Referee Report on ar-2023-16

Title: Influence of soot aerosol properties on the counting efficiency of PN-PTI instruments

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General Comments

The paper describes a follow-up study of Vasilatou et al. 2023, focusing on the influence of various polydisperse soot aerosols for the in-field calibration of DC based PN counters for PTI of Diesel vehicles. It reveals that the aerosol properties affect the CE of the instruments under test. In the actual study, the authors focused on combustion generated soot particles. In the previous study, the influence on the CE was enormous when using various types of test aerosols (salt, soot-like). In this study, when using combustion generated soot particles only, the influence on the CE is still significant, but could not fully be explained by the particle morphology, that was claimed the main influence quantity besides the particle size. Based on the findings, the authors recommend the usage of one of the used soot generators for type approval and annual calibration.

Strengths of the paper

- This work revealed the importance of test aerosol properties, like the particle material, which was not addressed in the various device specifications for PN PTI measurement.
- The experimental methods were well-founded (except the choice of the reference instrument), and the properties of the test aerosols were well characterized.

Weaknesses of the paper

- The main flaw of the paper is, that it does not deliver an explanation of the influence mechanisms on the CE of the various instruments. There is absolutely no common trend towards the various instruments, therefore, it is not possible to draw general conclusions about DC based instruments or the usage of generators. The aerosol properties were investigated regarding the particle morphology quite detailed. At the beginning of Section 3.1 it is stated, that DC based instruments are generally affected by the particle morphology because the average number of charges within the diffusion charging process will vary with the particle shape. However, there is no deeper explanation on how the instruments' CE is affected by morphology. Other studies or explanation by the manufacturers should be considered for the paper!
- The second point is, that the choice of the reference instrument is questionable, because it is just one PTI instrument and the bias of -23% against the METAS reference could be problematic for practical applications. There are at least two questions that need to be answered.
    1. Was the reference instrument tested against other METAS references up to the required concentrations of 5E6 cm^{-3} using polydisperse particles?? (The ISO27891 does not include a linearity measurement with polydisperse aerosols!)
    2. An explanation why the CE is up to -23% against the METAS reference must be given! Was there a traceable calibration by the manufacturer before? Why is

there such a large difference? Was the instrument used before calibration and did it drift to such an extend??

If this instrument would be used as a reference in the field, a bias of -23% could be problematic since the maximum permissible error in some regulations (like the NPTI proposal) is 25% only!!! The *"COMMISSION RECOMMENDATION of 20.3.2023 on particle number measurement for the periodic technical inspection of vehicles equipped with compression ignition engines*" also states the requirement that the reference systems' MU shall be less than 20% for subsequent verification!

- There was no added value from the profound investigation of the test aerosol properties. None of the parameters listed in table 1 delivered an explanation of the CE behavior of the instruments under test.
- Is the test aerosol from one EURO5 vehicle representative for "Diesel soot" in general?

Specific comments

- Line 93: reference instrument
    1. Was this instrument tested against other METAS references up to the required concentrations of 5E6 cm^{-3}?? (The ISO27891 does not include a linearity measurement with polydisperse aerosol)
    2. Please explain why CE is -23% against the METAS reference! Was there a traceable calibration by the manufacturer before? Why is there such a large difference? Was the instrument used before calibration and did it drift to such an extend??

  If this instrument would be used as a reference in the field, a bias of -23% could be problematic, since the maximum permissible error in some regulations (like the NPTI proposal) is 25% only!!! The " COMMISSION RECOMMENDATION of 20.3.2023 on particle number measurement for the periodic technical inspection of vehicles equipped with compression ignition engines" also states the requirement that the reference systems MU shall be less than 20% for subsequent verification!
- Line 123: aerosol properties
  The investigation of the aerosol properties was interesting and detailed but limited to the morphology of the particles. This is fine under the assumption that the particle morphology is the main parameter that affects the CE of DC based instruments. Are you sure that there is no other parameter, that affects the found behavior in the same order of magnitude?
- Line 189/190 & Line 195/196
  It would be interesting to have an explanation how the CE varies with different GMDs and particle materials. To my impression, this very much depends on the measuring principle of each individual device, and thus, it would be good to explain the differences by the various measuring principles!
- Line 202/203
  This conclusion is questionable! An explanation of the scattering of the values must be delivered, rather than conducting the test at more comfortable test conditions!!
- Figure 5b)
  The comparison with Vasilatou et al., 2023 shows, that there might be other influence quantities than the particle morphology only. The importance of pre-existing charges is obvious in figure 5b) and might be even more important if there are internal correction

factors used, as in the case of CAP3070! I recommend to read Knoll et al., 2021 regarding influence of pre-charges on DC based instruments.

- Line 297/298
  The link to this reference does not work!
- Line 204 / Figures S6 – S9 in supplement
  There were some significant fluctuations of the CE signal using the differnet aerosol generators:
  1. The DX280 and the Knestel had big fluctualtions with the MiniCast 5201 under fuel rich conditions
  2. The fluctualtions of all instruments, except the HEPaC and the CAP3070 were very large with the MiniCAST 6204
  3. The AEM had fluctuations of about 50% CE using the MISG without cyclone

  --> Please explain why those signals were so unstable!!!

  --> What was the reason (pressure fluctuations, flow rate, heating, signal processing of instruments, etc.) and why is there no clear trend towards the instruments and the generators used?

  --> Can you exclude instabilities of the reference instrument?

Further literature to be considered

- Bainschab et al., 2020 (https://doi.org/10.1016/j.aeaoa.2020.100095)
  Calculation of false pass / false fail scenarios and general impact of PN PTI on fleet emissions.
- Krasa et al., 2023
  https://tandf.figshare.com/articles/journal_contribution/Toward_a_simplified_calibration_method_for_23_nm_automotive_particle_counters_using_atomized_inorganic_salt_particles/22121581
  For the sake of completeness in the introduction, the study of Krasa et al., 2021 should be mentioned. It shows a significant impact of the test aserosol also for CPCs.
- Knoll et al., 2021 (https://doi.org/10.1080/02786826.2021.1873910)
  Influence of pre-charges on DC based instruments.