Fast Aerosol Delivery Measurement when Vaping E-Cigarettes – Using the EPD system

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Introduction

Clause 39 of EU Directive 2014/40/EU – often known as TPD2 – states "Only electronic cigarettes that deliver nicotine doses at consistent levels should be allowed to be placed on the market". This is rationalised as a safety concern that high dose nicotine is not delivered in error. This also resonates strongly with consumer satisfaction. Random "Nicotine hits" are unlikely to be a selling feature of any e-cigarette product!

Today, to establish that the same level of vapour is delivered throughout the life of an e-cigarette, be this cigalike, pod, closed system or open system, the laboratory scientist usually vapes in "blocks" and looks at the total aerosol matter produced by weight.
This has the merit of being conceptually simple and relatively easy to perform, if somewhat time consuming. All that is needed is a balance and vaping machine.

There is problem in the lack of granularity of data. If a product delivers roughly 200 puffs we are faced with the problem of how often do we want to take a reading of aerosol delivery throughout the product life? Is this once every 50 puffs, once per 20, once per 10? The more frequently we get data the better our understanding can be of the aerosol formation process but it increases the complexity of the experiment.

This problem is magnified when we start to examine individual device to device variation and not just delivery uniformity across the lifetime of a single device type.
We can get greater information on the uniformity of delivery and also on device to device variation if we are able to establish the amount of aerosol delivered by each puff.

Experimental

Individual puff examination is possible using a system that utilises the light scattering properties of the aerosol under consideration, such as the Cerulean End Point Detection (EPD) System Figure 1.

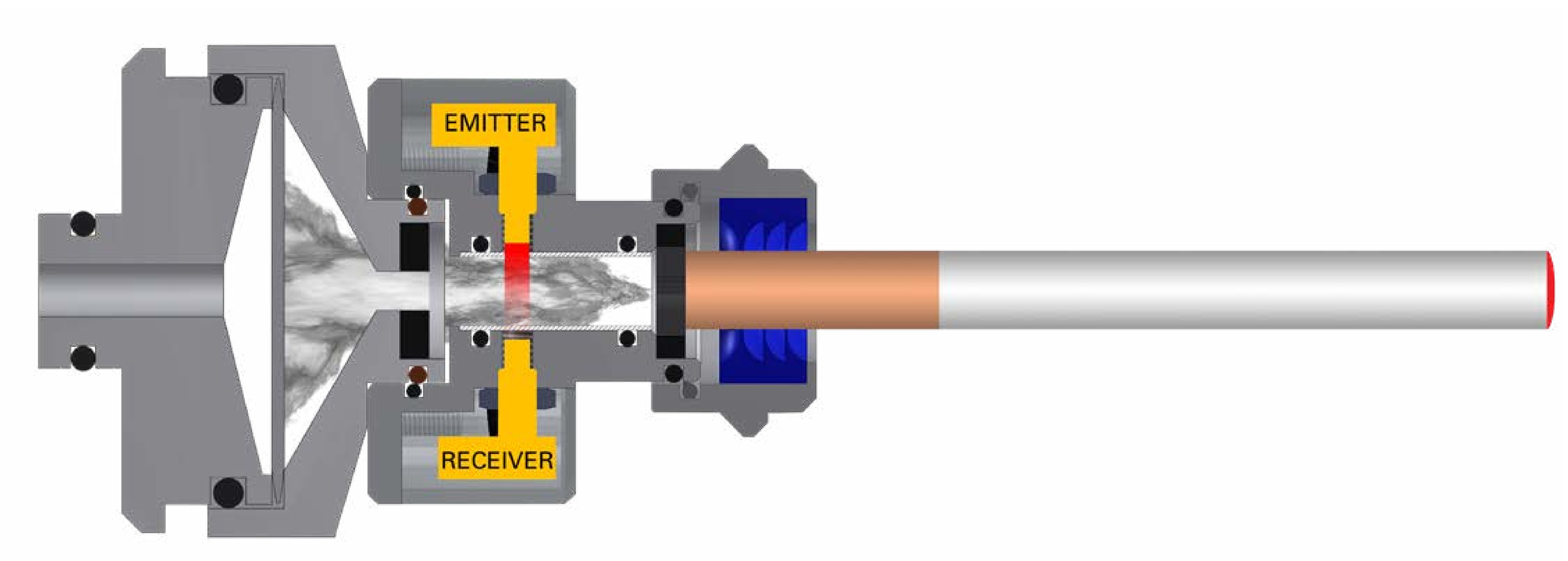

Fig. 1 Schematic of Cerulean End Point Detection System

This consists of a short section of easy to clean glass tube through which the aerosol from an e-cigarette or THP (Tobacco heating product) passes. Either side of the tube is an emitter and light receiver. When there is no aerosol in the tube the receiver has maximum signal from the emitter.

