

Draft Amendment 1 to UN GTR No. 24– Agreed changes

Topic/Problem	Explanation/Proposed Solution	Proposed Text (Red indicates added text. Strikethrough indicates deleted text)	Pages affected in the GTR-24
Off-road vehicles have erroneously been excluded from the scope of the GTR instead of the originally intended non-road machinery	Off-road vehicles are not defined separately in the '98 agreement (GTRs). Therefore, there is no reason to have them excluded from the GTR. Wording needs to be amended and include non-road machinery instead.	This version of the UN GTR does not contain test requirements specific to other types of vehicles e.g. non-road machinery off-road , special purpose, and heavy-duty vehicles. Thus, these vehicles are not included in the scope of this UN GTR.	Page 3
Summarize the most important changes in the GTR24.	Add a paragraph with the main changes for this amendment (to start now and finalize it in Dec with the rest changes)	22. In the first amendment of this UN GTR, the IWG on PMP introduces a more elaborated method for calculating the friction braking share coefficients of pure electric vehicles and hybrid electric vehicles with a traction REESS nominal voltage greater than 12V. Additionally, characteristics of brake emissions families for non-original and original replacement brake systems are defined for the first time. The first amendment also introduces other changes with the aim of improving the overall protocol.	Pages 6-7
Paragraph 3.2.8. Is the use of the term absolute humidity (g/kg H ₂ O) correct?	It seems the proper term shall be specific humidity (g/kg) instead of absolute humidity (g/m ³). This is confirmed also with the exhaust emissions regulation. This shall be replaced in the next version of the GTR.	3.2.8. "Cooling air specific absolute -humidity" represents the amount of water in grams present in one kilogram of dry air. It is measured upstream of the brake enclosure.	18 appearances in the GTR need to be replaced. Pages 11, 17, 30, 92, 103, 128
Description Brakes hardware point 3.3.12.	Describe the Carbon Ceramic Disc more precisely. There are variants with partly non reinforced sections	<i>"Carbon-ceramic disc" means a brake disc manufactured of a carbon fiber reinforced ceramic matrix material with or without a ceramic friction layer.</i>	Page 12

<p>A definition for precision and accuracy is missing.</p>	<p>There has been a discussion of the difference between precision and accuracy. GTR 15 and UN R154 contain a definition of accuracy and precision that would be worth including.</p>	<p>3.6.9. "Accuracy" means the difference between a measured value and a reference value, traceable to a national standard and describes the correctness of a result. 3.6.10. "Precision" means the degree to which repeated measurements under unchanged conditions show the same results. In this UN GTR, precision always refers to one standard deviation.</p>	<p>Page 16</p>
<p>Paragraph 5.2.1.: Brake emissions family for aftermarket and restructuring of the relevant chapter</p>	<p>Elaborated tables for disc and drum brakes grouping shall be introduced in the GTR in Paragraph 5.</p>	<p>5.2.1. Characteristics of Brake Emissions Families for Original Brake Systems All vehicle types independent of their electrification grade ... may be part of the same brake emissions family. The eligibility criteria for becoming a part of the brake emissions family may be extended in the first amendment to this UN GTR: ... 5.2.2. Characteristics of Brake Emissions Families for Replacement Brake Parts and Systems Brakes that feature the same characteristics as defined in (a)-(g) may be part of the same brake emissions family. Tables 5.1. and 5.2. provide an overview of the families for replacement disc and drum brakes, respectively: (a) Type of calliper (floating or fixed calliper); (b) Vehicle axle where the brake is located (front or rear); (c) Friction material formulation. Each brake pad and shoe material constitutes a unique family; (d) Brake disc (cast iron, coated cast iron, carbon-ceramic, other) or drum (cast iron, other) material;</p>	<p>Page 23: Restructuring: Amend 5.2.1. titled "Characteristics of brake emissions families for original brake systems". Remove from 5.2.1 the sentence <i>"The eligibility criteria for becoming a part of the brake emissions family may be extended in the first amendment to this UN GTR"</i>. Add 5.2.2 titled "Characteristics of brake emissions families for replacement brake parts and systems". Amend current 5.2.2 to 5.2.3 and adjust the text accordingly to include all types of brakes. ...</p>

