Submitted by the IWG on PTI

Informal document **GRPE-89-24-Rev.2**
89th GRPE, 30 May - 2 June 2023
Agenda item 13.

Proposal for amendments to ECE/TRANS/WP.29/GRPE/2023/9

ECE/TRANS/WP.29/GRPE/2023/9, replace to read:

I. Proposal

Part 1 Proposal for amendments to UN Rule No. 1

Annex, paragraph 3., amend to read:

"3. Environmental nuisances

3.1. Exhaust emissions

3.1.1. Vehicles with positive-ignition engines:

Item	*Method*	*Main Reasons for Rejection*	*Defect Assessment*		
			Minor	*Major*	*Dangerous*
3.1. Positive ignition engine emissions					
3.1.1. Exhaust emissions control equipment	Visual inspection	(a) Emission control equipment fitted by the manufacturer absent, modified or obviously defective. (b) Leaks which would affect emission measurements		X X	
3.1.2. Gaseous emissions	For vehicles up to emission classes Euro 5 and Euro V or equivalent: Measurements using an exhaust gas analyser in accordance with the requirements[1] or reading of OBD. Tailpipe testing shall be the default method of exhaust emission assessment. On the basis of an assessment of equivalence, and by taking into account the relevant type approval legislation, Contracting Parties may authorise the use of OBD in accordance with the manufacturer's recommendation and other requirements. For vehicles as of emission classes Euro 6 and Euro VI or equivalent:	(a) Either gaseous emissions exceed the specific levels given by the manufacturer; (b) Or, if this information is not available the CO emissions exceed, (i) For vehicles not controlled by an advanced emission controls system: 4.5%, or 3.5% According to the date of first registration or use specified in requirements[1] (ii) for vehicles controlled by an advanced emission control system:		X X	

Item	*Method*	*Main Reasons for Rejection*	*Defect Assessment*		
			Minor	*Major*	*Dangerous*
	Measurement using an exhaust gas analyser in accordance with requirements[1] or reading of OBD in accordance with manufacturer's recommendations and other requirements[1]. Measurements not applicable for two-stroke engines	- At engine idle: 0.5% - At high idle: 0.3% for vehicles of emission class Eur 5 and Euro 6 or equivalent: - At engine idle: 0.3% - At high idle: 0.2% According to the date of first registration or use specified in requirements[1] (c) Lambda coefficient outside the range 1± 0.03 or not in accordance with manufacturer's specification; (d) OBD read-out indicating significant malfunction		X X	

Item	*Method*	*Main Reasons for Rejection*	*Defect Assessment*		
			Minor	*Major*	*Danger ous*
3.2 Compression ignition engine emissions					
3.2.1. Exhaust emissions control equipment	Visual inspection	(a) Emission control equipment fitted by the manufacturer absent or obviously defective. (b) Leaks which would affect emission measurements		X X	
3.2.2. **Exhaust emissions measurement**	**Test procedures:** **For vehicle up to emission classes Euro ~~4~~ 5a and Euro ~~I~~V or equivalent:** **Apply 3.2.2.1** **For vehicles as of emission classes Euro 5b and Euro VI or equivalent:** **Apply either 3.2.2.1 or 3.2.2.2 according to national implementation.** **Mutual recognition of periodic technical inspection certificate is not affected by the choice of the Exhaust emissions test procedures.**				
3.2.2.**1.** Opacity Vehicles registered or put into service before 1 January 1980 are ~~**excepted**~~ **exempted** from this requirement	For vehicle up to emission classes Euro 5 and Euro V or equivalent: Exhaust gas opacity to be measure during free acceleration (no load from idle up to cut-off speed) with gear lever in neutral and clutch engaged or reading of OBD. The tailpipe testing shall be the default method of exhaust emissions assessment. On the basis of an assessment of equivalence, Contracting Parties may authorise the use of OBD in accordance with the manufacturer's recommendation and other requirements. For vehicles as of emission classes Euro 6 and Euro VI or equivalent: Exhaust gas opacity to be measured during free acceleration (no load from idle up to cut-off speed) with gear lever in neutral and clutch engaged or reading of OBD in accordance with the manufacturer's recommendations and other requirements[1] Vehicle preconditioning:	(a) For vehicle registered or put into service for the first time after the date specified in the requirements[1] Opacity exceeds the level recorded on the manufacturer's plate on the vehicle.		X	

