Council of the European Union

Brussels, 21 December 2016
(OR. en)

15755/16
ADD 1

ENT 238
MI 809
ENV 821
DELACT 259

COVER NOTE

From:	Secretary-General of the European Commission, signed by Mr Jordi AYET PUIGARNAU, Director
date of receipt:	19 December 2016
To:	Mr Jeppe TRANHOLM-MIKKELSEN, Secretary-General of the Council of the European Union
No. Cion doc.:	C(2016) 8381 final ANNEXES 1 to 5
Subject:	ANNEXES to the Commission Delegated Regulation (EU) .../... 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(2016) 8381 final ANNEXES 1 to 5.

Encl.: C(2016) 8381 final ANNEXES 1 to 5

EUROPEAN
COMMISSION

Brussels, 19.12.2016
C(2016) 8381 final

ANNEXES 1 to 5

ANNEXES

to the

Commission Delegated Regulation (EU) .../...

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

ANNEXES

ANNEX I

Requirements for any other specified fuels, fuel mixtures or fuel emulsions

1. Requirements for engines fuelled with liquid fuels

1.1. When applying for an EU type-approval, manufacturers may select one of the following options with regard to the engine's fuel range:

(a) standard fuel range engine, in accordance with the requirements set out in point 1.2.; or,

(b) fuel-specific engine, in accordance with the requirements set out in point 1.3..

1.2. Requirements for a standard fuel range (diesel, petrol) engine

A standard fuel range engine shall meet the requirements specified in points 1.2.1 to 1.2.4.

1.2.1. The parent engine shall meet the applicable limit values set out in Annex II to Regulation (EU) 2016/1628 and the requirements set out in this Regulation when the engine is operated on the reference fuels specified in sections 1.1 or 2.1 of Annex IX.

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[1], 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 an Fatty-Acid Methyl Ester ("FAME") content not greater than 7,0 % 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 an FAME content not greater than 7,0 % v/v. The manufacturer may optionally specify other parameters (eg for lubricity).

1.2.2.1. The engine manufacturer shall not indicate at the moment of EU type-approval 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..

(a) In the case of petrol, Directive 98/70/EC or the CEN standard EN 228:2012. Lubricating oil may be added according to the specification of the manufacturer;

[1] 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).

(b) In the case of diesel (other than non-road gas-oil), Directive 98/70/EC of the European Parliament and of the Council or the CEN standard EN 590:2013;

(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 7,0 % v/v.

1.2.3. If the manufacturer permits engines to run on additional market fuels other than those identified in point 1.2.2., such as running on B100 (EN 14214:2012+A1:2014), B20 or B30 (EN16709:2015), or on specific fuels, fuel mixtures or fuel emulsions, all of the following actions shall be taken by the manufacturer in addition to the requirements of point 1.2.2.1.:

(a) declare, in the information document set out in Commission Implementing Regulation 2016/CCC on administrative requirements[2], the specification of the commercial fuels, fuel mixtures or emulsions on which the engine family is capable to run;

(b) demonstrate the capability of the parent engine to meet the requirements of this Regulation on the fuels, fuel mixtures or emulsions declared;

(c) be liable to meet the requirements of in-service monitoring specified in Commission Delegated Regulation 2016/BBB on monitoring of in-service engines[3] on the fuels, fuel mixtures or emulsions declared, including any blend between the declared fuels, fuel mixtures or emulsions, and the applicable market fuel identified in point 1.2.2.1..

1.2.4. For SI engines, the fuel/oil mixture ratio must be the ratio which shall be recommended by the manufacturer. The percentage of oil in the fuel/lubricant mixture shall be recorded in the information document set out in Commission Implementing Regulation 2016/CCC on administrative requirements.

1.3. Requirements for a fuel-specific (ED 95 or E 85) engine

A specific fuel (ED 95 or E 85) engine shall meet the requirements specified in points 1.3.1 and 1.3.2..

1.3.1. For ED 95, the parent engine shall meet the applicable limit values set out in Annex II to Regulation (EU) 2016/1628 and the requirements set out in this Regulation when the engine is operated on the reference fuel specified in point 1.2. of Annex IX.

1.3.2. For E 85, the parent engine shall meet the applicable limit values set out in Annex II to Regulation (EU) 2016/1628 and the requirements set out in this Regulation when the engine is operated on the reference fuel specified point 2.2 of Annex IX.

2. Requirements for engines fuelled with natural gas/biomethane (NG) or liquefied petroleum gas (LPG), including dual-fuel engines

---

2 [Please OJ insert the full title of the implementing regulation and a reference to publication in the OJ.]

3 [Please OJ insert the full title of the delegated regulation and a reference to publication in the OJ.]

2.1. When applying for an EU type-approval, manufacturers may select one of the following options with regard to the engine's fuel range:

(a) universal fuel range engine, in accordance with the requirements set out in point 2.3.;

(b) restricted fuel range engine, in accordance with the requirements set out in point 2.4.;

(c) fuel-specific engine, in accordance with the requirements set out in point 2.5..

2.2. Tables summarizing the requirements for EU type-approval of natural gas/biomethane fuelled engines, LPG-fuelled engines and dual-fuel engines are provided in Appendix 1.

2.3. Requirements for a universal fuel range engine

2.3.1. For engines fuelled with natural gas/biomethane, including dual-fuel engines, the manufacturer shall demonstrate the parent engine's capability to adapt to any natural gas/biomethane composition that may occur across the market. That demonstration shall be carried out in accordance with this section 2. and in case of dual-fuel engines, also in accordance with the additional provisions regarding the fuel adaptation procedure set out in point 6.4. of Annex VIII.

2.3.1.1. For engines fuelled with compressed natural gas/biomethane (CNG) there are generally two types of fuel, high calorific fuel (H-gas) and low calorific fuel (L-gas), but with a significant spread within both ranges; they differ significantly in their energy content expressed by the Wobbe Index and in their λ-shift factor (S_λ). Natural gases with a λ-shift factor between 0,89 and 1,08 ($0,89 \leq S_\lambda \leq 1,08$) are considered to belong to H-range, while natural gases with a λ-shift factor between 1,08 and 1,19 ($1,08 \leq S_\lambda \leq 1,19$) are considered to belong to L-range. The composition of the reference fuels reflects the extreme variations of S_λ.

The parent engine shall meet the requirements of this Regulation on the reference fuels G_R (fuel 1) and G_{25} (fuel 2), as specified in Annex IX, or on the equivalent fuels created using admixtures of pipeline gas with other gases as specified in Appendix 1 of Annex IX, without any manual readjustment to the engine fuelling system between the two tests (self-adaptation is required). One adaptation run is permitted after the change of the fuel. The adaption run shall consist of performing the pre-conditioning for the following emission test according to the respective test cycle. In the case of engines tested on the non-road steady-state test cycles ("NRSC"), where the pre-conditioning cycle is in-adequate for the engine fuelling to self-adapt an alternative adaption run specified by the manufacturer may be performed prior to pre-conditioning the engine.

2.3.1.1.1. The manufacturer may test the engine on a third fuel (fuel 3) if the λ-shift factor (S_λ) lies between 0,89 (that is the lower range of G_R) and 1,19 (that is the upper range of G_{25}), for example when fuel 3 is a market fuel. The results of this test may be used as a basis for the evaluation of the conformity of the production.

2.3.1.2. For engines fuelled with liquefied natural gas/liquefied biomethane (LNG), the parent engine shall meet the requirements of this Regulation on the reference fuels G_R (fuel 1) and G_{20} (fuel 2), as specified in Annex IX, or on the equivalent fuels created using admixtures of pipeline gas with other gases as specified in Appendix 1 of Annex IX, without any manual readjustment to the engine fuelling system between the two tests (self-adaptation is required). One adaptation run is permitted after the change of the fuel. The adaption run shall consist of performing the pre-conditioning for the following emission test according to the respective test cycle. In the case of engines tested on the NRSC, where the pre-conditioning cycle is in-adequate for the engine fuelling to self-adapt an alternative adaption run specified by the manufacturer may be performed prior to pre-conditioning the engine.

2.3.2. For engines fuelled with compressed natural gas/biomethane (CNG) which are self-adaptive for the range of H-gases on the one hand and the range of L-gases on the other hand, and which switch between the H-range and the L-range by means of a switch, the parent engine shall be tested on the relevant reference fuel as specified in in Annex IX for each range, at each position of the switch. The fuels are G_R (fuel 1) and G_{23} (fuel 3) for the H-range of gases and G_{25} (fuel 2) and G_{23} (fuel 3) for the L-range of gases, or the equivalent fuels created using admixtures of pipeline gas with other gases as specified in Appendix 1 of Annex IX. The parent engine shall meet the requirements of this Regulation at both positions of the switch without any readjustment to the fuelling between the two tests at each position of the switch. One adaptation run is permitted after the change of the fuel. The adaption run shall consist of performing the pre-conditioning for the following emission test according to the respective test cycle. In the case of engines tested on the NRSC, where the pre-conditioning cycle is in-adequate for the engine fuelling to self-adapt an alternative adaption run specified by the manufacturer may be performed prior to pre-conditioning the engine.

2.3.2.1. The manufacturer's may test the engine on a third fuel instead of G_{23} (fuel 3) if the λ-shift factor (S_λ) lies between 0,89 (that is the lower range of G_R) and 1,19 (that is the upper range of G_{25}), for example when fuel 3 is a market fuel. The results of this test may be used as a basis for the evaluation of the conformity of the production.

2.3.3. For engines fuelled with natural gas/biomethane, the ratio of the emission results "r" shall be determined for each pollutant as follows:

$$r = \frac{\text{emission result on reference fuel 2}}{\text{emission result on reference fuel 1}}$$

or,

$$r_a = \frac{\text{emission result on reference fuel 2}}{\text{emission result on reference fuel 3}}$$

and

$$r_b = \frac{\text{emission result on reference fuel 1}}{\text{emission result on reference fuel 3}}$$

2.3.4. For engines fuelled with LPG the manufacturer shall demonstrate the parent engine's capability to adapt to any fuel composition that may occur across the market.

For engines fuelled with LPG there are variations in C_3/C_4 composition. These variations are reflected in the reference fuels. The parent engine shall meet the emission requirements on the reference fuels A and B as specified in Annex IX without any readjustment to the fuelling between the two tests. One adaptation run is permitted after the change of the fuel. The adaption run shall consist of performing the pre-conditioning for the following emission test according to the respective test cycle. In the case of engines tested on the NRSC, where the pre-conditioning cycle is in-adequate for the engine fuelling to self-adapt an alternative adaption run specified by the manufacturer may be performed prior to pre-conditioning the engine.

2.3.4.1. The ratio of emission results "r" shall be determined for each pollutant as follows:

$$r = \frac{\text{emission result on reference fuel B}}{\text{emission result on reference fuel A}}$$

2.4. Requirements for a restricted fuel range engine

A restricted fuel range engine shall meet the requirements specified in points 2.4.1. to 2.4.3..

2.4.1. For engines fuelled with CNG and designed for operation on either the range of H-gases or on the range of L-gases

2.4.1.1. The parent engine shall be tested on the relevant reference fuel, as specified in Annex IX, for the relevant range. The fuels are G_R (fuel 1) and G_{23} (fuel 3) for the H-range of gases and G_{25} (fuel 2) and G_{23} (fuel 3) for the L-range of gases or the equivalent fuels created using admixtures of pipeline gas with other gases as specified in Appendix 1 of Annex IX. The parent engine shall meet the requirements of this Regulation without any readjustment to the fuelling between the two tests. One adaptation run is permitted after the change of the fuel. The adaption run shall consist of performing the pre-conditioning for the following emission test according to the respective test cycle. In the case of engines tested on the NRSC, where the pre-conditioning cycle is in-adequate for the engine fuelling to self-adapt an alternative adaption run specified by the manufacturer may be performed prior to pre-conditioning the engine.

2.4.1.2. The manufacturer's may test the engine on a third fuel instead of G_{23} (fuel 3) if the λ-shift factor (S_λ) lies between 0,89 (that is the lower range of G_R) and 1,19 (that is the upper range of G_{25}), for example when fuel 3 is a market fuel. The results of this test may be used as a basis for the evaluation of the conformity of the production.

2.4.1.3. The ratio of emission results "r" shall be determined for each pollutant as follows:

$$r = \frac{\text{emission result on reference fuel 2}}{\text{emission result on reference fuel 1}}$$

or,

$$r_a = \frac{\text{emission result on reference fuel 2}}{\text{emission result on reference fuel 3}}$$

and

$$r_b = \frac{\text{emission result on reference fuel 1}}{\text{emission result on reference fuel 3}}$$

2.4.1.4. On delivery to the customer the engine shall bear a label as specified in Annex III to Regulation (EU) 2016/1628 stating for which range of gases the engine is EU type-approved.

2.4.2. For engines fuelled with natural gas or LPG and designed for operation on one specific fuel composition

2.4.2.1. The parent engine shall meet the emission requirements on the reference fuels G_R and G_{25} or on the equivalent fuels created using admixtures of pipeline gas with other gases as specified in Appendix 1 of Annex IX in the case of CNG, on the reference fuels G_R and G_{20} or on the equivalent fuels created using admixtures of pipeline gas with other gases as specified in Appendix 2 of Annex VI in the case of LNG, or on the reference fuels A and B in the case of LPG, as specified in Annex IX. Fine-tuning of the fuelling system is allowed between the tests. This fine-tuning will consist of a recalibration of the fuelling database, without any alteration to either the basic control strategy or the basic structure of the database. If necessary the exchange of parts that are directly related to the amount of fuel flow such as injector nozzles is allowed.

2.4.2.2. For engines fuelled with CNG, the manufacturer may test the engine on the reference fuels G_R and G_{23}, or on the reference fuels G_{25} and G_{23}, or on the equivalent fuels created using admixtures of pipeline gas with other gases as specified in Appendix 1 of Annex IX, in which case the EU type-approval is only valid for the H-range or the L-range of gases respectively.

2.4.2.3. On delivery to the customer the engine shall bear a label as specified in Annex III to Commission Implementing Regulation 2016/CCC on administrative requirements stating for which fuel range composition the engine has been calibrated.

2.5. Requirements for a fuel-specific engine fuelled with liquefied natural gas/liquefied biomethane (LNG)

A fuel-specific engine fuelled with liquefied natural gas/liquefied biomethane shall meet the requirements specified in points 2.5.1. to 2.5.2..

2.5.1. Fuel-specific engine fuelled with liquefied natural gas/liquefied biomethane (LNG)

2.5.1.1. The engine shall be 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 %.

2.5.1.2. If the requirements set out in point 2.5.1.1.are not fulfilled, the manufacturer shall apply for a universal fuel engine according to the specifications set out in point 2.1.3.2..

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

2.5.2.1. For a dual-fuel engine family the engines shall be 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.

2.6. EU type-approval of a member of a family

2.6.1. With the exception of the case mentioned in point 2.6.2., the EU type-approval of a parent engine shall be extended to all family members, without further testing, for any fuel composition within the range for which the parent engine has been EU type-approved (in the case of engines described in point 2.5.) or the same range of fuels (in the case of engines described in either point 2.3. or 2.4.) for which the parent engine has been EU type-approved.

2.6.2. Where the technical service determines that, with regard to the selected parent engine the submitted application does not fully represent the engine family defined in Annex IX to Commission Implementing Regulation 2016/CCC on administrative requirements, an alternative and if necessary an additional reference test engine may be selected by the technical service and tested.

2.7. Additional requirements for dual-fuel engines

In order to receive an EU type-approval of a dual-fuel engine type or engine family, the manufacturer shall:

(a) conduct the tests in accordance with Table 1.3. of Appendix 1;

(b) in addition to the requirements set out in section 2., demonstrate that the dual-fuel engines are subject to the tests and comply with the requirements set out in Annex VIII.

Appendix 1

Summary of approval process for natural gas and LPG fuelled engines including dual-fuel engines

Tables 1.1. to 1.3.show a summary of the approval process for of natural gas fuelled engines and LPG fuelled engines and of the minimum number of tests required for approval of dual-fuel engines.

Table 1.1.

