Particle Measurement Programme

PMP-IWG

Non-Exhaust Emissions
Draft GTR Feedback
Part 1

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LIST OF TOPICS COVERED IN PART 1

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3.	7.4.2. Brake enclosure design – Design specifications (l) and (m)
4.	7.4.3. Brake enclosure design – Dimensions (b)
5.	7.5. Design of the Sampling Tunnel (i)
6.	9. WLTP-Brake Cycle
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8.	12.2.2.2. Sample conditioning
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10.	12.3. Mass Loss Measurement (e)
11.	Overall Protocol
12.	**5.2. Definition of brake family**

TOPICS FOR REVISION – PART 1

	Excerpt from	Current text	Discussion Item – Proposed changes
1.	7.2.1.1 Cooling Air Conditioning - Cooling Air Temperature	Current text: (a) Set the cooling air temperature at 20 °C. The average cooling air temperature shall not deviate more than ±2 °C of the set (nominal) value. Testing facilities shall aim for keeping the temperature as close as possible to the nominal value of 20 °C; (…) Several references thereafter.	It has been proposed by one stakeholder to set the cooling temperature requirement at 23 ºC to align with exhaust testing facilities. The cooling air temperature has been set at 20 ºC since the beginning of the development phase. ILS1 data (TF1) showed that a shift of 5°C in the cooling settings resulted in a similar or slightly lower shift of brake temperature regimes. Very recent data show that the effect to brake emissions is negligible and below the measurement uncertainty. JRC's suggestion/position: If the PMP group agrees we could proceed with the proposed amendment. However, it would require adjustments to the cooling adjustment method. Since we have studied the effect of cooling temperature to the brake temperature thoroughly our suggestion would be to only increase the upper threshold values for IBT and FBT by 5 ºC to compensate for the increase of the cooling temperature by 3 ºC. Does the group agree with this approach? Is there any other implication that might have been omitted?

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	Excerpt from	Current text	Discussion Item – Proposed changes
2.	7.2.3 Cooling airflow	The text as is allows for the measurement of either air velocity or air flow. For example is it mentioned: "(a) When the cooling airflow is measured, report both the actual and normalised values as defined in Table 13.6 in paragraph 13.4" and "(c) When the cooling airspeed is measured, report the values as defined in Table 13.6 in paragraph 13.4".	It has been proposed by several stakeholders to mandate the measurement of only one parameter (i.e. airflow) and not allow for air velocity measurement. This will allow for some flexibility in the design of the ducting after the sampling plane (measuring the velocity in the center of the duct will make it impossible to determine the exact mass flow through ducts of different diameters at different flow velocities; therefore, a change in the duct diameter is not possible) and will help harmonizing the system since all testing facilities will be measuring the same parameter. JRC's suggestion: If the PMP group agrees with the proposal we would agree in mandating the flow measurement and make the necessary adaptations to the text. As a result we could allow different duct diameters AFTER the end of the sampling plane (i.e. two diameters after the sampling plane); however, introducing some boundaries to avoid excessive pressure drops. What is the group's opinion?

TOPICS FOR REVISION – PART 1

	Excerpt from	Current text	Discussion Item – Proposed changes
3.	7.4.2 Brake enclosure design – Design specifications (l) and (m)	Current text: (l) Apply Computational Fluid Dynamics (CFD) to calculate the airspeed values at the nine positions of plane C. Carry out the computation at three different cooling airflow settings representing the minimum, 50 per cent, and the maximum of the operational airflow range of the test system. The simulation time shall be of sufficient duration to detect any instability in the airspeed pattern that may affect the airspeed values. Conduct the simulation without a brake assembly or a brake fixture installed. Airspeed at each position shall not vary by more than ±20 per cent of the arithmetic mean of all measurements for a given flow; (m) It is strongly recommended that the testing facilities conduct physical measurements instead of the CFD simulations to verify the uniformity of the airspeed using the nine positions defined in points (k) and (l) of this paragraph;	It has been proposed by several stakeholders to mandate the experimental validation of the speed uniformity check and make the CFD optional. The proposed text would be: (l) Measure the airspeed values at the nine positions of plane C. Carry out the measurement at three different cooling airflow settings representing the minimum, 50 per cent, and the maximum of the operational airflow range of the test system. Conduct the measurement without a brake assembly or a brake fixture installed. Airspeed at each position shall not vary by more than ±35 per cent of the arithmetic mean of all measurements for a given flow; ~~(m) It is recommended that the testing facilities conduct also CFD simulations to verify the uniformity of the airspeed using the nine positions defined in points (k) and (l) of this paragraph. In this case, the simulation time shall be of sufficient duration to detect any instability in the airspeed pattern that may affect the airspeed values;~~ JRC's suggestion: We agree in mandating the experimental validation of the speed uniformity. We think that the allowed flexibility shall increase to ±35 per cent of the arithmetic mean of all measurements for a given flow to account for the measurement uncertainty. We recommend completely omitting the CFD measurement in this context as it does not add any value.

