Cambustion

DMS500 Mk3

Fast Particle Sizer

Third generation

Re-engineered modular design
to support a wider range of applications and budgets

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MORE INFO

size distribution, number & mass
for aerosols from 5 nm to 2.5 microns
from ambient & high concentration sources

Raw Engine Exhaust and Stack Sampling

Ambient, Roadside & Air Quality

Combustible & E-cigarettes

Engineered Nanoparticles

Flame Sampling

and more...

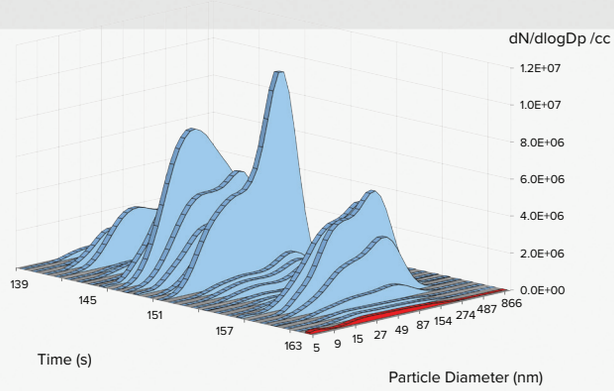
Fastest time response
(200 ms $T_{10\text{-}90\%}$ @ 10 Hz)

Widest size range
(5 nm – 1 µm or 2.5µm)

Class-leading accuracy & reproducibility

Widest concentration range (9 orders)

Best sensitivity
— amongst fast response particle sizers



Real-time size distributions from bacon cooking

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DMS500

The Mk3 is the third generation of Cambustion's highly successful DMS500 fast aerosol sizer, with hundreds of units sold since introduction in 2002.

Flexible configurations for different applications

With ongoing development and enhancements, the DMS500 is now available with capabilities and configurations to suit a wide range of both applications and budgets.

Size range options

Basic configuration 5 nanometers – 1 micron

The lowest cost DMS500 offers the unique opportunity to measure real-time size distributions between 5 nm and 1 µm, sampled at 10 Hz with a 200 ms $T_{10\text{-}90\%}$ response time.

This configuration, without sampling and dilution options, is suitable for rapidly changing aerosols which are not of** very **high concentration, such as ambient, Air Quality or personal exposure measurements.

Extended size range 5 nanometers – 2.5 micron option

The DMS500 may be operated at different setpoints to measure from 5 nm up to 2.5 µm, with reduced sensitivity and a slower time response.

This option is always *additional* to the standard 5 nm – 1000 nm measurement range — users can easily switch between the two ranges as desired.

Dilution & sample handling

Compressed gas diluter option

Aerosols which are at high temperature and contain evaporated liquids may undergo condensation as they cool through a sampling system, e.g. condensing water from a directly sampled combustion aerosol. This leads to both changes in the aerosol being measured, and a risk of instrument damage.

The gas diluter option for the DMS500 allows precision dilution for user selected factors between 1 and 6. Use of externally supplied dry gas such as air or nitrogen prevents condensation, even when sampling "wet" aerosols.

The gas diluter is software controlled, with mass flow measurement for accuracy. All measured data may be automatically online corrected for the true dilution factor.

Rotating disc diluter option

When sampling high concentration aerosols, even those which do not contain condensible gases, the concentration may sometimes exceed the ideal for an instrument.

In the extreme case, the concentration may be too high to measure without saturating the instrument detectors. Alternatively, the concentration may be measurable, but prolonged exposure can require premature cleaning by the user.

The rotating disc diluter allows precision dilution for user selected factors between 12 and 500. The diluter may also be bypassed (1:1) in software to retain maximum sensitivity.

This flexibility makes matching the DMS500 to an aerosol straightforward; simply adjust the rotating disc diluter according to the on-screen indicator and achieve both an extended cleaning interval and good Signal to Noise Ratio.