EU type-approval of natural gas fuelled engines

	Point 2.3: Requirements for an universal fuel range engine	*Number of test runs*	*Calculation of "r"*	*Point 2.4: Requirements for a restricted fuel range engine*	*Number of test runs*	*Calculation of "r"*
Refer to point 2.3.1. NG-engine adaptable to any fuel composition	G_R (1) and G_{25} (2) At manufacturer's request engine may be tested on an additional market fuel (3), if S_λ = 0,89 – 1,19	2 (max. 3)	$r = \frac{\text{fuel 2 } (G_{25})}{\text{fuel 1 } (G_R)}$ and, if tested with an additional fuel; $r_a = \frac{\text{fuel 2 } (G_{25})}{\text{fuel 3 (market fuel)}}$ and $r_b = \frac{\text{fuel 1 } (G_R)}{\text{fuel 3 } (G_{23} \text{ or market fuel})}$			
Refer to point 2.3.2. NG-engine which is self-adaptive by a switch	G_R (1) and G_{23} (3) for H and G_{25} (2) and G_{23} (3) for L At manufacturer's request engine may be tested on a market fuel (3) instead of G_{23}, if S_λ = 0,89 – 1,19	2 for the H-range, and 2 for the L-range; at respective position of switch	$r_b = \frac{\text{fuel 1 } (G_R)}{\text{fuel 3 } (G_{23} \text{ or market fuel}}$ and $r_a = \frac{\text{fuel 2 } (G_{25})}{\text{fuel 3 } (G_{23} \text{ or market fuel})}$			
Refer to point 2.4.1. NG-engine laid out for operation on either H-range gas or L-range gas				G_R (1) and G_{23} (3) for H or G_{25} (2) and G_{23} (3) for L At manufacturer's request engine may be tested on a market fuel (3) instead of G_{23}, if S_λ = 0,89 – 1,19	2 for the H-range or 2 for the L-range 2	$r_b = \frac{\text{fuel 1 } (G_R)}{\text{fuel 3 } (G_{23} \text{ or market fuel})}$ for the H-range or $r_a = \frac{\text{fuel 2 } (G_{25})}{\text{fuel 3 } (G_{23} \text{ or market fuel})}$ for the L-range

Refer to point 2.4.2. NG-engine laid out for operation on one specific fuel composition				G_R (1) and G_{25} (2), Fine-tuning between the tests allowed. At manufacturer's request engine may be tested on: G_R (1) and G_{23} (3) for H or G_{25} (2) and G_{23} (3) for L	2 2 for the H-range or 2 for the L-range	

Table 1.2.

EU type-approval of LPG fuelled engines

	Point 2.3: Requirements for an universal fuel range engine	*Number of test runs*	*Calculation of "r"*	*Point 2.4: Requirements for a restricted fuel range engine*	*Number of test runs*	*Calculation of "r"*
Refer to point 2.3.4. LPG-engine adaptable to any fuel composition	Fuel A and fuel B	2	$r = \frac{\text{fuel B}}{\text{fuel A}}$			
Refer to point 2.4.2. LPG-engine laid out for operation on one specific fuel composition				Fuel A and fuel B, fine-tuning between the tests allowed	2	

Table 1.3.

Minimum number of tests required for EU type-approval of dual-fuel engines

Dual-fuel type	Liquid-fuel mode	Dual-fuel mode			
		CNG	LNG	LNG_{20}	LPG
1A		Universal or restricted (2 tests)	Universal (2 tests)	Fuel-specific (1 test)	Universal or restricted (2 tests)
1B	Universal (1 test)	Universal or restricted (2 tests)	Universal (2 tests)	Fuel-specific (1 test)	Universal or restricted (2 tests)
2A		Universal or restricted (2 tests)	Universal (2 tests)	Fuel-specific (1 test)	Universal or restricted (2 tests)
2B	Universal (1 test)	Universal or restricted (2 tests)	Universal (2 tests)	Fuel-specific (1 test)	Universal or restricted (2 tests)
3B	Universal	Universal or	Universal	Fuel-specific	Universal or

	(1 test)	restricted (2 tests)	(2 tests)	(1 test)	restricted (2 tests)

ANNEX II

Arrangements with regard to conformity of production

1. Definitions

For the purposes of this Annex the following definitions shall apply:

1.1. "quality management system" means a set of interrelated or interacting elements that organisations use to direct and control how quality policies are implemented and quality objectives are achieved;

1.2. "audit" means an evidence-gathering process used to evaluate how well audit criteria are being applied; it should be objective, impartial and independent, and the audit process should be both systematic and documented;

1.3. "corrective actions" means a problem-solving process with subsequent steps taken to remove the causes of a nonconformity or undesirable situation and designed to prevent their recurrence;

2. Purpose

2.1. The conformity of production arrangements aim to ensure that each engine is in conformity with the specification, performance and marking requirements of the approved engine type or engine family.

2.2. Procedures include, inseparably, the assessment of quality management systems, referred as 'initial assessment' and set out in section 3. and verification and production-related controls, referred to as 'product conformity arrangements' and set out in section 4..

3. Initial assessment

3.1. Before granting EU type-approval, the approval authority shall verify the existence of satisfactory arrangements and procedures established by the manufacturer for ensuring effective control so that engines when in production conform to the approved engine type or engine family.

3.2. Guidelines for quality and/or environmental management systems auditing set out in the EN ISO 19011:2011 standard shall apply to the initial assessment.

3.3. The approval authority shall be satisfied with the initial assessment and the product conformity arrangements in section 4. taking account as necessary of one of the arrangements described in points 3.3.1. to 3.3.3. or a combination of those arrangements in full or in part as appropriate.

3.3.1. The initial assessment and/or verification of product conformity arrangements shall be carried out by the approval authority granting the approval or an appointed body acting on behalf of the approval authority.

3.3.1.1. When considering the extent of the initial assessment to be carried out, the approval authority may take account of available information relating to the manufacturer's certification which has not been accepted under point 3.3.3.

3.3.2. The initial assessment and verification of product conformity arrangements may also be carried out by the approval authority of another Member State, or the appointed body designated for this purpose by the approval authority.

3.3.2.1. In such a case, the approval authority of the other Member State shall prepare a statement of compliance outlining the areas and production facilities it has covered as relevant to the engines to be EU type-approved.

3.3.2.2. On receiving an application for a compliance statement from the approval authority of a Member State granting EU type-approval, the approval authority of another Member State shall send forthwith the statement of compliance or advise that it is not in a position to provide such a statement.

3.3.2.3. The statement of compliance shall include at least the following:

3.3.2.3.1. group or company (e.g. XYZ manufacturing);

3.3.2.3.2. particular organisation (e.g. European division);

3.3.2.3.3. plants/sites (e.g. engine plant 1 (United Kingdom) — engine plant 2 (Germany));

3.3.2.3.4. Engine types/engine families included

3.3.2.3.5. areas assessed (e.g. engine assembly, engine testing, after-treatment manufacture)

3.3.2.3.6. documents examined (e.g. company and site quality manual and procedures);

3.3.2.3.7. date of the assessment (e.g. audit conducted from 18 to 30.5.2013);

3.3.2.3.8. planned monitoring visit (e.g. October 2014).

3.3.3. The approval authority shall also accept the manufacturer's suitable certification to harmonised standard EN ISO 9001:2008 or an equivalent harmonised standard as satisfying the initial assessment requirements of point 3.3. The manufacturer shall provide details of the certification and undertake to inform the approval authority of any revisions to its validity or scope.

4. Product conformity arrangements

4.1. Every engine EU type-approved pursuant to Regulation (EU) 2016/1628, Commission Delegated Regulation 2016/AAA on technical and general requirements, Commission Delegated Regulation 2016/BBB on monitoring of in-service engines and Commission Implementing Regulation 2016/CCC on administrative requirements shall be so manufactured as to conform to the approved engine type or engine family by meeting the requirements of this Annex, Regulation (EU) 2016/1628 and the abovementioned Commission delegated and implementing Regulations.

4.2. Before granting a EU type-approval pursuant to Regulation (EU) 2016/1628 and the delegated and implementing acts adopted pursuant to that Regulation, the approval authority shall verify the existence of adequate arrangements and documented control plans, to be agreed with the manufacturer for each approval, to carry out at specified intervals those tests or associated checks necessary to verify continued conformity with the approved engine type or engine family, including, where applicable, tests specified in Regulation (EU) 2016/1628 and the delegated and implementing acts adopted pursuant to that Regulation.

4.3. The holder of the EU type-approval shall:

4.3.1. ensure the existence and application of procedures for effective control of the conformity of engines to the approved engine type or engine family;

4.3.2. have access to the testing or other appropriate equipment necessary for checking conformity to each approved engine type or engine family;

4.3.3. ensure that test or check result data are recorded and that annexed documents remain available for a period of up to 10 years to be determined in agreement with the approval authority;

4.3.4. for engine categories NRSh and NRS, except for NRS-v-2b and NRS-v-3, ensure that for each type of engine, at least the checks and the tests prescribed in Regulation (EU) 2016/1628 and the delegated and implementing acts adopted pursuant to that Regulation are carried out. For other categories tests at a component or assembly of components level with appropriate criterion may be agreed between the manufacturer and the approval authority.

4.3.5. analyse the results of each type of test or check, in order to verify and ensure the stability of the product characteristics, making allowance for variation in industrial production;

4.3.6. ensure that any set of samples or test pieces giving evidence of non-conformity in the type of test in question gives rise to a further sampling and test or check.

4.4. If the further audit or check results referred to in point 4.3.6. are deemed not to be satisfactory in the opinion of the approval authority, the manufacturer shall ensure that conformity of production is restored as soon as possible by corrective actions to the satisfaction of the approval authority.

5. Continued verification arrangements

5.1. The authority which has granted EU type-approval may at any time verify the conformity of production control methods applied in each production facility by means of periodic audits. The manufacturer shall for that purpose allow access to the manufacture, inspection, testing, storage and distribution sites and shall provide all necessary information with regard to the quality management system documentation and records.

5.1.1. The normal approach for such periodic audits shall be to monitor the continued effectiveness of the procedures laid down in sections 3. and 4. (initial assessment and product conformity arrangements).

5.1.1.1. Surveillance activities carried out by the technical services (qualified or recognised as required in point 3.3.3.) shall be accepted as satisfying the requirements of point 5.1.1. with regard to the procedures established at initial assessment.

5.1.1.2. The minimum frequency of verifications (other than those referred to in point 5.1.1.1.) to ensure that the relevant conformity of production controls applied in accordance with sections 3. and 4. are reviewed over a period consistent with the climate of trust established by the approval authority shall be at least once every two years. However, additional verifications shall be carried out by the approval authority depending on the yearly production, the results of previous evaluations, the need to monitor corrective actions and upon a reasoned request from another approval authority or any market surveillance authority.

5.2. At every review, the records of tests, checks and production records, and in particular the records of those tests or checks documented as required in point 4.2., shall be available to the inspector.

5.3. The inspector may select random samples to be tested in the manufacturer's laboratory or in the facilities of the technical service, in which case only physical tests shall be carried out. The minimum number of samples may be determined according to the results of the manufacturer's own verification.

5.4. Where the level of control appears unsatisfactory, or when it seems necessary to verify the validity of the tests carried out in application of point 5.2., or upon a reasoned request from another approval authority or any market surveillance authority, the inspector shall select samples to be tested in the manufacturer's laboratory or sent to the technical service to perform physical tests in accordance with the requirements set out in section 6., in Regulation (EU) 2016/1628 and in the delegated and implementing acts adopted pursuant to that Regulation.

5.5. Where unsatisfactory results are found by the approval authority during an inspection or a monitoring review, or by an approval authority in other Member State, in accordance with Article 39(3) of Regulation (EU) 2016/1628, the approval authority shall ensure that all necessary steps are taken to restore conformity of production as rapidly as possible.

6. Conformity of production test requirements in cases of an unsatisfactory level of product conformity control as referred to in point 5.4.

6.1. In case of an unsatisfactory level of product conformity control as referred to in point 5.4. or point 5.5., conformity of production shall be checked by emissions testing on the basis of the description in the EU type-approval certificates set out in Annex IV to Commission Implementing Regulation 2016/CCC on administrative requirements.

6.2. Except otherwise provided in point 6.3., the following procedure shall apply:

6.2.1. Three engines and, if applicable, three after-treatment systems shall randomly be taken for inspection from the series production of the engine type under consideration. Additional engines shall be taken as necessary to reach a pass or fail decision. For reaching a pass decision, a minimum of four engines needs to be tested.

6.2.2. After the inspector's selection of the engines, the manufacturer shall not carry out any adjustment to the engines selected.

6.2.3. Engines shall be subjected to emissions testing in accordance with the requirements of Annex VI, or, in the case of dual fuel engines, in accordance with Appendix 2 of Annex VIII, and shall be subject to the test cycles relevant for the engine type in accordance with Annex XVII.

6.2.4. The limit values shall be those set out in Annex II to Regulation (EU) 2016/1628. Where an engine with after-treatment regenerates infrequently as referred to in point 6.6.2. of Annex VI, each gaseous or particulate pollutant emission result shall be adjusted by the factor applicable to the engine type. In all cases each gaseous or particulate pollutant emission result shall be adjusted by application of the appropriate deterioration factors (DFs) for that engine type, as determined in accordance with Annex III.

6.2.5. The tests shall be carried out on newly manufactured engines.

6.2.5.1. At the request of the manufacturer, the tests may be conducted on engines which have been run-in, up either 2 % of the emission durability period or, if this is a shorter period of time, 125 hours. Where the run-in procedure shall be conducted by the manufacturer who shall undertake not to make any adjustments to those engines. Where the manufacturer has specified a run-in procedure in point 3.3. of the information document, as set out in Annex I to Commission Implementing Regulation (EU) 2016/CCC on administrative requirements, the run-in shall be conducted using that procedure.

6.2.6. On the basis of tests of the engine by sampling as set out in Appendix 1, the series production of the engines under consideration is regarded as conforming to the approved type where a pass decision is reached for all the pollutants and as non-conforming to the approved type where a fail decision is reached for one pollutant, in accordance with the test criteria applied in Appendix 1, and as shown in Figure 2.1..

6.2.7. When a pass decision has been reached for one pollutant, this decision may not be changed as a consequence of a result from any additional tests made in order to reach a decision for the other pollutants.

If a pass decision is not reached for all the pollutants and no fail decision is reached for any of the pollutant, a test shall be carried out on another engine.

6.2.8. If no decision is reached, the manufacturer may at any time decide to stop testing. In that case a fail decision shall be recorded.

6.3. By derogation from point 6.2.1., the following procedure shall apply for engine types with a sales volume within the EU of less than 100 units per year:

6.3.1. One engine and, if applicable, one after-treatment system shall be taken randomly for inspection from the series production of the engine type under consideration.

6.3.2. If the engine meets the requirements outlined in point 6.2.4., a pass decision is reached and no further test is necessary.

6.3.3. If the test does not satisfy the requirements outlined in point 6.2.4., the procedure outlined in points 6.2.6. to 6.2.9. shall be followed.

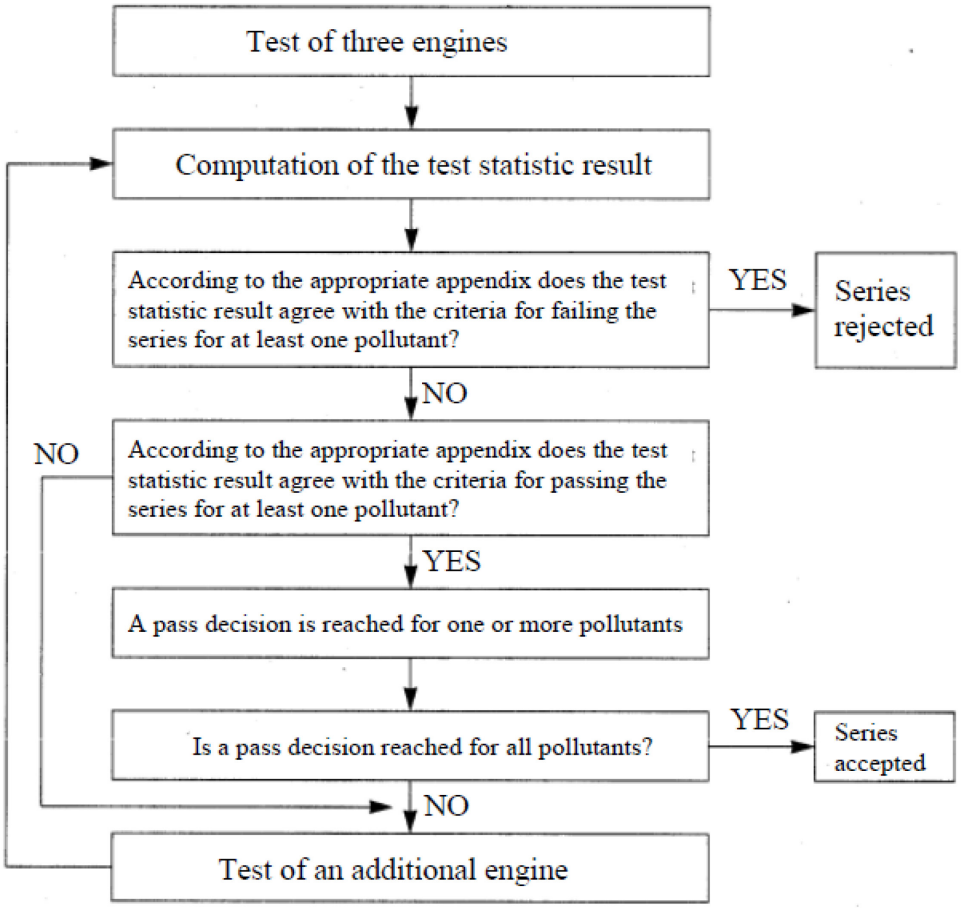
6.4. All these tests may be conducted with the applicable market fuels. However, at the manufacturer's request, the reference fuels described in Annex IX shall be used. This implies tests, as described in Appendix 1 of Annex I, with at least two of the reference fuels for each gaseous-fuelled engine, except in the case of a gaseous-fuelled engine with a fuel-specific EU type-approval where only one reference fuel is required. Where more than one gaseous reference fuel is used the results shall demonstrate that the engine meets the limit values with each fuel.