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	Excerpt from	Current text	Discussion Item – Proposed changes
4.	7.4.3 Brake enclosure design – Dimensions (b)	Current text: (b) Design the brake enclosure symmetrically to plane D. The length of plane D (h_D) represents the longest distance (height) of the enclosure perpendicular to the flow direction. Plane D's height shall be between 600 mm and 750 mm (600 mm ≤ hD ≤ 750 mm);	Comment received: Due to the calliper's positioning at 12 'o clock, the original criteria of h_D is suggested to be set to 650 mm as a min to accommodate calliper and a max rotor of 450 mm for M1/N1 LDV. During the ILS, the largest calliper was that of the BMW X7 front brake and featured a width of 40 mm from rotor OD to end of calliper housing. For a 600 mm enclosure height this brake system combination allows for a 300-(450/2+40) = 35 mm gap between the rotor OD and the enclosure's wall. Such low gaps are expected to lead to excessive wall deposition of emitted particles. Instead, a 650 mm enclosure height allows for a minimum 60 mm gap, whereas for most brakes the gap would be at least 100 mm. JRC's suggestion/position: We agree to the proposed amendment. It takes into account testing of bigger brake systems and is also in the direction of further restricting the specifications as requested by some stakeholders.

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	Excerpt from	Current text	Discussion Item – Proposed changes
5.	7.5 Design of the Sampling Tunnel (i)	Current text: (i) The provisions for the ducts described in points (a), (c), and (d) of this paragraph shall apply at least to the tunnel ducting from two duct diameters (2·di) upstream of the enclosure's inlet to two duct diameters (2·di) downstream of the flow measurement device.	Two stakeholders requested for allowing different duct diameter in the area of the flow measurement device compared to the sampling tunnel. According to the feedback, certain airflow measurement techniques do not provide accurate measurements within the spec (2%) when applied in large ducts and thus a change in the duct diameter would be required for the correct application. JRC's suggestion/position: This topic shall be examined in conjunction with the topic of flow/velocity measurement. If flow measurement is mandated, then inner diameter changes between the sampling plane and the flow measurement device can be allowed within certain limits to avoid excessive pressure drops. What is the group's opinion?

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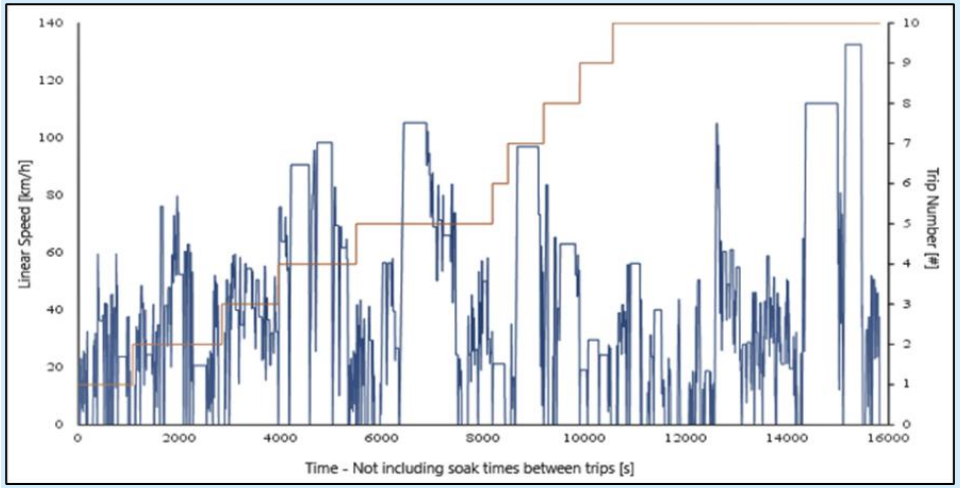
	Excerpt from	Current text	Discussion Item – Proposed changes
6.	9. WLTP-Brake Cycle		Based on the feedback received in July, Japan requested an amendment of the full WLTP-Brake cycle to exclude the Extra-High phase (i.e. >110 kph). Japan stated that they can accept the cycle without the Extra-High phase – this option is allowed also in GTR15 (WLTP). The EC commented that the purpose of the GTR is to prepare a globally accepted technical regulation. Possible different needs of the various stakeholders can be addressed in the respective regional regulations. Additionally, based on July's feedback OICA stated that a description for vehicles with speed limitation is missing. JRC's suggestion/position: A modification of the cycle at this stage is not feasible and cannot be supported by the necessary data. Based on the "*Request for authorization to develop a new UN GTR on brake particulate emissions*" (ECE/TRANS/WP.29/2021/150), the second development phase defines (a) "Definition of a real-world cycle/s for use in the laboratory". The item proposed by JAPAN and OICA could very well fit this future phase and; therefore, be examined in this context provided that data will be brought to the PMP for consideration.

