An Investigation by NPL into the Airborne Particle Removal Efficiency of a Commercial Extraction System in a Dental Surgery

J. T. Tompkins[1], J.J. Allerton[1], D.M. Butterfield[1], F. Matsakas[2], A. S. Brown[1]

[1] Air Quality & Aerosol Metrology Group, National Physical Laboratory, Teddington, Middlesex, TW11 0LW, UK
[2] MyDentist, Europa House, Kearsley, Manchester, M261GG, UK
Presenting author email: jordan.tompkins@npl.co.uk

Project Aims and Experimental Set-up

There are two types of dentistry routinely performed; Two-handed and Four-handed.

- Two handed – a dentist performs the dental procedure alone
- Four handed – a dentist performs the dental procedure with the assistance of a trained dental assistant

A third option is to use a portable extraoral aerosol filtration system (EAFS) in place of the dental assistant for some procedures.

The National Physical Laboratory (NPL) conducted a study into the measurement of aerosols produced by dental Aerosol Generating Procedures (AGPs) at a MyDentist dental surgery. This project investigated the performance of a commercially available EAFS, when AGPs were performed on a training manikin (Figure 1 & Figure 5) at the dental practice in June 2021. The training manikin had upper and lower sets of teeth and built-in drainage to simulate a mouth. The AGPs could be performed around the manakin mouth simulating differing aerosol emissions.

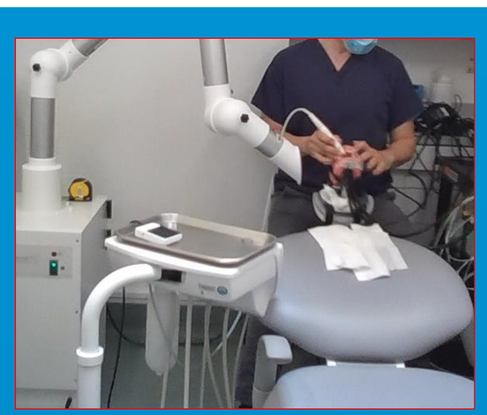

Figure 1: Dentist preforming AGP on a dental manikin with EAFS extraction

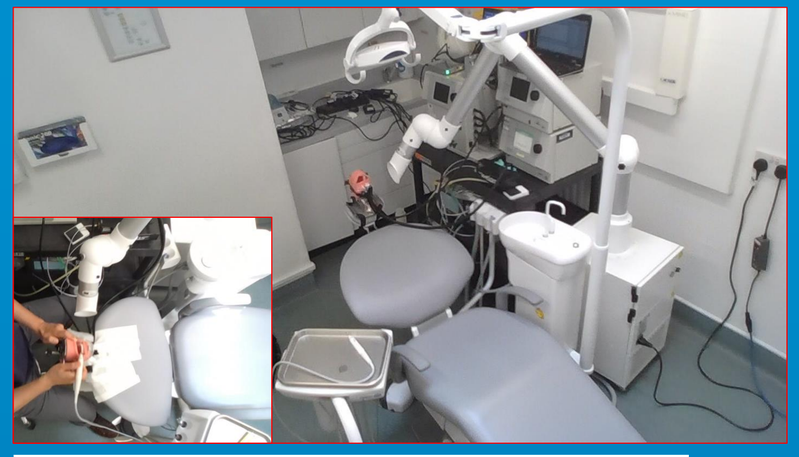

Figure 2: Equipment set up in MyDentist surgery; Inset: AGP being performed with EAFS extraction

Using an Optical Particle Counter (OPC), Condensation Particle Counter (CPC), Mobility Particle Size Spectrometer (MPSS) and a Particle Mass Concentration (PM) air quality monitor, particle measurements were obtained across a particle size range of approximately 4 nm to 10 µm. This allowed an assessment of the effects of AGPs and EAFS extraction to be evaluated in the closed surgery setting (Figure 2 & Figure 3). A series of 11 runs were performed (Figure 4) with the EAFS extraction head in different positions relative to the dental manikin.