		<p>(e) Brake disc surface form (plain or not plain);</p> <p>(f) Friction material surface area. For brake pads there are 10 classes of 10 cm² increments as defined in Table 5.1;</p> <p>(g) Brake drum diameter. For drum brakes there are 8 classes of 20 mm increments as defined in Table 5.2.</p>	Caution: Current Table 5.1. shall be changed to 5.3.
Update Table 5.1 and the note below.	Introduction of another NOVC-HEV category to cover vehicles with a battery capacity between 12-20 V. Introduction of a comment under Table 5.1. stating that individual values can be applied. Categories 0, 1 and 2 are proposed in place of 1a, 1b and 2 to avoid confusion with the levels in UN R154.	<p><i>"Not off-vehicle charging hybrid electric vehicle – Category 0" (NOVC-HEV Cat. 0) means a hybrid electric vehicle that features a traction REESS with a nominal voltage higher than 12V and lower than or equal to 20V that cannot be charged from an external source.</i></p> <p><i>Table 5.1 (now 5.3) - NOVC-HEV Cat. 0 (Friction Braking Share Coefficient (c) – 0.90)</i></p> <p><i>Note: Testing facilities may use vehicle-specific friction braking share coefficients measured and calculated according to Annex C of this UN GTR.</i></p>	Page 24 ... Page 16
Vehicle specific friction braking share coefficients	Introduction of Annex C	Annex C as in the main document.	ANNEX C – Definitions – Abbreviations – Table 5.3.
Clarify how replacement parts shall be tested	Separate the definition of the head of the family (5.2.3.) and the testing provisions (new 5.2.4.). Clarify the difference between brake parts (replacement) and brake assemblies (original and non-original)	<p>5.2.4. Brake Emissions Family Testing</p> <p>The brake assembly both for original and non-original replacement brake systems shall be tested on the test stand using the test wheel load corresponding to the brake emissions family parent as described in paragraph 8.1.1. (when the family parent is a pure ICE vehicle) or in paragraph 8.1.2. (when the family parent is a NOVC-HEV, OVC-HEV, or PEV) of this UN GTR.</p> <p>replacement brake parts (discs, pads, drums, shoes) shall be tested on the test stand coupled</p>	Page 24

		<p>with the corresponding original brake part (e.g. an original brake pad shall be used to test a replacement brake disc). The test wheel load that corresponds to the brake emissions family parent as described in paragraphs 8.1.1. and 8.1.2. of this UN GTR shall be applied.</p> <p>The final brake PM and PN emission factors for the brake emissions family parent are calculated after multiplying the reference PM and PN emissions of the tested brake with the c value of the brake emissions family parent vehicle as described in paragraphs 12.1.5. and 12.2.4. of this UN GTR, respectively.</p>	
<p>Paragraph 7.2.1.2.: The absolute humidity requirement matches the relative humidity requirement for 20°C. Important update!</p>	<p>The absolute humidity requirement must be changed to match the 23°C requirement. Topic to be further discussed and finalized in December for fixing the correct values.</p>	<p>In addition to the specifications defined for the relative humidity, the testing facility shall ensure that the average specific humidity of the cooling air is kept between [6 gH2O/kg and 11 gH2O/kg dry air] throughout the entire brake emissions test (soaking sections during emissions measurement are not included).</p>	<p>Page 30</p>
<p>Paragraph 8.2.1. (f): Some testing facilities reported that the placement of the dial gauge tip causes some practical issues here. Since the temperature sensor is already placed at this position, it is physically difficult to have both in the exact same position.</p>	<p>Rephrase the text accordingly to avoid misunderstanding.</p>	<p>8.2.1. Full-Friction and Non-Friction Braking</p> <p>The testing facility shall perform the following tasks before commencing a brake emissions test:</p> <p>...</p> <p>(f) Measure the brake run out (BRO) by placing the dial gauge tip 10 mm outwards from the centreline of the disc outboard surface (disc brakes) away from the outer edge (OD) on outboard surface (disc brakes) or by placing the dial gauge radially outwards and 10 mm away from the centreline of the inner surface of the drum (drum brakes). Brake pads or shoes shall not be mounted during this measurement. Verify that</p>	<p>Page 49</p>

