Cambustion

CPMA Mk2

MORE INFO

Centrifugal Particle Mass Analyser

Classify positively or negatively charged aerosol particles by mass : charge ratio

Measure true mass properties, independently of particle morphology

Established for over 10 years and now in its second generation, the CPMA has been adopted globally by both industry and aerosol research.

The CPMA MK2 is ideally suited for experiments where mass is the preferred metric, or the relationship between mass and other properties are of interest.

Capabilities

Produce a mass:charge monodisperse aerosol
with high resolution and high transmission

Switchable polarity
to classify positively or negatively charged particles

Measure mass distributions
when combined with a CPC

Measure mass - mobility distributions
when combined with a DMA & CPC

Determine density and morphology
when combined with a DMA & CPC

Applications

New! Enhanced characterisation of non-spherical particles
50 nm – 3 µm as part of the new M^2AS

Black carbon mixing state studies
via direct interface with the DMT SP2

Tandem DMA / Aerosol Conditioner / CPMA experiments
to measure hygroscopic & secondary coating effects

Aerosol mass reference standard
as part of the CERMS, e.g. to calibrate other instruments

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Applications

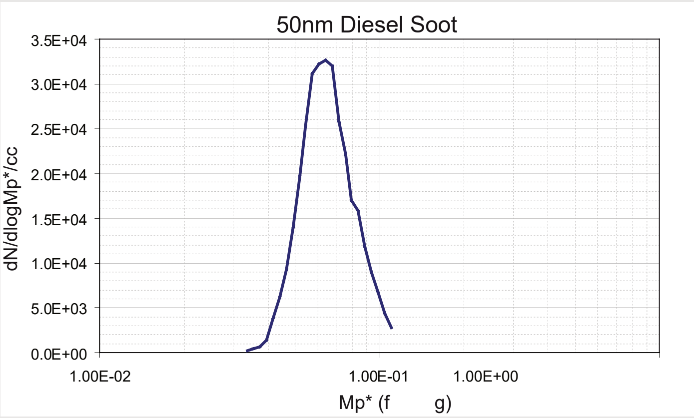
Monodisperse aerosol selection

Combined with a neutraliser (or charger), the CPMA offers a capable alternative to a Differential Mobility Analyser (DMA) to select a monodisperse aerosol from a polydisperse input[1].

This aerosol is monodisperse by mass:charge rather than by electrical mobility as with a DMA. A much higher resolution in mass terms is thus achieved with the CPMA (compared with the DMA), particularly for non-spherical particles.

Since the CPMA selects directly by mass:charge ratio, a doubly-charged particle will be transmitted only if it also has double the mass. Multiple charging therefore correlates directly with the mass, meaning that no artefacts are introduced in the data and that more aggressive charging can be exploited in certain applications.

Mass distribution measurements



The CPMA supports direct connection to detectors such as CPCs and aerosol electrometers. The software can step-scan the setpoint of the CPMA to measure the mass distribution of a charged aerosol. Measured distributions are displayed on the touchscreen and recorded on USB memory, with automatic particle loss correction. Offline multiple charge correction is required.

A wide range of CPCs and electrometers from different manufacturers are supported, and others can be added.

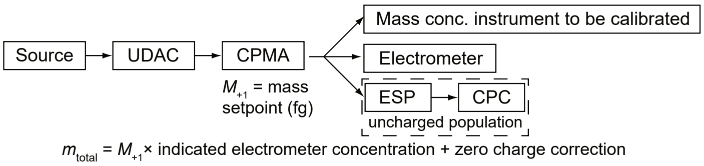
The mass output may be automatically converted to mobility diameter using a user-entered factor, either of known constant density, or using a known mass-mobility relationship to accommodate an aerosol with a size-varying density (such as soot).

With an assumed density, conversion to size spectral density (dN/dlogDp/cc) is also automatic.

Aerosol mass calibration standard

The CPMA is used as a calibration standard for other instruments such as aerosol mass spectrometers and black carbon detectors.

