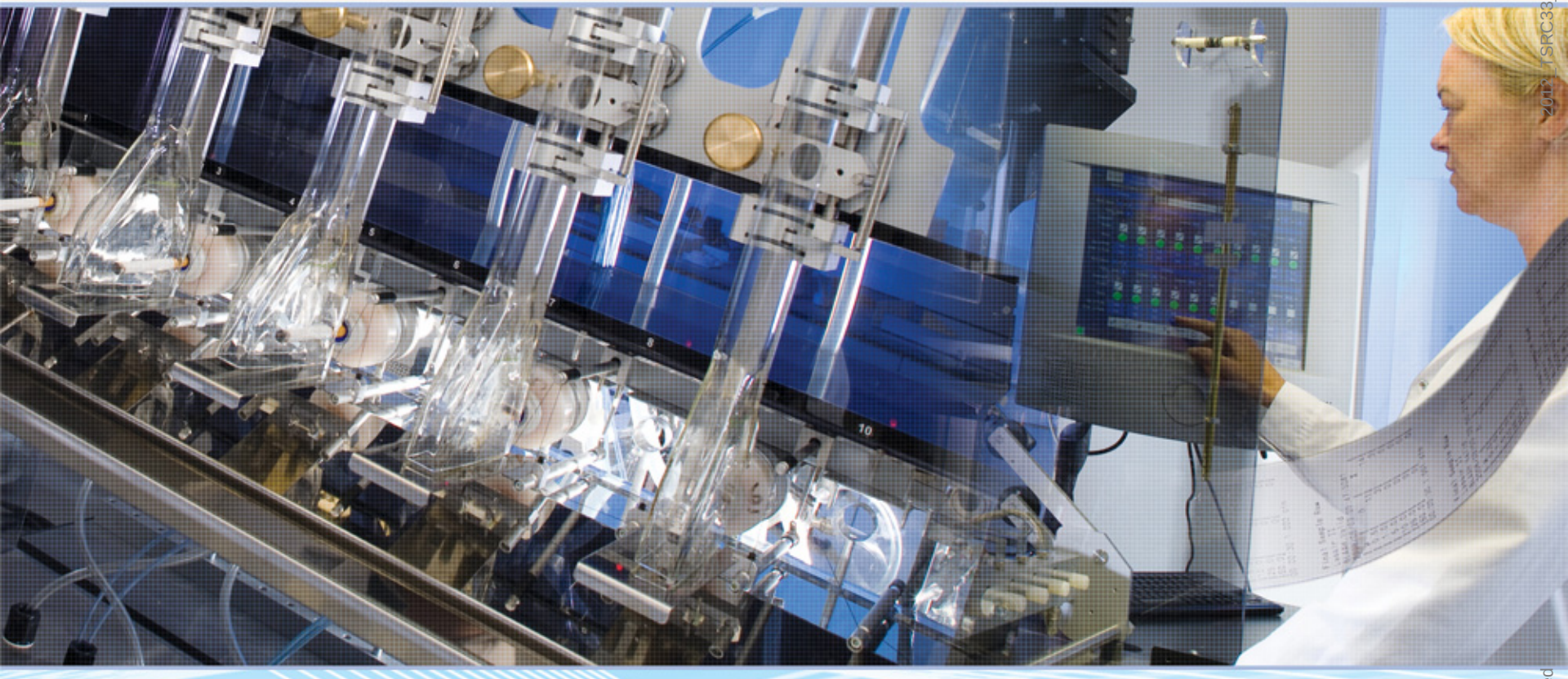
{ accredited } { independent } { analytical } { solutions }



The Effect of Smoking Parameters on the Yields of e-Cigarettes

Filtrona Scientific Services

the difference is { everything }

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E-Cigarette Market Development

- E-cigarettes were first developed in China in 2003
- Initially launched commercially in Asia in 2004
- Introduced in the US and UK in about 2008
- Since their introduction e-cigarettes have increased in popularity, with estimated annual growth rates of around 50%
- By 2011 the estimated global sales were $300M and around 2.5 M people regularly use e-cigarettes
- Some analysts expect the market to increase four fold by 2014

What are e-Cigarettes?

