# Particle Measurement Programme

PMP-IWG

## Non-Exhaust Emissions
## Draft GTR Feedback
## Part 2

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*04 OCT 2022*

# LIST OF TOPICS COVERED IN PART 1

| | Excerpt from |
|---|---|
| 1. | 7.2.1.1. Cooling Air Conditioning - Cooling Air Temperature |
| 2. | 7.2.3. Cooling airflow |
| 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 |
| 7. | 12.1.4. Weighing procedure (g) Sample filter weighing: |
| 8. | 12.2.2.2. Sample conditioning |
| 9. | 12.2.2.3. PN Internal Transfer Line |
| 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:<br>(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;<br>(…) 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.<br>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.<br><br>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?<br><br>Outcome: No objections received. Topic agreed for application. |

# TOPICS FOR REVISION – PART 1

| | 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:<br>"(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<br>"(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.<br>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.<br><br>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?<br><br>Outcome: No objections received. Topic agreed for application. Text will be proposed with the doc on 11.10.22 for final check. |

# 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:<br>(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;<br>(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:<br>(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;<br>~~(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;~~<br><br>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.<br><br>Outcome: No objections received. Topic agreed for application. |

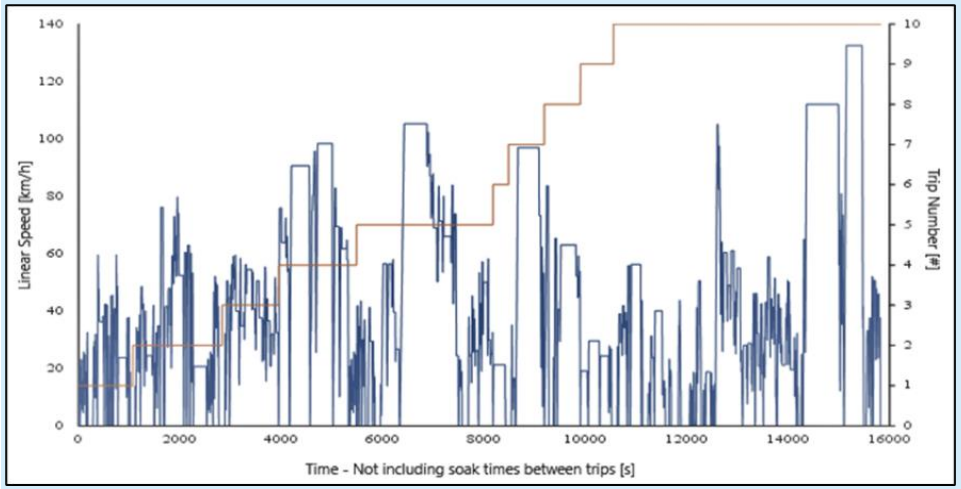
# TOPICS FOR REVISION – PART 1

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| 4. | 7.4.3 Brake enclosure design – Dimensions (b) | Current text:<br>(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.<br><br>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.<br><br>Outcome: Objections were received on this topic. Main reasoning relates to the need for having the flexibility to use 600 mm for designing enclosures that are not oversized for the vast majority of the brakes in the market. |

# TOPICS FOR REVISION – PART 1

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| 5. | 7.5 Design of the Sampling Tunnel (i) | Current text:<br>(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.<br><br>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?<br><br>Outcome: No objections received. Topic agreed for application. |

# TOPICS FOR REVISION – PART 1

| | 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).<br>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.<br>Additionally, based on July's feedback OICA stated that a description for vehicles with speed limitation is missing.<br><br>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.<br><br>Outcome: No objections received. The Japanese delegation submitted its approval for the proposed way forward. Topic agreed for application. |

European Commission

# TOPICS FOR REVISION – PART 1

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| 7. | 12.1.4 Weighing procedure (g) Sample filter weighing: | Current text:<br>(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).<br>(i) Weigh each filter twice and register the weights in the PM-Mass Measurement File;<br>(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;<br>(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;<br>(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;<br>(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;<br>(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;<br>(vii) Take the filter out of quarantine after at least 24h and weight each filter twice following items (i, ii) in this paragraph;<br>(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.<br><br>JRC's suggestion/position: If the group agrees we would propose to apply this method instead of the previously proposed.<br><br>Outcome: No objections received. Topic agreed for application. |