6.5. Non-compliance of gaseous-fuelled engines

In the case of dispute concerning compliance of gaseous-fuelled engines, including dual-fuel engines, when using a market fuel, the tests shall be performed with each reference fuel on which the parent engine has been tested, and, at the request of the manufacturer, with the possible additional third fuel, as referred to in points 2.3.1.1.1., 2.3.2.1. and 2.4.1.2. of Annex I, on which the parent engine may have been tested. When applicable, the result shall be converted by a calculation, applying the relevant factors "r", "r_a" or "r_b" as described in points 2.3.3., 2.3.4.1. and 2.4.1.3. of Annex I. If r, r_a or r_b are less than 1, no correction shall take place. The measured results and, when applicable, the calculated results shall demonstrate that the engine meets the limit values with all relevant fuels (for example fuels 1, 2 and, if applicable, the third fuel in the case of natural gas/bio-methane engines, and fuels A and B in the case of LPG engines).

Figure 2.1.

Schematic of production conformity testing


Test of three engines
Computation of the test statistic result
According to the appropriate appendix does the test statistic result agree with the criteria for failing the series for at least one pollutant?
YES
Series rejected
NO
According to the appropriate appendix does the test statistic result agree with the criteria for passing the series for at least one pollutant?
NO
YES
A pass decision is reached for one or more pollutants
Is a pass decision reached for all pollutants?
YES
Series accepted
NO
Test of an additional engine

Appendix 1

Procedure for production conformity testing

1. This appendix describes the procedure to be used to verify production conformity for the emissions of pollutants.

2. With a minimum sample size of three engines, the sampling procedure shall be set out so that the probability of a lot passing a test with 30 % of the engines defective is 0,90 (producer's risk = 10 %) while the probability of a lot being accepted with 65 % of the engines defective is 0,10 (consumer's risk = 10 %).

3. The following procedure is used for each of the emission pollutants (see Figure 2.1.):

   Let: n = the current sample number.

4. Determine for the sample the test statistic quantifying the cumulative number of nonconforming tests at the n^{th} test.

5. Then:

   (a) If the test statistic is less than or equal to the pass decision number for the sample size given in Table 2.1., a pass decision shall be reached for the pollutant;

   (b) If the test statistic is greater than or equal to the fail decision number for the sample size given in Table 2.1., a fail decision shall be reached for the pollutant;

   (c) Otherwise, an additional engine is tested in accordance with point 6.2 and the calculation procedure shall be applied to the sample increased by one more unit.

   In Table 2.1. the pass and fail decision numbers shall be calculated by means of the International Standard ISO 8422/1991.

Table 2.1.

Test statistics for production conformity testing

Minimum sample size: 3 Minimum sample size for pass decision: 4

Cumulative number of engines tested (sample size)	*Pass decision number*	*Fail decision number*
3	—	3
4	0	4
5	0	4
6	1	5
7	1	5
8	2	6
9	2	6
10	3	7
11	3	7
12	4	8
13	4	8
14	5	9
15	5	9
16	6	10
17	6	10
18	7	11
19	8	9

ANNEX III

Methodology for adapting the emission laboratory test results to include the deterioration factors

1. Definitions

For the purposes of this Annex, the following definitions apply:

1.1. "Ageing cycle" means the non-road mobile machinery or engine operation (speed, load, power) to be executed during the service accumulation period.

1.2. "Critical emission-related components" means the exhaust after- treatment system, the electronic engine control unit and its associated sensors and actuators, and the exhaust gas recirculation (EGR) including all related filters, coolers, control valves and tubing.

1.3. "Critical emission-related maintenance" means the maintenance to be performed on critical emission-related components of the engine.

1.4. "Emission-related maintenance" means the maintenance which substantially affects emissions or which is likely to affect emissions performance of the non-road mobile machinery or the engine during normal in-use operation.

1.5. "Engine-after-treatment system family" means a manufacturer's grouping of engines that comply with the definition of engine family, but which are further grouped into a family of engine families utilising a similar exhaust after-treatment system.

1.6. "Non-emission-related maintenance" means maintenance which does not substantially affect emissions and which does not have a lasting effect on the emissions performance deterioration of the non-road mobile machinery or the engine during normal in-use operation once the maintenance is performed.

1.7. "Service accumulation schedule" means the ageing cycle and the service accumulation period for determining the deterioration factors for the engine-after-treatment system family.

2. General

2.1. This Annex details the procedures for selecting engines to be tested over a service accumulation schedule for the purpose of determining deterioration factors for engine type or engine family EU type-approval and conformity of production assessments. The deterioration factors shall be applied to the emissions measured in accordance with Annex VI and calculated in accordance with Annex VII in accordance with the procedure set out in point 3.2.7. or point 4.4.6., respectively.

2.2. The service accumulation tests or the emissions tests performed to determine deterioration need not be witnessed by the approval authority.

2.3. This Annex also details the emission-related and non-emission-related maintenance that should be or may be carried out on engines undergoing a service accumulation

schedule. Such maintenance shall conform to the maintenance performed on in-service engines and communicated to the end-users of new engines.

3. Engine categories NRE, NRG, IWP, IWA, RLL, RLR, SMB, ATS and sub-categories NRS-v-2b and NRS-v-3

3.1. Selection of engines for establishing emission durability period deterioration factors

3.1.1. Engines shall be selected from the engine family defined in section 2 of Annex IX to Commission Implementing Regulation 2016/CCC on administrative requirements for emission testing to establish emission durability period deterioration factors.

3.1.2. Engines from different engine families may be further combined into families based on the type of exhaust after-treatment system utilised. In order to place engines with a different cylinder configuration but 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.

3.1.3. The engine manufacturer shall select one engine representing the 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., and 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-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.

3.2. Determination of emission durability period deterioration factors

3.2.1. General

Deterioration factors applicable to 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.

3.2.1.1. At the request of the manufacturer, the approval authority may allow the use of deterioration factors that have been established using alternative procedures to those specified in points 3.2.2. to 3.2.5.. In that case, the manufacturer shall demonstrate to the satisfaction of the approval authority that the alternative procedures used are not less rigorous than those set out in points 3.2.2. to 3.2.5..

3.2.2. Service accumulation schedule

Service accumulation schedules may be carried out at the choice of the manufacturer by running a non-road mobile machinery equipped with the selected engine over an "in-service" accumulation schedule or by running the selected engine over a "dynamometer service" accumulation schedule. The manufacturer shall not be required to use reference fuel for the service accumulation in-between emission measurement test points.

3.2.2.1. In-service and dynamometer service accumulation

3.2.2.1.1. The manufacturer shall determine the form and duration of the service accumulation and the ageing cycle for engines in a manner consistent with good engineering judgment.

3.2.2.1.2. The manufacturer shall determine the test points where gaseous and particulate emissions will be measured over the applicable cycles, as follows:

3.2.2.1.2.1. When running a service accumulation schedule shorter than the emission durability period in accordance with point 3.2.2.1.7., the minimum number of test points shall be three, one at the beginning, one approximately in the middle and one at the end of the service accumulation schedule.

3.2.2.1.2.2. When completing the service accumulation up to the end of the emission durability period, the minimum number of test points shall be two, one at the beginning and one at the end of the service accumulation.

3.2.2.1.2.3. The manufacturer may additionally test at evenly spaced intermediate points.

3.2.2.1.3. The emission values at the start point and at the emission durability period endpoint either calculated in accordance with point 3.2.5.1. or measured directly in accordance with point 3.2.2.1.2.2., shall be within the limit values applicable to the engine family. However individual emission results from the intermediate test points may exceed those limit values.

3.2.2.1.4. For engine categories or sub-categories to which a NRTC applies, or for engines category or sub-categories NRS to which a large spark-ignition engines non-road transient test cycles ("LSI-NRTC") applies, the manufacturer may request the agreement of the approval authority to run only one test cycle (either the hot-start NRTC or LSI-NRTC, as applicable, or NRSC) at each test point, and to run the other test cycle only at the beginning and at the end of the service accumulation schedule.

3.2.2.1.5. In the case of engine categories or sub-categories for which there is no applicable non-road transient cycle given in Annex IV to Regulation (EU) 2016/1628, only the NRSC shall be run at each test point.

3.2.2.1.6. Service accumulation schedules may be different for different engine-after-treatment system families.

3.2.2.1.7. Service accumulation schedules may be shorter than the emission durability period, but shall not be shorter than the equivalent of at least one quarter of the relevant emission durability period specified in Annex V to Regulation (EU) 2016/1628.

3.2.2.1.8. Accelerated ageing by adjusting the service accumulation schedule on a fuel consumption basis is permitted. The adjustment shall be based on the ratio between the typical in-use fuel consumption and the fuel consumption on the ageing cycle, but fuel consumption on the ageing cycle shall not exceed typical in-use fuel consumption by more than 30 %.

3.2.2.1.9. The manufacturer may use, if agreed by the approval authority, alternative methods of accelerated ageing.

3.2.2.1.10. The service accumulation schedule shall be fully described in the application for EU type-approval and reported to the approval authority before the start of any testing.

3.2.2.2. If the approval authority decides that additional measurements need to be performed between the points selected by the manufacturer it shall notify the manufacturer. The revised service accumulation schedule shall be prepared by the manufacturer and agreed by the approval authority.

3.2.3. Engine testing

3.2.3.1. Engine stabilisation

3.2.3.1.1. For each engine-after-treatment system family, the manufacturer shall determine the number of hours of non-road mobile machinery or engine running after which the operation of the engine-after-treatment system has stabilised. If requested by the approval authority the manufacturer shall make available the data and analysis used to make this determination. As an alternative, the manufacturer may run the engine or non-road mobile machinery between 60 and 125 hours or the equivalent time on the ageing cycle to stabilise the engine-after-treatment system.

3.2.3.1.2. The end of the stabilisation period determined in point 3.2.3.1.1. shall be deemed to be the start of the service accumulation schedule.

3.2.3.2. Service accumulation testing

3.2.3.2.1. After stabilisation, the engine shall be run over the service accumulation schedule selected by the manufacturer, as described in point 3.2.2.. At the periodic intervals in the service accumulation schedule determined by the manufacturer, and, where applicable, decided by the approval authority in accordance with point 3.2.2.2., the engine shall be tested for gaseous and particulate emissions over the hot-start NRTC and NRSC, or LSI-NRTC and NRSC applicable to the engine category, as set out in Annex IV to Regulation (EU) 2016/1628.

The manufacturer may select to measure the pollutant emissions before any exhaust after-treatment system separately from the pollutant emissions after any exhaust after-treatment system.

In accordance with point 3.2.2.1.4., if it has been agreed that only one test cycle (hot-start NRTC, LSI-NRTC or NRSC) be run at each test point, the other test cycle (hot-start NRTC, LSI-NRTC or NRSC) shall be run at the beginning and at the end of the service accumulation schedule.

In accordance with point 3.2.2.1.5., in the case of engine categories or sub-categories for which there is no applicable non-road transient cycle given in Annex IV to Regulation (EU) 2016/1628, only the NRSC shall be run at each test point.

3.2.3.2.2. During the service accumulation schedule, maintenance shall be carried out on the engine in accordance with point 3.4..

3.2.3.2.3. During the service accumulation schedule, unscheduled maintenance on the engine or non-road mobile machinery may be performed, for example if the manufacturer's normal diagnostic system has detected a problem that would have indicated to the non-road mobile machinery operator that a fault had arisen.

3.2.4. Reporting

3.2.4.1. The results of all emission tests (hot-start NRTC, LSI-NRTC and NRSC) conducted during the service accumulation schedule shall be made available to the approval authority. If an emission test is declared to be void, the manufacturer shall provide reasons why the test has been declared void. In such a case, another series of emission tests shall be carried out within the following 100 hours of service accumulation.

3.2.4.2. The manufacturer shall retain records of all information concerning all the emission tests and maintenance carried out on the engine during the service accumulation schedule. This information shall be submitted to the approval authority along with the results of the emission tests conducted over the service accumulation schedule.

3.2.5. Determination of deterioration factors

3.2.5.1. When running a service accumulation schedule in accordance with point 3.2.2.1.2.1. or point 3.2.2.1.2.3., for each pollutant measured over the hot-start NRTC, LSI-NRTC and NRSC at each test point during the service accumulation schedule, a "best fit" linear regression analysis shall be made on the basis of all test results. The results of each test for each pollutant shall be expressed to the same number of decimal places as the limit value for that pollutant, as applicable to the engine family, plus one additional decimal place.

Where in accordance with point 3.2.2.1.4. or point 3.2.2.1.5., only one test cycle (hot-start NRTC, LSI-NRTC or NRSC) has been run at each test point, the regression analysis shall be made only on the basis of the test results from the test cycle run at each test point.

The manufacturer may request the prior approval of the approval authority for a non-linear regression.

3.2.5.2. The emission values for each pollutant at the start of the service accumulation schedule and at the emission durability period end point that is applicable for the engine under test shall be either:

(a) determined by extrapolation of the regression equation in point 3.2.5.1., when running a service accumulation schedule in accordance with point 3.2.2.1.2.1. or point 3.2.2.1.2.3., or

(b) measured directly, when running a service accumulation schedule in accordance with point 3.2.2.1.2.2..

Where emission values are used for engine families in the same 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..

3.2.5.3. The deterioration factor (DF) for each pollutant is defined as the ratio of the applied emission values at the emission durability period end point and at the start of the service accumulation schedule (multiplicative deterioration factor).

The manufacturer may request the prior approval of the approval authority for the application of an additive DF for each pollutant may be applied. The additive DF is defined as the difference between the calculated emission values at the emission durability period end point and at the start of the service accumulation schedule.

An example for determination of DFs by using linear regression is shown in Figure 3.1. for NO_x emission.

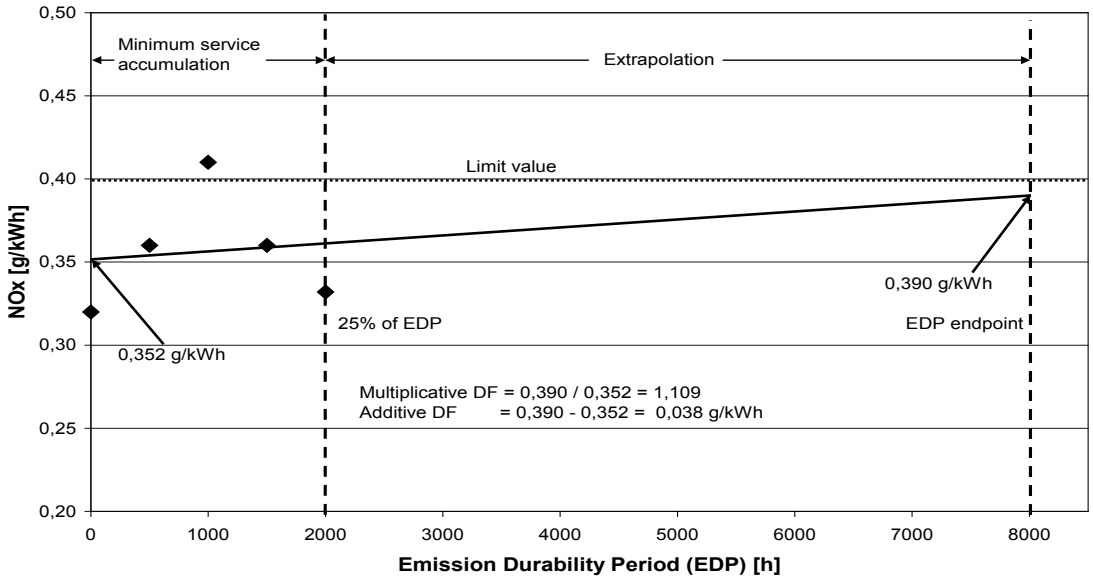
Mixing of multiplicative and additive DFs within one set of pollutants is not permitted.

If the calculation results in a value of less than 1,00 for a multiplicative DF, or less than 0,00 for an additive DF, then the deterioration factor shall be 1,0 or 0,00, respectively.

In accordance with point 3.24.2.1.4., if it has been agreed that only one test cycle (hot-start NRTC, LSI-NRTC or NRSC) be run at each test point and the other test cycle (hot-start NRTC, LSI-NRTC or NRSC) run only at the beginning and end of the service accumulation schedule, the deterioration factor calculated for the test cycle that has been run at each test point shall be applicable also for the other test cycle.

Figure 3.1.

Example of DF determination



3.2.6. Assigned deterioration factors

3.2.6.1. As an alternative to using a service accumulation schedule to determine DFs, engine manufacturers may select to use assigned multiplicative DFs, as given in Table 3.1..

Table 3.1.

Assigned deterioration factors

Test cycle	*CO*	*HC*	*NO_x*	*PM*	*PN*
NRTC and LSI-NRTC	1,3	1,3	1,15	1,05	1,0
NRSC	1,3	1,3	1,15	1,05	1,0

Assigned additive DFs shall not be given. The assigned multiplicative DFs shall not be transformed into additive DFs.

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.

3.2.6.2. Where assigned DFs are used, the manufacturer shall present to the approval authority robust evidence that the emission control components can reasonably be

expected to have the emission durability associated with those assigned factors. This evidence may be based upon design analysis, or tests, or a combination of both.