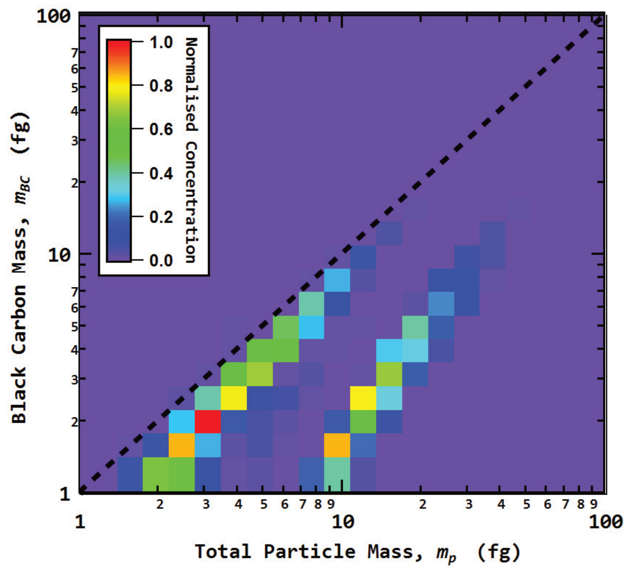
The CPMA forms part of the CPMA Electrometer Reference Mass Standard (CERMS). Combined with a unipolar charger (Cambustion UDAC) and an aerosol electrometer, the CERMS offers a traceable standard for suspended aerosol particle mass[2].



With the CERMS, a source of particles of accurately known mass concentration can be generated for instrument calibration. In this configuration (above), the CPMA directly displays a mg/m³ output concentration which can be compared to the reading of the instrument being calibrated.

Black carbon studies

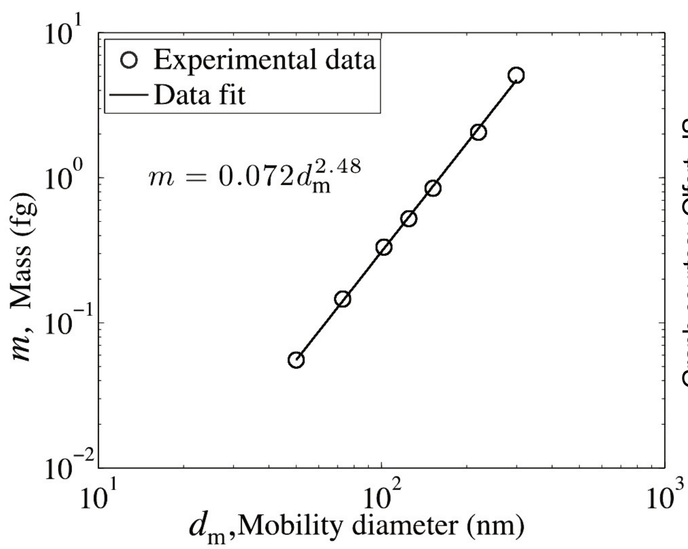
The CPMA interfaces directly with the Single Particle Soot Photometer (SP2) by Droplet Measurement Technologies. The combination of instruments allows the determination of the mass of coating, providing information about the particle mixing state for both lab-based and atmospheric measurements[3 & 4].



