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From:	Secretary-General of the European Commission, signed by Mr Jordi AYET PUIGARNAU, Director
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To:	Mr Jeppe TRANHOLM-MIKKELSEN, Secretary-General of the Council of the European Union
No. Cion doc.:	C(2018) 2473 final ANNEXES 1 to 11
Subject:	ANNEXES to the COMMISSION DELEGATED REGULATION (EU) .../... amending and correcting Delegated Regulation (EU) 2017/654 supplementing Regulation (EU) 2016/1628 of the European Parliament and of the Council with regard to technical and general requirements relating to emission limits and type-approval for internal combustion engines for non-road mobile machinery

Delegations will find attached document C(2018) 2473 final ANNEXES 1 to 11.

Encl.: C(2018) 2473 final ANNEXES 1 to 11

EUROPEAN
COMMISSION

Brussels, 18.5.2018
C(2018) 2473 final

ANNEXES 1 to 11

ANNEXES

to the

COMMISSION DELEGATED REGULATION (EU) .../...

amending and correcting Delegated Regulation (EU) 2017/654 supplementing Regulation (EU) 2016/1628 of the European Parliament and of the Council with regard to technical and general requirements relating to emission limits and type-approval for internal combustion engines for non-road mobile machinery

ANNEX I

Annex I to Delegated Regulation (EU) 2017/654 is amended as follows:

(1) point 1.2.2. is replaced by the following:

‘1.2.2. In the absence of either a standard from the European Committee for Standardization (‘CEN standard’) for non-road gas-oil or a table of fuel properties for non-road gas-oil in Directive 98/70/EC of the European Parliament and of the Council(*), the diesel (non-road gas-oil) reference fuel in Annex IX shall represent market non-road gas-oils with a sulphur content not greater than 10 mg/kg, cetane number not less than 45 and a Fatty-Acid Methyl Ester (‘FAME’) content not greater than 8,0 % v/v. Except where otherwise permitted in accordance with points 1.2.2.1., 1.2.3. and 1.2.4., the manufacturer shall make a corresponding declaration to the end-users in accordance with the requirements in Annex XV that operation of the engine on non-road gas-oil is limited to those fuels with a sulphur content not greater than 10 mg/kg (20 mg/kg at point of final distribution) cetane number not less than 45 and a FAME content not greater than 8,0 % v/v. The manufacturer may optionally specify other parameters (e.g. for lubricity).

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* Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC (OJ L 350, 28.12.1998, p. 58).’;

(2) point 1.2.2.1. is amended as follows:

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

‘The engine manufacturer shall not indicate at any time that an engine type or engine family may be operated within the Union on market fuels other than those that comply with the requirements in this point unless the manufacturer additionally complies with the requirement in point 1.2.3.’;

(b) point (c) is replaced by the following:

‘(c) In the case of diesel (non-road gas-oil), Directive 98/70/EC and also both a cetane number not less than 45 and FAME not greater than 8,0 % v/v.’;

(3) point 2.4.1.4. is deleted.

ANNEX II

Annex II to Delegated Regulation (EU) 2017/654 is amended as follows:

(1) the following point 6.2.3.1. is inserted:

‘6.2.3.1. Notwithstanding point 6.2.3, in the case of engines of category RLL where an existing test report is used for type-approval in accordance with Article 7(2) of Implementing Regulation (EU) 2017/656, the per cent load and power and the weighting factor for the mode number of the test cycle type F for the purpose of this Annex may be the same as that used for the type-approval test.’;

(2) in point 6.2.4., the words ", as determined in accordance with Annex III" are replaced by the words "that were determined in accordance with Annex III";

(3) in point 6.4., the third sentence is replaced by the following:

‘For engines fuelled with natural gas/biomethane (NG) or liquefied petroleum gas (LPG), including dual-fuel engines, the tests shall be performed with at least two of the reference fuels for each gaseous-fuelled engine, except in the case of a gaseous-fuelled engine with a fuel-specific type-approval where only one reference fuel is required, as described in Appendix 1 to Annex I.’.

ANNEX III

Annex III to Delegated Regulation (EU) 2017/654 is amended as follows:

(1) points 3.1.3. and 3.1.4. are replaced by the following:

‘3.1.3. The test engine shall represent the emission deterioration characteristics of the engine families that will apply the resulting deterioration factors for type approval. The engine manufacturer shall select one engine representing the engine family, group of engine families or engine-after-treatment system family, as determined in accordance with point 3.1.2., for testing over the service accumulation schedule referred to in point 3.2.2., which shall be reported to the approval authority before any testing commences.

3.1.4. If the approval authority decides that the worst case emissions of the engine family, group of engine families or engine-after-treatment system family can be better characterised by another test engine, the test engine to be used shall be selected jointly by the approval authority and the engine manufacturer.’;

(2) point 3.2.1. is replaced by the following:

‘3.2.1. General

Deterioration factors applicable to an engine family, group of engine families or an engine-after-treatment system family shall be developed from the selected engines based on a service accumulation schedule that includes periodic testing for gaseous and particulate emissions over each test cycle applicable to the engine category, as given in Annex IV to Regulation (EU) 2016/1628. In the case of non-road transient test cycles for engines of category NRE (‘NRTC’), only the results of the hot-start run of the NRTC (‘hot-start NRTC’) shall be used.’;

(3) in point 3.2.5.2., the last paragraph is replaced by the following:

‘Where emission values are used for engine families in the same group of engine families or engine-after-treatment family but with different emission durability periods, then the emission values at the emission durability period end point shall be recalculated for each emission durability period by extrapolation or interpolation of the regression equation as determined in point 3.2.5.1.’;

(4) in point 3.2.6.1., the last paragraph is deleted;

(5) the following point 3.2.6.1.1. is inserted:

‘3.2.6.1.1. Notwithstanding point 3.2.6.1., for PN, either an additive DF of 0,0 or a multiplicative DF of 1,0 may be used, in conjunction with the results of previous DF testing that did not establish a value for PN if both of the following conditions are fulfilled:

(a) the previous DF test was conducted on engine technology that would have qualified for inclusion in the same engine after-treatment system family, as set out in point 3.1.2., as the engine family to which it is intended to apply the DFs; and,

(b) the test results were used in a previous type-approval granted before the applicable EU type-approval date given in Annex III to Regulation (EU) 2016/1628.'.

ANNEX IV

Annex IV to Delegated Regulation (EU) 2017/654 is amended as follows:

(1) the following points 2.2.3.1. and 2.2.4. are inserted:

‘2.2.3.1. Notwithstanding point 2.2.3., in the case of engine (sub-)categories that are not subject to non-road transient test cycles for EU type-approval purposes, the base emission control strategy may identify when transient operating conditions occur and apply the corresponding emission control strategy. In this case, this emission control strategy shall be included in the overview of the base emission control strategy required by point 1.4. of Annex I to Implementing Regulation (EU) 2017/656 and in the confidential information on emission control strategy set out in Appendix 2 to that Annex.

2.2.4 The manufacturer shall demonstrate to the technical service at the time of the EU type-approval test that the operation of the base emission control strategy complies with the provisions of this section on the basis of the documentation referred to in point 2.6.’;

(2) in point 2.6., the paragraph under the heading is deleted;

(3) the following points 2.6.1. and 2.6.2. are inserted:

‘2.6.1. The manufacturer shall comply with the documentation requirements laid down in point 1.4. of Part A of Annex I to Implementing Regulation (EU) 2017/656 and Appendix 2 to that Annex.

2.6.2. The manufacturer shall ensure that all documents used for this purpose are marked with an identification number and date of issue. The manufacturer shall notify to the approval authority whenever the particulars recorded are changed. In this case, it shall issue, either a updated version of the documents concerned where the relevant pages are marked clearly showing the date of revision and the nature of the amendment, or alternatively, a new consolidated version accompanied by an index containing a detailed description and date of each amendment.’;

(4) Appendix 1 is amended as follows:

(a) point 2.2.1. is replaced by the following:

‘2.2.1. Monitoring for reagent level in the storage tank shall be conducted under all conditions where measurement is technically feasible (for instance, under all conditions when a liquid reagent is not frozen).’;

(b) the following points 2.2.2. and 2.2.3. are inserted:

‘2.2.2. Reagent freeze protection shall apply at ambient temperatures at or below 266 K (– 7 °C).

2.2.3. All elements of the NO_x control diagnostic system other than those listed in points 2.2.1. and 2.2.2. shall, at a minimum, be operational at the applicable control conditions set out in point 2.4. of this Annex for each engine category. The diagnostic system shall remain operational outside of this range where technically possible.’;

(c) the following point 2.3.2.2.4. is inserted:

‘2.3.2.2.4. Evaluation of the design criteria may be performed in a cold chamber test cell using an entire non-road mobile machinery or parts representative of those to be installed on a non-road mobile machinery or based on field tests.’;

(d) point 2.3.2.3. is replaced by the following:

‘2.3.2.3. Activation of the operator warning and inducement system for a non-heated system’;

(e) the following points 2.3.2.3.1. and 2.3.2.3.2. are inserted:

2.3.2.3.1. The operator warning system described in points 4 to 4.9. shall be activated if no reagent dosing occurs at an ambient temperature ≤ 266 K (– 7 °C).

2.3.2.3.2. The severe inducement system as referred to in point 5.4. shall be activated if no reagent dosing occurs within a maximum of 70 minutes after engine start at an ambient temperature ≤ 266 K (– 7 °C).’;

(f) points 2.3.3, 2.3.3.1., and 2.3.3.2. are deleted;

(g) in point 5.2.1.1., the following point (ea) is inserted:

‘(ea) A description of the connection for, and method to read, the records referred to in point (e) shall be included in the information folder set out in Part A of Annex I to Implementing Regulation (EU) 2017/656;’;

(h) point 9.5 is replaced by the following:

‘9.5. As an alternative to the monitoring requirements set out in point 9.2, the manufacturer may monitor for failures using a NO_x sensor located in the exhaust system. In this case,

(a) the NO_x value at which the NCM shall be detected shall not exceed the lower of either the applicable NO_x limit multiplied by 2,25 or the applicable NO_x limit plus 1,5 g/kWh. For engine sub-categories with a combined HC and NO_x limit, the applicable NO_x limit value for the purpose of this point shall be the combined limit value for HC and NO_x reduced by 0,19 g/kWh.

(b) a single warning may be used, including, where messages are used, the statement ‘high NO_x – root cause unknown’,

(c) in point 9.4.1 the maximum number of engine operating hours between the activation of the operator warning system and the activation of the low-level inducement system shall be reduced to 10,

(d) in point 9.4.2 the maximum number of engine operating hours between the activation of the operator warning system and the activation of the severe inducement system shall be reduced to 20.’;

(i) points 10.3.1. to 10.3.3.1. are replaced by the following:

‘10.3.1. The compliance of the warning system activation shall be demonstrated by performing two tests: lack of reagent, and one failure category identified in sections 7, 8 or 9.

10.3.2. Selection of the failure to be tested among those referred to in sections 7, 8 or 9.

10.3.2.1. The approval authority shall select one failure category. In the case that a failure is selected from points 7 or 9, the additional requirements set out in points 10.3.2.2. or 10.3.2.3. shall apply, respectively.

10.3.2.2. For the purpose of demonstrating the activation of the warning system in case of a wrong reagent quality, a reagent shall be selected with a dilution of the active ingredient at least as dilute as that communicated by the manufacturer in accordance with the requirements set out in points 7 to 7.3.3.

10.3.2.3. For the purpose of demonstrating the activation of the warning system in case of failures that may be attributed to tampering, and are defined in section 9 the selection shall be performed in accordance with the following requirements:

10.3.2.3.1. The manufacturer shall provide the approval authority with a list of such potential failures.

10.3.2.3.2. The failure to be considered in the test shall be selected by the approval authority from the list referred to in point 10.3.2.3.1.

10.3.3. Demonstration

10.3.3.1. For the purpose of this demonstration, a separate test shall be performed for the lack of reagent and the failure selected in accordance with points 10.3.2. to 10.3.2.3.2.’;

(j) the following points 10.5. and 10.5.1. are inserted:

‘10.5. Documentation of the demonstration

10.5.1. A demonstration report shall document the demonstration of the NCD system. The report shall:

(a) identify the failures examined;

(b) describe the demonstration performed including the applicable test cycle;

(c) confirm that the applicable warnings and inducements were activated as required by this regulation; and

(d) be included in the information folder as set out in Part A of Annex I of Implementing Regulation (EU) 2017/656.’;

(k) points 11.4.1.1. and 11.4.1.1.1. are replaced by the following:

‘11.4.1.1. To comply with the requirements of this Appendix, the system shall contain counters to record the number of hours during which the engine has been operated while the system has detected any of the following NCM:

(a) an incorrect reagent quality;

(b) an interruption of reagent dosing activity;

(c) an impeded EGR valve;

(d) a failure of the NCD system.

11.4.1.1.1. The manufacturer may use one or more counters for grouping the NCMs indicated in point 11.4.1.1.';

(l) the following points 13.4. and 13.4.1. are added:

'13.4. Documentation of the demonstration

13.4.1. A demonstration report shall document the demonstration of the minimum acceptable reagent concentration. The report shall:

(a) identify the failures examined;

(b) describe the demonstration performed including the applicable test cycle;

(c) confirm that the pollutant emissions arising from this demonstration did not exceed the NO_x threshold specified in point 7.1.1.;

(d) be included in the information folder as set out in Part A of Annex I to Implementing Regulation (EU) 2017/656.';

(5) Appendix 2 is amended as follows:

(a) points 2. to 4.5. are replaced by the following:

'2. General requirements

The requirements of Appendix 1 apply to engines in scope of this Appendix, except as set out in points 3 and 4 of this Appendix.

3. Exceptions to the requirements of Appendix 1

In order to account for safety concerns the operator inducement system set out in points 5 and 11.3. of Appendix 1 shall not apply to engines under the scope of this Appendix. The requirement to store data in an on-board computer log set out in point 4 of this Appendix shall apply wherever the inducement would have been activated in accordance with points 2.3.2.3.2., 6.3., 7.3., 8.4. and 9.4. of Appendix 1.

4. Requirement for storing incidents of engine operation with inadequate reagent injection or reagent quality

4.1. The on-board computer log must record in non-volatile computer memory or counters the total number and duration of all incidents of engine operation with inadequate reagent injection or reagent quality in a manner to ensure that the information cannot be intentionally deleted.

4.1.1. It shall be possible for national inspection authorities to read these records with a scan tool.

4.1.2. A description of the connection for, and method to read, these records shall be included in the information folder as set out in Part A of Annex I of Implementing Regulation (EU) 2017/656.

4.2. The duration of an incident of inadequate reagent level recorded in the on-board computer log as specified in point 4.1., in place of an inducement in accordance with point 6.3. of Appendix 1, shall commence when the reagent tank becomes empty, that is, when the dosing system is unable to draw further reagent from the tank, or at any level below 2,5 % of its nominally full capacity at the discretion of the manufacturer.

4.3. The duration of an incident recorded in the on-board computer log as specified in point 4.1, in place of the inducement specified in points 6.3., 7.3., 8.4. and 9.4. of Appendix 1, shall commence when the respective counter reaches the value for severe inducement in Table 4.4 of Appendix 1.

