AAC

Aerodynamic Aerosol Classifier

Classify aerosol particles by aerodynamic diameter, without charging

The AAC is the ideal instrument for generating a truly monodisperse aerosol from a polydisperse source. With no charger or neutralizer, only the desired particle size is selected, without additional peaks from multiple charges. Unhindered by charging, particle transmission efficiency is high across the AAC's wide size range, limited only by diffusional and impaction losses.

Applications:

- Alternative to DMA
- Produce aerodynamic size distributions when paired with a CPC
- New! Use as a **low-pass separator**

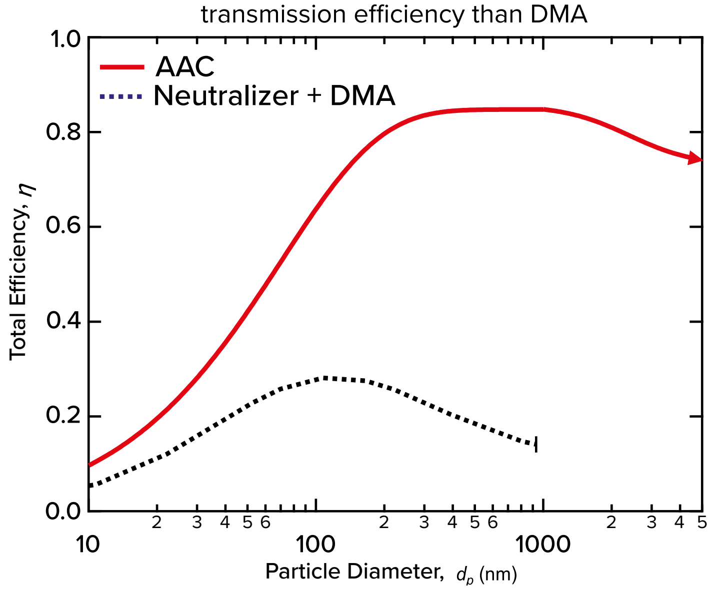
  ... with simple (reversible) user modifications
- Wherever radioactive / X-ray sources are prohibited or inconvenient
- Generate calibration aerosol
- Inhalation and particle deposition studies
- Where charge correction is problematic: metrology, tandem instrumentation etc.
- Measure:
  - Mass - mobility
  - Shape factor
  - Effective density

  ... when paired with a DMA / CPMA

Key Features and benefits:

- Wide particle size range: 25nm to > 5µm aerodynamic diameter
- True monodisperse aerosol output
- No multiple charging complication

AAC offers wider size range and better transmission efficiency than DMA



Aerodynamic Aerosol Classifier

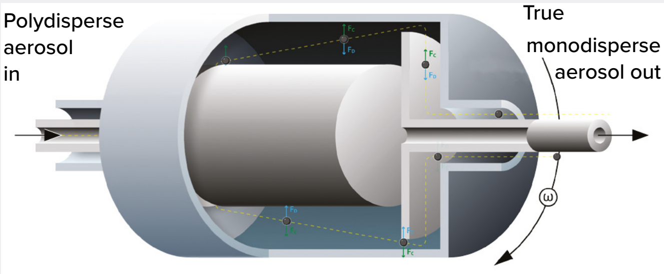
Principle of Operation

The AAC may be thought of as translating the DMA into a rotating frame, where the electrical force on the particles is replaced by a centrifugal force. Particles are carried along the classifier by a sheath of clean air. The rotation of the classifier imparts a centrifugal force onto the particles, opposed by their drag force in air.

Particles which are larger than the selected diameter adhere to the outer wall of the classifier, those smaller than the target size exit with the excess sheath flow, particles at the selected diameter exit through the sample port.

