



Measuring the uniformity of aerosol delivery in Tobacco Heating Products

05/06/2019

Introduction

- James Okpeh, product portfolio manager at Cerulean
- Cerulean has over 70 years manufacturing experience of precision test and measurement equipment
- Product range includes:-



Vaping machines



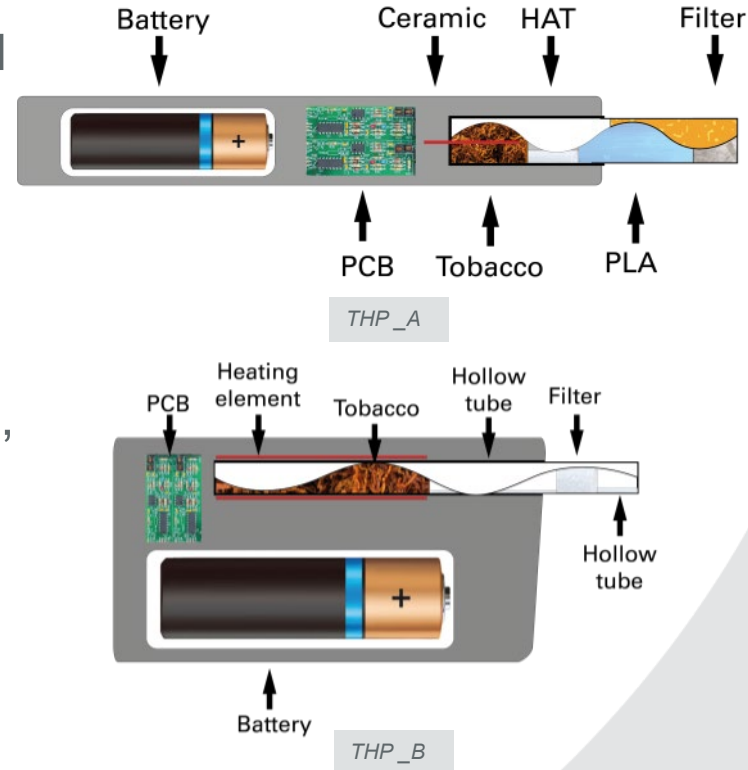
Smoking machines



Physical testing machines

What are Tobacco Heating Products (THPs)?

- THP heat tobacco using a battery-powered heating system
- Tobacco is heated to a temperature below combustion point (approx. 240-350°C)
- Aerosol is generated that contains nicotine, flavours and other chemicals which are inhaled



Critical Questions

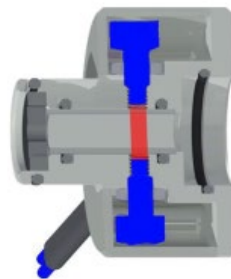
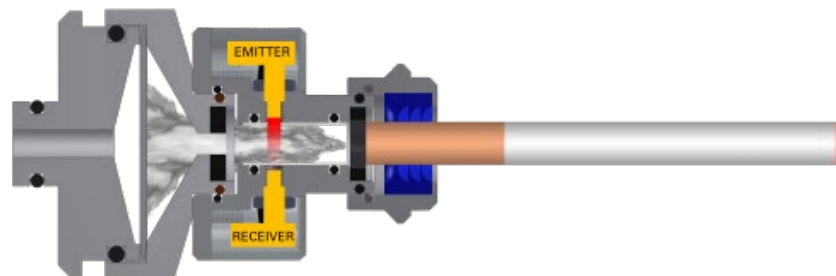
- *Does your tobacco heating product deliver a consistent level of aerosol from the first to the very last puff?*
- *Are consumers inhaling the same quality of aerosol during every puff cycle?*
- *Are your THP products manufactured consistently?*

How to find out?

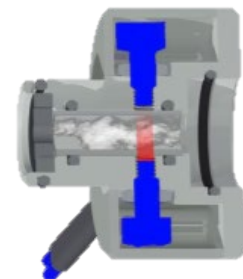
- Three key parameters could provide answers to these questions:-
 - *Aerosol density*
 - *Aerosol temperature*
 - *The amount of carbon monoxide (CO) formed during puffing*

How is aerosol density measured?

