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To:	General Secretariat of the Council
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Subject:	ANNEXES to the COMMISSION REGULATION (EU) …/… amending Regulation (EU) No 582/2011 as regards Auxiliary Emission Strategies (AES), access to vehicle OBD information and vehicle repair and maintenance information, measurement of emissions during cold engine start periods and use of portable emissions measurement systems (PEMS) to measure particle numbers, with respect to heavy duty vehicles

Delegations will find attached document D062755/02.

Encl.: D062755/02

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COMMISSION

Brussels, XXX
D062755/02
[…](2019) XXX draft

ANNEXES 1 to 3

ANNEXES

to the

COMMISSION REGULATION (EU) …/…

amending Regulation (EU) No 582/2011 as regards Auxiliary Emission Strategies (AES), access to vehicle OBD information and vehicle repair and maintenance information, measurement of emissions during cold engine start periods and use of portable emissions measurement systems (PEMS) to measure particle numbers, with respect to heavy duty vehicles

ANNEX I

Annex I to Regulation (EU) No 582/2011 is amended as follows:

(1) in point 3.1., the introductory wording is replaced by the following:

In the case of an engine type-approved as a separate technical unit or a vehicle type-approved with regard to emissions, the engine shall bear:';

(2) point 3.4. is replaced by the following:

'3.4. In the case of an application for EU type-approval of a vehicle with an approved engine with regard to emissions or for EU type-approval of a vehicle with regard to emissions, the label specified in Section 3.3 shall also be placed close to the fuel filling aperture.';

(3) Section 8 is replaced by the following:

‘8. DOCUMENTATION

8.1. The documentation package required by Articles 5, 7 and 9 enabling the approval authority to evaluate the emission control strategies and the systems on-board the vehicle and engine to ensure the correct operation of NOx control measures, as well as the documentation packages required by Annex VI (off-cycle emissions), Annex X (OBD) and Annex XVIII (dual-fuel engines) shall include the following information:

(a) a full description of the inducement system required by Annex XIII, including the associated monitoring strategies;

(b) the description of the anti-tampering measures considered in point (b) of Article 5(4) and in point (a) of Article 7(4).’;

(4) Appendix 4 is amended as follows:

(a) the first paragraph is replaced by the following:

'relating to:

EU type-approval of an engine or engine family as a separate technical unit,

EU type-approval of a vehicle with an approved engine with regard to emissions,

EU type-approval of a vehicle with regard to emissions.';

(b) under the heading ‘Explanatory notes (regarding filling in the table)’, the fourth, fifth and sixth paragraphs are replaced by the following:

'In the case of application for EU type-approval of an engine or engine family as a separate technical unit the general part and Part 1 shall be filled in.

In the case of application for EU type-approval of a vehicle with an approved engine with regard to emissions the general part and Part 2 shall be filled in.

In the case of application for EU type-approval of a vehicle with regard to emissions the general part and Parts 1 and 2 shall be filled in.;

(c) in the "general part" of the table, the fifth row is replaced by the following:

‘0.2.0.3.	Engine type as separate technical unit/engine family as separate technical unit/vehicle with an approved engine with regard to emissions/vehicle with regard to emissions([1])	';

(d) below the "general part" of the table, the words ‘Part 3: ACCESS TO VEHICLE REPAIR AND MAINTENANCE INFORMATION’ are deleted;

(e) Part 3 of the table is deleted;

(5) in Appendix 5, in Table 6a (PEMS demonstration test) under point 1.4.4. of the Addendum to an EU type-approval certificate, the rows concerning "Pass-fail results" for the "Work window conformity factor" and the " CO_2 mass window conformity factor" are replaced by the following:

‘Pass-fail results ([7])	CO	THC	NMHC	CH_4	NO_x	PM number
Work window conformity factor([11])						
CO_2 mass window conformity factor([11])						';

(6) in Appendix 7, in Table 6a (PEMS demonstration test) under point 1.4.4. of the Addendum to an EU type-approval certificate, the rows concerning "Pass-fail results" for the "Work window conformity factor" and the "CO_2 mass window conformity factor" are replaced by the following:

'

‘Pass-fail results ([7])	CO	THC	NMHC	CH_4	NO_x	PM number
Work window conformity factor([11])						
CO_2 mass window conformity factor([11])						';

(7) in Appendix 9, Table 1 and the accompanying Key are replaced by the following:

'