Graph courtesy Broda et al. 2018

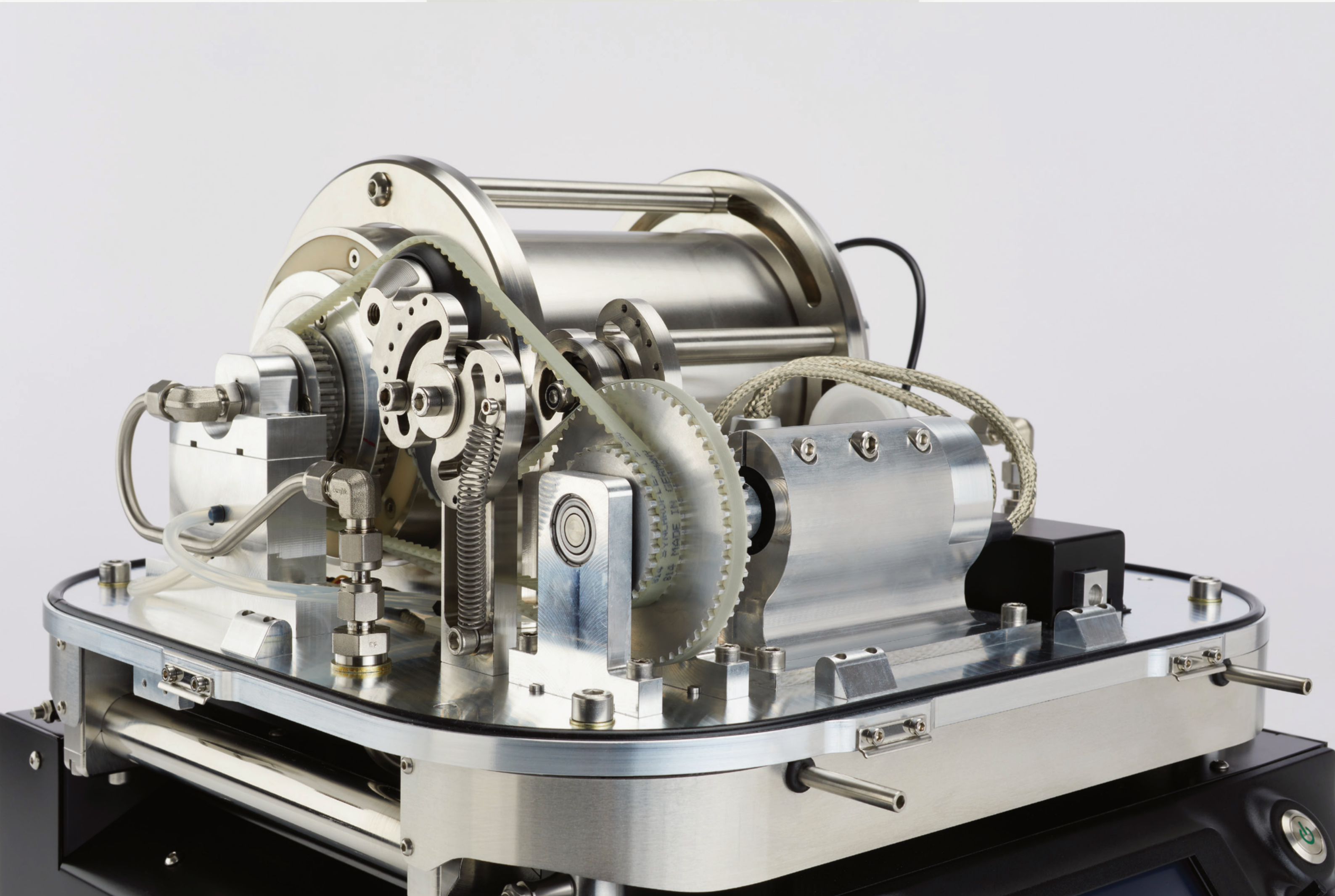
Effective density / shape factor

The combination of the CPMA with a DMA or an Aerodynamic Aerosol Classifier (AAC) allows measurement of fractal shape / effective density of non-spherical particles[5].



