

PMP – Particle Measurement Program Informal Working Group

Task Force 2– Brake Dust Sampling and Measurement

Meeting #44 – Wednesday 18 MAY 2022 15:00 – 17:00 CEST

Minutes of Meeting – Final Version

1. Participants: As in the file “*44th TF2 Meeting Attendance*” uploaded in TEAMS.

2. Introduction: Theo Grigoratos (TG) welcomed the TF2 members and summarized the status of the various documents. A clean version of Clause 6 became available last week. A clean version of Clause 7 will become available by the end of Week 20. Comments on Clause 9 have been received – the deadline has been set for 20.05 – a clean version will become available by the end of Week 21. High-level comments on Clause 11 have also been received – TG will circulate the proposal within Week 21. TG also informed the group that the TF2 workshop will be held on May 30. Today’s discussion was dedicated to the PN measurement and all relevant topics.

3. Clause 10 presentations: TG provided a presentation related to the PN measurement protocol. The details of the proposal and the data-supported evidence are summarized in the attached presentation “GTR - Clause 10”. The proposal is available in the submitted document “PMP Brake Protocol - Clause 10 Clean”. Three different sub-clauses have been introduced in the newly formulated Clause 10; however, this might be further amended.

Introduction – Discusses the target parameters (Total-PN and Solid-PN) and provides a general description of the proposed setup;

Clause 10.1 – Describes the general elements related to particle extraction. It also defines the sampling plane and the proposed specifications for the probes and the nozzles;

Clause 10.2 – Discusses particle treatment and conditioning. Specifications about the pre-classifier and the particle conditioning are provided. Additionally, provisions regarding the particle transfer line to the measurement equipment are described;

Clause 10.3 – Describes the general specifications for the particle measurements including specifications for the Particle Number Counter and the volumetric flow. Finally, the PN EF calculation is described.

The main results from the ILS campaign were discussed. TG first discussed the importance of the background and analyzed the reasons for excluding three labs from the further analysis related to PN emissions. Then, the overall ILS results for all brakes and all labs were presented. The total-PN (TPN) repeatability within the labs and reproducibility between the labs was discussed in detail (Slides 8-9). The overall conclusion is that despite the lack of strict specifications for the PN measurement defined by the TF2 and the lack of experience of many labs in measuring TPN, laboratories seem to have managed to measure these emissions in an acceptably reproducible manner when volatile particles are not present. Then, TG discussed the observed PN concentrations in the tunnel and those measured in the CPCs – it seems that a dilution stage between 1:10 and 1:100 is necessary to ensure that the certified range of the employed CPCs is respected. Isokinetic and isoaxial sampling was briefly discussed – TG proposed to introduce a less strict isokinetic ratio for PN measurements compared to PM to minimize particle losses. Finally, the formation of volatile particles was discussed – despite that TPN measurements seem repeatable and reproducible; there are cases where the presence of volatiles is reported, and thus significantly reduced reproducibility is observed. In a

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conclusion, SPN measurement is necessary to serve as reference PN measurement for lab to lab comparisons, whereas TPN measurement remains significant to identify high emitting brakes.

TG presented an indicative PN sampling setup for illustration purposes and briefly described all the individual parts of the setup. A presentation of the specifications for the PN measurement followed. The detailed specifications are available for comments and feedback in the attached proposal. The most important highlights are: Two probes shall be used for sampling TPN and SPN – alternatively one probe can be applied provided that the flow-splitting device does not compromise the particle penetration efficiency. The proposed value for the isokinetic ratio has been set to between 0.6-1.5. TG requested the group's feedback on whether these values would be sufficient or a stricter range shall be mandated. A single cyclonic separator shall be used as a pre-classifier to protect the instrumentation and avoid the possibility of contaminating the system. A dilution system (TPN) and a VPR (SPN) shall be applied – these shall follow specifications similar to those prescribed in the GTR15. Additionally, The Particle Number Counter (PNC) requirements are overall similar to those of the exhaust regulations.

An extensive discussion on the need for applying isokinetic sampling took place. Bob Anderson (BA) mentioned that it shall not be important for PN measurement; however, a relaxed ratio range could be proposed. Michael Arndt (MA) agreed and added that the flow specifications can be relaxed compared to the PM measurement – in any case, there should be a ratio range to follow otherwise the risk of losing particles is real. Stefan Carli (SC) added that since the size distribution of brake particles indicates they are rather big (0.8-1.0 μm), then it makes sense to introduce an isokinetic range but always keep in mind not to make it much more complicated. A discussion on the CPC's flow followed a comment by Heinz Bacher (HB) that the instrument flow shall not be changed. BA added that the flow shall be constant already from the probe – whatever changes in the isokinetic ratio shall be regulated by the use of the right nozzles. SC added that if the primary PN metric for the GTR is SPN, then an isokinetic ratio range shall be defined.

A discussion on the volatile formation and the need for measuring both TPN and SPN followed. HB noted that there are not a significant number of brakes with volatiles; therefore testing for volatiles seems an overkill – TG replied that we tested high-quality brakes but we don't know what is the case with other brakes in the market so we should keep this test to make sure that bad quality high emitting brakes are penalized. HB asked about the risk of a certain region simply using the GTR and applying a limit on TPN – TG replied that along with the GTR there will be a technical report explaining all the details and the decisions. It is clear that we don't have enough data to regulate TPN; therefore, it will be strongly discouraged until we collect data and make sure that the method provides robust results. HB also mentioned that according to **ISO XXXXX** a certified calibration procedure shall be in place which is not the case for TPN – TG replied that we will rely on the calibration procedure for the SPN which seems to have worked at the ILS. Barouch Giechaskiel (BG) added that emery oil would work fine for the purpose of the TPN measurement (BA confirmed).

Alejandro Hortet (AH) asked whether the GTR will provide specifications for the measurement of other parameters (e.g. size distribution) – TG replied that it is out of the scope; however, the proposed setup allows for introducing other measurements provided that the target parameters are not compromised. MA added that the exhaust regulations allow for sampling from different parts of the tunnel – TG replied that this would be challenging for brake setups and anyway forbidden anywhere between the enclosure and the PM/PN sampling plane. SC pointed out that the calculation

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of the average PCRF might not be representative of actual brake emissions that peak at a much larger size. BG replied that the penetration of systems usually reaches the plateau at 100 nm and depending on the design of the system will drop at sizes >1 µm. So on average, the expected overestimation will probably be very small. Additionally, we are expecting to be underestimating at bigger particle sizes and this will partially cancel out the effect described above. Christophe Jouy (CJ) asked whether the use of flow splitters can be extended to include also other instruments – TG replied positively adding that the labs shall demonstrate that the efficiency is not compromised.

4. Next Meeting: The next meeting (workshop) will take place on Monday 30.05.2022 from 12.00-16.00. The topic will be open issues.