

## Real-time Aerosol Size Distributions

Size, number and mass measurement  
of rapidly - changing PM1 & PM2.5 aerosols  
from ambient and high concentration sources

Indoor Air Quality & Occupational Monitoring

Raw Engine Exhaust and Stack Sampling

Ambient, Roadside & Air Quality

Combustible & E-cigarettes

Engineered Nanoparticles

Flame Sampling

and more...

Unique capabilities:

Fastest time response  
(200ms  $T_{10-90\%}$  @ 10Hz)

Widest size range  
(5nm – 1 $\mu$ m or 2.5 $\mu$ m)

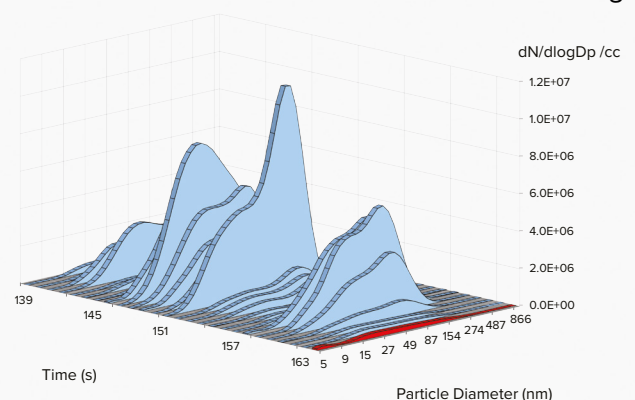
Class-leading accuracy & reproducibility

Widest concentration range (9 orders)

Best sensitivity  
— amongst fast response particle sizers



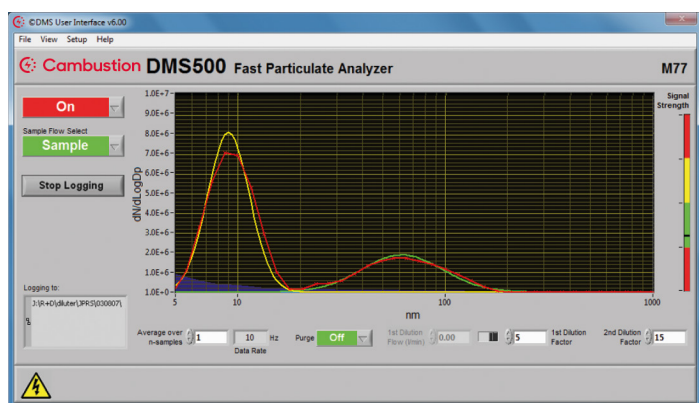
Indoor Air Quality  
Real-time size distributions from bacon cooking



## DMS500

Even ambient aerosols are rarely stable second-to-second or minute-to-minute, with mixing and aerosol evolution taking place. With over 20 years' of continuous development, the DMS500 offers real-time particle size distribution measurements over a uniquely wide size range.

Able to produce a full size distribution 10 times per second with a true step change response ( $T_{10-90\%}$ ) as low as 200 ms, the DMS500 enables real-time measurements of a wide range of aerosols.



The DMS500 combines patented measurement technology with Cambustion's many years of experience at the forefront of aerosol innovation.

Available for both ambient applications, and with a fully integrated (hardware and software) dilution system for high concentration sources, the DMS500 is an indispensable tool in any aerosol laboratory.

It is available with several options to suit various applications:

- Internal, fully integrated diluter (1:1 – 500:1)
- Heated sampling line for direct combustion exhaust sampling (and condensing aerosols with primary dilution of 1:1 – 6:1)
- Catalytic Stripper Accessory to remove volatile particles
- SCS Smoking & Vaping Machine
- *NEW*: Reduced sensitivity option for sampling of full concentration e-cigarette aerosol