# TOPICS FOR REVISION – PART 1

| | 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:<br>fr(15nm)/fr(100nm) [min 0,95 - max 2,0]<br>fr(30nm)/fr(100nm) [min 0,95 - max 1,3]<br>fr(50nm)/fr(100nm) [min 0,95 - max 1,2]<br><br>JRC's suggestion/position: Agreed. A table similar to the one proposed will be added in 14.5.1.<br><br>Outcome: No objections received. Topic agreed for application. |

# TOPICS FOR REVISION – PART 1

| | 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.<br><br>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.<br><br>Outcome: No objections received. Topic agreed for application. |

# TOPICS FOR REVISION – PART 1

| | 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).<br>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.<br><br>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?<br><br>Outcome: Objections were received mainly on the second element for this topic. To be addressed later in the document with wear measurement. |

# TOPICS FOR REVISION – PART 1

<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?<br>
Similarly, Annex B would include a similar Table with the main parameters for the 303 brake events.<br><br>
Outcome: No objections received. Topic agreed for application.</td></tr>
</table>

# LIST OF TOPICS COVERED IN PART 2

| | Excerpt from |
|---|---|
| 12. | 3.3.15. Definitions |
| 13. | 5.3. Rounding Requirements |
| 14. | 7.2.1.2. Cooling Air Humidity |
| 15. | 7.2.2.2.1. Particle Background Verification at the System Level |
| 16. | 10.1.3. Computation of Verification Parameters and Acceptance Criteria |
| 17. | 7.4.3. Brake enclosure design – Dimensions |
| 18. | 7.4.3. Brake enclosure design – Dimensions |
| 19. | 12.1.4. Weighing procedure |
| 20. | 12.3. Mass Loss Measurement |
| 21. | 12.1.3.1. Filter Holder |

# TOPICS FOR REVISION – PART 2

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| **12.** | 3.3.15 Definitions | 3.3.15. "Lateral runout" means the change in the axial distance (from a datum plane) to the braking surface of the brake disc during one complete revolution at a given radial position. | One stakeholder commented that there is no clear description which plane serves as the datum plane. Another stakeholder commented that there is a need to replace the word "lateral runout and LRO" with "Brake runout and BRO" in order to account for drum brakes. Drum brakes runout is in radial direction whereas disc brake runout in the current context is lateral.<br><br>JRC's suggestion/position: Alternative definition: ***“"Brake runout" means the displacement of a point (from initial static position) located either 10 mm radially above the centreline of the outboard braking surface of the brake disc or on the centreline of the inner rubbing surface of the brake drum during one complete revolution.”*** JRC requests the group to confirm the agreement on THE LOCATIONS for reference points or propose and explain the selection of alternative points. |

# TOPICS FOR REVISION – PART 2

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| **13.** | 5.3 Rounding Requirements | Rounding of data in the data exchange file is not permitted. In the pre-processing file, the data may be rounded to the same order of magnitude of the accuracy of the measurement of a respective parameter and based on the number of decimals defined for the parameter in paragraph 13 of this UN GTR. | One stakeholder proposed the following text for a more technical and realistic approach: ***"All data must be processed using at least six significant digits. If fewer significant digits are available, data must be processed using all available significant digits. Rounding of intermediate results is not permitted. Final result values for a given parameter may be rounded to the number of significant digits necessary to match the number of decimal places defined for the parameter in paragraph 13 of this GTR."***<br><br>JRC's suggestion/position: If the group agrees we can adopt the new wording for the rounding requirements. |

# TOPICS FOR REVISION – PART 2

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| **14.** | 7.2.1.2 Cooling Air Humidity | Cooling air relative humidity shall be constant throughout the entire brake emissions test. The testing facility shall carry out the following steps:<br>(a) …<br>(b) …<br>(c) …<br>(d) …<br>(e) … | One stakeholder suggested to add a provision regarding absolute humidity. This would narrow down the range of possible operation of the brake test considering the relative humidity changes with altitude. The proposed sentence to be added is "The absolute humidity of the cooling air shall be kept between 5 and 11 g of water per kg dry air". If the draft GTR definitions for relative humidity is converted to absolute humidity we get 5.7 to 8.9 g/kg at sea level.<br><br>JRC's suggestion/position: If the group agrees we can add a provision for the absolute humidity as follows ***"The absolute humidity of the cooling air shall be kept between 5 and 10 g$H_2O$/kg dry air throughout the entire brake emissions test".*** Would the accuracy requirement for the measurement sensor of 1 g$H_2O$/kg dry air as defined in the PEMS (UNR) be acceptable? |

