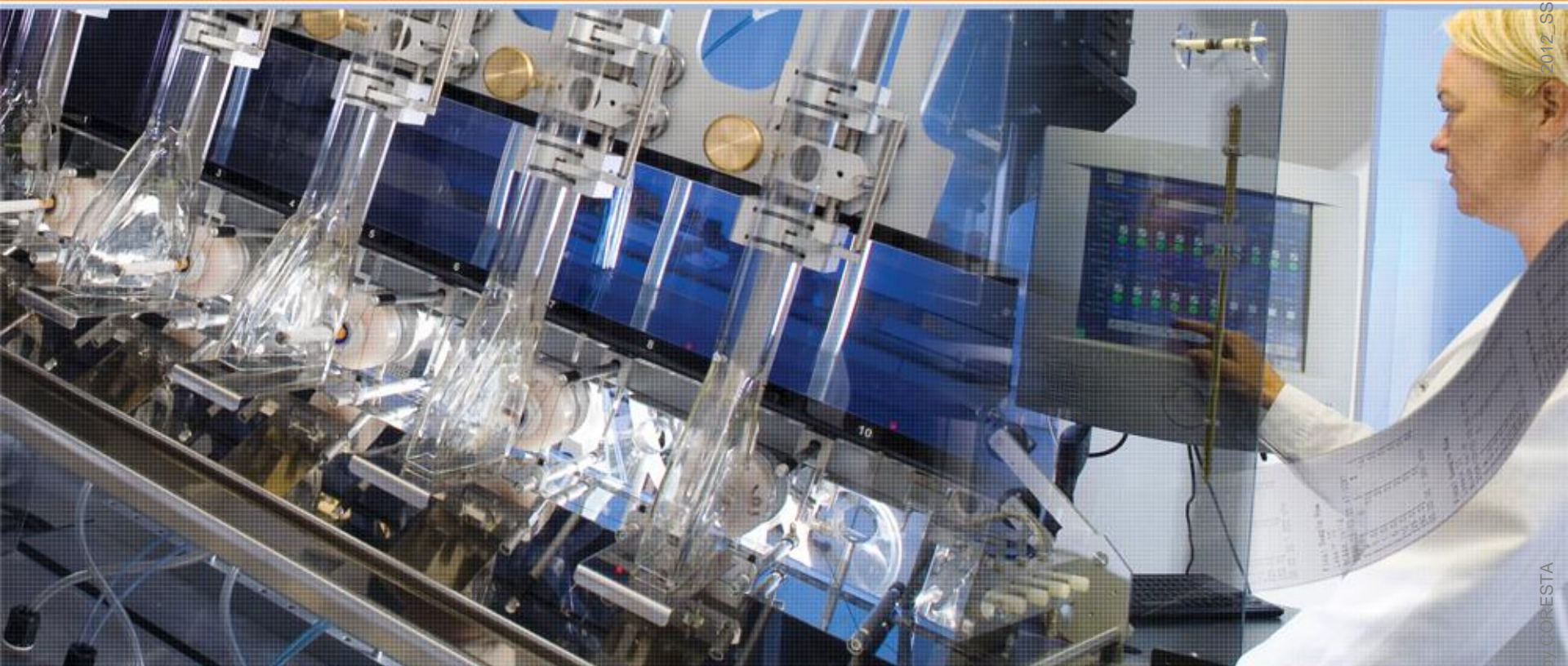


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## The Effect of Puff Duration and Volume on the Yields of e-Cigarettes

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CORESTA Congress, Sapporo, 23 to 28 September 2012

Filtrona Scientific Services

the difference is { everything }

## Introduction

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- E-cigarettes were first developed in 2003 and launched commercially in 2004
- Initially launched in China in 2004
- Introduced in the US and UK in about 2008
- Since their introduction e-cigarettes have increased in popularity
- By 2011 the estimated global sales were \$300M and an estimated 2.5 M people regularly use e-cigarettes
- Some analysts expect the market to increase four fold by 2014

## Introduction

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- Despite the popularity in some areas e-cigarettes have not been universally welcomed
- Some countries only allow the nicotine free versions and e-cigarettes containing nicotine are banned in Australia, Canada and Mexico
- E-cigarettes are banned in Singapore, Brazil and some other countries
- In some countries they must be registered as medicinal products such as Denmark and New Zealand

## E-Cigarettes

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- 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 often contains nicotine and a range of flavours for delivery to the user
- Nicotine free versions are also available presumably for use as smoking cessation devices
- E-Cigarettes are often advertised as NO TAR, NO TOBACCO, NO RESTRICTIONS and NO SMELL
- They were initially perceived as smoking cessation products but many of the current products have disclaimers saying they are not smoking cessation devices