As aerosol is introduced light is scattered and so less reaches the receiver. This is a function of the droplet size and the chemical composition of the aerosol. Most e-cigarettes have aerosols that contain both propylene glycol (PG) and glycerine (VG) so scattering or light beam obscuration can be used as a measure of the amount of aerosol produced.

We can thus use the degree of obscuration by a particular product as a measure of the quantity of aerosol formed. To do this we must first calibrate for the particular product or e-liquid formulation under test.

Taking a known number of puffs we can weigh the amount of aerosol captured by a conventional Cambridge Filter Holder fitted to the Cerulean SM450e and relate that to the reported percentage obscuration of the EPD system. From this we can produce a calibration such that for a measured obscuration we have a measure of the mass of aerosol delivered Figure 2.

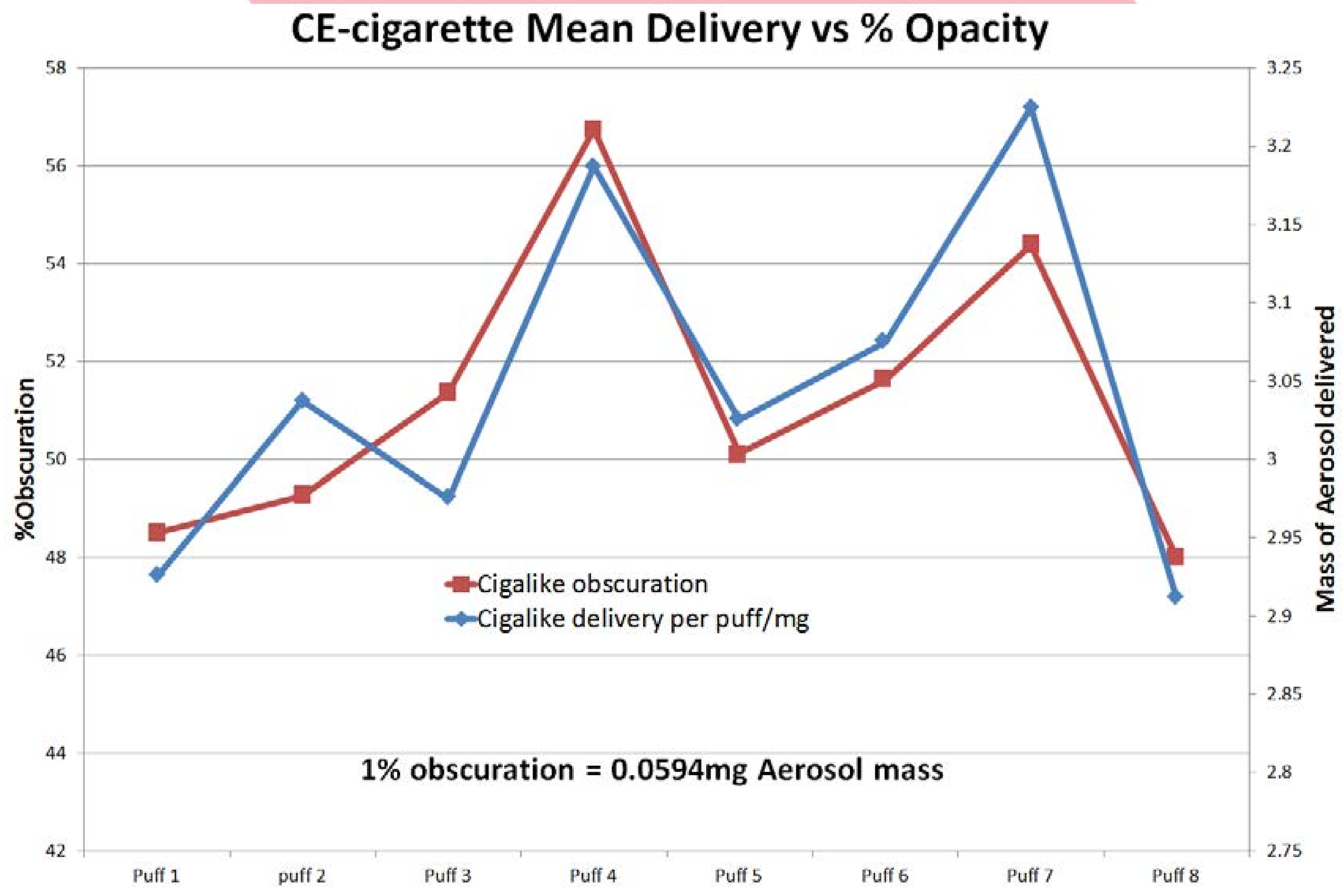

Fig. 2 Mass yield and opacity for a typical disposable e-cigarette device

Once this calibration has been established we can take puff by puff deliveries from individual devices so giving critical information regarding both the long term stability of delivery but also the variation between individual devices.