# TOPICS FOR REVISION – PART 2

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| **15.** | 7.2.2.2.1 Particle Background Verification at the System Level | (d) Perform the background verification at three different cooling airflow settings representing the entire operating range of the test facility. Apply the minimum, 50 per cent, and maximum operational airflow of the system. The test facility shall sample both TPN10 and SPN10 during the system background verification. The test facility may use a single nozzle size for sampling TPN10 and SPN10 during the system background verification when applying different airflow settings.<br>…<br>Multiple appearances of the "operational flow" or similar in the current text of the draft GTR. | One stakeholder commented that the concept of the operational range of the test facility is not clearly defined. Agreement should be achieved on defining the "nominal operational flow" (or any other term) that defines the maximum flow that may be achieved with the system by fulfilling "all" requirements of this UN GTR. Then the test should be performed at 10%, 50% and 90% of this value.<br>JRC's suggestion/position: Please review this point in conjunction with the next point in the list.<br>We agree with the spirit of this comment. We believe that defining the "maximum operational flow" and the "minimum operational flow" already in the definition's section will simplify and will provide a clear guidance for the use of the terms throughout the text. Our proposal for the definitions is as follows:<br>***""Maximum operational flow" is the maximum flow that the system can achieve while fulfilling all relevant cooling air conditioning and measurement requirements defined in this UN GTR".***<br>***""Minimum operational flow" is the minimum flow that the system can achieve while fulfilling all relevant cooling air conditioning and measurement requirements defined in this UN GTR. The minimum operational airflow shall be at maximum 20% of the maximum operational flow or at least lower by 1000 $m^3/h$ from the operational flow, whichever results in a greater air flow difference between the maximum and the minimum operational flow.".*** |

**Explanation**

**Why the last sentence in the definition of the minimum operational flow is needed?** This is to avoid the misuse of the specifications and not allow for testing facilities running at one flowrate or a very narrow range of flowrates.

**Why two options for the values are needed?** Assuming that a testing facility declares as maximum flow 500 $m^3/h$ and minimum flow 100 $m^3/h$. The testing facility fulfils the requirement for a minimum operational airflow at maximum 20% of the maximum operational flow; however, there is a high risk that the testing facility will not perform a successful cooling air adjustment for many brake systems. For this reason, it is necessary to define also a minimum difference to be respected.

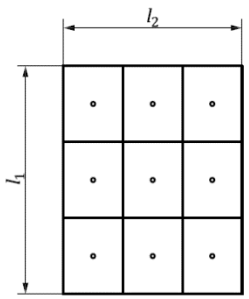
# TOPICS FOR REVISION – PART 2

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| 16. | 10.1.3 Computation of Verification Parameters and Acceptance Criteria | (d) In case of (c), the testing facility shall submit the reporting files for the non-successful cooling adjustment tests. In the case of brakes with calculated temperatures lower than the lower threshold values of the target temperatures, the testing facility shall demonstrate that the minimum operational airflow of the setup was applied and full compliance with the target parameters was not possible. In the case of brakes with calculated temperatures higher than the higher threshold values of the target temperatures, the testing facility shall demonstrate that the maximum operational airflow of the setup was applied and full compliance with the target parameters was not possible. | One stakeholder commented that this opens the door for intentionally failing the limits. Someone could test at too high or too low temperatures due to using a non-suitable measurement system.<br><br>JRC's suggestion/position: JRC agrees to this comment. In fact, this practically allows a testing facility to operate at a single airflow and adjust the entire measurement system to it. For example, if a testing facility selects 500 $m^3/h$ and designs the PM/PN sampling units accordingly they could have all elements of the test valid for all tested brakes but the cooling adjustment. This is not acceptable. |