- 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” or “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 – Regulatory Status

- Despite the popularity in some area's 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 medical devices such as Denmark and New Zealand

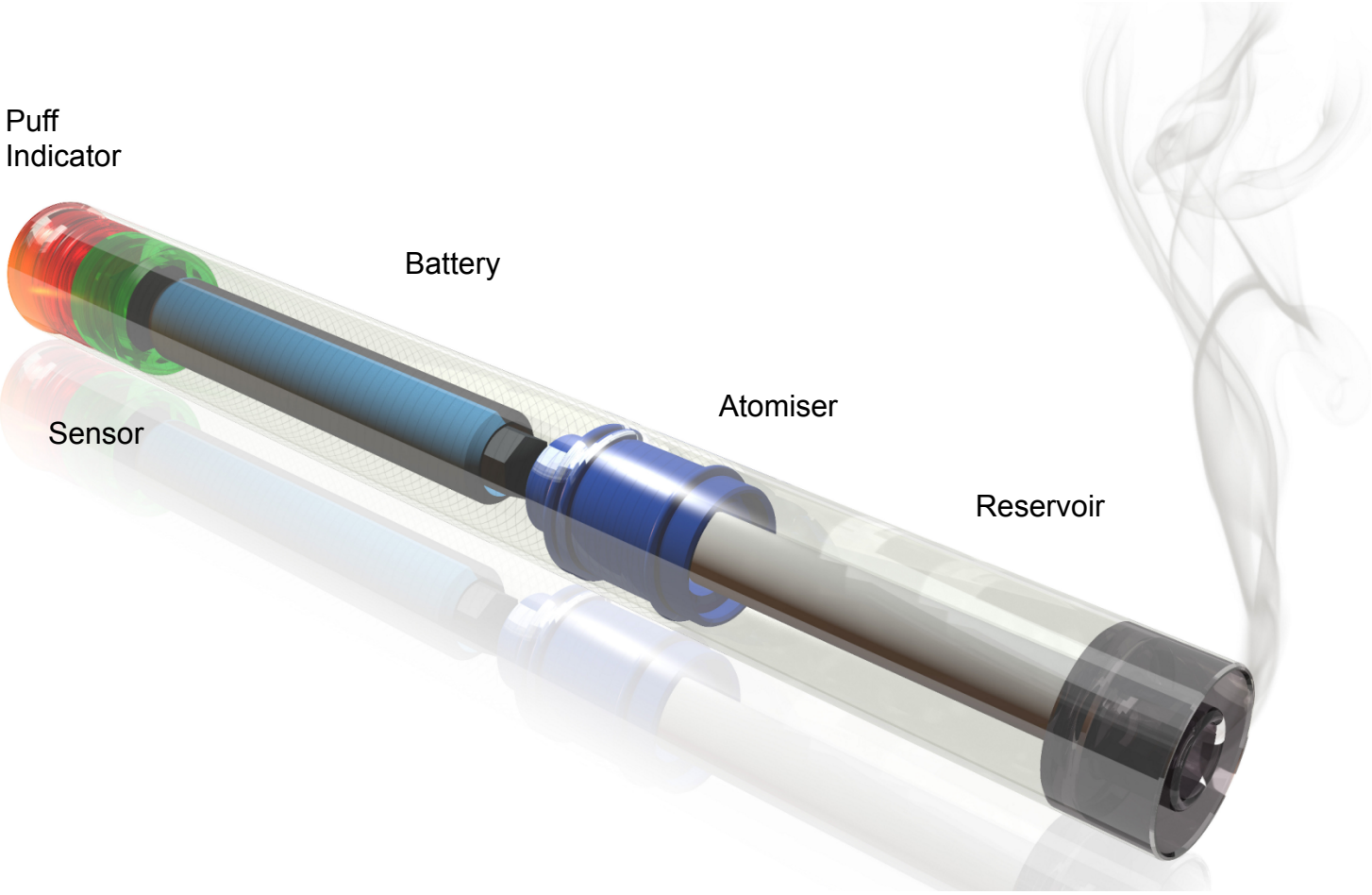
Construction of e-Cigarettes

- 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

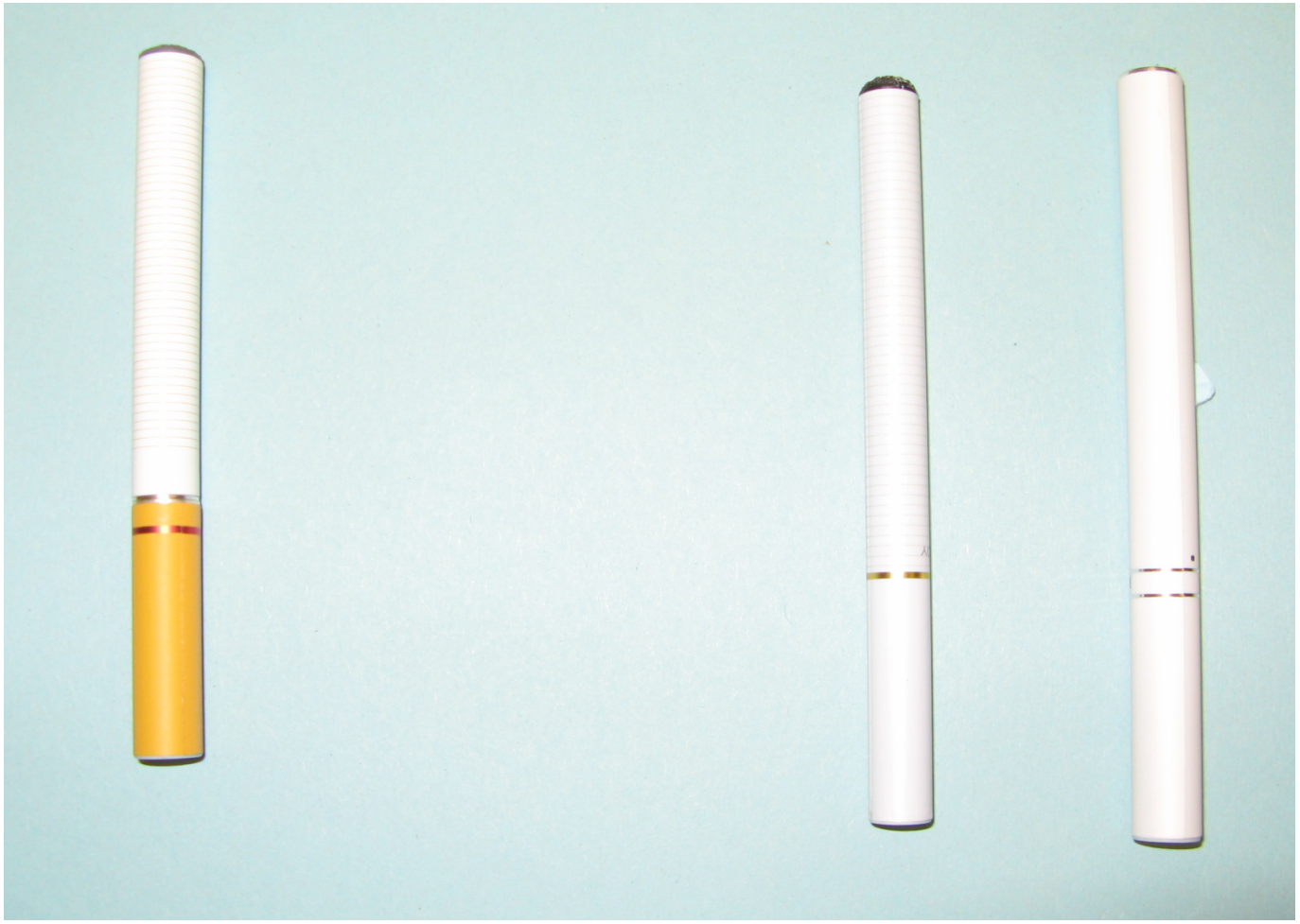
Types of e-Cigarettes

- Two main types are currently available – disposable and reusable
- Disposable – these often resemble a traditional cigarette in size and are normally sold on the basis of equivalence to standard cigarettes.
- 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. The user simply buys replacement reservoirs.
- Many reusable products sell the replacement reservoirs in 3 or 4 strengths based on nicotine content usually zero and then light /low, regular/medium and high.
- Menthol versions are available for both disposable and reusable products

