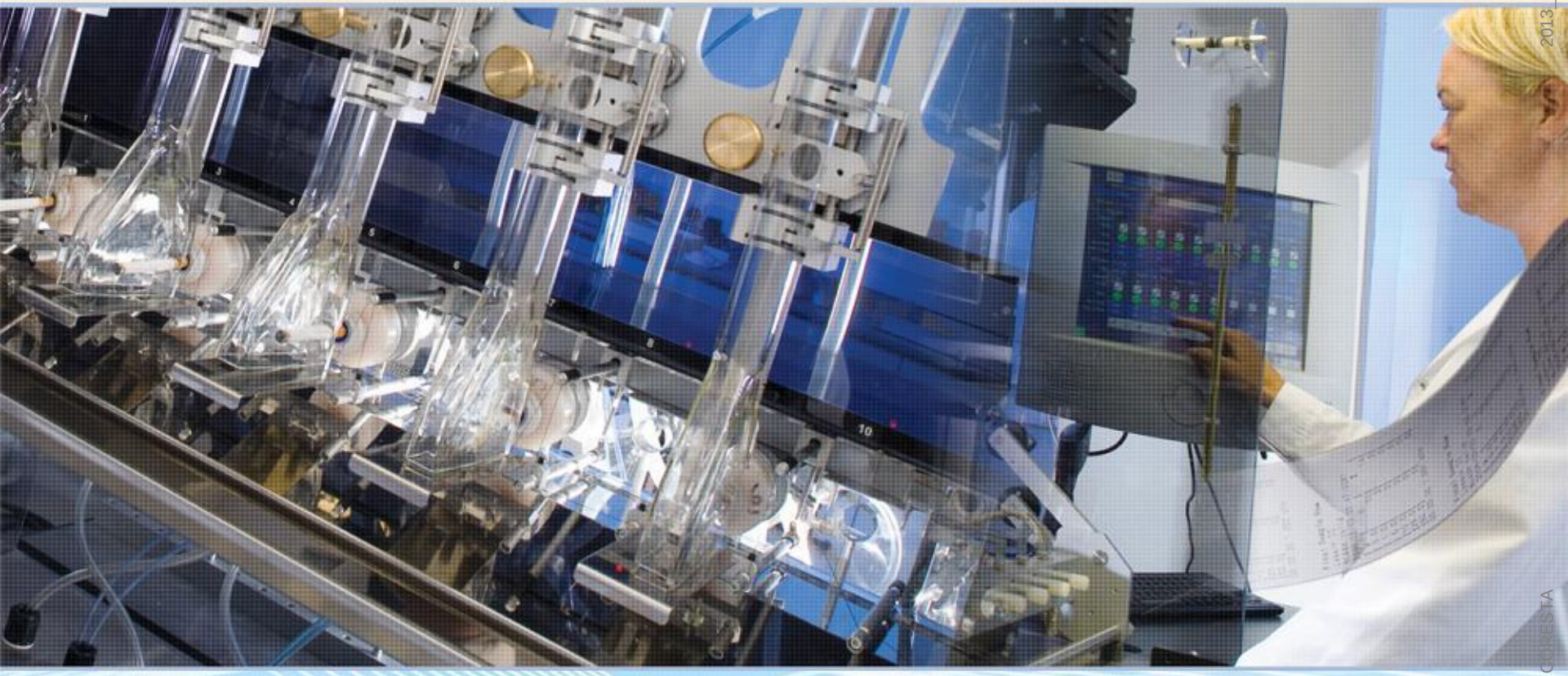
{ accredited } { independent } { analytical } { solutions }



The Effect of Puff Profile and Volume on the Yields of E-Cigarettes

Filtrona Scientific Services

the difference is { everything }

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Smoke Science/Product Technology Meeting