'*Table 1*

Charac ter	NO_x OTL[1]	PM OTL[2]	CO OTL[3]	IUPR[4]	Reagen t quality	Additi onal OBD monit	Power thresh old requir	Cold start and PM	Imple menta tion dates:	Imple menta tion dates:	Last date of registr

						ors[5]	ements[6]	number	new types	all vehicles	ation
A[7][8] B[8]	Row 'phase-in period' of Table 1 or Table 2	Performance Monitoring[9]	N/A	Phase-in[10]	Phase-in[11]	N/A	20 %	N/A	31.12.2012	31.12.2013	31.8.2015[7] 30.12.2016[8]
B[12]	Row 'phase-in period' of Tables 1 and 2	N/A	Row 'phase-in period' of Table 2	N/A	Phase-in[11]	N/A	20 %	N/A	1.9.2014	1.9.2015	30.12.2016
C	Row 'general requirements' of Table 1 or Table 2	Row 'general requirements' of Table 1	Row 'general requirements' of Table 2	General[13]	General[14]	Yes	20 %	N/A	31.12.2015	31.12.2016	31.8.2019
D	Row 'general requirements' of Table 1 or Table 2	Row 'general requirements' of Table 1	Row 'general requirements' of Table 2	General[13]	General[14]	Yes	10 %	N/A	1.9.2018	1.9.2019	31.12.2021
E	Row 'general requirements' of Table	Row 'general requirements' of Table	Row 'general requirements' of Table	General[13]	General[14]	Yes	10 %	Yes	1.1.2021[15]	1.1.2022[15]	

	1 or Table 2	1	2								

Key:

1 'NO_x OTL' monitoring requirements as set out in Table 1 of Annex X for compression ignition and dual-fuel engines and vehicles and Table 2 of Annex X for positive ignition engines and vehicles.

2 'PM OTL' monitoring requirements as set out in Table 1 of Annex X for compression ignition and dual-fuel engines and vehicles.

3 'CO OTL' monitoring requirements as set out in Table 2 of Annex X for positive ignition engines and vehicles.

4 IUPR specifications are set out in Annex X. Positive Ignition engines and vehicles equipped with such engines are not subjected to IUPR.

5 Additional provisions concerning monitoring requirements as set out in paragraph 2.3.1.2 of Annex 9A to UNECE Regulation No 49.

6 ISC requirement set out in Appendix 1 to Annex II.

7 For positive-ignition engines and vehicles equipped with such engines.

8 For compression-ignition and dual-fuel engines and vehicles equipped with such engines.

9 'Performance monitoring' requirements as set out in point 2.1.1 of Annex X.

10 IUPR 'Phase-in' requirements as set out in Section 6 of Annex X

11 Reagent quality 'phase-in' requirements as set out in point 7.1 of Annex XIII.

12 Only applicable to positive-ignition engines and vehicles equipped with such engines.

13 IUPR 'General' requirements as set out in Section 6 of Annex X.

14 Reagent quality 'general' requirements as set out in point 7.1.1 of Annex XIII.

15 Subject to transitional measures laid down in Article 17a.

N/A Not applicable.**';**

(8) in Appendix 10, the following explanatory note is inserted:

'(11) CF_{final} needs to be stated, if applicable'.;

(9) the following Appendix is added:

'Appendix 11

AES DOCUMENTATION PACKAGE

The AES documentation package shall include the following:

(A) information on all AES:

(a) a declaration of the manufacturer that the engine system or engine family type approved as a separate technical unit, or the vehicle with an approved engine system with regard to emissions, or an vehicle type approved with regard to emissions, does not contain any defeat strategy;

(b) a description of the engine and the emission control strategies and devices employed, whether software or hardware, and any condition(s) under which the strategies and devices will not operate as they do during testing for Type Approval;

(c) a declaration of the software versions used to control the AES/BES, including the appropriate checksums of these software versions and instructions to the authority on how to read the checksums; the declaration shall be updated and sent to the approval authority that holds this documentation package each time there is a new software version that has an impact to the AES/BES;

(d) detailed technical reasoning of any AES including a risk assessment estimating the risk with and without the AES, and including the following:

(i) information on the hardware element(s) that need to be protected by the AES, where applicable;

(ii) proof of sudden and irreparable engine damage that cannot be prevented by regular maintenance and would occur in the absence of the AES, where applicable;

(iii) a reasoned explanation on why there is a need to use an AES upon engine starting or warm up, where applicable;

(e) a description of the fuel system control logic, timing strategies and switch points during all modes of operation;

(f) a description of the hierarchical relations among the AES (i.e., when more than one AES can be active concurrently, an indication of which AES is primary in responding, the method by which strategies interact, including data flow diagrams and decision logic and how does the hierarchy assure emissions from all AES are controlled to the lowest practical level;

(g) a list of parameters which are measured and/or calculated by the AES, along with the purpose of every parameter measured and/or calculated and how each of those parameters relates to engine damage; including the method of calculation and how well these calculated parameters correlate with the true state of the parameter being controlled and any resulting tolerance or factor of safety incorporated into the analysis;

(h) a list of engine/emission control parameters which are modulated as a function of the measured or calculated parameter(s) and the range of modulation for each engine/emission control parameter; along with the relationship between engine/emission control parameters and measured or calculated parameters;

(i) an evaluation of how the AES will control real-driving emissions to the lowest practical level, including a detailed analysis of the expected increase of total regulated pollutants and CO_2 emissions by using the AES, compared to the BES;.