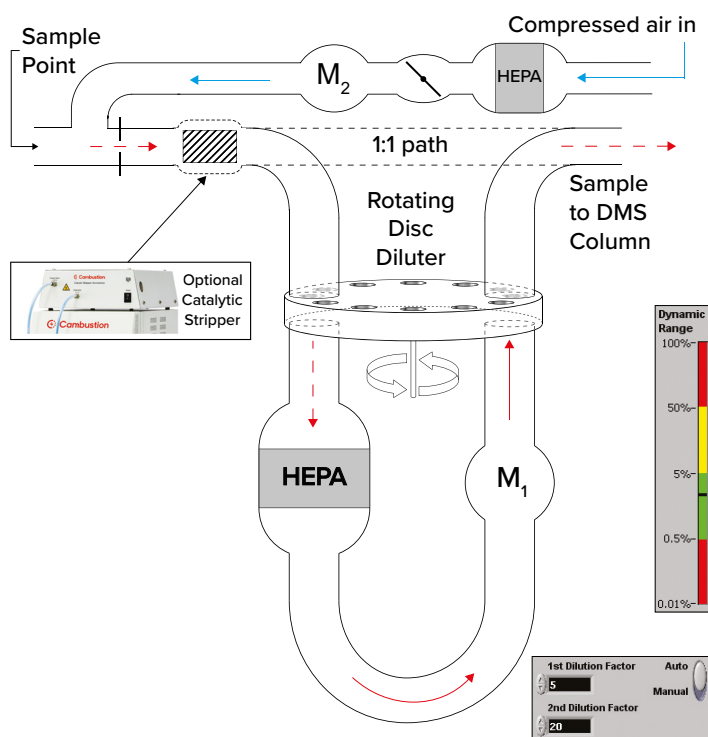
### Widest Size Range

The DMS500 offers size measurement over a uniquely wide size range. The standard measurement range is 5 nm – 1000 nm. This can be supplemented with an optional 5 nm – 2500 nm range. If this option is selected, the user can switch between the two measurement ranges as required.

## Fully Integrated Sampling & Dilution system

The DMS500 is available with two optional dilution stages; a metered compressed air 1st stage and a rotating disc 2nd stage.

DMS500 Sampling & Dilution System (with optional CSA)



The 1st stage can be used to dilute high concentration aerosol close to the sampling point to minimise aerosol evolution, for example in flame sampling.

The high factor 2nd stage enables sampling from a very wide range of aerosol concentrations, with over 9 orders of magnitude dynamic range. A single instrument is thus well matched for applications ranging from ambient monitoring to sampling the highly concentrated smoke from pyrotechnic devices or combustion processes.

Dilution is set in the main PC-based user interface, while measured data is automatically corrected for the total applied dilution. A software signal strength indicator guides the user to set dilution to an appropriate level. When prompted by the software, cleaning takes only 10 minutes with the supplied tool.

The instrument measures its own baseline sensitivity during the auto-zeroing function and displays it on screen during operation. An optional heated sampling line can operate at up to 191°C and allows sampling directly from raw combustion aerosol with no need for any other dilution.



An optional Catalytic Stripper Accessory (pictured below) removes volatile particles and is easily bypassed when desired.

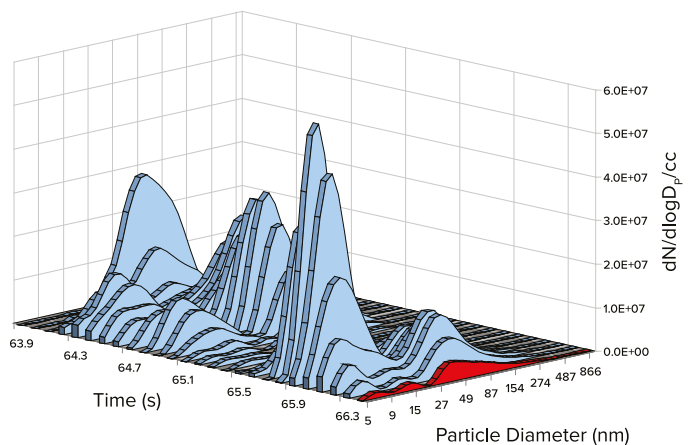
### Indoor Ambient: Woodsmoke

The waterfall below shows measured exposure to the operator during lighting a domestic woodstove.

