

AVL List GmbH (Headquarters)



CPC calibrations

Effect of k-factor and calibration material
on 23 nm efficiency specifications

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k-factor post adjustment and why this is wrong

To establish the proper approach, one needs to consider the ideal performance, i.e. $k\text{-factor}=1$.

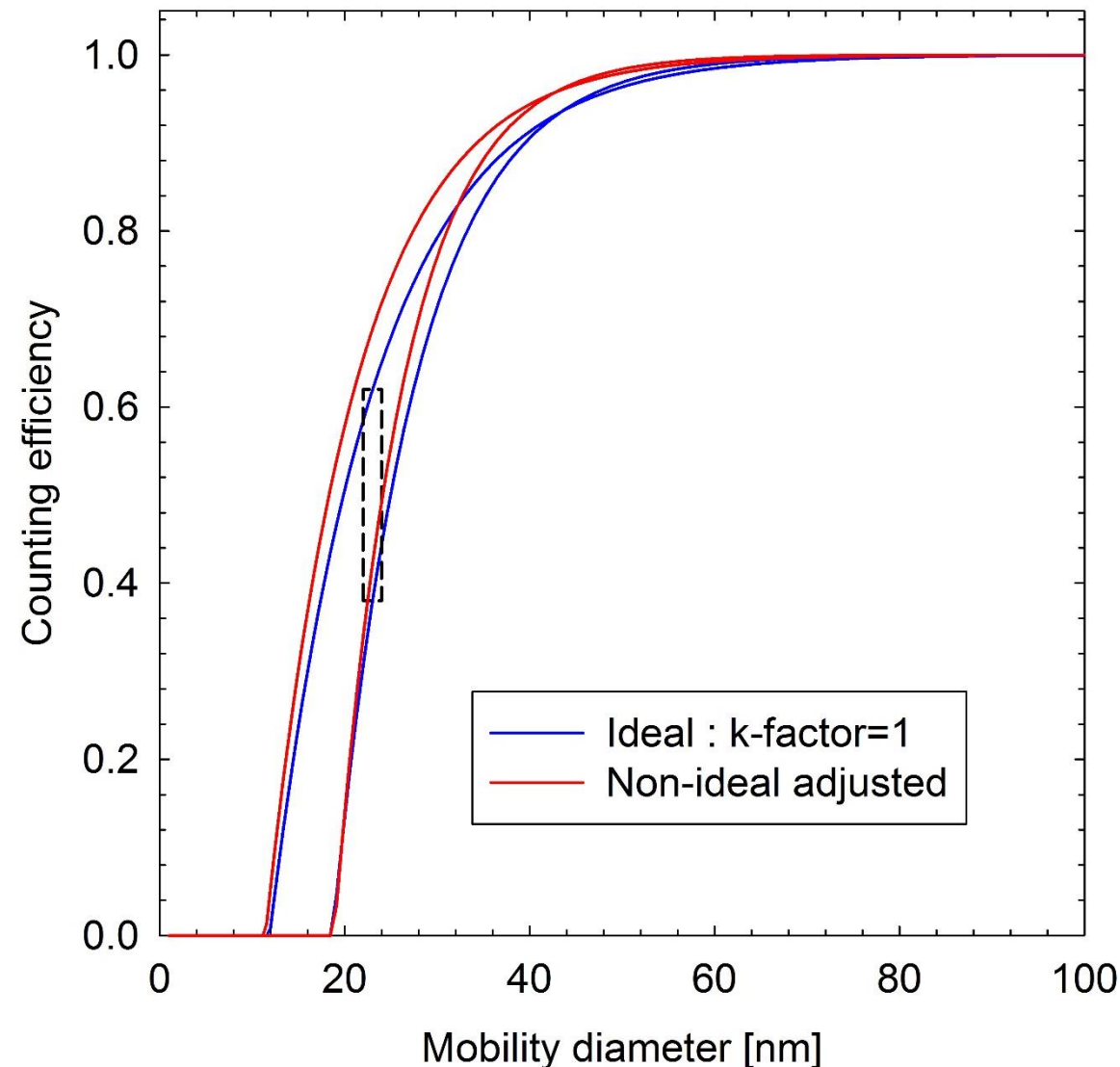
By adjusting the operating temperatures one can then set the efficiency at 23 nm within the allowed range of 0.38 and 0.62.