Heated sampling line option

For wet, high temperature aerosols, condensation and aerosol evolution can occur if the sample gas is allowed to cool without dilution. The heated sampling line accessory combines both the compressed gas diluter, preventing condensation and minimising agglomeration and a flexible heated sample tube to connect to the DMS500 itself. All heaters can run at up to 191°C.

When combined with the two dilution options, the heated sampling line adds plug and play direct sampling of aerosols such as combustion / engine exhaust, with no additional hardware required.

Online correction of the measured aerosol data for both diluter particle losses and applied dilution is fully automatic in the DMS500 software.

Volatile particle remover option

Many aerosols contain a mixture of volatile and solid particles, resulting in an unstable aerosol as volatile particles grow or shrink through evaporation.

Particularly for combustion / engine exhaust the formation of volatile particles is highly dependent on dilution; volatile particles may form inside the exhaust system, then evaporate in the atmosphere.

The CSA (Catalytic Stripper Accessory) volatile particle remover allows users to remove volatile particles, enabling measurement of only the non-volatile component. The CSA can be bypassed by the user if desired, supporting measurements of volatile/non-volatile fraction.

The CSA contains an oxidation catalyst and is heated to

400°C. Volatile particles are driven into the gas phase and then oxidised through catalytic activity. The gas is then cooled to pass to the DMS500 for measurement.

Software control of both heating and cooling ensure accurate and repeatable performance, and the DMS500 software can automatically correct the measured aerosol data for the well characterised particle losses.

Reduced sensitivity options

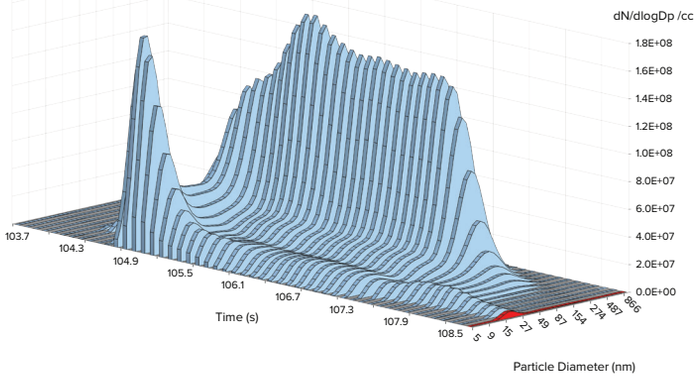
Measurement of volatile, very high concentration aerosols such as e-cigarettes presents conflicting challenges. Lack of dilution may saturate instrument detectors, while a long residence time at high concentration can lead to particles coalescing. Providing dilution to avoid these two challenges can lead to evaporation of volatile particles and a reduction of the measured particle size / mass concentration.

The DMS500 is well suited to measurements of e-cigarette aerosol, where both very high and time varying concentrations are encountered. To ensure the most accurate measurements, we offer *reduced* sensitivity options. These include less sensitive detectors (able to accept a higher maximum concentration) and the option to have only a portion of the inlet flow fed to the detectors, further reducing the effective sensitivity. By maintaining the upstream flows constant, long residence times which would otherwise lead to coalescence and particle losses are avoided.

SCS smoking & vaping machine

The SCS is Cambustion's standalone smoking and vaping machine. The DMS500 can be integrated with the SCS in both hardware and software, allowing direct measurement of aerosol while smoking or vaping under controlled and repeatable conditions.

