



Transmitted by OICA

**OICA Draft Technical comments on report on
Particle Number Counter (PNC) calibration Procedures**

General comments:

- I.) There has been a small update in the latest PNC calibration document, but no substantial progress. OICA concludes that the PMP roadmap timing is seriously compromised. Additionally, since there is no real PMP equipment available (only PMP-like systems) the calibration procedures will not be able to be checked and verified in the timeframe given – and so this step of the PMP roadmap will also not be fulfilled.
- II.) A calibration as described here is not a simple process and has to be carried out by highly trained people (e.g., academic laboratories). It is not clear how readily such a procedure can be implemented in a routine emissions measurement facility, and no data has been reported. It is stated that the Technical Services will be responsible for completing the calibration. OICA has a number of major concerns around this which are explained in more detail later.
- III.) A second issue is: Once calibrated, how well is the calibration maintained? Some CPC designs are more stable over time than others. In practice this can change quite quickly over time. Depending on use, the detector can become misaligned, or coated with butanol (e.g., if the instrument is tipped or not correctly filled). No data has been reported.
- IV.) A third issue is that the penetration of particles through the sampling system in the emissions application must match the sampling system used in calibration. In other words, the calibration procedure does not account for losses in the sampling system.
- V.) Finally, owing to the above comments on the different natures of various CPCs currently available, and their stability over time, it is unlikely that the proposed secondary calibration procedure will be robust. Furthermore, the CPC calibration factor is size dependent, and this size dependence varies from one type of CPC to another.
- VI.) OICA supports the development of a calibration procedure in ISO. However, OICA prefers that the procedure is developed with specific reference to automotive activity and is therefore handled under TC22 rather than TC24.
- VII.) OICA supports the error analysis step included in the PMP roadmap.

Specific Comments:

- 1.) "Primary Calibration Method":
No detailed description of the calibration method is provided. The paper is lacking: details on the generation of the aerosol, size selection with the electrostatic classifier, proof of no double charged particles, procedure to setup the electrometer, calibration of electrometer current. Connection to CPCs and electrometers should not only provide identical residence time. It is also needed to minimize particle losses especially by preventing electrostatic, or thermophoretic losses. The primary calibration method must be described in as much detail as the secondary method.
- 2.) The 50% counting efficiency of the CPC is only checked at 23 nm, but not the 90% efficiency at 41 nm. No material dependence of the CPC efficiency curves is addressed.

- 3.) There is no calibration below 1000 / cm³, except the zero check. For example software bugs, or unexpected non-linearity would not be discovered. This means that measurement of particle emission below 1000 / cm³ will be carried out with an un-calibrated setup. According to one manufacturer, typical measurement levels are expected at 30 particles/cm³ on most parts of the European driving cycle using a well set up sampling system. The noise at low concentrations may itself lead to higher particle numbers being reported. One potential source is electronic noise and could be different between different PNCs.
The fact that there is no calibration below 1000cm⁻³ is not in accordance with the specific requirement written in appendix 5 of the draft particulate measurement method amendment to ECE Regulation 83 : "The particle concentration measurement device shall have a linear response to particle concentration over 1 to 10000 particles/cm⁻³, have a counting accuracy of $\pm 10\%$ across the range 100cm⁻³ to 1000 cm⁻³ and $\pm 10\text{part cm}^{-3}$ below this concentration range against a traceable standard."
- 4.) The calibration is carried out with 'emery oil'. It needs to be proven that the response is identical for soot particles, especially in the D10, D50, D90 region of the CPC. Some PNC manufacturers use silver or other metallic particles for calibration. If the response is independent of material, this needs to be either proven or literature references provided. It is also not satisfactory to provide a recommended calibration material specification and then to permit any other material to be used.
- 5.) "Secondary Calibration Method"
This is a 'Transfer Standard Method' and is in fact a tertiary calibration. There are risks that the 'calibrated' CPC will not perform as 'Transfer Standard' as expected, due to contamination, liquid spill, improper handling or damage, improper connection, and others. The paper and the literature are lacking any information if this is feasible.
- 6.) The comparison is carried out with 'emery oil'. It needs to be proven that the response is identical for soot particles, especially in the D10, D50, D90 region of the CPC.
The other points in comment (4) also apply.
- 7.) The electrostatic classifier shall be set to a particle diameter larger than D90 (41nm). The size performance of the electrostatic classifier is not calibrated. It must be calibrated if it is to be used. OICA recommends a size corresponding to D100 (see manufacturers specification) or at least 65nm.
- 8.) The particle concentration shall be varied by adjusting the electrostatic classifier voltage. This will also vary the particle size, i.e the CPC comparison will occur at non-constant particle size. Since, the size of the particles used will be different for each point of the calibration curve, it could occur that the selected particle size moves along the CPC fall-off curve, since it is only specified that the initial particle diameter should be larger than D90 of the CPC.
- 9.) If the aerosol source has a significant number of larger multiple charged particles, and the CPC's have different efficiency fall-off curves at larger diameters, this could create an error. The upper size range of the calibration aerosol needs to be defined.
- 10.) For proper operation the slope of the calibration should be unity +/- the uncertainty created by basic parameters, like volume flow rates. If the slope is outside this range, one CPC, or both CPC's are malfunctioning, where it is not possible to tell which one. Both CPCs will have to undergo primary calibration as there is no way to prove which one is giving false readings. However, the malfunctioning CPC could be the 'Transfer standard' itself, which makes this procedure questionable. The use of a calibration factor without further knowledge why the issue was created is not acceptable.
- 11.) It is necessary to have data concerning stability of different CPCs between two primary calibration operations.

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