- Knowing when a device delivers insufficient aerosol is a key performance characteristic
- Cerulean's aerosol detection system (ADS) records the product aerosol delivery
- It uses light (sensors) to measure the aerosol density



No aerosol – full light received



Aerosol – reduced light received

How is aerosol density measured?

- The ADS:-
 - Monitors and records aerosol opacity in real time
 - Triggering an alarm when the aerosol opacity drops below a threshold
 - Compatible with both e-cigarettes and THP products

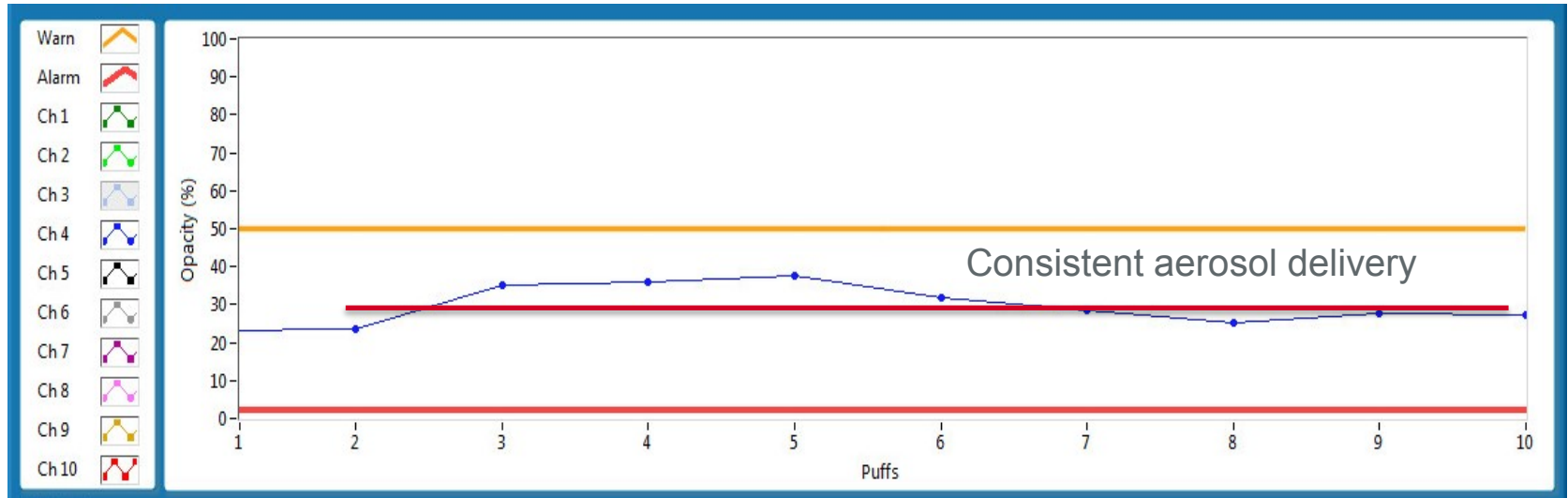
The Experiment – aerosol delivery between two THPs

- THP products were tested using the Cerulean CETI8 integrated with ADS
- A 44mm filter pad trap captures the aerosol
- Up to 10 consecutive puffs
- Intense puffing conditions - 55ml/3s/30s