		the BRO is less than 50 µm while manually rotating the disc or drum installed on the dynamometer. If the BRO is above 50 µm, adjustments to brake fixturing and/or inspection of the brake parts shall be made to reduce BRO to a value below 50 µm. In case the BRO before the start of the test remains above the limit defined in this paragraph, the test shall be invalid;	
Section 8.2.1 Paragraph (l) talks about checking items based on paragraph 10.2.4. No paragraph 10.2.4 in the final GTR.	There was an error in the GTR-24. The correct reference is paragraph 10.1.4.	(l) When the cooling airflow for the axle and brake type under test is not known, adjust to a known value used for similar brakes as described in paragraph 10.1.4. Verify that the selected cooling airflow meets the specifications defined in paragraph 10. If not, adjust its value following the instructions in paragraph 10.1.4. until the nominal value is defined;	Page 50
In 8.4.2 of the GTR, it is prescribed that the parking brake shall be dismantled for carrying out a brake emissions test. Alternatively, a calliper without the parking brake feature shall be selected for the test. Some labs reported that in some cases, it is not possible to remove the EPB components completely as there would be a leakage! If then no version without EPB	This provision was introduced to reduce the challenges of brake bleed for some (mechanical) parking brake systems and improve piston retraction during testing. The latter reduces the risk of residual torque during testing. Another reason for this provision is to reduce potential interference with incoming airflow as stated in the same paragraph 8.4.2. For parking brake caliper, this interference is expected by the additional 'actuator housing'. It is proposed to remove this provision altogether since: 1. There is already a defined limit in the residual torque discussed in 8.2.1 (j) that needs to be respected anyway, 2. The alternative calliper chosen may not have all the retraction design features matching the EPB caliper, and 3. Since the calliper mounting is mandated to be at 12 'o clock position, the	8.4.2. Calliper Orientation The testing facility shall position the calliper to minimise potential interference with the incoming cooling air. Install the calliper above the disc with the centre of the calliper in a 12-o'clock position as illustrated in Figure 8.6. irrespective of the mounting position at the vehicle. Other calliper orientations (e.g. vehicle's mounting position) or configurations are not allowed and shall invalidate the test. The parking brake shall not be dismantled for carrying out a brake emissions test. Alternatively, a calliper without the parking brake feature shall be selected for the test. ... 10.1.4. Brake Dynamometer Testing to Adjust the Cooling Airflow	Page 53 ... Page 65

<p>would be available, it would not be possible to correctly measure this brake system!</p>	<p>potential interference due to black block will be much less compared to other clock positions. However, it is proposed to add a line under cooling air adjustment to take care of disc temperature variations, if any, due to the presence of black block.</p>	<p>The testing facility shall carry out the following steps to adjust the cooling airflow when testing a brake for the first time on a given dynamometer. (a) Follow the test setup preparation specifications described in paragraph 8.2.1.; ... (f) In the case of front brakes, proceed with the subsequent sections of the brake emissions test ensuring the application of the same dynamometer settings as in the cooling adjustment procedure. The same set of brakes shall be used for brake emissions testing. The testing facility shall use the same calliper as during the cooling air adjustment section for both bedding and emissions testing sections;</p>	
<p>Paragraph 9.2.3.: The Vehicle Control Strategy needs to be somehow reflected to account for activation of active filtering devices when testing on the brake dyno. Important update!</p>	<p>Introduce a fixed amount of time allowed (e.g. 1 sec) to activate the filtering devices before the start of the brake event. Important update! The passage has been introduced in square brackets. There are certain aspects that need to be discussed before agreeing to introduce such a sentence in the amendment. Indicative questions include: 1. How to deal with active filter systems that are running permanently; 2. How to install the filter at the dynamometer bench; 3. How to handle the filtered volume flow (e.g. release point); 4. When to apply the filter systems (already during bedding?); 5. Filter conditions (new, unused filters?); 6. Clarification of the impact on cooling air flow control stability and tolerances; 7. How to incorporate/access a “dynamometer mode” of the filtering systems (different behavior for dyno and vehicle usage); 8. Definition of</p>	<p>9.2.3. Emissions Measurement Section The correct execution of the WLTP-Brake cycle ... (f) Run the WLTP-Brake cycle without any interruption. Paragraph 9.3.3. describes the necessary actions in the case of interruptions; [(g) In case of active brake filtering devices, the testing facility may activate the active filtering function (up to a maximum of) 1 sec before the brake event start time as defined in 13.1. In such a case, the active filtering function shall be deactivated at the brake event end time as defined in 13.1.] The minimum threshold temperature of 30 °C specified in this paragraph applies to all brakes. Failure to comply with the described brake temperature provisions shall result in an invalid emissions test.</p>	<p>Page 56</p>