4.4. The duration of an incident recorded in the on-board computer log as specified in point 4.1., in place of the inducement specified in point 2.3.2.3.2. of Appendix 1, shall commence when inducement would have commenced.

4.5. The duration of an incident recorded in the on-board computer log as specified in point 4.1. shall end when the incident has been remedied.';

(b) the following point 4.6. is inserted:

'4.6. When conducting a demonstration pursuant to section 10.4. of Appendix 1, the demonstration shall be conducted in accordance with the requirements applicable to demonstration of the severe inducement system, but the demonstration of severe inducement system shall be replaced by a demonstration of the storage of an incident of engine operation with inadequate reagent injection or reagent quality.';

(6) Appendix 4 is amended as follows:

(a) point 2.2.1. is replaced by the following:

'2.2.1. The PCD system shall, at a minimum, be operational at the applicable control conditions set out in point 2.4. of Annex IV for each engine category. The diagnostic system shall remain operational outside of this range where technically possible.';

(b) point 3.1. is replaced by the following:

'3.1. The OEM shall provide to all end-users of new non-road mobile machinery written instructions about the emission control system and its correct operation as required in Annex XV.';

(c) the following point 5.4. is inserted:

'5.4. A description of the connection for, and method to read, these records shall be included in the information folder as set out in Part A of Annex I of Implementing Regulation (EU) 2017/656.';

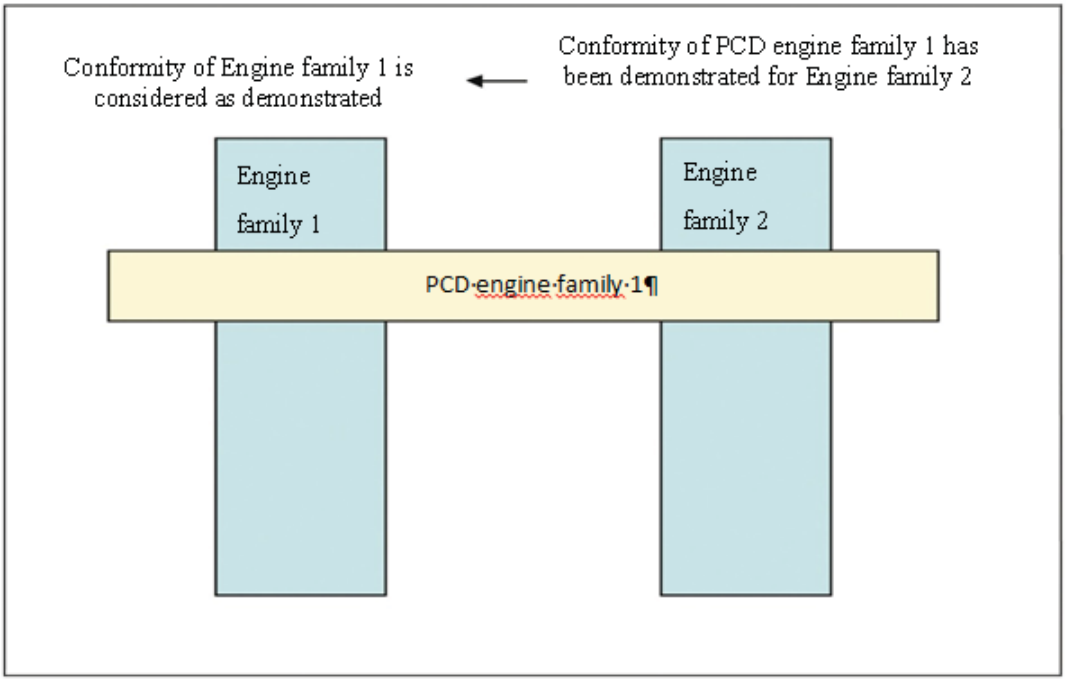
(d) point 9.2.1. is replaced by the following:

'9.2.1. In the case where engines of an engine family belong to a PCD engine family that has already been EU type-approved, in

accordance with point 2.3.6. (Figure 4.8), the compliance of that engine family is deemed to be demonstrated without further testing, provided the manufacturer demonstrates to the authority that the monitoring systems necessary for complying with the requirements of this Appendix are similar within the considered engine and PCD engine families.

Figure 4.8.

Previously demonstrated conformity of a PCD engine family



’;

(e) in point 9.3.3.6.2., point (a) is replaced by the following:

‘(a) the requested test-cycle results in a monitor that will run in real world operation conditions; and’;

(f) the following points 9.3.6. and 9.3.6.1. are added:

‘9.3.6. Documentation of the demonstration

9.3.6.1. A demonstration report shall document the demonstration of the PCD system. The report shall:

(a) identify the failures examined;

(b) describe the demonstration performed including the applicable test cycle;

(c) confirm that the applicable warnings were activated as required by this regulation;

(d) be included in the information folder as set out in Part A of Annex I to Implementing Regulation (EU) 2017/656.’.

ANNEX V

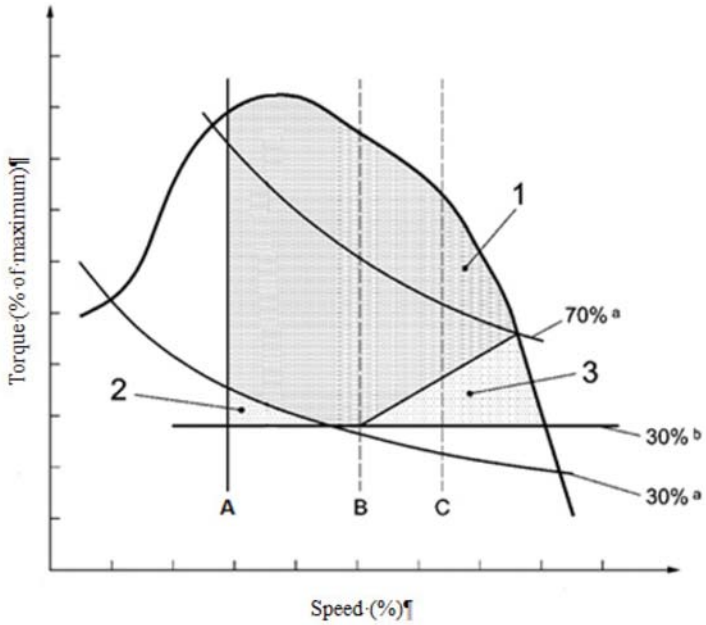
Annex V to Delegated Regulation (EU) 2017/654 is amended as follows:

(1) point 2.1.2. is amended as follows:

(a) Figure 5.2 is replaced by the following:

'*Figure 5.2.*

Control area for variable-speed engines of category NRE with maximum net power < 19 kW and variable-speed engines of category IWA with maximum net power < 300 kW, speed C < 2400 rpm



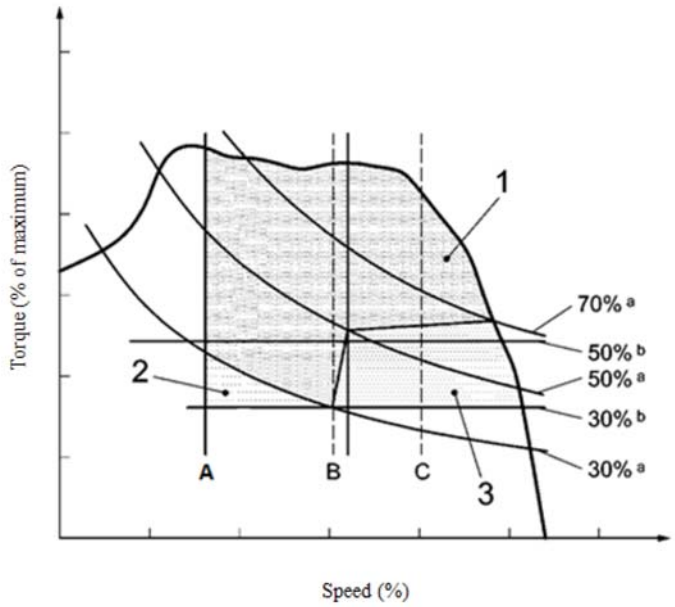
Key

1	Engine Control Area	2	All Emissions Carve-Out
3	PM Carve-Out	a	% of maximum net power
b	% of maximum torque';		

(b) Figure 5.3 is replaced by the following:

‘*Figure 5.3.*

Control area for variable-speed engines of category NRE with maximum net power < 19 kW and variable-speed engines of category IWA with maximum net power < 300 kW, speed C ≥ 2400 rpm



Key

1	Engine Control Area	2	All Emissions Carve-Out
3	PM Carve-Out	a	Percent of maximum net power
b	Percent of maximum torque’;		

(2) the following point 3.1. is inserted:

‘3.1. For the purpose of the random selections required in point 3, acknowledged statistical methods of randomization shall be used.’;

(3) point 4 is amended as follows:

(a) the introductory wording is replaced by the following

‘The test shall be carried out immediately after the applicable NRSC as follows:';

(b) point (a) is replaced by the following:

'(a) the test of the randomly selected torque and speed points shall either be carried out immediately after the discrete-mode NRSC test sequence described in points (a) to (e) of point 7.8.1.2. of Annex VI but before the post test procedures (f) or after the ramped modal non-road steady- state test cycle (‘RMC’) test sequence described in points (a) to (d) of point 7.8.2.3. of Annex VI but before the post test procedures (e) as relevant;';

(c) points (e) and (f) are replaced by the following:

'(e) for gaseous and PN, if applicable, summation calculations, N_{mode} in equations (7-64) or (7-131) and (7-178) shall be set to 1 and a weighting factor of 1 shall be used;

(f) for PM calculations the multiple filter method shall be used; for summation calculations, N_{mode} in equations (7-67) or (7-134) shall be set to 1 and a weighting factor of 1 shall be used.';

(4) the following point 5 is added:

'5. Regeneration

In the case that a regeneration event occurs during or immediately preceding the procedure set out in point 4, upon completion of that procedure the test may be voided at the request of the manufacturer, irrespective of the cause of the regeneration. In this case the test shall be repeated. The same torque and speed points shall be used although the running order may be changed. It shall not be deemed necessary to repeat any torque and speed points for which a pass result has already been obtained. The following procedure shall be used for repeating the test:

(a) The engine shall be operated in a manner to ensure that the regeneration event has completed and, where applicable, the soot load in the particulate after-treatment system has been re-established;

(b) The engine warm-up procedure shall be performed in accordance with point 7.8.1.1. of Annex VI;

(c) The test procedure specified in point 4 shall be repeated commencing at the stage referred to in point 4(b).'.

ANNEX VI

Annex VI to Delegated Regulation (EU) 2017/654 is amended as follows:

(1) point 1 is replaced by the following:

‘1. Introduction

This Annex describes the method of determining emissions of gaseous and particulate pollutants from the engine to be tested and the specifications related to the measurement equipment. As from section 6, the numbering of this Annex is consistent with the numbering of the Global technical regulation No 11* (GTR No 11) and UNECE Regulation No 96.04 series of amendments**, Annex 4B. However, some points of the GTR No 11 are not needed in this Annex, or are modified in accordance with the technical progress.

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* Global technical regulation No 11 on Engine Emissions from agricultural and forestry tractors and from non-road mobile machinery under the Global Registry created on 18 November 2004, pursuant to Article 6 of the Agreement concerning the establishing of global technical regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles.

** Regulation No 96 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of compression ignition (C.I.) engines to be installed in agricultural and forestry tractors and in non-road mobile machinery with regard to the emissions of pollutants by the engine.’;

(2) in point 5.1., the second, third and fourth paragraphs are replaced by the following:

‘The measured values of gaseous and particulate pollutants and of CO_2 exhausted by the engine refer to the brake-specific emissions in grams per kilowatt-hour (g/kWh), or number per kilowatt-hour (#/kWh) for PN.

The gaseous and particulate pollutants that shall be measured are those for which limit values are applicable to the engine sub-category being tested as set out in Annex II to Regulation (EU) 2016/1628. The results, inclusive of:

(a) the crankcase emissions determined in accordance with section 6.10., if relevant,

(b) the adjustment factors for infrequent regeneration of the after-treatment system determined in accordance with section 6.6., if relevant, and

(c) as the final step of the calculation, the deterioration factor determined in accordance with Annex III,

shall not exceed the applicable limit values.

The CO_2 shall be measured and reported for all engine sub-categories as required by Article 43(4) of Regulation (EU) 2016/1628.’;

(3) point 5.2.5.1.1. is replaced by the following:

‘5.2.5.1.1. Calculation of MTS

In order to calculate the MTS the transient mapping procedure shall be performed in accordance with point 7.4. The MTS is then determined from the mapped values of engine speed versus power. MTS shall be calculated by means of one of the following options:

(a) Calculation based upon low speed and high speed values

$$MTS = n_{lo} + 0{,}95 \cdot (n_{hi} - n_{lo}) \qquad (6\text{-}1)$$

where:

n_{hi} is the high speed as defined in Article 1(12),

n_{lo} is the low speed as defined in Article 1(13).

(b) Calculation based upon the longest vector method

$$MTS = n_i \qquad (6\text{-}2)$$

where:

n_i is the average of the lowest and highest speeds at which (n^2_{normi} + P^2_{normi}) is equal to 98 % of the maximum value of (n^2_{normi} + P^2_{normi})

If there is only one speed at which the value of (n^2_{normi} + P^2_{normi}) is equal to 98 % of the maximum value of (n^2_{normi} + P^2_{normi}):

$$MTS = n_i \qquad (6\text{-}3)$$

where:

n_i is the speed at which the maximum value of (n^2_{normi} + P^2_{normi}) occurs.

where:

n is the engine speed

i is an indexing variable that represents one recorded value of an engine map

n_{normi} is an engine speed normalized by dividing it by n_{Pmax}

P_{normi} is an engine power normalized by dividing it by P_{max}

n_{Pmax} is the average of the lowest and highest speeds at which power is equal to 98 % of P_{max}.