## Applications

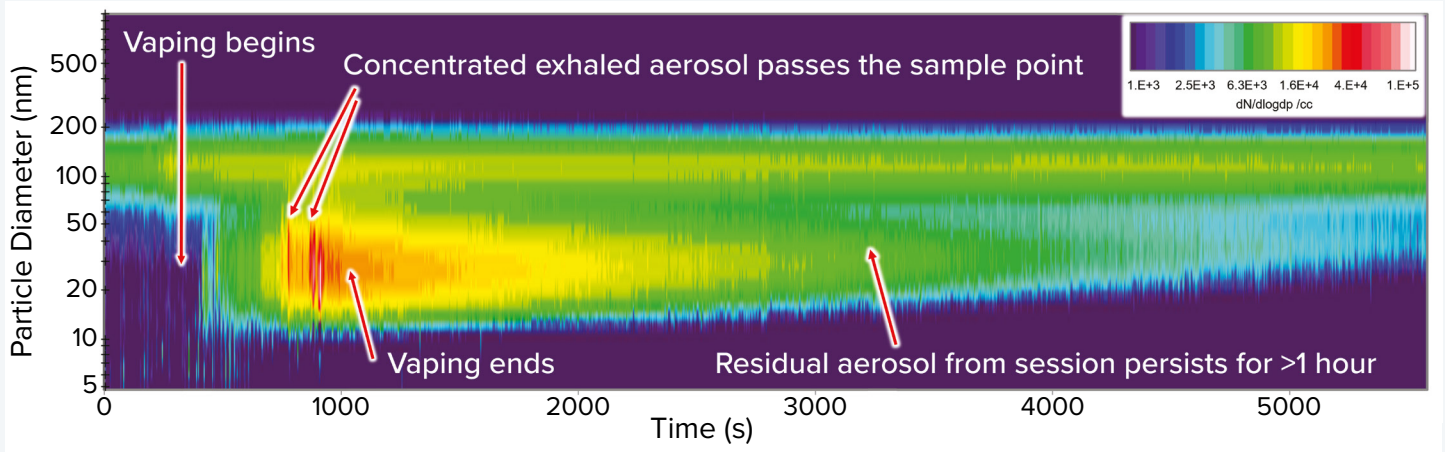
### Ambient, Roadside and Indoor Air Quality

With the best sensitivity amongst real-time particle sizers, the DMS500 Mk2 brings transient capabilities to ambient pollution measurement. The instrument is capable of unattended operation with scheduled sampling and auto-zeroing, and there is no limit to the length of data files. External devices such as cameras can be triggered when the particle concentration exceeds a preset level. The rapid response ensures that indoor or roadside individual events can be isolated for study.



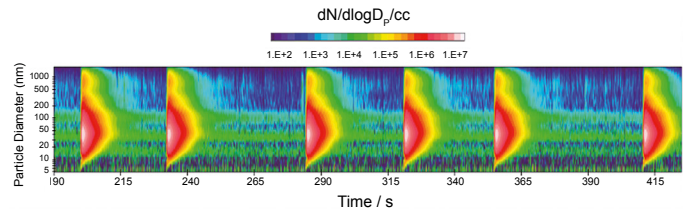
## Indoor Ambient: e-cigarette

A vaping session (contour plot below) took place in a closed room, with low air exchange. The rapid increase in background concentration associated with vaping is clear — together with some high concentration events when relatively undiluted exhaled vape aerosol passes the sampling point. In the absence of good air exchange, the increased background persists for over 1 hour after the vaping session ends.



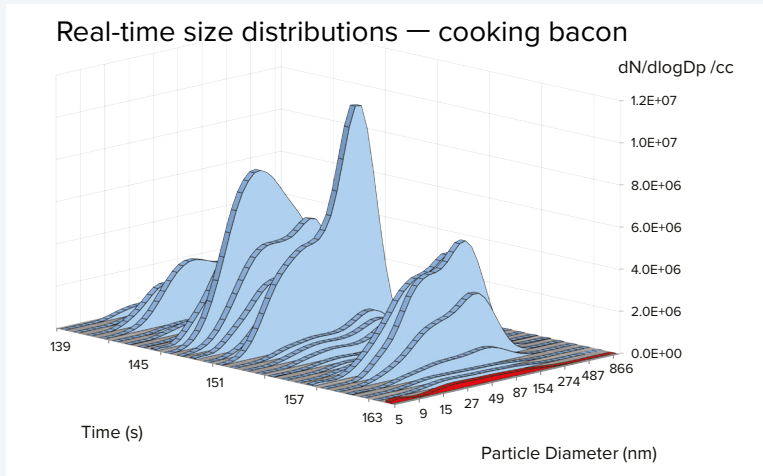
## Pharmaceutical

This plot below shows the release and evolution of the aerosol from a pMDI over several puffs — data collected in real-time.