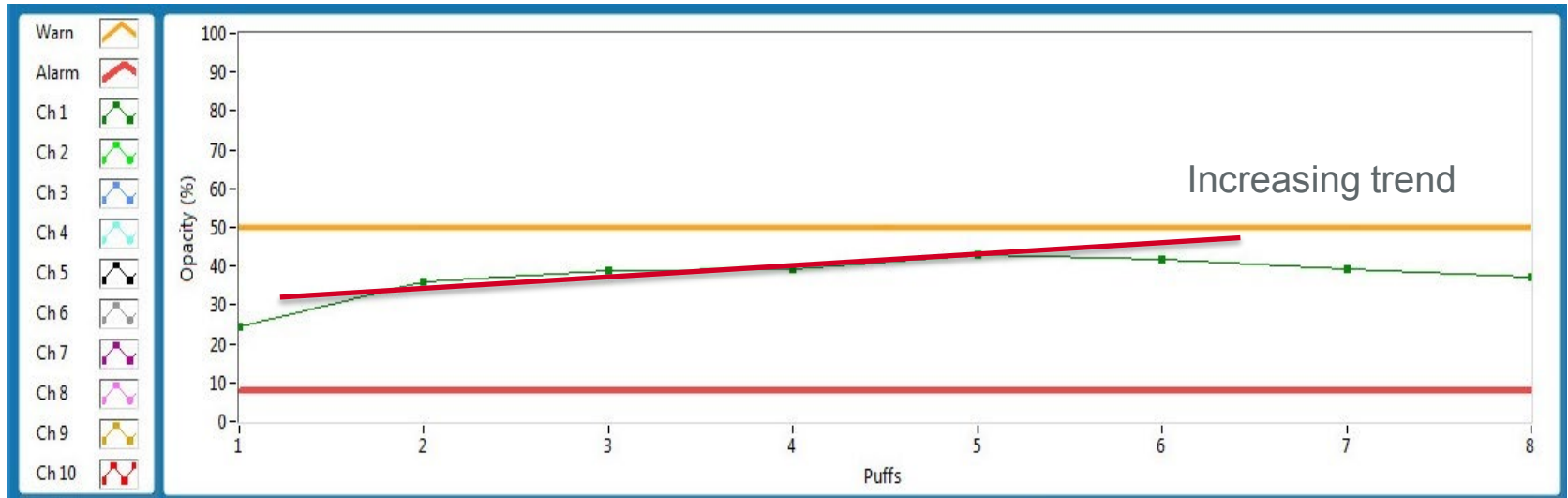


Cerulean CETI8 with integrated ADS

The Result – THP_A



The Result – THP_B



Conclusions from aerosol density experiment

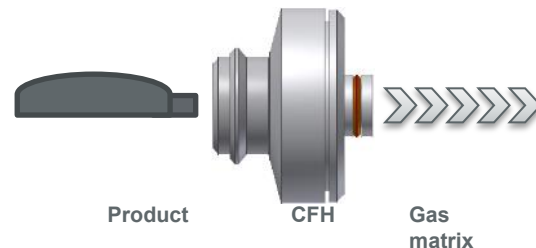
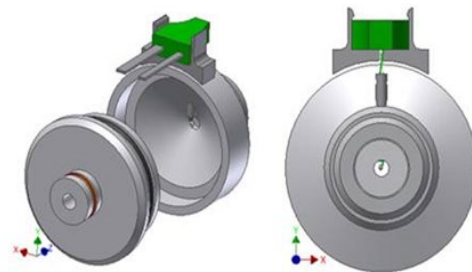
- Less aerosol delivered for the first puff than subsequent puffs
- THP_A delivered approximately consistent aerosol
- THP_B increased its aerosol delivery during the puffing cycle

Why is aerosol temperature measurement important?

- The aerosol temperature from a THP could provide answers to questions including:-
 - *At what temperature during the puff cycle are specific harmful and potentially harmful compounds (HPHC) prevalent?*
 - *How many puffs before the aerosol temperature peaks?*
 - *Is the aerosol temperature from an e-cigarette or THP always consistent during the puffing cycle?*

How is aerosol temperature measured?

- Thermocouple sensor with a data logging system
- The thermocouple sensor is directly in the aerosol stream
- The data logging system allows the temperature profile to be logged on a puff-by-puff basis