Linear interpolation shall be used between the mapped values to determine:

(i) the speeds where power is equal to 98 % of P_{max}. If there is only one speed at which power is equal to 98 % of P_{max}, n_{Pmax} shall be the speed at which P_{max} occurs;

(ii) the speeds where (n^2_{normi} + P^2_{normi}) is equal to 98 % of the maximum value of (n^2_{normi} + P^2_{normi}).';

(4) point 5.2.5.2. is amended as follows:

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

'The rated speed is defined in Article 3(29) of Regulation (EU) 2016/1628. Rated speed for variable-speed engines subject to an

emission test other than those tested on a constant-speed NRSC defined in Article 1(31) of this Regulation shall be determined from the applicable mapping procedure set out in point 7.6. of this Annex. Rated speed for variable-speed engines tested on a constant-speed NRSC shall be declared by the manufacturer according to the characteristics of the engine. Rated speed for constant-speed engines shall be declared by the manufacturer according to the characteristics of the governor. Where an engine type equipped with alternative speeds as permitted by Article 3(21) of Regulation (EU) 2016/1628 is subject to an emission test, each alternative speed shall be declared and tested.';

(b) the third paragraph is replaced by the following:

'For engines of category NRSh the 100 % test speed shall be within ± 350 rpm of the rated speed declared by the manufacturer.';

(5) point 5.2.5.3. is amended as follows:

(a) the introductory wording of the first paragraph is replaced by the following:

'Where required, the maximum torque speed determined from the maximum torque curve established by the applicable engine mapping procedure in point 7.6.1 or 7.6.2 shall be one of the following:';

(b) in the last paragraph, the words "engines of category NRS or NRSh" are replaced by the words "engines of category NRS";

(6) in point 6.2., the first paragraph is replaced by the following:

'A charge-air cooling system with a total intake-air capacity that represents production engines' in-use installation shall be used. Any laboratory charge-air cooling system shall be designed to minimize accumulation of condensate. Any accumulated condensate shall be drained and all drains shall be completely closed before emission testing. The drains shall be kept closed during the emission test. Coolant conditions shall be maintained as follows:

(a) a coolant temperature of at least 293 K (20 °C) shall be maintained at the inlet to the charge-air cooler throughout testing;

(b) at the rated speed and full load, the coolant flow rate shall be set to achieve an air temperature within ± 5 K (± 5 °C) of the value designed by the manufacturer after the charge-air cooler's outlet. The air- outlet temperature shall be measured at the location specified by the manufacturer. This coolant flow rate set point shall be used throughout testing;

(c) if the engine manufacturer specifies pressure-drop limits across the charge-air cooling system, it shall be ensured that the pressure drop across the charge-air cooling system at engine conditions specified by the manufacturer is within the manufacturer's specified limit(s). The pressure drop shall be measured at the manufacturer's specified locations;';

(7) point 6.3.4. is replaced by the following:

'6.3.4. Determination of auxiliary power

Where applicable as per point 6.3.2 and 6.3.3, the values of auxiliary power and the measurement / calculation method for determining

auxiliary power shall be submitted by the engine manufacturer for the whole operating area of the applicable test cycles, and approved by the approval authority.';

(8) point 6.6.2.3. is amended as follows:

(a) the last sentence of the first paragraph is replaced by the following:

'The exact procedure to determine this frequency shall be agreed by the approval authority based upon good engineering judgement.';

(b) the title of Figure 6.1 is replaced by the following:

'Figure 6.1

Scheme of infrequent regeneration with *n* number of measurements and n_r number of measurements during regeneration';

(c) equation (6-9) and the legend thereof are replaced by the following:

'$$\bar{e}_w = \frac{n \cdot \bar{e} + n_r \cdot \bar{e}_r}{n + n_r} \qquad (6\text{-}9)$$

Where:

n is the number of tests in which regeneration does not occur,

n_r is the number of tests in which regeneration occurs (minimum one test),

$\bar{e}$ is the average specific emission from a test in which the regeneration does not occur [g/kWh or #/kWh]

$\bar{e}_r$ is the average specific emission from a test in which the regeneration occurs [g/kWh or #/kWh]';

(d) equations (6-10) and (6-11) are replaced by the following:

'$$k_{ru,m} = \frac{\bar{e}_w}{\bar{e}} \qquad \text{(upward adjustment factor)} \qquad (6\text{-}10)$$

$$k_{rd,m} = \frac{\bar{e}_w}{\bar{e}_r} \qquad \text{(downward adjustment factor)} \qquad (6\text{-}11)$$';

(a) equations (6-12) and (6-13) are replaced by the following:

'$$k_{ru,a} = \overline{e_w} - \bar{e} \qquad \text{(upward adjustment factor)} \qquad (6\text{-}12)$$

$$k_{rd,a} = \overline{e_w} - \overline{e_r} \qquad \text{(downward adjustment factor)} \qquad (6\text{-}13)$$';

(9) in point 6.6.2.4., in the third paragraph, point (b) is replaced by the following:

'(b) Upon request by the manufacturer, the approval authority may account for regeneration events differently than pursuant to point (a). However, this option only applies to events that occur extremely infrequently, and which cannot be practically addressed using the adjustment factors described in point 6.6.2.3.';

(10) point 7.3.1.1. is amended as follows:

(a) the heading is replaced by the following:

‘7.3.1.1. General requirements for preconditioning the sampling system and the engine';

(b) the following paragraph is added:

'Engines fitted with an after-treatment system may be operated prior to cycle-specific preconditioning set out in points 7.3.1.1.1. to 7.3.1.1.4., so that the after-treatment system is regenerated and, where applicable, the soot load in the particulate after-treatment system is re-established.’;

(11) point 7.3.1.1.5. is deleted;

(12) points 7.3.1.2. to 7.3.1.5. are replaced by the following:

‘7.3.1.2. Engine cool-down (NRTC)

A natural or forced cool-down procedure may be applied. For forced cool-down, good engineering judgment shall be used to set up systems to send cooling air across the engine, to send cool oil through the engine lubrication system, to remove heat from the coolant through the engine cooling system, and to remove heat from an exhaust after-treatment system. In the case of a forced after-treatment cool down, cooling air shall not be applied until the exhaust after-treatment system has cooled below its catalytic activation temperature. Any cooling procedure that results in unrepresentative emissions is not permitted.

7.3.1.3. Verification of HC contamination

If there is any presumption of an essential HC contamination of the exhaust gas measuring system, the contamination with HC may be checked with zero gas and the hang-up may then be corrected. If the amount of contamination of the measuring system and the background HC system has to be checked, it shall be conducted within 8 hours of starting each test-cycle. The values shall be recorded for later correction. Before this check, the leak check has to be performed and the FID analyzer has to be calibrated.

7.3.1.4. Preparation of measurement equipment for sampling

The following steps shall be taken before emission sampling begins:

(a) Leak checks shall be performed within 8 hours prior to emission sampling in accordance with point 8.1.8.7.;

(b) For batch sampling, clean storage media shall be connected, such as evacuated bags or tare-weighed filters;

(c) All measurement instruments shall be started in accordance with the instrument manufacturer's instructions and good engineering judgment;

(d) Dilution systems, sample pumps, cooling fans, and the data-collection system shall be started;

(e) The sample flow rates shall be adjusted to desired levels, using bypass flow, if desired;

(f) Heat exchangers in the sampling system shall be pre-heated or pre-cooled to within their operating temperature ranges for a test;

(g) Heated or cooled components such as sample lines, filters, chillers, and pumps shall be allowed to stabilize at their operating temperatures;

(h) Exhaust gas dilution system flow shall be switched on at least 10 minutes before a test sequence;

(i) Calibration of gas analyzers and zeroing of continuous analyzers shall be carried out in accordance with the procedure of point 7.3.1.5.;

(j) Any electronic integrating devices shall be zeroed or re-zeroed, before the start of any test interval.

7.3.1.5. Calibration of gas analyzers

Appropriate gas analyzer ranges shall be selected. Emission analyzers with automatic or manual range switching are allowed. During a test using transient (NRTC or LSI-NRTC) test cycles or RMC and during a sampling period of a gaseous emission at the end of each mode for discrete-mode NRSC testing, the range of the emission analyzers shall not be switched. Also the gains of an analyzer's analogue operational amplifier(s) shall not be switched during a test cycle.

All continuous analyzers shall be zeroed and spanned using internationally-traceable gases that meet the specifications of point 9.5.1. FID analyzers shall be spanned on a carbon number basis of one (C_1).';

(13) the following point 7.3.1.6. is inserted:

7.3.1.6. PM filter preconditioning and tare weighing

The procedures for PM filter preconditioning and tare weighing shall be performed in accordance with point 8.2.3.';

(14) point 7.4. is replaced by the following:

'7.4. Test cycles

The EU type-approval test shall be conducted using the appropriate NRSC and, where applicable, NRTC or LSI-NRTC, specified in Article 18 of Regulation (EU) 2016/1628 and Annex IV thereto. The technical specifications and characteristics of the NRSC, NRTC and LSI-NRTC are laid down in Annex XVII of this Regulation and the method for determination of the torque, power and speed settings for these test cycles set out in section 5.2.';

(15) point 7.5. is amended as follows:

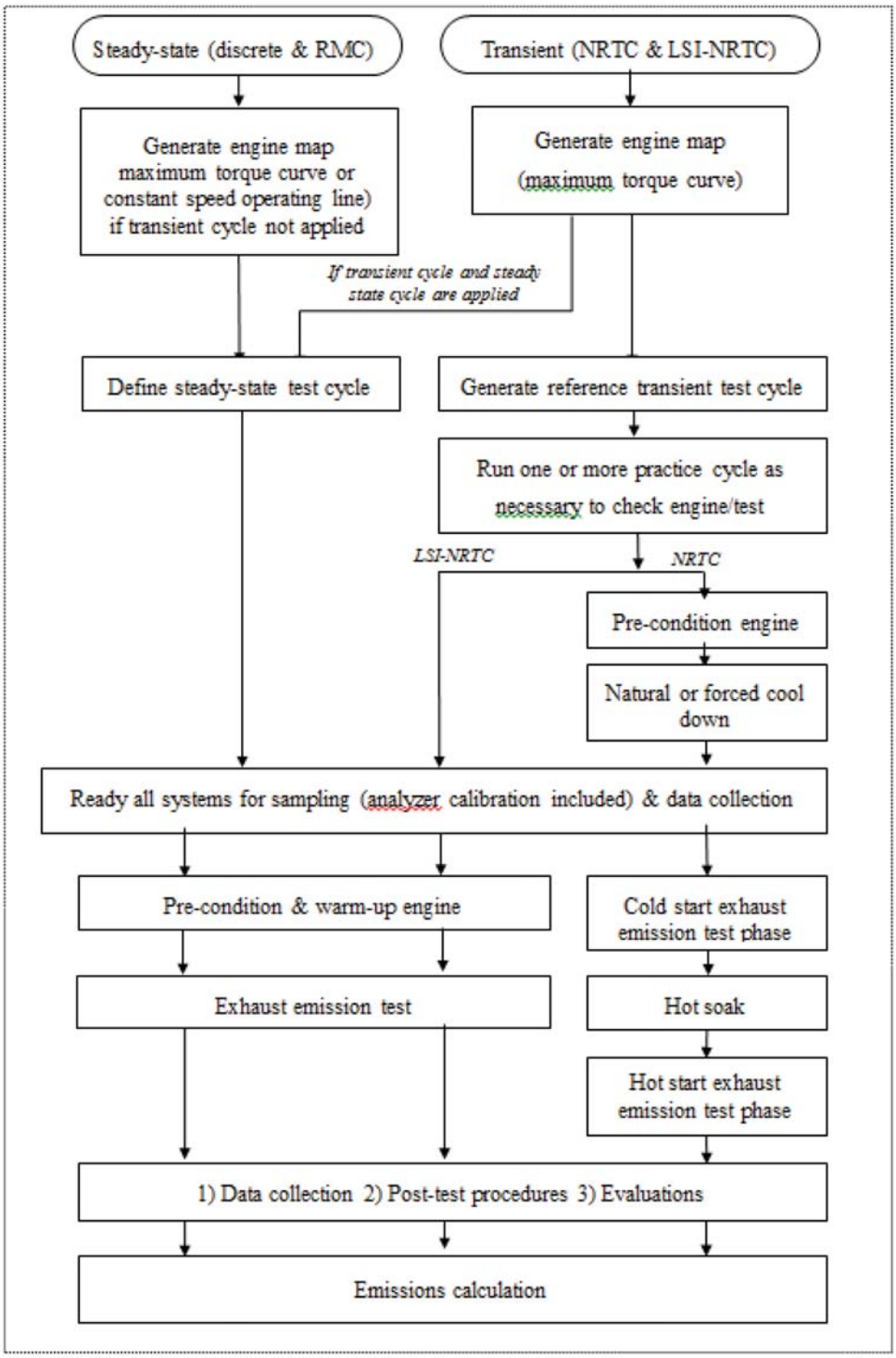
(a) in the first paragraph, point (h) is replaced by the following:

'(h) PM filter(s) shall be pre-conditioned, weighed (empty weight), loaded, re-conditioned, again weighed (loaded weight) and then samples shall be evaluated in accordance with the pre-test (point 7.3.1.6.) and post-test (point 7.3.2.2.) procedures;';

(b) Figure 6.4 is replaced by the following:

'Figure 6.4

Test sequence



(16) in point 7.5.1.2., points (a) and (b) are replaced by the following:

‘(a) If the engine stalls anywhere during the cold start run of the NRTC, the entire test shall be voided;

(b) If the engine stalls anywhere during the hot-start run of the NRTC, only this run shall be voided. The engine shall be soaked in accordance with point 7.8.3., and the hot-start run repeated. In this case, the cold-start run does not need to be repeated;’;

(17) point 7.8.1.2. is amended as follows:

(a) point (b) is replaced by the following:

‘(b) Each mode has a mode length of at least 10 minutes. In each mode the engine shall be stabilised for at least 5 minutes. Gaseous emissions, and, where applicable, PN, shall be sampled for 1 to 3 minutes at the end of each mode and PM emissions shall be sampled in accordance with point (c).

Notwithstanding the previous paragraph, when either testing spark ignition engines using cycles G1, G2 or G3 or when conducting measurements in accordance with Annex V of this Regulation each mode has a mode length of at least 3 minutes. In this case gaseous emissions, and, where applicable, PN, shall be sampled for at least the last 2 minutes of each mode and PM emissions shall be sampled in accordance with point (c). The mode length and sampling time may be extended to improve accuracy.

The mode length shall be recorded and reported.’;

(b) in point (c), the first paragraph is replaced by the following:

'For PM emissions, the PM sampling may be done either with the single filter method or with the multiple filter method. Since the results of the methods may differ slightly, the method used shall be declared with the results.’;

(18) in point 7.8.2.4., the last sentence of the first paragraph is replaced by the following:

‘When conducting testing of engines of reference power greater than 560 kW the regression line tolerances of Table 6.2 and the point deletion of Table 6.3 may be used.’;

(19) in point 7.8.3.5., Table 6.3 is replaced by the following:

Table 6.3.

