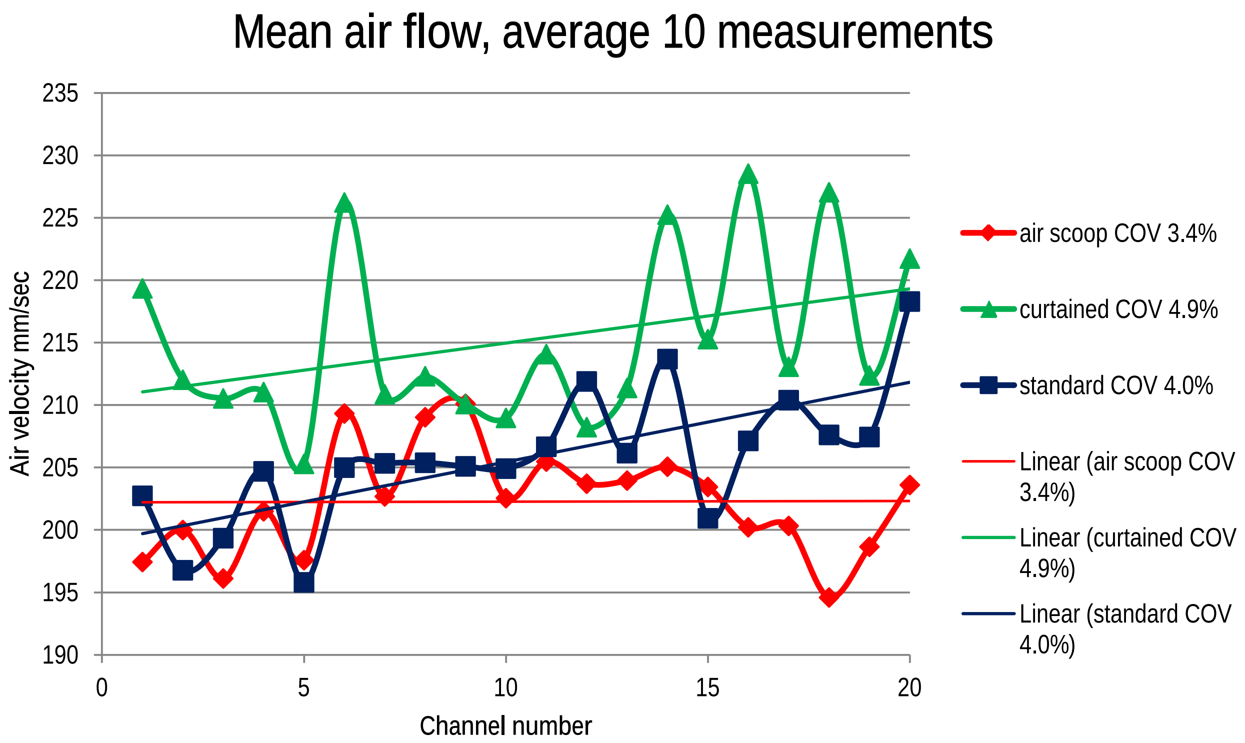


Visual representation of new scheme



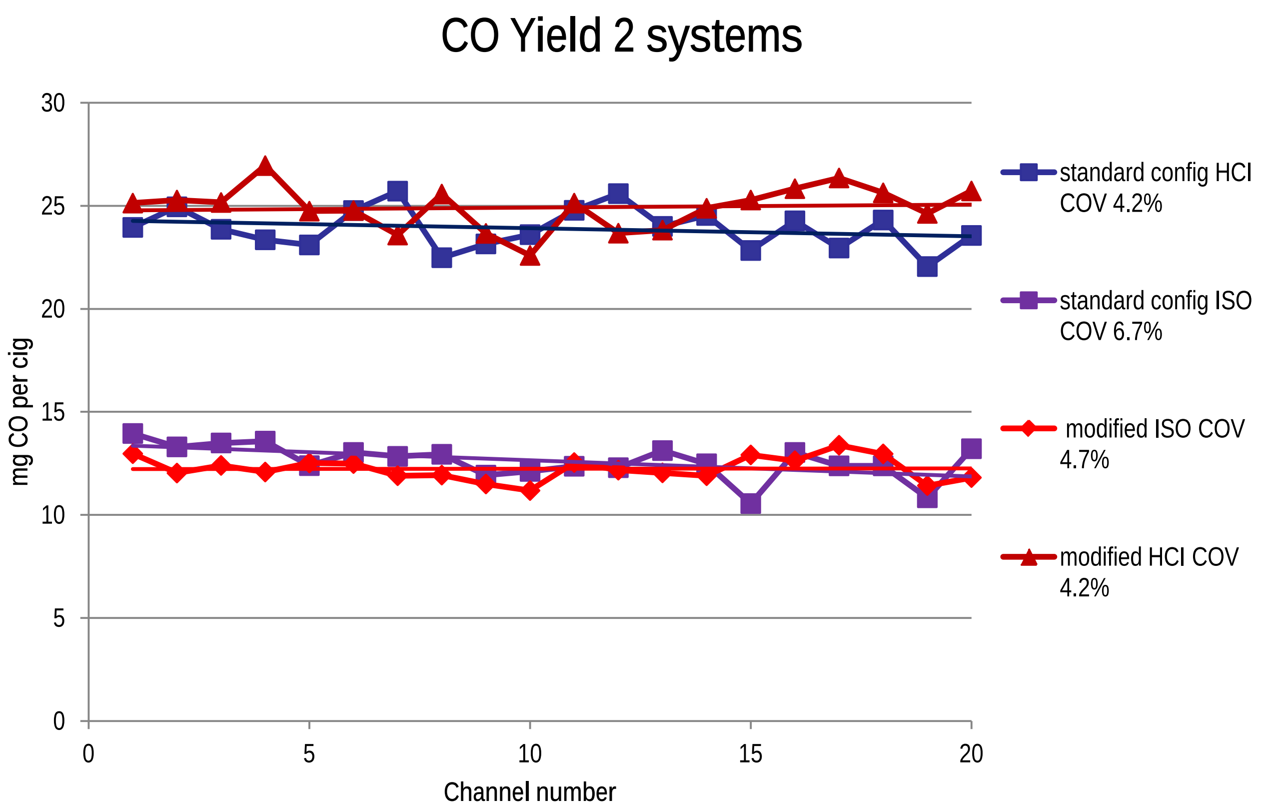
Air flow as measured

- How does this change in ashtray form influence the variation in measured air flow – what would the user experience?



Smoking results for new scheme

- CO yield most sensitive to turbulence



CONCLUSIONS

Conclusions From Experiment

- ETS as evidenced from CO measurements does not emerge from the smoking machine front
- Adding a curtain does not improve random airflows
- Increasing turbulence increases yield variability
- The edges of the machine change turbulence and cross flows exist
- Changing some regions around the ashtray can improve the uniformity of air flow
- This is measureable in terms of flow and in terms of yield uniformity across the machine

Acknowledgements

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- Molins PLC for funding the work
- Nigel Brooks for making and designing the air scoop and fin system
- 1-D Cole for finite element analysis

References / Further reading

1. Health Canada Test Method T-115 – Determination of Tar, Water, Nicotine and Carbon Monoxide in Mainstream Tobacco Smoke, 1999-12-31
2. ISO 3308:2012 Routine analytical cigarette-smoking machine -- Definitions and standard conditions
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4. WHO TobLabNet official method SOP 01 “Standard operating procedure for intense smoking of cigarettes”
5. Tindall, Mason “The effect of flow vectors on the yields from “unusual design cigarettes” when smoked in an ISO compliant manner” CORESTA Congress 2006
6. IARC Monographs volume 83 p1191