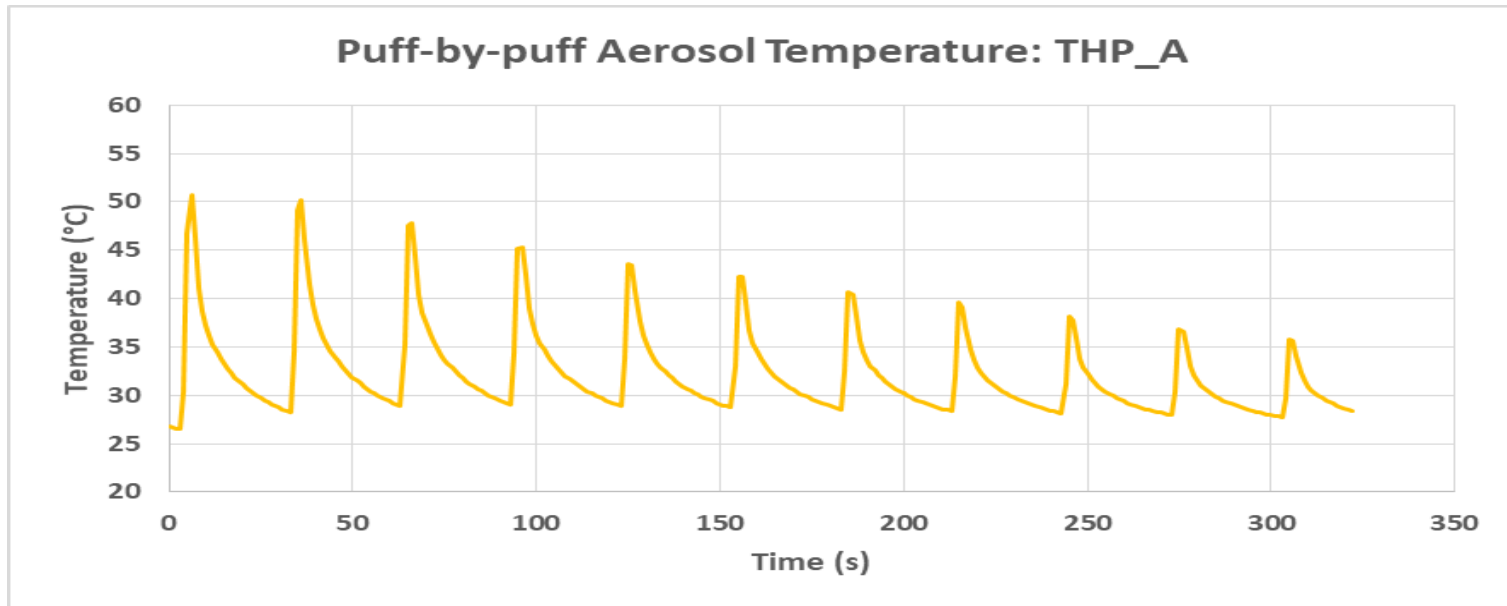
The Experiment – aerosol temperature between two THPs

- THP products were tested using the Cerulean SM450e integrated with the temperature sensor CFHs
- A 44mm filter pad captures the aerosol
- Up to 12 consecutive puffs
- Intense puffing conditions - 55ml/3s/30s