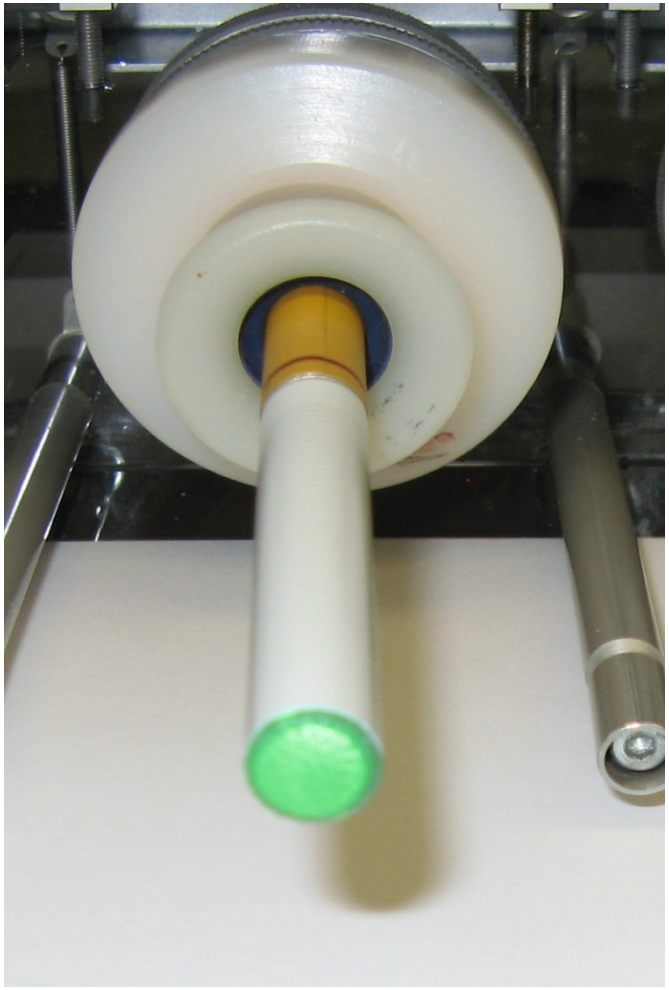
Schematic Diagram of an e-Cigarette



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
- 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 present study, three e-cigarette products were selected at random from the market, two reusable and one disposable.
- One reusable product ("Reusable 1") was a three piece product, whilst the other ("Reusable 2") was a two piece product
- For both reusable products the highest strength refills were used
- As these devices are not consumed in a short number of puffs as per conventional cigarettes, preliminary smoking trials were conducted to assess reasonable testing protocols
- E-cigarettes were found to be extremely variable during machine smoking testing especially in the first few puffs. 20 puffs were taken from each product before quantitative testing was started and a maximum of further 90 puffs taken for each product
- To test the e-cigarettes, each test comprised taking a discrete number of puffs and allowing a ten minute rest period before taking the next set of puffs
- Mean yield values could then be calculated per batch of puffs.