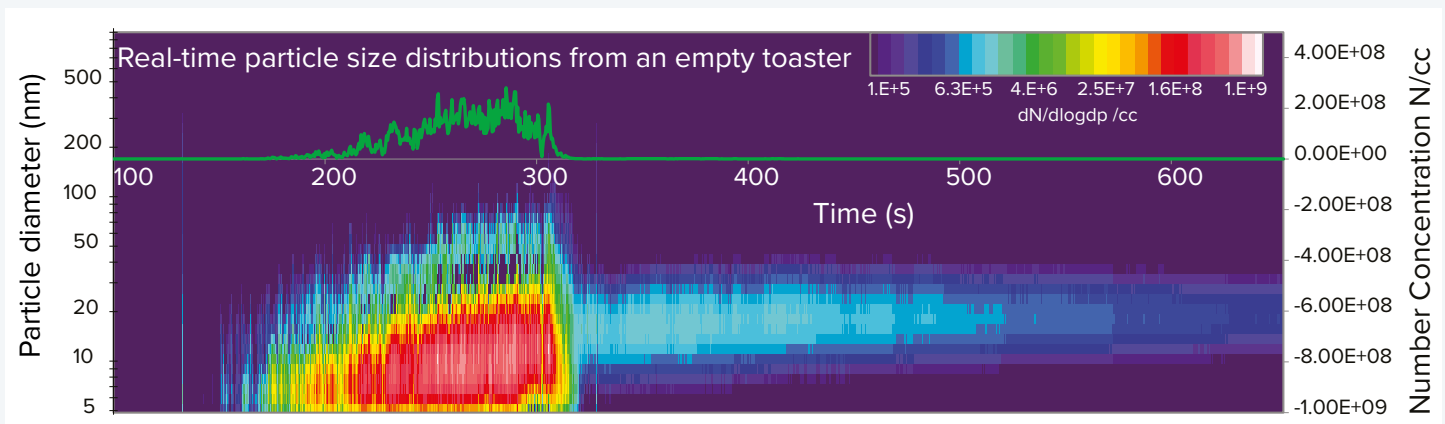
## Indoor Ambients: Cooking

The waterfall below shows the effect on the indoor air quality of cooking bacon — a significant burst of particles is released when the bacon is turned. This leads to significant personal exposure for the chef, as well as an effect on the indoor air quality after mixing has occurred.



The contour plot at the bottom of this page highlights the release of small (presumed metal oxide) nanoparticles from an empty domestic toaster.

The growth in size and number concentration during operation is illustrated, as is the decay after the toaster switches off.