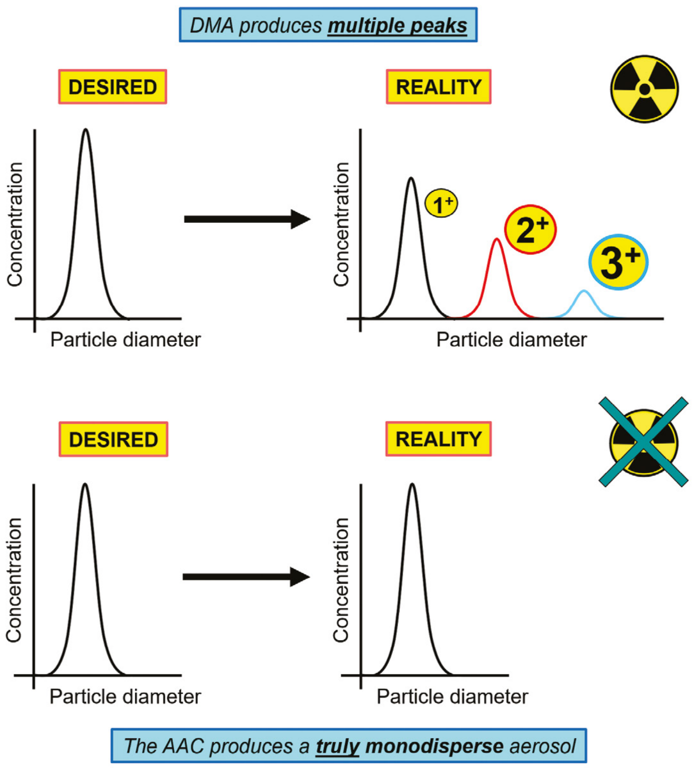
Since the only forces acting on the particles are due to their mass and drag (i.e. aerodynamic diameter), charging is not required and charge state has no effect on classification.

View animation at: cambustion.com/aac



An Alternative to a DMA

The AAC may be used in most applications where a DMA is traditionally used to select aerosol by size. The main advantage over a DMA is that only one peak is produced – no additional particles at larger sizes with higher charge states pass through the AAC.



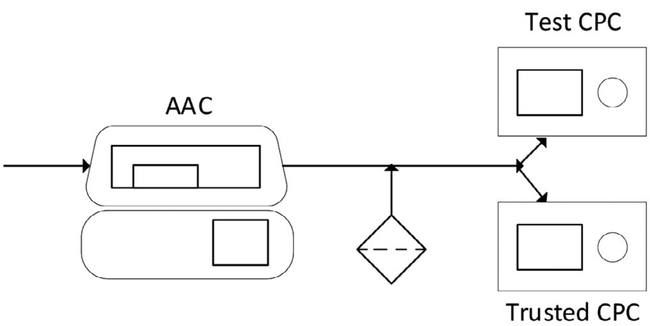
Also, because only up to a fifth of particles gain a single charge in a bipolar charger, most particles do not pass through a DMA at all, which means that the practical transmission efficiency of a DMA when used with a neutralizer is quite low. (See chart on front page)

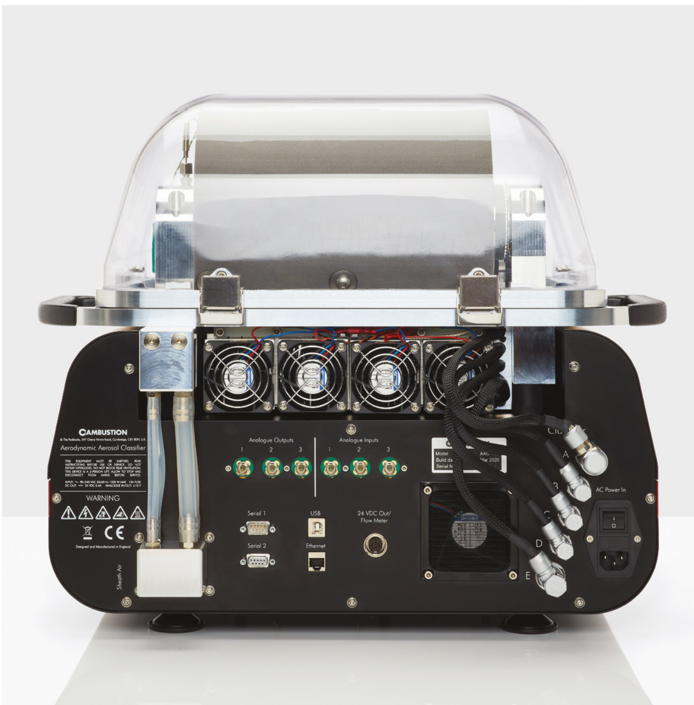
Conversion between mobility and aerodynamic diameters is automatic and built into the software, both for aerosols of known constant density, and those with a size varying density for which a mass-mobility relationship is known (such as soot).