The AES documentation package shall be limited to 100 pages and shall include all the main elements to allow the approval authority to assess the AES (according to the requirements of Annex VI, appendix 2), the effectiveness of the inducement system and the anti-tampering measures. The package may be complemented with annexes and other attached documents, containing additional and complementary elements, if necessary. The manufacturer shall send a new version of the AES documentation package to the approval authority every time changes are introduced to the AES. The new version shall be limited to the changes and their effect. The new version of the AES shall be evaluated and approved by the approval authority.

The AES documentation package shall be structured as follows:

AES Documentation Package No. YYY/OEM

Parts	paragraph	point	Explanation
Introduction documents		Introduction letter to TAA	Reference of the document with the version, the date of issuing the document, signature by the relevant person in the manufacturer organisation
		Versioning table	Content of each version modifications: and with part is modified
		Description of the (emission) types concerned	
		Attached documents table	List of all attached documents
		Cross references	Link to paragraph (a) to (i) of Appendix 11 (where to find each requirement of the regulation)
		Absence of defeat device declaration	+ Signature
Core document	0	Acronyms/abbreviations	
	1	GENERAL DESCRIPTION	
	1.1	Engine general presentation	Description of main characteristics: displacement, after treatment,…
	1.2	General system architecture	System bloc diagram: list of sensors and actuators, explanation of engine general functions
	1.3	Reading of software and calibration version	E.g. scan-tool explanation
	2	Base Emission Strategies	
	2.x	BES x	Description of strategy x
	2.y	BES y	Description of strategy y
	3	Auxiliary Emission Strategies	
	3.0	Presentation of the AESs	Hierarchical relations among AES: description and justification (e.g. safety, reliability, etc.)
	3.x	AES x	3.x.1 AES justification 3.x.2 measured and/or modelled parameters for AES characterization 3.x.3 Action mode of AES - Parameters used 3.x.4 Effect of AES on pollutants and CO_2

	3.y	AES y	3.y.1 3.y.2 etc.
	4.	Description of the inducement system, including the associated monitoring strategies	
	5.	Description of the anti-tampering measures	
	100 page limit ends here		
	Annex		List of types covered by this BES-AES: including Type Approval reference, software reference, calibration number, checksums of each version and of each electronic control unit (engine and/or after-treatment if any)
Attached documents		Technical note for AES justification n°xxx	Risk assessment or justification by testing or example of sudden damage, if any
		Technical note for AES justification n°yyy	
		Test report for specific AES impact quantification	Test report of all specific tests done for AES justification, test conditions details, description of the vehicle / date of the tests emission/CO_2 impact with/without AES activation';

'.

ANNEX II

Annex II to Regulation (EU) No 582/2011 is amended as follows:

(1) in point 4.1. the following is inserted between the second and third paragraph:

' In case the legally permissible maximum vehicle weight is lower than the technically permissible laden mass of the vehicle, it is permitted to use the legally permissible maximum vehicle weight to determine the vehicle payload for the test run.';

(2) point 4.6.2. is replaced by the following:

'4.6.2. Emissions and other data sampling shall start prior to starting the engine. Cold start emissions shall be included in the emissions evaluation, in accordance with point 2.6.1. of Appendix 1.';

(3) point 6.3. , including Table 2, is replaced by the following:

'6.3. The final conformity factor for the test (CF_{final}) for each pollutant calculated in accordance with Appendix 1 shall not exceed the maximum allowed conformity factor for that pollutant set out in Table 2.

Table 2

Maximum allowed conformity factors for in-service conformity emission testing

Pollutant	Maximum allowed conformity factor
CO	1,50
THC(1)	1,50
NMHC(2)	1,50
CH_4(2)	1,50
NO_x	1,50
PM number	1,63(3)

1 For compression-ignition engines.

2 For positive-ignition engines.

3 Subject to transitional measures laid down in Article 17a';

(4) the following point is inserted after point 10.1.8.5.:

'10.1.8.5a PM number concentration [#/cm^3]';

(5) the following point is inserted after point 10.1.9.5.:

'10.1.9.5a PM number flux [#/s] ';

(6) the following point is inserted after point 10.1.9.10.:

'10.1.9.10a PM number [#]';

(7) the following point is inserted after point 10.1.9.19.:

'10.1.9.19a Work window PM number conformity factor [-]';

(8) the following point is inserted after point 10.1.9.24.:

'10.1.9.24a CO_2 mass window PM number conformity factor [-]';

(9) the following point is inserted after point 10.1.10.12.:

'10.1.10.12a. PM number [#]. ';

(10) the following point is inserted after point 10.1.11.5.:

'10.1.11.5a. Work window PM number conformity factor [-].';

(11) the following point is inserted after point 10.1.11.9.:

'10.1.11.9a CO_2 mass window PM number conformity factor [-].';

(12) the following point is inserted after point 10.1.12.4.:

'10.1.12.4a PM number analyser zero, pre and post test.';