| JRC's new proposal/suggestion – Alternative 1 | JRC's new proposal/suggestion – Alternative 2 |
|---|---|
| **Solution 1:** Follow the definition of the minimum and maximum operational flows as described in the previous point and introduce the provisions described below. This solution combines provisions for failure of meeting the temperature requirements and a minimum assurance that the testing facility tested a wide range of flows:<br>***(d) In the case of brake temperatures colder than the lower threshold values of the target temperatures, the testing facility shall demonstrate that the minimum operational flow was applied and full compliance with the target parameters was not possible;***<br>***(e) In the case of brake temperatures hotter than the higher threshold values of the target temperatures, the testing facility shall demonstrate that the maximum operational flow was applied and full compliance with the target parameters was not possible.*** | **Solution 2:** Delete the last part of the definition of the minimum operational flow (i.e. The minimum operational airflow shall be at maximum 20% of the maximum operational flow or at least lower by 1000 $m^3/h$ from the operational flow, whichever results in a greater air flow difference between the maximum and the minimum operational flow.) BUT ALSO replace the 10.1.3 (d) with the provision described below. This is the least desirable solution:<br>***(d) In the case of brake temperatures colder than the lower threshold values of the target temperatures or hotter than the higher threshold values of the target temperatures, the cooling adjustment shall be considered invalid.***<br><br>What is the group's opinion? |

# TOPICS FOR REVISION – PART 2

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| 17. | 7.4.3 Brake enclosure design – Dimensions | (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.<br>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.<br>Outcome: Objections were received on this topic. Main reasoning relates to the need for having the flexibility to use 600 mm for designing enclosures that are not oversized for the vast majority of the brakes in the market. |

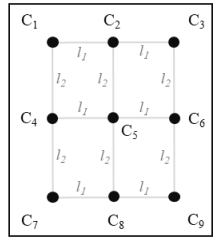



**JRC's new proposal/suggestion – Alternative 1**

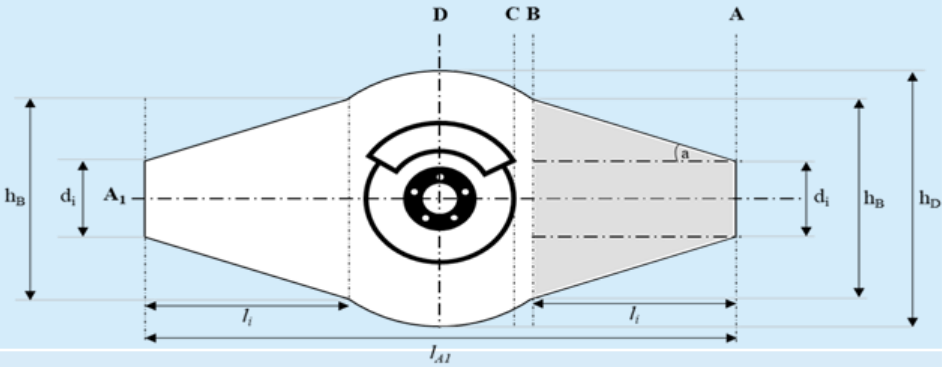
We propose to go back to the previous specifications described in the draft GTR (i.e. 600 mm ≤ hD ≤ 750 mm). To tackle the issue with the wall distance, we propose to define the 9 points for speed uniformity test as originally defined at the TF2 level taking into account the actual dimensions of the enclosure (based on ISO 9096 – Annex 2). This would be as follows: "Measure the airspeed values at nine positions in plane C as defined in Figure 7.4. Plane C is tangential to a disc diameter of 450 mm. Divide plane C into nine equal areas by lines parallel to the sides of the plane. Point C5 shall be the centre of plane C. The remaining 8 points shall be equally distributed around point C5 and placed in the middle of the imaginary lines between point C5 and the enclosure's walls at plane C".

**JRC's new proposal/suggestion – Alternative 2**

Alternatively, we propose making the speed uniformity measurement more representative and conduct it at plane D which is the actual place where the particles are formed. In this case, the text could read as follows: "Measure the airspeed values at nine positions in plane D as defined in Figure 7.4. Point D5 shall be the centre of plane D and the shared vertex of four imaginary rectangles. The remaining 8 points represent the vertices of these rectangles. Lines D5-D2 and D5-D8 are the longer sides of the rectangles with dimensions of $h_d/2$ - 75 mm (l2 = $h_d/2$ - 75 mm). Lines D5-D4 and D5-D6 are the shorter sides of the rectangles with dimensions of $d_d/2$ - 75 mm (l1 = $d_d/2$ - 75 mm)". The later proposal would still consider the airspeed tangentially to a disc of 450 mm at the point where the caliper is positioned and would assure that no interference of the enclosure's walls to the measurement equipment occurs.