Because no neutralizer is required, the AAC can be used in places and situations where legislation or practical consideration limits or prohibits the use of radioactive or X-ray sources.

Another advantage over a DMA is the much wider size range of the AAC, from 25 nm to >5 µm in aerodynamic diameter. As the relationship between aerodynamic and mobility diameters is density dependent, by using dense test aerosols (for example, silver, gold, CsCl), it is possible to reach small (<10 nm) mobility equivalent diameters (Symonds 2018).

The resolution of the AAC is determined by the ratio of sheath to sample flow, as for a DMA, and very similar high resolution is achievable with the AAC. Applications where the AAC has already found use as a DMA alternative include filter penetration testing, aerosol charger efficiency testing and CPC calibration:





Use when you need Aerodynamic Diameter

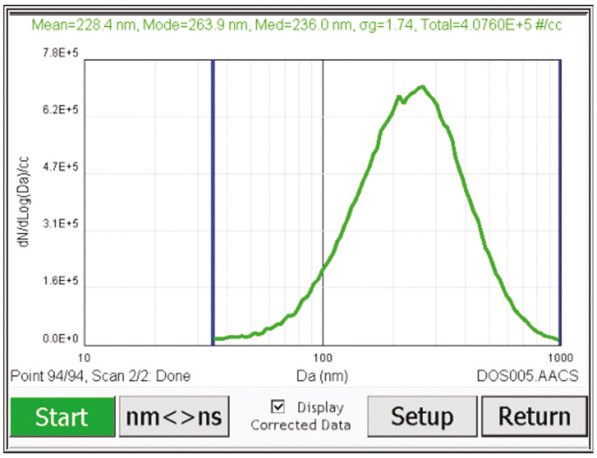
In many areas of aerosol science, Aerodynamic Diameter is the metric of choice, for example in inhalation studies. The AAC allows for the first time selection of aerosol by aerodynamic size over a finite size range. Whilst impactors provide a large particle cut-off, and virtual impactors a small particle cut-off, only the AAC allows selection of particles by aerodynamic diameter over a finite range with selectable, very high, resolution.

Scanning operation

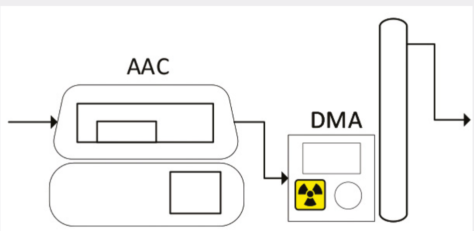
In addition to monodisperse classification, the AAC can scan its rotational speed to produce a size distribution when paired with a particle counter such as a CPC, while requiring no charge correction. **NEW:** In addition to the original step scanning mode, there is now a continuous scanning (speed ramping) mode, similar to an SMPS™ in operation. This considerably reduces the scanning time.

Digital connection to a wide range of commercial CPCs is supported (see specifications at end). Data is logged in plain text format to any USB flash drive.

The scanning data inversions are built into the AAC's software, and include correction for particle losses. Details of step scanning can be found in Johnson et al. (2018), which shows good agreement with the ELPI™, and when converted to mobility diameter, with the SMPS™.