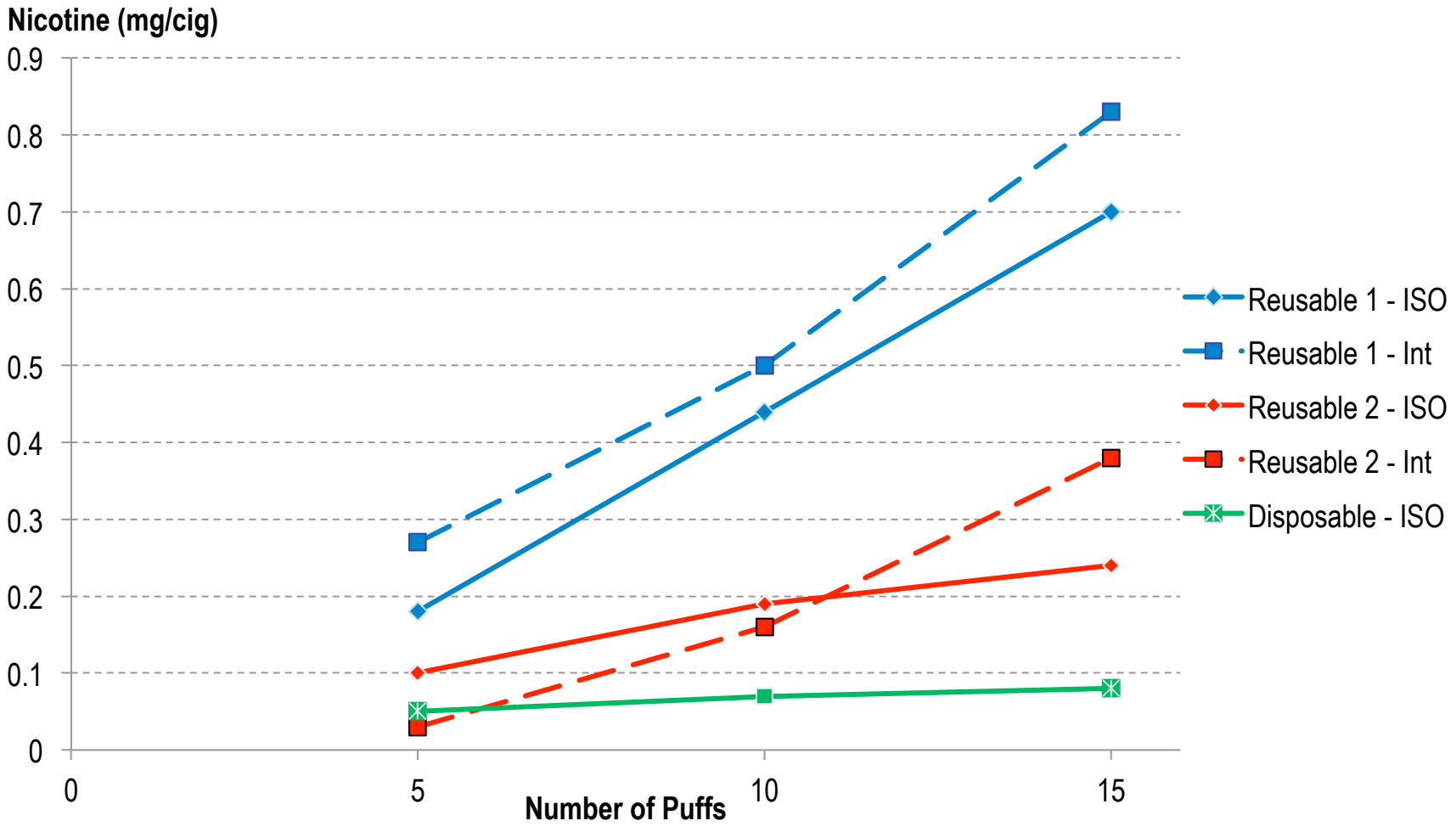
E-Cigarette Testing

- Smoking variables studied during this work were:
  - Smoking regimes – ISO and Canadian Intense
  - Puff duration – 2, 3 and 4 seconds
  - Puff number – batches of 5, 10, 15 and 30 puffs
- Tests were carried out in a randomised order
- Each test was carried out over 4 channels
- A new product (or refill) used for each smoking regime
- Nicotine and 'Particulate Matter' yields quantified
- This present paper looks at the effect of puff number and smoking regime
- A further paper (CORESTA 2012) looks at the effect of puff duration and smoking regime