Item	*Method*	*Main Reasons for Rejection*	*Defect Assessment*		
			Minor	*Major*	*Dangerous*
	1. Vehicles may be tested without preconditioning, although for safety reasons checks should be made that the engine is warm and in a satisfactory mechanical condition				
	2. Precondition requirements: (i) Engine shall be fully warm, for instance the engine oil temperature measured by a probe in the oil level dipstick tube to be at least 80ºC or normal operating temperature if lower, or the engine block temperature measured by the level of infrared radiation to be at least an equivalent temperature. If, owing to the vehicle configuration, this measurement is impractical, the establishment of the engine's normal operating temperature may be made by other means, for example by the operation of the engine cooling fan. (ii) Exhaust system shall be purged by at least three free acceleration cycles or by an equivalent method.				
	Test procedure: 1. Engine and any turbocharger fitted, to be at idle before the start of each free acceleration cycle. For heavy-duty diesels, this means waiting for at least 10 seconds after the release of the throttle. 2. To initiate each free acceleration cycle, the throttle pedal must be fully depressed quickly and continuously (in less than one second) but not violently, so as to obtain maximum delivery from the injection pump.	(b) Where this information is not available or requirements[1] do not allow the use of reference values, - For naturally aspirated engines: 2.5 m^{-1} - For turbo-charged engines: 3.0 m^{-1} - For vehicles identified in requirements[1] or first registered or put into service for the first time after the date specified in requirements: for vehicles of emission classes Euro 5 and Euro V or equivalent 1.5 m^{-1} for vehicles of emission classes Euro 6 and Euro VI or equivalent 0.7 m^{-1}		X	

Item	*Method*	*Main Reasons for Rejection*	*Defect Assessment*		
			Minor	*Major*	*Dangerous*
	3. During each free acceleration cycle, the engine shall reach cut-off speed or, for vehicles with automatic transmissions, the speed specified by the manufacturer or, if this data is not available, then two thirds of the cut-off speed, before the throttle is released. This could be checked, for instance, by monitoring engine speed or by allowing a sufficient time to elapse between initial throttle depression and release, which in the case of vehicles of categories M_2, M_3, N_2 and N_3, should be at least two seconds.				
	4. Vehicles shall only be failed if the arithmetic means of at least the last three free acceleration cycles are in excess of the limit value. This may be calculated by ignoring any measurement that depart significantly from the measured mean, or the result of any other statistical calculation that takes account of the scattering of the measurements. Contracting Parties may limit the number of test cycles. 5. To avoid unnecessary testing, Contracting Parties may fail vehicles which have measured values significantly in excess of the limit values after fewer than three free acceleration cycles or after the purging cycles. Equally to avoid unnecessary testing, Contracting Parties may pass vehicles which have measured values significantly below the limits after fewer than three free acceleration cycles or after the purging cycles.				
3.2.2.2. Particulate Number counting	**Vehicle preparation** **At the beginning of the test the vehicle should be:** **— Hot, i.e., engine coolant temperature > 60 °C but preferably > 70 °C** **— Conditioned, by operating for a period of time at low idling and/or performing stationary accelerations up to maximum 2 000 rpm engine**	**Measurement results exceed 1 000 000 (1/cm^3)**		**X**	

Item	Method	Main Reasons for Rejection	Defect Assessment		
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	speed or by driving. Conditioning is done in order to ensure that the DPF efficiency is not influenced by a recent regeneration. Conditioning time is considered the period in which the engine is switched on including pre-test phases (e.g., stabilization phase). The recommended total conditioning time is 300 seconds. **A fast pass test is possible with engine coolant temperature < 60 °C. However, if the vehicle fails to pass the test, then the test is repeated and the vehicle should fulfil the requirements set for the engine coolant temperature and the conditioning.** **PN-PTI instrument preparation:** **— The PN-PTI instrument is powered on for at least the warm-up time indicated by the manufacturer;** **— Self-checks of the instrument defined in Annex 1 to R.E.6 monitor the proper operation of the instrument during operation and trigger a warning or message in case of malfunction;** **Before each test, the good condition of the sampling system is verified, including checking the sampling hose and probe for damage.** **Test procedure:** **— Before the start of a measurement, the following data is registered:** **(a) vehicle registration number,** **(b) vehicle identification number,** **(c) type-approved emissions level (Euro emission standard);** **— The software of the particle counter automatically guides the instrument operator through the test procedure;**				

