TSI Comments on PMP Draft Calibration Document

Thank you for sending me the CPC Calibration Procedure draft. We (Wei, Oliver and I) have reviewed it and have the following comments/recommendations to the procedure (section 4.2) for your consideration as follows.

Prepare both CPCs for use:

* Fill with working fluid to the specified level and avoid moving the CPCs thereafter
* Switch on and allow the saturator and condenser to reach their specified temperatures

TSI: --> Why in this order? Normally, one would switch on the CPC first and than fill it. For the 3010D CPC, you have to turn it on first and press the FILL button to fill butanol.

* Check the inlet flow rate with an appropriate calibrated flow meter

TSI: --> There are no recommendations about the type of flowmeter that is prescribed. We recommend using a "fast & low pressure drop" flowmeter to check the flow.

* Ensure that the particle residence time in the pipe work from the electrostatic classifier to both CPCs is identical. Take into account the inlet flow to each CPC and the internal diameter and length of the interconnecting pipe work. Take particular care if the inlet flows into each CPC are different. This will require either different path lengths with pipe work of the same internal diameter or the same path length with pipe work of different diameters.

TSI: --> This section does not address electrophoretic losses at all. We recommend adding a comment about "using conductive tubing being critical because it reduces the build-up of static charge and minimizes particle loss to the tubing wall." Furthermore, we also suggest the use of a flow splitter "to smooth flow transitions and provide equal flow distribution to the reference CPC and the CPC under calibration." In practice, we also often move the CPC position around to evaluate whether the flow split is correct so the results are not affected by the position of the CPCs.

* Generate the calibration aerosol and select a voltage on the electrostatic classifier corresponding to a particle diameter larger than the D90 of either CPC. Continue logging CPC data and ensure that neither CPC is reporting a concentration above its maximum concentration limit. If not, adjust the electrostatic classifier voltage until the reported concentration is below the maximum limit. Thereafter, gradually adjust the electrostatic classifier voltage to vary the concentration delivered to the CPCs

TSI: --> Adjusting the classifier voltage to change the aerosol concentration is not the best practice approach. Doing so will first of all, change the particle size and secondly, affect the aerosol concentration. Instead, we recommend the use of a dilution bridge to rapidly change the concentration in steps. In practice, we put a dilution bridge between the electrospray aerosol

generator and the DMA to adjust the concentration instead of adjusting the voltage of the DMA. Note: our electrostatic classifier can handle aerosol flow rate up to 2 L/min. If the total flow rate of the two CPCs is higher than 2 L/min, you will need to add makeup air into the flow after the DMA and before splitting into two CPCs.

On a side note, there is now a peer-reviewed SAE paper available on the subject of CPC calibration. Here is the reference.

Liu, W.; Osmondson, B.L.; Bischof, O.F.; Sem, G.J. Calibration of Condensation Particle Counters; Paper No. 2005-01-0189; Emissions Measurement and Testing 2005; Society of Automotive Engineers (SAE) Book No. SP-1941

Good luck with your meeting next week. I hope that our comments/recommendations are helpful. Let us know if you have any questions or can be of further assistance.

Best Regards,

Brian Osmondson
TSI