Puff Profile Simulator for Tobacco Smoke 
Particle Diameter and Mass Measurement

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INTRODUCTION
This paper describes a system for cigarette testing, measuring fresh 
TPM (total particulate matter) mass, median particle 
diameter, and particle number concentration, with any desired 
flow profile. This allows measurements at conditions 
representative of human smoking or for regulatory pre-defined 
machine smoking profiles. The size data are collected at 10 Hz 
time resolution with cumulative number and TPM mass 
measurement in real time on a puff by puff basis.

The system is designed to be used with real-time aerosol 
insitutions such as DMS-type fast electrical mobility 
spectrometers (Reavell et al, 2002) to provide continuous 
measurement of the aerosol inhaled from the cigarette during 
smoking. The flow through the cigarette is metered with an 
orifice pressure-drop type flow sensor and controlled to follow a 
specified profile at 12.5 Hz (Figure 1). To follow highly dynamic 
puff profiles a feed-forward type controller is used. The complete 
smoking of a cigarette with a different profile for each puff can be 
reproduced.

EXPERIMENTAL
The sampling head (Figure 2) contains the orifice for metering the 
cigarette flow, an annular slot mixer for the dilution air and a pinch 
valve to shut off the cigarette between puffs. The sampling head is 
typically mounted near the analyser input to maximise the 
frequency response of concentration measurements. The control 
unit contains the dilution flow control and metering system, the ΔP 
sensor for the cigarette flow orifice meter, the blower to provide 
dilution air and the power supplies and electronics for the system. 
The interface software allows cigarette flow profiles to be loaded, 
tests to be started and stopped, the instrument to be calibrated and 
configured, and it displays the flow profile desired and 
achieved. The flow drawn through the cigarette is diluted with 
filtered air close to the filter holder to halt agglomeration 
processes. The system operates with a constant total diluted flow to 
minimise errors in the measurement of total mass emissions from 
the cigarette. A dilution ratio signal is provided to allow 
calculation of the undiluted concentrations if desired. The system 
has been tested with standard machine profiles and those 
measured from human smokers. Control of cigarette flows down 
approximately 1 ml/s is possible, with a dynamic range of at 
least 30:1. The typical error in the integrated volume of a puff is 
around 1%.

RESULTS
Size and concentration data from a human smoked profile of a 
commercial 9 mg yield cigarette are shown in Figures 3 
spectrometer data) and 4 (summary of data generated from 
alogue outputs).

Flow profiles were checked by re-recording by the SA7 smoking 
analysers using calibration sinusoidal, triangular, early triangular 
and square wave puffs each at 25, 50, 75 and 100 ml. Compliance 
(n = 408) was 25.4 ± 0.7, 48.8 ± 1.1, 72.6 ± 1.3 and 98.6 ± 1.9 ml 
respectively. As an example, Figure 5 shows a complex double 
puff on lighting the cigarette and the compliance with the recorded 
trace.

REFERENCES
Reavell, K. et al. (2002). A fast response particulate spectrometer for 