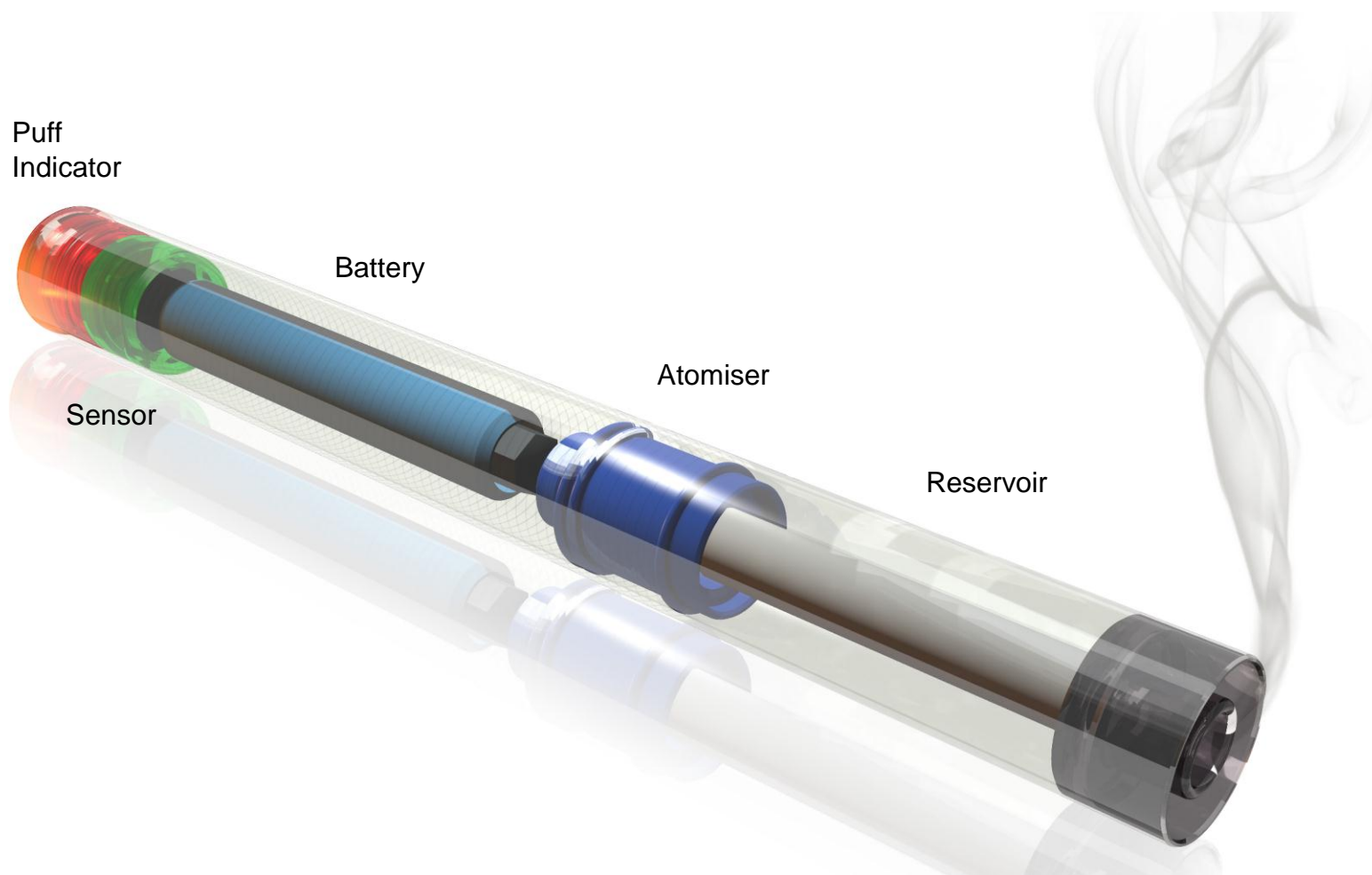
## E-Cigarettes

- The main components of e-cigarettes are usually
  - A battery
  - A flow sensor and indicator light
  - A heating element
  - An atomiser
  - A liquid reservoir that usually contains Glycerol or a mixture of Glycerol and Propylene Glycol, Water, Nicotine and Flavours and Aromas.
- Usually the reservoir is in direct physical contact with the atomiser a porous material designed to present a high surface area of solution to the flow path. The heating element can be in direct contact with the reservoir or remote from the reservoir
- When the device is puffed the flow sensor activates the heating element so that the reservoir is heated or heated air is passed over the atomiser to convert some liquid to vapour for delivery to the user