A non-ideal UNECE R83 compliant CPC will have a peak efficiency of as low as 0.9 ($k\text{-factor}=1.11$).

Assume that no adjustment for the slope is performed before setting the operating temperatures to achieve the 0.38 to 0.62 efficiencies at 23 nm.

And after adjustment for the $k\text{-factor}$, the efficiencies of the non-ideal CPC at 23 nm will range between 0.42 and 0.69

The actual effective range is 0.35 to 0.69 since $k\text{-factor}$ is allowed to be between $1/1.1=0.91$ and $1/0.9=1.11$.

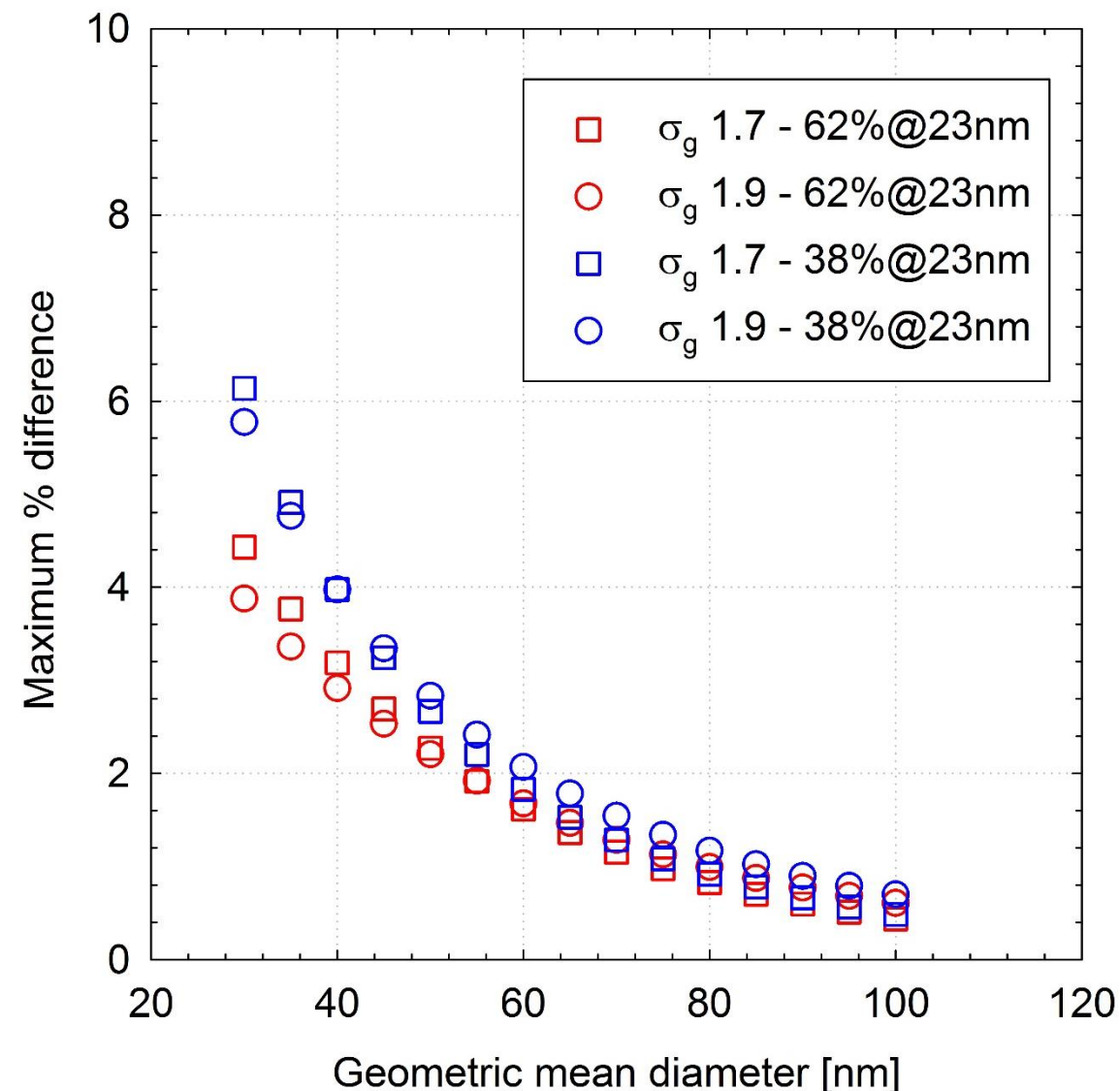


Effect of k-factor post adjustment on measurements

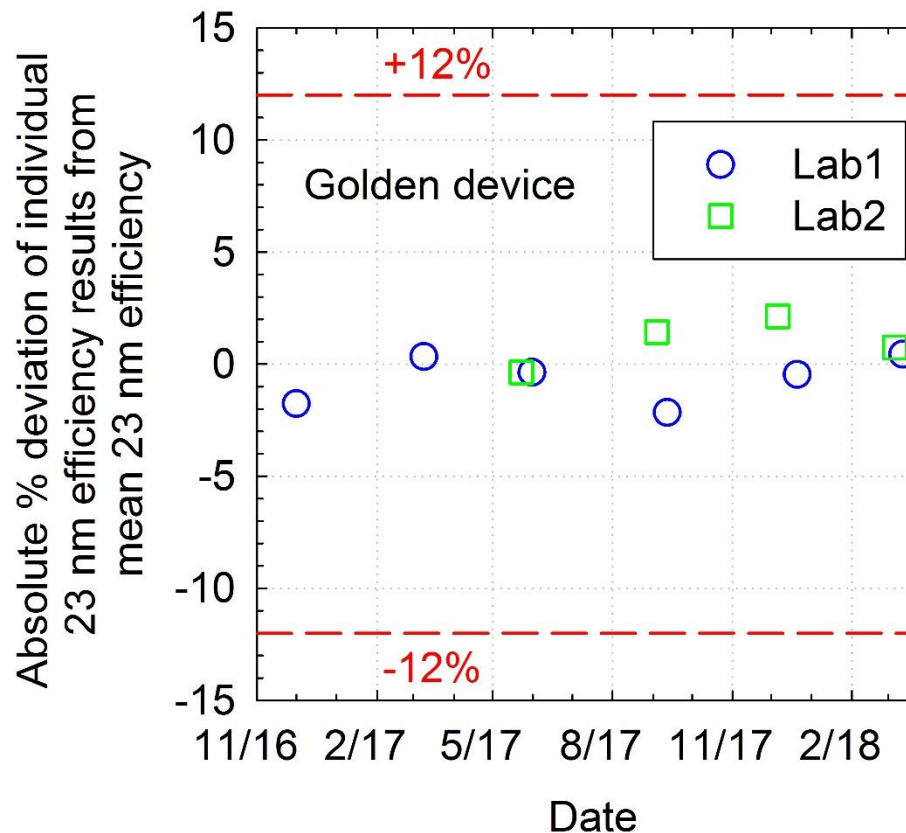
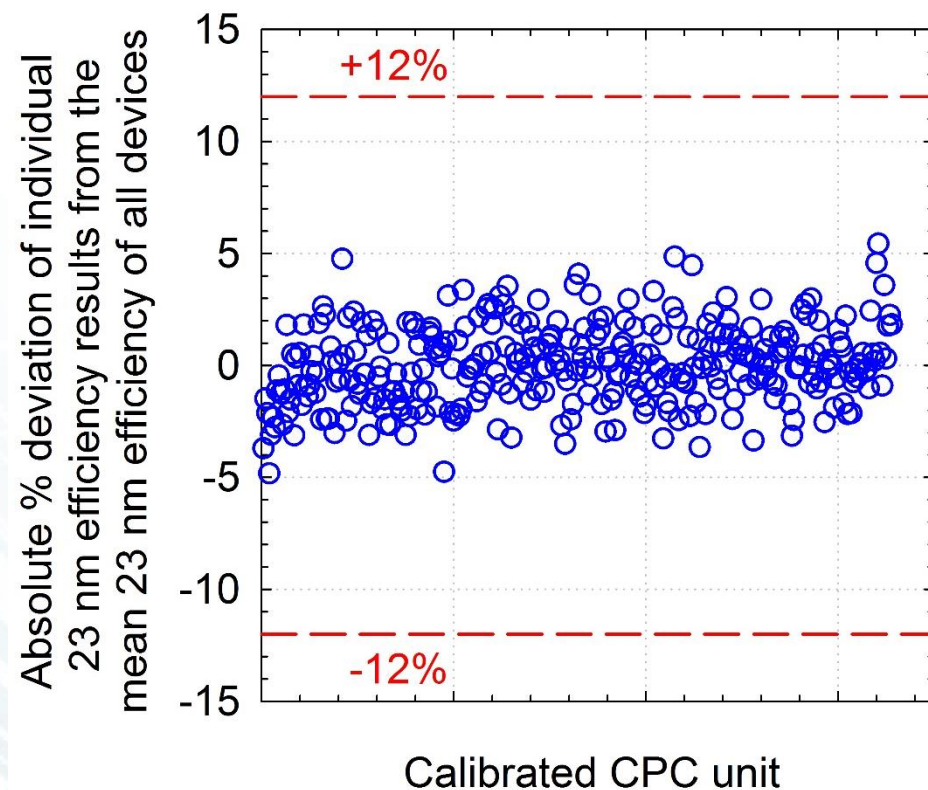
Assuming that the above two CPCs can be precisely calibrated to achieve a desired counting efficiency at 23 nm and 41 nm, and are sampling the same polydisperse aerosol, they will register different concentrations.