Permitted point deletions from regression analysis

‘Event	Conditions (n = engine speed, T = torque)	Permitted point deletions
Minimum operator demand (idle point)	$n_{ref} = n_{idle}$ and $T_{ref} = 0$ % and $T_{act} > (T_{ref} - 0{,}02\ T_{maxmappedtorque})$ and $T_{act} < (T_{ref} + 0{,}02\ T_{maxmappedtorque})$	speed and power
Minimum operator demand	$n_{act} \leq 1{,}02\ n_{ref}$ and $T_{act} > T_{ref}$ or $n_{act} > n_{ref}$ and $T_{act} \leq T_{ref}$ or	power and either torque or speed

	$n_{act} > 1{,}02\ n_{ref}$ and $T_{ref} < T_{act} \leq (T_{ref} + 0{,}02\ T_{maxmappedtorque})$	
Maximum operator demand	$n_{act} < n_{ref}$ and $T_{act} \geq T_{ref}$ or $n_{act} \geq 0{,}98\ n_{ref}$ and $T_{act} < T_{ref}$ or $n_{act} < 0{,}98\ n_{ref}$ and $T_{ref} > T_{act} \geq (T_{ref} - 0{,}02\ T_{maxmappedtorque})$	power and either torque or speed

Where:

n_{ref}	is the reference speed (see section 7.7.2.),
n_{idle}	is the idle speed,
n_{act}	is the actual (measured) speed,
T_{ref}	is the reference torque (see section 7.7.2.),
T_{act}	is the actual (measured) torque,
$T_{maxmappedtorque}$	is the highest value of torque on the full-load torque curve mapped in accordance with section 7.6.’;

(20) in point 8.1.2., Table 6.4 is amended as follows:

(a) the row referring to point 8.1.11.4. is replaced by the following:

‘8.1.11.4.: Sample dryer NO_2 penetration (chiller)	Upon initial installation and after major maintenance.’;

(b) the row referring to point 8.1.12.1. is replaced by the following:

‘8.1.12.: Sample dryer verification	For thermal chillers: upon installation and after major maintenance. For osmotic membranes: upon installation, within 35 days of testing and after major maintenance. ’;

(21) point 8.1.7. is replaced by the following:

‘8.1.7. Measurement of engine parameters and ambient conditions

Internal quality procedures traceable to recognised national or international standards shall be applied. Otherwise the following procedures apply.’;

(22) in point 8.1.8.4.1.(f), the first paragraph is replaced by the following:

‘CFV or SSV may alternatively be removed from its permanent position for calibration as long as the following requirements are met when installed in the CVS:’;

(23) in point 8.1.8.5.1.(a), point (iv) is replaced by the following:

‘(iv) The hydrocarbon contamination verification in the sample system shall be performed as described in point 7.3.1.3.;’;

(24) in point 8.1.8.5.4., the first and second sentence below the heading are replaced by the following:

‘Vacuum side leak check verification of the HC sampling system may be performed in accordance with point (g). If this procedure is used, the HC contamination procedure set out in point 7.3.1.3. may be used.’;

(25) point 8.1.8.5.8. is deleted;

(26) point 8.1.9.1.2. is replaced by the following:

‘8.1.9.1.2. Measurement principles

H_2O can interfere with an NDIR analyzer's response to CO_2. If the NDIR analyzer uses compensation algorithms that utilize measurements of other gases to meet this interference verification, these other measurements shall be conducted simultaneously to test the compensation algorithms during the analyzer interference verification.’;

(27) in point 8.1.9.1.4., point (b) is replaced by the following:

‘(b) A humidified test gas shall be created by bubbling zero air that meets the specifications set out in point 9.5.1. through distilled water in a sealed vessel. If the sample is not passed through a dryer, control the vessel temperature to generate an H_2O content in the test gas at least as high as the maximum expected during testing. If the sample is passed through a dryer during testing, control the vessel temperature to generate an H_2O content in the test gas at least as high as the maximum expected at the outlet of the dryer, in accordance with point 9.3.2.3.1.1.;’;

(28) point 8.1.9.2.4.(b) is replaced by the following:

‘(b) A humidified CO_2 test gas shall be created by bubbling a CO_2 span gas through distilled water in a sealed vessel. If the sample is not passed through a dryer, the vessel temperature shall be controlled to generate an H_2O content in the test gas at least as high as the maximum expected during testing. If the sample is passed through a dryer during testing, the vessel temperature shall be controlled to generate an H_2O content in the test gas at least as high as the maximum expected at the outlet of the dryer, in accordance with point 9.3.2.3.1.1. A CO_2 span gas concentration shall be used at least as high as the maximum expected during testing;’;

(29) point 8.1.10.1.3. is amended as follows:

(a) in point (b), the last sentence is replaced by the following:

‘With the FID fuel and airflow rates set at the manufacturer's recommendations, a span gas shall be introduced to the analyzer;’;

(b) point (c) is amended as follows:

(i) point (i) is replaced by the following:

‘(i) The response at a given FID fuel flow shall be determined from the difference between the span gas response and the zero gas response;’;

(ii) in point (ii), the last sentence is replaced by the following:

‘The span and zero response at these FID fuel flows shall be recorded;’;

(30) in point 8.1.10.2.4 (a), the second sentence is deleted;

(31) point 8.1.11.1.5. is amended as follows:

(a) point (e) is replaced by the following:

‘(e) The NO span gas shall be humidified by bubbling it through distilled water in a sealed vessel. If the humidified NO span gas sample does not pass through a sample dryer for this verification test, the vessel temperature shall be controlled to generate an H_2O content in the span gas approximately equal to the maximum mole fraction of H_2O expected during emission testing. If the humidified NO span gas sample does not pass through a sample dryer, the quench verification calculations in point 8.1.11.2.3. scale the measured H_2O quench to the highest mole fraction of H_2O expected during emission testing. If the humidified NO span gas sample passes through a dryer for this verification test, the vessel temperature shall be controlled to generate an H_2O content in the span gas at least as high as the maximum expected at the outlet of the dryer in accordance with point 9.3.2.3.1.1. In this case, the quench verification calculations set out in point 8.1.11.2.3. do not scale the measured H_2O quench;’;

(b) the last sentence of point (f) is replaced by the following: ‘Note that the sample dryer shall meet the sample dryer verification check in point 8.1.12;’;

(32) in point 8.1.11.3.4.(g), the introductory wording is replaced by the following:

‘This difference shall be multiplied by the ratio of the expected mean HC concentration to the HC concentration measured during the verification. The analyzer meets the interference verification of this point if this result is within ± 2 % of the NO_x concentration expected at the emission limit value, as set out in equation (6-25):’;

(33) in point 8.1.11.4.2., the words "cooling bath" are replaced by the words "sample dryer".

(34) point 8.1.12. is replaced by the following:

‘8.1.12.Sample dryer verification

If a humidity sensor for continuous monitoring of dew point at the sample dryer outlet is used this check does not apply, as long as it is ensured that the dryer outlet humidity is below the minimum values used for quench, interference, and compensation checks.

If a sample dryer is used as allowed in point 9.3.2.3.1. to remove water from the sample gas, the performance shall be verified upon installation, after major maintenance, for thermal chillers. For osmotic membrane dryers, the performance shall be verified upon installation, after major maintenance, and within 35 days of testing.

Water can inhibit an analyzer's ability to properly measure the exhaust component of interest and thus is sometimes removed before the sample gas reaches the analyzer. For example water can negatively interfere with a CLD's NO_x response through collisional quenching and can positively interfere with an NDIR analyzer by causing a response similar to CO.

The sample dryer shall meet the specifications as determined in point 9.3.2.3.1. for dew point, T_{dew}, and absolute pressure, p_{total}, downstream of the osmotic-membrane dryer or thermal chiller.

The following sample dryer verification procedure method shall be used to determine sample dryer performance, or good engineering judgment shall be used to develop a different protocol:

(i) polytetrafluoroethylene ("PTFE") or stainless steel tubing shall be used to make necessary connections;

(ii) N_2 or purified air shall be humidified by bubbling it through distilled water in a sealed vessel that humidifies the gas to the highest sample dew point that is estimated during emission sampling;

(iii) The humidified gas shall be introduced upstream of the sample dryer;

(iv) The humidified gas temperature downstream of the vessel shall be maintained at least 5 K (5 °C) above its dew point;

(v) The humidified gas dew point, T_{dew}, and pressure, p_{total}, shall be measured as close as possible to the inlet of the sample dryer to verify that the dew point is the highest that was estimated during emission sampling;

(vi) The humidified gas dew point, T_{dew}, and pressure, p_{total}, shall be measured as close as possible to the outlet of the sample dryer;

(vii) The sample dryer meets the verification if the result of point (d)(vi) of this section is less than the dew point corresponding to the sample dryer specifications as determined in point 9.3.2.3.1 plus 2 K (2 °C) or if the mol fraction from (d)(vi) is less than the corresponding sample dryer specifications plus 0,002 mol/mol or 0,2 volume %. Note for this verification, sample dew point is expressed in absolute temperature, Kelvin.';

(35) points 8.1.12.1. to 8.1.12.2.5. are deleted;

(36) the following points 8.1.13. to 8.1.13.2.5. are inserted:

'8.1.13. PM measurements

8.1.13.1. PM balance verifications and weighing process verification

8.1.13.1.1. Scope and frequency

This section describes three verifications.

(a) Independent verification of PM balance performance within 370 days prior to weighing any filter;

(b) Zero and span of the balance within 12 h prior to weighing any filter;

(c) Verification that the mass determination of reference filters before and after a filter weighing session be less than a specified tolerance.

8.1.13.1.2. Independent verification

The balance manufacturer (or a representative approved by the balance manufacturer) shall verify the balance performance within 370 days of testing in accordance with internal audit procedures.

8.1.13.1.3. Zeroing and spanning

Balance performance shall be verified by zeroing and spanning it with at least one calibration weight, and any weights that are used shall meet the specifications in point 9.5.2. to perform that verification. A manual or automated procedure shall be used:

(a) A manual procedure requires that the balance shall be used in which the balance shall be zeroed and spanned with at least one calibration weight. If normally mean values are obtained by repeating the weighing process to improve the accuracy and precision of PM measurements, the same process shall be used to verify balance performance;

(b) An automated procedure is carried out with internal calibration weights that are used automatically to verify balance performance. These internal calibration weights shall meet the specifications in point 9.5.2. to perform that verification.

8.1.13.1.4. Reference sample weighing

All mass readings during a weighing session shall be verified by weighing reference PM sample media (e.g. filters) before and after a weighing session. A weighing session may be as short as desired, but no longer than 80 hours, and may include both pre- and post-test mass readings. Successive mass determinations of each reference PM sample media shall return the same value within ± 10 µg or ± 10 % of the expected total PM mass, whichever is higher. Should successive PM sample filter weighing events fail that criterion, all individual test filter mass readings mass readings occurring between the successive reference filter mass determinations shall be invalidated. These filters may be re-weighed in another weighing session. Should a post-test filter be invalidated then the test interval is void. That verification shall be performed as follows:

(a) At least two samples of unused PM sample media shall be kept in the PM-stabilization environment. These shall be used as references. Unused filters of the same material and size shall be selected for use as references;

(b) References shall be stabilized in the PM stabilization environment. References shall be considered stabilized if they have been in the PM-stabilization environment for a minimum of 30 min, and the PM-stabilization environment has been within the specifications of point 9.3.4.4. for at least the preceding 60 min;

(c) The balance shall be exercised several times with a reference sample without recording the values;

(d) The balance shall be zeroed and spanned. A test mass shall be placed on the balance (e.g. calibration weight) and then removed ensuring that the balance returns to an acceptable zero reading within the normal stabilization time;

(e) Each of the reference media (e.g. filters) shall be weighed and their masses recorded. If normally mean values are obtained by repeating the weighing process to improve the accuracy and precision of reference media (e.g. filters) masses, the same process shall be used to measure mean values of sample media (e.g. filters) masses;

(f) The balance environment dew point, ambient temperature, and atmospheric pressure shall be recorded;

(g) The recorded ambient conditions shall be used to correct results for buoyancy as described in point 8.1.13.2. The buoyancy-corrected mass of each of the references shall be recorded;

(h) Each of the reference media's (e.g. filter's) buoyancy-corrected reference mass shall be subtracted from its previously measured and recorded buoyancy-corrected mass;

(i) If any of the reference filters' observed mass changes by more than that allowed under this section, all PM mass determinations made since the last successful reference media (e.g. filter) mass validation shall be invalidated. Reference PM filters may be discarded if only one of the filters mass has changed by more than the allowable amount and a special cause for that filter's mass change can be positively identified which would not have affected other in-process filters. Thus the validation can be considered a success. In that case, the contaminated reference media shall not be included when determining compliance with paragraph (j) of this point, but the affected reference filter shall be discarded and replaced;

(j) If any of the reference masses change by more than that allowed under point 8.1.13.1.4., all PM results that were determined between the two times that the reference masses were determined shall be invalidated. If reference PM sample media is discarded in accordance with point (i), at least one reference mass difference that meets the criteria set out in point 8.1.13.1.4. shall be available. Otherwise, all PM results that were determined between the two times that the reference media (e.g. filters) masses were determined shall be invalidated.

8.1.13.2. PM sample filter buoyancy correction

8.1.13.2.1. General

PM sample filter shall be corrected for their buoyancy in air. The buoyancy correction depends on the sample media density, the density of air, and the density of the calibration weight used to calibrate the balance. The buoyancy

correction does not account for the buoyancy of the PM itself, because the mass of PM typically accounts for only (0,01 to 0,10) % of the total weight. A correction to this small fraction of mass would be at the most 0,010 %. The buoyancy-corrected values are the tare masses of the PM samples. These buoyancy-corrected values of the pre-test filter weighing are subsequently subtracted from the buoyancy-corrected values of the post-test weighing of the corresponding filter to determine the mass of PM emitted during the test.

8.1.13.2.2. PM sample filter density

Different PM sample filter have different densities. The known density of the sample media shall be used, or one of the densities for some common sampling media shall be used, as follows:

(a) For PTFE-coated borosilicate glass, a sample media density of 2 300 kg/m^3 shall be used;

(b) For PTFE membrane (film) media with an integral support ring of polymethylpentene that accounts for 95 % of the media mass, a sample media density of 920 kg/m^3 shall be used;

(c) For PTFE membrane (film) media with an integral support ring of PTFE, a sample media density of 2 144 kg/m^3 shall be used.

8.1.13.2.3. Air density

Because a PM balance environment shall be tightly controlled to an ambient temperature of 295 ± 1 K (22 ± 1°C) and a dew point of 282,5 ± 1 K (9,5 ± 1°C), air density is primarily function of atmospheric pressure. Therefore a buoyancy correction is specified that is only a function of atmospheric pressure.

8.1.13.2.4. Calibration weight density

The stated density of the material of the metal calibration weight shall be used.

8.1.13.2.5. Correction calculation

The PM sample filter shall be corrected for buoyancy by means of equation (6-27):

$$m_{cor} = m_{uncor} \cdot \left(\frac{1 - \frac{\rho_{air}}{\rho_{weight}}}{1 - \frac{\rho_{air}}{\rho_{media}}} \right) \qquad (6\text{-}27)$$

Where:

m_{cor} is the PM sample filter mass corrected for buoyancy

m_{uncor} is the PM sample filter mass uncorrected for buoyancy

ρ_{air} is the density of air in balance environment

ρ_{weight} is the density of calibration weight used to span balance

ρ_{media} is the density of PM sample filter

with

$$\rho_{air} = \frac{p_{abs} \cdot M_{mix}}{R \cdot T_{amb}} \quad (6\text{-}28)$$

Where:

p_{abs} is the absolute pressure in balance environment

M_{mix} is the molar mass of air in balance environment

R is the molar gas constant.