An example is shown in figure 3 where we have a single brand of flow activated e-cigarette that has been calibrated in an initial experiment, each device having its delivery tracked for 8 puffs.

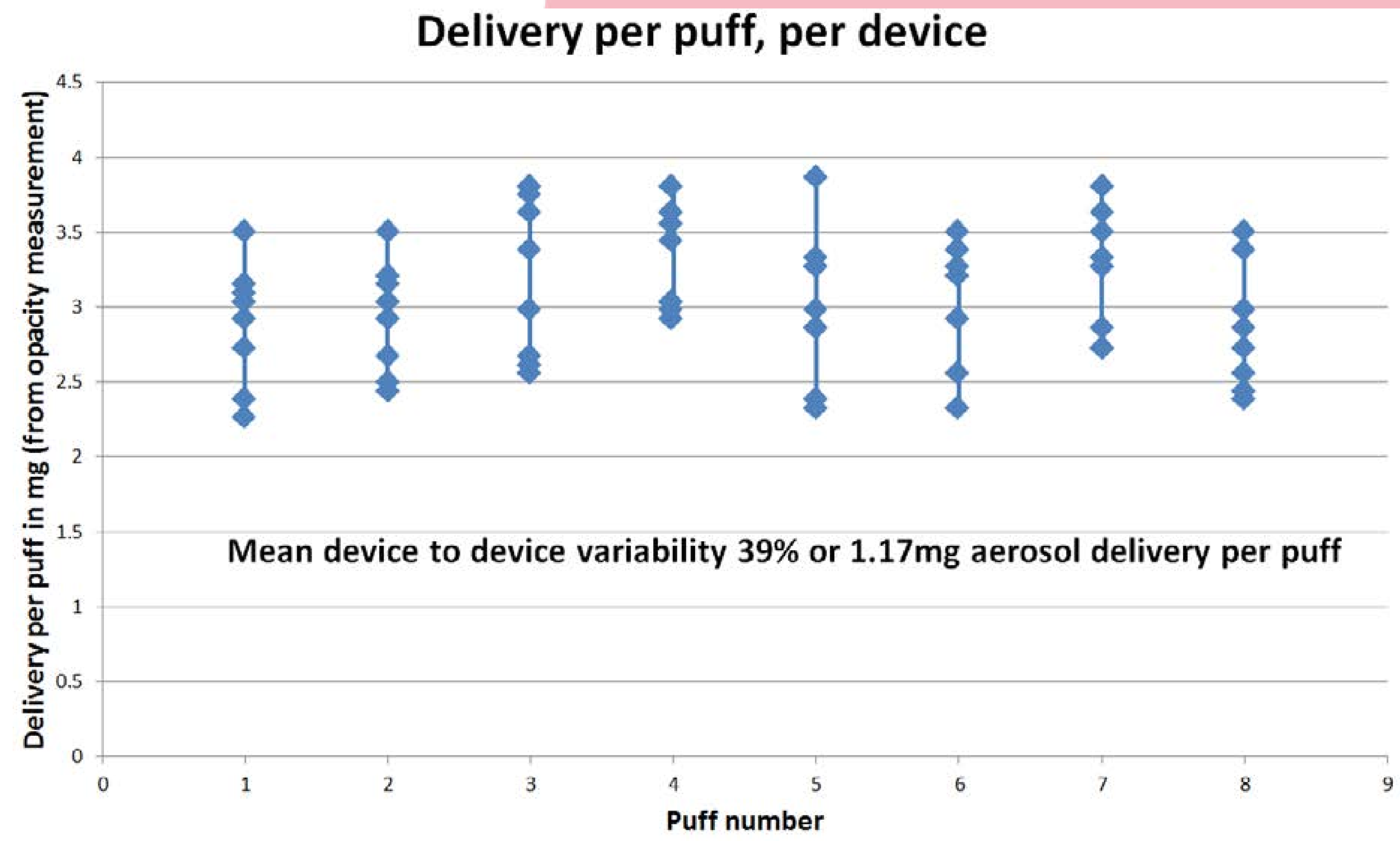

Fig. 3 Variability in puff aerosol delivery for individual e-cigarettes

Not only is this useful for e-cigarettes, the same approach can be used for THP products. Here (figure 4) the variation in performance of the electrical heating systems is quite marked; the first two devices gave maximum aerosol at puff 6 whilst devices 3 and 4 had a maximum at puff 3. On closer inspection it was found that a mixture of different generation heater devices were used for a test that employed the same heat sticks.