	“switching off” the filter (Immediately stop the flow or stop the additional blower, allowing the rotating fan to still transport air?)		
Table 10.2: Carbon-ceramic (CSiC) discs show a different temperature behaviour than CI discs	Short term: Introduce a relaxed temperature regime for CSiC to the low side by 15°C. Properly define CSiC to avoid misuse. Long term: Collect data and build a table similar to Table 10.2 for CSiC discs	Page 61: (a) “The target values and the corresponding tolerances for the three check parameters apply to all types of front brakes mounted in all types of vehicles within the scope of this UN GTR except for carbon-ceramic disc brakes. For carbon-ceramic disc brakes, the default temperature metrics apply; however, the ABT [A₁] temperature metrics are lowered by 15 °C and the tolerances to the low end of the temperature regime for the IBT [A₂] and FBT [A₃] are further relaxed by 15 °C”.	- Page 61 - Page 12: Introduction of definition for carbon-ceramic discs after 3.3.9 (maybe also define cast-iron discs including all types of products (e.g. coated))
Paragraph 10.1.4.: It is not clarified that only front brakes shall be used for defining the cooling airflow.	Introduce an additional sentence clarifying that the front axle brake will be used to determine the cooling airflow for brakes of both axles.	10.1.4. Brake Dynamometer Testing to Adjust the Cooling Airflow The testing facility shall carry out the following steps to adjust the cooling airflow when testing a brake for the first time on a given dynamometer for a given vehicle. The test facility shall use the front axle to determine the cooling airflow for both axles—irrespective of the type or size of the brake mounted on the rear axle.	Page 64
Paragraph 12.1.2.1. The GTR 24 does not prescribe the materials allowed for the cyclone used as a pre-separator in PN measurements. This could be critical for PN because (for non-conductive material)	Add a clarification sentence in the specifications regarding the allowed materials for the cyclone used both for PM measurement and as a pre-classifier for the PN measurement.	12.1.2.1. PM Separation Device Single cyclonic separators followed by gravimetric filter holders shall be used for the collection of the PM10 and PM2.5 samples. The testing facility shall select cyclonic separators following the provisions described below: (a) Commercially available cyclonic separators with cut-off sizes of 10 µm and 2.5 µm for the collection of the PM10 and PM2.5 samples, respectively shall be used;	Page 69 Pages 80-81

<p>there could be some electrophoretic losses.</p>		<p>(b) The PM10 and PM2.5 cyclones shall fulfil the specifications for the separation efficiency described in Tables 12.1. and 12.2., respectively;</p> <p>(c) The cyclone shall be made of electrically conductive materials that do not react with brake particles. It shall be electrically grounded to avoid electrical/electrostatic effects;</p> <p>(d) Place the cyclonic separators at the outlet of the sampling probe...</p> <p>...</p> <p>12.2.2.1. PN Pre-classifier</p> <p>The testing facility shall use a cyclonic separator to protect the dilution system and the VPR from possible contamination. ...</p> <p>(e) The cyclone shall achieve a minimum penetration efficiency of 80 per cent for a particle diameter of 1.5 µm-;</p> <p>(f) The cyclone shall be made of electrically conductive materials that do not react with brake particles. It shall be electrically grounded to avoid electrical/electrostatic effects.</p>	
<p>Paragraph 12.1.3.1.: Multi-filter holders shall be allowed to better automate the testing procedure and allow for better evaluation of the bedding procedure</p>	<p>Introduction of the possibility to use multi-filter holders provided that no additional changes in the flow direction are applied for PM measurements. Several other provisions shall apply to ensure a robust system.</p>	<p>12.1.3.1. Filter Holder</p> <p>The PM samples shall be collected on 47 mm single filters per test mounted within a dedicated holder. ...</p> <p>(a) Select a filter holder made of inert and non-corroding material such as stainless steel or anodized aluminium. All parts of the filter holder in contact with the aerosol and filters shall be electrically conductive and grounded;</p> <p>(b) Use a filter holder suitable for the insertion of circular filters. The diameter of the exposed area through which the sampled air</p>	<p>Page 72 ... Page 117</p>

