PARTICLE MEASUREMENT PROGRAMME

PMP-IWG

TASK FORCE 2 – BRAKE EMISSIONS

TF2 PROTOCOL – OPEN ITEMS

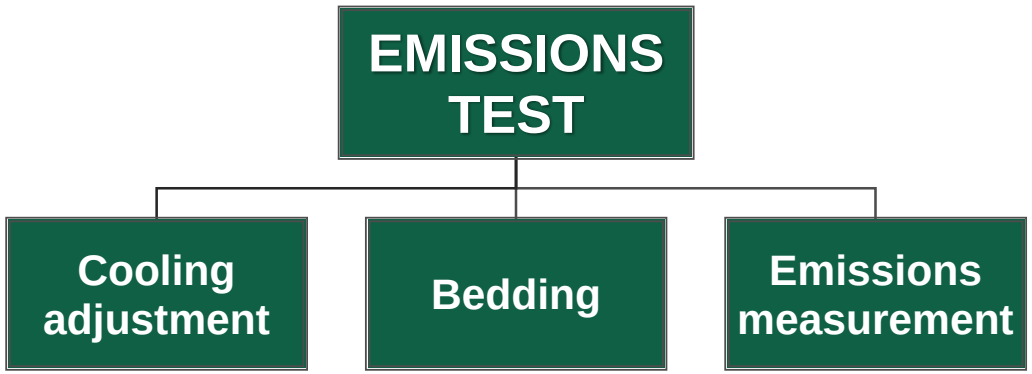
Joint
Research
Centre

CLAUSE 1

TOPIC: ***There is no clear definition of the "overall" brake emissions test that includes all three steps i.e. cooling air adjustment, bedding procedure, and emissions measurement***

Comment: As a result, there are some parts of the text referring only to the last part (i.e. emissions measurement) without having specified the difference or provided a suitable definition.

JRC's suggestion: Provide a suitable definition and clearly define already at the beginning of the document that a ***brake emissions TEST (or brake emissions sequence or other definition?) includes cooling air adjustment, bedding procedure, and emissions measurement***. Clearly define that brake emissions MEASUREMENT refers to only the last part of the overall test (or sequence) to avoid misunderstandings. Other suggestions for the terminology?



CLAUSE 1

TOPIC: Excerpt from sub-clause 1.2.3 (a) ***"Commence Trip #1 of the WLTP-Brake Cycle at a brake disc temperature of 20±5°C, without conducting any warm-up stops or snubs"***

Comment: ***"We would recommend 23+/-2°C as this temperature is defined for WLTP exhaust and would correspond to vehicle tests on a chassis dyno. It would also fit the temperatures defined in GTR15 and related legislation"***

JRC's reply: (a): The suggestion is to set the targets for the initial temperature aligned with the climatic settings of the cooling air temperature (20°C and 50% RH).

(b) We have been using this set of temperature and relative humidity since the beginning of the development phase and we have based all analysis on the cooling method on these values.

(c) In general, we agree in aligning the regulations as much as possible. However, we see no added value in making such a change at this point particularly when we don't have a dataset that would make us comfortable in making this change.

(d) Vehicle testing on a chassis dyno is a completely different approach not foreseen to be applied for brake testing for any reason in the future. Therefore, temperature alignment for that reason is not a strong argument to make the change.

(e) In any case, the current proposal (20±5°C) allows the testing facility to set up its system to function within the recommended thresholds (23+/-2°C ➔ min 21°C and max 25°C) if for any reason there should be a need to compare with vehicle parameters.

JRC's suggestion: <u>Keep the temperature and humidity conditioning as is since we have based the development phase on these values.</u>

CLAUSE 1

TOPIC: ***WLTP-Brake Cycle quality checks –*** We have already agreed in defining three quality check criteria. There is a proposal for introducing another one.

Comment: **As distance is directly connected to the final emission factor, it seems to be appropriate to check for the actual "driving distance" in the test.**

JRC's suggestion: JRC does not have a strong opinion in favour or against adding such a quality criterion. A quick look at the ILS data showed that all labs that submitted correct Time-based files were well within 1% (0.1-0.2%) of the nominal distance (192.2 km). ***Would we like to add this and if yes what would be the recommended tolerance for successful execution of the cycle?***

CLAUSE 2

TOPIC: ***Subclause 2.3 – Cooling adjustment quality checks*** – There is an overlap of the first two quality check criteria (linear speed violations and kinetic energy dissipation) between Clause 1 and 2.