3.2.7. Application of deterioration factors

3.2.7.1. The engines shall meet the respective emission limits for each pollutant, as applicable to the engine family, after application of the deterioration factors to the test result as measured in accordance with Annex VI (cycle-weighted specific emission for particulate and each individual gas). Depending on the type of DF, the following provisions apply:

(a) Multiplicative: (cycle weighted specific emission) * DF ≤ emission limit

(b) Additive: (cycle weighted specific emission) + DF ≤ emission limit

Cycle weighted specific emission may include the adjustment for infrequent regeneration, where applicable.

3.2.7.2. For a multiplicative NO_x + HC DF, separate HC and NO_x DFs shall be determined and applied separately when calculating the deteriorated emission levels from an emissions test result before combining the resultant deteriorated NO_x and HC values to establish compliance with the emission limit.

3.2.7.3. The manufacturer may carry across the DFs determined for an engine-after-treatment system family to an engine that does not fall into the same engine-after-treatment system family. In such cases, the manufacturer shall demonstrate to the approval authority that the engine for which the engine-after-treatment system family was originally tested and the engine for which the DFs are being carried across have similar technical specifications and installation requirements on the non-road mobile machinery and that the emissions of such engine are similar.

Where DFs are carried across to an engine with a different emission durability period, the DFs shall be recalculated for the applicable emission durability period by extrapolation or interpolation of the regression equation as determined in point 3.2.5.1..

3.2.7.4. The DF for each pollutant for each applicable test cycle shall be recorded in the test report set out in Appendix 1 of Annex VI to Commission Implementing Regulation 2016/CCC on administrative requirements.

3.3. Checking of conformity of production

3.3.1. Conformity of production for emissions compliance is checked on the basis of Section 6. of Annex II.

3.3.2. The manufacturer may measure the pollutant emissions before any exhaust after-treatment system at the same time as the EU type-approval test is being performed. For that purpose, the manufacturer may develop informal DFs separately for the engine without after-treatment system and for the after-treatment system that may be used by the manufacturer as an aid to end of production line auditing.

3.3.3. For the purposes of EU type-approval, only the DFs determined in accordance with point 3.2.5. or 3.2.6. shall be recorded in the test report set out in Appendix 1 of Annex VI to Commission Implementing Regulation 2016/CCC on administrative requirements.

3.4. Maintenance

For the purpose of the service accumulation schedule, maintenance shall be performed in accordance with the manufacturer's manual for service and maintenance.

3.4.1. Scheduled emission-related maintenance

3.4.1.1. Scheduled emission-related maintenance during engine running, undertaken for the purpose of conducting a service accumulation schedule, shall occur at equivalent intervals to those that are specified in the manufacturer's maintenance instructions to the end-user of the non-road mobile machinery or engine. This schedule maintenance may be updated as necessary throughout the service accumulation schedule provided that no maintenance operation is deleted from the maintenance schedule after the operation has been performed on the test engine.

3.4.1.2. Any adjustment, disassembly, cleaning or exchange of critical emission-related components which is performed on a periodic basis within the emission durability period to prevent malfunction of the engine, shall only be done to the extent that is technologically necessary to ensure proper functioning of the emission control system. The need for scheduled exchange, within the service accumulation schedule and after a certain running time of the engine, of critical emission-related components other than those qualifying as routine exchange items shall be avoided. In this context, consumable maintenance items for regular renewal or items that require cleaning after a certain running time of the engine, shall qualify as routine exchange items.

3.4.1.3. Any scheduled maintenance requirements shall be subject to approval by the approval authority before an EU type-approval is granted and shall be included in the customer's manual. 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 1.6.1.4..

3.4.1.4. The engine manufacturer shall specify for the service accumulation schedules any adjustment, cleaning, maintenance (where necessary) and scheduled exchange of the following items:

– filters and coolers in the exhaust gas recirculation (EGR)

– positive crankcase ventilation valve, if applicable

– fuel injector tips (only cleaning is permitted)

– fuel injectors

– turbocharger

– electronic engine control unit and its associated sensors and actuators

– particulate after-treatment system (including related components)

– NO_x after-treatment system (including related components)

– exhaust gas recirculation (EGR), including all related control valves and tubing

– any other exhaust after-treatment system.

3.4.1.5. Scheduled critical emission-related maintenance shall only be performed if it is required to be performed in-use and that requirement is communicated to the end-user of the engine or non-road mobile machinery.

3.4.2. Changes to scheduled maintenance

The manufacturer shall submit a request to the approval authority for approval of any new scheduled maintenance that it wishes to perform during the service accumulation schedule and subsequently to recommend to end-users of non road mobile machinery and engines. The request shall be accompanied by data supporting the need for the new scheduled maintenance and the maintenance interval.

3.4.3. Non-emission-related scheduled maintenance

Non-emission-related scheduled maintenance which is reasonable and technically necessary (for example oil change, oil filter change, fuel filter change, air filter change, cooling system maintenance, idle speed adjustment, governor, engine bolt torque, valve lash, injector lash, adjustment of the tension of any drive-belt, etc.) may be performed on engines or non-road mobile machinery selected for the service accumulation schedule at the least frequent intervals recommended by the manufacturer to the end-user (for example not at the intervals recommended for severe service).

3.5. Repair

3.5.1. Repairs to the components of an engine selected for testing over a service accumulation schedule shall be performed only as a result of component failure or engine malfunction. Repair of the engine itself, the emission control system or the fuel system is not permitted except to the extent defined in point 3.5.2..

3.5.2. If the engine, its emission control system or its fuel system fails during the service accumulation schedule, the service accumulation shall be considered void, and a new service accumulation shall be started with a new engine.

The previous paragraph shall not apply when the failed components are replaced with equivalent components that have been subject to a similar number of hours of service accumulation.

4. Engine categories and sub-categories NRSh and NRS, except for NRS-v-2b and NRS-v-3

4.1. The applicable EDP category and corresponding deterioration factor (DF) shall be determined in accordance with this section 4..

4.2. An engine family shall be considered as compliant with the limit values required for an engine sub-category when the emissions test results of all engines representing the engine family, once adjusted by multiplication by the DF laid down in section 2, are lower than or equal to the limit values required for that engine sub-category. However, where one or more emission test results of one or more engines representing the engine family, once adjusted by multiplication by the DF laid down in section 2, are higher than one or more single emission limit values required for that engine sub-category, the engine family shall be considered not compliant with the limit values required for that engine sub-category.

4.3. DFs shall be determined as follows:

4.3.1. On at least one test engine representing the configuration chosen to be the most likely to exceed HC + NO_x emission limits, and constructed to be representative of production engines, , the (full) test procedure emission testing shall be conducted as described in Annex VI after the number of hours representing stabilised emissions.

4.3.2. If more than one engine is tested, the results shall be calculated as the average of the results for all the engines tested, rounded to the same number of decimal places as in the applicable limit, expressed to one additional significant figure.

4.3.3. Such emission testing shall be conducted again following ageing of the engine. The ageing procedure should be designed to allow the manufacturer to appropriately predict the in-use emission deterioration expected over the EDP of the engine, taking into account the type of wear and other deterioration mechanisms expected under typical consumer use which could affect emissions performance. If more than one engine is tested, the results shall be calculated as the average of the results for all the engines tested, rounded to the same number of decimal places contained in the applicable limit, expressed to one additional significant figure.

4.3.4. The emissions at the end of the EDP (average emissions, if applicable) for each regulated pollutant shall be divided by the stabilised emissions (average emissions, if applicable) and rounded to two significant figures. The resulting number shall be the DF, unless it is less than 1,00, in which case the DF shall be 1,00.

4.3.5. The manufacturer may schedule additional emission test points between the stabilised emission test point and the end of the EDP. If intermediate tests are scheduled, the test points shall be evenly spaced over the EDP (plus or minus two hours) and one such test point shall be at one half of full EDP (plus or minus two hours).

4.3.6. For each pollutant HC + NO_x and CO, a straight line must be fitted to the data points treating the initial test as occurring at hour zero, and using the method of least-squares. The DF is the calculated emission at the end of the durability period divided by the calculated emission at zero hours.

The DF for each pollutant for the applicable test cycle shall be recorded in the test report set out in Appendix 1 of Annex VII Annex VI to Commission Implementing Regulation 2016/CCC on administrative requirements.

4.3.7. Calculated deterioration factors may cover families in addition to the one on which they were generated if the manufacturer submits a justification acceptable to the approval authority in advance of EU type-approval that the affected engine families can be reasonably expected to have similar emission deterioration characteristic based on the design and technology used.

A non-exclusive list of design and technology groupings is given below:

– conventional two-stroke engines without after treatment system,

– conventional two-stroke engines with a catalyst of the same active material and loading, and the same number of cells per cm^2,

– stratified scavenging two-stroke engines,

– stratified scavenging two-stroke engines with a catalyst of the same active material and loading, and the same number of cells per cm^2,

– four-stroke engines with catalyst with same valve technology and identical lubrication system,

– four-stroke engines without catalyst with the same valve technology and identical lubrication system.

4.4. EDP categories

4.4.1. For those engine categories in Table V-3 or V-4 of Annex V to Regulation (EU) 2016/1628 that have alternative values for EDP, manufacturers shall declare the applicable EDP category for each engine family at the time of EU type-approval. Such category shall be the category from Table 3.2. which most closely approximates the expected useful lives of the equipment into which the engines are expected to be installed as determined by the engine manufacturer. Manufacturers shall retain data appropriate to support their choice of EDP category for each engine family. Such data shall be supplied to the approval authority upon request.

Table 3.2.

EDP categories

EDP Category	Application of Engine
Cat 1	Consumer products
Cat 2	Semi-professional products
Cat 3	Professional products

4.4.2. The manufacturer shall demonstrate to the satisfaction of the approval authority that the declared EDP category is appropriate. Data to support a manufacturer's choice of EDP category, for a given engine family, may include but are not limited to:

– surveys of the life spans of the equipment in which the subject engines are installed,

– engineering evaluations of field aged engines to ascertain when engine performance deteriorates to the point where usefulness and/or reliability is impacted to a degree sufficient to necessitate overhaul or replacement,

– warranty statements and warranty periods,

– marketing materials regarding engine life,

– failure reports from engine customers, and

– engineering evaluations of the durability, in hours, of specific engine technologies, engine materials or engine designs.

ANNEX IV

Requirements with regard to emission control strategies, NO_x control measures and particulate control measures

1. Definitions abbreviations and general requirements

1.1. For the purposes of this Annex, the following definitions and abbreviations apply:

(1) "diagnostic trouble code ("DTC")" means a numeric or alphanumeric identifier which identifies or labels a NCM and/ PCM;

(2) "confirmed and active DTC" means a DTC that is stored during the time the NCD and/or PCD system concludes that a malfunction exists;

(3) "NCD engine family" means a manufacturer's grouping of engines having common methods of monitoring/diagnosing NCMs;

(4) "NO_x Control Diagnostic system (NCD)" means a system on-board the engine which has the capability of

(a) detecting a NO_x Control Malfunction,

(b) identifying the likely cause of NO_x control malfunctions by means of information stored in computer memory and/or communicating that information off-board;

(5) "NO_x Control Malfunction (NCM)" means an attempt to tamper with the NO_x control system of an engine or a malfunction affecting that system that might be due to tampering, that is considered by this Regulation as requiring the activation of a warning or an inducement system once detected;

(6) “Particulate Control Diagnostic system (PCD)” means a system on-board the engine which has a capability of:

(a) detecting a Particulate Control Malfunction,

(b) identifying the likely cause of particulate control malfunctions by means of information stored in computer memory and/or communicating that information off-board;

(7) "Particulate Control Malfunction (PCM)" means an attempt to tamper with the particulate after-treatment system of an engine or a malfunction affecting the particulate after-treatment system that might be due to tampering, that is considered by this Regulation as requiring the activation of a warning once detected;

(8) “PCD engine family” means a manufacturer’s grouping of engines having common methods of monitoring/diagnosing PCMs;

(9) "Scan-tool" means an external test equipment used for off-board communication with the NCD and/or PCD system.

1.2. Ambient temperature

Notwithstanding Article 2(7), where reference is made to ambient temperature in relation to environments other than a laboratory environment, the following provisions shall apply:

1.2.1. For an engine installed in a test-bed, ambient temperature shall be the temperature of the combustion air supplied to the engine, upstream of any part of the engine being tested.

1.2.2. For an engine installed in non-road mobile machinery, ambient temperature shall be the air temperature immediately outside the perimeter of the non-road mobile machinery.

2. Technical requirements relating to emission control strategies

2.1. This section 2. shall apply for electronically controlled engines of categories NRE, NRG, IWP, IWA, RLL and RLR, complying with “Stage V” emission limits set out in Annex II to Regulation (EU) 2016/1628 and using electronic control to determine both the quantity and timing of injecting fuel or using electronic control to activate, de-activate or modulate the emission control system used to reduce NO_x.

2.2. Requirements for base emission control strategy

2.2.1. The base emission control strategy shall be designed as to enable the engine, in normal use, to comply with the provisions of this Regulation. Normal use is not restricted to the control conditions as specified in point 2.4.

2.2.2. Base emission control strategies are, but not limited to, maps or algorithms for controlling:

(a) timing of fuel injection or ignition (engine timing);

(b) exhaust gas recirculation (EGR);

(c) SCR catalyst reagent dosing.

2.2.3. Any base emission control strategy that can distinguish engine operation between a standardised EU type-approval test and other operating conditions and subsequently reduce the level of emission control when not operating under conditions substantially included in the EU type-approval procedure is prohibited.

2.3. Requirements for auxiliary emission control strategy

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

2.3.1.1. does not permanently reduce the effectiveness of the emission control system;

2.3.1.2. operates only outside the control conditions specified in points 2.4.1., 2.4.2. or 2.4.3. for the purposes defined in point 2.3.5. and only as long as is needed for those purposes, except as permitted by points 2.3.1.3., 2.3.2. and 2.3.4.;

2.3.1.3. is activated only exceptionally within the control conditions in points 2.4.1., 2.4.2. or 2.4.3., respectively, has been demonstrated to be necessary for the purposes identified in point 2.3.5. has been approved by the approval authority, and is not activated for longer than is needed for those purposes;

2.3.1.4. ensures a level of performance of the emission control system that is as close as possible to that provided by the base emission control strategy.

2.3.2. Where the auxiliary emission control strategy is activated during the EU type-approval test, activation shall not be limited to occur outside the control conditions set out in point 2.4, and the purpose shall not be limited to the criteria set out in point 2.3.5.

2.3.3. Where the auxiliary emission control strategy is not activated during the EU type-approval test, it must be demonstrated that the auxiliary emission control strategy is active only for as long as required for the purposes set out in point 2.3.5.

2.3.4. Cold temperature operation

An auxiliary emission control strategy may be activated on an engine equipped with exhaust gas recirculation (EGR) irrespective of the control conditions in point 2.4. if the ambient temperature is below 275 K (2 °C) and one of the two following criteria is met:

(a) intake manifold temperature is less than or equal to the temperature defined by the following equation: IMTc = PIM / 15,75 + 304,4, where: IMTc is the calculated intake manifold temperature, K and PIM is the absolute intake manifold pressure in kPa;

(b) engine coolant temperature is less than or equal to the temperature defined by the following equation: ECTc = PIM / 14,004 + 325,8, where: ECTc is the calculated engine coolant temperature, K and PIM is the absolute intake manifold pressure, kPa.

2.3.5. Except as permitted by point 2.3.2., an auxiliary emission control strategy may solely be activated for the following purposes:

(a) by on-board signals, for protecting the engine (including air-handling device protection) and/or non-road mobile machinery into which the engine is installed from damage;

(b) for operational safety reasons;

(c) for prevention of excessive emissions, during cold start or warming-up, during shut-down;

(d) if used to trade-off the control of one regulated pollutant under specific ambient or operating conditions, for maintaining control of all other regulated pollutants, within the emission limit values that are appropriate for the engine concerned. The purpose is to compensate for naturally occurring phenomena in a manner that provides acceptable control of all emission constituents.

2.3.6. The manufacturer shall demonstrate to the technical service at the time of the EU type-approval test that the operation of any auxiliary emission strategy complies with the provisions of this section. The demonstration shall consist of an evaluation of the documentation referred to in point 2.6..

2.3.7. Any operation of an auxiliary emission control strategy non-compliant with points 2.3.1. to 2.3.5. is prohibited.

2.4. Control conditions

The control conditions specify an altitude, ambient temperature and engine coolant range that determines whether auxiliary emission control strategies may generally or only exceptionally be activated in accordance with point 2.3..

The control conditions specify an atmospheric pressure which is measured as absolute atmospheric static pressure (wet or dry) ("Atmospheric pressure")

2.4.1. Control conditions for engines of categories IWP and IWA:

(a) an altitude not exceeding 500 metres (or equivalent atmospheric pressure of 95,5 kPa);

(b) an ambient temperature within the range 275 K to 303 K (2 °C to 30 °C);

(c) the engine coolant temperature above 343 K (70 °C).