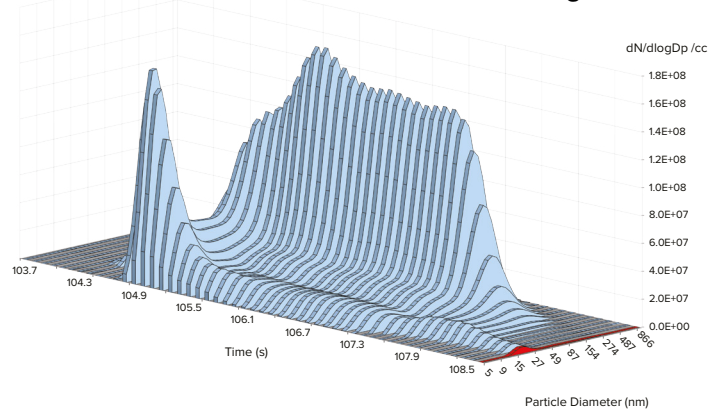


### Cigarettes, e-cigarettes and heat-not-burn

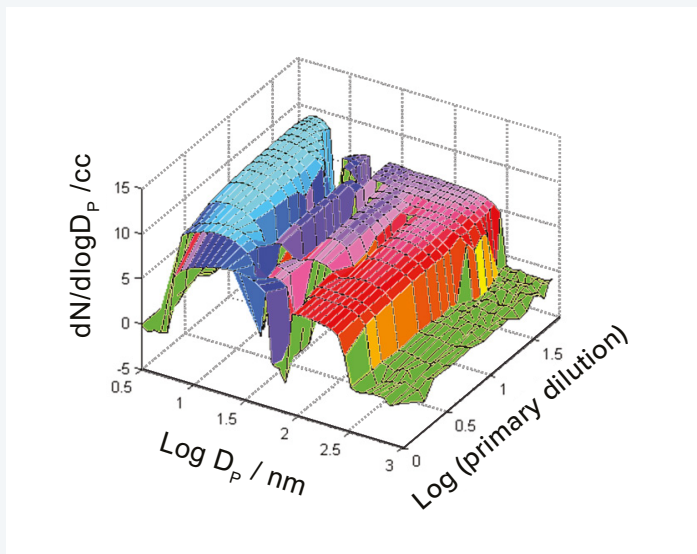
The unique combination of a wide size range and rapid time response makes the DMS500 ideal for cigarette and e-cigarette studies. Cambustion's standalone SCS Smoking & Vaping Machine can also be coupled to the DMS500 for real-time sizing and instantaneous mass calculation.

The DMS500 is now available with special modifications which allow direct sampling of undiluted aerosol from high output e-cigarettes, since some e-cigarette aerosols are highly volatile and will change if diluted. The waterfall to the right shows size distributions through a single ISO20768 puff on a e-cigarette.

Real-time size distributions from an E-cigarette



### Flame Sampling & Combustion Science



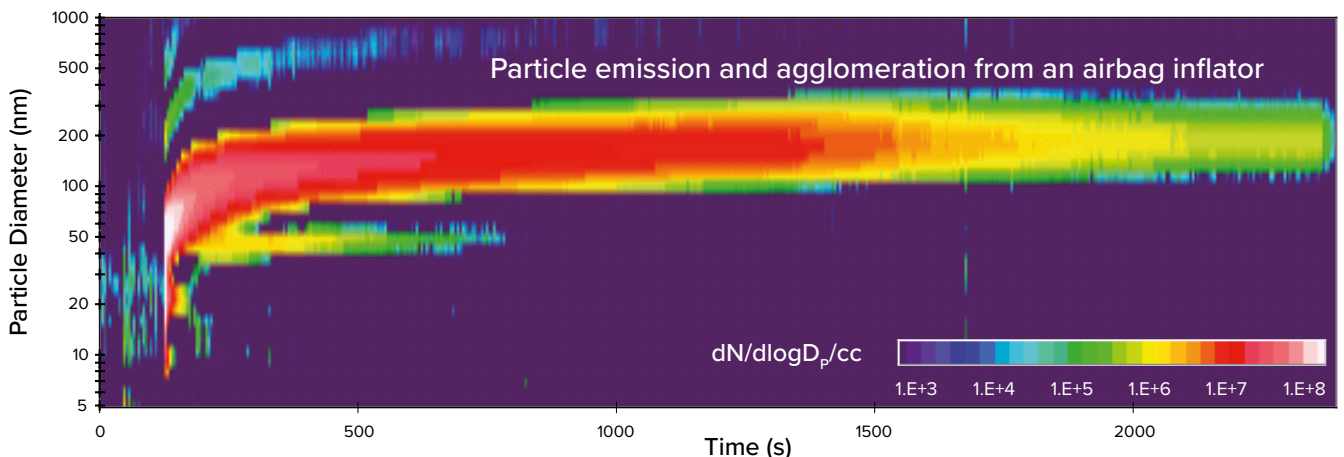
The graph to the left shows particle size distributions from flame, into which a solution of  $MgCl_2$  was atomized. The DMS500's 1st stage was used to provide a flow of nitrogen for dilution and quenching at the sample probe, and the plot shows the size distribution as a function of this dilution.

(Fennell, P.S., Dennis, J.S. and Hayhurst, A.N. 5th International Seminar on Flame Structure, The Siberian Academy of Sciences, Novosibirsk, July, 2005.)