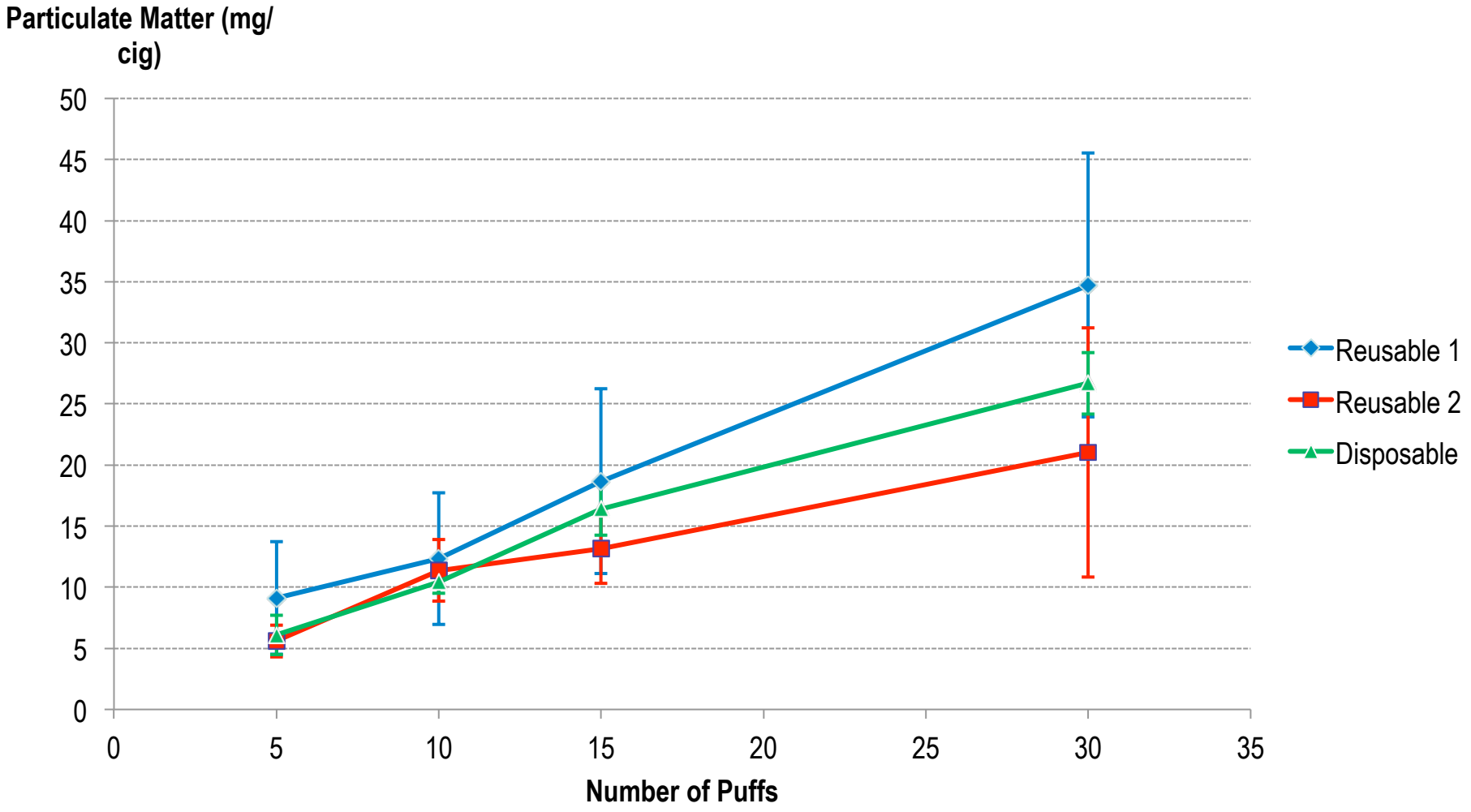
E-Cigarette Yields

Product	ISO (mg /10puffs)		Canadian Int. (mg/10 puffs)	
	Nicotine	Particulate Matter	Nicotine	Particulate Matter
Reusable 1	0.44	12.3	0.50	21.9
Reusable 2	0.19	11.4	0.22	13.4
Disposable	0.13	10.4	Not measured	Not measured

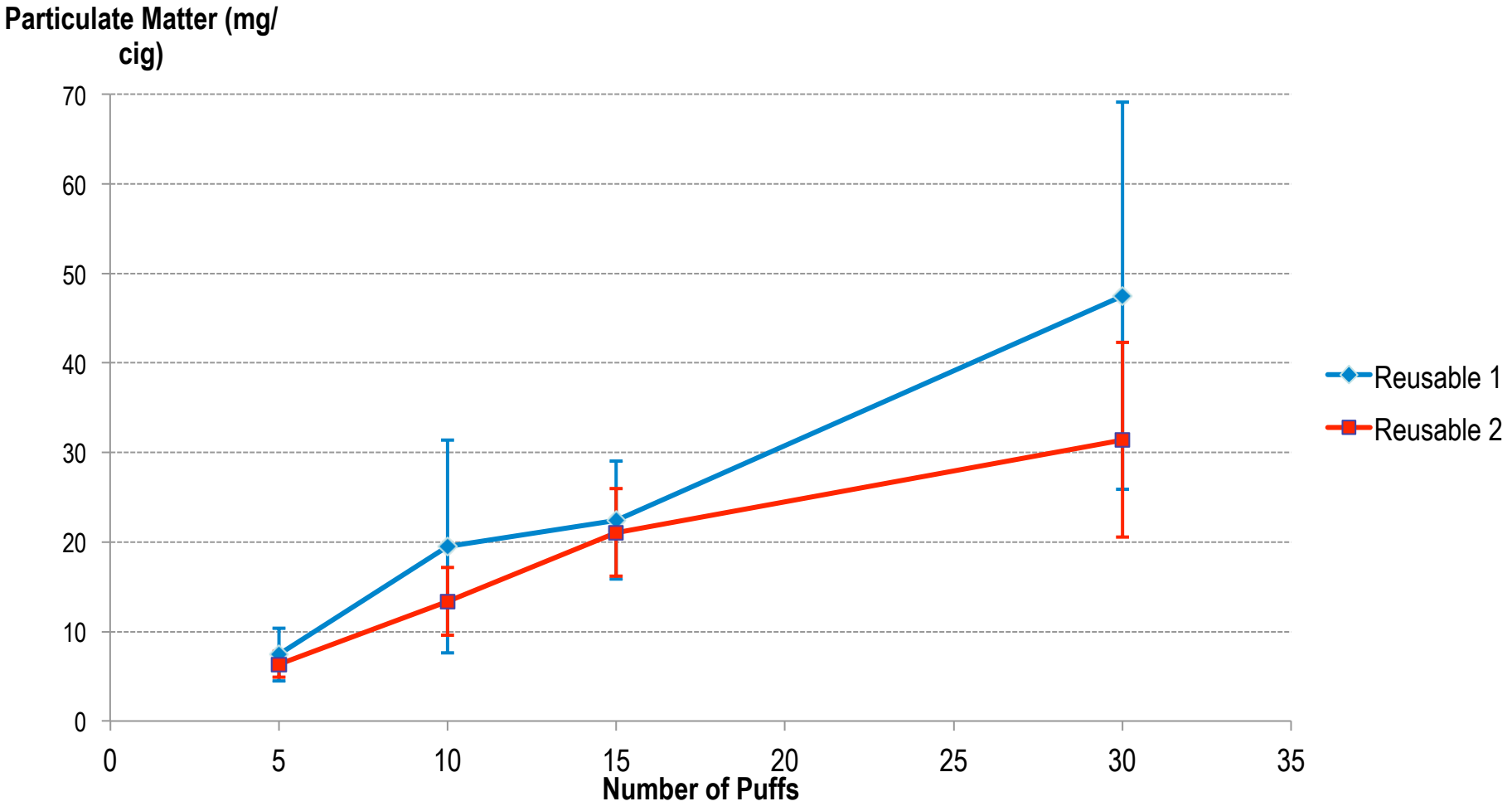
E-Cigarette Nicotine Yields – ISO vs. Intense