2.4.2. Control conditions for engines of category RLL:

(a) an altitude not exceeding 1000 metres (or equivalent atmospheric pressure of 90 kPa);

(b) an ambient temperature within the range 275 K to 303 K (2 °C to 30 °C);

(c) the engine coolant temperature above 343 K (70 °C).

2.4.3. Control conditions for engines of categories NRE, NRG and RLR:

(a) the atmospheric pressure greater than or equal to 82,5 kPa;

(b) the ambient temperature within the following range:

– equal to or above 266 K (– 7 °C),

– less than or equal to the temperature determined by the following equation at the specified atmospheric pressure: Tc = -0,4514 • (101,3 –

Pb) + 311, where: Tc is the calculated ambient air temperature, K and Pb is the atmospheric pressure, kPa;

(c) the engine coolant temperature above 343 K (70 °C).

2.5. Where the engine inlet air temperature sensor is being used to estimate ambient air temperature the nominal offset between the two measurement points shall be evaluated for an engine type or engine family. Where used, the measured intake air temperature shall be adjusted by an amount equal to the nominal offset to estimate ambient temperature for an installation using the specified engine type or engine family.

The evaluation of the offset shall be made using good engineering judgement based on technical elements (calculations, simulations, experimental results, data etc.) including:

(a) the typical categories of non-road mobile machinery into which the engine type or engine family will be installed; and,

(b) the installation instructions provided to the OEM by the manufacturer.

A copy of the evaluation shall be made available to the approval authority upon request.

2.6. Documentation requirements

The manufacturer shall comply with the documentation requirements laid down in point 1.4. of Part A of Annex I to Commission Implementing Regulation 2016/CCC on administrative requirements and Appendix 2 to that Annex.

3. Technical requirements relating to NO_x control measures

3.1. This section 3. shall apply to electronically controlled engines of categories NRE, NRG, IWP, IWA, RLL and RLR, complying with "stage V" emission limits set out in Annex II to Regulation (EU) 2016/1628 and using electronic control to determine both the quantity and timing of injecting fuel or using electronic control to activate, de-activate or modulate the emission control system used to reduce NO_x.

3.2. The manufacturer shall provide complete information on the functional operational characteristics of the NO_x control measures using the documents set out in Annex I to Regulation (EU) 2016/1628.

3.3. The NO_x control strategy shall be operational under all environmental conditions regularly occurring in the territory of the Union, especially at low ambient temperatures.

3.4. The manufacturer shall demonstrate that the emission of ammonia during the applicable emission test cycle of the EU type-approval procedure, when a reagent is used, does not exceed a mean value of 25 ppm for engines of category RLL and 10 ppm for engines of all other applicable categories.

3.5. If reagent containers are installed on or connected to a non-road mobile machinery, means for taking a sample of the reagent inside the containers must be included. The sampling point must be easily accessible without requiring the use of any specialised tool or device.

3.6. In addition to the requirements set out in points 3.2. to 3.5., the following requirements shall apply:

(c) For engines of category NRG the technical requirements set out in Appendix 1;

(d) For engines of category NRE:

(a) the requirements set out in Appendix 2, when the engine is exclusively intended for use in the place of Stage V engines of categories IWP and IWA, in accordance with Article 4(1), point (1)(b) of Regulation (EU) 2016/1628, or

(b) the requirements set out in Appendix 1 for engines not covered by indent i.;

(e) For engines of category IWP, IWA and RLR the technical requirements set out in Appendix 2;

(f) For engines of category RLL the technical requirements set out in Appendix 3.

4. Technical requirements relating to particulate pollutant control measures

4.1. This section shall apply to engines of sub-categories subject to a PN limit in accordance with the "stage V" emission limits set out in Annex II to Regulation (EU) 2016/1628 fitted with a particulate after-treatment system In cases where the NO_x control system and the particulate control system share the same physical components (e.g. same substrate (SCR on filter), same exhaust gas temperature sensor) the requirements of this section shall not apply to any component or malfunction where, after consideration of a reasoned assessment provided by the manufacturer, the approval authority concludes that a particulate control malfunction within the scope of this section would lead to a corresponding NO_x control malfunction within the scope of section 3..

4.2. The detailed technical requirements relating to particulate pollutant control measures are specified in Appendix 4.

Appendix 1

Additional technical requirements on NO_x control measures for engines of categories NRE and NRG, including the method to demonstrate these strategies

1. Introduction

This Appendix sets out the additional requirements to ensure the correct operation of NO_x control measures. It includes requirements for engines that rely on the use of a reagent in order to reduce emissions. The EU type-approval shall be made conditional upon the application of the relevant provisions on operator instruction, installation documents, operator warning system, inducement system and reagent freeze protection that are set out in this Appendix.

2. General requirements

The engine shall be equipped with a NO_x Control Diagnostic system (NCD) able to identify the NO_x control malfunctions (NCMs). Any engine covered by this section 2. shall be designed, constructed and installed so as to be capable of meeting these requirements throughout the normal life of the engine under normal conditions of use. In achieving this objective it is acceptable that engines which have been used in excess of the emission durability period as specified in Annex V to Regulation (EU) 2016/1628 show some deterioration in the performance and the sensitivity of the NO_x Control Diagnostic system (NCD), such that the thresholds specified in this Annex may be exceeded before the warning and/or inducement systems are activated.

2.1. Required information

2.1.1. If the emission control system requires a reagent, the type of reagent, information on concentration when the reagent is in solution, its operational temperature conditions a reference to international standards for composition and quality and other characteristics of that reagent shall be specified by the manufacturer in accordance with Part B of Annex I to Commission Implementing Regulation 2016/CCC on administrative requirements.

2.1.2. Detailed written information fully describing the functional operation characteristics of the operator warning system set out in section 4. and of the operator inducement system set out in section 5. shall be provided to the approval authority at the time of EU type-approval.

2.1.3. The manufacturer shall provide the OEM with documents with instructions on how to install the engine in the non-road mobile machinery in such manner that the engine, its emission control system and the non-road mobile machinery parts, operate in conformity with the requirements of this Appendix. This documentation shall include the detailed technical requirements of the engine (software, hardware, and

communication) needed for the correct installation of the engine in the non-road mobile machinery.

2.2. Operating conditions

2.2.1. The NO_x control diagnostic system shall be operational at

(a) ambient temperatures between 266 K and 308 K (-7°C and 35°C);

(b) all altitudes below 1600 m;

(c) engine coolant temperatures above 343 K (70°C).

This section 2. does not apply to monitoring for reagent level in the storage tank where monitoring shall be conducted under all conditions where measurement is technically feasible (for instance, under all conditions when a liquid reagent is not frozen).

2.3. Reagent freeze protection

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 point 2.3.2. A non-heated system shall meet the requirements of point 2.3.3..

2.3.1.1. The use of a non-heated reagent tank and dosing system shall be indicated in the written instructions to the end-user of the non-road mobile machinery.

2.3.2. Reagent tank and dosing system

2.3.2.1. If the reagent has frozen, the reagent shall be available for use within a maximum of 70 minutes after the start of the engine at 266 K (- 7 °C) ambient temperature.

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 this section 2. when tested using the procedure defined.

2.3.2.2.1. The reagent tank and dosing system shall be soaked at 255 K (- 18°C) for 72 hours or until the reagent becomes solid, whichever occurs first.

2.3.2.2.2. After the soak period set out in point 2.3.2.2.1., the non-road mobile machinery/engine shall be started and operated at 266 K (- 7 °C) ambient temperature or lower as follows:

(a) 10 to 20 minutes idling, followed by

(b) up to 50 minutes at no more than 40 % of rated load.

2.3.2.2.3. At the conclusion of the test procedure set out in point 2.3.2.2.2., the reagent dosing system shall be fully functional.

2.3.2.3. 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.

2.3.3. Activation of the operator warning and inducement system for a non-heated system

2.3.3.1. The operator warning system described in section 4. shall be activated if no reagent dosing occurs at an ambient temperature ≤ 266 K (- 7°C).

2.3.3.2. The severe inducement system described 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).

2.4. Diagnostic requirements

2.4.1 The NO_x Control Diagnostic system (NCD) shall be able to identify the NO_x control malfunctions (NCMs) by means of Diagnostic Trouble Codes (DTCs) stored in the computer memory and to communicate that information off-board upon request.

2.4.2 Requirements for recording Diagnostic Trouble Codes (DTCs)

2.4.2.1 The NCD system shall record a DTC for each distinct NO_x Control Malfunction (NCM).

2.4.2.2 The NCD system shall conclude within 60 minutes of engine operation whether a detectable malfunction is present. At this time, a "confirmed and active" DTC shall be stored and the warning system be activated according to section 4..

2.4.2.3 In cases where more than 60 minutes running time is required for the monitors to accurately detect and confirm a NCM (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.).

2.4.3. Requirements for erasing Diagnostic trouble codes (DTCs)

(a) DTCs shall not be erased by the NCD system itself from the computer memory until the failure related to that DTC has been remedied.

(b) The NCD system may erase all the DTCs upon request of a proprietary scan or maintenance tool that is provided by the engine manufacturer upon request, or using a pass code provided by the engine manufacturer.

2.4.4. An NCD system shall not be programmed or otherwise designed to partially or totally deactivate based on age of the non-road mobile machinery during the actual life of the engine, nor shall the system contain any algorithm or strategy designed to reduce the effectiveness of the NCD system over time.

2.4.5. Any reprogrammable computer codes or operating parameters of the NCD system shall be resistant to tampering.

2.4.6. NCD engine family

The manufacturer is responsible for determining the composition of an NCD engine family. Grouping engines within an NCD engine family shall be based on good engineering judgment and be subject to approval by the approval authority.

Engines that do not belong to the same engine family may still belong to the same NCD engine family.

2.4.6.1. Parameters defining an NCD engine family

An NCD engine family is characterized by basic design parameters that shall be common to engines within the family.

In order that engines are considered to belong to the same NCD engine family, the following list of basic parameters shall be similar:

(a) emission control systems;

(b) methods of NCD monitoring;

(c) criteria for NCD monitoring;

(d) monitoring parameters (e.g. frequency).

These similarities shall be demonstrated by the manufacturer by means of relevant engineering demonstration or other appropriate procedures and subject to the approval of the approval authority.

The manufacturer may request approval by the approval authority of minor differences in the methods of monitoring/diagnosing the NCD system due to engine configuration variation, when these methods are considered similar by the manufacturer and they differ only in order to match specific characteristics of the components under consideration (for example size, exhaust gas flow, etc.); or their similarities are based on good engineering judgment.

3. Maintenance requirements

3.1. The manufacturer shall furnish or cause to be furnished to all end-users of new engines or machines written instructions about the emission control system and its correct operation in accordance with Annex XV.

4. Operator warning system

4.1. The non-road mobile machinery shall include an operator warning system using visual alarms that informs the operator when a low reagent level, incorrect reagent quality, interruption of dosing or a malfunction specified in section 9. has been detected that will lead to activation of the operator inducement system if not rectified in a timely manner. The warning system shall remain active when the operator inducement system described in section 5. has been activated.

4.2. The warning shall not be the same as the warning used for the purposes of malfunction or other engine maintenance, though it may use the same warning system.

4.3. The operator warning system may consist of one or more lamps, or display short messages, which may include, for example, messages indicating clearly:

(a) the remaining time before activation of the low-level and/or severe inducements,

(b) the amount of low-level and/or severe inducement, for example the amount of torque reduction,

(c) the conditions under which non-road mobile machinery disablement can be cleared.

Where messages are displayed, the system used for displaying these messages may be the same as the one used for other maintenance purposes.

4.4. At the choice of the manufacturer, the warning system may include an audible component to alert the operator. The cancelling of audible warnings by the operator is permitted.

4.5. The operator warning system shall be activated as specified in points 2.3.3.1., 6.2., 7.2., 8.4., and 9.3. respectively.

4.6. The operator warning system shall be deactivated when the conditions for its activation have ceased to exist. The operator warning system shall not be automatically deactivated without the reason for its activation having been remedied.

4.7. The warning system may be temporarily interrupted by other warning signals providing important safety related messages.

4.8. Details of the operator warning system activation and deactivation procedures are described in section 11..

4.9. As part of the application for EU type-approval under this Regulation, the manufacturer shall demonstrate the operation of the operator warning system, as specified in section 11..

5. Operator inducement system

5.1. The engine shall incorporate an operator inducement system based on one of the following principles:

5.1.1. a two-stage inducement system starting with a low-level inducement (performance restriction) followed by a severe inducement (effective disablement of non-road mobile machinery operation);

5.1.2. a one-stage severe inducement system (effective disablement of non-road mobile machinery operation) activated under the conditions of a low-level inducement system as specified in points 6.3.1., 7.3.1., 8.4.1., and 9.4.1..

Where the manufacturer elects to shut down the engine to fulfil the requirement for one-stage severe inducement then the inducement for reagent level may, at the choice of the manufacturer, be activated under the conditions of point 6.3.2. instead of the conditions of point 6.3.1..

5.2. The engine may be fitted with a means to disable the operator inducement on condition that it complies with the requirements of point 5.2.1.

5.2.1 The engine may be fitted with a means to temporarily disable the operator inducement during an emergency declared by a national or regional government, their emergency services or their armed services.

5.2.1.1 All of the following conditions shall apply when a means to temporarily disable the operator inducement in an emergency is fitted to an engine:

(a) The maximum operating period for which the inducement may be disabled by the operator shall be 120 hours;

(b) The method of activation shall be designed to prevent accidental operation by requiring a double voluntary action and shall be clearly marked, at a miminum, with the warning “EMERGENCY USE ONLY”;

(c) The disablement shall de-activate automatically after the 120 hours has expired, and there shall be a means for the operator to manually de-activate the disablement if the emergency has ended;

(d) After the 120 hours of operation has expired it shall no longer be possible to disable the inducement unless the means to disable has been re-armed by the input of a manufacturer’s temporary security code, or re-configuration of the engine’s ECU by a qualified service technician, or an equivalent security feature that is unique to each engine;

(e) The total number and duration of activations of the disablement must be stored in non-volatile electronic memory or counters in a manner to ensure that the information cannot be intentionally deleted. It shall be possible for national inspection authorities to read these records with a scan tool;

(f) The manufacturer shall maintain a record of each request to re-arm the means to temporarily disable the operator inducement and shall make those records available to Commission or national authorities upon request.

5.3. Low-level inducement system

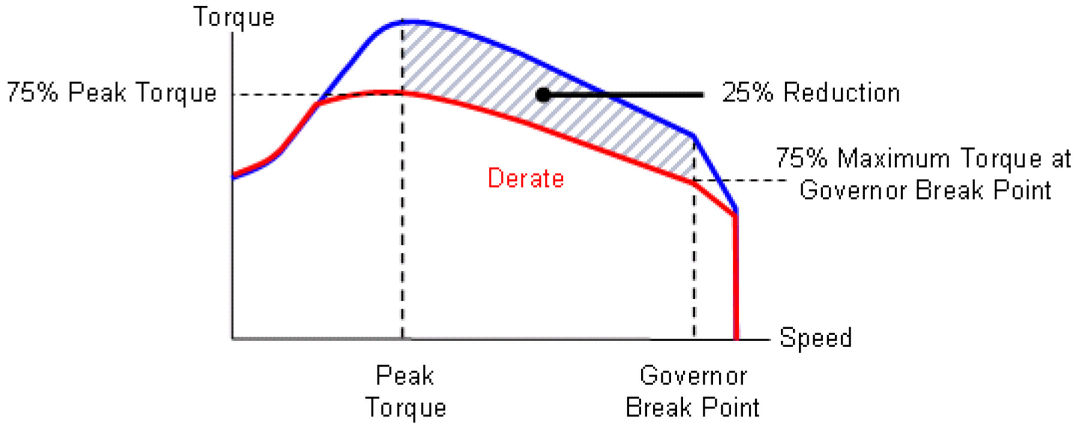
5.3.1. The low-level inducement system shall be activated after any of the conditions specified in points 6.3.1., 7.3.1., 8.4.1., and 9.4.1. has occurred.

5.3.2. The low-level inducement system shall gradually reduce the maximum available engine torque across the engine speed range by at least 25 % between the peak torque speed and the governor breakpoint as shown in Figure 4.1.. The rate of torque reduction shall be a minimum of 1% per minute.

5.3.3. Other inducement measures that are demonstrated to the approval authority as having the same or greater level of severity may be used.

Figure 4.1.

Low-level inducement torque reduction scheme



5.4. Severe inducement system

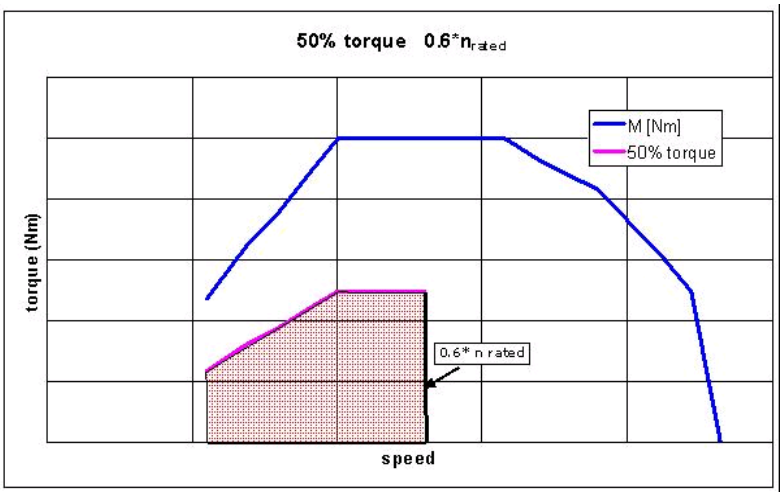
5.4.1. The severe inducement system shall be activated after any of the conditions specified in points 2.3.3.2., 6.3.2., 7.3.2., 8.4.2., and 9.4.2. has occurred.