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	— The probe is inserted at least 0.20 m into the outlet of the exhaust system. In justified exemptions where sampling at this depth is not possible, the probe is inserted at least 0.05 m. The sampling probe does not touch the walls of the tailpipe; **— If the exhaust system has more than one outlet, the test is done to all of them and the respective PN-PTI limit is respected at all tests. In this case, the highest measured PN concentration measured at different exhaust system outlets is considered to be the vehicle's PN concentration;** **— The vehicle operates at low idling. In case the engine of a vehicle is not switched on at static conditions then the start/stop system is deactivated by the test operator. For hybrid and plug-in hybrid vehicles, the thermal engine is required to be switched on (e.g., by switching on the air-conditioning system for hybrids or by selecting battery charging mode for plug-in hybrids);** **— After the probe has been inserted into the tailpipe, the following steps are followed for the PN-PTI test:** **(a) A stabilization period of at least 15 seconds with the engine running at idle speed. Optionally, before the stabilization period 2-3 accelerations up to maximum 2 000 rpm engine speed are performed,** **(b) After the stabilisation period, the PN concentration emissions are measured. The duration of the test is at least 15 seconds (total measurement duration). The test result is the average PN concentration of the measurement duration. If the measured PN concentration is more than two times the PN-PTI limit then the measurement may stop immediately before waiting for 15**				

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	seconds to elapse and the test result is reported. **After the completion of the test procedure, the PN-PTI instrument reports (and stores or prints) the average PN concentration of the vehicle and a "PASS" or "FAIL" message.** **— If the test result is less than or equal to the PN-PTI limit, the instrument reports a "PASS" message and the test was passed.** **— If the test result is greater than the PN-PTI limit, the instrument reports a "FAIL" message and the test failed.**				

3.3. Test equipment

Vehicle emissions are tested using equipment designed to establish accurately whether the limit values prescribed or indicated by the manufacturer have been complied with.

For the particulate number counting test, the equipment shall comply with the requirements laid down in the Resolution R.E.6 on test-equipment, skills and training of inspectors, supervision, chapter 3."

Part 2 Proposal for amendments to R.E.6.

Insert a new Paragraph 3.3., to read:

"3.3. Technical requirements concerning the equipment to measure number of particles;

All the technical requirements can be found in Annex 1 of this Resolution."

Insert a new Annex 1, to read:

"Annex 1 : Technical requirements concerning the equipment to measure number of particles

1. Metrological requirements

1.1. Indication of the measurement result

The instrument should ensure that:

(a) The PN per volume is expressed as number of particles per cm^3;

(b) The inscriptions for this unit are assigned unambiguously to the indication; "#/cm^3", "cm^{-3}", "particles/cm^3", "1/cm^3" are allowed.

1.2. Measuring range

The instrument should ensure that:

(a) The minimum measuring range, that may be subdivided, is from 5 000 1/cm^3 (maximum value for lower range) to twice the PN-PTI limit value (minimum value for the upper range);

(b) The exceedance of the range is indicated visibly by the instrument (e.g. warning message or flashing number);

(c) The measuring range is declared by the PN-PTI instrument manufacturer and complies with the minimum range defined in this paragraph. It is recommended that the PN-PTI instrument display range is wider than the measuring range, ranging from zero up to at least five times the PN-PTI limit value.

1.3. Resolution of the displaying device (for digital indicating instruments only)

The instrument should ensure that:

(a) PN concentrations as measurement results are legible, clear and unambiguously shown with their unit to the user;

(b) Digital figures are at least 5 mm high;

(c) The display provides a minimum resolution of 1 000 1/cm^3. If required by the NMI, during type examination/initial verification/subsequent verification access to a minimum resolution of 100 1/cm^3 between zero and 50 000 1/cm^3 is available.

1.4. Response time

The instrument should ensure that:

(a) For measuring PN concentration, the PN-PTI instrument including the

sampling line and sample preconditioning device (if any) indicates 95 % of the final value of a reference PN sample within 15 s after changing from HEPAfiltered or ambient air.

(b) Optionally, this test may be performed with two different PN concentrations.

(c) The PN-PTI instrument may be provided with a logging device to check that requirement.

1.5. Warm-up time

The instrument should ensure that:

(a) The PN-PTI instrument does not indicate the measured PN concentration during the warm-up time;

(b) After the warm-up time, the PN-PTI instrument meets the metrological requirements indicated in this Section.

1.6. Maximum permissible error ('MPE')

The MPE is relative to the actual concentration value (MPE_{rel}) or an absolute concentration value (MPE_{abs}), whicheveris greater.

(a) Reference operating conditions (see Section 1.13): MPErel is 25 % of the actual concentration but not lower than MPEabs

(b) Rated operating conditions (see Section 1.13): MPErel is 50 % of the actual concentration but not lower than MPEabs

(c) Disturbances (see Section 1.14): MPErel is 50 % of the actual concentration but not lower than MPE_{abs}

The MPE_{abs} is recommended to be less than or equal to 25 000 1/cm^3.

