TNA User Report

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Project title	Instrument Intercomparison Workshop: Mobility Particle Size Spectrometer and Condensation Particle Counter
Name of the accessed calibration center	WCCAP
Number of users in the project	1
Project objectives (max 100 words)	The objectives of the work were to verify the performance of two TSI 3776 Ultrafine Condensation Particle Counters to the ACTRIS and GAW standards and compare their performance against the manufacturer's specification.
Description of work (max 100 words):	The work included running monodisperse, silver nanoparticles in the size range 5 – 40 nm and comparing the CPC counting efficiencies against a traceable aerosol electrometer.

Principal Investigator's and group's information	
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[1] Physics; Chemistry, Earth Sciences & Environment; Engineering & Technology; Mathematics; Information & Communication Technologies; Material Sciences; Energy; Social sciences; Humanities.
[2] UNI= University and Other Higher Education Organisation;
RES= Public Research Organisation (including international research organisations and private research organisations controlled by public authority);
SME= Small and Medium Enterprise;
PRV= Other Industrial and/or Profit Private Organisation;
OTH= Other type of organization.
[3] UND= Undergraduate; PGR= Post graduate; PDOC= Post-doctoral researcher; RES= Researcher EXP= Engineer; ACA= Academic; TEC= Technician.
[4] Reproduce the table for each user who accessed the infrastructure

Trans-National Access (TNA) Scientific Report

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Please limit the report to max 5 pages, you can include tables and figures. Please make sure to address any comments made by the reviewers at the moment of the project evaluation (if applicable, in this case you were informed beforehand). Please do not alter the layout of the document and keep it in Word version. The report will be made available on the eurochamp.org website. Should any information be confidential or not be made public, please inform us accordingly (in this case it will only be accessible by the European Commission, the EUROCHAMP-2020 project partners, and the reviewers). Please include:

- Introduction and motivation
- Scientific objectives
- Reason for choosing the calibration facility
- Method and experimental set-up
- Data description
- Preliminary results and conclusions
- Outcome and future studies
- References

Instructions

Name of the PI: Paul I. Williams
Calibration center's name and location: WCCAP, Leipzig
Campaign name and period: Instrument Intercomparison Workshop: Mobility Particle Size Spectrometer and Condensation Particle Counter, 16-20 March 2020

Introduction and Motivation

CPCs are the cornerstone of most aerosol research and provide one of the most basic but important aerosol metrics: particle number concentration. Whilst CPCs are classed as total particle counters, they do have a finite size range (albeit it a very broad one) over which they count. In the atmosphere, the number concentration of particles is dominated by particles in the fine fraction, so understanding the lower limit of a CPC is important.

Manufactures of CPCs will specify a D_{50}, the diameter at which the particle counter will count 50% of the particles it samples. This is always the lower limit of the counter. It is also the most challenging to verify. In addition, the sharpness of the fall and rise of the efficiency curve either side of the D_{50} affects the counting efficiency of the CPC. The combination of steepness of the cut and the D_{50} are often referred to as the counting efficiency, or counting efficiency curve, of a CPC.

The motivation for this work is to compare the performance against the manufacturers specifications. This work is highly specialized and requires precision sizing and number counting and is not part of the routine service and maintenance offered by the original manufacturer.

Scientific Objectives

The two CPCs tested at the WCCAP facility were TSI 3776 Ultrafine Condensation Particle Counters (UCPC). These counters have a quoted D_{50} of 2.5nm, with a sharp cut. The scientific objectives were:

- Run basic diagnostic checks (e.g. flow rate check)
- Verify the D_{50} cut point
- Determine the slope of the efficiency curve

Reason for choosing WCCAP

As stated above, the calibration and testing of the CPC efficiency curve is highly specialised. The work requires the ability to produce accurate, precise and repeatable nanoparticles and to be able to count them using a traceable standard. WCCAP is a world leader in this field, pioneering many of the protocols used for particle sizing and counting.

Method and experimental set up

Each CPC was first inspected and all the flows and internal diagnostics were checked. The flow rates were verified using a high precision flow meter. To determine the efficiency curve, the CPC sampled size selected silver nanoparticles, generated in a tube furnace. The procedure is adapted from the early work of Scheibel & Porstendörfer (1983). The number concentration reported by the CPC was compared to an electrometer, a TSI model 3068. Plotting the ratio of the test CPC to electrometer number concentrations verse particle diameter yields the efficiency curve, from which the D_{50} can be determined. The curve and D_{50} can be compared with the manufacturer's specifications.

Data description

The data produced is a series of instrumental checks (e.g. reported pressure), flow rate check and performance of the size dependent efficiency testing, including the D_{50}.

Preliminary results and conclusions

Table 1 Temperature (T, C) and Pressure (P, kPa) as reported by the instruments and measured flow rate (l/min)

CPC S/N	T Sat	T Con	T Opt	T Cab	P Amb	P Or	P No	Laser	Flow
70626074	39.0	10	40.0	30.4	101.5	55.7	3.6	33	0.3
70820072	39.0	10	40.0	32.7	101.4	50.0	3.7	29	0.3

Table 1 above shows the temperatures and pressures as reported by each CPC, and the measured inlet flow rate. All parameters are within specification, there was no physical damage to either CPC and they both passed functional tests.