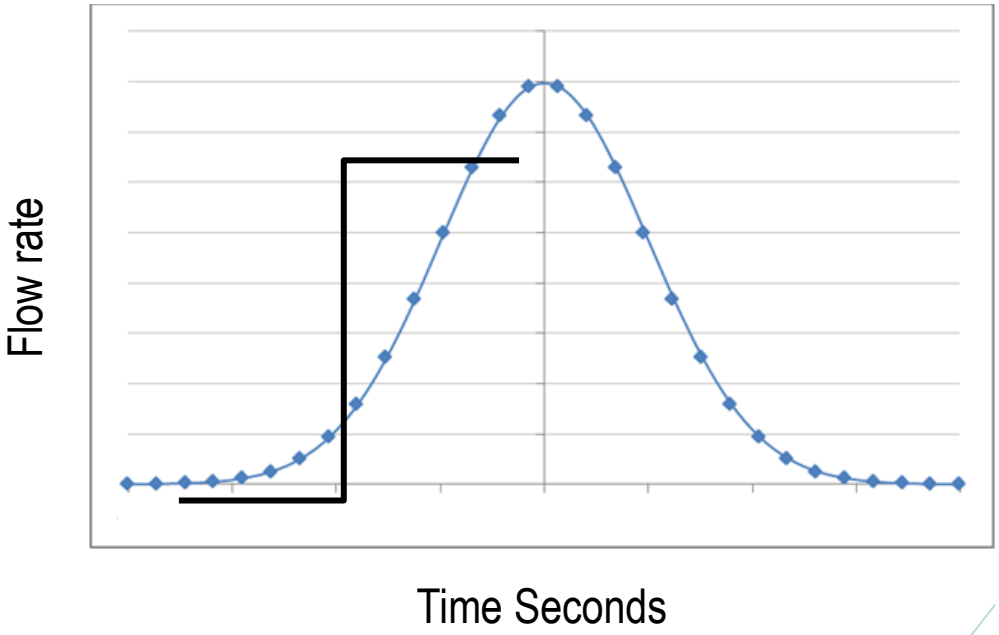
Seville, Spain, 29 September to 03 October 2013

Introduction

- An electronic or e-cigarette is an electrical device that simulates the act of smoking
- These products produce a vapour when inhaled that can replicate the sensation and often the flavour of tobacco smoke without its odour
- They use heat and airflow to vaporise a solution that generally contains glycerol or a mixture of glycerol and propylene glycol, water, nicotine and flavours for delivery to the user
- E-cigarettes can be either disposable or re-usable
- Re-usable e-cigarettes have a separate battery unit that can be recharged via a USB port - users buy replacement reservoirs (or combined atomiser/reservoirs) of the desired flavour/nicotine level
- Since their introduction around 10 years ago, e-cigarettes have increased in popularity with estimated annual growth rates of around 50 to 100 %
- Universal methods for testing e-cigarettes have yet to be agreed
- The levels of potentially harmful minor constituents found in the vapour of e-cigarettes is the subject of discussion

e-Cigarette Testing

- e-Cigarettes are obviously different to standard cigarettes and work in a different way
- Little information has been published on the parameters that may affect the measured yields from e-cigarettes
- As many e – cigarettes are activated by puffing it may be expected that different puff profiles could affect the point at which the product activates



E – Cigarettes Products Tested

- Two Different products have been tested
- Both were selected at random from the UK market
- Both are rechargeable
- Product 1 was described as regular containing 2.4 % nicotine
- Product 2 was described as high containing 15 mg nicotine per refill
- A CORESTA CM7 monitor cigarette was also tested for comparison

Smoking Regimes

- All work carried out using a two second puff duration
- Three replicates analysed for each test
- Batteries fully charged before each block of puffs
- Two smoking regimes used for all testing
  - ISO – 35 ml puff volume with one puff per minute
  - Intense – 55 ml puff volume with one puff every 30 second
- Three different puff profiles used for each regime
  - Standard ISO profile – bell shaped
  - Triangle
  - Square