1.7. Efficiency requirements

The counting efficiency requirements are listed below:

	Particle size or geometric mean diameter [nm]	*Counting efficiency [-]*
Required	23 ± 5 %	0.2-0.6
Optional	30 ± 5 %	0.3-1.2
Required	50 ± 5 %	0.6-1.3
Required	70 or 80 ± 5 %	0.7-1.3
Optional	100 ± 5 %	0.7-1.3
Optional	200 ± 10 %	0.5-3.0

(a) The counting efficiency is determined with monodisperse particles with sizes defined in this Section or with polydisperse particles with geometric mean diameter ('GMD') defined in this Section and geometric standard deviation ('GSD') lower or equal to 1.6;

(b) The minimum concentration used for the efficiency tests should be higher than the lower value of the measuring range of the PN-PTI instrument divided by the lower counting efficiency defined for each

particle size in this Section. E.g. for a lower value of the measuring range 5 000 1/cm3, at 23 nm, the concentration of the particles measured by the reference system should be at least 25 000 1/cm3;

(c) Counting efficiency tests are performed under reference operating conditions (see Section 1.13) with thermally stable and soot-like particles. If needed, any neutralization and/or drying of the generated particles takes place before the splitter to the reference and test instrument(s). In case of monodisperse particles testing, the correction for multiple charged particles is not higher than 10 % (and is reported);

(d) The reference instrument is a traceable faraday cup electrometer or a traceable particle counter with counting efficiency > 0.5 at 10 nm (combined with a traceable diluter if necessary for polydisperse particles). The expanded uncertainty of the reference system, including the diluter if applicable, is less than 12.5 % but preferably less than or equal to one-third of the MPE at reference operating conditions;

(e) If the PN-PTI instrument includes any internal adjustment factor, it should remain the same (fixed) for all tests described in this paragraph.

(f) The whole PN-PTI instrument (i.e. including the sampling probe and sampling line, if present) should fulfil the counting efficiency requirements. At the request of the manufacturer, the PN-PTI instrument counting efficiencies may be tested in separate parts at representative conditions inside the instrument. In that case, the efficiency of the whole PN-PTI instrument (i.e. multiplication of efficiencies of all parts) fulfils the counting efficiency requirements.

1.8. Linearity requirements

The linearity testing should ensure that:

(a) The whole PN-PTI instrument is tested for its linearity with thermally stable, polydisperse soot-like particles with GMD 70 ± 10 nm and GSD lower or equal to 1.6;

(b) The reference instrument is a traceable particle counter with counting efficiency > 0.5 at 10 nm. The reference instrument may be accompanied by a traceable diluter in order to measure high concentrations, but the entire reference system (diluter + particle counter) expanded uncertainty remains below 12.5 % but preferably less than or equal to one-third of the MPE at reference operating conditions;

(c) The linearity tests are done with at least 9 different concentrations within the measuring range and the MPE at reference operating conditions (see Section 1.6) is respected.

(d) It is recommended to include at the testing concentrations the lower value of the measuring range, the applicable PN-PTI limit (± 10 %), twice the PN-PTI limit (± 10 %), and PN-PTI limit times 0.2. At least one concentration should be between the PN-PTI limit and the higher value of the measuring range as well as at least 3 concentrations distributed equally between the point where the MPE changes from absolute to relative and the PN-PTI limit.

(e) If the device is tested in parts, the linearity check may be limited to the particle detector, but the efficiencies of the rest of the parts should be taken into account for the error calculation.

The linearity requirements are summarized below:

Control location	*Reference*	*Minimum number of tested concentrations*	*MPE*
NMI	Traceable particle counter with traceable diluter	9	Reference operating conditions (see Section 1.6)

1.9. Zero-level

The zero point is tested with a HEPA filter. Zero-level is the average signal of the PN-PTI instrument with a HEPAfilter at its inlet over a period of at least 15 s after a stabilization period of at least 15 s. The maximum permissiblezero-level is 5 000 1/cm^3.

1.10. Volatile removal efficiency

The volatile removal efficiency testing should ensure that the system achieves > 95 % removal efficiency of tetracontane ($C_{40}H_{82}$) particles with electrical mobility size 30 nm ± 5 % and with concentration between 10 000and 30 000 1/cm^3. If needed, neutralisation of the tetracontane particles takes place before the splitter to the reference and test instrument(s). Alternatively, polydisperse tetracontane particles may be used with GMD between 30 and 35 nm and total concentration between 50 000 and 150 000 1/cm^3. In both cases (testing with monodisperse or polydisperse tetracontane particles), the reference system fulfils the same requirements as described in Section 1.8.

Volatile removal efficiency tests with larger tetracontane particle size (monodisperse) or GMD (polydisperse) and/or higher tetracontane concentrations than those described in this Section may be accepted only if the PN-PTI instrument passes the test (> 95 % removal efficiency).

1.11. Stability with time or drift

For the stability test, the PN-PTI instrument is used in accordance with the manufacturer's operating instructions.The stability testing of the instrument has to ensure that the measurements made by the PN-PTI instrument under stable environmental conditions remain within the MPE at reference operating conditions (see in Section 1.6). No PN-PTI instrument adjustment can be performed during the stability test.