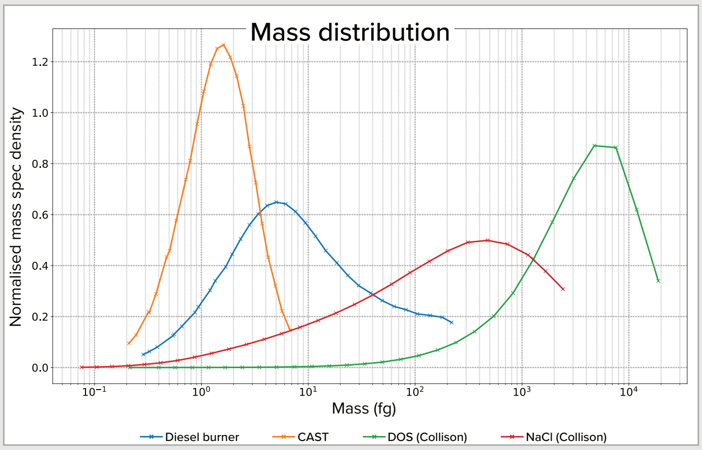
Graph courtesy Olfert, JS

Analogue Outputs
±10 V
Breakers
Aux
Motor
AC Inlet
400 VA, 85 – 264 VAC, 50 – 60 Hz
230V:T3.15A, 115V:T5A
Classifier
High Voltage
0 – 1kV
Serial 1
Serial 2
WARNING
THIS EQUIPMENT MUST BE EARTHED. READ INSTRUCTIONS BEFORE USE OR SERVICE. DO NOT DEFEAT INTERLOCKS. DO NOT BLOCK REAR VENTILATION. THIS DEVICE IS A 2-PERSON LIFT. ALLOW TO STOP AND DISCONNECT FROM MAINS BEFORE SERVICE.
DO NOT BLOCK
Cambustion
J6 The Paddocks,
347 Cherry Hinton Road,
Cambridge, CB1 8DH, U.K.
CPMA Mk2
Designed and Manufactured in the U.K.

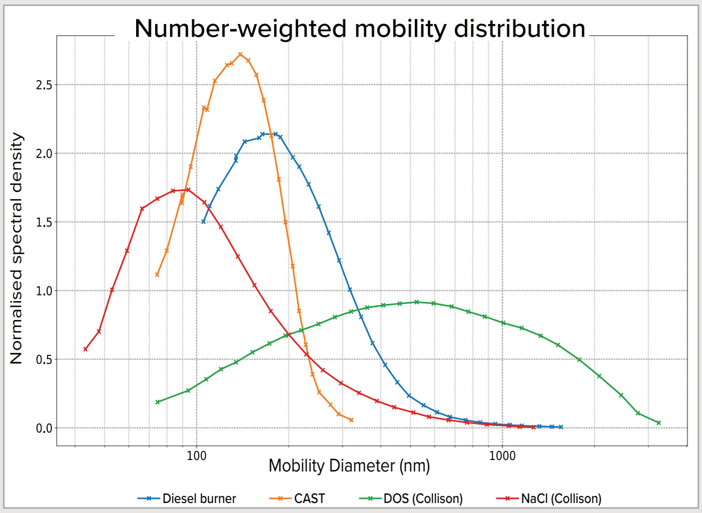


New! Mass & Mobility Aerosol Spectrometer (M^2AS)

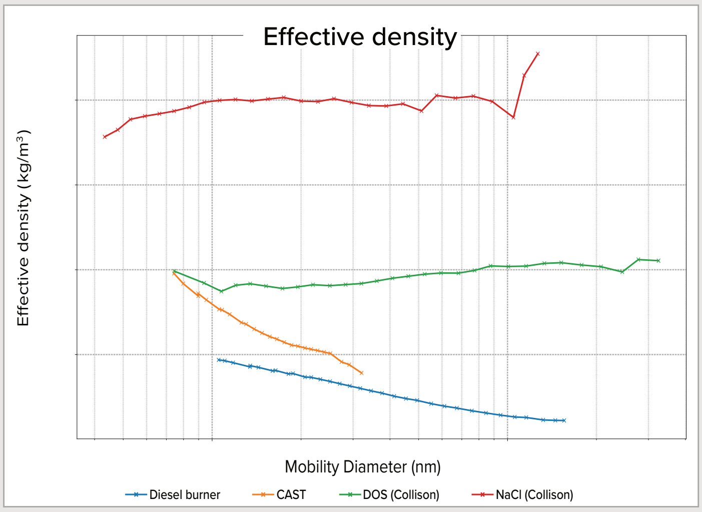
The CPMA is a key component of Cambustion's Mass & Mobility Aerosol Spectrometer (M^2AS) – see separate brochure. The M^2AS offers simultaneous measurement of aerosol mass, mobility and density distributions, even with non-spherical aerosols.



No assumptions are required about the charge state of the particles and the high level of charging enables a wide measurement range of ~50 nm – 3 µm, far wider than can be achieved with a DMA-based technique.



Custom software integrates all the instruments and performs the data inversion, which uses the measured charge state to calculate morphological properties of non-spherical particles with unique accuracy.



Advantages

Increased particle transmission

The CPMA offers reduced particle loss and gives a higher transmission even at high resolution.