(13) Appendix 1 is amended as follows:

(a) in point 1, the first paragraph is replaced by the following:

'This Appendix describes the procedure to determine pollutant emissions from on-vehicle on-road measurements using Portable Emissions Measurement Systems (hereinafter 'PEMS'). The pollutant emissions to be measured from the exhaust of the engine include the following components: carbon monoxide, total hydrocarbons, nitrogen oxides and PM number for compression ignition engines and carbon monoxide, non-methane hydrocarbons, methane, nitrogen oxides and PM number for positive ignition engines. Additionally, carbon dioxide shall be measured to enable the calculation procedures described in Section 4.';

(b) point 2.1.1. is replaced by the following:

'2.1.1. Gas analysers and PM number analysers to measure the concentrations of regulated pollutants in the exhaust gas.';

(c) in point 2.2., Table 1 is replaced by the following:

'*Table 1*

Test parameters

Parameter	Unit	Source
THC concentration(1)	ppm	Gas analyser
CO concentration(1)	ppm	Gas analyser
NO_x concentration(1)	ppm	Gas analyser
CO_2 concentration(1)	ppm	Gas analyser
CH_4 concentration(1)(2)	ppm	Gas analyser
PM number concentration	# / cm^3	PM number analyser

Dilution setting (if applicable)	-	PM number analyser
Exhaust gas flow	kg/h	Exhaust Flow Meter (hereinafter 'EFM')
Exhaust temperature	K	EFM
Ambient temperature(3)	K	Sensor
Ambient pressure	kPa	Sensor
Engine torque(4)	Nm	ECU or Sensor
Engine speed	rpm	ECU or Sensor
Engine fuel flow	g/s	ECU or Sensor
Engine coolant temperature	K	ECU or Sensor
Engine intake air temperature(3)	K	Sensor
Vehicle ground speed	km/h	ECU and GPS
Vehicle latitude	degree	GPS
Vehicle longitude	degree	GPS

(1) Measured or corrected to a wet basis.

(2) Gas engines only.

(3) Use the ambient temperature sensor or an intake air temperature sensor.

(4) The recorded value shall be either (a) the net brake engine torque in accordance with point 2.4.4 of this Appendix or (b) the net brake engine torque calculated from the torque values in accordance with point 2.4.4 of this Appendix.';

(d) in Section 2.4, the following points are added:

'2.4.6. Installation of PM number analyser

The installation and operation of the PEMS shall be leak-tight and minimise heat loss. To avoid the generation of particles, connectors shall be thermally stable at the exhaust gas temperatures expected during the test. Where elastomer connectors are used to connect the vehicle exhaust outlet and the connecting tube, those connectors shall have no contact with the exhaust gas to avoid artefacts at high engine load.

2.4.7. Sampling of PM number emissions

Emissions sampling shall be representative and conducted at locations of well-mixed exhaust gas where the influence of ambient air downstream of the sampling point is minimal. Where applicable, emissions shall be sampled downstream of the exhaust mass flow meter, respecting a distance of at least 150 mm to the flow sensing element. The sampling probe shall be fitted at least 3 times the inner diameter of the exhaust pipe upstream of the point at which the exhaust exits into the environment. The exhaust shall be sampled from the centre of the exhaust stream. Where several probes are used for emissions sampling, the particle sampling probe shall be placed upstream of the other sampling probes. The particle sampling probe shall not interfere with the sampling of gaseous pollutants. The type and specifications of the probe and its mounting shall be documented in detail, either in the test report of the Technical Service (in the case of testing at type approval) or in the vehicle manufacturer's own documentation (in case of in-service conformity testing).

Where particles are sampled and not diluted at the tailpipe, the sampling line from the raw exhaust sample point to the point of dilution or particle detector shall be heated to a minimum of 373 K (100 °C).

All parts of the sampling system, from the exhaust pipe to the particle detector, which are in contact with raw or diluted exhaust gas, shall be designed to minimise the deposition of particles. All parts shall be made from anti-static material to prevent electrostatic effects.';

(e) in Section 2.5, the following point is added:

'2.5.5. Checking the PM number analyser

The PEMS shall function free of errors and critical warnings. The zero level of the PM number analyser shall be recorded by sampling high efficiency particulate filtered ambient air (HEPA) at the inlet of the sampling line in the 12 hour-period before test start. The signal shall be recorded at a constant frequency of at least 1,0 Hz averaged over a period of 2 minutes. The final absolute concentration shall be within the manufacturer's specifications and, in addition, shall not exceed 5000 particles per cubic centimetre. ';

(f) point 2.6.1. is replaced by the following:

'2.6.1. *Test start*

For the purposes of the test procedure, 'test start' shall mean the first ignition of the internal combustion engine.

Emissions sampling, measurement of the exhaust parameters and recording of the engine and ambient data shall commence prior to the test start. Artificial warming up of the emission control systems of the vehicle prior to the test start shall be prohibited.