5.4.2. The severe inducement system shall reduce the non-road mobile machinery's utility to a level that is sufficiently onerous as to cause the operator to remedy any problems related to sections 6. to 9. The following strategies are acceptable:

5.4.2.1. Engine torque between the peak torque speed and the governor breakpoint shall be gradually reduced from the low-level inducement torque in Figure 4.1. by a minimum of 1 % per minute to 50 % of maximum torque or lower and for variable-speed engines the engine speed shall be gradually reduced to 60 % of rated speed or lower within the same time period as the torque reduction, as shown in Figure 4.2..

Figure 4.2.

Severe inducement torque reduction scheme



5.4.2.2. Other inducement measures that are demonstrated to the approval authority as having the same or greater level of severity may be used.

5.5. In order to account for safety concerns and to allow for self-healing diagnostics, use of an inducement override function for releasing full engine power is permitted provided it

(a) is active for no longer than 30 minutes, and

(b) is limited to 3 activations during each period that the operator inducement system is active.

5.6. The operator inducement system shall be deactivated when the conditions for its activation have ceased to exist. The operator inducement system shall not be automatically deactivated without the reason for its activation having been remedied.

5.7. Details of the operator inducement system activation and deactivation procedures are described in section 11..

5.8. As part of the application for EU type-approval under this Regulation, the manufacturer shall demonstrate the operation of the operator inducement system, as specified in section 11..

6. Reagent availability

6.1. Reagent level indicator

The non-road mobile machinery shall include an indicator that clearly informs the operator of the level of reagent in the reagent storage tank. The minimum acceptable

performance level for the reagent indicator is that it shall continuously indicate the reagent level whilst the operator warning system referred to in section 4. is activated. The reagent indicator may be in the form of an analogue or digital display, and may show the level as a proportion of the full tank capacity, the amount of remaining reagent, or the estimated operating hours remaining.

6.2. Activation of the operator warning system

6.2.1. The operator warning system specified in section 4. shall be activated when the level of reagent goes below 10 % of the capacity of the reagent tank or a higher percentage at the choice of the manufacturer.

6.2.2. The warning provided shall be sufficiently clear, in conjunction with the reagent indicator, for the operator to understand that the reagent level is low. When the warning system includes a message display system, the visual warning shall display a message indicating a low level of reagent. (for example “urea level low”, “AdBlue level low”, or “reagent low”).

6.2.3. The operator warning system does not initially need to be continuously activated (for example a message does not need to be continuously displayed), however activation shall escalate in intensity so that it becomes continuous as the level of the reagent approaches empty and the point where the operator inducement system will come into effect is approached (for example frequency at which a lamp flashes). It shall culminate in an operator notification at a level that is at the choice of the manufacturer, but sufficiently more noticeable at the point where the operator inducement system in point 6.3. comes into effect than when it was first activated.

6.2.4. The continuous warning shall not be easily disabled or ignored. When the warning system includes a message display system, an explicit message shall be displayed (for example “fill up urea”, “fill up AdBlue”, or “fill up reagent”). The continuous warning may be temporarily interrupted by other warning signals providing important safety related messages.

6.2.5. It shall not be possible to turn off the operating warning system until the reagent has been replenished to a level not requiring its activation.

6.3 Activation of the operator inducement system

6.3.1 The low-level inducement system described in point 5.3. shall be activated if the reagent tank level goes below 2,5 % of its nominally full capacity or a higher percentage at the choice of the manufacturer.

6.3.2. The severe inducement system described in point 5.4. shall be activated if the reagent tank is 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.

6.3.3. Except to the extent permitted by point 5.5., it shall not be possible to turn off the low-level or severe inducement system until the reagent has been replenished to a level not requiring their respective activation.

7. Reagent quality monitoring

7.1. The engine or non-road mobile machinery shall include a means of determining the presence of an incorrect reagent on board a non-road mobile machinery.

7.1.1. The manufacturer shall specify a minimum acceptable reagent concentration CD_{min}, which results in tailpipe NO_x emissions not exceeding 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.

7.1.1.1. The correct value of CD_{min} shall be demonstrated during EU type-approval by the procedure defined in section 13. and recorded in the extended documentation package as specified in section 8. of Annex I.

7.1.2. Any reagent concentration lower than CD_{min} shall be detected and be regarded, for the purpose of point 7.1., as being incorrect reagent.

7.1.3. A specific counter ("the reagent quality counter") shall be attributed to the reagent quality. The reagent quality counter shall count the number of engine operating hours with an incorrect reagent.

7.1.3.1. Optionally, the manufacturer may group the reagent quality failure together with one or more of the failures listed in sections 8. and 9. into a single counter.

7.1.4. Details of the reagent quality counter activation and deactivation criteria and mechanisms are described in section 11..

7.2. Activation of the operator warning system

When the monitoring system confirms that the reagent quality is incorrect, the operator warning system described in section 4. shall be activated. When the warning system includes a message display system, it shall display a message indicating the reason of the warning (for example “incorrect urea detected”, “incorrect AdBlue detected”, or “incorrect reagent detected”).

7.3 Activation of the operator inducement system

7.3.1. The low-level inducement system described in point 5.3. shall be activated if the reagent quality is not rectified within a maximum of 10 engine operating hours after the activation of the operator warning system as described in point 7.2..

7.3.2. The severe inducement system described in point 5.4. shall be activated if the reagent quality is not rectified within a maximum of 20 engine operating hours after the activation of the operator warning system as described in point 7.2..

7.3.3. The number of hours prior to activation of the inducement systems shall be reduced in case of a repetitive occurrence of the malfunction according to the mechanism described in section 11..

8. Reagent dosing activity

8.1 The engine shall include a means of determining interruption of dosing.

8.2. Reagent dosing activity counter

8.2.1. A specific counter shall be attributed to the dosing activity (the "dosing activity counter"). The counter shall count the number of engine operating hours which occur with an interruption of the reagent dosing activity. This is not required where such interruption is demanded by the engine ECU because the non-road mobile machinery operating conditions are such that the non-road mobile machinery's emission performance does not require reagent dosing.

8.2.1.1. Optionally, the manufacturer may group the reagent dosing failure together with one or more of the failures listed in sections 7. and 9. into a single counter.

8.2.2. Details of the reagent dosing activity counter activation and deactivation criteria and mechanisms are described in section 11..

8.3. Activation of the operator warning system

The operator warning system described in section 4. shall be activated in the case of interruption of dosing which sets the dosing activity counter in accordance with point 8.2.1.. When the warning system includes a message display system, it shall display a message indicating the reason of the warning (e.g. “urea dosing malfunction”, “AdBlue dosing malfunction”, or “reagent dosing malfunction”).

8.4. Activation of the operator inducement system

8.4.1. The low-level inducement system described in point 5.3. shall be activated if an interruption in reagent dosing is not rectified within a maximum of 10 engine operating hours after the activation of the operator warning system in accordance with point 8.3..

8.4.2. The severe inducement system described in point 5.4. shall be activated if an interruption in reagent dosing is not rectified within a maximum of 20 engine operating hours after the activation of the operator warning system in accordance with point 8.3..

8.4.3. The number of hours prior to activation of the inducement systems shall be reduced in case of a repetitive occurrence of the malfunction according to the mechanism described in section 11..

9. Monitoring 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) impeded exhaust gas recirculation (EGR) valve;

(b) failures of the NO_x Control Diagnostic (NCD) system, as described in point 9.2.1..

9.2. Monitoring requirements

9.2.1. 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 points 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.

9.2.2. EGR valve counter

9.2.2.1. A specific 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.

9.2.2.1.1. Optionally, the manufacturer may group the impeded EGR valve failure together with one or more of the failures listed in sections 7., 8. and point 9.2.3. into a single counter.

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

9.2.3. NCD system counter(s)

9.2.3.1. A specific counter shall be attributed to each of the monitoring failures considered in point 9.1(b). 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. Grouping of several faults into a single counter is permitted.

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

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

9.3. Activation of the operator warning system

The operator warning system set out in section 4. shall be activated in case any of the failures specified in point 9.1. occur, and shall indicate that an urgent repair is required. When the warning system includes a message display system, it shall display a message indicating either the reason of the warning (for example “reagent dosing valve disconnected”, or "critical emission failure").

9.4. Activation of the operator inducement system

9.4.1. The low-level inducement system described in point 5.3. shall be activated if a failure specified in point 9.1. is not rectified within a maximum of 36 engine operating hours after the activation of the operator warning system set out in point 9.3..

9.4.2. The severe inducement system described in point 5.4. shall be activated if a failure specified in point 9.1. is not rectified within a maximum of 100 engine operating hours after the activation of the operator warning system set out in point 9.3..

9.4.3. The number of hours prior to activation of the inducement systems shall be reduced in case of a repetitive occurrence of the malfunction according to the mechanism described in section 11..

9.5. As an alternative to the requirements set out in point 9.2., the manufacturer may use a NO_x sensor located in the exhaust system. In this case,

(a) the NO_x value 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) use of a single failure "high NO_x - root cause unknown" may be used,

(c) point 9.4.1. shall read "within 10 engine hours",

(d) point 9.4.2. shall read "within 20 engine hours".

10. Demonstration requirements

10.1. General

The compliance to the requirements of this Appendix shall be demonstrated during EU type-approval by performing, as illustrated in Table 4.1. and specified in this section 10.:

(a) a demonstration of the warning system activation

(b) a demonstration of the low level inducement system activation, if applicable

(c) a demonstration of the severe inducement system activation

10.2. Engine families and NCD engine families

The compliance of an engine family or an NCD engine family with the requirements of this section 10. may be demonstrated by testing one of the members of the considered family, provided the manufacturer demonstrates to the approval authority that the monitoring systems necessary for complying with the requirements of this Appendix are similar within the family.

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

10.2.2. The test engine is selected by the manufacturer in agreement with the approval authority. It may or may not be the parent engine of the considered family.

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 according to 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.

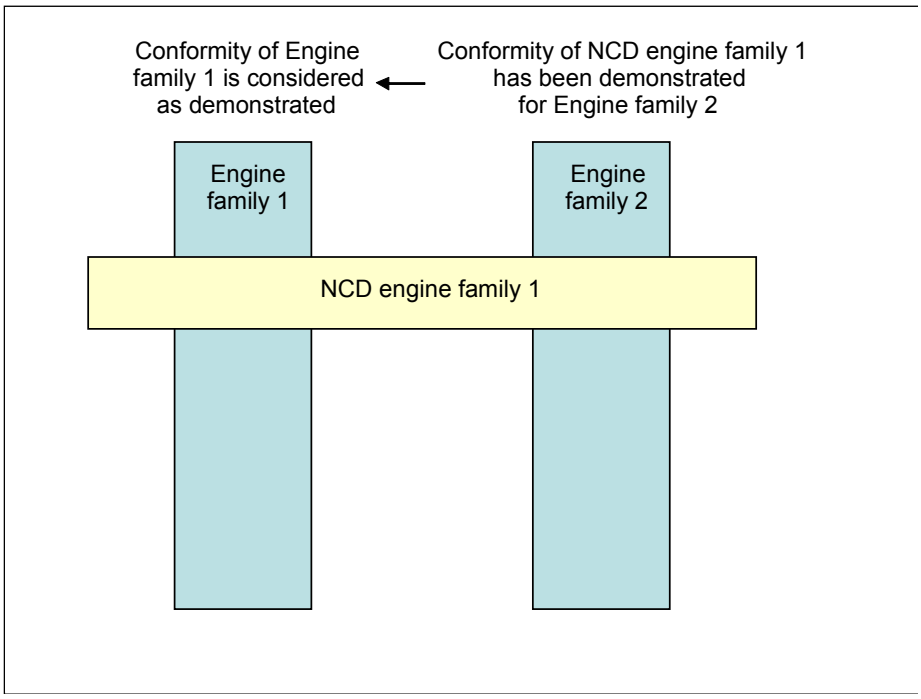
Table 4.1.

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 10.4.6.	• 2 activation tests (incl. lack of reagent) • Supplementary demonstration elements, as appropriate

Figure 4.3.

Previously demonstrated conformity of an NCD engine family



10.3. Demonstration of the warning system activation

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

10.3.2. Selection of the failures to be tested

10.3.2.1. 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 according to the requirements set out in section 7..

10.3.2.2. 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 according to the following requirements:

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

10.3.2.2.2. The failure to be considered in the test shall be selected by the approval authority from this list referred to in point 10.3.2.2.1.

10.3.3. Demonstration

10.3.3.1. For the purpose of this demonstration, a separate test shall be performed for each of the failures considered in point 10.3.1.

10.3.3.2. During a test, no failure shall be present other than the one addressed by the test.

10.3.3.3. Prior to starting a test, all DTC shall have been erased.

10.3.3.4. At the request of the manufacturer, and with the agreement of the approval authority, the failures subject to testing may be simulated.

10.3.3.5. Detection of failures other than lack of reagent.

For failures other than lack of reagent, once the failure installed or simulated, the detection of that failure shall be performed as follows:

10.3.3.5.1. The NCD system shall respond to the introduction of a failure selected as appropriate by the approval authority in accordance to the provisions of this Appendix. This is considered to be demonstrated if activation occurs within two consecutive NCD test-cycles according to point 10.3.3.7..

When it has been specified in the monitoring description and agreed by the approval authority that a specific monitor needs more than two NCD test-cycles to complete its monitoring, the number of NCD test-cycles may be increased to 3 NCD test-cycles.

Each individual NCD test-cycle in the demonstration test may be separated by an engine shut-off. The time until the next start-up shall take into consideration any monitoring that may occur after engine shut-off and any necessary condition that must exist for monitoring to occur at the next start up.

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 according to point 10.3.2.1., the warning system has been properly activated and the DTC for the selected failure has got the “confirmed and active” status.

10.3.3.6. Detection in case of lack of reagent availability

For the purpose of demonstrating the activation of the warning system in case of lack of reagent availability, the engine shall be operated over one or more NCD test cycles at the discretion of the manufacturer.

10.3.3.6.1. The demonstration shall start with a level of reagent in the tank to be agreed between the manufacturer and the approval authority but representing not less than 10 % of the nominal capacity of the tank.

10.3.3.6.2. The warning system is deemed to have performed in the correct manner if the following conditions are met simultaneously:

(a) the warning system has been activated with a reagent availability greater or equal to 10 % of the capacity of the reagent tank, and

(b) the "continuous" warning system has been activated with a reagent availability greater or equal to the value declared by the manufacturer in accordance with the provisions of section 6..

10.3.3.7. NCD test cycle

10.3.3.7.1 The NCD test cycle considered in this section 10. for demonstrating the correct performance of the NCD system is the hot-start NRTC cycle for engines of sub-category NRE-v-3, NRE-v-4, NRE-v-5 NRE-v-6 and the applicable NRSC for all other categories.

10.3.3.7.2 On request of the manufacturer and with approval of the approval authority, an alternative NCD test-cycle can be used (e.g. other than the NTRC or the NRSC) for a specific monitor. The request shall contain elements (technical considerations, simulation, test results, etc.) demonstrating:

(a) the requested test-cycle results in a monitor that will run in real world operations, and;

(b) the applicable NCD test-cycle specified in point 10.3.3.7.1. is shown to be less appropriate for the considered monitoring.

10.3.4. The demonstration of the warning system activation is deemed to be accomplished if, at the end of each demonstration test performed according to point 10.3.3., the warning system has been properly activated.

10.4. Demonstration of the inducement system

10.4.1. The demonstration of the inducement system shall be done by tests performed on an engine test bench.

10.4.1.1. Any components or sub-systems not physically mounted on the engine, such as, but not limited to, ambient temperature sensors, level sensors, and operator warning and information systems, that are required in order to perform the demonstrations shall be connected to the engine for that purpose, or shall be simulated, to the satisfaction of the approval authority.

10.4.1.2. If the manufacturer chooses, and subject to the agreement of the approval authority, the demonstration tests may be performed on a complete non-road mobile machinery or machinery either by mounting the non-road mobile machinery on a suitable test bed or, notwithstanding point 10.4.1., by running it on a test track under controlled conditions.

10.4.2. The test sequence shall demonstrate the activation of the inducement system in case of lack of reagent and in case of one of the failures defined in sections 7., 8., or 9..

10.4.3. For the purpose of this demonstration,

(a) the approval authority shall select, in addition to the lack of reagent, one of the failures defined in sections 7., 8. or 9. that has been previously used in the demonstration of the warning system,

(b) 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,

(c) 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. Separate torque measurement during the inducement system demonstration is not required in this case,

(d) the severe inducement shall be demonstrated according to the requirements of point 10.4.6..