Simulations with lognormal distributions suggest that the effect is more pronounced as the mean size of the distribution is shifted to smaller sizes, reaching up to 4% at 40 nm (G-DI exhaust).

If 2 CPCs with k-factors of 0.91 and 1.11 are compared the effect will be even higher (up to 8% at 40 nm).

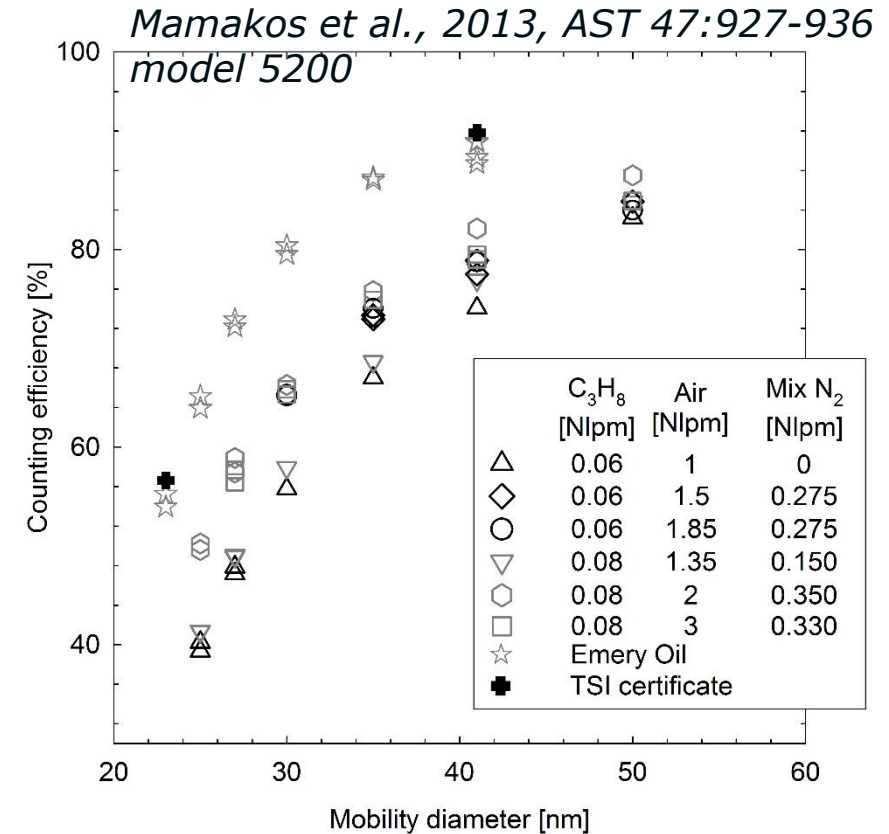
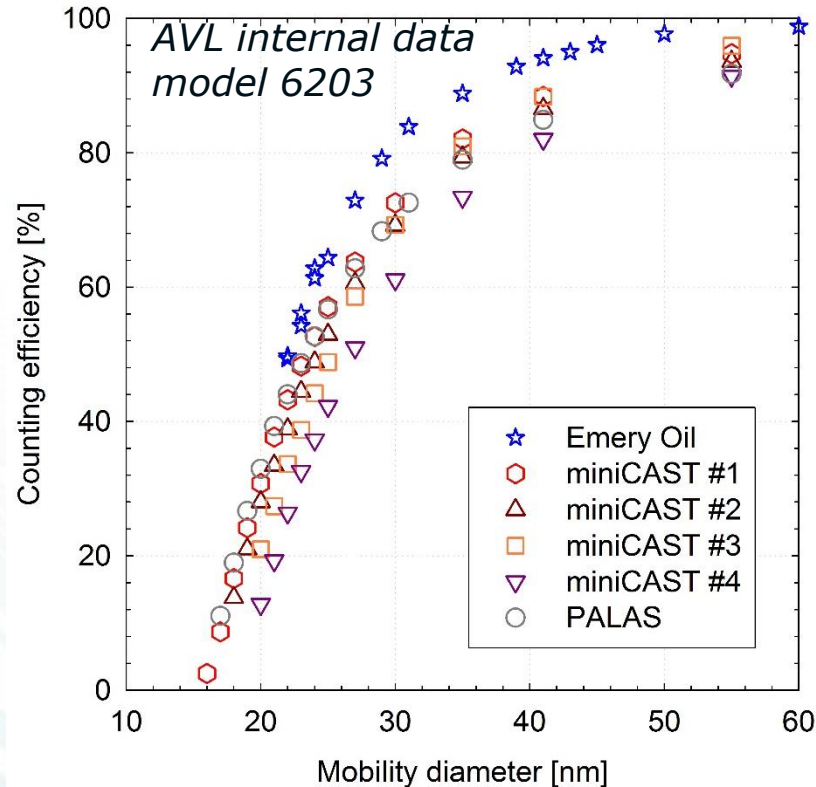


Efficiency requirements for 23 nm Capabilities at AVL's ISO 17025 certified labs



The $\pm 12\%$ requirement at 23 nm is rather wide for a ISO 17025 certified lab and **emery oil** calibration

Unequivocal calibrations with CAST?



The operating conditions of the **same** CAST (and perhaps also the burner design/model) is known to have a strong effect on the counting efficiencies of UNECE R83 CPCs:

- ~30-50% at 23 nm from AVL internal data using a 6203 CAST burner
- ~40-50% at 25 nm from a SwRI study using a 520x CAST burner

Conclusions

- We always need to keep in mind what is the focus of the CPC calibration activities: Refine the specifications and calibration procedures. But for what? Do we aim at reducing uncertainties in the field?
- The lack of a clear specification on how the k-factor should be applied, effectively leads to an unnecessary broadening of the 23 nm efficiency requirements to -15% +19%.
- Electrospray / emery oil calibration has become common practice for CPC suppliers, as it is proven to offer precise and repeatable/reproducible calibrations. The specific approach even offers the potential to further tighten the specifications at 23 nm.
- On the contrary, owing to the already established dependency of CPC efficiencies on the complex physicochemical properties of CAST particles, a shift to CAST is expected to necessitate relaxing the specifications at 23 nm and lead to less consistent results in the field.

Thank You



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