At test start, the temperature of the coolant shall not exceed the ambient temperature by more than 5 °C, and shall not exceed 303 K (30 °C). The data evaluation shall start once the coolant temperature has reached 303 K (30 °C) for the first time or once the coolant temperature is stabilised within +/– 2 K over a period of 5 minutes, whichever occurs first, but in any event no later than 10 minutes after test start.';

(g) point 2.6.3 is replaced by the following:

'2.6.3 *Test end*

Test end is reached when the vehicle has completed the trip and the internal combustion engine is switched off.

The internal combustion engine shall be switched off as soon as practicable at the end of the trip. Data shall continue to be recorded until the response time of the sampling systems has elapsed.';

(h) in Section 2.7., point 2.7.4. paragraph (a) is replaced by the following:

'(a) if the difference between the pre-test and post-test results is less than 2 % as specified in points 2.7.2 and 2.7.3, the measured concentrations may be used uncorrected or shall, at the request of the manufacturer, be corrected for drift according to point 2.7.5.';

(i) in Section 2.7, the following point is added:

'2.7.6 Checking the PM number analyser

The zero level of the PM number analyser shall be checked before test start and after test end and recorded in accordance with the requirements of point 2.5.5.';

(j) points 3.1.1., 3.1.2. and 3.1.3. are replaced by the following:

'3.1.1. *Analysers data*

The data from the gas analysers shall be properly aligned using the procedure laid down in paragraph 9.3.5 of Annex 4 to UNECE Regulation No 49. The data from the PM number analyser shall be time aligned with its own transformation time, according to the instrument manufacturer's instructions.

3.1.2. *Analysers and Exhaust Flow Meter (EFM) data*

The data from the gas analysers and the PM number analysers shall be properly aligned with the data of the EFM using the procedure in point 3.1.4.

3.1.3. PEMS and engine data

The data from the PEMS (gas analysers, PM number analyser and EFM) shall be properly aligned with the data from the engine ECU using the procedure in point 3.1.4.';

(k) in point 3.1.4, '1: Gas analysers (THC, CO, CO_2, NO_x concentrations);' is replaced by the following:

'1 : Gas analysers (THC, CO, CO_2, NO_x concentrations) and PM number analyser;'

(l) in Section 3, the following point is added:

'3.6. Calculation of the instantaneous PM number emissions

The instantaneous PM number (PN_i) emissions [#/s] shall be determined by multiplying the instantaneous concentration of the PM number [#/cm^3] with the instantaneous exhaust mass flow rate [kg/s], both corrected and aligned for the transformation time, according to paragraph 1.4.3. of Appendix 3. All negative instantaneous emissions values shall enter subsequent data evaluations as zero. All significant digits of intermediate results shall enter the calculation of the instantaneous emissions. The following formula shall apply for the purposes of determining the instantaneous PM number emissions:

$PN_i = c_{PNi} . q_{mewi} / \rho_e$

where:

PN_i is the instantaneous PM number emissions [#/s]

c_{PNi} is the measured PM number concentration [#/m^3] normalised at 273 K (0°C) including internal dilution and particle losses

q_{mewi} is the measured exhaust mass flow rate [kg/s]

ρ_e is the density of the exhaust gas [kg/m^3] at 273 K (0°C).';

(m) points 4.2.1 and 4.2.1.1. are replaced by the following:

4.2.1. Calculation of the specific emissions

The specific emissions *e* ([mg/kWh] or [#/kWh]) shall be calculated for each window and each pollutant in the following way:

$$e = \frac{m}{W(t_{2,i}) - W(t_{1,i})}$$

where:

m is the mass emission of the pollutant [mg/window] or the PM number [#/window]

$W(t_{2,i}) - W(t_{1,i})$ is the engine work during the i^{th} averaging window [kWh].

4.2.1.1. Calculation of the specific emissions for a declared market fuel

If a test pursuant to this Annex was performed with a market fuel declared in point 3.2.2.2.1 of Part 1 in Appendix 4 to Annex I, the specific emissions *e* ([mg/kWh] or [#/kWh]) shall be calculated for each window and each pollutant by multiplying the specific emissions determined in accordance with point 4.2.1. with the power correction factor determined pursuant to point 1.1.2 (a1) of Annex I.';

(n) point 4.2.3. is replaced by the following:

'4.2.3. *Calculation of the conformity factors*

The conformity factors shall be calculated for each individual valid window and each individual pollutant in the following way:

$$CF = \frac{e}{L}$$

where:

e is the brake-specific emission of the gaseous pollutant [mg/kWh] or [#/kWh];

L is the applicable limit [mg/kWh] or [#/kWh].';

(o) point 4.3.2. is replaced by the following:

'4.3.2. Calculation of the conformity factors

The conformity factors shall be calculated for each individual valid window and each individual pollutant in the following way:

$$CF = \frac{CF_I}{CF_C}$$

Where:

$$CF_I = \frac{m}{m_{CO2}(t_{2,i}) - m_{CO2}(t_{1,i})}$$ (in service ratio) and

$$CF_C = \frac{m_L}{m_{CO2,ref}}$$ (certification ratio)

where:

m is the mass emission of the gaseous pollutant [mg/window], or the PM number [#/window];