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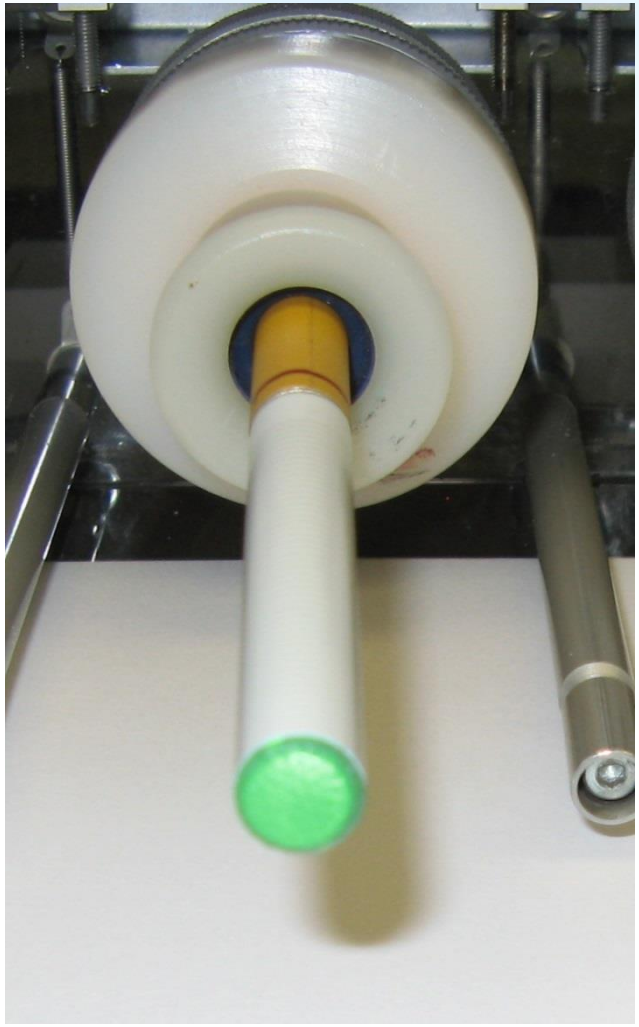
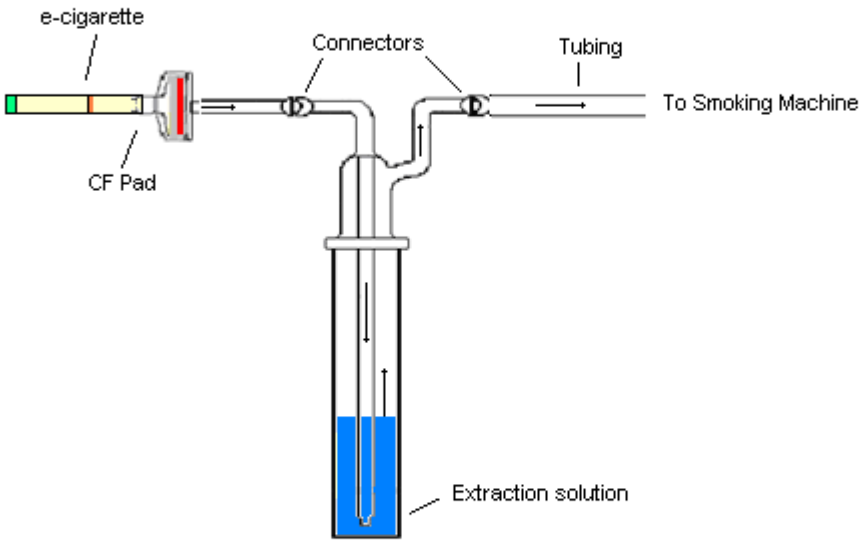
E-Cigarette Puffing on Smoking Machine



E – Cigarettes Tests Carried Out

- An initial test was carried out to study the trapping efficiency of a standard smoke trap for nicotine in e – cigarette vapour. For this test only the largest puff volume was used taking 30 puffs from each product and an impinger containing 50 ml of methanol was placed behind the smoke trap and analysed for nicotine to measure any breakthrough from the pad
- Pad nicotine was determined by the standard GC-FID method
- Nicotine in the impinger was determined by GC-MS to give lower levels of detection
- The yields of TPM, Nicotine, water and NFDPM were measured at each puff volume and for each puff profile
- The yields of TSNA's were measured at each puff volume and for each puff profile