10.4.4. The manufacturer shall, in addition, demonstrate the operation of the inducement system under those failure conditions defined in sections 7., 8. or 9. which have not been chosen for use in demonstration tests described in points 10.4.1. to 10.4.3.

These additional demonstrations may be performed by presentation to the approval authority of a technical case using evidence such as algorithms, functional analyses, and the result of previous tests.

10.4.4.1. These additional demonstrations shall in particular demonstrate to the satisfaction of the approval authority the inclusion of the correct torque reduction mechanism in the engine ECU.

10.4.5. Demonstration test of the low level inducement system

10.4.5.1. This demonstration starts when the warning system or when appropriate "continuous" warning system has been activated as a result of the detection of a failure selected by the approval authority.

10.4.5.2. When the system is being checked for its reaction to the case of lack of reagent in the tank, the engine shall be run until the reagent availability has reached a value of 2,5 % of the tank nominal full capacity of the tank or the value declared by the manufacturer in accordance with point 6.3.1. at which the low-level inducement system is intended to operate.

10.4.5.2.1. The manufacturer may, with the agreement of the approval authority, simulate continuous running by extracting reagent from the tank, either whilst the engine is running or is stopped.

10.4.5.3. When the system is checked for its reaction in the case of a failure other than a lack of reagent in the tank, the engine shall be run for the relevant number of operating hours indicated in Table 4.3. or, at the choice of the manufacturer, until the relevant counter has reached the value at which the low-level inducement system is activated.

10.4.5.4. The demonstration of the low level inducement system shall be deemed to be accomplished if, at the end of each demonstration test performed according to points 10.4.5.2. and 10.4.5.3., the manufacturer has demonstrated to the approval authority that the engine ECU has activated the torque reduction mechanism.

10.4.6. Demonstration test of the severe inducement system

10.4.6.1. This demonstration shall start from a condition where the low-level inducement system has been previously activated and may be performed as a continuation of the tests undertaken to demonstrate the low-level inducement system.

10.4.6.2. When the system is checked for its reaction in the case of lack of reagent in the tank, the engine shall be run until the reagent tank is empty, or has reached the level below 2,5 % of nominal full capacity of the tank at which the manufacturer has declared to activate the severe inducement system.

10.4.6.2.1. The manufacturer may, with the agreement of the approval authority, simulate continuous running by extracting reagent from the tank, either whilst the engine is running or is stopped.

10.4.6.3. When the system is checked for its reaction in the case of a failure that is not a lack of reagent in the tank, the engine shall then be run for the relevant number of operating hours indicated in Table 4.4. or, at the choice of the manufacturer, until the relevant counter has reached the value at which the severe inducement system is activated.

10.4.6.4. The demonstration of the severe inducement system shall be deemed to be accomplished if, at the end of each demonstration test performed according to points 10.4.6.2. and 10.4.6.3., the manufacturer has demonstrated to the approval authority that the severe inducement mechanism considered in this Appendix has been activated.

10.4.7. Alternatively, if the manufacturer chooses, and subject to the agreement of the approval authority, the demonstration of the inducement mechanisms may be performed on a complete non-road mobile machinery in accordance with the requirements of points 5.4. and 10.4.1.2., either by mounting the non-road mobile machinery on a suitable test bed or by running it on a test track under controlled conditions.

10.4.7.1. The non-road mobile machinery shall be operated until the counter associated with the selected failure has reached the relevant number of operating hours indicated in Table 4.4. or, as appropriate, until either the reagent tank is empty or, has reached the level below 2,5 % of nominal full capacity of the tank at which the manufacturer has chosen to activate the severe inducement system.

11. Description of the operator warning and inducement activation and deactivation mechanisms

11.1 To complement the requirements specified in this Appendix concerning the warning and inducement activation and deactivation mechanisms, this section 11. specifies the technical requirements for an implementation of those activation and deactivation mechanisms.

11.2. Activation and deactivation mechanisms of the warning system

11.2.1. The operator warning system shall be activated when the diagnostic trouble code (DTC) associated with a NCM justifying its activation has the status defined in Table 4.2..

Table 4.2.

Activation of the operator warning system

Failure type	DTC status for activation of the warning system
poor reagent quality	confirmed and active
interruption of dosing	confirmed and active
impeded EGR valve	confirmed and active
malfunction of the monitoring system	confirmed and active
NO_x threshold, if applicable	confirmed and active

11.2.2. The operator warning system shall be deactivated when the diagnosis system concludes that the malfunction relevant to that warning is no longer present or when the information including DTCs relative to the failures justifying its activation is erased by a scan tool.

11.2.2.1 Requirements for erasing "NO_x control information"

11.2.2.1.1. Erasing / resetting "NO_x control information" by a scan-tool

On request of the scan tool, the following data shall be erased or reset to the value specified in this Appendix from the computer memory (see Table 4.3.).

Table 4.3.

Erasing / resetting "NO_x control information" by a scan-tool

NO_x control information	Erasable	Resetable
all DTCs	X	
the value of the counter with the highest number of engine operating hours		X
the number of engine operating hours from the NCD counter(s)		X

11.2.2.1.2. NO_x control information shall not be erased by disconnection of the non-road mobile machinery's battery(s).

11.2.2.1.3. The erasing of "NO_x control information" shall only be possible under “engine-off” conditions.

11.2.2.1.4. When "NO_x control information" including DTCs are erased, any counter associated with these failures and which is specified in this Appendix shall not be erased, but reset to the value specified in the appropriate section of this Appendix.

11.3. Activation and deactivation mechanism of the operator inducement system

11.3.1. The operator inducement system shall be activated when the warning system is active and the counter relevant to the type of NCM justifying their activation have reached the value specified in Table 4.4..

11.3.2. The operator inducement system shall be deactivated when the system no longer detects a malfunction justifying its activation, or if the information including the DTCs relative to the NCMs justifying its activation has been erased by a scan tool or maintenance tool.

11.3.3. The operator warning and inducement systems shall be immediately activated or deactivated as appropriate according to the provisions of section 6. after assessment of the reagent quantity in the reagent tank. In that case, the activation or deactivation mechanisms shall not depend upon the status of any associated DTC.

11.4. Counter mechanism

11.4.1. General

11.4.1.1. To comply with the requirements of this Appendix, the system shall contain at least 4 counters to record the number of hours during which the engine has been operated while the system has detected any of the following:

(a) an incorrect reagent quality;

(b) an interruption of reagent dosing activity;

(c) an impeded EGR valve;

(d) a failure of the NCD system according to point 9.1.(b).

11.4.1.1.1. Optionally, the manufacturer may use one or more counters for grouping the failures indicated in point 11.4.1.1..

11.4.1.2. Each of the counters shall count up to the maximum value provided in a 2 byte counter with 1 hour resolution and hold that value unless the conditions allowing the counter to be reset to zero are met.

11.4.1.3. A manufacturer may use a single or multiple NCD system counters. A single counter may accumulate the number of hours of 2 or more different malfunctions relevant to that type of counter, none of them having reached the time the single counter indicates.

11.4.1.3.1. When the manufacturer decides to use multiple NCD system counters, the system shall be capable of assigning a specific monitoring system counter to each malfunction relevant according to this Appendix to that type of counters.

11.4.2. Principle of counters mechanism

11.4.2.1. Each of the counters shall operate as follows:

11.4.2.1.1. If starting from zero, the counter shall begin counting as soon as a malfunction relevant to that counter is detected and the corresponding diagnostic trouble code (DTC) has the status defined in Table 4.2..

11.4.2.1.2. In case of repeated failures, one of the following provisions shall apply at the choice of the manufacturer.

(a) If a single monitoring event occurs and the malfunction that originally activated the counter is no longer detected or if the failure has been erased by a scan tool or a maintenance tool, the counter shall halt and hold its current value. If the counter stops counting when the severe inducement system is active, the counter shall be kept frozen at the value defined in Table 4.4. or a value of greater than or equal to the counter value for severe inducement minus 30 minutes.

(b) The counter shall be kept frozen at the value defined in Table 4.4. or a value of greater than or equal to the counter value for severe inducement minus 30 minutes.

11.4.2.1.3. In the case of a single monitoring system counter, that counter shall continue counting if a NCM relevant to that counter has been detected and its corresponding Diagnostic trouble code (DTC) has the status "confirmed and active". It shall halt and hold one of the values specified in point 11.4.2.1.2., if no NCM that would justify the counter activation is detected or if all the failures relevant to that counter have been erased by a scan tool or a maintenance tool.

Table 4.4.

Counters and inducement

	DTC status for first activation of the counter	counter value for low-level inducement	counter value for severe inducement	Frozen value held by the counter
reagent quality counter	confirmed and active	≤ 10 hours	≤ 20 hours	≥ 90 % of counter value for severe inducement
dosing counter	confirmed and active	≤ 10 hours	≤ 20 hours	≥ 90 % of counter value for severe inducement
EGR valve counter	confirmed and active	≤ 36 hours	≤ 100 hours	≥ 95 % of counter value for severe inducement
monitoring system counter	confirmed and active	≤ 36 hours	≤ 100 hours	≥ 95 % of counter value for severe inducement
NO_x threshold, if applicable	confirmed and active	≤ 10 hours	≤ 20 hours	≥ 90 % of counter value for severe inducement

11.4.2.1.4. Once frozen, the counter shall be reset to zero when the monitors relevant to that counter have run at least once to completion of their monitoring cycle without having detected a malfunction and no malfunction relevant to that counter has been detected during 40 engine operating hours since the counter was last held (see Figure 4.4.).

11.4.2.1.5. The counter shall continue counting from the point at which it had been held if a malfunction relevant to that counter is detected during a period when the counter is frozen (see Figure 4.4.).

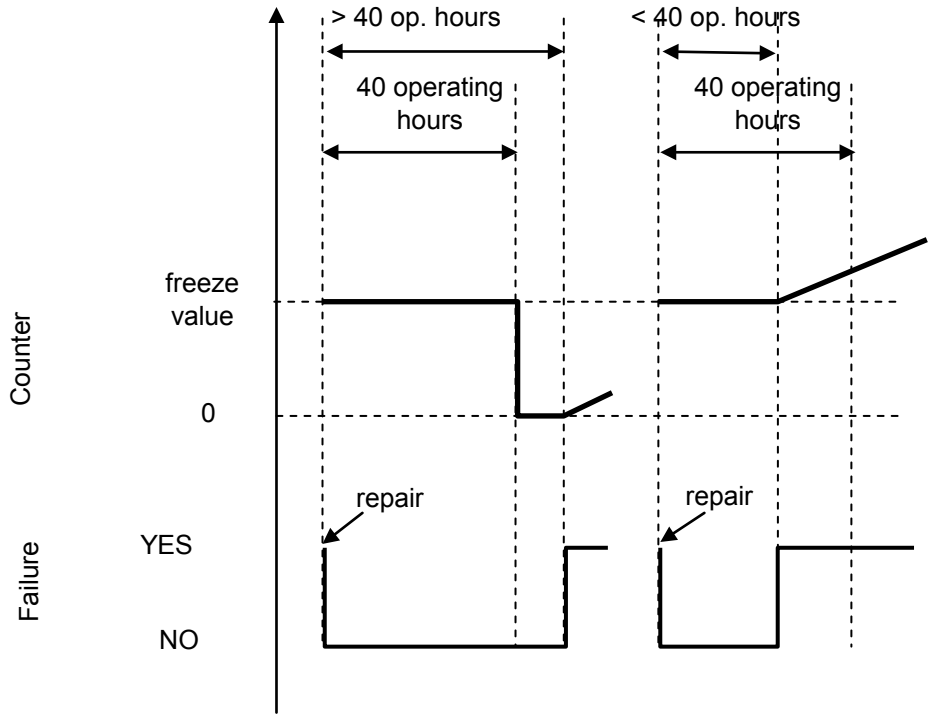
12. Illustration of the activation and deactivation and counter mechanisms

12.1. This section 12. illustrates the activation and deactivation and counter mechanisms for some typical cases. The Figures and descriptions given in points 12.2., 12.3. and 12.4. are provided solely for the purposes of illustration in this Appendix and should not be referenced as examples of either the requirements of this Regulation or as definitive statements of the processes involved. The counter hours in Figures 4.6. and 4.7. refer to the maximum severe inducement values in Table 4.4.. For simplification

purposes, for example, the fact that the warning system will also be active when the inducement system is active has not been mentioned in the illustrations given.

Figure 4.4.

Reactivation and resetting to zero of a counter after a period when its value has been frozen



12.2. Figure 4.5. illustrates the operation of the activation and deactivation mechanisms when monitoring the reagent availability for four cases:

(a) use case 1: the operator continues operating the non-road mobile machinery in spite of the warning until non-road mobile machinery operation is disabled;

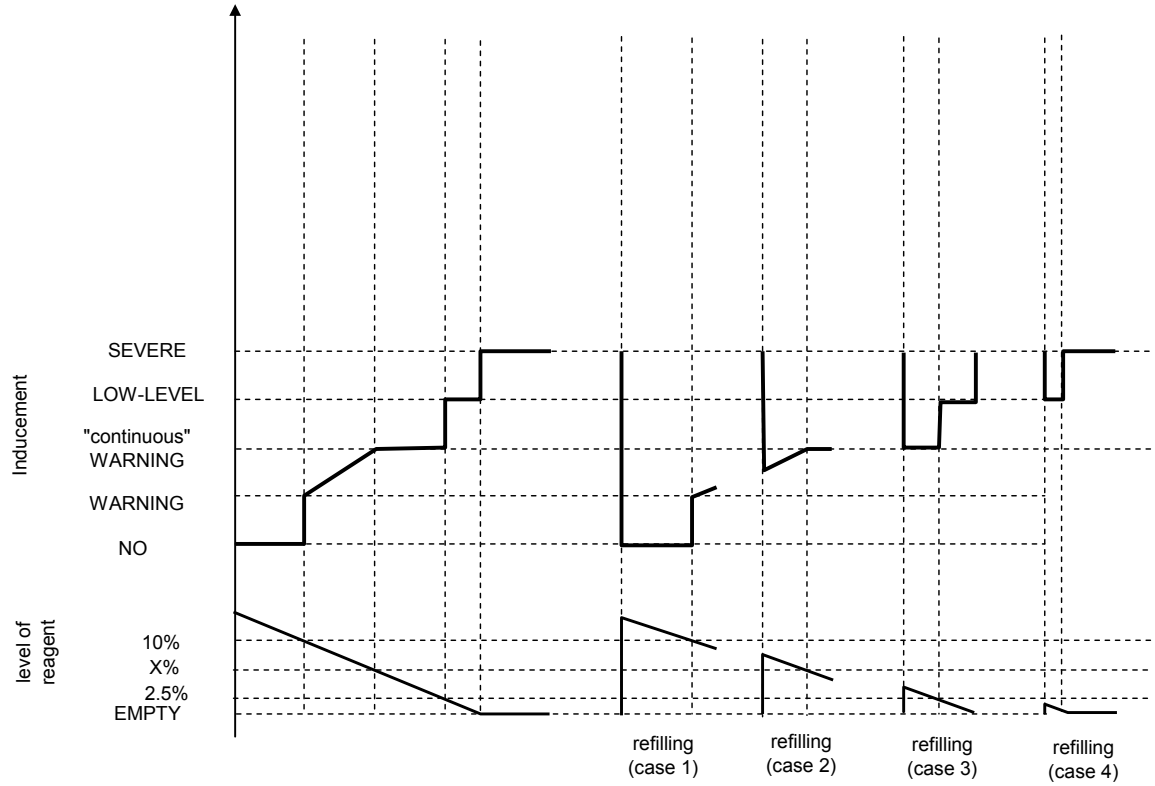
(b) refilling case 1 ("adequate" refilling): the operator refills the reagent tank so that a level above the 10% threshold is reached. Warning and inducement are de-activated;

(c) refilling cases 2 and 3 ("inadequate" refilling): The warning system is activated. The level of warning depends on the amount of available reagent;

(d) refilling case 4 ("very inadequate" refilling): The low level inducement is activated immediately.

Figure 4.5.