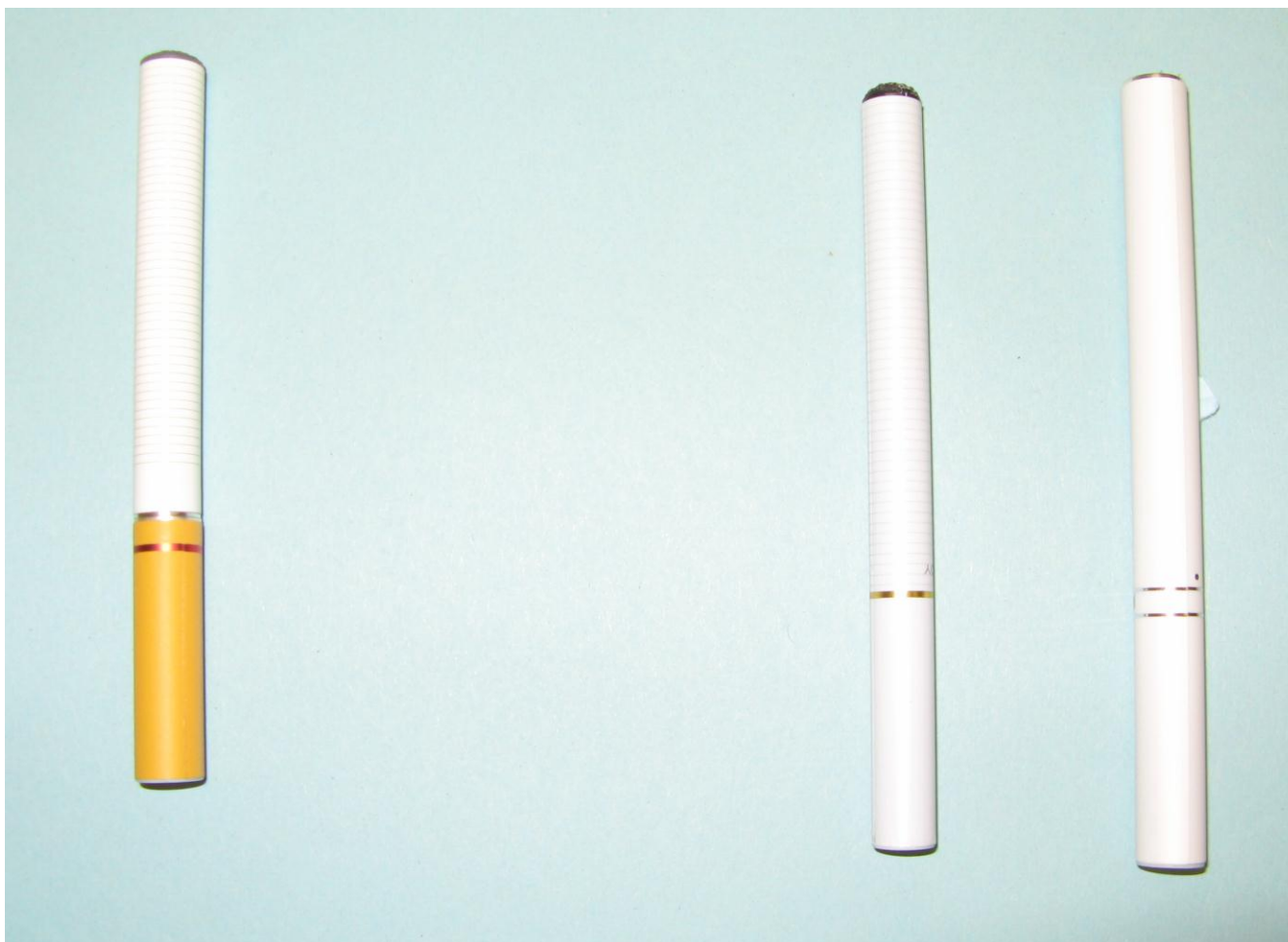
## E-Cigarettes

- Two types are available
- Disposable – these often resemble a traditional cigarette in size and are normally sold on the basis of equivalence to standard cigarettes. For example the packs would have messages such as equals about 40 cigarettes or equivalent to about 2 packs.
- Disposable devices would be considered to be consumed when the indicator flashes (or does not light during smoking) to show the battery power is almost finished or when the liquid in the reservoir is consumed
- Reusable - supplied with a separate battery unit that can be recharged via a computer USB port
- Reusable products further subdivide into 2 and 3 piece e-cigarettes. In the 2 piece the atomiser and reservoir are supplied as one sealed unit and in the 3 piece the atomiser and reservoir are separate pieces
- Many reusable products sell the replacement reservoirs in 3 or 4 strengths based on nicotine content usually 0 and then light and regular or low medium and high.
- Menthol versions are available for both disposable and reusable products