If the instrument is equipped with a means for drift compensation, such as an automatic zero or automatic internal adjustment, the action of those adjustments does not produce an indication that can be confused with a measurement of an external gas. The stability measurements are performed for at least 12 h (not necessarily continuously) with nominal concentration of at least 100 000 1/cm^3. The comparison to a reference instrument (same requirements as the reference system described in Section 1.8) is done at least every hour. Accelerated stability test of 3 h with nominal concentration at least 10 000 000 1/cm^3 is permitted. In this case, the comparisonto the reference instrument is done hourly but with nominal concentration 100 000 1/cm^3.

1.12. Repeatability

The repeatability testing should ensure that for 20 consecutive measurements of the same reference PN samplecarried out by the same person with the same instrument within relatively short time intervals, the experimental standard

deviation of the 20 results is not greater than one third of the MPE (reference operating conditions) for the relevant sample. Repeatability is tested with a nominal concentration of at least 100 000 1/cm^3. Between every two consecutive measurements, HEPA filtered airflow or ambient airflow is supplied to the PN-PTI instrument.

1.13. Influence quantities

Reference operating conditions are presented below. The MPE specified for "Reference operating conditionsapplies (see in Section 1.6)

Ambient temperature	20 °C ± 2 °C
Relative humidity	50 % ± 20 %
Atmospheric pressure	Stable ambient (± 10 hPa)
Mains voltage	Nominal voltage ± 5 %
Mains frequency	Nominal frequency ± 1 %
Vibration	None/negligible
Voltage of battery	Nominal voltage of the battery

The minimum requirements for rated operating conditions testing are presented below. The MPE specified for"rated operating conditions" applies (see in Section 1.6).

Ambient temperature (IEC 60068-2-1, IEC 60068-2-2, IEC 60068-3-1)	From + 5 °C (test level index 2 according to OIML D11) (or less if specified by the manufacturer) to + 40 °C (test level index 1 according to OIML D11) (or more if specified by the manufacturer). When critical internal temperatures of the PN-PTI instrument are out of range, then the instrument does not indicate the measured value and indicates a warning
Relative humidity (IEC 60068-2-78, IEC 60068-3-4, IEC 60068-2-30)	Up to 85 %, no condensation (test level index 1 according to OIML D11) (when used inside) Up to 95 % condensing (when used outside)
Atmospheric pressure	860 hPa to 1 060 hPa
Mains voltage (IEC 61000-2-1, IEC 61000-4-1)	- 15 % to + 10 % of the nominal voltage (test level index 1 according to OIML D11)
Mains frequency (IEC 61000-2-1, IEC 61000-2-2, IEC 61000-4-1)	± 2 % of the nominal frequency (test level index 1 according to OIML D11)
Voltage of the road vehicle battery (ISO 16750-2)	12 V battery: 9 V to 16 V; 24 V battery: 16 V to 32 V

Voltage of internal battery	Low voltage, as specified by the manufacturer, up to the voltage of a new or fully charged battery of the specified type
1.14. Disturbances	
Significant faults as specified in MPE for disturbances (see in Section 1.6) should either not occur or should be detected and acted upon by means of checking facilities in case of the following minimum requirements for disturbances described below.	
Mechanical shock (IEC 60068-2-31)	Handheld: 1 fall of 1 m on each bottom edge Transportable: 1 fall of 25 mm on each bottom edge (test level index 1 according to OIML D11)
Vibration only for hand-held instruments (IEC 60068-2-47, IEC 60068-2-64, IEC 60068-3-8)	10 Hz to 150 Hz, 1.6 ms-2, 0.05 m2s-3, -3 dB/octave (test level index 1 according to OIML D11)
AC mains voltage dips, short interruptions and reductions (IEC 61000-4-11, IEC 61000-6-1, IEC 61000-6-2)	0.5 cycles – reduction to 0 % 1 cycle – reduction to 0 % 25/30 (*) cycles – reduction to 70 % 250/300 (*) cycles – reduction to 0 % (*) For 50 Hz/60 Hz respectively (test level index 1 according to OIML D11)
Burst (transients) on AC mains (IEC 61000-4-4)	Amplitude 2 kV Repetition rate 5 kHz (test level index 3 according to OIML D11)
Burst (transients) on signal, data and control lines (IEC 61000-4-4)	Amplitude 1 kV Repetition rate 5 kHz (test level index 3 according to OIML D11)
Surges on AC mains power lines (IEC 61000-4-5)	Line to line 1.0 kV Line to ground 2.0 kV (test level index 3 according to OIML D11)
Surges on signal, data and control lines (IEC 61000-4-5)	Line to line 1.0 kV Line to ground 2.0 kV (test level index 3 according to OIML D11
Electrostatic discharge (IEC 61000-4-2)	6 kV contact discharge 8 kV air discharge (test level index 3 according to OIML D11)
Radiated, radio-frequency, electromagnetic fields (IEC 61000-4-3, IEC 61000-4-20)	80 (26*) MHz up to 6 GHz, 10 V/m (test level index 3 according to OIML D11) * For an equipment under test, without any cabling to apply the test, the lower frequency limit is 26 MHz
Conducted radio-frequency fields (IEC 61000-4-6)	0.15 up to 80 MHz, 10 V (e.m.f.) (test level index 3 according to OIML D11)