Real-time size distributions from an E-cigarette



Applications

Ambient & indoor Air Quality

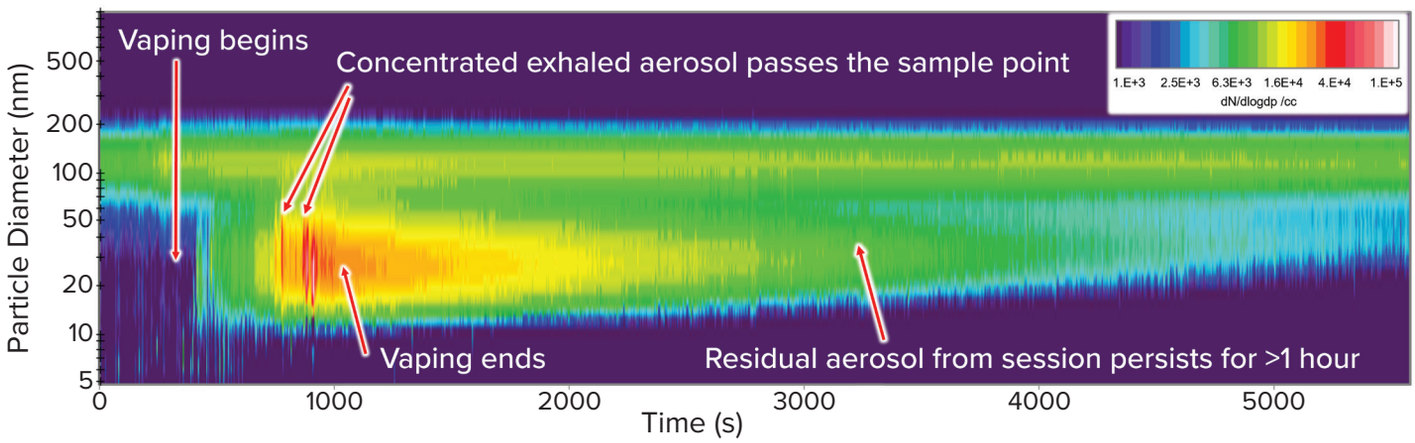
With the best sensitivity amongst real-time particle sizers, the DMS500 Mk3 brings transient capabilities to ambient pollution measurement.

Capable of long term unattended operation via scheduled operation and requiring no liquid consumables, X-rays or

radioactive sources, the DMS500's rapid time response ensures that short duration events and emitters are resolved, while faithfully monitoring longer term trends.

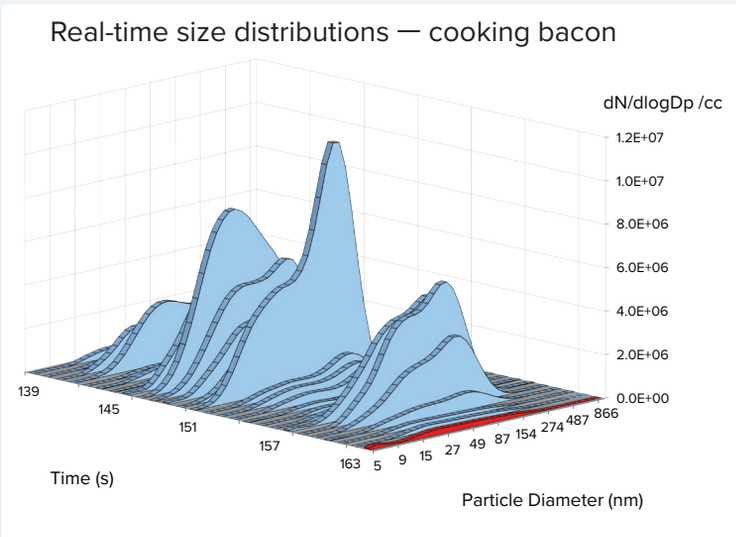
Cigarettes, e-cigarettes and heat-not-burn

Aerosols from cigarettes and vaping devices are high concentration, short emission events. The DMS500 is able to measure both mainstream and ambient aerosol, to better understand both the exposure of product users and the effects on air quality. Cambustion's standalone SCS smoking & vaping machine may also be coupled to the DMS500 for real-time sizing and instantaneous mass calculation.



Fire safety

Fires are dynamic and rapidly evolving. The emission of toxic gases and particles presents survival challenges for both occupants and first responders. The DMS500's fast time response and wide size range make it well suited for both material testing (e.g. in cone calorimeters) and larger scale measurements of simulated building fires.