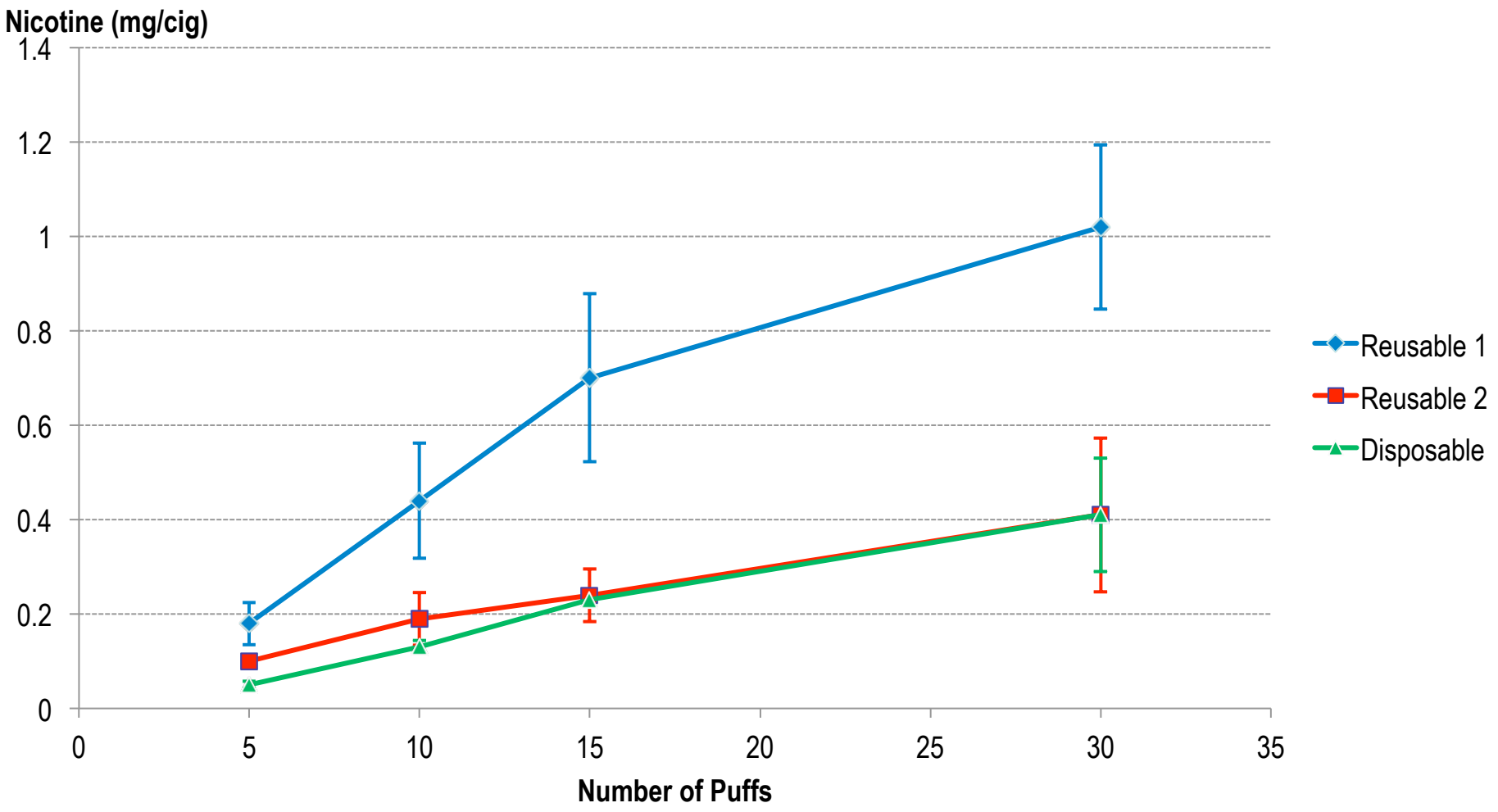
E-Cigarette Particulate Matter Yields – ISO Smoking