Nicotine Trapping Efficiency



Nicotine Trapping Efficiency

Product	Puff Profile	Nicotine mg/pad	Nicotine ng/Imp	% Breakthrough
1	ISO	0.11	4.0	0.0036
	Triangle	0.10	26.7	0.026
	Square	0.11	7.8	0.0071
2	ISO	0.46	311.2	0.067
	Triangle	0.42	551.4	0.131
	Square	0.44	467	0.106
CM 7	ISO	2.63	10.9	0.0004
	Triangle	2.57	127.4	0.005
	Square	2.45	52.3	0.002

E – Cigarettes Effect of Puff Volume

- For all three puff profiles two puff volumes have been studied
- A 35 ml puff once per minute (standard ISO)
- A 55 ml puff once every 30 seconds (intense)
- A similar effect was observed for all three puff profiles with an increase in yield as puff volume increases

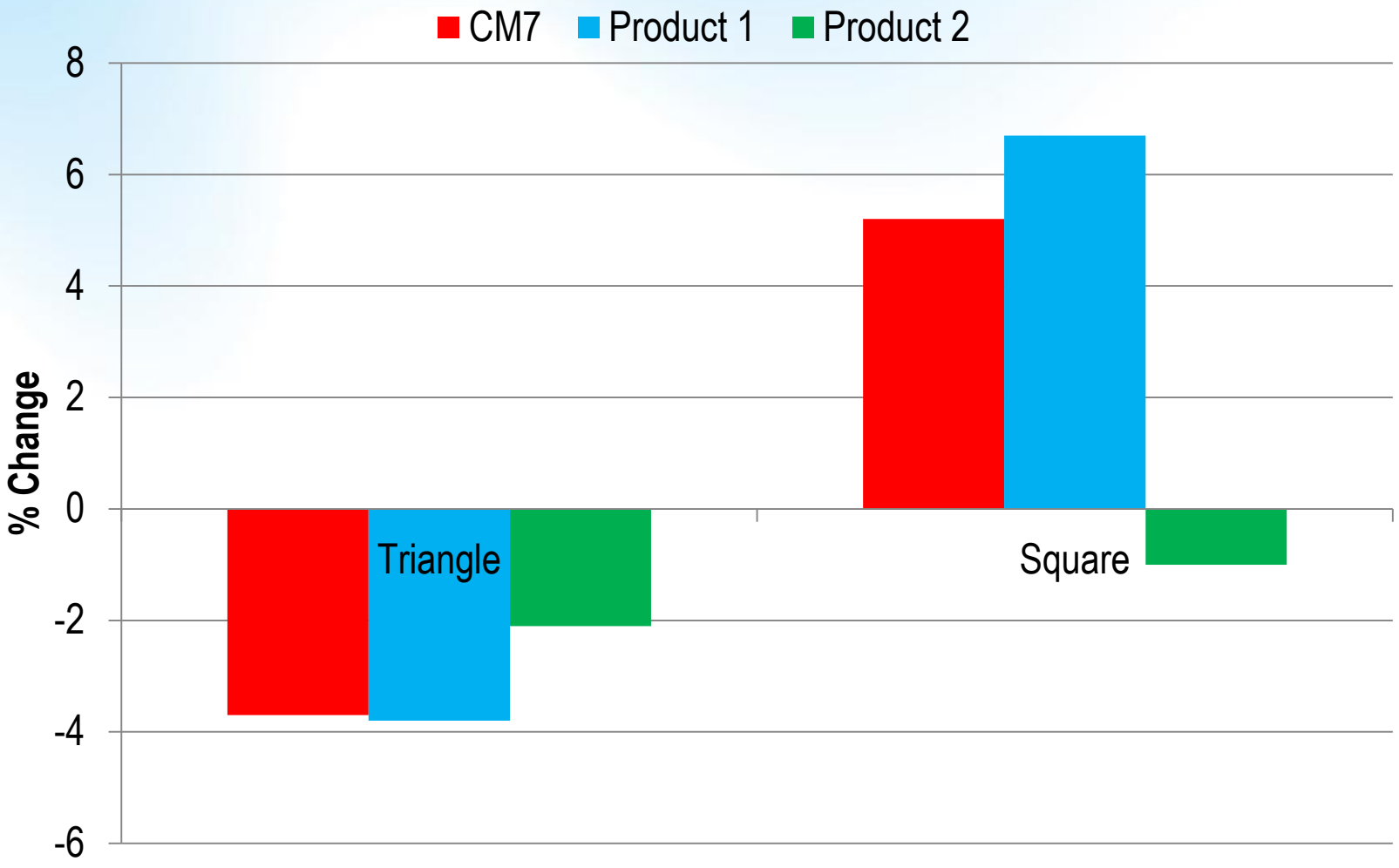
E-Cigarette Yields Effect of Puff Volume ISO Profile