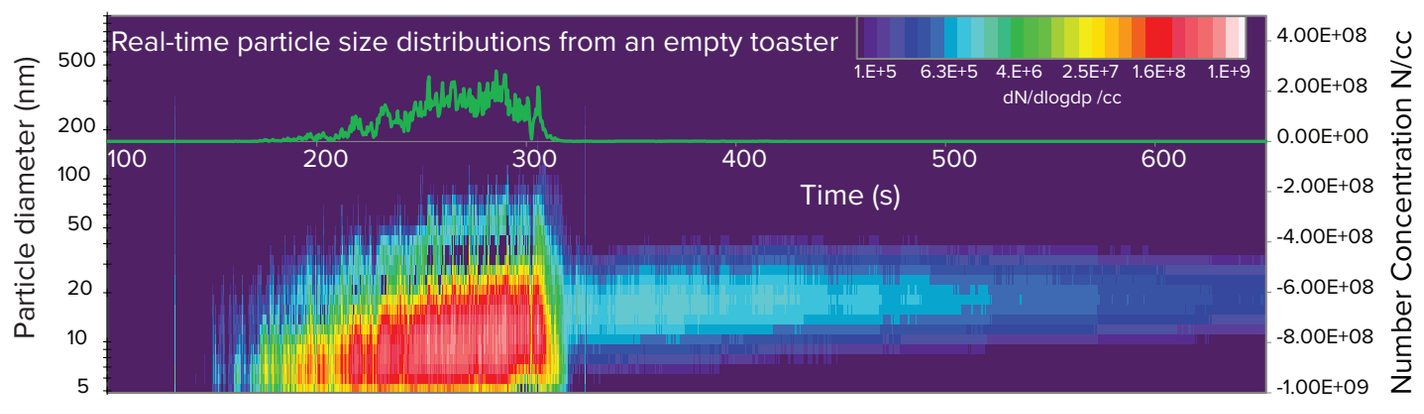


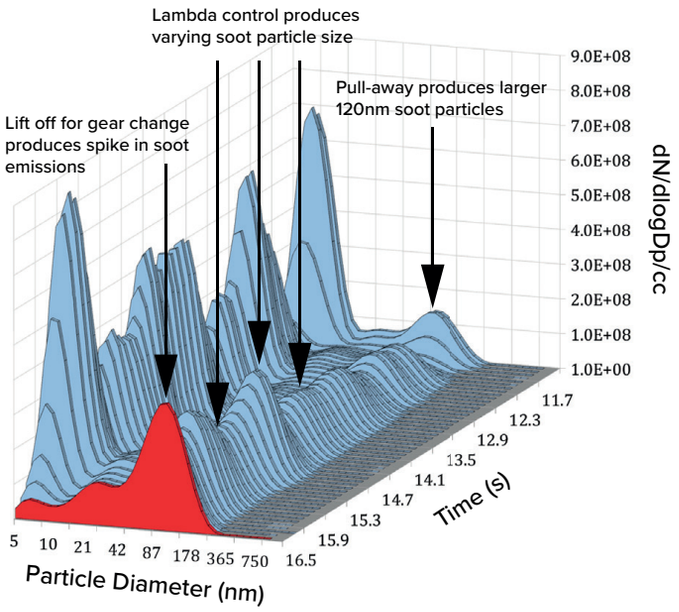
Wildfires

Wildfires present risks to property and health. The DMS500's fast time response and wide dynamic range support measurements during both laboratory and real-world campaigns.

Battery safety

Battery fires are increasingly of concern. A fire which starts inside a cell can result in very rapid and exothermic release of both toxic gases and particles over a very short space of time, with a very high number of particles being emitted in just a few seconds. The DMS500 is easily able to measure and resolve such short duration and high concentration events.