T_{amb} is the absolute ambient temperature of balance environment';

(37) in point 9.3.2.1.1., the first sentence is replaced by the following:

'When used in accordance with point 9.3.1.1.1., the internal volume of the mixing chamber shall not be less than ten times the individual cylinder swept volume of the engine under test.';

(38) in point 9.3.2.2., point (b) is replaced by the following:

'(b) For THC transfer lines a wall temperature tolerance throughout the entire line of (464 ± 11) K [(191 ± 11) °C] shall be maintained. If sampled from raw exhaust gas, an unheated, insulated transfer line may be connected directly to a probe. The length and insulation of the transfer line shall be designed to cool the highest expected raw exhaust gas temperature to no lower than 191 °C, as measured at the transfer line outlet. For dilute sampling a transition zone between the probe and transfer line of up to 0,92 m in length is allowed to transition the wall temperature to (464 ± 11) K [(191 ± 11) °C].';

(39) in point 9.3.2.3.1.1., the last paragraph is replaced by the following:

'For the highest expected water vapour concentration H_m, the water removal technique shall maintain humidity at ≤ 5 g water/kg dry air (or about 0,8 volume % H_2O), which is 100 % relative humidity at 277,1 K (3,9 °C) and 101,3 kPa. This humidity specification is equivalent to about 25 % relative humidity at 298 K (25 °C) and 101,3 kPa. This may be demonstrated by either:

(a) measuring the temperature at the outlet of the sample dryer; or

(b) measuring humidity at a point just upstream of the CLD; or

(c) performing the verification procedure in point 8.1.12.';

(40) in point 9.3.3.4.3., the second sentence is replaced by the following:

'Sample temperature shall be controlled to a 320 ± 5 K (47 ± 5 °C) tolerance, as measured anywhere within 200 mm upstream or 200 mm downstream of the PM filter media.';

(41) in point 9.3.4.4., in point (b), the last sentence is replaced by the following:

'This value shall be used to calculate the PM sample filter buoyancy correction in point 8.1.13.2.';

(42) in point 9.4.1.2., the last sentence is replaced by the following:

'Where more than one instrument for a particular measurement is specified, one of them will be identified by the approval authority upon application as the reference for showing that an alternative procedure is equivalent to the specified procedure.';

(43) in point 9.4.1.3., the first sentence is replaced by the following:

‘Data from multiple instruments to calculate test results for a single test may be used for all measurement instruments described in this point, with prior approval of the approval authority.’;

(44) in point 9.4.5.3.2., the first sentence is replaced by the following:

‘For the purpose of controlling of a partial flow dilution system to extract a proportional raw exhaust gas sample, a flow meter response time faster than indicated in Table 6.8 is required.’;

(45) in point 9.4.6., the last sentence is replaced by the following:

‘The NDIR-based system shall meet the calibration and verifications set out in point 8.1.9.1. or 8.1.9.2., as applicable.’;

(46) in point 9.4.12., the paragraph below the heading is replaced by the following:

‘A FTIR (Fourier transform infrared) analyser, NDUV or laser infrared analyser may be used in accordance with Appendix 4.’;

(47) point 9.5.1.1.(a) is amended as follows,

(a) point (i) is replaced by the following:

‘(i) 2 % contamination, measured relative to the mean concentration expected at the emission limit value. For example, if a CO concentration of 100,0 μmol/mol is expected, then it would be allowed to use a zero gas with CO contamination less than or equal to 2,000 μmol/mol;’;

(b) in point (iii), in Table 6.9, the third row is replaced by the following:

‘CO_2	≤ 10 μmol/mol	≤ 10 μmol/mol’;

(48) in point 9.5.1.1.(c), point (i) is replaced by the following:

‘(i) CH_4, balance purified synthetic air and/or N_2 (as applicable);’;

(49) in point 9.5.1.2., point (b) is replaced by the following:

‘(b) Calibration gases may be relabelled and used after their expiration date if it is approved in advance by approval authority.’;

(50) in point 9.5.1.3, the second paragraph below the heading is deleted;

(51) Appendix 1 is amended as follows:

(a) in point 1.3.4., the first sentence is replaced by the following:

‘For particle number measurement, exhaust gas mass flow rate, determined according to any of the methods described in points 2.1.6.1. to 2.1.6.4. of Annex VII, is used for controlling the partial flow dilution system to take a sample proportional to the exhaust gas mass flow rate.’;

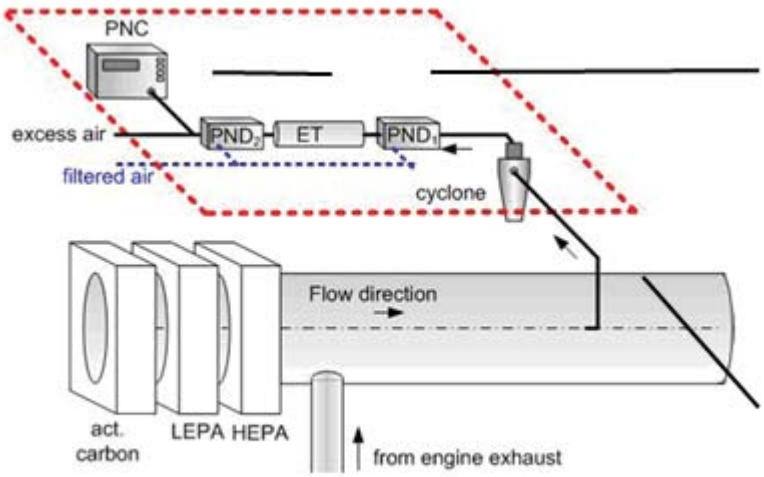
(b) in point 2.1.3.3.3., the first sentence is replaced by the following:

‘Control heated stages to constant nominal operating temperatures, within the range specified in point 2.1.3.3.2., to a tolerance of ±10 K (± 10 °C).’;

(c) in point 2.1.4., figure 6.10 is replaced by the following

‘Figure 6.10.

Schematic of recommended particle sampling system – Full flow sampling



’;

(52) in Appendix 3, in point 3, in the second paragraph, the first sentence is replaced by the following:

‘The torque broadcast by the ECU shall be accepted without correction if, at each point where measurements were taken, the factor calculated from dividing the torque value from the dynamometer by the torque value from the ECU is not less than 0,93 (i.e. a maximum difference of 7 %).’;

(53) Appendix 4 is amended as follows:

(a) in point 4.2.7., the last sentence is replaced by the following:

‘The expiration date of the calibration gases shall be recorded.’;

(b) in point 4.2.8., point (j) is replaced by the following:

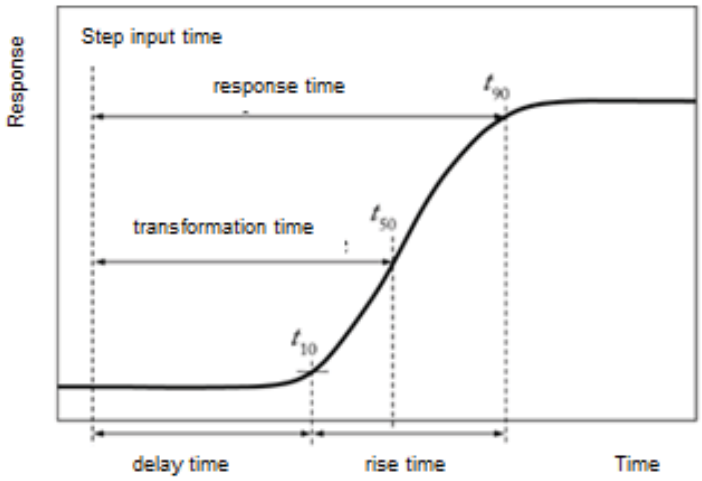
‘(j) Analyser shall have combined interference within ± 2 % of the applicable mean value of ammonia (NH_3) specified in point 3.4 of Annex IV.’;

(54) Appendix 5 is amended as follows:

(a) in point 2.4., figure 6-11 is replaced by the following:

‘*Figure 6-11*

Illustration of system responses



’.

(b) the following point 2.5. is added:

‘2.5. Step input time is the time at which there is a change in the parameter being measured.’.

ANNEX VII

Annex VII to Delegated Regulation (EU) 2017/654 is amended as follows:

(1) point 2.1 is replaced by the following:

'2.1. Measurement of gaseous emissions in raw exhaust gas';

(2) in point 2.1.1., equation (7-1) is replaced by the following:

$$' q_{mgas,i} = k_h \cdot k \cdot u_{gas} \cdot q_{mew,i} \cdot c_{gas,i} \cdot 3600 \quad (7\text{-}1)';$$

(3) in point 2.1.3., equation (7-4) is replaced by the following:

$$' k_{w,a} = \frac{\left(1 - \frac{1{,}2442 \cdot H_a + 111{,}19 \cdot w_H \cdot \frac{q_{mf,i}}{q_{mad,i}}}{773{,}4 + 1{,}2442 \cdot H_a + \frac{q_{mf,i}}{q_{mad,i}} \cdot k_f \cdot 1000}\right)}{\left(1 - \frac{p_r}{p_b}\right)} \quad (7\text{-}4)';$$

(4) in point 2.1.5.2., equation (7-13) is replaced by the following:

$$' M_{e,i} = \frac{1 + \frac{q_{mf,i}}{q_{maw,i}}}{\frac{q_{mf,i}}{q_{maw,i}} \cdot \frac{\frac{\alpha}{4} + \frac{\varepsilon}{2} + \frac{\delta}{2}}{12{,}011 + 1{,}00794 \cdot \alpha + 15{,}9994 \cdot \varepsilon + 14{,}0067 \cdot \delta + 32{,}065 \cdot \gamma} + \frac{\frac{H_a \cdot 10^{-3}}{2 \times 1{,}00794 + 15{,}9994} + \frac{1}{M_a}}{1 + H_a \cdot 10^{-3}}} \quad (7\text{-}13)';$$

(5) in point 2.1.6.4., in the legend of equation (7-21), the row corresponding to the term "w_C" is replaced by the following:

'w_C = carbon content of fuel [% mass] (see equation (7-82) of point 3.3.3.1. or table 7.3)';

(6) in point 2.2.3., in the legend of equation (7-34), the rows corresponding to the terms "$M_{da,w}$" and "$M_{r,w}$" are replaced by the following:

'$M_{da,w}$ = molar mass of dilution air [g/mol] (see equation (7-144) of point 3.9.3.)

$M_{r,w}$ = molar mass of raw exhaust gas [g/mol] (see Appendix 2 point 5)';

(7) point 2.3.1. is replaced by the following:

'2.3.1. Transient (NRTC and LSI-NRTC) test cycles and RMC

The particulate mass shall be calculated after buoyancy correction of the particulate sample mass in accordance with point 8.1.13.2.5. of Annex VI.';

(8) in point 2.3.1.1.2., equation (7-46) is replaced by the following:

$$' q_{medf,i} = q_{mew,i} \cdot r_{d,i} \quad (7\text{-}46)';$$

(9) point 2.4.1.1. is amended as follows:

(a) in the legend of equation (7-59), the following row is added:

'Δt_i = the measurement interval [s]';

(b) in the legend of equation (7-60), the row corresponding to the term "$T_{i,AUX}$" is replaced by the following:

‘$T_{i,\mathrm{AUX}}$ = corresponding value of torque required to drive auxiliaries determined in accordance with equation (6-18) of Annex VI.’;

(10) in point 2.4.1.2., the legend of equation (7-64) is amended as follows:

(a) the row corresponding to the term "P_i" is replaced by the following:

‘P_i = engine power for the mode i [kW] calculated by adding to the measured power P_{meas} [kW] the power required to drive auxiliaries P_{AUX} [kW] determined in accordance with equation (6-8) of Annex VI ($P_i = P_{meas} + P_{AUX}$).’;

(b) the following row is added:

‘N_{mode} = number of modes in applicable discrete-mode NRSC’;

(11) point 2.4.2.2.is amended as follows:

(a) equation (7-66) is replaced by the following:

$$'e_{\mathrm{PM}} = \frac{q_{m\mathrm{PM}}}{\sum_{i=1}^{N_{mode}}(P_i \cdot WF_i)} \qquad (7\text{-}66)'$$;

(b) the legend of equation (7-66) is amended as follows:

(i) the row corresponding to the term "P_i" is replaced by the following:

‘P_i = engine power for the mode i [kW] calculated by adding to the measured power P_{meas} [kW] the power required to drive auxiliaries P_{AUX} [kW] determined in accordance with equation (6-8) of Annex VI ($P_i = P_{meas} + P_{AUX}$).’;

(ii) the following row is added:

‘N_{mode} = number of modes in applicable discrete-mode NRSC’;

(c) equation (7-67) is replaced by the following:

$$'e_{\mathrm{PM}} = \frac{\sum_{i=1}^{N_{mode}}(q_{m\mathrm{PM}i} \cdot WF_i)}{\sum_{i=1}^{N_{mode}}(P_i \cdot WF_i)} \qquad (7\text{-}67)'$$;

(d) the legend of equation (7-67) is amended as follows:

(i) the row corresponding to the term "P_i" is replaced by the following:

‘P_i = engine power for the mode i [kW] calculated by adding to the measured power P_{meas} [kW] the power required to drive auxiliaries P_{AUX} [kW] determined in accordance with equation (6-8) of Annex VI ($P_i = P_{meas} + P_{AUX}$).’;

(ii) the following row is added:

‘N_{mode} = number of modes in applicable discrete-mode NRSC’;

(12) in point 3.3.4., the first paragraph is replaced by the following:

‘For HC measurement, $x_{\mathrm{THC[THC\text{-}FID]}}$ shall be calculated by using the initial THC contamination concentration $x_{\mathrm{THC[THC\text{-}FID]init}}$ from point 7.3.1.3. of Annex VI by means of equation (7-83):’;

(13) in point 3.3.5., the last sentence is replaced by the following:

‘A certain flow-weighted mean concentration of an emission at the emission limit value might be already expected based on previous testing with similar engines or testing with similar equipment and instruments.’;

(14) point 3.5. is replaced by the following.