# TOPICS FOR REVISION – PART 2

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| 18. | 7.4.3 Dimensions | (a) Design the brake enclosure symmetrically to plane A1. The length of plane A1 (lA1) represents the most extended length of the enclosure along the flow direction. Plane A1's length shall be between 1200 mm and 1400 mm (1200 mm ≤ lA1 ≤ 1400 mm);<br>(b) Design the brake enclosure symmetrically to plane D. The length of plane D (hD) 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);<br>(c) The distance from plane C to plane D is as long as the radius of the largest market available brake on vehicles within the scope of this GTR (i.e. approximately 200-250 mm). …;<br>(d) Design the height at plane B (hB) such that the hB/hD ratio is always greater than 60 percent (hB/hD > 60 %). …;<br>(e) Design the outlet's transition length (li) and height (hB) such that they equate to the inlet's transition length (li) and height (hB);<br>(f) The inlet and outlet diameters (di) shall equal to the diameter of the duct in the sampling tunnel as specified in paragraph 7.5;<br>(g) The maximum axial depth of the brake enclosure at plane D (parallel to the brake rotation axis) shall be between 400 mm and 500 mm. | One stakeholder proposed a diamond-shaped enclosure design with fixed dimensions. More specifically:<br>(a) Proposal: 1380 – 1400mm. Alternatively 1180 – 1200mm;<br>(b) Proposal: 580 – 600mm;<br>(c) Proposal: 225mm +/- 5mm;<br>(d) Proposal: hB/hD ratio = 1;<br>(e) Proposal: li = 390 – 400mm. hb = 580 – 600mm;<br>(f) Proposal: di = 200mm+/-5mm or 203,2mm+/-5mm;<br>(g) Proposal: 590 – 600mm.<br>  |

**JRC's proposal/suggestion**

JRC's suggestion/position: The topic has been discussed several times also at the PMP level. The vast majority of the stakeholders have agreed with the specifications and the flexibility allowed in the draft GTR for the enclosure design. Furthermore, the proposed values and shape has not been adopted, tested, or validated by any stakeholder.

One possible alternative would be to proceed with the approach already proposed in the draft GTR and add some recommendations for the length, height, and depth of the design. Setting recommendations for (a), (b), and (g) would also affect the other design points indirectly so there would be no need to recommend values also for points (d) and (e). This would result in more comparable designs for those who select to follow these recommendations. The text could read as follows: ***(a) Design the brake enclosure symmetrically to plane A1. The length of plane A1 (lA1) represents the most extended length of the enclosure along the flow direction. Plane A1's length shall be between 1200 mm and 1400 mm (1200 mm ≤ lA1 ≤ 1400 mm). It is recommended to design an enclosure with a length close to 1300 mm; (b) Design the brake enclosure symmetrically to plane D. The length of plane D (hD) 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). It is recommended to design an enclosure with a height close to 650 mm; …; (g) The maximum axial depth of the brake enclosure at plane D (parallel to the brake rotation axis) shall be between 400 mm and 500 mm. It is recommended to design an enclosure with an axial depth close to 400 mm.*** Would such an approach be acceptable for the group?

# TOPICS FOR REVISION – PART 2

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| 19. | 12.1.4 Weighing Procedure | (d) Pre-sampling conditioning and weighing – Condition/stabilise the filters at (22 ± 2) °C and (45 ± 8) per cent RH for a minimum of 2 hours before weighing. Weigh the filter at the end of the stabilization period following the procedure described in (g) of this paragraph and register its weight in all relevant test sheets. No deviation from the conditions specified in this paragraph is permitted during the weighing operation. Store the filter in a closed petri dish (or equivalent) or sealed filter holder until testing. Use the filter within 24h of its removal from the weighing chamber or room. | Some stakeholders commented that this time interval shall give the ability to place the filter in the holder before starting the bedding procedure and to keep it inside the holder until the emission test has been finished. The industrialized workflow of a brake test could lead to the situation that the bedding lasts longer than 24h.<br><br>JRC's suggestion/position: If the group agrees we can remove this provision and substitute it with *"Place the filter in the filter holder within 1h of its removal from the weighing chamber (or room). Use the closed petri dish (or equivalent) or sealed filter holder to transfer the filter to the test rig"*. The filter holder has already been specified to keep a temperature above 15 °C during the entire brake emissions test to avoid condensation; therefore, the risk of compromising the empty filter is low (if any). What is the group's opinion? |