$m_{CO2}(t_{2,i}) - m_{CO2}(t_{1,i})$ is the CO_2 mass during the i^{th} averaging window [kg];

$m_{CO2,ref}$ is the engine CO_2 mass determined for the WHTC [kg];

m_L is the mass emission of the gaseous pollutant or the PM number corresponding to the applicable limit on the WHTC [mg] or [#] respectively]. ';

(p) in Section 4, the following points are added:

'4.4. Calculation of the final conformity factor for the test

4.4.1. The final conformity factor for the test (CF_{final}) for each pollutant shall be calculated as follows:

$$CF_{final} = 0.14 \cdot CF_{cold} + 0.86 \cdot CF_{warm}$$

where:

CF_{cold} is the conformity factor of the period of cold operation of the test, which shall be equal to the highest conformity factor of the moving averaging windows starting below 343 K (70 °C) coolant temperature, determined for that pollutant in accordance with the calculation procedures specified in points 4.1. and either 4.2. or , as applicable, 4.3.;

CF_{warm} is the conformity factor of the period of warm operation of the test, which shall be equal to the 90^{th} cumulative percentile of the conformity factors determined for that pollutant in accordance with the calculation procedures specified in points 4.1 and either 4.2. or , as applicable, 4.3., when the data evaluation is started after the coolant temperature has reached 343 K (70 °C) for the first time.';

(14) Appendix 2 is amended as follows:

(a) point 1 is replaced by the following:

'1. *GENERAL*

The gaseous emissions and the PM number shall be measured according to the procedure set out in Appendix 1. This Appendix describes the characteristics of the portable measurement equipment that shall be used to perform such measurement tests.';

(b) in Section 2, the following points are added:

'2.5 PM number analysers

2.5.1 General

2.5.1.1. The PM number analyser shall consist of a pre-conditioning unit and a particle detector (see Figure 1). The particle detector may also pre-condition the aerosol. The analyser's sensitivity to shocks, vibrations, aging, variations in temperature and air pressure, electromagnetic interferences and other things that could affect the operation of the vehicle or the analyser shall be kept to a minimum as far as possible and shall be clearly stated in the supporting documentation produced by the instrument manufacturer. The PM number analyser shall fulfil the requirements of this Regulation and the specifications of the instrument manufacturer.

Figure 1

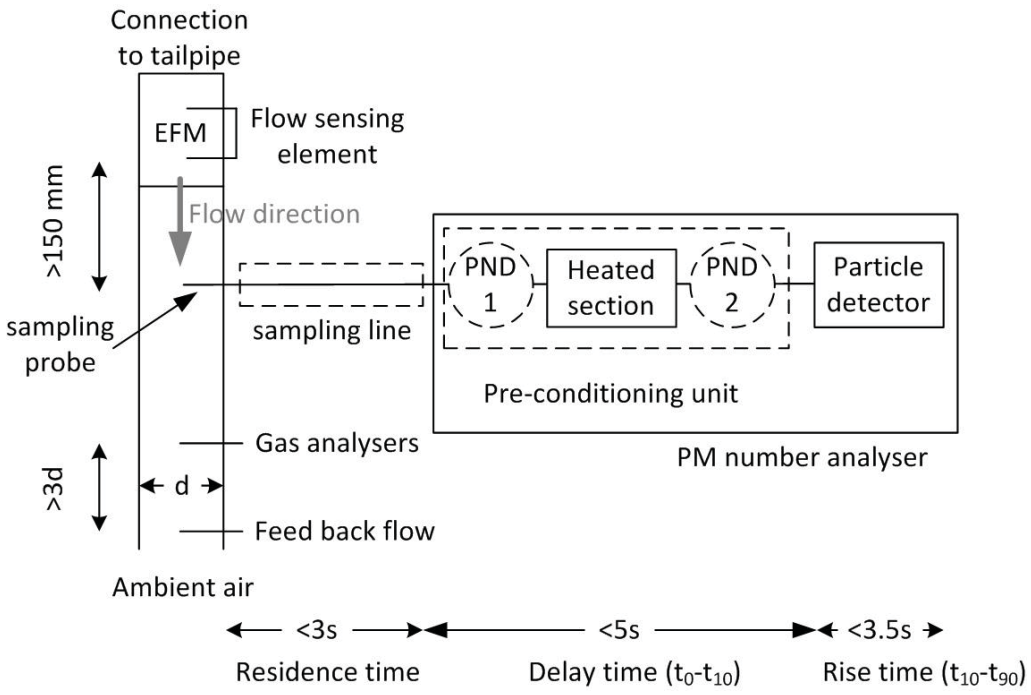
Example of a PM number analyser setup

(dotted lines depict optional parts)

EFM: Exhaust mass Flow Meter

d: inner diameter

PND: PM Number Diluter



2.5.1.2. The PM number analyser shall be connected to the sampling point via a sampling probe which extracts a sample from the centreline of the tailpipe tube. If particles are not diluted at the tailpipe, the sampling line shall be heated to a minimum temperature of 373 K (100 °C) until the point of first dilution of the PM number analyser or the particle detector of the analyser. The residence time of the sample in the particle sampling line shall be less than 3 seconds to the point of first dilution or to the particle detector.