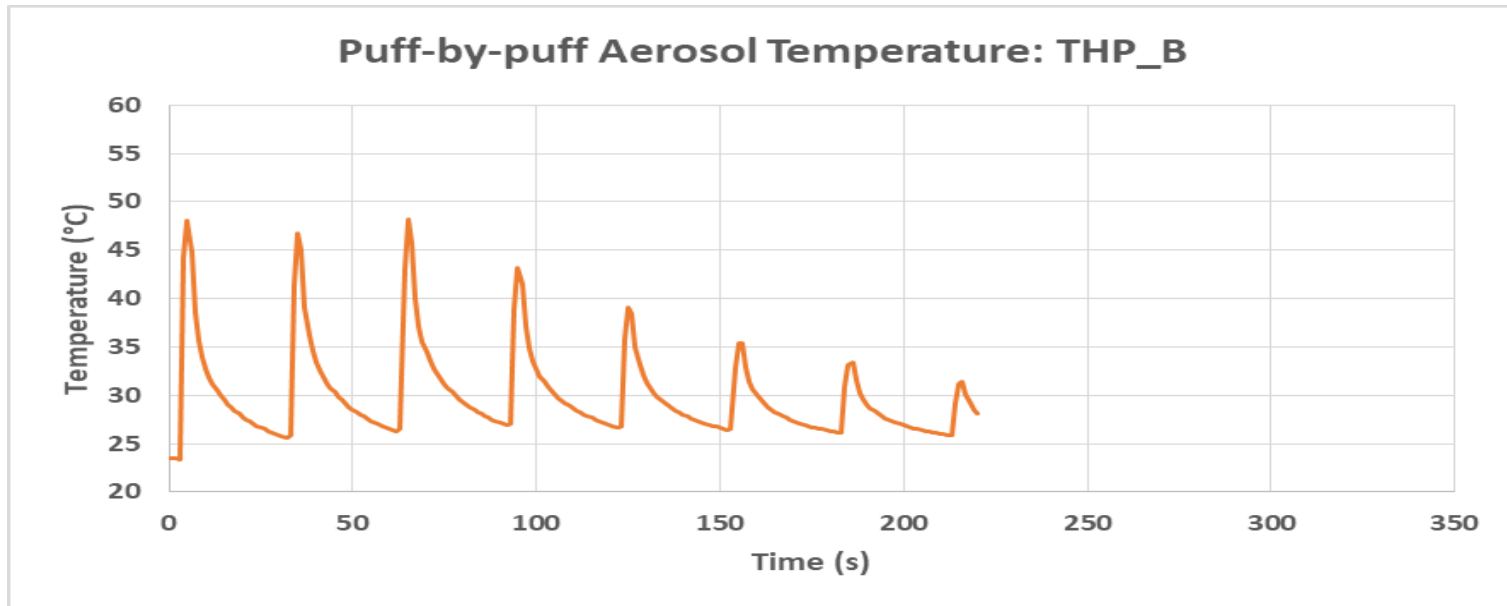


Cerulean SM450e with integrated temperature sensors

The Result – THP_A



The Result – THP_B



Conclusions from aerosol temperature experiment

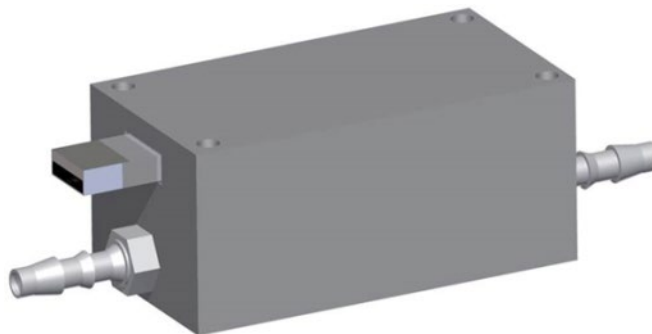
- The same aerosol temperature characteristics displayed
- The aerosol temperature decrease as the number of puff increases

How is Carbon Monoxide (CO) from a THP measured?

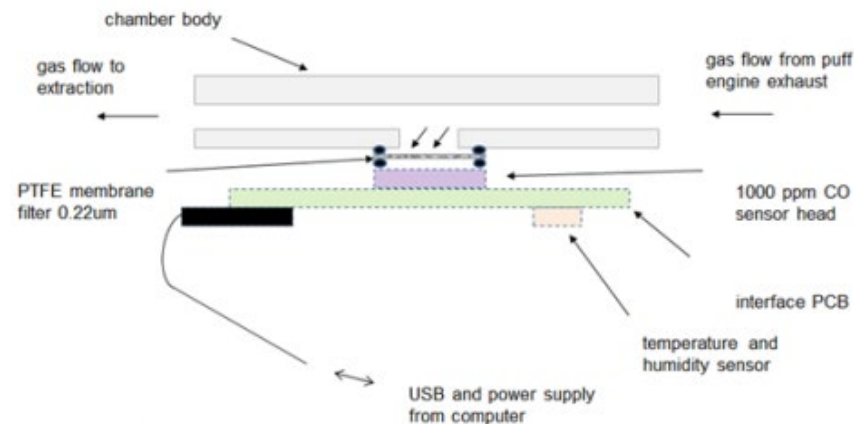
- A cost effective solution for CO measurement
- Low cost electrochemical sensor system to detect traces of CO
- CO concentration up to 1000 parts per million