# TOPICS FOR REVISION – PART 2

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| **20.** | 12.3 Mass Loss Measurement | (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;<br><br>The test facility can also measure the thickness of brake discs or brake drums. The thickness loss can sometimes be below the detection limit or below the resolution of the measurement instrument. The same measuring position ensures the repeatability and reproducibility of the thickness loss data.<br><br>Wear measurement specifications and methodology have been adopted from the SAE J2986:2019 Recommended Practice. It is not required that the test facility reports the wear measurement results.<br><br>(a) …<br>(b) …<br>(c) …<br>(d) … | 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. [See point 10 for more details].<br>Another stakeholder commented 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.<br>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?<br>Outcome: Objections received mainly on the second element for this topic. Additionally, a comment regarding wear measurement has been submitted. According to one stakeholder, if data does not need to be reported it should not be part of a legal procedure. MS could require fulfilling this part independent of the statement in this GTR. In this case, this part would get legally binding. This would lead to the situation that the requirements and procedure is not included in enough details and need severe improvement. |

**JRC's new proposal/suggestion**

1. Since the group does not have any major objection in relaxing the provisions of the climatic room where the weighing scale is installed we propose to make this a recommendation; 2. Regarding the conditioning of the brakes, there are several objections and reasonable arguments; therefore, we propose not to introduce it in the current version of the GTR. The topic will be monitored for possible intervention in the future; 3. Finally, JRC agrees in removing the part of wear measurement. In our point of view, the most important parameter from this measurement is weight loss that is directly linked to this GTR's objective. Testing facilities that still want to perform wear measurement shall follow the specifications of the already established SAE J2986:2019 Recommended Practice. What is the group's opinion?

# TOPICS FOR REVISION – PART 2

| | Excerpt from | Current text | Discussion Item – Proposed changes |
|---|---|---|---|
| 21. | 12.1.3.1 Filter Holder | The particle samples shall be collected on 47 mm single filters per test mounted within a dedicated holder. The filter holder shall be located as close as possible to the cyclonic separator's outlet. The testing facility shall follow the specifications described below for the filter holder assembly:<br>(a) Select a filter holder made of inert and non-corroding material such as stainless steel or anodized aluminium;<br>(b) Use a filter holder suitable for the insertion of circular filters. The diameter of the exposed area through which the sampled air passes shall be between 34 mm and 44 mm;<br>(c) Use a filter holder that provides an even flow distribution across the filter stain area;<br>(d) Design the filter holder arrangement in a way that no condensation of water can occur. The temperature at the filter holder shall follow the specification for the entire sample path defined in 12.1.2.2 and shall always remain above 15 °C during the entire brake emissions test. | It has been suggested by two stakeholders that the current description of the procedure does not allow an adequate use-time of the equipment. It is not possible to start a test later than Wednesday afternoon and finish it before the weekend: Multifilter holders 1. Allow the sampling either during bedding or for additional emission measurement tests; 2. It helps to check if bedding is completed; 3. It allows to run tests without non-friction braking and with friction braking in a sequence and identify the differences without any change to the brake assembly. There is a possibility of particle loss, which can be overcome by design and even loss correction. |

**JRC's proposal/suggestion**

The reason for not agreeing to this option in the first place relates to the application of changes in the direction of the flow in these systems. This might have a negative impact on the PM10 measurement. Unlike exhaust emissions, brake emissions are dominated by coarse particles (60-70%). These particles are prone to higher losses when changes in the direction of the flow occur.

**JRC could agree in allowing the use of these systems provided that the testing facility proves that the multiholder system can achieve at least 90% penetration of 10 µm particles for all filter holder ends at the typical operating flow of the PM sampling system (loss correction is not applied in this GTR at any point). JRC requested for experimental data in mid-June's PMP meeting but we did not receive any. What is the instrument manufacturers' opinion? Would such a verification be feasible as a one-off exercise?**

**If such data can be brought to the PMP in the next months and if the method for testing regenerative braking requires the execution of back-to-back emission measurement sections, we agree in allowing this possibility in December's informal document that will address regenerative braking.**

# Thank you



European Commission