JRC's suggestion: Mandate the quality checks already in Clause 1 also for the cooling adjustment method and not include them again here. ***Both criteria fit better the purpose of Clause 1 as they examine the correct execution of the cycle.***

ADDITIONALLY: There is a third quality criterion that refers to the average cooling airflow. This mandates that the average cooling airflow during bedding and emissions measurement is within ±5% of the value defined during the cooling adjustment procedure. However, a similar provision has been foreseen in Clause 3 – maybe there is a need to slightly amend the text to accurately specify the described requirement.

JRC's suggestion: ***Delete the quality criteria from this clause. They better fit in clauses 1 and 3 as described above.***

CLAUSE 2

TOPIC: ***"Cooling adjustment method" – Applicability to other types of discs.***

Comment: ***Do the proposed temperatures apply to Ceramic disks / lightweight discs? From our testing experience, the NWL/DM categories are fine for all the GCI discs (coated discs included) but we think that a correction should be applied for carbo-ceramic discs. We propose to add a parameter to correct the NWL/DM which is the ratio between the density of the Cast iron and the one of the carbo-ceramic***

JRC's reply: (a) The target temperatures apply to all types of discs. These temperatures were derived with 85%-90% of the data being from grey cast iron discs and 10-15% from other types of discs.

(b) We understand there might be issues with other types of discs, including carbon-ceramic discs due to few data points. In the current situation, we don't have the data to apply any kind of correction in the method and be safe that it will work.

(c) We believe that after i.e. 1 year of testing and collecting data we could introduce an amendment to cover different types of discs in case we see the need.

(d) In any case, this first year would not require any official regulatory testing; therefore, there will be no real consequences if these discs do not meet 100% of the requirements. The important thing will be to collect data and introduce the appropriate corrections.

JRC's suggestion: <u>Keep the proposal as is – do not create a sub-category without sufficient data – properly define lightweight discs in the period to come – test these discs with the new GTR – come up with a proposal for corrections (if necessary) on time ahead of any regulation on brake emissions</u>

CLAUSE 3

TOPIC: ***Use of cooling air flow/speed throughout the text*** – it may be misleading keeping both terms flow and speed in the text.

Comment: We received several comments that since the parameter of interest is volumetric flow it would make sense to keep only cooling air flow in the text? Do we want to mandate only flow measurement? If this would be acceptable to the group it would significantly simplify the text.

3.1 Cooling air flow/speed measurement

Cooling air flow/speed shall be measured throughout the entire brake testing procedure, including cooling air adjustment, bedding procedure, and emissions test. The cooling air flow/speed shall be measured downstream of the enclosure and the sampling plane. The measurement of air flow or speed (air flow/speed) shall meet the following requirements:

(a) The method of measuring cooling air flow/speed shall be such that measurement is accurate to ±2% under all operating conditions;

(b) For a single-point measurement, locate the flow/speed measurement element at the centre of the duct, at least five diameters downstream and two diameters upstream of any flow disturbance;

(c) For a multi-point measurement, install the flow/speed measurement element perpendicular to the flow direction, at least five diameters downstream and two diameters upstream of any flow disturbance;

(d) Use a flow/speed measurement device calibrated to report air flow/speed at both operating and standard conditions (273.15 K and 101.325 kPa). The temperature sensor shall have an accuracy of ±1°C. The pressure measurements shall have precision and accuracy of ±0.4 kPa;

JRC's suggestion: JRC does not have a strong opinion in favour or against removing speed measurement. ***If there is an agreement at the TF2 for removing it we could delete the option. If no agreement can be reached we suggest leaving this as-is for the public consultation***.