Flexible operation

High aerosol flow (up to ~8 lpm) is well suited to use with an electrometer or as a source of particles for other analysers.

Simultaneous scanning of speed and voltage allows constant resolution over a scan. Faster scans are possible by keeping the speed constant and allowing resolution to vary.

The setpoint of the CPMA does not depend upon the gas properties; any carrier gas may be used.

Both bipolar (radioactive, X-Ray) and unipolar (corona) chargers may be use to charge the particles prior to the CPMA, offering a choice of charge distributions which can be harnessed in different applications.

Traceable calibration

Every CPMA undergoes a traceable calibration process at Cambustion and a certificate is provided.

Easy operation

Commercially available since 2012 – and with a second generation in 2020 – the CPMA has become well established in aerosol research and metrology labs around the world thanks to its ease of use.

As a stand-alone bench-top instrument it has a built-in touchscreen which allows operation and data recording, with no requirement for an external PC.

Speed and voltage are calculated automatically from the desired mass (or size) setpoint and resolution, and scanning capability is included in the software.

The CPMA Mk2 features spring auto belt tensioning, for easier user cleaning of the classifier.

Multiple interfaces

The CPMA features a variety of interfacing options for remote control. Physical interfaces include USB, RS232 and Ethernet.

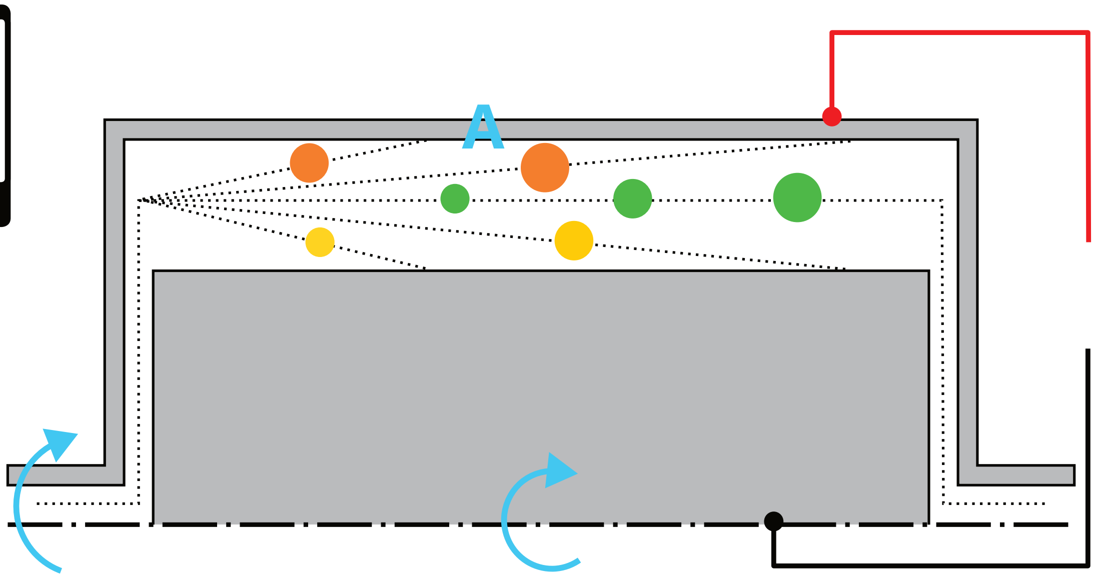
Software offered includes a remote Ethernet client, a Windows application, and an API library for user programs. Remote file access is also possible.

The CPMA can interface with many detectors using RS232. Ethernet communication with TSI 375x and 3789 CPCs is now also supported.

Three highly configurable analogue inputs and outputs allow users ultimate flexibility in quickly interfacing with any detector with an analogue output connection.

Excel tools for visualising data are provided along with an Excel/VBA project which can control both the CPMA and a DMA (via an analogue output) allowing automated mass-mobility exponent determination.

Output data is automatically scanned into an Excel workbook.