Product	Profile	ISO mg/10 puffs		CINT mg/10 puffs	
		Nicotine	Particulate Matter	Nicotine	Particulate Matter
Product 1	ISO	0.14	7.0	0.23	10.5
Product 2		0.25	9.0	0.38	14.2
CM 7/cig		1.25	13.9	2.53	30.8
Product 1	Square Wave	0.15	7.5	0.26	11.4
Product 2		0.26	8.9	0.40	14.8
CM 7/cig		1.27	14.6	2.56	29.9

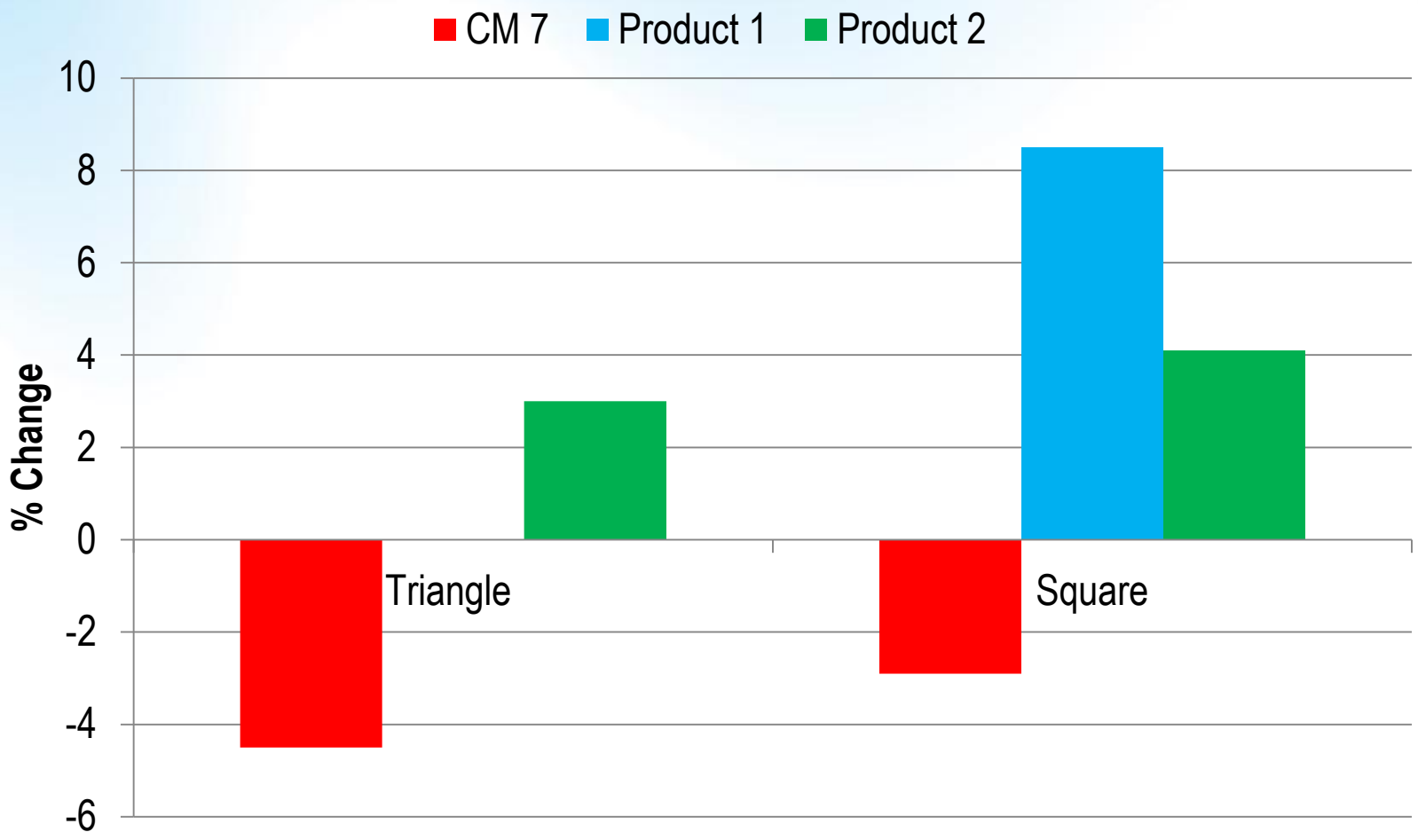
Effect of Puff Profile

- The plots that follow show the effect of puff profile on the deliveries of NFDPM and nicotine on the yields of the products studied
- The data is expressed as the percentage difference when compared to the standard ISO 'bell shaped' puff profile
- Percentage difference has been used to allow easy comparison of different numbers as the yields from the CM 7 and the e – cigarettes studied are quite different
- One disadvantage if this approach is that a small change in a small number can be a large percentage but not necessarily a significant change especially in view of the variability found in some e – cigarettes
- If, for example, a particular puff profile gave a different yield to the standard ISO profile it would be expected that a large positive change would be seen in the following graphs