2.5.1.3. All parts in contact with the sampled exhaust gas shall be always kept at a temperature that avoids condensation of any compound in the device. That may be achieved e.g. by heating to a higher temperature and diluting the sample or oxidising the (semi)volatile species.

2.5.1.4. The PM number analyser shall include a heated section at wall temperature ≥573K (300 °C). The pre-conditioning unit shall control the heated stages to constant nominal operating temperatures, within a tolerance of ±10 K and provide an indication of whether or not heated parts are at their correct operating temperatures. Lower temperatures are acceptable as long as the volatile particle removal efficiency meets the specifications set out in point 2.5.4.

2.5.1.5. Pressure, temperature and other sensors shall monitor the operation of the instrument during its operation and shall trigger a warning or message in case of malfunction.

2.5.1.6. The delay time inside the PM number analyser shall be <5 s. Delay time means the time difference between a change of concentration at the reference point and a system response of 10% of the final reading.

2.5.1.7. The PM number analyser (and/or particle detector) shall have a rise time of <3.5 s.

2.5.1.8. Particle concentration measurements shall be reported normalised to 273 K (0 °C) and 101.3 kPa. If considered necessary using best engineering judgement, the pressure and/or temperature at the inlet of the detector shall be measured and reported for the purposes of normalising the particle concentration.

2.5.1.9. PM number analysers that comply with the calibration requirements of UNECE Regulation No 83 or 49 or GTR 15 shall be deemed to comply with the calibration requirements of this Annex.

2.5.2. Efficiency requirements

2.5.2.1. The complete PM number analyser system and the sampling line, shall meet the efficiency requirements of Table 1:

Table 1: PM number analyser system (and sampling line) efficiency requirements

dp [nm]	sub-23	23	30	50	70	100	200
E(dp)	--*	0.2-0.6	0.3-1.2	0.6-1.3	0.7-1.3	0.7-1.3	0.5-2.0

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(*) Will be defined at a later stage.

2.5.2.2. Efficiency E(dp) is the ratio in the readings of the PM number analyser system to a reference Condensation Particle Counter (CPC)'s (d50=10nm or lower, checked for linearity and calibrated with an electrometer) or an Electrometer's number concentration measuring in parallel monodisperse aerosol of mobility diameter dp and normalised at the same temperature and pressure conditions. The material shall be thermally stable and soot-like (e.g. spark discharged graphite or diffusion flame soot with thermal pre-treatment). If the efficiency curve is measured with a different aerosol (e.g. NaCl), the correlation to the soot-like curve shall be provided in the form of a chart which compares the efficiencies obtained using both test aerosols. The differences in the counting efficiencies shall be taken into account by adjusting the measured efficiencies based on that comparison chart to give soot-like aerosol efficiencies. Any correction for multiple charged particles shall be applied and documented, but it shall not exceed 10%. The final efficiencies (e.g. adjusted for the different material and multiple charged particles) shall cover the PM number analyser and sampling line. The PM number analyser may alternatively be calibrated in parts (i.e. the pre-conditioning unit separately from the particle detector) provided that the PM number analyser and the sampling line together meet the requirements of Table 1. The signal measured from the detector shall be >2 times the limit of detection (here defined as the zero level plus 3 standard deviations).

2.5.3. Linearity requirements

2.5.3.1. The linearity requirements shall be verified whenever damage is observed, as required by internal audit procedures or by the instrument manufacturer, at least once within the 12-month period leading up to a test.

2.5.3.2. The PM number analyser, and the sampling line, shall meet the linearity requirements set out in Table 2.

Table 2: Linearity requirements of PM number analyser (and the sampling line)

Measurement parameter / instrument	$\lvert\chi_{min} \times (a_1 - 1) + a_0\rvert$	Slope a_1	Standard error SEE	Coefficient of determination r^2
PM number analyser	≤5% max	0.85-1.15	≤10% max	≥0.950

2.5.3.3. The PM number analyser system and the sampling line, shall meet the linearity requirements of Table 2 using monodisperse or polydisperse soot-like particles. The particle size (mobility diameter or count median diameter) shall be larger than 45 nm. The reference instrument shall be an Electrometer or a Condensation Particle Counter (CPC) with d50=10 nm or lower, verified for linearity. Alternatively, the reference instrument may be a particle number system that complies with the requirements of UNECE Regulation No 49.