Power frequency for magnetic fields (IEC 61000-4-8)	Continuous 100 A/m Short duration 1 000 A/m for 1 s (test level index 5 according to OIML D11)

For instruments powered by a road vehicle battery:

Electrical transient conduction along supply lines	Pulses 2a, 2b, 3a, 3b, test level IV (ISO 7637-2)
Electrical transient conduction via lines other than supply lines	Pulses a and b, test level IV (ISO 7637-3)
Load dump	Test B (ISO 16750-2)

2. Technical requirements

2.1. Construction

The instrument should fulfil the following specifications:

(a) All parts from the exhaust pipe up to the particle detector, which are in contact with raw and diluted exhaust gas, are made of corrosion-resistant material and do not influence the composition of the gas sample. The material of the sampling probe withstands the exhaust gas temperature;

(b) The PN-PTI instrument incorporates good particle sampling practices for minimization of particle losses;

(c) The sampling probe is so designed that it can be inserted at least 0.2 m (at least 0.05 m in justified exemptions) into the exhaust tail pipe of the vehicle and be securely held in place by a retaining device regardless of the depth of insertion and the tail pipe shape, size, and wall thickness. The sampling probe design facilitates sampling at the inlet of the sampling probe without touching the wall of the exhaust tail pipe;

(d) The instrument either contains a device that prevents water condensation from forming in the sampling and measuring components or a detector that gives an alarm and prevents a measurement result to be indicated. Some examples of devices or techniques that can prevent water condensation are heating of sampling line or dilution with ambient air near the sampling probe;

(e) If an adjustment reference is needed due to the measurement technique, simple means to provide such a sample (for example a sample/adjustment/verification port) is available with the instrument;

(f) When a dilution unit is included in the PN-PTI instrument, the dilution factor remains constant during a measurement;

(g) The device conveying the exhaust gas is mounted so that its vibrations do not affect the measurements. It can be switched on and off by the user separately from the other instrument components. However, no measurement can be performed when it is switched off. The gas handling system should be flushed automatically with ambient air before the device conveying the exhaust gas is switched off;

(h) The instrument is equipped with a device that indicates when the gas flow rate is lower than the minimum flow rate and, thus, the flow

decreases to a level that would cause the detection to exceed either the response time or the MPE at reference operating conditions (see in1.6). Additionally, and according to the technology used, the particle detector is equipped with temperature, current, voltage or any other relevant sensors that monitor critical parameters for the operation of PN-PTI instrument in order to remain within the MPE specified in these guidelines;

(i) The sample preconditioning device (when applicable) has to be airtight to such an extent that the influence of dilution air on the measurement results is not more than 5 000 1/cm^3;

(j) The instrument may be equipped with an interface permitting coupling to any peripheral device(s) or other instrument(s), as long as the metrological functions of the instrument(s) or their measurement data are not influenced by the peripheral devices, by other interconnected instruments or by disturbances acting on the interface. Functions that are performed or initiated via an interface meet the relevant requirements and conditions. If the instrument is connected to a data printer or an external data storage device, then the data transmission from the instrument to the printer is designed so that the results cannot be falsified. It is not possible to print out a document or store the measuring data in an external device (for legal purposes) if the instrument checking facility(ies) detect(s) a significant fault or a malfunction. The PN-PTI instrument interface respects the requirements of OIML D 11 and OIML D 31;

(k) The PN-PTI instrument has a reporting frequency equal to or greater than 1 Hz;

(l) The instrument is designed according to good engineering practice to ensure that particle counting efficiencies are stable across the test;

(m) The PN-PTI instrument or the device with the relevant software permits the logging time defined by the measurement procedure described in item 3.2.2.2. of the UN Rule No. 1 and reports the measurement and the test result according to the measurement procedure;

(n) The PN-PTI instrument or the device with the relevant software guides the user through the steps described in the measurement procedure described item 3.2.2.2. of the UN Rule No. 1;

(o) Optionally the PN-PTI instrument or the device with the relevant software may count the hours of operation in measurement mode.