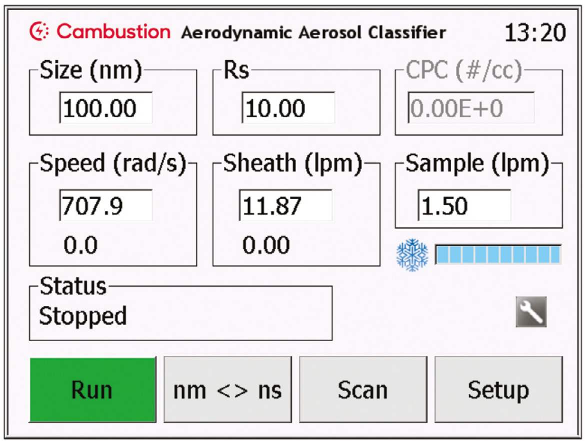
Use in tandem with other Classifiers



The AAC can be used in tandem with other particle classifiers to yield further information about particle properties. When used with a DMA, information about particle density and shape factor is obtainable (e.g. Tavakoli and Olfert, 2014). When used with a CPMA, information about particle mobility is obtainable.

Easy to use, easy to integrate into experiments

The AAC is fully standalone and controllable from the built-in touchscreen:



The classifier can be run at constant sheath flow, or at constant size resolution. In the latter case, the sheath flow is automatically adjusted as a function of size.

The instrument may be controlled remotely via a VNC client (screen sharing over Ethernet), the supplied Windows application or automated from your own programs via text commands or the supplied Dynamic Link Library. Remote control is possible over USB, RS232 (serial), or Ethernet. Control via any of three software configurable analogue inputs is also possible. Three software configurable analogue outputs are provided.

Traceable Measurement

The AAC's principle of operation means that aerodynamic diameter is dependent upon the classifier speed, the sheath flow, the classifier dimensions, air viscosity and mean free path (Cunningham slip correction, C_C). The speed and sheath flows are traceably calibrated at Cambustion with calibration certificates provided. The air viscosity and mean free path is accounted for using pressure and temperature sensors in the sheath flow. The following expression relates the aerodynamic diameter to the physical characteristics of the classifier:

$$\frac{C_c(d_{ae})\rho_0 d_{ae}^2}{18\mu} = \frac{2Q_{sh}}{\pi\omega^2(r_i+r_o)^2 L}$$

An optional traceable classifier gauging service is also available to further reduce experimental uncertainties.

Optional Aerosol Flowmeter

The AAC is compatible with the new AF10 precision orifice aerosol flowmeter – see separate brochure.

Alternatively, a simpler digital flowmeter is available which can be placed inline with the aerosol exit flow, and measures the flow by means of the pressure difference across an orifice plate. This allows the AAC to automatically adjust the sheath flow to maintain a constant resolution, in situations where the sample flow is unknown, or flow through the AAC is varying. Where the sample flow is fixed and known (e.g. when using a CPC), the flow can simply be entered into the AAC software.

New Application – Use as a low-pass separator

An easy (and reversible) modification which can be carried out by the user now allows the AAC to be used as a “low-pass” separator, for experiments which require particles not exceeding a specified size.

At the outlet of the AAC classifier, all the particles smaller than the set-point are carried in the sheath flow, which can be recovered and used for further analysis or testing. The cut-off diameter can be freely specified within the standard operating range of the AAC and the steepness of the roll-off can be adjusted by changing the resolution.

References (See full list: cambustion.com/publications/aac)