‘3.5. Measurement of gaseous emissions in raw exhaust gas’;

(15) in point 3.5.3., in point (c), equation (7-113) is replaced by the following:

‘$\dot{n}_{exh} = \frac{\dot{m}_{fuel} \cdot w_C \cdot (1 + X_{H2Oexhdry})}{M_C \cdot X_{Ccombdry}}$ (7-113)’;

(16) point 3.6.1. is replaced by the following

‘3.6.1. Emission mass calculation and background correction

The calculation of gaseous emissions mass m_{gas} [g/test] as a function of molar emissions flow rates shall be calculated as follows:

(a) Continuous sampling, varying flow rate, shall be calculated by means of equation (7-106):

$m_{gas} = \frac{1}{f} \cdot M_{gas} \cdot \sum_{i=1}^{N} \dot{n}_{exhi} \cdot X_{gasi}$ [see equation (7-106)]

Where:

M_{gas} = generic emission molar mass [g/mol]

$\dot{n}_{exhi}$ = instantaneous exhaust gas molar flow rate on a wet basis [mol/s]

x_{gasi} = instantaneous generic gas molar concentration on a wet basis [mol/mol]

f = data sampling rate [Hz]

N = number of measurements [-]

(b) Continuous sampling, constant flow rate, shall be calculated by means of equation (7-107):

$m_{gas} = M_{gas} \cdot \dot{n}_{exh} \cdot \overline{x}_{gas} \cdot \Delta t$ [see equation (7-107)]

Where:

M_{gas} = generic emission molar mass [g/mol]

$\dot{n}_{exh}$ = exhaust gas molar flow rate on a wet basis [mol/s]

$\overline{x}_{gas}$ = mean gaseous emission molar fraction on a wet basis [mol/mol]

Δt = time duration of test interval

(c) Batch sampling, regardless the flow rate is varying or constant, shall be calculated by means of equation (7-108):

$m_{gas} = \frac{1}{f} \cdot M_{gas} \cdot \overline{x}_{gas} \cdot \sum_{i=1}^{N} \dot{n}_{exhi}$ [see equation (7-108)]

Where:

M_{gas} = generic emission molar mass [g/mol]

$\dot{n}_{exhi}$ = instantaneous exhaust gas molar flow rate on a wet basis [mol/s]

$\overline{x}_{gas}$ = mean gaseous emission molar fraction on a wet basis [mol/mol]

f = data sampling rate [Hz]

N = number of measurements [-]

(d) In case of diluted exhaust gas calculated values for mass of the pollutants shall be corrected by subtracting the mass of background emissions, due to dilution air:

(i) Firstly, the molar flow rate of dilution air n_{airdil} [mol/s] shall be determined over the test interval. This may be a measured quantity or a quantity calculated from the diluted exhaust gas flow and the flow-weighted mean fraction of dilution air in diluted exhaust gas, $\overline{x}_{dil/exh}$;

(ii) The total flow of dilution air n_{airdil} [mol] shall be multiplied by the mean concentration of background emission. This may be a time-weighted mean or a flow-weighted mean (e.g., a proportionally sampled background). The product of n_{airdil} and the mean concentration of a background emission is the total amount of a background emission;

(iii) If the result is a molar quantity, it shall be converted to a mass of the background emission m_{bkgnd} [g] by multiplying it by emission molar mass, M_{gas} [g/mol];

(iv) Total background mass shall be subtracted from total mass to correct for background emissions;

(v) The total flow of dilution air may be determined by a direct flow measurement. In this case, the total mass of background shall be calculated, using the dilution air flow, n_{airdil}. The background mass shall be subtracted from the total mass. The result shall be used in brake-specific emission calculations;

(vi) The total flow of dilution air may be determined from the total flow of diluted exhaust gas and a chemical balance of the fuel, intake air, and exhaust gas as described in point 3.4. In this case, the total mass of background shall be calculated, using the total flow of diluted exhaust gas, n_{dexh}. Then this result shall be multiplied by the flow-weighted mean fraction of dilution air in diluted exhaust gas, $\overline{x}_{dil/exh}$.

Considering the two cases (v) and (vi), equations (7-115) and (7-116) shall be used:

$$m_{bkgnd} = M_{gas} \cdot x_{gasdil} \cdot n_{airdil} \quad \text{or} \quad m_{bkgnd} = M_{gas} \cdot \overline{x}_{dil/exh} \cdot \overline{x}_{bkgnd} \cdot n_{dexh} \qquad (7\text{-}115)$$

$$m_{gascor} = m_{gas} - m_{bkgnd} \qquad (7\text{-}116)$$

where:

m_{gas} = total mass of the gaseous emission [g]

m_{bkgnd} = total background masses [g]

m_{gascor} = mass of gas corrected for background emissions [g]

M_{gas} = molecular mass of generic gaseous emission [g/mol]

x_{gasdil} = gaseous emission concentration in dilution air [mol/mol]

n_{airdil} = dilution air molar flow [mol]

$\overline{x}_{dil/exh}$ = flow-weighted mean fraction of dilution air in diluted exhaust gas [mol/mol]

$\overline{x}_{bkgnd}$ = gas fraction of background [mol/mol]

n_{dexh} = total flow of diluted exhaust gas [mol]';

(17) in point 3.6.3., point (b) is amended as follows:

(a) in point (i), the introductory wording is replaced by the following;

'PDP molar flow rate. Based upon the speed at which the Positive Displacement Pump (PDP) operates for a test interval, the corresponding slope a_1, and intercept, a_0 [-], as calculated with the calibration procedure set out in point 3.9.2, shall be used to calculate molar flow rate $\dot{n}$ [mol/s] by means of equation (7-117):';

(b) in point (ii), the introductory wording is replaced by the following:

'SSV molar flow rate. Based on the C_d versus $R_e^{\#}$ equation determined in accordance with point 3.9.4., the Sub-Sonic Venturi (SSV) molar flow rate during an emission test $\dot{n}$ [mol/s] shall be calculated by means of equation (7-119):';

(c) in point (iii), the introductory wording is replaced by the following:

'CFV molar flow rate. To calculate the molar flow rate through one venturi or one combination of venturis, its respective mean C_d and other constants, determined in accordance with point 3.9.5., shall be used. The calculation of its molar flow rate $\dot{n}$ [mol/s] during an emission test shall be calculated by means of equation (7-120):';

(18) point 3.8.1.1. is amended as follows:

(a) equation (7-126) is replaced by the following:

'$W_{act} = \sum_{i=1}^{N} P_i \cdot \Delta t_i = \frac{1}{f} \cdot \frac{1}{3600} \cdot \frac{1}{10^3} \cdot \frac{2 \cdot \pi}{60} \cdot \sum_{i=1}^{N} (n_i \cdot T_i)$ (7-126)';

(b) in the legend of equation (7-126), the following row is added:

'Δt_i = the measurement interval [s]';

(c) the legend of equation (7-127) is replaced by the following:

'Where:

$T_{i,meas}$ is the measured value of instantaneous engine torque

$T_{i,AUX}$ is the corresponding value of torque required to drive auxiliaries determined in accordance with point 7.7.2.3.(b) of Annex VI.';

(19) in point 3.8.1.2., the legend of equation (7-131) is amended as follows:

(a) the row corresponding to the term "P_i" is replaced by the following:

'P_i = engine power for the mode i [kW] calculated by adding to the measured power P_{meas} [kW] the power required to drive auxiliaries P_{AUX} [kW] determined in accordance with equation (6-8) of Annex VI ($P_i = P_{meas} + P_{AUX}$).';

(b) the following row is added:

'N_{mode} = number of modes in applicable discrete-mode NRSC';

(20) point 3.8.2.2.1. is amended as follows:

(a) equation (7-133) is replaced by the following:

$$'e_{PM} = \frac{\dot{m}_{PM}}{\sum_{i=1}^{N_{mode}}(P_i \cdot WF_i)} \qquad (7\text{-}133)';$$

(b) the legend of equation (7-133) is amended as follows:

(i) the row corresponding to the term "P_i" is replaced by the following:

'P_i = engine power for the mode i [kW] calculated by adding to the measured power P_{meas} [kW] the power required to drive auxiliaries P_{AUX} [kW] determined in accordance with equation (6-8) of Annex VI ($P_i = P_{meas} + P_{AUX}$).';

(ii) the following row is added:

'N_{mode} = number of modes in applicable discrete-mode NRSC';

(21) point 3.8.2.2.2. is amended as follows:

(a) equation (7-134) is replaced by the following:

$$'e_{PM} = \frac{\sum_{i=1}^{N_{mode}}(\dot{m}_{PMi} \cdot WF_i)}{\sum_{i=1}^{N_{mode}}(P_i \cdot WF_i)} \qquad (7\text{-}134)';$$

(b) the legend of equation (7-134) is amended as follows:

(i) the row corresponding to the term "P_i" is replaced by the following:

'P_i = engine power for the mode i [kW] calculated by adding to the measured power P_{meas} [kW] the power required to drive auxiliaries P_{AUX} [kW] determined in accordance with equation (6-8) of Annex VI ($P_i = P_{meas} + P_{AUX}$).';

(ii) the following row is added:

'N_{mode} = number of modes in applicable discrete-mode NRSC';

(22) in point 3.9.3., in point (a), equation (7-140) is replaced by the following:

$$'C_d = \dot{n}_{ref} \cdot \frac{\sqrt{Z \cdot M_{mix} \cdot R \cdot T_{in}}}{C_f \cdot A_t \cdot p_{in}} \qquad (7\text{-}140)';$$

(23) in Appendix 3, in point 5, the following Table 7.9 and Table 7.10 are added:

'Table 7-9

Critical F values, F_{crit90}, versus N-1 and N_{ref-1} at 90 per cent confidence

N-1 N_{ref}-1	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	1000+
1	39.86	49.50	53.59	55.83	57.24	58.20	58.90	59.43	59.85	60.19	60.70	61.22	61.74	62.00	62.26	62.52	62.79	63.06	63.32
2	8.526	9.000	9.162	9.243	9.293	9.326	9.349	9.367	9.381	9.392	9.408	9.425	9.441	9.450	9.458	9.466	9.475	9.483	9.491
3	5.538	5.462	5.391	5.343	5.309	5.285	5.266	5.252	5.240	5.230	5.216	5.200	5.184	5.176	5.168	5.160	5.151	5.143	5.134
4	4.545	4.325	4.191	4.107	4.051	4.010	3.979	3.955	3.936	3.920	3.896	3.870	3.844	3.831	3.817	3.804	3.790	3.775	3.761
5	4.060	3.780	3.619	3.520	3.453	3.405	3.368	3.339	3.316	3.297	3.268	3.238	3.207	3.191	3.174	3.157	3.140	3.123	3.105
6	3.776	3.463	3.289	3.181	3.108	3.055	3.014	2.983	2.958	2.937	2.905	2.871	2.836	2.818	2.800	2.781	2.762	2.742	2.722
7	3.589	3.257	3.074	2.961	2.883	2.827	2.785	2.752	2.725	2.703	2.668	2.632	2.595	2.575	2.555	2.535	2.514	2.493	2.471
8	3.458	3.113	2.924	2.806	2.726	2.668	2.624	2.589	2.561	2.538	2.502	2.464	2.425	2.404	2.383	2.361	2.339	2.316	2.293
9	3.360	3.006	2.813	2.693	2.611	2.551	2.505	2.469	2.440	2.416	2.379	2.340	2.298	2.277	2.255	2.232	2.208	2.184	2.159
10	3.285	2.924	2.728	2.605	2.522	2.461	2.414	2.377	2.347	2.323	2.284	2.244	2.201	2.178	2.155	2.132	2.107	2.082	2.055
11	3.225	2.860	2.660	2.536	2.451	2.389	2.342	2.304	2.274	2.248	2.209	2.167	2.123	2.100	2.076	2.052	2.026	2.000	1.972
12	3.177	2.807	2.606	2.480	2.394	2.331	2.283	2.245	2.214	2.188	2.147	2.105	2.060	2.036	2.011	1.986	1.960	1.932	1.904
13	3.136	2.763	2.560	2.434	2.347	2.283	2.234	2.195	2.164	2.138	2.097	2.053	2.007	1.983	1.958	1.931	1.904	1.876	1.846
14	3.102	2.726	2.522	2.395	2.307	2.243	2.193	2.154	2.122	2.095	2.054	2.010	1.962	1.938	1.912	1.885	1.857	1.828	1.797
15	3.073	2.695	2.490	2.361	2.273	2.208	2.158	2.119	2.086	2.059	2.017	1.972	1.924	1.899	1.873	1.845	1.817	1.787	1.755
16	3.048	2.668	2.462	2.333	2.244	2.178	2.128	2.088	2.055	2.028	1.985	1.940	1.891	1.866	1.839	1.811	1.782	1.751	1.718
17	3.026	2.645	2.437	2.308	2.218	2.152	2.102	2.061	2.028	2.001	1.958	1.912	1.862	1.836	1.809	1.781	1.751	1.719	1.686
18	3.007	2.624	2.416	2.286	2.196	2.130	2.079	2.038	2.005	1.977	1.933	1.887	1.837	1.810	1.783	1.754	1.723	1.691	1.657
19	2.990	2.606	2.397	2.266	2.176	2.109	2.058	2.017	1.984	1.956	1.912	1.865	1.814	1.787	1.759	1.730	1.699	1.666	1.631
20	2.975	2.589	2.380	2.249	2.158	2.091	2.040	1.999	1.965	1.937	1.892	1.845	1.794	1.767	1.738	1.708	1.677	1.643	1.607
21	2.961	2.575	2.365	2.233	2.142	2.075	2.023	1.982	1.948	1.920	1.875	1.827	1.776	1.748	1.719	1.689	1.657	1.623	1.586
20	2.949	2.561	2.351	2.219	2.128	2.061	2.008	1.967	1.933	1.904	1.859	1.811	1.759	1.731	1.702	1.671	1.639	1.604	1.567
23	2.937	2.549	2.339	2.207	2.115	2.047	1.995	1.953	1.919	1.890	1.845	1.796	1.744	1.716	1.686	1.655	1.622	1.587	1.549
24	2.927	2.538	2.327	2.195	2.103	2.035	1.983	1.941	1.906	1.877	1.832	1.783	1.730	1.702	1.672	1.641	1.607	1.571	1.533
25	2.918	2.528	2.317	2.184	2.092	2.024	1.971	1.929	1.895	1.866	1.820	1.771	1.718	1.689	1.659	1.627	1.593	1.557	1.518
26	2.909	2.519	2.307	2.174	2.082	2.014	1.961	1.919	1.884	1.855	1.809	1.760	1.706	1.677	1.647	1.615	1.581	1.544	1.504
27	2.901	2.511	2.299	2.165	2.073	2.005	1.952	1.909	1.874	1.845	1.799	1.749	1.695	1.666	1.636	1.603	1.569	1.531	1.491
28	2.894	2.503	2.291	2.157	2.064	1.996	1.943	1.900	1.865	1.836	1.790	1.740	1.685	1.656	1.625	1.593	1.558	1.520	1.478
29	2.887	2.495	2.283	2.149	2.057	1.988	1.935	1.892	1.857	1.827	1.781	1.731	1.676	1.647	1.616	1.583	1.547	1.509	1.467
30	2.881	2.489	2.276	2.142	2.049	1.980	1.927	1.884	1.849	1.819	1.773	1.722	1.667	1.638	1.606	1.573	1.538	1.499	1.456
40	2.835	2.440	2.226	2.091	1.997	1.927	1.873	1.829	1.793	1.763	1.715	1.662	1.605	1.574	1.541	1.506	1.467	1.425	1.377
60	2.791	2.393	2.177	2.041	1.946	1.875	1.819	1.775	1.738	1.707	1.657	1.603	1.543	1.511	1.476	1.437	1.395	1.348	1.291
120	2.748	2.347	2.130	1.992	1.896	1.824	1.767	1.722	1.684	1.652	1.601	1.545	1.482	1.447	1.409	1.368	1.320	1.265	1.193
1000+	2.706	2.303	2.084	1.945	1.847	1.774	1.717	1.670	1.632	1.599	1.546	1.487	1.421	1.383	1.342	1.295	1.240	1.169	1.000

Table 7-10

Critical F values, F_{crit95}, versus N-1 and N_{ref-1} at 95 per cent confidence