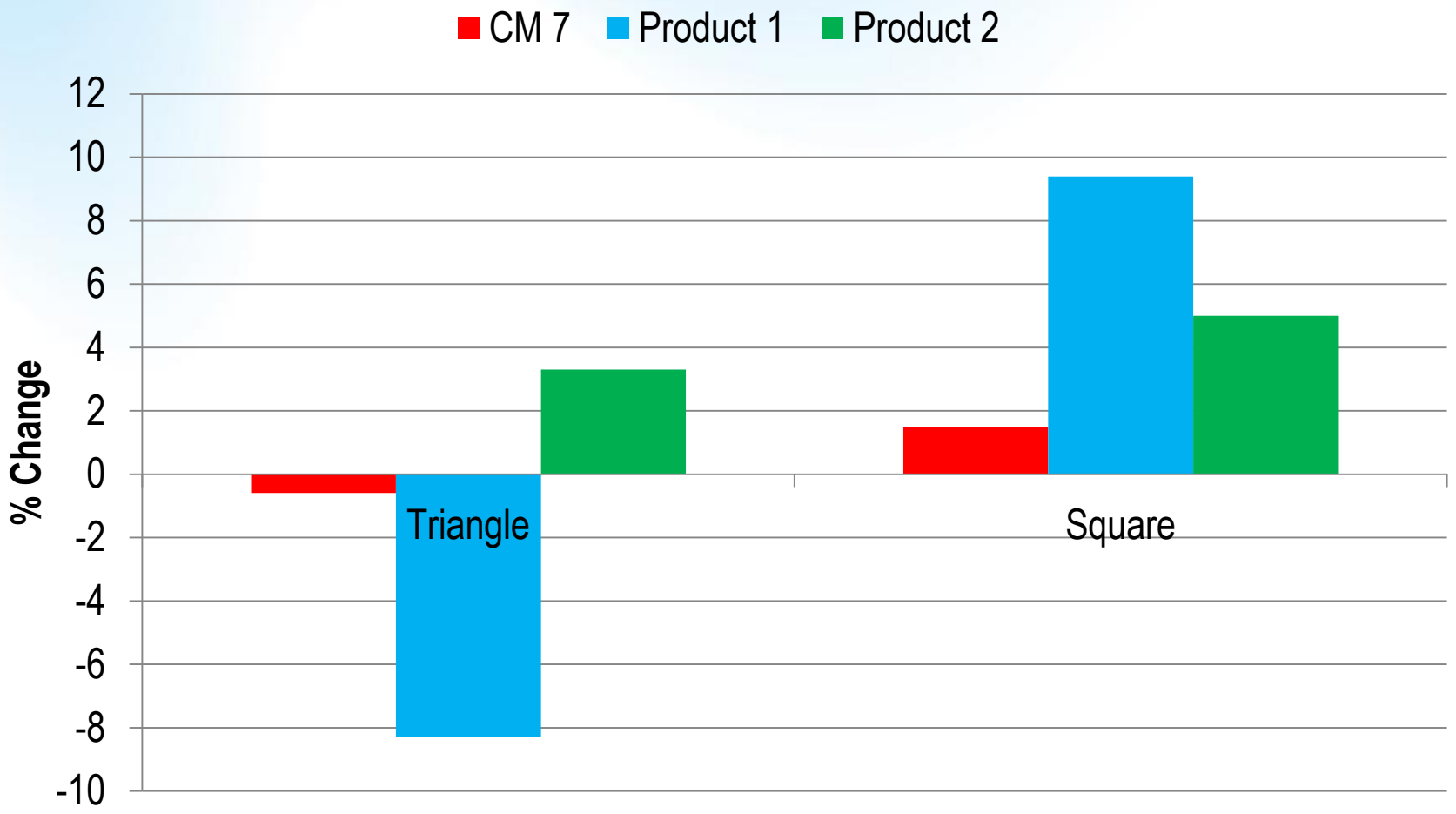
Percentage Changes NFDPM 35 ml Puff Volume