## Schematic Diagram of an E-Cigarette

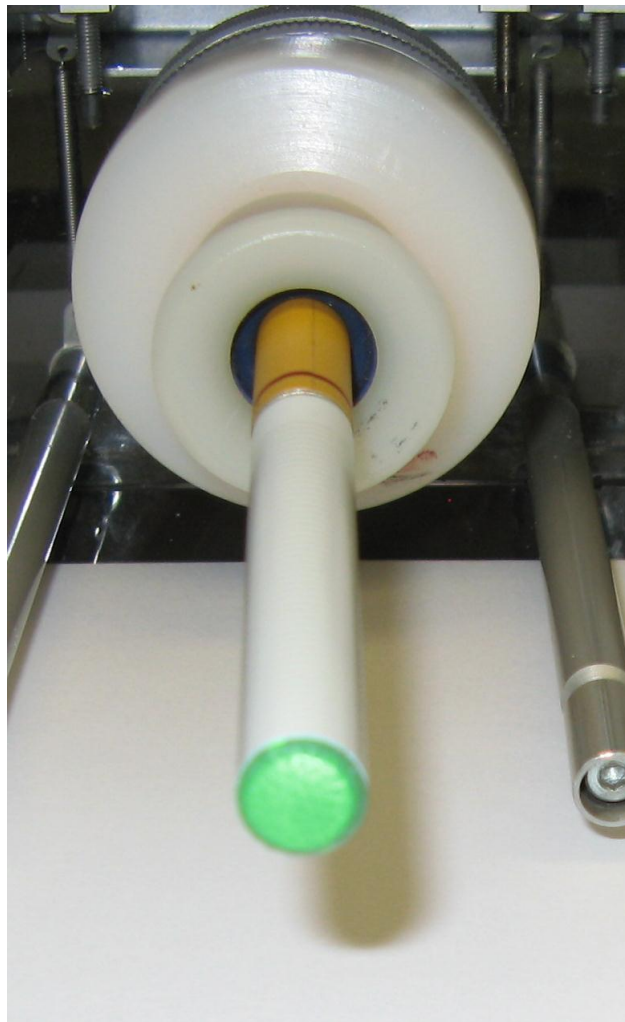


## Typical e-Cigarettes





## E-Cigarette Puffing on Smoking Machine



## E-Cigarette Testing

- E-Cigarettes are obviously different to standard cigarettes and work in a different way
- Very little information is available on the parameters that may effect the measured yields of e-cigarettes and to a lesser extent what is actually delivered in terms of major and minor components
- As e-cigarettes rely on a signal from a sensor to start the heating process and rely on a capillary action to 'charge' the atomiser it may be expected that parameters affecting the performance would be different to standard cigarettes
- The main parameters often studied are puff frequency and volume but it could be expected that due to the time taken to heat the reservoir after puff initiation that puff duration may have an effect on e-cigarettes
- Also in order to give the atomiser time to charge with liquid it may be appropriate to allow a rest time between groups of puffs when testing e-cigarettes

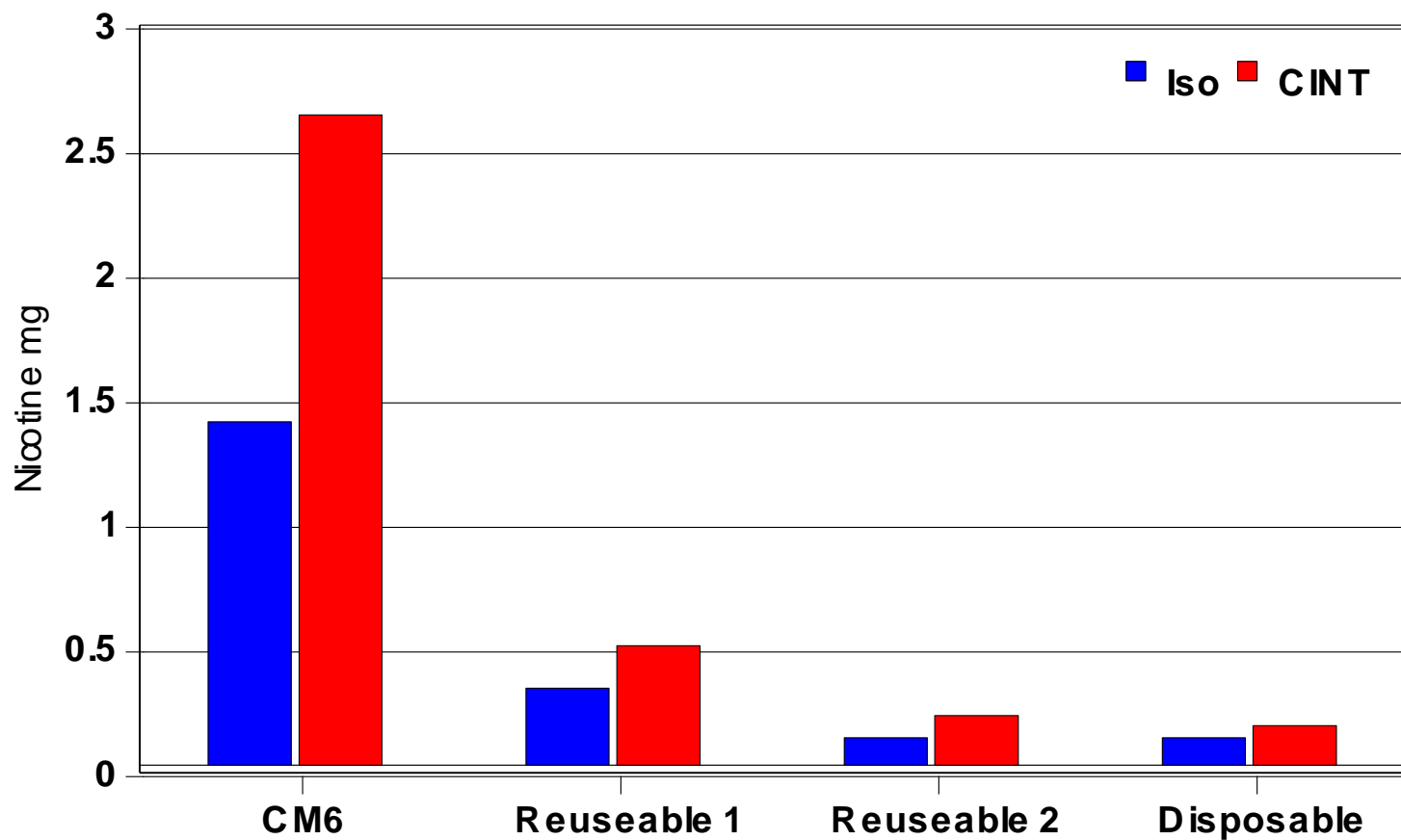
## E-Cigarette Testing

- For the study described here three e-Cigarette products were selected at random from the market, two reusable and one disposable. Reusable 1 is a three piece product and reusable 2 a two piece product
- For the reusable products the high strength refills were used
- To test the e-cigarettes each test was taken as a batch of 10 puffs and a ten minute rest period was left between each batch of ten puffs.
- As previous experience had shown that e-cigarettes were very variable during machine smoking testing especially in the first few puffs, 20 puffs were taken from each product before testing was started and a maximum of another 90 puffs taken for each product
- The products were tested using two smoking regimes and three puff durations. When comparing puff durations the order of testing was randomised and a new product (or refill) used for each smoking regime
- For comparative purposes the work was repeated using a CORESTA monitor cigarette and standard smoking procedures
- E-cigarette yield values are quoted on the total yield for a block of 10 puffs
- To allow ease of comparison of data trends from products with dissimilar absolute yields where appropriate the data comparing puff volume and duration is plotted as percentage change