N-1 N_{ref}-1	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	1000+
1	161.4	199.5	215.7	224.5	230.1	233.9	236.7	238.8	240.5	241.8	243.9	245.9	248.0	249.0	250.1	251.1	252.2	253.2	254.3
2	18.51	19.00	19.16	19.24	19.29	19.33	19.35	19.37	19.38	19.39	19.41	19.42	19.44	19.45	19.46	19.47	19.47	19.48	19.49
3	10.12	9.552	9.277	9.117	9.014	8.941	8.887	8.845	8.812	8.786	8.745	8.703	8.660	8.639	8.617	8.594	8.572	8.549	8.526
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.912	5.858	5.803	5.774	5.746	5.717	5.688	5.658	5.628
5	6.608	5.786	5.410	5.192	5.050	4.950	4.876	4.818	4.773	4.735	4.678	4.619	4.558	4.527	4.496	4.464	4.431	4.399	4.365
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.060	4.000	3.938	3.874	3.842	3.808	3.774	3.740	3.705	3.669
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.637	3.575	3.511	3.445	3.411	3.376	3.340	3.304	3.267	3.230
8	5.318	4.459	4.066	3.838	3.688	3.581	3.501	3.438	3.388	3.347	3.284	3.218	3.150	3.115	3.079	3.043	3.005	2.967	2.928
9	5.117	4.257	3.863	3.633	3.482	3.374	3.293	3.230	3.179	3.137	3.073	3.006	2.937	2.901	2.864	2.826	2.787	2.748	2.707
10	4.965	4.103	3.708	3.478	3.326	3.217	3.136	3.072	3.020	2.978	2.913	2.845	2.774	2.737	2.700	2.661	2.621	2.580	2.538
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.788	2.719	2.646	2.609	2.571	2.531	2.490	2.448	2.405
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.687	2.617	2.544	2.506	2.466	2.426	2.384	2.341	2.296
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.604	2.533	2.459	2.420	2.380	2.339	2.297	2.252	2.206
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.534	2.463	2.388	2.349	2.308	2.266	2.223	2.178	2.131
15	4.543	3.682	3.287	3.056	2.901	2.791	2.707	2.641	2.588	2.544	2.475	2.403	2.328	2.288	2.247	2.204	2.160	2.114	2.066
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	2.494	2.425	2.352	2.276	2.235	2.194	2.151	2.106	2.059	2.010
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.494	2.450	2.381	2.308	2.230	2.190	2.148	2.104	2.058	2.011	1.960
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.456	2.412	2.342	2.269	2.191	2.150	2.107	2.063	2.017	1.968	1.917
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.423	2.378	2.308	2.234	2.156	2.114	2.071	2.026	1.980	1.930	1.878
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.348	2.278	2.203	2.124	2.083	2.039	1.994	1.946	1.896	1.843
21	4.325	3.467	3.073	2.840	2.685	2.573	2.488	2.421	2.366	2.321	2.250	2.176	2.096	2.054	2.010	1.965	1.917	1.866	1.812
22	4.301	3.443	3.049	2.817	2.661	2.549	2.464	2.397	2.342	2.297	2.226	2.151	2.071	2.028	1.984	1.938	1.889	1.838	1.783
23	4.279	3.422	3.028	2.796	2.640	2.528	2.442	2.375	2.320	2.275	2.204	2.128	2.048	2.005	1.961	1.914	1.865	1.813	1.757
24	4.260	3.403	3.009	2.776	2.621	2.508	2.423	2.355	2.300	2.255	2.183	2.108	2.027	1.984	1.939	1.892	1.842	1.790	1.733
25	4.242	3.385	2.991	2.759	2.603	2.490	2.405	2.337	2.282	2.237	2.165	2.089	2.008	1.964	1.919	1.872	1.822	1.768	1.711
26	4.225	3.369	2.975	2.743	2.587	2.474	2.388	2.321	2.266	2.220	2.148	2.072	1.990	1.946	1.901	1.853	1.803	1.749	1.691
27	4.210	3.354	2.960	2.728	2.572	2.459	2.373	2.305	2.250	2.204	2.132	2.056	1.974	1.930	1.884	1.836	1.785	1.731	1.672
28	4.196	3.340	2.947	2.714	2.558	2.445	2.359	2.291	2.236	2.190	2.118	2.041	1.959	1.915	1.869	1.820	1.769	1.714	1.654
29	4.183	3.328	2.934	2.701	2.545	2.432	2.346	2.278	2.223	2.177	2.105	2.028	1.945	1.901	1.854	1.806	1.754	1.698	1.638
30	4.171	3.316	2.922	2.690	2.534	2.421	2.334	2.266	2.211	2.165	2.092	2.015	1.932	1.887	1.841	1.792	1.740	1.684	1.622
40	4.085	3.232	2.839	2.606	2.450	2.336	2.249	2.180	2.124	2.077	2.004	1.925	1.839	1.793	1.744	1.693	1.637	1.577	1.509
60	4.001	3.150	2.758	2.525	2.368	2.254	2.167	2.097	2.040	1.993	1.917	1.836	1.748	1.700	1.649	1.594	1.534	1.467	1.389
120	3.920	3.072	2.680	2.447	2.290	2.175	2.087	2.016	1.959	1.911	1.834	1.751	1.659	1.608	1.554	1.495	1.429	1.352	1.254
1000+	3.842	2.996	2.605	2.372	2.214	2.099	2.010	1.938	1.880	1.831	1.752	1.666	1.571	1.517	1.459	1.394	1.318	1.221	1.000’;

(24) Appendix 5 is amended as follows:

(a) in point 2.2., in the legend of equation (7-178), the row corresponding to the term "P_i" is replaced by the following:

‘P_i = engine power for the mode i [kW] calculated by adding to the measured power P_{meas} [kW] the power required to drive auxiliaries P_{AUX} [kW] determined in accordance with equation (6-8) of Annex VI ($P_i = P_{meas} + P_{AUX}$).’;

(b) in point 2.3., the first sentence is replaced by the following:

‘The final NRSC and weighted average NRTC test results shall be rounded in one step to three significant figures in accordance with ASTM E 29–06B.’.

ANNEX VIII

Annex VIII to Delegated Regulation (EU) 2017/654 is amended as follows:

(1) in point 4.2.2.2., in the last paragraph, the following sentence is added:

'A description of the connection for, and method to read, those records shall be included in the information folder as set out in Part A of Annex I of Implementing Regulation (EU) 2017/656.';

(2) in point 4.5.1., point (b) is replaced by the following:

'(b) In case of a Type 2 engine, the resulting difference between the highest and the lowest maximum GER_{cycle} within the family shall never exceed the range set out in point 2.4.15. of Annex IX to Implementing Regulation (EU) 2017/656, except as permitted by point 3.1.';

(3) point 6.4.1. is replaced by the following:

'6.4.1. The manufacturer shall present the approval authority with evidence showing that the GER_{cycle} span of all members of the dual-fuel engine family remains within the range set out in point 2.4.15. of Annex IX to Implementing Regulation (EU) 2017/656, or in the case of engines with an operator-adjustable GER_{cycle} satisfy the requirements of point 6.5. (for example, through algorithms, functional analyses, calculations, simulations, results of previous tests, etc.).';

(4) the following point 6.8. is inserted:

'6.8. Documentation of the demonstration

A demonstration report shall document the demonstration conducted pursuant to points 6.1. to 6.7.1. The report shall:

(a) describe the demonstration performed, including the applicable test cycle;

(b) be included in the information folder as set out in Part A of Annex I of Implementing Regulation (EU) 2017/656.';

(5) Appendix 2 is amended as follows:

(a) in point 7.1.3.2.1., the introductory wording of the first paragraph is replaced by the following:

'In the case that the exact equations are applied to calculate instantaneous values of u_{gas} in accordance with paragraph 7.1.3.2.(a) then, when calculating the mass per test of a gaseous emission for transient (NRTC and LSI-NRTC) test cycles and RMC, u_{gas} shall be included in the summation in equation (7-2) of point 2.1.2. of Annex VII by means of equation (8-1):';

(b) in point 7.1.3.3., the second paragraph is replaced by the following:

'The requirements of point 8.2.1.2. of Annex VI shall apply for controlling the dilution ratio. In particular, if the combined transformation time of the exhaust gas flow measurement and the partial flow system exceeds 0,3 s, look-ahead control based on a pre-recorded test run shall be used. In this case, the combined rise time shall be $\leq$ 1 s and the combined delay time $\leq$ 10 s. Except in the case that the exhaust

gas mass flow is measured directly the determination of exhaust gas mass flow shall use values of α, γ, δ and ε determined in accordance with point 7.1.5.3.';

(c) in point 7.1.3.4., in the paragraph under the heading, the first sentence is replaced by the following:

'The flow meter referred to in points 9.4.5.3. and 9.4.5.4. of Annex VI shall not be sensitive to the changes in exhaust gas composition and density.';

(d) in point 7.1.4.1., the heading is replaced by the following:

'7.1.4.1. Determination of the background corrected concentrations';

(e) point 7.1.5.2. is replaced by the following:

'7.1.5.2. Calculation of the fuel mixture components

Equations (8-2) to (8-7) shall be used to calculate the elemental composition of the fuel mixture:

$$q_{mf} = q_{mf1} + q_{mf2} \quad (8\text{-}2)$$

$$w_{\mathrm{H}} = \frac{w_{\mathrm{H1}} \times q_{mf1} + w_{\mathrm{H2}} \times q_{mf2}}{q_{mf1} + q_{mf2}} \quad (8\text{-}3)$$

$$w_{\mathrm{C}} = \frac{w_{\mathrm{C1}} \times q_{mf1} + w_{\mathrm{C2}} \times q_{mf2}}{q_{mf1} + q_{mf2}} \quad (8\text{-}4)$$

$$w_{\mathrm{S}} = \frac{w_{\mathrm{S1}} \times q_{mf1} + w_{\mathrm{S2}} \times q_{mf2}}{q_{mf1} + q_{mf2}} \quad (8\text{-}5)$$

$$w_{\mathrm{N}} = \frac{w_{\mathrm{N1}} \times q_{mf1} + w_{\mathrm{N2}} \times q_{mf2}}{q_{mf1} + q_{mf2}} \quad (8\text{-}6)$$

$$w_{\mathrm{O}} = \frac{w_{\mathrm{O1}} \times q_{mf1} + w_{\mathrm{O2}} \times q_{mf2}}{q_{mf1} + q_{mf2}} \quad (8\text{-}7)$$

where:

q_{mf1}	is the fuel mass flow rate of fuel 1 [kg/s]
q_{mf2}	is the fuel mass flow rate of fuel 2 [kg/s]
w_{H}	is the hydrogen content of fuel [% mass]
w_{C}	is the carbon content of fuel [% mass]
w_{S}	is the sulphur content of fuel [% mass]
w_{N}	is the nitrogen content of fuel [% mass]
w_{O}	is the oxygen content of fuel [% mass]';

(f) the following point 7.1.5.3. is inserted:

'7.1.5.3. Calculation of the molar ratios of H, C, S, N and O related to C for the fuel mixture

The calculation of the atomic ratios (especially the H/C-ratio α) is given in Annex VII by means of equations (8-8) to (8-11):

$$\alpha = 11.9164 \cdot \frac{w_H}{w_C} \quad (8\text{-}8)$$

$$\gamma = 0.37464 \cdot \frac{w_S}{w_C} \quad (8\text{-}9)$$

$$\delta = 0.85752 \cdot \frac{w_N}{w_C} \quad (8\text{-}10)$$

$$\varepsilon = 0.75072 \cdot \frac{w_O}{w_C} \quad (8\text{-}11)$$

where:

w_H is the hydrogen content of fuel, mass fraction [g/g] or [% mass]

w_C is the carbon content of fuel, mass fraction [g/g] or [% mass]

w_S is the sulphur content of fuel, mass fraction [g/g] or [% mass]

w_N is the nitrogen content of fuel, mass fraction [g/g] or [% mass]

w_O is the oxygen content of fuel, mass fraction [g/g] or [% mass]

α is the molar hydrogen ratio (H/C)

γ is the molar sulphur ratio (S/C)

δ is the molar nitrogen ratio (N/C)

ε is the molar oxygen ratio (O/C)

referring to a fuel $CH\alpha O\varepsilon N\delta S\gamma$'.

(g) in point 7.2.3., in the first paragraph, the last sentence is replaced by the following:

'The instantaneous molar component ratios shall be input in the equations (7-88), (7-90), and (7- 91) of Annex VII for the continuous chemical balance.';

(h) in point 7.2.3.1., the introductory wording of equation (8-16) is replaced by the following:

'In cases where exhaust gas mass flow rate is calculated based on the mixed fuel rate then w_C in equation (7-113) of Annex VII shall be calculated by means of equation (8-16):'.

ANNEX IX

In point 2 of Appendix 2 of Annex IX to Delegated Regulation (EU) 2017/654, the introductory wording before equation (9-5) is replaced by the following:

> ‘The value of S_λ may be determined from the ratio of the ratio of the stoichiometric composition of oxygen and methane to the ratio of the stoichiometric composition of oxygen and the fuel blend supplied to the engine, as set out in equation (9-5):’.

ANNEX X

In Annex XIII to Delegated Regulation (EU) 2017/654, point 1 is amended as follows:

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

‘(1) EU type-approvals granted on the basis of Regulation (EC) No 595/2009 of the European Parliament and of the Council* and its implementing measures, where a technical service confirms that the engine type meets:

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* Regulation (EC) No 595/2009 of the European Parliament and of the Council of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC (OJ L 188, 18.7.2009, p. 1.)’;

(2) in point (2), the introductory wording is replaced by the following:

‘(2) type-approvals in conformity with UNECE Regulation No 49.06 series of amendments**, where a technical service confirms that the engine type meets:

** Regulation No 49 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the measures to be taken against the emission of gaseous and particulate pollutants from compression-ignition engines and positive ignition engines for use in vehicles (OJ L 171, 24.6.2013, p. 1’.

ANNEX XI

In point 3(15) of Annex XV to Delegated Regulation (EU) 2017/654, point (a) is replaced by the following:

‘(a) where the engine is to be operated within the Union on diesel or non-road gas-oil, a statement indicating that a fuel with sulphur content not greater than 10 mg/kg (20 mg/kg at point of final distribution) cetane number not less than 45 and a FAME content not greater than 8 % v/v shall be used.’.

ANNEX XII

Annex I to Delegated Regulation (EU) 2017/654 is corrected as follows:

(1) point 2.4.1. is replaced by the following:

‘2.4.1. Engines fuelled with CNG and designed for operation on either the range of H-gases or on the range of L-gases’;

(2) points 2.5.2. and 2.5.2.1. are replaced by the following:

‘2.5.2. Fuel-specific dual-fuel engine fuelled with Liquefied Natural Gas (LNG)

2.5.2.1. For a dual-fuel engine family where the engines are calibrated for a specific LNG gas composition resulting in a λ-shift factor not differing by more than 3 % from the λ-shift factor of the G_{20} fuel specified in Annex IX, and the ethane content of which does not exceed 1,5 %, the parent engine shall only be tested on the G_{20} reference gas fuel, or on the equivalent fuel created using an admixture of pipeline gas with other gases, as specified in Appendix 1 of Annex IX.’.

ANNEX XIII

Annex III to Delegated Regulation (EU) 2017/654 is corrected as follows:

(1) point 3.1.2. is replaced by the following:

> '3.1.2. Engines from different engine families may be further combined into families based on the type of exhaust after-treatment system utilised or where no after-treatment is used, based upon the similarity of the technical characteristics of the emission control system. Engines of different bore and stroke, different configuration, different air management systems or different fuel systems may be considered equivalent in respect to emissions deterioration characteristics if the manufacturer provides data to the approval authority that there is a reasonable technical basis for such determination. In order to place engine families having similar technical specifications and installation for the exhaust after-treatment systems into the same engine after-treatment system family, the manufacturer shall provide data to the approval authority that demonstrates that the emissions reduction performance of such engines is similar.';

(2) in point 3.4.1.3., the second sentence is replaced by the following:

> 'The approval authority shall not refuse to approve maintenance requirements that are reasonable and technically necessary, including but not limited to those identified in point 3.4.1.4.'.