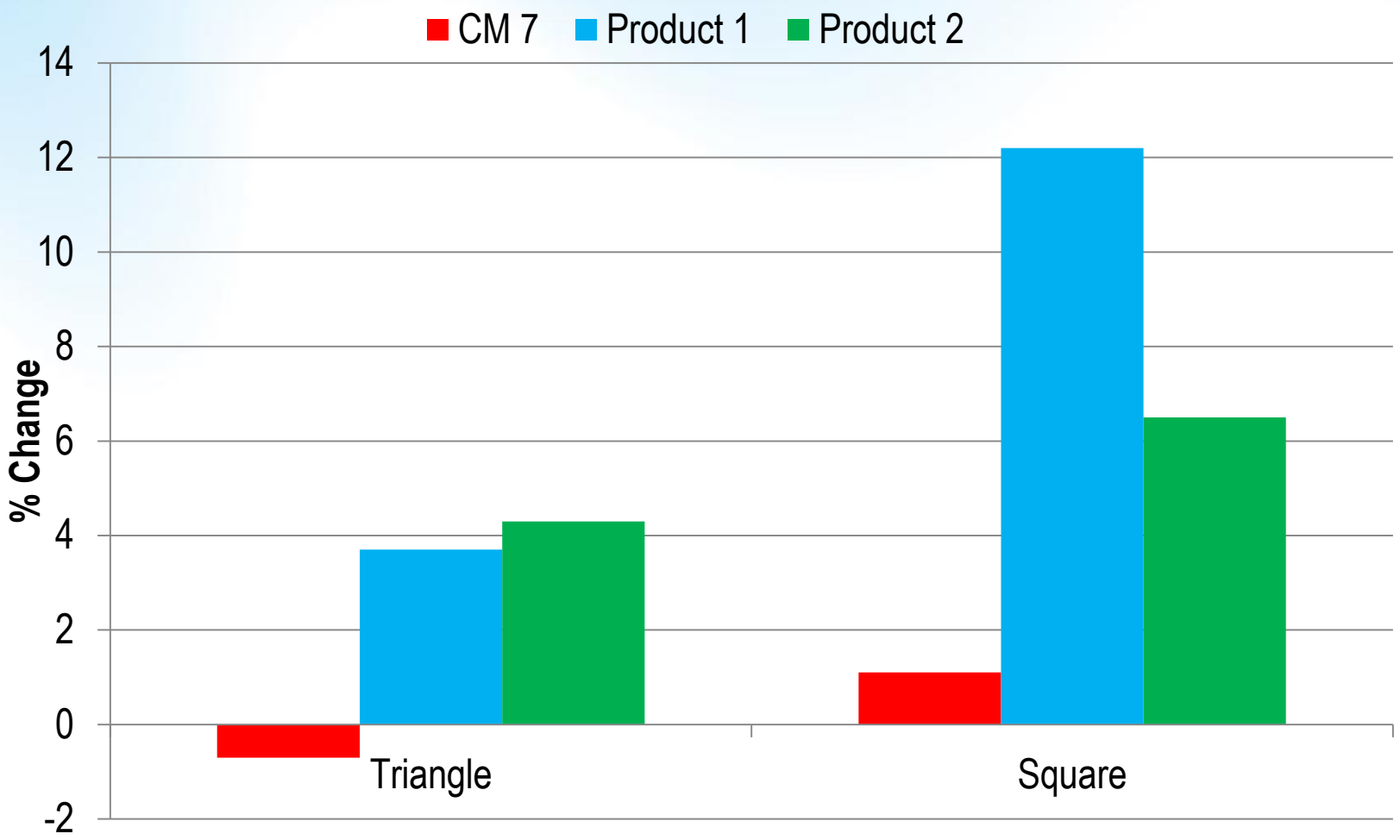
Percentage Changes NFDPM 55 ml Volume



Percentage Changes Nicotine 35 ml Puff Volume



Percentage Changes Nicotine 55 ml Puff Volume



E – Cigarettes TSNA Analysis

- Collect Vapour from 100 puffs on a 44 mm CF Pad
- Spike pad with 100 µL IS solution containing D4 versions of all four TSNA's
- Extract with 20 mls of Ammonium Acetate buffer solution
- Shake and filter with 0.45 µm syringe filter in to LC vial
- Analyse using LC-MS/MS
- Column 150 x 4.6 mm, 5µm Gemini C6 Phenyl
- Flow 250 µL/min
- Injection volume 10 µL
- Column Temperature Ambient
- Mobile Phase Gradient
- Run Time Approximately 16 minutes

E – Cigarettes TSNA Analysis

Compound	Puff Profile	Product 1	Product 2	CM7
NAB	ISO	< 0.4	< 0.4	9.8
	Triangle			9.4
	Square			8.9
NAT	ISO	< 0.4	< 0.4	104.3
	Triangle			108.8
	Square			99.7
NNN	ISO	< 0.4	< 0.4	37.8
	Triangle			37.6
	Square			37.0
NNK	ISO	< 0.4	1.0	48.5
	Triangle		1.0	49.0
	Square		0.6	47.2

Values in ng/100 puffs for e-cigarettes and ng/cig for CM7

Conclusions

- A standard Cambridge Filter smoke trap seems to be acceptable for the trapping of nicotine in e – cigarette vapour
- Methods for measuring the yields of potentially harmful compounds such as TSNA's can be modified for use with e – cigarettes
- As puff volume increases the yields of e – cigarettes increase but this effect is smaller than observed for tobacco cigarettes
- For the two products studied a square wave puff profile may give slightly higher measured yields but the difference is slight and more work would be needed with larger numbers of replicates and a number of different products to confirm this effect

Thank You for Your Attention

Any questions?