		<p>passes (i.e. filter stain area) shall be between 34 mm and 44 mm;</p> <p>(c) Use a filter holder that provides an even flow distribution across the filter stain area;</p> <p>(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 paragraph 12.1.2.2. and shall always remain above 15 °C during the entire brake emissions test.</p> <p>Multi filter-holders may be used for the PM samples collection. Multi filter-holders shall fulfil the following requirements in addition to those defined in 12.1.3.1. (a)-(d):</p> <p>(e) All filters shall be placed in the same multi-filter holder device under the same conditions within a closed housing to avoid contamination;</p> <p>(f) Use only one filter at a time for the PM sampling during each section of a given brake emissions test;</p> <p>(g) The use of a multi-filter holder device shall not introduce any change in the flow direction prior to or within the multi-filter holder device.</p> <p>...</p> <p>Line 184 in Table 13.6: Verify that the PM2.5 filter holder meets all the requirements defined in paragraph 12.1.3.1. (a)-(g)</p> <p>Line 185 in Table 13.6: Verify that the PM10 filter holder meets all the requirements defined in paragraph 12.1.3.1. (a)-(g)</p>	
Paragraph 12.1.4. (e): For practical considerations and the	Based on the data presented by AVL in the last PMP meeting (29.09.2023) it seems that the 8h provision specified in the GTR24 is not necessary.	(e) Post-sampling conditioning and weighing – Take the filters to the conditioning room within 8 hours after testing is completed. The filters may	Page 73

<p>nature of brake emission testing (long cycles, automation), it would be useful to remove the 8h (after testing) requirement or extend it substantially.</p>	<p>However, precautions shall be taken not to allow for a misuse of relaxation. Testing facilities capable to demonstrate relatively constant conditions shall be allowed to transfer the filters outside the defined timeframe.</p>	<p>remain in the testing room for a longer period of time provided that they remain sealed within the filter holder and that the conditions in the testing room are stable within $\pm 5^{\circ}\text{C}$ for temperature and $\pm 15\%$ for RH. Use a closed petri dish (or equivalent) or sealed filter holder to transfer the filter to the conditioning room. Alternatively, transfer the filter without removing it from the filter holder ensuring that filter holders are not tilted during transfer.</p>	
<p>12.1.4. (g): Several stakeholders repeatedly see very low ($\ll 100\mu\text{g}$) loadings on the PM filters for brakes that emit close to the proposed limits. These data call for more stringent definitions in 12.1.4 (g).</p>	<p>Typical filter loadings for low emitting brakes can be very low. Testing experience shows that filter loadings of even $< 30\mu\text{g}$ are not uncommon. Based on the data presented by AVL in the last PMP meeting (29.09.2023), it is strongly suggested to limit the repeatability requirement for the repeated weighing to $10\mu\text{g}$ (instead of $30\mu\text{g}$). Any state-of-the-art emission lab should be able to handle this. The current procedure could be applied with all values being adjusted to $\sim 1/3$rd of the current levels.</p>	<p>(g) Sample filter weighing – Follow the procedure described below to perform both pre- and post-sampling filter weighing: (i) Weigh the filter twice and report the weights in the Mass Measurement File; (ii) If the difference between the first and second measurements is $10\mu\text{g}$ or less, use the arithmetic mean to report the $\text{Pe}(\text{Uncorrected})$ and calculate the $\text{Pe}(\text{Corrected})$ weights in accordance with point (h) of this paragraph; (iii) If the difference between the first and second measurements is greater than $10\mu\text{g}$, perform two additional weighings and report the weights in the Mass Measurement File; (iv) When the difference between the minimum and maximum weights of the four measurements is $13\mu\text{g}$ or less, use the arithmetic mean of the four weights to report the $\text{Pe}(\text{Uncorrected})$ and calculate the $\text{Pe}(\text{Corrected})$ weights in accordance with point (h) of this paragraph; (v) When the difference between the minimum and maximum weights of the four</p>	<p>Pages 74-75</p>

