Response to Review

We would like to thank Reviewer 2 for the constructive feedback. Please find below the point-to-point response to the questions raised.

- The paper examines the properties of soot that influence the counting efficiency of instruments for periodic technical inspection. The instruments used in the study are all based on diffusion charging. Since diffusion charging by itself is particle size dependent, different operating strategies are used to limit the influence of particle size. Therefore, the operating principles of the instruments differ significantly. A comprehensive description of the measurement principles used and explanations for the different responses to soot based on the measurement principle would be a very valuable contribution.

Answer: This is a good point but, unfortunately, most manufacturers have not officially revealed any information on the exact operating principle of their DC-sensor. The only relevant publications we could find were by Dr. Martin Fierz on the Partector. We are very grateful to all manufacturers who lent us instruments for this study, especially for giving us their consent to publish the results naming explicitly the devices (many studies in the past have only published anonymised results), and we would like to encourage them to share more information on the design of their DC sensors with the aerosol community.

- As the size dependence is crucial, it would have been very interesting to see larger sizes (e.g. up to 200 nm) as some legislation requires CEs up to 200 nm.

Answer: We chose to focus on particles with a GMD_{mob} of up to about 100 nm because these particles are more representative of soot emitted from diesel vehicles (typical GMD mob between 50 and 90 nm). We estimate that soot particles with a mobility diameter of 200 nm would correspond to less than 10 % of the total number of particles emitted by the diesel vehicles, thus their influence on the counting efficiency of the PN-PTI instrument would be small. For this reason, some countries, e.g. the Netherlands and Belgium do not pose any requirements on the counting efficiency of PN-PTI instruments at a mobility diameter of 200 nm (technical specifications are only defined for particles with a mobility diameter of ≤80 nm).

We have added the following clarification in Section 1 "Introduction":

"PN-PTI instruments go through a type-examination procedure which may differ in each country. Among several tests, type-examination includes a counting efficiency and a linearity check typically performed with combustion aerosols. During their lifetime, PN-PTI instruments are checked for their linearity with polydisperse particles (typically with a GMD_{mob} of 70 ± 20 nm).

…

The geometric mean diameter of the test aerosol was in the range used for linearity checks of PN-PTI instruments as well as in typical size range emitted by diesel engines. The scope of our study was to investigate possible differences that may arise when using different combustion aerosol generators during the type-examination and verification of PN-PTI instruments as well as to correlate with diesel engine emitted soot. We focused on DC-based instruments because we expect a larger impact of the aerosol properties on their response compared to CPC-based ones (Vasilatou et al., 2023)."

- It is well known that (diffusion) charge-based sensor principles are sensitive to particle morphology. A discussion of this influence as well as a morphological characterisation (e.g. fractal dimension) of the soot produced by the different generators is missing.

Answer: Thank you for this comment. We have now calculated the fractal dimension and amended Table 1 (see last column).

We have also amended the text as follows: "The fractal dimension D_f of soot particles with a nominal GMD_{mob} of 100 nm was derived via image analysis of high-quality TEM-images using the FracLac feature of ImageJ 1.53e (ImageJ, National institutes of Health, USA). In a first step, the greyscale TEM-images were converted into binary images utilizing the auto-convert function of FracLac. In a second step, the D_f values were determined via the so-called box counting, averaging 12 rotations of each image. The D_f values summarised in Table 1 represent the average values obtained from at least 10 particles for each type of soot. These values agree well with those reported in previous studies for bare (i.e. freshly emitted) soot particles (Pang et al., 2022; Wang et al., 2017)".

- The rationale for the selection of particle properties (EC/TC mass fraction, effective density, primary particle size) to assess the counting characteristics of the PN-PTI instruments is unclear and should be explained.

Answer: We have amended the text in Subsection 3.1 as follows: "To characterise the aerosols, the following aerosol properties were determined: particle size distribution, EC/TC ratio, primary particle size and fractal dimension. Particle size and morphology have been shown to have an effect on the counting efficiency of PN-PTI instruments (see (Vasilatou et al., 2023) and references therein). EC/TC ratio can also have an effect on the morphology of the soot particles. Soot particles formed in premixed flames (i.e. high EC/TC) exhibit a loose agglomerate structure where the primary particles are clearly distinguishable from one another, while soot generated in fuel-rich flames (high OC/TC) has a more compact structure and the primary particles tend to merge with each other (see Fig. 3 in Ess at al. https://doi.org/10.1080/02786826.2021.1901847)."

- Chapter 4 makes recommendations based on the results of the study. What specific results led to the recommendations? Why is soot the best calibration aerosol? It seems that BigCAST Aerosol gives different CE results (e.g. 1.4 in Fig. 5a and 1.0 in Fig. 5b for CAP3070).

Answer: In our opinion, combustion-based soot is the most suitable calibration aerosol because it reproduces well the morphology and size of soot from diesel engines. As shown in our previous study, particles from spark discharge generators and salt nebulisers produce particles that are too fractal or have a cubic shape, respectively, and thus lead to deviations up to a factor of 2 in the CE efficiency of PN-PTI instruments with respect to soot from a Euro 3 diesel engine (see, for instance, Figure 5 in Vasilatou et al. https://doi.org/10.1016/j.jaerosci.2023.106182). The deviations in CE when using combustion-based aerosol with respect to a Euro 5b engine are much smaller (see Figure 4a of present study).

- Minor: Why is a rather complicated aerosol aftertreatment (CS, dehumidifier, 1:10 diluter, blower, dilution bridge, …) after the soot generators used? Why is it different for the EU5b exhaust?

Answer: The aerosol aftertreatment between lab experiments (Fig. 5a) and field measurements (Fig. 5b) is quite similar in our opinion. In both cases there is a catalytic stripper, a dilution unit and a custom-made dilution bridge.