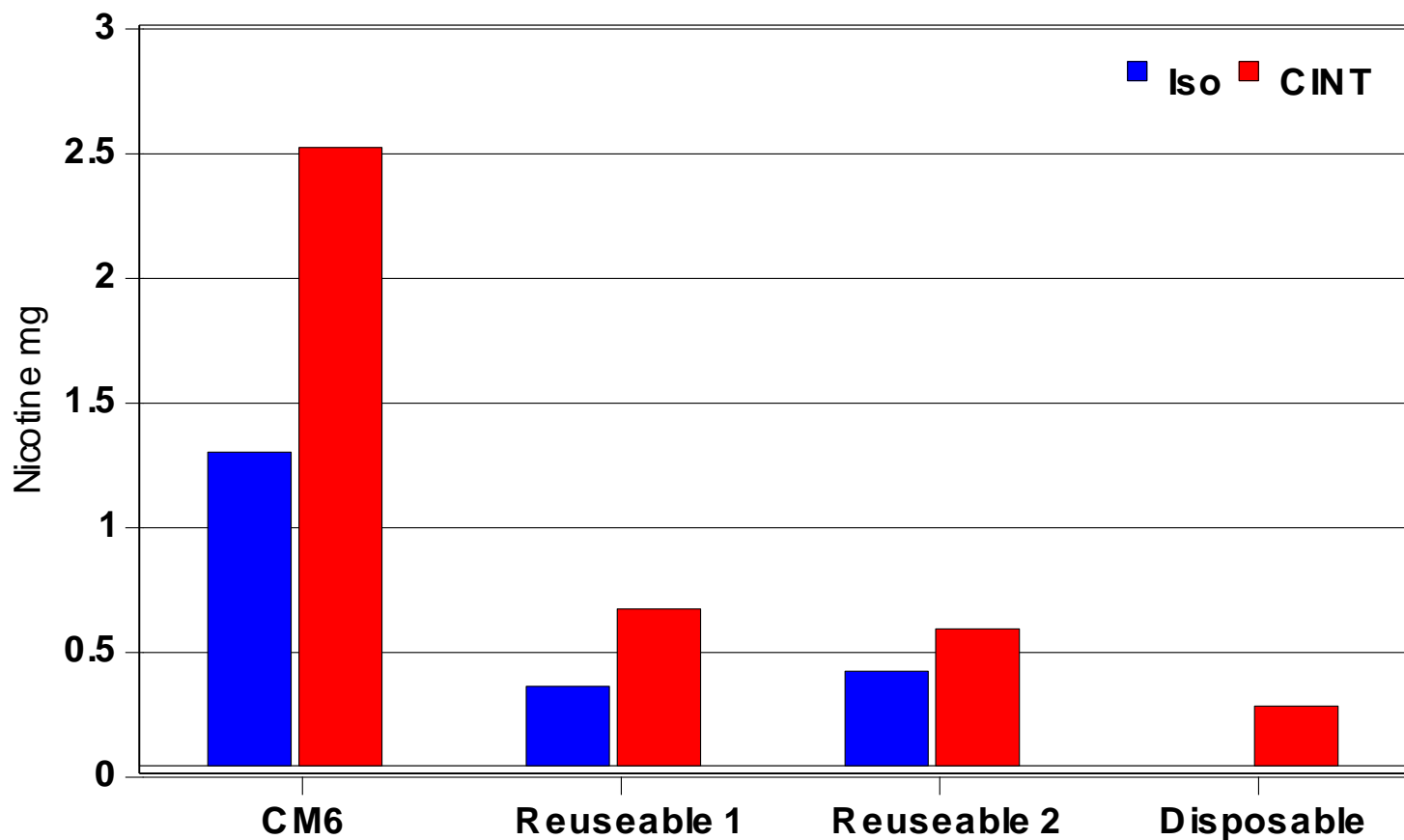
## E-Cigarette Yields

Product	ISO mg/10 puffs		CINT mg/10 puffs	
	Nicotine	Particulate Matter	Nicotine	Particulate Matter
Reusable 1	0.34	11.6	0.51	17.3
Reusable 2	0.14	7.0	0.23	10.5
Disposable	0.14	8.9	0.19	12.0