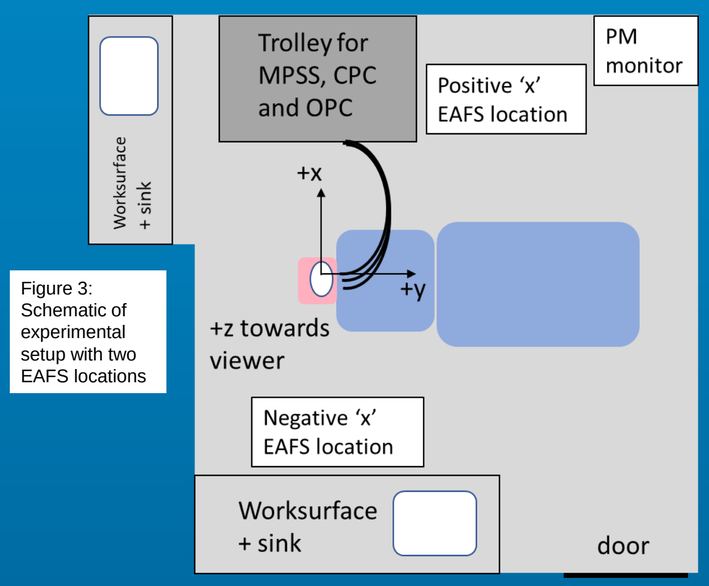

Figure 3: Schematic of experimental setup with two EAFS locations

Run number	AGP Duration	EAFS unit status	Extraction head positioning (cm) (x, y, z)
1	10:00 – 10:15	Off	(14, 0, 0)
2	10:20 – 10:35	Off	(14, 0, 0)
3	10:40 – 10:55	Off	(14, 0, 0)
4	11:10 - 11:25	On	(14, 0, 0)
5	11:35 - 11:50	On	(14, 0, 0)
6	11:55 – 12:10	On	(14, 0, 0)
7	13:40 – 13:55	On	(30, 0, 0)
8	14:00 – 14:15	On	(30, 7, 0)
9	14:20 – 14:35	On	(14, 7, 0)
10	14:40 – 14:55	On	(-14, 0, 0)
11	15:00 – 15:15	On	(-30, 0, 0)

Figure 4: Summary of tests performed with and without EAFS extraction at various extraction head positions

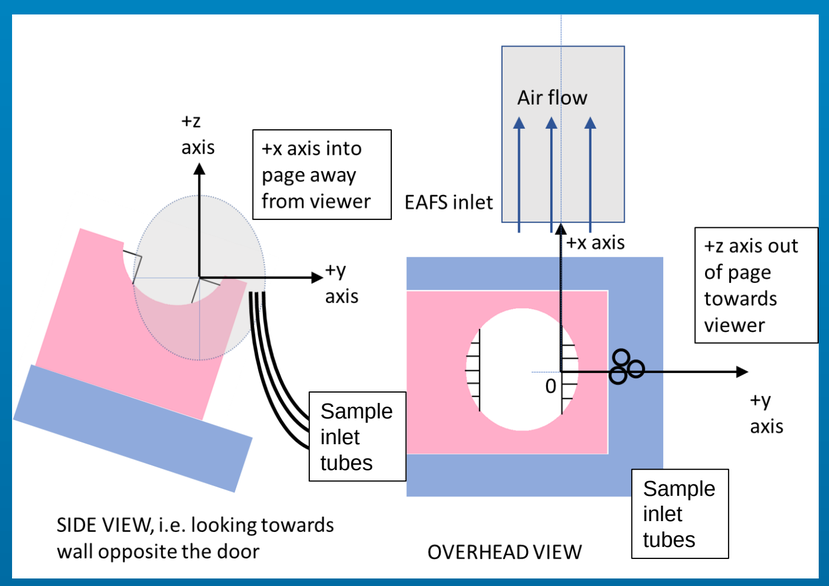

Figure 5: Schematic of a side view and overhead view of the mouthpiece manakin, EAFS extraction inlet and the sampling inlet tubes

Results

- A significant decrease (~95%) in near-field particle number concentrations measured by the OPC instrument was observed when AGPs were performed with the aerosol filtration system switched on (Figure 6 & Figure 8).
- A less significant decrease (~50%) was detected by the CPC when AGPs were performed with the aerosol filtration system on (Figure 7).
- The distance of the EAFS extraction head from the manikin affected the reduction in the OPC-measured particle number concentration with the EAFS switched on compared to when the unit was off: a ~98 % decrease was observed at a 14 cm separation compared with a ~95 % decrease at a 30 cm separation.
- Although use of the EAFS reduced the near-field CPC measured particle number concentration, the particle number concentration increased again when the unit was switched off (Figure 7).
- The results suggest that for the smaller particle size fractions (below 150 nm), the EAFS was only removing particles in the near-field and not the whole surgery. These particulates would most likely consist of a combination of background particles and residual particles from previous AGPs.
- In contrast, the PM air quality monitor showed that the use of the EAFS lowered the measured far-field particle mass concentrations for all particle size fractions measured (PM_1, $PM_{2.5}$, PM_4 and PM_{10}).