- Accelerated measurements of aerosol size distributions by continuously scanning the aerodynamic aerosol classifier; Tyler J. Johnson, Jonathan P. R. Symonds, Jason S. Olfert, Adam M. Boies; Aerosol Science & Technology; (2020) https://doi.org/10.1080/02786826.2020.1830941
- Generating an aerosol of homogeneous, non-spherical particles and measuring their bipolar charge distribution; T.J. Johnson, R.T. Nishida, X. Zhang, J.P.R. Symonds, J.S. Olfert, A.M. Boies; Journal of Aerosol Science, (2020) https://doi.org/10.1016/j.jaerosci.2020.105705
- Measuring aerosol size distributions with the aerodynamic aerosol classifier; T.J. Johnson, M. Irwin, J.P.R. Symonds, J.S. Olfert, A.M. Boies; Aerosol Science & Technology; (2018) https://doi.org/10.1080/02786826.2018.1440063
- Determination of particle mass, effective density, mass-mobility exponent, and dynamic shape factor using an Aerodynamic Aerosol Classifier and a Differential Mobility Analyzer in tandem; F. Tavakoli & J.S. Olfert; Journal of Aerosol Science, (2014) https://doi.org/10.1016/j.jaerosci.2014.04.010
- Generation of a monodisperse size-classified aerosol independent of particle charge; F. Tavakoli, J.P.R. Symonds, J.S. Olfert; Aerosol Science & Technology; (2014) https://doi.org/10.1080/02786826.2013.877121
- An instrument for the classification of aerosols by particle relaxation time: Theoretical models of the Aerodynamic Aerosol Classifier; F. Tavakoli & J.S. Olfert; Aerosol Science & Technology; (2013) https://doi.org/10.1080/02786826.2013.802761

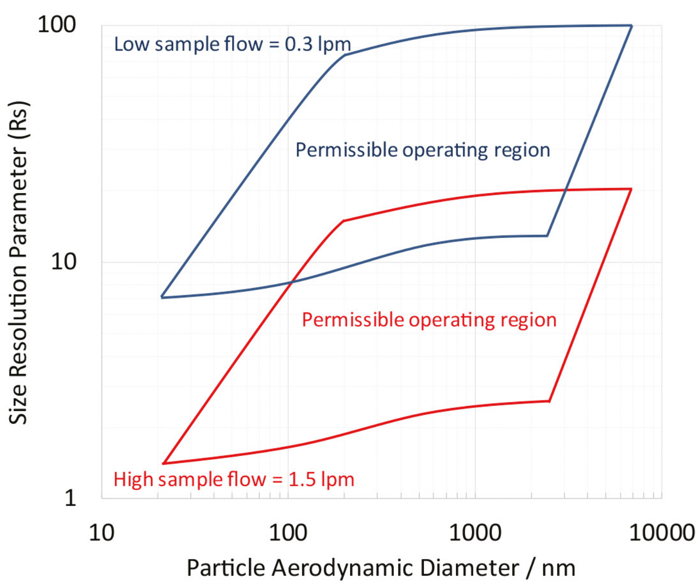
The Aerodynamic Aerosol Classifier includes technology licensed from the University of Alberta and is protected by the following international patents: US8966958, JP5658244, CA2764522A1, GB2550185B, EP2449359B1.

Specifications

Particle size range (see plot below)	25 nm – >5 µm (aerodynamic equivalent diameter)
Sample flow range	0.3 – 1.5 LPM
Sheath flow range	2 – 15 LPM
Rotational speed	20 – 700 rad/s
Ambient conditions	10 – 40˚C (0 – 95% RH)
User Interface	Built-in touchscreen
PC remote control	via Ethernet, USB or RS232
CPC communication	RS232 or analogue
Compatible CPCs (via RS232 serial). Others can be added on request.	Aerosol Devices MAGIC, Airmodus A20, Brechtel 1720, Grimm 54xx, PALAS UF CPC, TSI 30xx, 375x, 377x, 378x
Analogue inputs and outputs	3 inputs, 3 outputs, 0 – 10 V (software configurable)
Electrical supply	90 – 240 VAC, 50/60 Hz, 1kW
Dimensions / Weight	570 (w) x 520 (d) x 480 (h) mm / 61 kg
All specifications subject to review and change without notice	

Operating size range

This is dependent upon the resolution (R_S) required, and the sample flow used. R_S is defined as Dae /Δ Dae, FWHM. The resolution is changed by changing the sheath flow to sample flow ratio, which is taken care of by the AAC software.



View AAC practical tutorial video: www.youtube.com/watch?v=9zuKM7-Ag0o

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