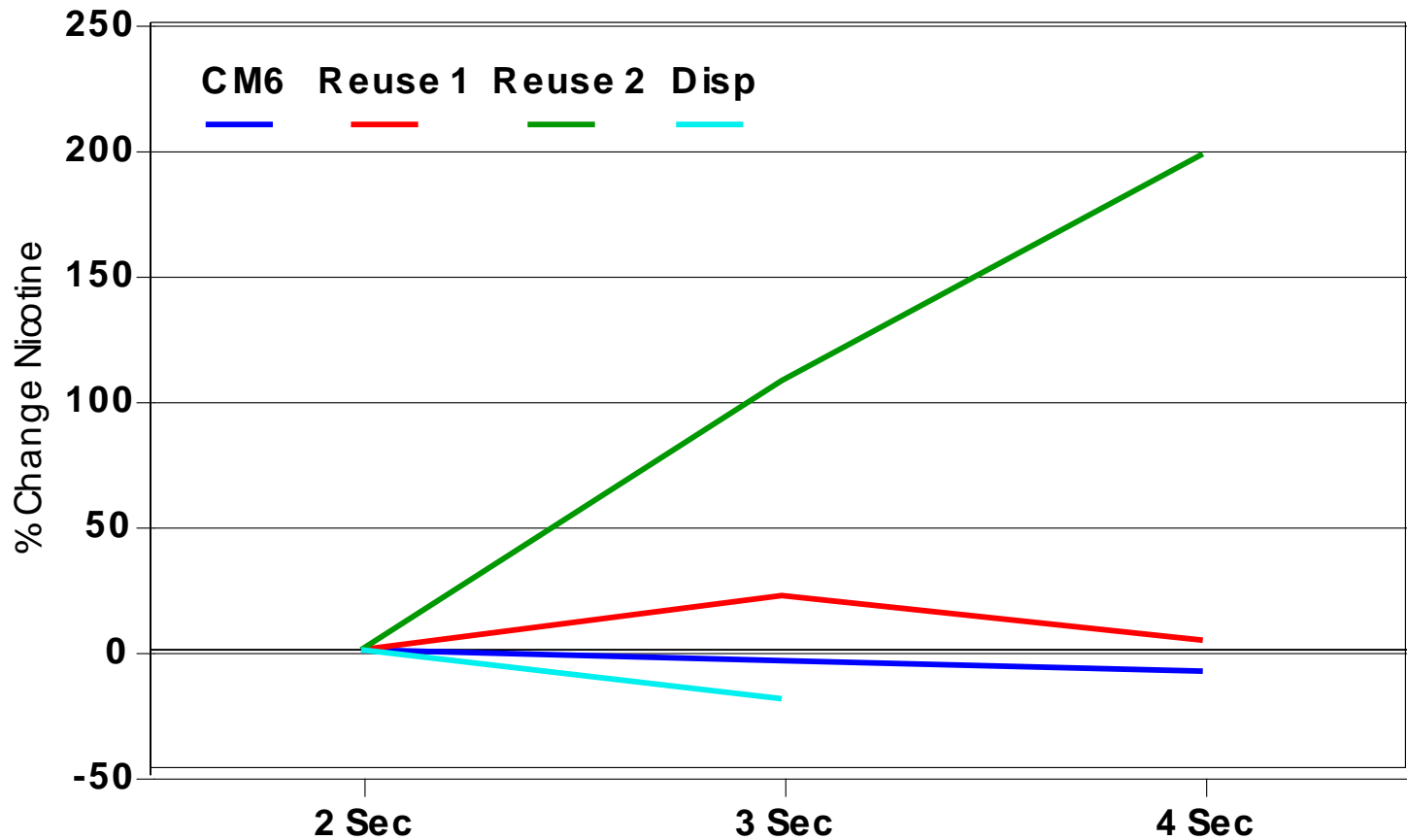
## Nicotine Yields Two Second Puff Duration