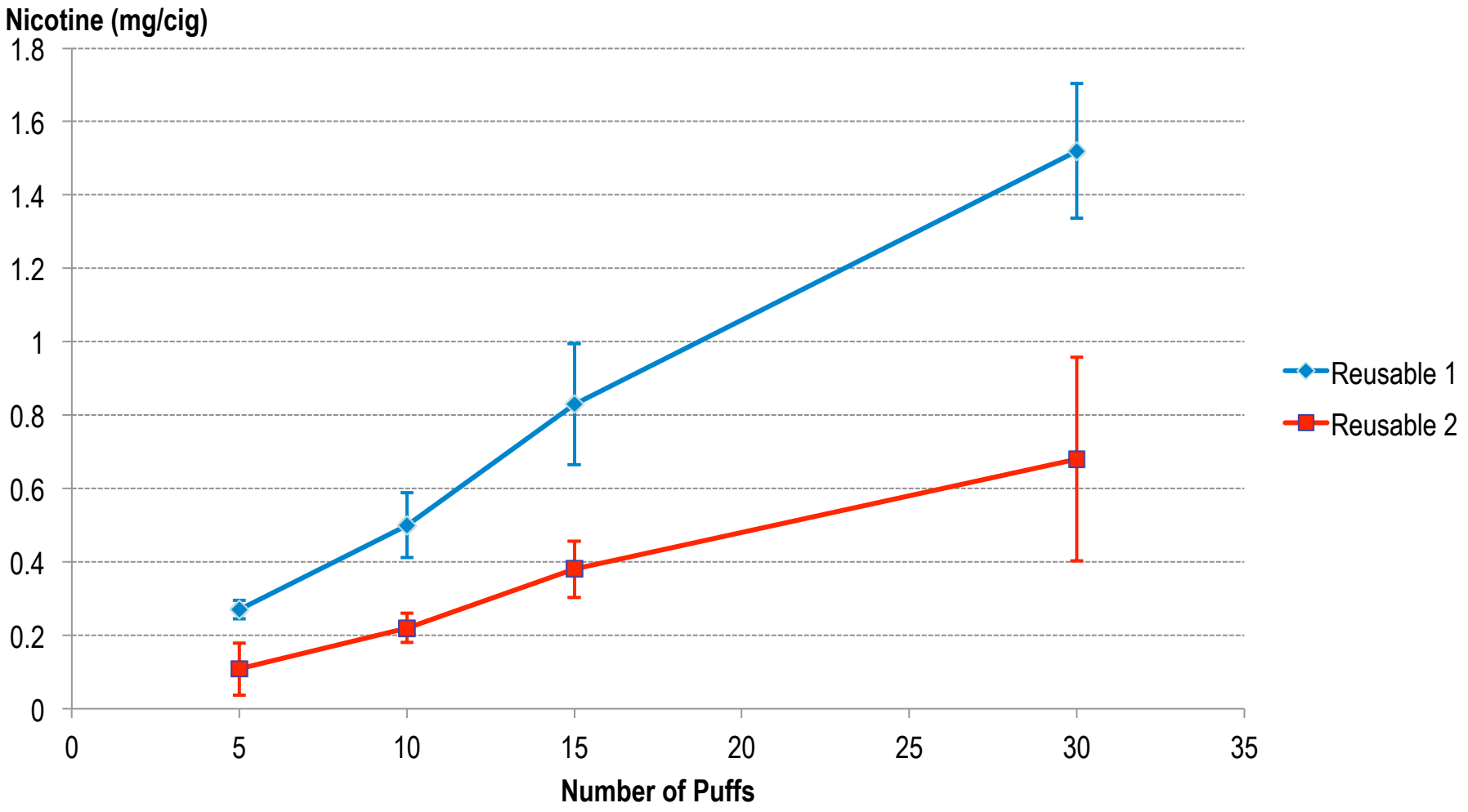
E-Cigarette Particulate Matter Yields – Intense Smoking



E-Cigarette Nicotine Yields – ISO Smoking



E-Cigarette Nicotine Yields – Intense Smoking



Conclusions

- Numerous special precautions that need to be followed when smoking e-cigarettes in comparison to regular cigarettes
- The performance of e-cigarettes seems to vary with the type of product
- For all products tested, yields of particulate matter and nicotine tend to increase in a fairly linear manner with puff number, although the slope of this line differs from product-to-product
- At a constant puff number, there is less difference between the yields from e-cigarettes smoked under ISO and Canadian Intense puffing regimes than may be expected for standard cigarettes
- The yield variability associated with present e-cigarettes is much higher than for regular cigarettes
- Particulate matter yields are more variable than nicotine yields

Thank You for Your Attention

- The effects of puff duration and smoking regime will be reported in forthcoming paper
- Any questions?