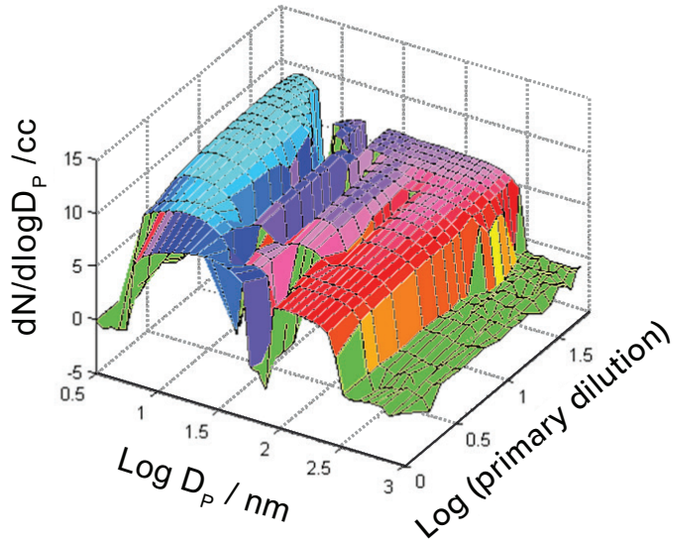


Workplace exposure

Awareness is growing of human exposure to potentially harmful aerosols in the workplace. Many aerosols are highly time variant, and thus 8 hour average exposure limits may significantly under-estimate the dosage to certain individuals from activities such as 3D printing, welding, soldering and more.

Flame Sampling & Combustion Science

The graph below 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.)

Combustion measurements

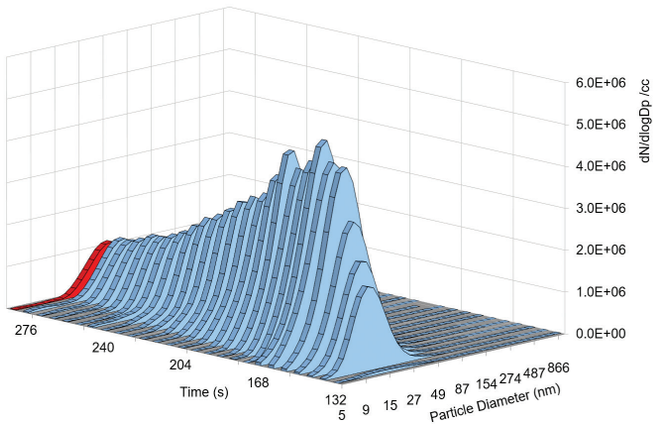
Engines and other combustion plant have highly transient operation, even when much legislation is expressed as averages.

The DMS500's flexible dilution and sampling options allow measurements directly from an exhaust, with real-time data revealing insights relevant for health and equipment operations / designers (see chart to left).

Climate effects

Cloud formation is driven by nuclei precursors in the atmosphere, and the DMS500 is used to understand the processes involved.

3D Print aerosol measurement
DMS waterfall plot showing a surge of freshly generated ABS particles at the start of the print. Initially the particles are around 15 nm, but they steadily increase in size and decrease in number through agglomeration.



Powerful, Easy to Use Software

DMS500 control and data recording is via a Windows laptop, and users are free to install the software on as many PCs as required without needing to purchase extra licences.

Features include programmable operation, optional digital remote control and optional four channels each of analogue input and output for integration with existing equipment.

The PC software includes full error detection and warnings.

Easy Operation

The DMS500 is ready to use in 30 minutes from switch-on and runs from standard electrical outlets.

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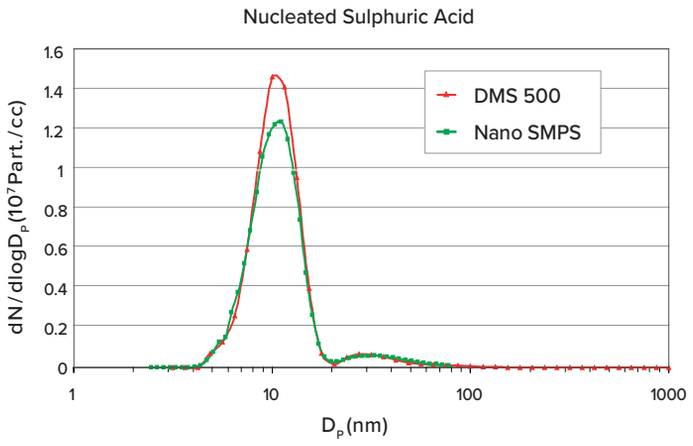
Measurement Principle — Electrical Mobility

The DMS500 uses a controlled unipolar corona charger — no radioactive or x-ray charger is required.