Schematic of the CO sensing system

- Comprises of a USB powered sensor assembly
- An exposure chamber body
- A hydrophobic filter protects the sensor from particles and moisture



Basic CO Sensor Exposure Chamber



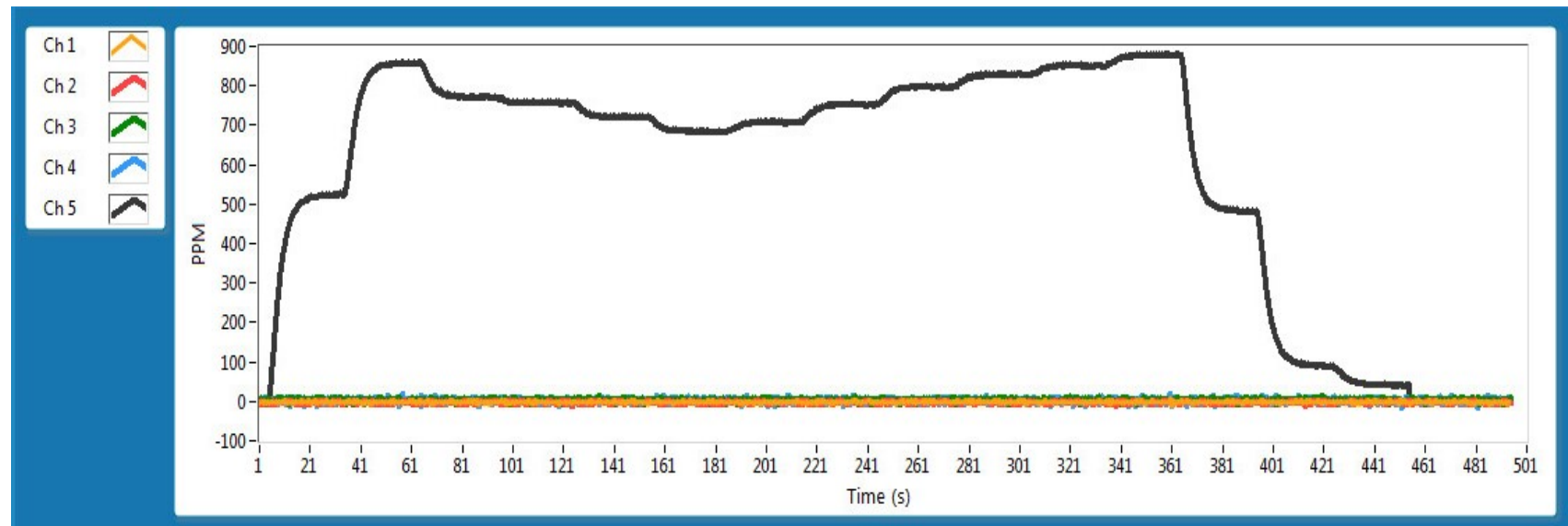
The Experiment – CO between two THP products

- THP products were tested using the Cerulean SM450e integrated with the CO sensor system
- A 44mm filter pad captures the aerosol
- Up to 12 consecutive puffs
- Intense puffing conditions - 55ml/3s/30s