2.5.3.4. In addition, the differences between the PM number analyser and the reference instrument at each of the points that are checked (except the zero point) shall be within 15% of their mean value. At least 5 points equally distributed (plus the zero point) shall be checked. The maximum checked concentration shall be the maximum allowed concentration of the PM number analyser.

If the PM number analyser is calibrated in parts, the linearity may be checked only for the detector, but the efficiencies of the other parts and the sampling line shall be taken into account in the slope calculation.

2.5.4. Volatile removal efficiency

2.5.4.1. The PM number analyser system shall achieve >99% removal of ≥30 nm tetracontane ($CH_3(CH_2)_{38}CH_3$) particles with an inlet concentration of ≥10,000 particles per cubic centimetre at the minimum dilution.

2.5.4.2. Additionally, the PM number analyser system shall also achieve a >99% removal efficiency of polydisperse alcane (decane or higher) or emery oil with count median diameter >50 nm and an inlet concentration of ≥ $5x10^6$ particles per cubic centimetre at the minimum dilution (equivalent mass >1 mg/m3).

2.5.4.3. The volatile removal efficiency with tetracontane and/or polydisperse alcane or oil need to be proven only once for the PEMS family. A PEMS family is considered to be a group of instruments with the same analysers, sample and thermal conditioning and software compensation algorithms. The instrument manufacturer shall provide the maintenance or replacement interval that ensures that the removal efficiency does not drop below the technical requirements. If such information is not provided by the instrument manufacturer, the volatile removal efficiency shall be checked yearly for each instrument.';

(15) in Appendix 3, the following point is added:

'1.4. PM number analyser calibration and verification

1.4.1. The PEMS leakage test shall be conducted either in accordance with the requirements set out in paragraph 9.3.4 of Annex 4 to UNECE Regulation No 49 or in accordance with the instrument manufacturer’s instructions.

1.4.2. The response time check of the PM number analyser shall be conducted in accordance with the requirements set out in paragraph 9.3.5 of Annex 4 to UNECE Regulation No 49 using particles if gases cannot be used.

1.4.3. The transformation time of the PM number analyser system and its sampling line, shall be determined in accordance with paragraph A.8.1.3.7. of Appendix 8 to Annex 4 to UNECE Regulation No 49. 'Transformation time' means the time difference between a change of concentration at the reference point and a system response of 50% of the final reading.

ANNEX III

Annex VI to Regulation (EU) No 582/2011 is amended as follows:

(1) in Section 8, the following paragraph is added:

'The methodology for the assessment of AES is described in Appendix 2 to this Annex. ';

(2) in Appendix 1, the second paragraph of point 3.1. is replaced by the following:

'The vehicle payload shall be 50-60 % of the maximum vehicle payload. A deviation from that range may be agreed with the approval authority. The reason for such a deviation shall be indicated in the test report. The additional requirements set out in Annex II shall apply. ';

(3) the following Appendix is added:

'Appendix 2

Methodology for the assessment of AES

For the purposes of assessing the AES, the approval authority shall verify at least whether the requirement laid down in this Appendix are fulfilled.

(1) The increase of emissions induced by the AES shall be kept at the lowest possible level:

(a) The increase of total emissions when using an AES shall be kept at the lowest possible level throughout the normal use and life of the vehicles;

(b) Whenever a technology or design that would allow for improved emission control is available on the market at the time of the AES preliminary assessment it shall be used with no unjustified modulation

(2) When used to justify an AES, the risk of sudden and irreparable damage to the engine, shall be appropriately demonstrated and documented, including the following information:

(a) Proof of catastrophic (i.e. sudden and irreparable) engine damage shall be provided by the manufacturer, along with a risk assessment which includes an evaluation of the likelihood of the risk occurring and severity of the possible consequences, including results of tests carried out to this effect;

(b) When a technology or design is available on the market at the time of the AES application that eliminates or reduces that risk, it shall be used to the largest extent technically possible (i.e. with no unjustified modulation);

(c) Durability and the long-term protection of the engine or components of the emission control system from wear and malfunctioning shall not be considered an acceptable reason to accept an AES.

(3) An adequate technical description shall document why it is necessary to use an AES for the safe operation of the vehicle:

(a) Proof of an increased risk to the safe operation of the vehicle should be provided by the manufacturer along with a risk assessment which includes an evaluation of the likelihood of the risk occurring and severity of the possible consequences, including results of tests carried out to this effect;

(b) When a different technology or design is available on the market at the time of the AES application that would allow for lowering the safety risk, it shall be used to the largest extent technically possible (i.e. with no unjustified modulation).

(4) An adequate technical description shall document why it is necessary to use an AES during engine start or warm up:

(a) Proof of the need to use an AES during engine start shall be provided by the manufacturer along with a risk assessment which includes an evaluation of the likelihood of the risk occurring and severity of the possible consequences, including results of tests carried out to this effect;

(b) Where a different technology or design is available on the market at the time of the AES application that would allow for improved emission control upon engine start, it shall be used to the largest extent technically possible.'.