2.2. Requirements for ensuring correct operation

(a) If the detection of one or more of disturbances is achieved by the use of automatic self-checking facilities, then it should be possible to check the correct functioning of such facilities;

(b) The instrument is controlled by an automatic checking facility that operates in such a way that, before a measurement can be indicated or printed, all adjustments, and all other checking facility parameters are confirmed for proper values or status (i.e. within limits);

(c) The following checks are integrated:

(i) The PN-PTI instrument automatically and continuously monitors relevant parameters that have a significant influence on the

measuring principle used (e.g. sample volume flow, detector temperature). If intolerable deviations occur, no measured value is displayed. If the PN-PTI requires a working fluid, performing measurements is not possible, if its level is not sufficient;

(ii) Memory test with clear verification of the software and function of the most important assemblies (automatically after each switch-on, then at the latest after each change of day);

(iii) A clean air or leakage test procedure to detect the specific maximum leakage (at least with each self-test, recommended before each measurement). If the measured value is larger than 5 000 1/cm^3, the instrument does not allow the user to further proceed with the measurement;

(iv) If required by the measuring principle, a zero-setting procedure performed with a HEPA filter at the inlet of the PN-PTI instrument (at least with each self-test, recommended before each measurement);

(d) Optionally, the PN-PTI instrument may integrate an ambient air or high PN concentration measurement procedure check, performed before the clean air or leakage test procedure, in which the PN-PTI instrument detects more particles than a predefined PN concentration;

(e) Instruments equipped with an automatic adjustment facility or a semi-automatic adjustment facility allow the user to make a measurement only after correct adjustments have been completed;

(f) Instruments equipped with a semi-automatic adjustment facility do not allow the user to make a measurement when an adjustment is required;

(g) A means for warning of a required adjustment may be provided for both automatic and semi-automatic adjustment facilities;

(h) Effective sealing devices are provided on all parts of the instrument that are not materially protected in another way against operations liable to affect the accuracy or the integrity of the instrument. This applies in particular to:

(i) adjustment means,

(ii) software integrity (see also OIML D 31 normal risk level or WELMEC 7.2 risk class C requirements);

(i) The legally relevant software is clearly identified. The identification is displayed or printed:

(i) on command, or

(ii) during operation, or

(iii) at start up for a measuring instrument that can be turned off and on again. All relevant provisions in OIML D 31 normal risk level or WELMEC 7.2 risk class C apply;

(j) Software is protected in such a way that evidence of any intervention (e.g. software updates, parameters changes) is available. All relevant provisions in OIML D 31 normal risk level or WELMEC 7.2 risk class C apply;

(k) The metrological characteristics of an instrument are not influenced in any inadmissible way by connecting it to another device, by any feature of the connected device itself or by any remote device that

communicates with the measuring instrument;

(l) A battery-operated instrument functions correctly with new or fully charged batteries of the specified type and either continues to function correctly or does not indicate any values whenever the voltage is below the manufacturer's specified value. Specific voltage limits for road vehicle batteries are prescribed in rated operating conditions (see Section 1.13).

3. Metrological controls

Metrological requirements are tested in three different stages:

(a) Type examination

(b) Initial verification

(c) Subsequent verification

3.1. Type examination

Compliance check is conducted for metrological requirements specified in Section 1 and technical requirements specified in Section 2, applied to at least one PN-PTI instrument, which represents the definitive instrument type. Tests are performed by a NMI.

3.2. Initial verification

For each PN-PTI instrument produced, the instrument manufacturer or a notified body chosen by the manufacturer does an initial verification.

The initial verification includes a linearity test with polydisperse particles with monomodal size distribution, GMD 70 ± 20 nm and GSD lower or equal to 2.1. The linearity check is performed with 5 reference PN samples. The MPE at reference operating conditions applies (see Section 1.6). The 5 reference PN samples concentration cover from one fifth of the PN-PTI limit to two times the PN-PTI limit (including those two concentrations, ±10 %) and also includes the PN-PTI limit (± 10 %).

The reference system consists of a traceable particle counter with counting efficiency at 23 nm higher or equal than 0.5 or fulfilling Section 1.7. The particle counter may be accompanied by a traceable diluter. The expanded uncertainty of the entire reference system remains below 12.5 % but preferably less than or equal to one-third of the MPE at reference operating conditions.

The material used for initial verification is thermally stable and soot-like. Other materials (e.g. salt particles) may be used.