Operating Principle

Classification

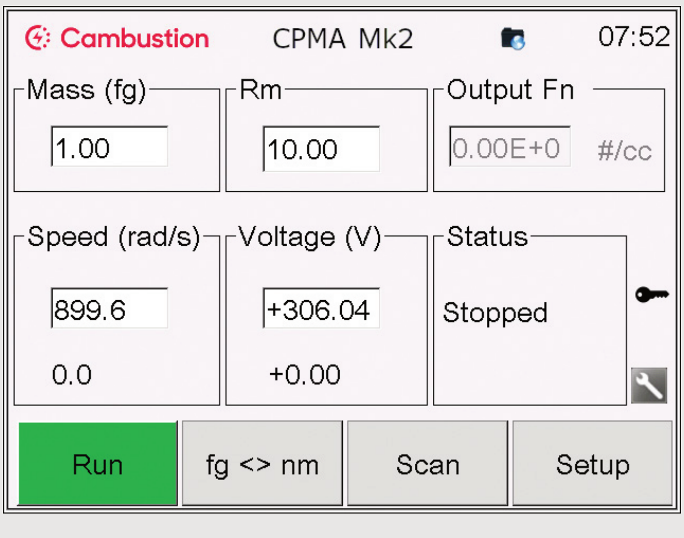
The CPMA classifier consists of two concentric rotating cylinders, with a variable voltage between them.Charged particles are therefore classified based on opposing centrifugal and electrical force fields.

Particles with a higher mass:charge ratio than that selected are lost to the outer cylinder. Particles which have a lower mass:charge ratio than that selected are lost to the inner cylinder. Particles which have the selected mass:charge ratio follow a trajectory through the classifier.

In a unique feature of the CPMA, the cylinders are rotated at slightly different speeds[1]. If the cylinders rotated at the same speed, particles of the correct mass:charge would only reach the exit if they also entered along the central trajectory.

The difference in rotation speed sets up a stable centrifugal/ electric field across the classification region. A particle of the correct mass:charge ratio will therefore exit the classifier independently of the radius at which it enters the classification region. This reduces particle losses in the CPMA, ensuring a high throughput even at high resolution.

The CPMA is a fundamental standard for particle mass – provided particles are singly charged, the mass setpoint depends only on the speed and voltage, and the physical dimensions of the classifier.



Unlike in a DMA, the setpoint does not depend upon the gas properties (such as viscosity and mean free path) or ambient conditions (temperature and pressure), and furthermore is not affected by particle morphology.

Resolution

The CPMA resolution is set by the combination of sample flow rate and the speed/voltage pair used to achieve a given user setpoint.

Increasing the sample flow will reduce the maximum resolution achievable; the less time particles spend in the classifier, the less time they are exposed to the classifying forces. Users may enter a resolution and mass (and the software calculates the speed voltage pair automatically) or enter a speed and voltage directly and allow resolution to float.

Aerosol flowmeter accessories

Knowledge of the sample flow is required in the CPMA to set the resolution. The sample flow may be entered manually by the user, or real-time measurement is possible.

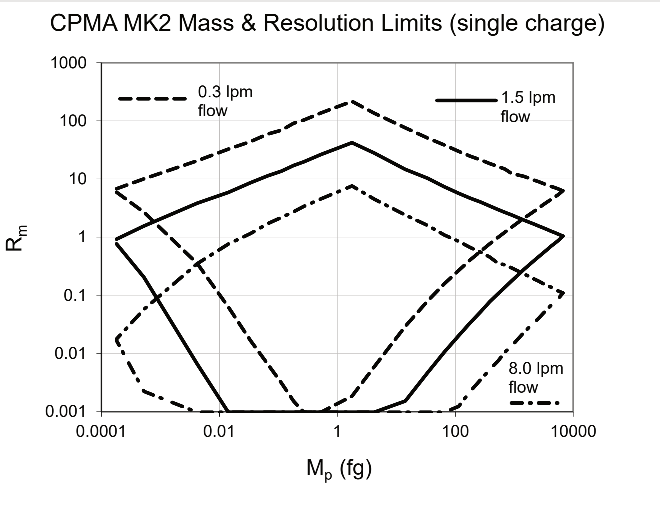
The CPMA is compatible with the new AF10 standalone aerosol flowmeter – see separate brochure.