### Airbags / Pyrotechnics

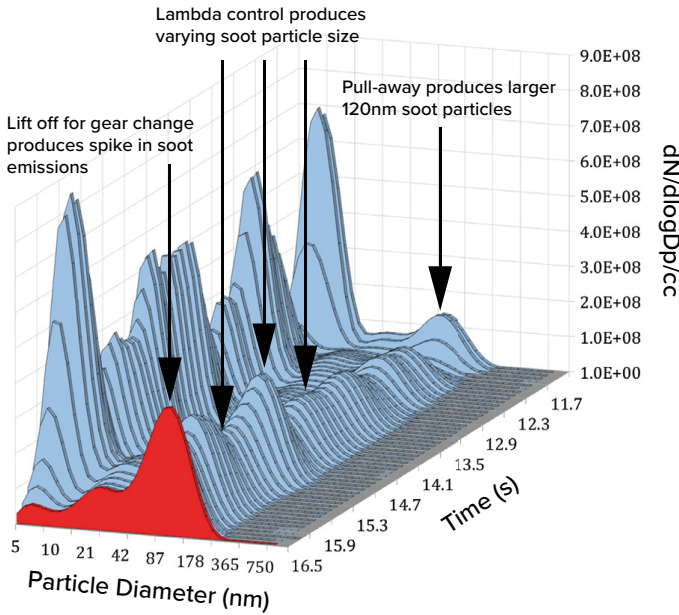
Deployment of vehicle airbags releases a large number of ultrafine particles in a short period, which then undergo agglomeration to larger sizes. The DMS500 is well suited to resolving both the initial release of particles, and subsequent evolution of the aerosol:



Data courtesy Ryan Wood, School of Technology, Oxford Brookes University

## Other Applications

The DMS500 is also suitable for engine measurements (see separate brochure).



## Powerful, Easy to Use Software

A Windows laptop controls the DMS500 and records data. Features include programmable operation, digital remote control and four channels each of analogue input and output for seamless integration with existing laboratory equipment.

The PC software includes full error detection and warnings, and users are free to install the software on as many PCs as required without needing to purchase extra licences.

## Easy Operation

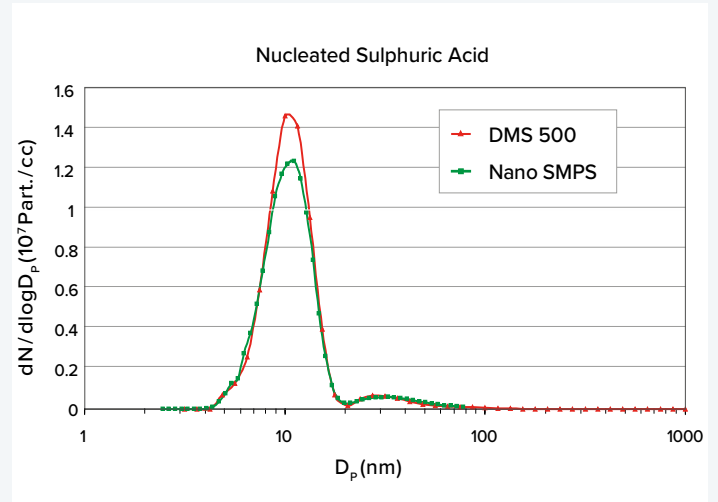
The instrument is ready to use in 30 minutes from switch-on, an internal HEPA filter allows automatic setting of the zero concentration every time. The DMS500 runs from a standard electrical outlet

## Measurement Principle - Electrical Mobility

The DMS500 uses a controlled unipolar corona charger — no radioactive charger is required.

Charged particles then enter the classifier column, where an electrical field deflects them across a sheath flow and then onto to the electrometer detectors. Particles are detected at different distances down the column, according to their electrical mobility (see schematic at bottom of this page). The outputs from the 22 electrometers are then processed in real-time to calculate the size distribution data.