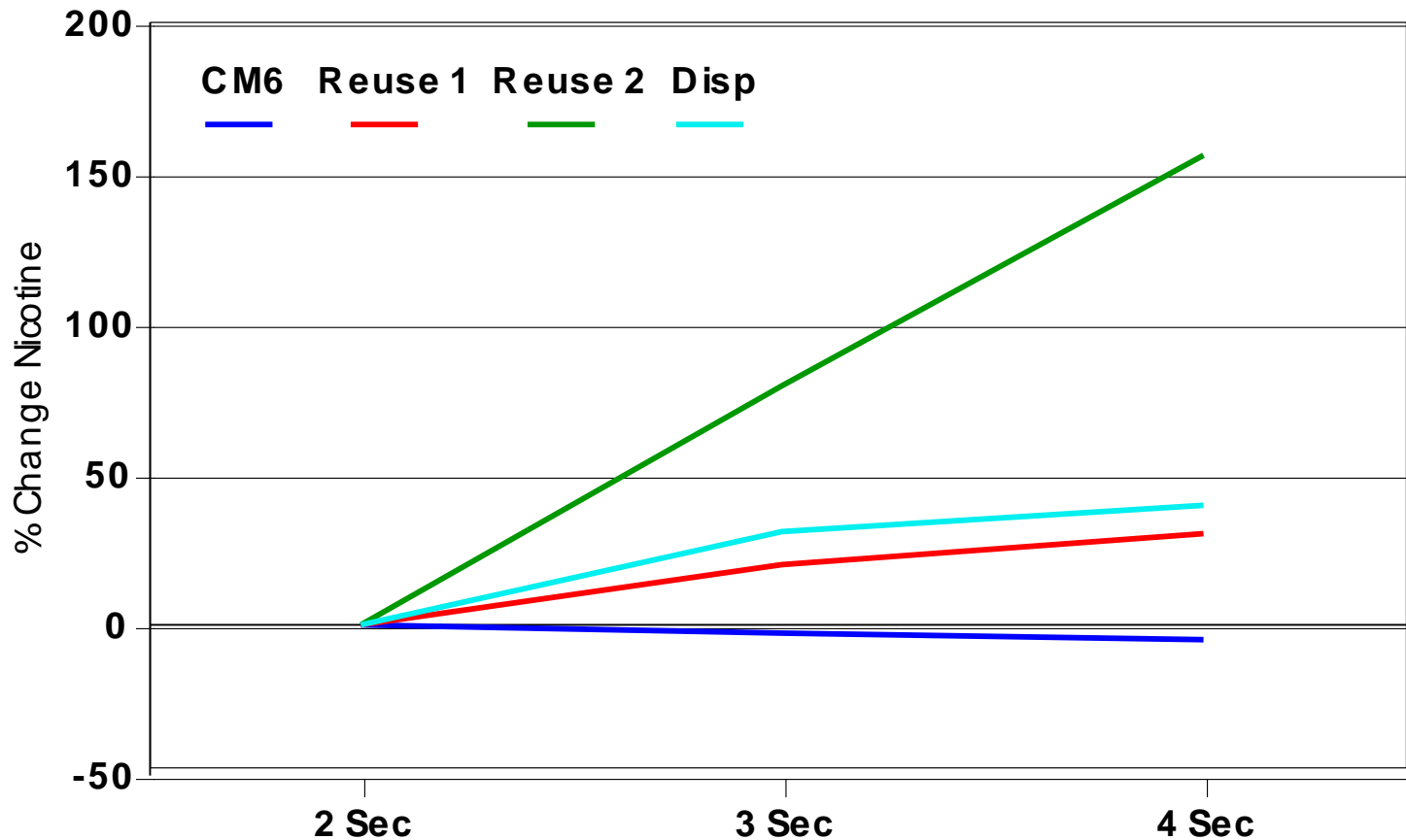
## Nicotine Yields Four Second Puff Duration