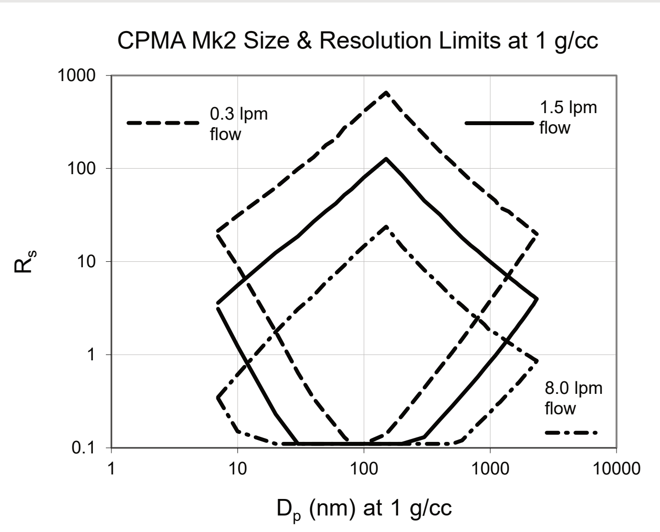
A more basic aerosol flowmeter is available for use only with the CPMA and AAC. Either of these options allows the CPMA to maintain constant resolution when the sample flow is varying or unknown. The flowmeters also provide a means to monitor performance of other connected equipment.

Operating range

For singly-charged particles, this depends on the resolution (R_m or R_s) required and the sample flow used.

R_m is defined as $\Delta M_p / M_p$ and R_s is defined as $\Delta D_p / D_p$, both Full Width Half Maximum.





When a corona charger is used to ensure multiple charging, larger particles can be classified with the CPMA. Unlike in a DMA, the mass of the classified particles is proportional to the charge and it is therefore possible to exploit the multiple charging while retaining information about the true mass.

Specifications

Mass range (single charge)	0.2 ag – 6.6 pg (see plot)
Equivalent diameter range at unit density (single charge) Multiple charges in M^2AS	7 nm – 2.3 µm (see plot) ~50 nm – 3 µm
Mass accuracy	5% or better (across entire size range)
Sample flow	Recommended 1.5 lpm Min. ~0.3 lpm (higher diffusional loss) Max. ~8 lpm (decreased resolution)
Ambient conditions	5 – 40°C non-condensing humidity
User Interface	Built-in 5.7" touchscreen
Remote control	Ethernet, USB & RS232 Control via PC remote application, via text commands (terminal) or via user software via API. Remote file access.
Detector input (CPC or electrometer)	RS232 (×2) & analogue (×3) Ethernet (×1)
Compatible detectors via RS232:	Aerosol Devices MAGIC, Airmodus A20, Brechtel 1720, Grimm 54xx, PALAS UF CPC, TSI 30xx, 375x, 377x, 378x, Keithley 651x electrometers, Palas Charme® electrometers and TSI 3068B aerosol electrometers
Compatible detectors via Ethernet:	TSI 375x, TSI 3789
Analogue inputs and outputs	3 inputs, 3 outputs, 0 – ±10 V (software configurable)
Data storage	USB flash drive (supplied)
Software supplied	Remote control application API dll for user programs Excel Utility and VBA API
Electrical supply	100 – 240 VAC, 50/60 Hz, 1,000 W maximum
Dimensions / Weight	46.1 (w) × 54.6 (d) × 44.5 (h) cm / 42 kg
Safety features	To BS EN 61010-020:2006

All specifications subject to change without notice

References:

1. Olfert & Collings, Journal of Aerosol Science 2005, https://doi.org/10.1016/j.jaerosci.2005.03.006
2. Symonds et al., Aerosol Science & Technology 2013, https://doi.org/10.1080/02786826.2013.801547
3. Cross et al., Aerosol Science & Technology 2010, https://doi.org/10.1080/02786826.2010.482113
4. Broda et al., Aerosol Science & Technology 2018, https://doi.org/10.1080/02786826.2018.1433812
5. Olfert, Symonds & Collings, Journal of Aerosol Science 2007, https://doi.org/10.1016/j.jaerosci.2006.10.002

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