CLAUSE 3

TOPIC: Excerpt from sub-clause 3.2.2 ***"Cooling air RH shall be constant throughout the entire brake testing procedure, including cooling air adjustment, bedding procedure, and emissions test as follows***"

Comment: ***"It is almost impossible to design your control system to exactly stay within the borders of relative humidity during every second, especially, if the temperature is changing after the actual humidification has been done. That is why the controlling or air-conditioning system is done based on absolute humidity. We recommend applying the same for brake emissions"***

JRC's reply: A direct correlation between emissions and relative humidity has not been demonstrated. However, RH has been used as the metric for humidity since the beginning of the development phase. JRC doesn't feel comfortable changing it literally at the last minute: 1. Due to lack of measured values and study of the behavior with the absolute humidity, 2. Due to a relatively small proportion of tests that did not fulfil the specification (9 out of 155 standard tests with 7 out of 9 violations coming from one single lab that did not control temperature and humidity).

JRC's suggestion: Keep the requirement for relative humidity as is – we already significantly relaxed the provision for the instantaneous relative humidity due to the non-apparent relationship with emissions – if we collect enough data in the next months and come up with robust values to define acceptable and reasonable thresholds an amendment can be introduced to change this parameter

CLAUSE 3

TOPIC: ***Background level*** – Excerpt from sub-clause 3.3.3 "***The average background concentration in the tunnel shall not exceed the maximum limit of 10 #/cm^3 for both PN$_{Back-Total}$ and PN$_{Back-Solid}$***"

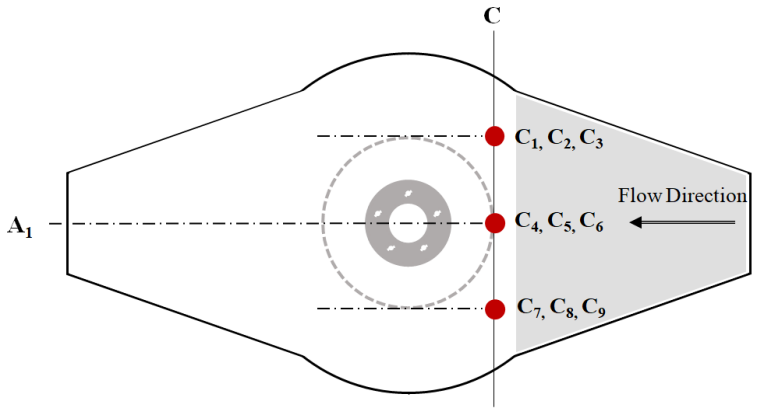
Comment: ***"We understand that the configuration of the measurement system is different from exhaust emission measurement system. Some systems consist of 2 stage diluter (Total DF: 100). Therefore, if the limitation is needed, we would like to propose <50 #/cm3. We think this is an appropriate limit by comparing it to the exhaust emission system even if the tunnel background is included."***

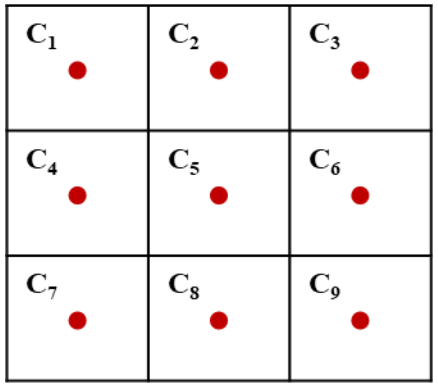
JRC's reply: Besides this comment there is consensus in TF2 with the proposed background limit. We have demonstrated that higher PN backgrounds (i.e. 50 #/cm3) lead to PN levels of E+09 for relatively high tunnel airflows. This is the level where most brake PN emission concentrations have been measured. Additionally, regen brakes are expected to be at even lower levels. Thus, we believe that a fixed dilution ratio of 1:100 will not allow for correct measurements and therefore labs shall be able to provide dilution ratios between 1:10 and 1:100.

JRC's suggestion: Leave the background limit as is. As a compromise maybe set a background limit at 20 #/cm3 – this would translate to PN background levels of 4E+08 #/km for a system operating at 850 m3/h, which still is considered acceptable for the emission levels observed at the ILS (but questionable for regen braking systems).