ANNEX XIV

Annex IV to Delegated Regulation (EU) 2017/654 is corrected as follows:

(1) point 2.3.1. is replaced by the following:

‘2.3.1. An auxiliary emission control strategy may be activated by an engine or a non-road mobile machinery, provided that the auxiliary emission control strategy:’;

(2) Appendix 1 is corrected as follows:

(a) point 2.3.1. is replaced by the following:

‘2.3.1. It is permitted to use a heated or a non-heated reagent tank and dosing system. A heated system shall meet the requirements of points 2.3.2.2. to 2.3.2.2.4. A non-heated system shall meet the requirements of point 2.3.2.3.’;

(b) point 2.3.2.2. is replaced by the following:

‘2.3.2.2. Design criteria for a heated system

A heated system shall be so designed that it meets the performance requirements set out in points 2.3.2. to 2.3.2.2.4. when tested using the procedure defined.’;

(c) point 3.1. is replaced by the following:

‘3.1. The OEM shall provide to all end-users of new non-road mobile machinery written instructions about the emission control system and its correct operation in accordance with Annex XV.’;

(d) point 7.1.1.1. is replaced by the following:

‘7.1.1.1. The value of CD_{min} specified by the manufacturer shall be used during the demonstration set out in section 13 and recorded in Part C of the information document specified in Annex I to Implementing Regulation (EU) 2017/656.’;

(e) points 9 to 9.2.3.2. are replaced by the following:

‘9. Other failures that may be attributed to tampering

9.1. In addition to the level of reagent in the reagent tank, the reagent quality, and the interruption of dosing, the following failures shall be monitored because they may be attributed to tampering:

(a) failures of the NO_x Control Diagnostic (NCD) system as described in point 9.2.1;

(b) failures of the exhaust gas recirculation (EGR) valve as described in point 9.2.2.

9.2. Monitoring requirements and counters

9.2.1. NCD system

9.2.1.1. The NO_x Control Diagnostic (NCD) system shall be monitored for electrical failures and for removal or deactivation of any

sensor that prevents it from diagnosing any other failures set out in sections 6 to 8 (component monitoring).

A non-exhaustive list of sensors that affect the diagnostic capability are those directly measuring NO_x concentration, urea quality sensors, ambient sensors and sensors used for monitoring reagent dosing activity, reagent level, or reagent consumption.

9.2.1.2. A counter shall be attributed to each of the monitoring failures. The NCD system counters shall count the number of engine operating hours when the DTC associated to a malfunction of the NCD system is confirmed to be active. Different NCD system failures may be grouped into a single counter.

9.2.1.2.1. The manufacturer may group the NCD system failure together with one or more of the systems listed in sections 7, 8 and point 9.2.2. into a single counter.

9.2.1.3. Details of the NCD system counter(s) activation and deactivation criteria and mechanisms are described in section 11.

9.2.2. Impeded EGR valve

9.2.2.1. The exhaust gas recirculation (EGR) system shall be monitored for an impeded EGR valve.

9.2.2.2. A counter shall be attributed to an impeded EGR valve. The EGR valve counter shall count the number of engine operating hours when the DTC associated to an impeded EGR valve is confirmed to be active.

9.2.2.2.1. The manufacturer may group the impeded EGR valve failure together with one or more of the systems listed in sections 7, 8 and point 9.2.1. into a single counter.

9.2.2.3. Details of the EGR valve counter activation and deactivation criteria and mechanisms are described in section 11.';

(f) point 10.2.1. is replaced by the following:

'10.2.1. The demonstration that the monitoring systems for other members of the NCD engine family are similar may be performed by presenting to the approval authorities such elements as algorithms, functional analyses, etc.';

(g) point 10.2.3. is replaced by the following:

'10.2.3. In the case where engines of an engine family belong to an NCD engine family that has already been EU type-approved, as referred to in point 10.2.1. (Figure 4.3), the compliance of that engine family is deemed to be demonstrated without further testing, provided the manufacturer demonstrates to the authority that the monitoring systems necessary for complying with the requirements of this Appendix are similar within the considered engine and NCD engine families.

Table 4.1.

Illustration of the content of the demonstration process in accordance with the provisions in points 10.3. and 10.4.

Mechanism	demonstration elements
Warning system activation specified in point 10.3.	• 2 activation tests (incl. lack of reagent) • Supplementary demonstration elements, as appropriate
Low-level inducement activation specified in point 10.4.	• 2 activation tests (incl. lack of reagent) • Supplementary demonstration elements, as appropriate • 1 torque reduction test
Severe inducement activation specified in point 10.4	• 2 activation tests (incl. lack of reagent) • Supplementary demonstration elements, as appropriate’;

(h) point 10.3.3.5.2. is replaced by the following:

‘10.3.3.5.2. The demonstration of the warning system activation is deemed to be accomplished if, at the end of each demonstration test performed in accordance with point 10.3.3., the warning system has been properly activated and the DTC for the selected failure has got the ‘confirmed and active’ status.’;

(i) points 10.4.2. and 10.4.3. are replaced by the following:

‘10.4.2. The test sequence shall demonstrate the activation of the inducement system in case of the failure selected by the approval authority from the list as referred to in point 10.3.2.1. for the test of the warning system.

10.4.3. For the purpose of this demonstration,

(a) the manufacturer shall, in agreement with the approval authority, be permitted to accelerate the test by simulating the achievement of a certain number of operating hours,

(b) the achievement of the torque reduction required for low-level inducement may be demonstrated at the same time as the general engine performance approval process performed in accordance with this Regulation. A

separate torque measurement during the inducement system demonstration is not required in this case,

(c) the low-level inducement, if applicable, shall be demonstrated in accordance with the requirements of point 10.4.5.,

(d) the severe inducement shall be demonstrated in accordance with the requirements of point 10.4.6.';

(j) point 13.3. is replaced by the following:

'13.3. The pollutant emissions resulting from this test shall not exceed the NO_x threshold specified in point 7.1.1.';

(3) Appendix 4 is corrected as follows:

(a) point 2.3.2.3. is replaced by the following:

'2.3.2.3. In cases where more than the period of running time indicated in Table 4.5 is required for the monitors to accurately detect and confirm a PCM (e.g. monitors using statistical models or with respect to fluid consumption on the non-road mobile machinery), the approval authority may permit a longer period for monitoring provided the manufacturer justifies the need for the longer period (for example by technical rationale, experimental results, in-house experience, etc.).'.;

(b) point 6.1. is replaced by the following:

'6.1. The PCD system shall detect the complete removal of the particulate after-treatment system inclusive of the removal of any sensors used to monitor, activate, de-activate or modulate its operation.'.

ANNEX XV

Point 1 of Annex V to Delegated Regulation (EU) 2017/654 is corrected as follows:

(1) the second and third paragraphs are replaced by the following:

'This Annex sets out the technical requirements relating to the area associated with the relevant NRSC, within which the amount by which the emissions shall be permitted to exceed the emission limits set out in Annex II to Regulation (EU) 2016/1628 is controlled.

When an engine is tested in the manner set out in test requirements of section 4 the emission of gaseous and particulate pollutants sampled at any randomly selected point within the applicable control area set out in section 2 shall not exceed the applicable emission limit values in Annex II to Regulation (EU) 2016/1628 multiplied by a factor of 2,0.';

(2) the last paragraph is replaced by the following:

'The installation instructions provided by the manufacturer to the OEM in accordance with Annex XIV shall identify the upper and lower boundaries of the applicable control area and shall include a statement to clarify that the OEM shall not install the engine in such a way that it constrains the engine to operate permanently at only combinations of speed and torque outside of the control area for the torque curve corresponding to the approved engine type or engine family.';

ANNEX XVI

Annex VI to Delegated Regulation (EU) 2017/654 is corrected as follows:

(1) in point 5.2.5.6., the second paragraph is replaced by the following:

‘Where the governor installed on the engine is used the 100 % speed shall be the engine governed speed as defined in Article 1(24).’;

(2) point 6.3.1. is replaced by the following:

‘6.3.1. Basis for emission measurement

The basis of specific emissions measurement is uncorrected net power as defined in Article 3(25) of Regulation (EU) 2016/1628.’;

(3) in point 6.3.3., the last sentence of the second paragraph is replaced by the following:

‘The power absorbed by auxiliaries shall be used to adjust the set values and to calculate the work produced by the engine over the test cycle in accordance with point 7.7.1.3. or point 7.7.2.3.(b).’;

(4) in point 7.4.2.1., the two paragraphs below Figure 6.3 are replaced by the following:

(a) point (a) is replaced by the following:

‘(a) the cold start run shall commence after either the engine and exhaust after-treatment systems have cooled down to room temperature after natural engine cool down, or after forced cool down, and the engine, coolant and oil temperatures, exhaust after-treatment systems and all engine control devices are stabilized between 293 K and 303 K (20 °C and 30 °C). The measurement of the emissions for this run shall be started with the start of the cold engine;’;

(b) point (c) is replaced by the following:

‘(c) the hot-start run shall commence immediately after the soak period with the cranking of the engine. The gaseous analyzers shall be switched on at least 10 seconds before the end of the soak period to avoid switching signal peaks. The measurement of emissions for this run shall be started in parallel with the cranking of the engine.

Brake specific emissions expressed in (g/kWh), or number per kilowatt-hour (#/kWh) for PN, shall be determined by using the procedures set out in this section for both the cold start run and hot-start run of the test cycle. Composite weighted emissions shall be computed by weighting the cold-start run results by 10 % and the hot-start run results by 90 % as detailed in Annex VII.’;

(5) in point 7.6., the words "as defined in Article 2(12)" are replaced by the words "as defined in Article 1(12)";

(6) in point 7.6.3.1., in point (b), the fourth and fifth sentences are replaced by the following:

‘The power recorded shall not exceed the rated power as defined in Article 3(27) of Regulation (EU) 2016/1628 by more than 12,5 %. If this value is exceeded the manufacturer shall revise the declared rated power.’;

(7) in point 7.7.2.3. in the legend of equation (6-16), the second row is replaced by the following:

‘*max.torque* is the maximum torque for the respective test speed taken from the engine mapping performed in accordance with point 7.6.2. adjusted where necessary in accordance with point 7.7.2.3.(b).’;

(8) in point 8.2.3.5., the last sentence is replaced by the following:

‘However, if a PM mass of 400 μg or more is expected, then the sample media shall be stabilised for at least 60 min.’;

(9) in point 9.2.1.(c), point (i) is replaced by the following:

‘(i) For removing background PM, the diluent shall be filtered with high-efficiency particulate air (HEPA) filters that have an initial minimum collection efficiency specification of 99,97 % (see Article 1(19) for procedures related to HEPA-filtration efficiencies);’;

(10) in point 9.2.2.(g), the last paragraph is replaced by the following:

‘For PM sampling, the already proportional flow coming from CVS goes through secondary dilution (one or more) to achieve the requested overall dilution ratio as shown in Figure 6.7 and set out in point 9.2.3.2.;’;

(11) in point 9.2.3.1., in the first paragraph, the last sentence is replaced by the following:

‘These need to satisfy other criteria such as in points 8.1.8.6. (periodic calibration) and 8.2.1.2. (validation) for varying dilution PFD, and point 8.1.4.5. as well as Table 6.5 (linearity verification) and point 8.1.8.5.7. (verification) for constant dilution PFD.’;

(12) in point 9.2.3.3., the last paragraph is replaced by the following:

‘The system may be used also for a previously diluted exhaust gas where, via a constant dilution-ratio, an already proportional flow is diluted (see Figure 6.7). This is the way of performing secondary dilution from a CVS tunnel to achieve the necessary overall dilution ratio for PM sampling.’;

(13) in Appendix 4, in point 3.4.1., the last sentence is replaced by the following:

‘The difference between the pre-test and post-test results shall be less than 2 % of full scale.’.

ANNEX XVII

Annex VII to Delegated Regulation (EU) 2017/654 is corrected as follows:

(1) point 2.4.1.1. is corrected as follows:

(a) equation (7-59) is replaced by the following:

'$W_{act} = \sum_{i=1}^{N} P_i \cdot \Delta t_i = \frac{1}{f} \cdot \frac{1}{3600} \cdot \frac{1}{10^3} \cdot \frac{2 \cdot \pi}{60} \cdot \sum_{i=1}^{N} (n_i \cdot T_i)$ (7-59)';

(2) point 3.9.5. is replaced by the following:

'3.9.5. CFV calibration

Some CFV flow meters consist of a single venturi and some consist of multiple venturis, where different combinations of venturis are used to meter different flow rates. For CFV flow meters that consist of multiple venturis, either calibration of each venturi independently to determine a separate discharge coefficient, C_d, for each venturi, or calibration of each combination of venturis as one venturi may be performed. In the case where a combination of venturis is calibrated, the sum of the active venturi throat areas is used as A_t, the square root of the sum of the squares of the active venturi throat diameters as d_t, and the ratio of the venturi throat to inlet diameters is the ratio of the square root of the sum of the active venturi throat diameters (d_t) to the diameter of the common entrance to all of the venturis (D). To determine the C_d for a single venturi or a single combination of venturis, the following steps shall be performed:

(a) With the data collected at each calibration set point an individual C_d for each point shall be calculated using equation (7-140);

(b) The mean and standard deviation of all the C_d values shall be calculated in accordance with equations (7-155) and (7-156);

(c) If the standard deviation of all the C_d values is less than or equal to 0,3 % of the mean C_d, then the mean C_d shall be used in equation (7-120), and the CFV shall be used only down to the lowest r measured during calibration;

$$r = 1 - \left(\Delta p / p_{in} \right) \quad (7\text{-}148)$$

(d) If the standard deviation of all the C_d values exceeds 0,3 % of the mean C_d, the C_d values corresponding to the data point collected at the lowest r measured during calibration shall be omitted;

(e) If the number of remaining data points is less than seven, corrective action shall be taken by checking calibration data or repeating the calibration process. If the calibration process is repeated, checking for leaks, applying tighter tolerances to measurements and allowing more time for flows to stabilize, is recommended;

(f) If the number of remaining C_d values is seven or greater, the mean and standard deviation of the remaining C_d values shall be recalculated;

(g) If the standard deviation of the remaining C_d values is less than or equal to 0,3 % of the mean of the remaining C_d, that mean C_d shall be used in equation (7-120) and the CFV values only down to the lowest *r* associated with the remaining C_d shall be used;

(h) If the standard deviation of the remaining C_d still exceeds 0,3 % of the mean of the remaining C_d values, the steps set out in points (d) to (g) shall be repeated.';

(3) in Appendix 6, equation (7-180) is replaced by the following:

'$c_{NH3} = (0.1 \times c_{NH3,cold}) + (0.9 \times c_{NH3,hot})$ (7-180)'.

ANNEX XVIII

Annex VIII to Delegated Regulation (EU) 2017/654 is corrected as follows:

(1) in point 4.6., the words "as required by" are deleted;

(2) in Appendix 2, in point 4., in the third paragraph below the heading, the last sentence is replaced by the following:

‘This shall be compensated via one of the methods described in point 7.’.