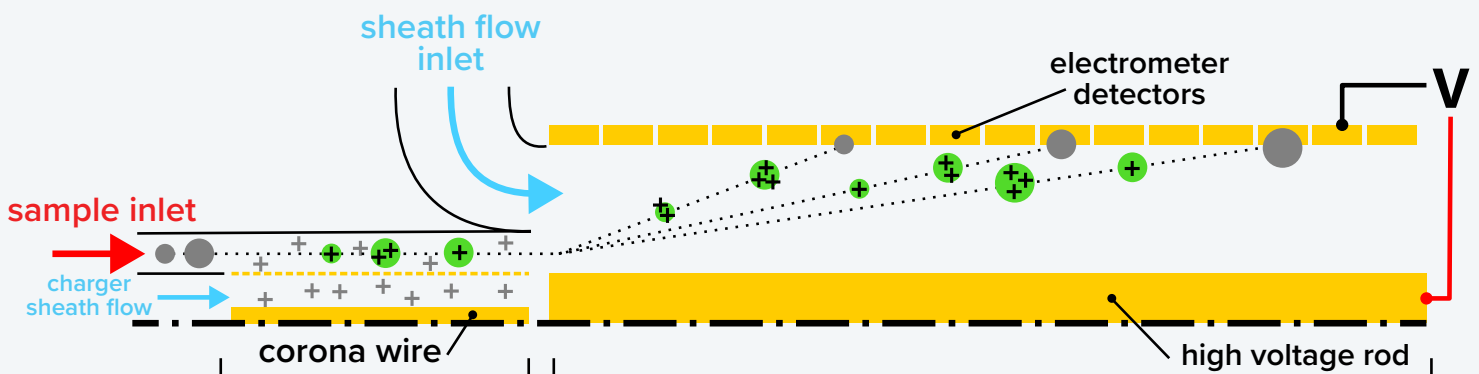
The DMS500 classifier operates at fixed pressure, which ensures that the calibration stays accurate even when sampling from high or low ambient pressures (e.g. at altitude).



Tests demonstrate good agreement with SMPS measurements for volatile or solid aerosols under steady state conditions.

A high sample inlet flow rate (up to 8slpm) and the unique use of multiple sheath flows in the charging system minimize particle loss by diffusion, even down to 5 nm.

To view an animation visit: [www.cambustion.com/products/dms](http://www.cambustion.com/products/dms)







## Calibration

For measurement of spherical aerosols, the DMS500 is traceably size calibrated against standard polystyrene latex spheres (PSL), and with a variety of representative aerosols through comparison with a Differential Mobility Analyser (DMA).

A traceable standard electrometer is used for number calibration.

For calibration on soot aerosols, a separate calibration (software selectable) is performed using hydrocarbon derived soot.

The calibration therefore takes account of particle transport losses inside the instrument, including the diluter. Every DMS500 is supplied with a traceable calibration certificate.

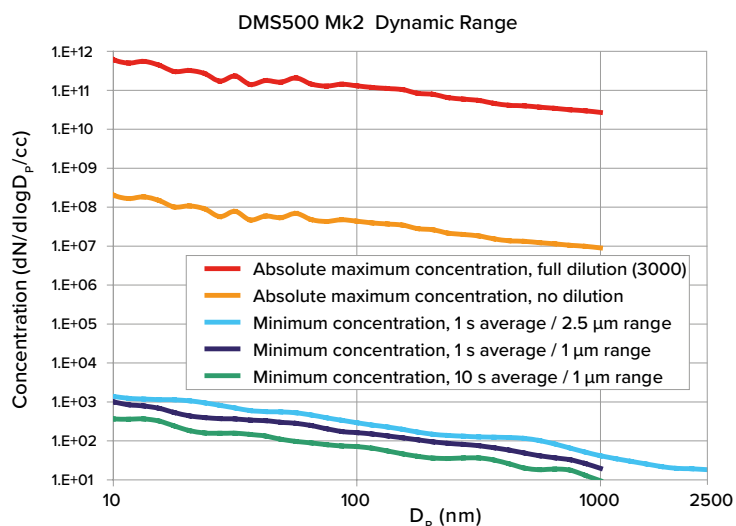
Published studies show class-leading accuracy & reproducibility between DMS500MK2 instruments, over the last 10 years.



## Sensitivity:

Note that the following sensitivity information is expressed in terms of size spectral density,  $dN/d\log D_p/cc$ . When comparing with other instruments' specifications, bear in mind that sometimes these are expressed in terms of total concentration (particles/cm<sup>3</sup>) versus size, which is not a useful metric for size distributions (and should only really be used when expressed as the integral over a finite range of sizes). To compare with these, the  $dN/d\log D_p/cc$  values below should be divided by 16. For ease of comparison, these N/cc/size class figures are given in the last column.