CLAUSE 7

TOPIC: ***Topic – Verification of speed uniformity in the enclosure.*** Excerpt from the text “Apply Computational Fluid Dynamics (CFD) to calculate the airspeed values at nine positions of plane C as defined in Figure 7.2. ... Airspeed at each position shall not vary by more than ±20% of the arithmetic mean of all nine measurements for a given flow”





JRC’s suggestion: ***Question 1: “Is 20% satisfactory for demonstrating the airspeed uniformity or do we need to make this spec stricter”. Question 2: Shall we also allow for experimental validation with the use of a flow meter for these points or shall we limit it to the CFD validation?***

CLAUSE 7

TOPIC: ***Topic – Minimum dimensions for the enclosure – Request and need for harmonizing the enclosure to the extend possible***

Comment: **Are the defined minimum dimensions for length and height necessary? Is the defined minimum 60% ratio necessary? Could we further relax these specifications?.**

JRC's reply: We understand the need for an enclosure as standardized as possible based also on the request of several TF2 members. For that reason, we have further restricted maximum length and height based on the ILS available systems. We have proposed lower limits for all dimensions (length, height, depth) based on the ILS data. We have further limited the transition angle and defined a ratio for hi/hc (>60%). We still believe that within these specifications the testing facilities shall have the opportunity to research for the optimal solution in terms of both temperature and particle transfer.

JRC's suggestion: Keep the requirements for the enclosure's dimensions as-is and not further neither relax nor restrict them

CLAUSE 9

TOPIC: ***Topic – Filter holder specifications.*** Excerpt from the text “Design the filter holder arrangement in such a way that the temperature of the filter holder and the filter are kept as close as possible to ambient temperature. Do not apply active heating or cooling and avoid water condensation”.

Comment: ***This requirement does not make sense. If we are not allowed transfer energy to the system (no heating or cooling), how should condensation be avoided? If the temperature allowed to be within 15°C and 25°C (20+/-5°C) this cannot be handled. Recommendation: Actively condition the device to 23+/-2°C. Alternatively, require the whole lab to be within 23+/-2°C. …similar to humidity.***

JRC’s suggestion: JRC does not have a strong opinion in favour or against the recommendation. ***Does the group agree with the suggested way to handle? Is there any other way to handle this?***

CLAUSE 9

TOPIC: ***Minimum duct dimensions.*** Excerpt from the text “Ducts shall have a constant inner diameter d_i of at least 175 mm and a maximum of 225 mm.” (THIS HAS BEEN RESTRICTED TO 225 mm BASED ON FEEDBACK RECEIVED)

Comment: **According to ISO 9096, B.1.1 General rule for circular ducts, the distance x of each sampling point i from the duct wall should be the center of the probe shown in Fig.B1, right? If so, the inner diameter would be 158 mm? Larger ducts result in higher airflow to cool the brakes resulting in lower particle concentrations. We are concerned that regenerative braking emissions cannot be measured.**

JRC’s reply: We used ISO 9096 in this case (but also in other cases in the text) to have a reference guideline for the system’s design. We do not need to be 100% ISO 9096 (or any other ISO or regulation) compliant. This is an entire new GTR on a topic that no previous regulation exists. We shall have the flexibility to use elements from the different regulations or standards when we think they fit our purposes. We have seen that layouts with 150 mm ducts were successful when other parameters in the system were appropriately designed. Since this is a global technical regulation maybe we should consider allowing for ducts down to 150 mm.

JRC’s suggestion: TF2 to decide on whether we shall relax this specification and allow for 150-225 mm or stay with the 175-225 mm.

CLAUSE 9

TOPIC: ***Topic – Wear measurement.*** During the ILS we requested the labs to apply SAE J2986:2019-01 for wear measurement of the brakes. The application of the protocol was successful in the vast majority of the cases. Total wear of 1-40 g was reported for the different brakes (Br1b the lowest and Br2 the highest). The measurement has proven useful (particularly weightings) for the analysis and for identifying issues in the overall test.

JRC's suggestion: ***Mandate weighing of the brake system before and after the brake emissions test and reporting total wear rate only as indicative and informational value.*** A balance with a resolution of at least 0.1 g will be required (25 kg/0.1g)

CLAUSE 10

TOPIC: ***Topic – Probe outlet – Pre-classifier.*** Excerpt from 10.1.4: “A suitable transfer tube shall be used to transfer particles from the probe’s outlet to the pre-classifier when the pre-classifier is not directly connected to the probe’s outlet”.

Comment: ***The pre-classifier should be mounted directly to the probe outlet.”.***

JRC’s suggestion: ***If TF2 agrees we could mandate mounting of the pre-classifier directly to the probe outlet and avoid one possible source of losses (i.e. the connecting tube).***

Thank you

European Commission