The entire experimental setup used for initial verification (particle generator, PN-PTI instrument and reference system) is tested by the responsible NMI (preferably during the type examination of the PN-PTI instrument) and a setup correction factor to the NMI's type examination testing is determined. The setup correction factor takes under consideration differences between type examination and initial verification tests that arise from e.g. the particles material and the particle size distribution as well as the different reference instruments. The setup correction factor should be constant over the aforementioned concentration range (coefficient of variation less than 10 %) and is recommended to be in the range from 0.65 to 1.5. When the reference system or the particle generator change, the initial verification experimental setup is tested again by the responsible NMI.

Initial verification linearity requirements are summarized below:

Control location	*Reference instrument*	*Minimum number of concentrations*	*MPE*
Manufacturer or a notified body chosen by the manufacturer	Traceable particle counter (optionally with a traceable diluter)	5	Reference operating conditions (see Section 1.6)

Additional tests during the initial verification include:

(a) a visual inspection to determine conformance with the approved PN-PTI instrument type,

(b) a check of the power supply voltage and frequency at the location of use to determine compliance with the specifications on the measuring instrument's label,

(c) a clean air or leakage test (as described in the operating instructions),

(d) a zero-level test (as described in Section 1.9) if it differs from the clean air or leakage check,

(e) a low gas flow check by restricting the gas flow supplied to the sampling probe,

(f) a response time check.

Optionally, high PN concentration, counting efficiency and repeatability tests may be performed.

3.3. Subsequent verification

Subsequent verification of the accuracy of the PN-PTI instrument should take place whenever required by the instrument manufacturer, but no later than one year from the latest verification. Subsequent verification is a test performed at 3 different concentrations with polydisperse particles with monomodal size distribution, GMD 70 ± 20 nm and GSD lower or equal to 2.1. The MPE at rated operating conditions applies. The concentrations used for the test are one fifth of the PN-PTI limit, the PN-PTI limit, and twice the PN-PTI limit (concentrations within 20 %).

The subsequent verification test may be done either:

(a) in the premises of the manufacturer or of a notified body chosen by the manufacturer; or
(b) at the place of use of the PN-PTI instrument.

When the subsequent verification is performed in the premises of the manufacturer or of a notified body chosen by the manufacturer using the same approved setup for the initial verification, the same setup correction factor applies.

When the subsequent verification is performed at the place of use of the PN-PTI instrument, the portable setup comprises a portable particle generator and a portable reference system (traceable particle counter and optionally a traceable diluter).

The particle size distribution produced by the portable particle generator is required to fulfil the GMD and GSD defined in Section 3.2 for a total of at least 3 h spread over 3 different days under the same conditions that will be used in the field. That test is required to be repeated at least annually.

The portable reference system fulfils the same requirements as the reference systems used for initial verification linearity tests (see Section 3.2) but its expanded uncertainty at rated operating conditions remains below 20 % but preferably less than or equal to one-third of the MPE at rated operating conditions.

The entire portable experimental setup used for subsequent verification (portable particle generator, PN-PTI instrument and reference system) is tested by the responsible NMI and a setup correction factor to the NMI's type examination testing is determined. The setup correction factor takes into consideration differences between type examination and subsequent verification tests that arise from e.g. the particles material and the particle size distribution as well as the different reference instruments. The setup correction factor should be constant over the Subsequent verification testing concentration range (coefficient of variation less than 10 %) and is recommended to be in the range from 0.65 to 1.5. When the portable reference system or the portable particle generator change, anew approval by the NMI is required.

The subsequent verification linearity requirements are summarized below:

Control location	*Reference instrument*	*Minimum number of concentrations*	*MPE*
Manufacturer or notified body facilities or field	Traceable particle counter (optionally with a traceable diluter)	3	Rated operating conditions (see Section 1.6)

Additional tests during the subsequent verification include:

(a) a visual inspection to determine the validity of the previous verification and the presence of all required stamps, seals and documents,

(b) a clean air or leakage check (as described in the operating instructions),

(c) a zero-level test (as described in Section 1.9) if it differs from the clean air or leakage check,

(d) a low gas flow check by restricting the gas flow supplied to the sampling probe,

(e) a response time check,

(f) a high PN concentration test (optionally).”

II. Justification

1. The proper working of a diesel particulate filter cannot be determined in the PTI with an opacity test because opacimeters have a lack of sensitivity and are not able to measure low particulate emissions. In order to measure low particulate emissions (near to zero) low cost particle counters were developed and these are now commercially available.

2. In daily use some diesel particulate filters fail or are removed. The particulate emissions of these vehicles raise dramatically and cause adverse health effects of human beings.

3. The measured PN-concentrations in the proposed low idle speed test are representative because they correlate reasonably well with PN emissions in chassis dynamometer tests.

4. The EU Commission recommendation on “particle number measurement for the periodic technical inspection of vehicles equipped with compression ignition engines” has been used as a basis for the modifications from ECE/TRANS/WP.29/GRPE/2023/9.