This highlights the importance of understanding the subtleties of these new categories of device and the criticality of using the same equipment with the same software versions when making effective comparisons.

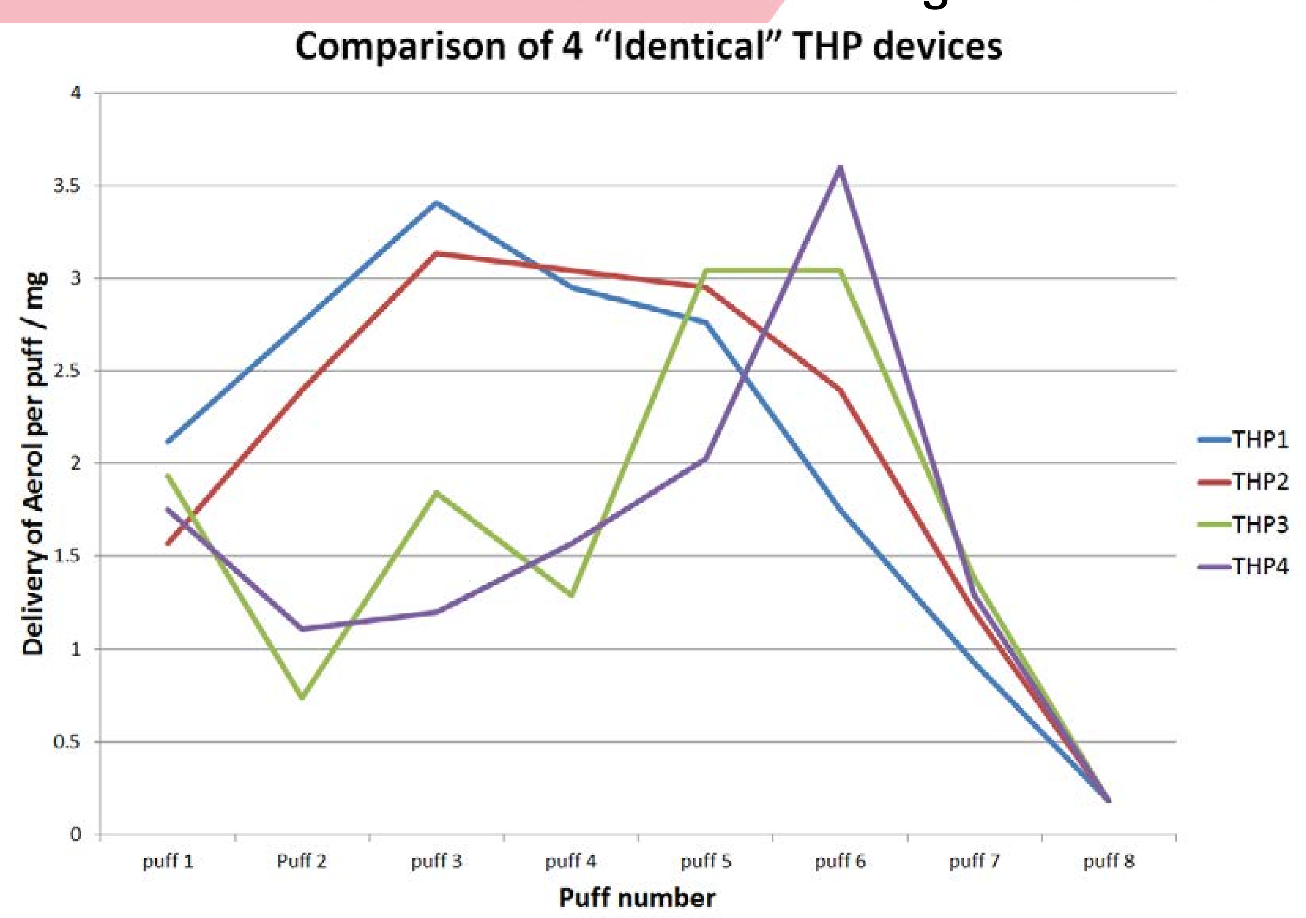

Fig. 4 Delivery from 4 THP products of nominally the same type – note two behaviours

Conclusions

The EPD system is an effective tool or obtaining real time data on aerosol delivery on a puff by puff basis, allowing the generation of a rich data set.
This can be correlated to device performance and device to device manufacturing variability.

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