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	Excerpt from	Current text	Discussion Item – Proposed changes
7.	12.1.4 Weighing procedure (g) Sample filter weighing:	Current text: (g) Weigh each filter twice and register the weighings in the PM-Mass Measurement File. If the difference between the first and second measurements is lower than 30 µg use the average to report $PM_{Uncorrected}$ and calculate $PM_{Corrected}$ following point (h) of this paragraph. When the difference between the first and second measurements is higher than 30 µg weigh the sampled filter for the third time. If the difference between the second and third measurements is lower than 30 µg use the average of the two measurements to report $PM_{Uncorrected}$ and calculate $PM_{Corrected}$ following point (h) of this paragraph. If the difference between the second and third measurements is higher than 30 µg consider the measurement invalid and the filter void. This procedure applies to both pre- and post-sampling filters	Based on the feedback received by one stakeholder the following sequence for determining the average filter weight would be more appropriate (based on ISO 5725-6). (i) Weigh each filter twice and register the weights in the PM-Mass Measurement File; (ii) When the difference between the first and second measurements is 30 µg or less, use the arithmetic mean to report the $PM_{Uncorrected}$ and calculate the $PM_{Corrected}$ weights following point (h) of this paragraph; (iii) If the difference between the first and second measurements exceeds 30 µg, perform two additional weighings and register the values in the PM-Mass Measurement File; (iv) When the difference between the maximum and minimum weights is 38 µg or less, use the arithmetic mean of the four weights to report the $PM_{Uncorrected}$ and calculate the $PM_{Corrected}$ weights following point (h) of this paragraph; (v) When the difference between the maximum and minimum weights is more than 38 µg and less than 42 µg, use the median of the four values to report the $PM_{Uncorrected}$ and calculate the $PM_{Corrected}$ weights following point (h) of this paragraph. The median value is the arithmetic mean of the second smallest and the third smallest values among the four weights taken; (vi) When the difference between the maximum and minimum weights is more than 42 µg reject the weighing session and quarantine the filter in the conditioning room. The testing facility may decide to void the filter and replace it with new for a pre-test weighing session, or discard the filter and repeat the brake emissions test for a post-test weighing session; (vii) Take the filter out of quarantine after at least 24h and weight each filter twice following items (i, ii) in this paragraph; (viii) If the difference between the first and second new measurements exceeds 30 µg, void the filter and reject the weighing session. Use a new filter for a pre-test weighing session, or discard the filter and repeat the brake emissions test for a post-test weighing session. JRC's suggestion/position: If the group agrees we would propose to apply this method instead of the previously proposed.

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	Excerpt from	Current text	Discussion Item – Proposed changes
8.	12.2.2.2 Sample conditioning	(f) It shall achieve a particle concentration reduction factor (PCRF) for particles of 15 nm, 30 nm, and 50 nm electrical mobility diameters not higher than 100 per cent, 30 per cent, and 20 per cent, respectively, compared to particles of 100 nm electrical mobility diameter for the system as a whole. Additionally, it shall achieve a PCRF for particles of 15 nm, 30 nm, and 50 nm not lower than 5 per cent than that for particles of 100 nm for the system as a whole. The calculation of the PCRF at different sizes shall follow the method described in paragraph 14.5.1;	One stakeholder suggested to add a mathematical explanation of the requirements for clarification. This could be added in 12.2.2.2 or in 14.5.1 and would look like: fr(15nm)/fr(100nm) [min 0,95 - max 2,0] fr(30nm)/fr(100nm) [min 0,95 - max 1,3] fr(50nm)/fr(100nm) [min 0,95 - max 1,2] JRC's suggestion/position: Agreed. A table similar to the one proposed will be added in 14.5.1.

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	Excerpt from	Current text	Discussion Item – Proposed changes
9.	12.2.2.3 PN Internal Transfer Line	(a) A bend may be applied to the PN internal transfer lines provided that the bending radius r_p is at least twenty-five times the inner diameter ($25 \cdot d_{tl}$) of the internal transfer line.	One stakeholder commented that since the flow of diluted aerosol in this area is typically low (1 lpm for most CPCs) it is not necessary to be that stringent here. The minimum bending radius of $10 \cdot d_{tl}$ would be by far sufficient here. This would also allow for keeping the transfer line shorter and therefore minimize diffusion losses. JRC's suggestion/position: If the group agrees we can relax this specification to allow for a minimum bending radius of $10 \cdot d_{tl}$ and enable the design of shorter internal transfer lines.