		<p>measurements is greater than 13 µg and less than or equal to 15 µg, use the median of the four values to report the Pe(Uncorrected) and calculate the Pe(Corrected) weights in accordance with point (h) of this paragraph. The median value is the arithmetic mean of the second-lowest and the third-lowest values among the four weights taken;</p> <p>(vi) When the difference between the minimum and maximum weights of the four measurements is greater than 15 µg invalidate the weighing session and quarantine the filter in the conditioning room. The testing facility may decide to void the filter and replace it with a new filter for a pre-sampling weighing session, or discard the filter and repeat the brake emissions test for a post-sampling weighing session;</p> <p>(vii) After a minimum of 24h take the filter out of quarantine and weigh it twice in accordance with points (i) and (ii) in this paragraph;</p> <p>(viii) If the difference between the first and second new measurements is greater than 10 µg, void the filter and reject the weighing session. Use a new filter for a pre-sampling weighing session, or discard the filter and repeat the brake emissions test for a post-sampling weighing session.</p>	
<p>Pressure values in mbar are given in 12.2.2.2. whereas pressure values in kPa are discussed in the GTR.</p>	<p>Replace mbar values by kPa values for consistency.</p>	<p>(j) It shall be capable of operating at sample pressures in the 850 to 1050 mbar kPa range and relative pressure differences from ambient in the ±50 mbar kPa range;</p> <p>...</p> <p>(v) It shall be capable of operating operate at sample pressures in the 850 to 1050 mbar kPa</p>	<p>Pages 82 and 83</p>

		range and relative pressure differences from ambient in the ±50 mbar kPa range.	
Paragraph 12.2.3.2. PN Sampling Flow: Mass flowmeters can directly determine normalised flowrate. It is not required to report flow under operating condition, because the average isokinetic ratios for both TPN10 and SPN10 are calculated from normalised flows.	Amend the specification related to reporting to both operating and standard conditions when mass flowmeters are used.	12.2.3.2. PN Sampling Flow The PN measurement system shall meet the following provisions for the regulation and measurement of the sampling flow (i.e. flow at the PN sampling probe). These apply to both TPN10 and SPN10 sampling: (a) The method of measuring the flow of the sampling and measurement system shall have a maximum permissible error of ±5 per cent of the reading under all operating conditions; (b) Use a flow measurement device calibrated to report flow at both operating and standard conditions. When the flow measurement device measures at operating conditions, it shall be capable of measuring the temperature and pressure with an accuracy of ±1.0 °C and the pressure measurements shall have a precision and accuracy of ±1.0 kPa, respectively;	Page 84
Paragraph 12.3. Different provisions regarding the verification of the proper functioning of the balance are given in the text.	Change the wording in 12.3. (e) and harmonize with 14.4.2.	“Use a weighing scale of a resolution of at least 0.1 g or better for parts below 20 kg of total weight. Use certified calibration weights to verify the stability and the proper function of the balance every month regularly (Table 14.1). ”	Page 86
Not correct use of word setup in Table 14.1.	As it is written now, one could consider as setup the entire lab, while the idea is major maintenance of the specific instrument. Remove the word setup and replace with the specific instrument.	- 6 months or 13 months depending on the setup specific instrument ... - 6 months or 13 months depending on the setup specific instrument	Pages 127 and 128

<p>Table 14.3. Calibration for brake fluid displacement. What does 0.5% of maximum mean? Important update!</p>	<p>The fluid displacement is a purely digital measurement. The calibration of this channel is more of a verification than a calibration. The operator looks for any obvious errors. Annually, the facility compares 5 different fluid volumes by displacing fluid into graduated cylinders and comparing that to the system display. These values should agree. If they don't, the fluid displacement sensor needs to be serviced. This is highly relevant for a bearing drag measurement tool. Important update with new values proposed by OICA.</p>	<p>Table 14.3. Brake Fluid Displacement (Calibration criterion) ± 0.5 per cent maximum in each one of 5 different fluid volumes from 1 cm³ to 20 cm³, or according to the manufacturer's specification.</p>	<p>Page 128</p>
<p>Correction of Table 14.6. title.</p>	<p>The given specifications do not refer only to the microgram balance (PM) but also to the brake parts balance</p>	<p>Verification criteria for microgram and brake parts balance</p>	<p>Page 130</p>