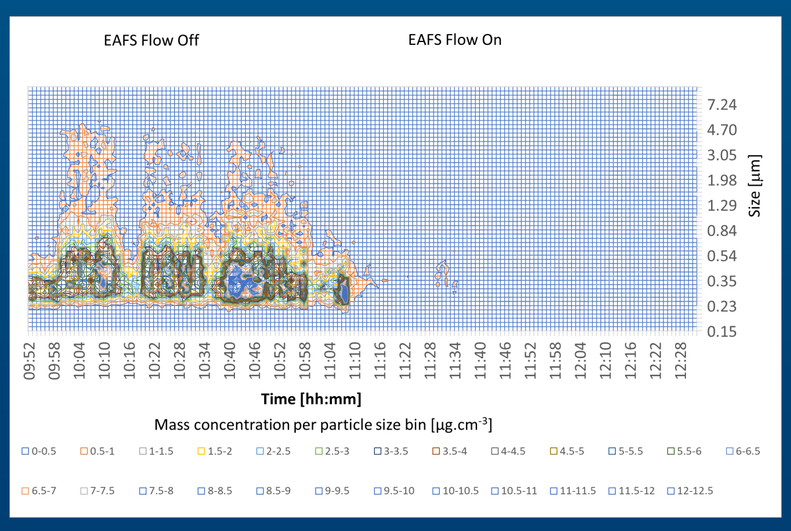

Figure 6: OPC variation over time represented by mass concentration and particle size. EAFS flow was off before 11:10 and on after that.

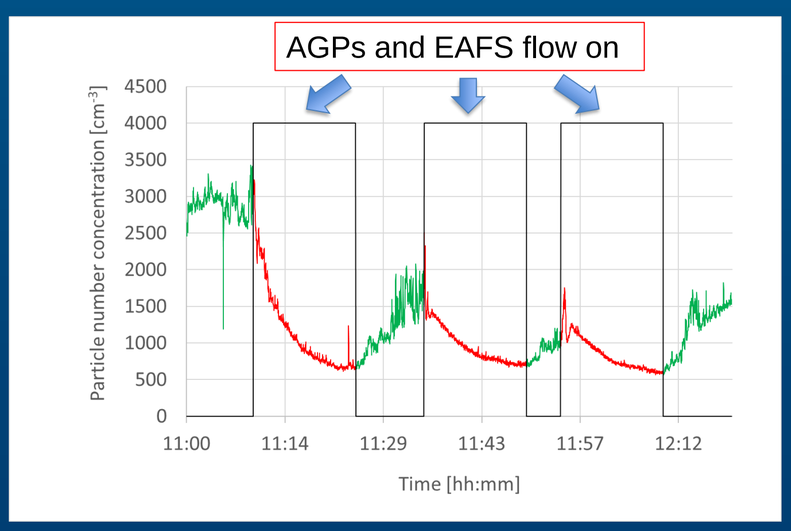

Figure 7: CPC particle number concentration variation during AGPs. EAFS flow switched on over AGP periods and switched off in between.

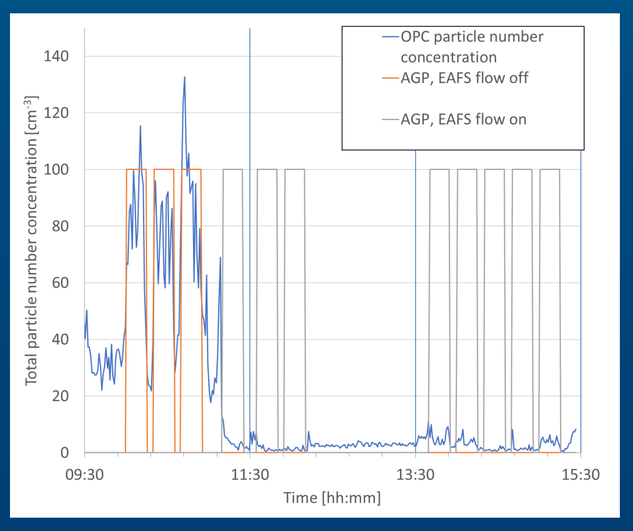

Figure 8: OPC total particle number concentration variation over time. EAFS flow was off before 11:10 and on during AGPs after that.

Conclusion

This study demonstrated the effectiveness on an EFAS in a real dental surgery during AGPs. The significant decrease in both near field and far field particle number concentrations with the EFAS in operation, could allow for increased confidence in two-handed dentistry with this system in place.

Department for Business, Energy & Industrial Strategy

FUNDED BY BEIS

The work was funded by the UK Government's Department for Business, Energy and Industrial Strategy (BEIS) through the UK's National Measurement System Measurement for Recovery (M4R) Programme. It also aligns with the OPC work in the AEROMET II EMPIR project which has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

www.npl.co.uk