| RMS at 1Hz, 1 $\mu$ m range   | $dN/d\log D_p/cc$  | $\sim N/cc/class$ |
|---|--|-------------------|
| 10nm  | $1.0 \times 10^3$  | 63                |
| 30nm  | $4.0 \times 10^2$  | 25                |
| 100nm   | $1.7 \times 10^2$  | 11                |
| 300nm   | $8.0 \times 10^1$  | 5                 |
| Sensitivity to typical Diesel accumulation mode (80nm, $\sigma_g = 1.8$ ) | Number: $\sim 170 N/cc$<br>Mass: $\sim 0.5 \mu g/m^3$<br>Indicates typical level at which lognormal mode falls below detection threshold |                   |
| All specifications subject to change without notice                       |  |                   |





## Specifications:

|                                  |   |
|----------------------------------|---|
| Particle size range              | 5 nm – 1 µm or 5 nm – 2.5 µm (software selectable option)           |
| Spectral Elements                | 38 (1 µm) or 45 (2.5 µm) (at 16/decade; 32/decade upon request)     |
| Size Classification              | Electrical Mobility   |
| Charger Type                     | Unipolar Corona Diffusion   |
| Dilution Factor Range (Optional) | 1–6 (1st stage)<br>1–500 (2nd stage)                                |
| Heated Sample Line (Optional)    | 7, 5 or 2 metres<br>max 191°C                                       |
| Sample Flow Rate                 | 8 slpm (1 µm range) /<br>2.5 slpm (2.5 µm range)<br>@ 0°C + 100 kPa |
| Minimum Sample Pressure          | 600 mbar<br>(4,200 m / 13,000 ft equivalent)                        |
| Analogue Outputs                 | 4; software configurable,<br>0–10 V, 47Ω                            |
| Analogue Inputs                  | 4; software configurable, ±10 V                                     |
| Instrument Zeroing               | Automatic; internal HEPA filter                                     |
| Stabilisation Time               | 30 minutes from switch on   |
| Number of Electrometers          | 22  |
| Minimum resolvable GSD           | 1.05 (lognormal output)   |
| Output Data Rate                 | 10/sec – 1/min  |
| Instrument Dimensions / Weight   | 98 H x 38 W x 52 L cms<br>80 kg with wheels                         |

|   |   |
|---|---|
| External Pump Dimensions/ Weight                    | 48H x 33W x 45L cms<br>46 kg with wheels  |
| Time Response                                       | $T_{90-10\%} \sim 200$ ms (1µm range)<br>$T_{90-10\%} \sim 500$ ms (2.5µm range)                                  |
| Calibrations:<br>Spherical                          | By NIST traceable PSL spheres & DMA size selected NaCl/H <sub>2</sub> SO <sub>4</sub> with standard electrometer. |
| Agglomerate (soot)                                  | DMA size selected soot, comparison with standard electrometer   |
| Max Concentration                                   | ≈ 10 <sup>11</sup> dN/dlogD <sub>p</sub> /cc (diluter on)   |
| Max Data File Length                                | Unlimited   |
| PC Interface  | Ethernet  |
| Remote Control                                      | AK Protocol   |
| PC Option   | Laptop or desktop   |
| Electrical Supply                                   | 100–115 / 220–240 V AC<br>50/60 Hz<br>1500 W main unit<br>750 W pump  |
| Inlet Pipe (No heated line)                         | 6 mm O.D. pipe stub on cyclone  |
| Exhaust pipe connection to heated line              | 6 mm or ¼ inch Swagelok or ¼ inch BSP thread  |
| Vac pump exhaust extract                            | 12 mm internal diameter pipe  |
| Compressed air (for 1st stage dilution only)        | Oil-free @ 3-8 bar gauge<br>Dewpoint 3°C or lower<br>ISO 8573 Class 1.4.1 or better                               |
| Max 1st Dilution & Line Temperature                 | 191°C (with heated sample line)   |
| Max Sample Temperature                              | 800°C (with heated sample line)   |
| Minimum Sample Pressure                             | 600mb (4,200m/13,000ft equivalent)  |
| Instrument Dimensions / Weight                      | 930W x 380W x 520D mm with wheels / 80Kg  |
| External Pump Dimensions / Weight                   | 443L x 328W x 372D mm with wheels / 44Kg  |
| Warranty period                                     | 12 months (extendable)  |
| All specifications subject to change without notice |   |

Key features of the DMS500 are protected by patent: US6,828,794.

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