Charged particles enter the classifier column, where an electrical field deflects them across a sheath flow and then onto to the electrometer detectors.

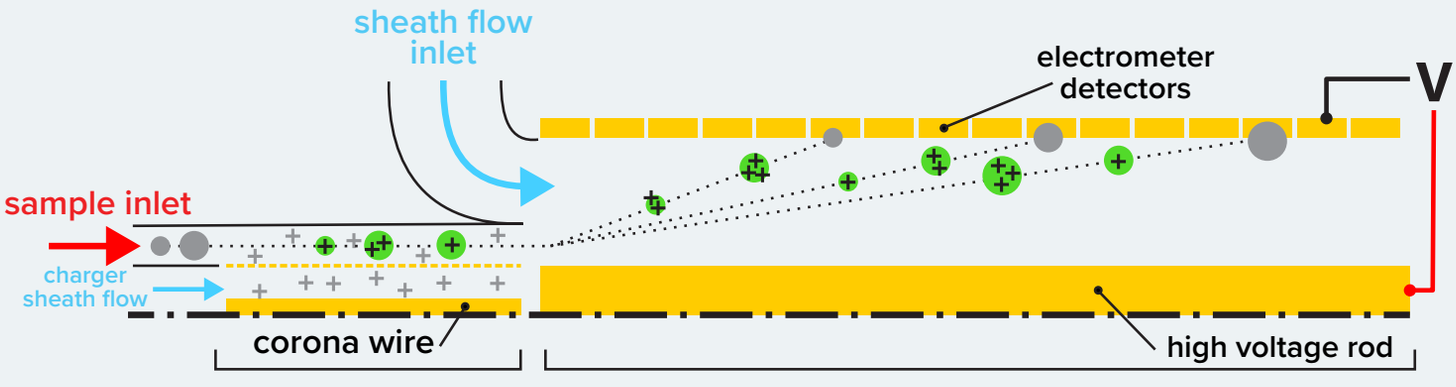
Particles are detected at different distances down the column, according to their electrical mobility (see schematic). The outputs from the 22 electrometers are then processed in real-time to calculate the size distribution data.

The DMS500 classifier operates at fixed pressure, which ensures that the calibration stays accurate even when sampling from varying ambient pressures (e.g. at altitude). Tests on stable aerosols demonstrate excellent agreement with SMPS measurements for both volatile or solid aerosols .



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

To view an animation visit: www.cambustion.com/products/dms



Fast Time Response

The DMS500 has carefully engineered fluid dynamics so it responds to transients within 200 ms. The time response of an instrument is a different concept to its data rate (in this case 10 Hz). Data rate is the rate the software outputs the results, but time response is fundamentally the fastest the instrument is able to respond to a change. If an instrument has a slow time response it will not resolve fast events without smearing them out, even if the data rate is high. The DMS500 has both a fast response and a high data rate.

Calibration

For spherical particle measurements, 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 soot aerosol measurement, an optional separate calibration (software selectable) is performed using hydrocarbon derived soot.