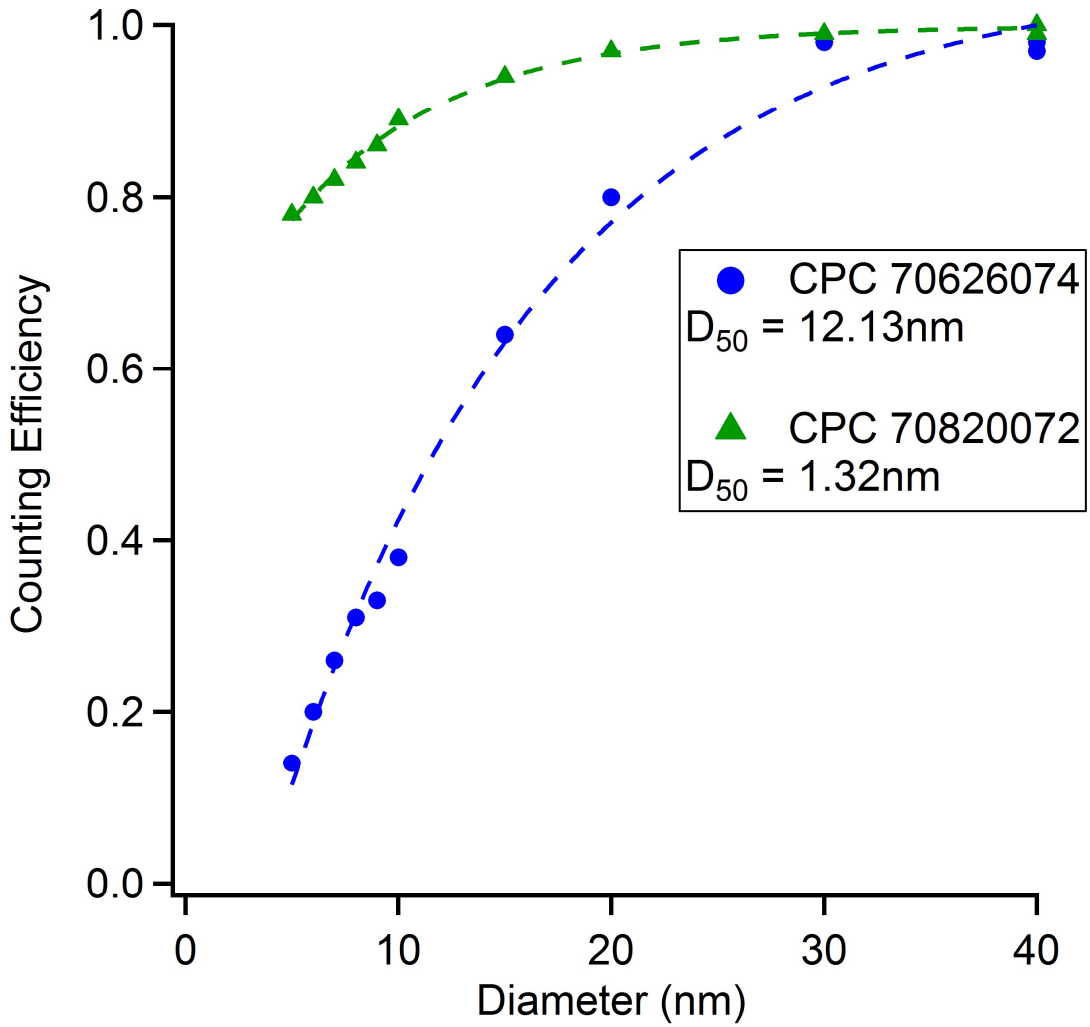

Figure 1 CPC counting efficiency curve, with calculated $D_{50,}$ against an aerosol electrometer; silver nanoparticles between 5 – 40 nm were used for calibration.

Figure 1 shows the efficiency curve for the 2 CPCs and the calculated D50. There are significant differences in the performance of the two CPCs. CPC s/n 70626074 did not reach 100% efficient until 40nm and the D50 was 12.13nm. This is well below the manufacturer's specifications. By contrast, CPC s/n 70820072, has a much steeper fall off and has a D50 of 1.32 nm, which is closer to the manufacturer's specification.

Outcome and future studies

CPC s/n 70626074 did not pass the ACTRIS or GAW standard tests and it is recommended that the CPC be returned to the manufacturer for service. CPC s/n 70820072 passed all tests.

References

Scheibel HG, & Porstendörfer J (1983). Generation of monodisperse Ag- and NaCl-aerosols with particle diameters between 2 and 300 nm. J Aerosol Sci 14:113–126. doi:10.1016/0021-8502(83)90035-6