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	Excerpt from	Current text	Discussion Item – Proposed changes
10.	12.3 Mass Loss Measurement (e)	(e) Use a weighing scale of a resolution of at least 0.01 g or better for parts below 30 kg of total weight. Install the weighing scale in a room with controlled air and humidity to standard laboratory conditions of (22 ± 2) °C and (45 ± 8) per cent RH;	One stakeholder commented that mass loss measurement of discs and pads helps to prove the tests robustness but does not influence the brake particle emissions test result itself. The measurement of disc and pad thickness and weight is standard for brake dyno tests but usually the weighing scale is not placed inside a room with controlled air temp and humidity. From their experience this is not necessary and has minor influence on the result. Therefore, they highly recommend softening this requirement and change from requirement to recommendation. The conditioning of the weighing scale should not exclude test labs from being able to performing GTR compliant emissions tests without high additional invest in an air temp- and humidity-controlled room just for disc and pads measurement (this comment does not affect the requirement for PM filter weighting). Another stakeholder commented that that brake pads may draw moisture when entering an air conditioned environment and thus, become heavier. This may alter/influence the mass loss measurement that must be reported according to paragraph 12.3. JRC's suggestion/position: If the group agrees we would propose to relax the provisions of the climatic room where the weighing scale is installed from mandated to recommended (this applies only to mass loss measurement, not the room where the microbalance for PM is installed). Additionally, we suggest introducing a stabilization of the friction materials before and after the test for at least 1 hr in the PM weighing area before measuring their weigh. What is the group's opinion?

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<table>
<tr><th></th><th>Excerpt from</th><th>Current text</th><th>Discussion Item – Proposed changes</th></tr>
<tr><td>11.</td><td>Overall Protocol</td><td>Introduction of the WLTP-Brake cycle into Annex</td><td>One stakeholder suggested instead of sharing the WLTP-Brake cycle through excel file to create a table with the cycle data and introduce it to the Annex. Similarly, a Table with the details of the 303 brake events shall be added to the Annex.
<table>
<tr><th>Event time start [s]</th><th>Event time end [s]</th><th>Trip [#]</th><th>Event Type</th><th>Speed at start [km/h]</th><th>Speed at end [km/h]</th></tr>
<tr><td>0</td><td>4</td><td>1</td><td>Idle</td><td>0.00</td><td>0.00</td></tr>
<tr><td>4</td><td>10</td><td>1</td><td>Accel.</td><td>0.00</td><td>20.69</td></tr>
<tr><td>10</td><td>18</td><td>1</td><td>Cruise</td><td>20.69</td><td>20.69</td></tr>
<tr><td>18</td><td>24</td><td>1</td><td>Decel.</td><td>20.69</td><td>0.00</td></tr>
<tr><td>24</td><td>27</td><td>1</td><td>Idle</td><td>0.00</td><td>0.00</td></tr>
<tr><td>27</td><td>46</td><td>1</td><td>Accel.</td><td>0.00</td><td>23.10</td></tr>
</table>
JRC’s suggestion/position: It is impossible to introduce the 1Hz speed trace of the cycle due to its very long duration (requires approximately 300 pages with 3 columns per page). Instead, the suggested option is to report the cycle as a collection of different driving and deceleration events as shown in the Table above. This option would cover about 13 pages with two such tables side-by-side per page as the total number of driving & deceleration events are around 1100 for WLTP cycle. This could be Annex A. Does the group agree with this addition?
Similarly, Annex B would include a similar Table with the main parameters for the 303 brake events.</td></tr>
</table>

TOPICS FOR REVISION – PART 1
BRAKE FAMILIES

Current text: *A brake family shall be composed of brake systems that may be used in the same vehicle category and that are the same in terms of the following emission characteristics and technical criteria (Criteria based on UNR 13 to be further elaborated and finalized before the submission of the final working document):*

[PLACEHOLDER]

The manufacturer shall identify the worst performing brake system in terms of emissions and submit it to the authority as a candidate for testing. The authority shall approve the selection if appropriate and may also select any member of the family for testing. The maximum number for testing during type approval is two brake systems per family.

- ✓ **The definition of the family concept shall take into account two different statuses: Brakes that are mounted as an integrated system on one or more vehicles and brakes that can be found in the aftermarket as stand-alone parts (i.e. friction materials or brake discs);**
- ✓ **Brakes that are mounted as an integrated system on one or more vehicles shall always be tested for their emissions; however, only once when mounted in different vehicles. The worst performing brake system in terms of emissions shall be defined based on the anticipated energy to be dissipated in the different vehicles – further elaboration and proposal from OICA is welcome/required;**
- ✓ **Brakes that are found in the aftermarket as stand-alone parts shall be categorized separately for the friction material and the discs. Brake pads can be categorized into groups based e.g. on their friction surface. Brake discs may categorized following the ECE R90 as it results in a reasonable amount of "families" – further elaboration or alternative proposals from CLEPA are welcome/required.**

Thank you

European Commission