## Percentage Change in Nicotine Yields ISO 35 ml Puff

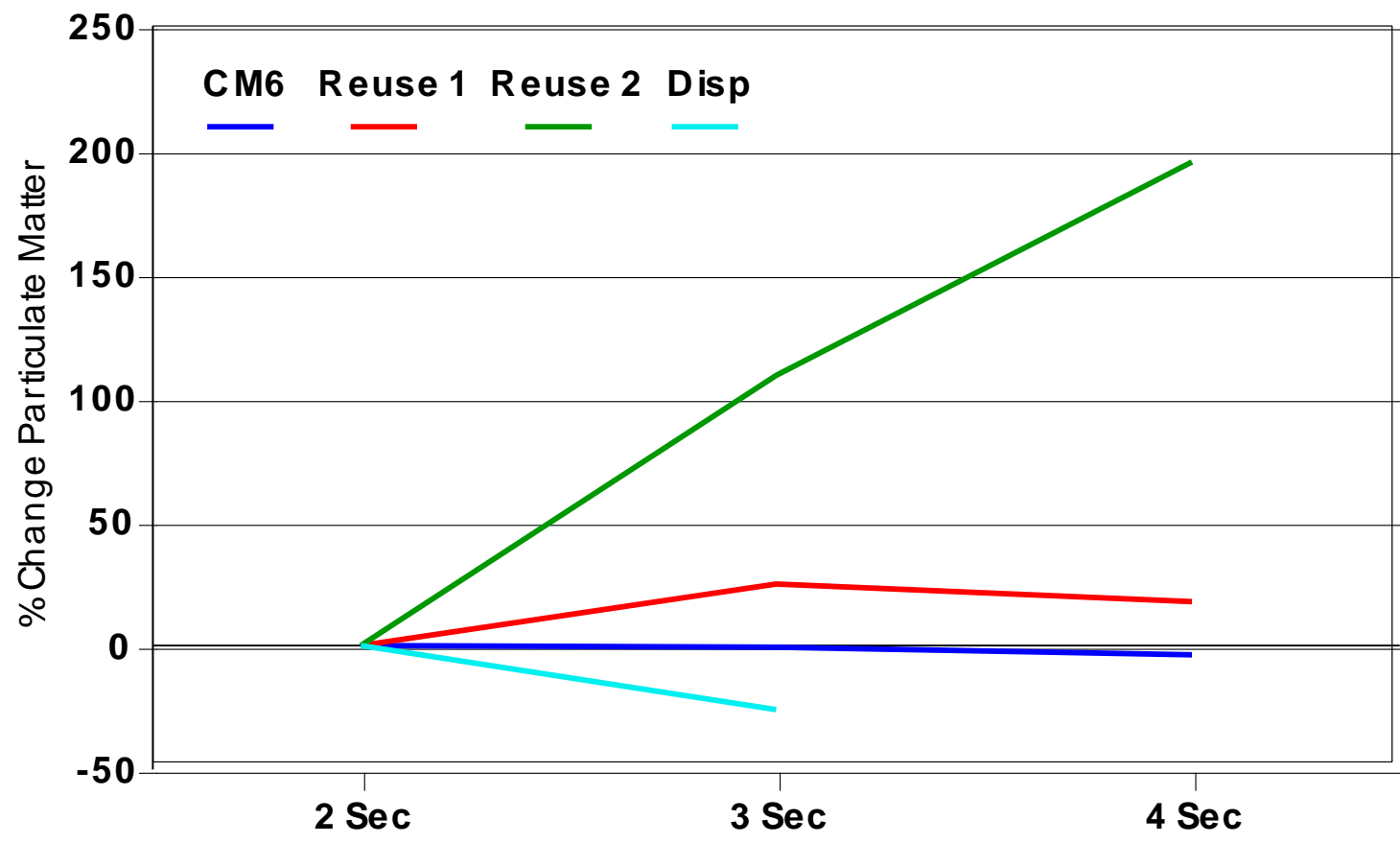


## Percentage Change in Nicotine Yields CINT 55 ml Puff

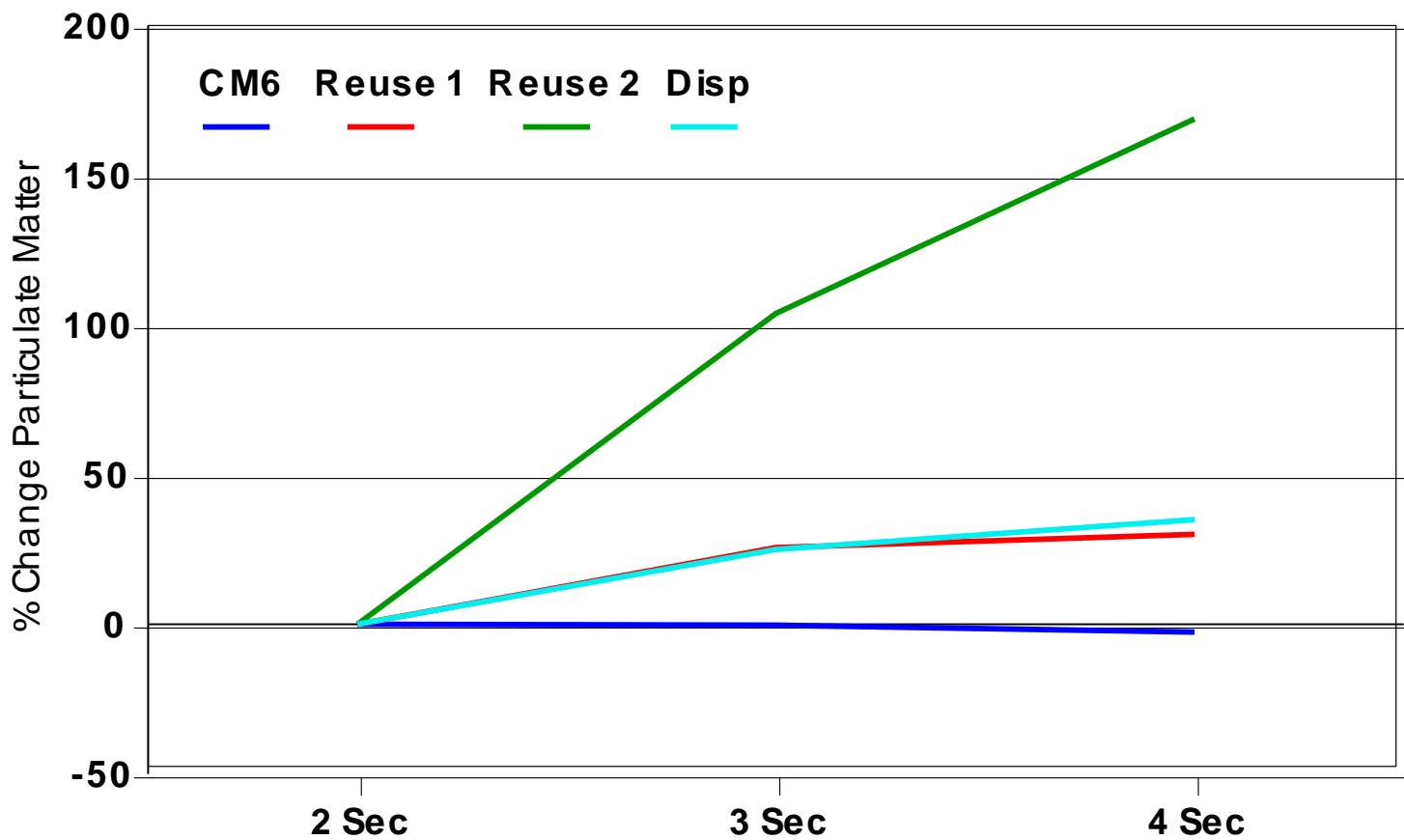




## Percentage Change in Particulate Matter Yields ISO 35 ml Puff



## Percentage Change in Particulate Matter Yields CINT 55 ml Puff



## Conclusions

- Measurable amounts of both nicotine and particulate matter are delivered by e-cigarettes
- The performance of e-cigarettes seems to vary with the type of product.
- For some products the puff duration is a significant factor in determining the measured yield of nicotine
- For the three different products tested one shows an almost linear increase in measured nicotine yield as puff volume increases for both smoking regimes
- For ISO smoking two of the products show very little change in yields when puff duration is varied but larger increases for CINT smoking when the puff duration is increased
- The yield increases measured when comparing the ISO smoking regime to CINT are much smaller for e-cigarettes than standard cigarettes

## Questions?

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