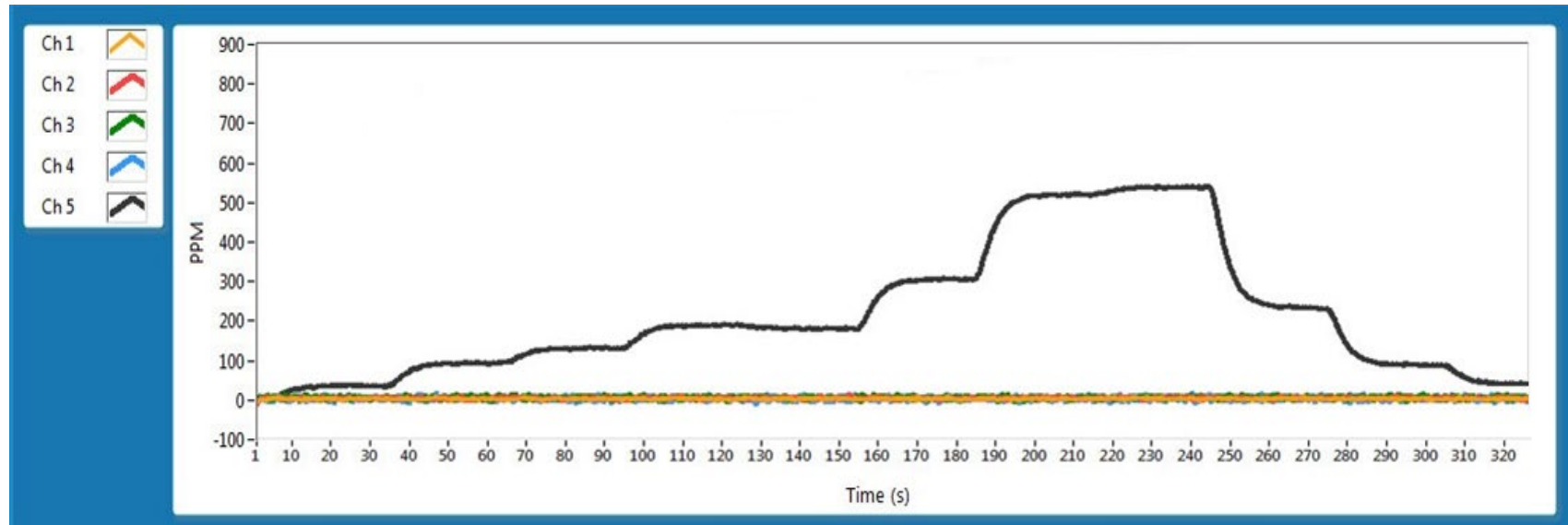


Cerulean SM450e with integrated in-line CO Sensors

The Result – THP_A



The Result – THP_B



Conclusions from aerosol CO experiment

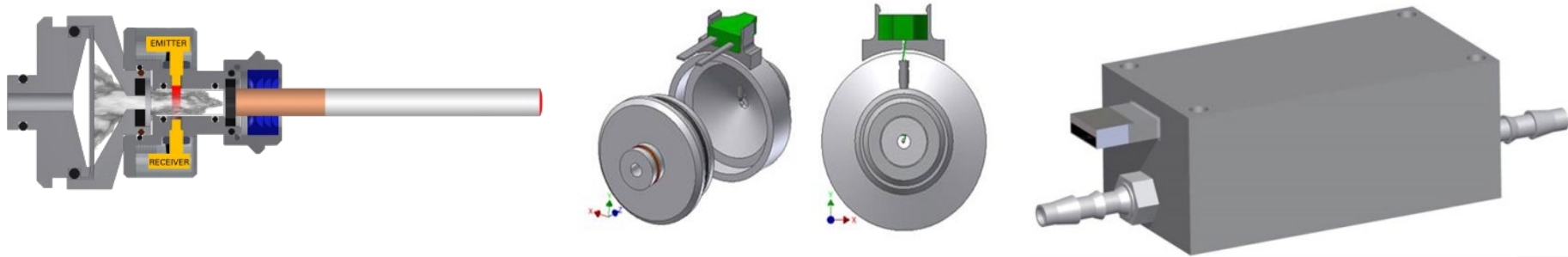
- Consistent level of CO detected for THP_A product
- Whilst for THP_B product, the CO level rises as the number of puff taken increases
- This difference might be due to the heating and ventilating element of each device

Conclusion

- The aerosol density, aerosol temperature and the amount of CO from two THP devices :-
 - *The first device (THP_A) has been designed to deliver a consistent experience from when the consumer takes the first to the very last puff*
 - *Whilst the latter device (THP_B) increase aerosol delivery and the amount of CO during the puffing cycle; resembling the behaviour of smoking conventional cigarettes*

Acknowledgements

- Akinwande Cole, Tim Mason, Hamzah Laimon and Jack East for developing the aerosol density, aerosol temperature and in-line CO solutions



Thank you

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