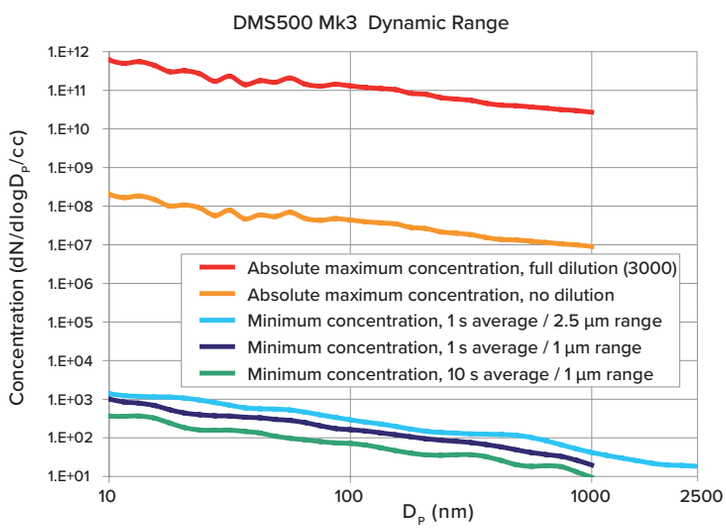
The calibration therefore takes account of particle transport losses inside the instrument, including the diluter. Every DMS500 is supplied with a traceable calibration certificate.

Published studies show class-leading accuracy & reproducibility between DMS500 MK2 instruments, over a 10 year study.

Sensitivity:

Note that the following sensitivity information is expressed in terms of size spectral density, $dN/dlogD_p/cc$. When comparing with other instruments' specifications, bear in mind that sometimes these are expressed in terms of total concentration (particles/cm^3) 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 $dN/dlogD_p/cc$ 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, 1µm range	$dN/dlogD_p/cc$	~ N/cc/class
10nm	1.0×10^3	63
30nm	4.0×10^2	25
100nm	1.7×10^2	11
300nm	8.0×10^1	5
Sensitivity to typical Diesel accumulation mode (80nm, $\sigma_g = 1.8$)	Number: ~170 N/cc Mass: ~0.5 µg/m^3 Indicates typical level at which lognormal mode falls below detection threshold	
All specifications subject to change without notice		



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Specifications:

Particle size range	Standard 5 nm – 1 µm Option 5 nm – 2.5 µm (software selectable)
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 (option)	1 – 6 (compressed gas) 1 – 500 (rotating disc)
Heated sample line (option)	7, 5 or 2 metres max 191°C
Sample flow rate	8 slpm (1 µm range) / 2.5 slpm (2.5 µm range) @ 0°C + 100 kPa
Minimum sample pressure	600 mbar (4,200 m / 13,000 ft equivalent)
Analogue outputs (optional)	4; software configurable, 0 – 10 V, 47 Ω
Analogue inputs (optional)	4; software configurable, ±10 V
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	98H x 38W x 52L cms 80 kg with wheels
External pump dimensions/ weight	48H x 33W x 45L cms 46 kg with wheels
Time response	$T_{90\text{-}10\%}$ ~200 ms (1 µm range) $T_{90\text{-}10\%}$ ~500 ms (2.5 µm range)
Calibrations: spherical agglomerate (soot) (optional)	 By NIST traceable PSL spheres & DMA size selected $NaCl/H_2SO_4$ with standard electrometer. DMA size selected soot, comparison with standard electrometer
Max concentration	≈10^{11} dN/dlogD_P/cc (diluter on)
Max data file length	Unlimited
PC interface	Ethernet
Remote control (optional)	AK protocol over Ethernet
PC	Windows laptop or desktop
Electrical supply	100 – 115 / 220 – 240 V AC 50/60 Hz 1500 W main unit 750 W pump
Inlet pipe (no heated line)	6 mm O.D. pipe stub on cyclone
Inlet pipe to optional 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 optional 1st stage dilution only)	Oil-free @ 3 – 8 bar gauge Dewpoint 3° C or lower ISO 8573 Class 1.4.1 or better
Max heated line setpoint temperature	191° C
Max sample temperature	900° C (with optional heated sample line)
Minimum sample Pressure	600 mb (4,200 m / 13,000 ft equivalent)
Warranty period	12 months (extendable)
All specifications subject to change without notice	

Cambustion is an independent, privately owned company with headquarters in Cambridge, UK.

We continue to research & develop novel instrumentation, and also offer measurement consultancy; helping our global clients to solve a wide range of particle & gas measurement challenges.

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To learn more, visit:

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