Reagent availability



12.3. Figure 4.6. illustrates three cases of wrong reagent quality:

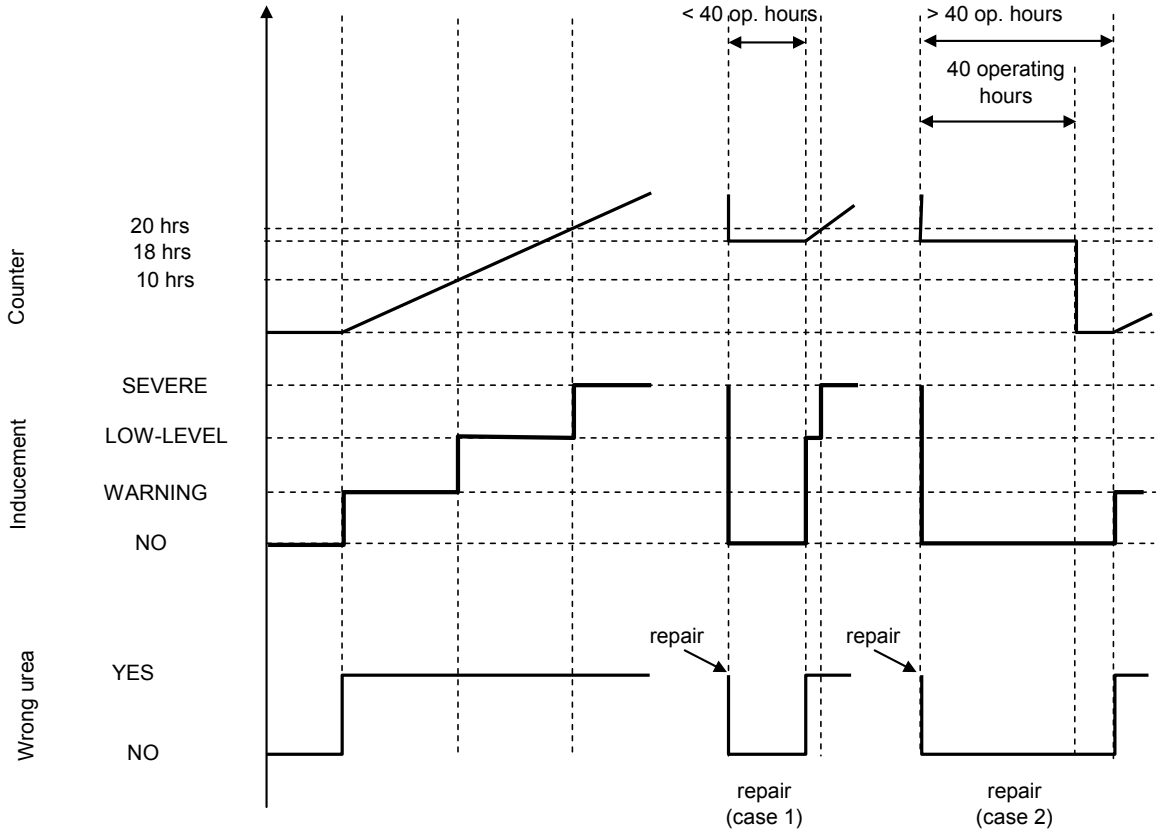
(a) use case 1: the operator continues operating the non-road mobile machinery in spite of the warning until non-road mobile machinery operation is disabled.

(b) repair case 1 ("bad" or "dishonest" repair): after disablement of the non-road mobile machinery, the operator changes the quality of the reagent, but soon after, changes it again for a poor quality one. The inducement system is immediately reactivated and non-road mobile machinery operation is disabled after 2 engine operating hours.

(c) repair case 2 ("good" repair): after disablement of the non-road mobile machinery, the operator rectifies the quality of the reagent. However some time afterwards, he refills again with a poor quality reagent. The warning, inducement and counting processes restart from zero.

Figure 4.6.

Filling with poor reagent quality



12.4. Figure 4.7. illustrates three cases of failure of the urea dosing system. This Figure also illustrates the process that applies in the case of the monitoring failures described in section 9..

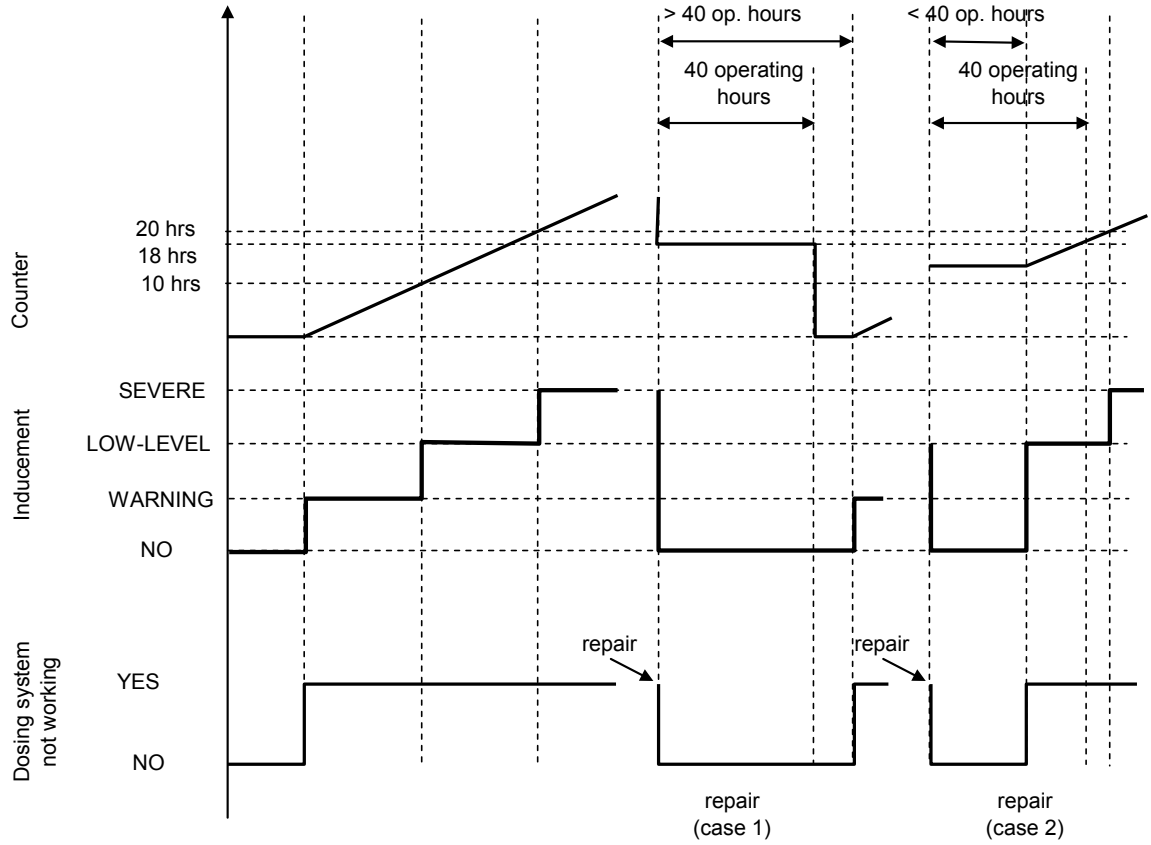
(a) use case 1: the operator continues operating the non-road mobile machinery in spite of the warning until non-road mobile machinery operation is disabled.

(b) repair case 1 ("good" repair): after disablement of the non-road mobile machinery, the operator repairs the dosing system. However some time afterwards, the dosing system fails again. The warning, inducement and counting processes restart from zero.

(c) repair case 2 ("bad" repair): during the low-level inducement time (torque reduction), the operator repairs the dosing system. Soon after, however, the dosing system fails again. The low-level inducement system is immediately reactivated and the counter restarts from the value it had at the time of repair.

Figure 4.7.

Failure of the reagent dosing system



13. Demonstration of the minimum acceptable reagent concentration CD_{min}

13.1. The manufacturer shall demonstrate the correct value of CD_{min} during EU type-approval by performing the hot-start NRTC cycle for engines of sub-category NRE-v-3, NRE-v-4, NRE-v-5 NRE-v-6 and the applicable NRSC for all other categories using a reagent with the concentration CD_{min}.

13.2. The test shall follow the appropriate NCD cycle(s) or manufacturer defined pre-conditioning cycle, permitting a closed loop NO_x control system to perform adaptation to the quality of the reagent with the concentration CD_{min}.

13.3. The pollutant emissions resulting from this test shall be lower than the NO_x threshold specified in point 7.1.1..

Appendix 2

Additional technical requirements on NO_x control measures for engines of categories IWP, IWA and RLR, including the method to demonstrate these strategies

1. Introduction

This Appendix sets out the additional requirements to ensure the correct operation of NO_x control measures for engines of categories IWP, IWA and RLR.

2. General requirements

The requirements of Appendix 1 apply additionally to engines in scope of this Appendix.

3. Exceptions to the requirements of Appendix 1

In order to account for safety concerns the inducements required in Appendix 1 shall not apply to engines in scope of this Appendix. Consequently the following points of Appendix 1 shall not apply: 2.3.3.2., 5., 6.3., 7.3., 8.4., 9.4., 10.4. and 11.3..

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.

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

4.2. The duration of an incident logged in the memory according to point 4.1. 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. For incidents other than those specified in point 4.1.1. the duration of an incident logged in the memory according to point 4.1. 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 logged in the memory according to point 4.1. shall end when the incident has been remedied.

4.5. When conducting a demonstration according to the requirements of section 10. of Appendix 1 the demonstration of the severe inducement system set out in point 10.1(c) of that Appendix and the corresponding Table 4.1. shall be replaced by a demonstration of the storage of an incident of engine operation with inadequate reagent injection or reagent quality.

In this case the requirements of point 10.4.1. of Appendix 1 shall apply and 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.

Appendix 3

Additional technical requirements on NO_x control measures for engines of category RLL

1. Introduction

This Appendix sets out the additional requirements to ensure the correct operation of NO_x control measures for engines of category RLL. It includes requirements for engines that rely on the use of a reagent in order to reduce emissions. The EU type-approval shall be made conditional upon the application of the relevant provisions on operator instruction, installation documents and operator warning system that are set out in this Appendix.

2. Required information

2.1. The manufacturer shall provide information that fully describes the functional operational characteristics of the NO_x control measures, in accordance with point 1.5. of Part A of Annex I to Commission Implementing Regulation 2016/CCC on administrative requirements.

2.2. If the emission control system requires a reagent, the characteristics of that reagent, including the type of reagent, information on concentration when the reagent is in solution, operational temperature conditions and reference to international standards for composition and quality must be specified by the manufacturer, in the information document set out in Appendix 3 of Annex I to Commission Implementing Regulation 2016/CCC on administrative requirements.

3. Reagent availability and operator warning system

When a reagent is used the EU type-approval shall be conditional upon providing indicators or other appropriate means, according to the configuration of the non-road mobile machinery, informing the operator on:

(a) the amount of reagent remaining in the reagent storage container and by an additional specific signal, when the remaining reagent is less than 10 % of the full container's capacity;

(b) when the reagent container becomes empty, or almost empty;

(c) when the reagent in the storage tank does not comply with the characteristics declared and recorded in the information document set out in Appendix 3 of Annex I to Commission Implementing Regulation 2016/CCC on administrative requirements, in accordance with the installed means of assessment.

(d) when the dosing activity of the reagent is interrupted, in cases other than those executed by the engine ECU or the dosing controller, reacting to engine operating conditions where the dosing is not required, provided that these operating conditions are made available to the approval authority.

4. Reagent quality

By the choice of the manufacturer the requirements of reagent compliance with the declared characteristics and the associated NO_x emission tolerance shall be satisfied by one of the following means:

(a) direct means, such as the use of a reagent quality sensor.

(b) indirect means, such as the use of a NO_x sensor in the exhaust system to evaluate reagent effectiveness.

(c) any other means, provided that its efficacy is at least equal to the one resulting by the use of the means of points (a) or (b) and the main requirements of this section 4. are maintained.

Appendix 4

Technical requirements on particulate pollutant control measures, including the method to demonstrate these measures

1. Introduction

This Appendix sets out the requirements to ensure the correct operation of particulate control measures.

2. General requirements

The engine shall be equipped with a Particulate Control Diagnostic system (PCD) able to identify the PARTICULATE AFTER-TREATMENT SYSTEM malfunctions considered by this Annex. Any engine covered by this section 2. shall be designed, constructed and installed so as to be capable of meeting these requirements throughout the normal life of the engine under normal conditions of use. In achieving this objective it is acceptable that engines which have been used in excess of the emission durability period as specified in Annex V to Regulation (EU) 2016/1628 show some deterioration in the performance and the sensitivity of the PCD.

2.1. Required information

2.1.1. If the emission control system requires a reagent e.g. fuel borne catalyst, the characteristics of that reagent, including the type of reagent, information on concentration when the reagent is in solution, operational temperature conditions and reference to international standards for composition and quality must be specified by the manufacturer, in the information document set out in Appendix 3 to Annex I to Commission Implementing Regulation 2016/CCC on administrative requirements.

2.1.2. Detailed written information fully describing the functional operation characteristics of the operator warning system in section 4. shall be provided to the approval authority at the time of EU type-approval.

2.1.3. The manufacturer shall provide installation documents that, when used by the OEM, will ensure that the engine, inclusive of the emission control system that is part of the approved engine type or engine family, when installed in the non-road mobile machinery, will operate, in conjunction with the necessary machinery parts, in a manner that will comply with the requirements of this Annex. This documentation shall include the detailed technical requirements and the provisions of the engine (software, hardware, and communication) needed for the correct installation of the engine in the non-road mobile machinery.

2.2. Operating conditions

2.2.1. The PCD system shall be operational at the following conditions:

(a) ambient temperatures between 266 K and 308 K (– 7 °C and 35 °C);

(b) all altitudes below 1600 m;

(c) engine coolant temperatures above 343 K (70 °C).

2.3. Diagnostic requirements

2.3.1. The PCD system shall be able to identify the particulate control malfunctions (PCM) considered by this Annex by means of Diagnostic Trouble Codes (DTCs) stored in the computer memory and to communicate that information off-board upon request.

2.3.2. Requirements for recording Diagnostic Trouble Codes (DTCs)

2.3.2.1. The PCD system shall record a DTC for each distinct PCM.

2.3.2.2. The PCD system shall conclude within the periods of engine operation indicated in Table 4.5. whether a detectable malfunction is present. At this time, a "confirmed and active" DTC shall be stored and the warning system specified in section 4. shall be activated.

2.3.2.3. In cases where more than the period of running time indicated in Table 1. 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.).

Table 4.5.

Monitor types and corresponding period within which a "confirmed and active" DTC shall be stored

Monitor type	Period of accumulated running time within which a "confirmed and active" DTC shall be stored
Removal of the particulate after-treatment system	60 minutes of non-idle engine operation
Loss of function of the particulate after-treatment system	240 minutes of non-idle engine operation
Failures of the PCD system	60 minutes of engine operation

2.3.3. Requirements for erasing Diagnostic trouble codes (DTCs):

(a) DTCs shall not be erased by the PCD system itself from the computer memory until the failure related to that DTC has been remedied;

(b) the PCD system may erase all the DTCs upon request of a proprietary scan or maintenance tool that is provided by the engine manufacturer upon request, or using a pass code provided by the engine manufacturer.

(c) the record of incidents of operation with a DTC confirmed and active that are stored in non-volatile memory as required by point 5.2. shall not be erased.

2.3.4. A PCD system shall not be programmed or otherwise designed to partially or totally deactivate based on age of the non-road mobile machinery during the actual life of the engine, nor shall the system contain any algorithm or strategy designed to reduce the effectiveness of the PCD system over time.

2.3.5. Any reprogrammable computer codes or operating parameters of the PCD system shall be resistant to tampering.

2.3.6. PCD engine family

The manufacturer is responsible for determining the composition of a PCD engine family. Grouping engines within a PCD engine family shall be based on good engineering judgment and be subject to approval by the approval authority.

Engines that do not belong to the same engine family may still belong to the same PCD engine family.

2.3.6.1. Parameters defining a PCD engine family

A PCD engine family is characterised by basic design parameters that shall be common to engines within the family.

In order that engines are considered to belong to the same PCD engine family, the following list of basic parameters shall be similar:

(a) working principle of PARTICULATE AFTER-TREATMENT SYSTEM (e.g. mechanical, aerodynamic, diffusional, inertial, periodically regenerating, continuously regenerating, etc.)

(b) methods of PCD monitoring;

(c) criteria for PCD monitoring;

(d) monitoring parameters (e.g. frequency).

These similarities shall be demonstrated by the manufacturer by means of relevant engineering demonstration or other appropriate procedures and subject to the approval of the approval authority.

The manufacturer may request approval by the approval authority of minor differences in the methods of monitoring/diagnosing the PCD monitoring system due to engine configuration variation, when these methods are considered similar by the manufacturer and they differ only in order to match specific characteristics of the components under consideration (for example size, exhaust gas flow, etc.); or their similarities are based on good engineering judgment.

3. Maintenance requirements

3.1. The manufacturer shall furnish or cause to be furnished to all end-users of new engines or machines written instructions about the emission control system and its correct operation as required in Annex XV.

4. Operator warning system

4.1. The non-road mobile machinery shall include an operator warning system using visual alarms.

4.2. The operator warning system may consist of one or more lamps, or display short messages.

The system used for displaying these messages may be the same as the one used for other maintenance or NCD purposes

The warning system shall indicate that an urgent repair is required. When the warning system includes a message display system, it shall display a message indicating the reason of the warning (for example “sensor disconnected”, or “critical emission failure”)

4.3. At the choice of the manufacturer, the warning system may include an audible component to alert the operator. The cancelling of audible warnings by the operator is permitted.

4.4. The operator warning system shall be activated as specified in point 2.3.2.2..

4.5. The operator warning system shall be deactivated when the conditions for its activation have ceased to exist. The operator warning system shall not be automatically deactivated without the reason for its activation having been remedied.

4.6. The warning system may be temporarily interrupted by other warning signals providing important safety related messages.

4.7. In the application for EU type-approval under Regulation (EU) 2016/1628, the manufacturer shall demonstrate the operation of the operator warning system, as specified in Section 9.

5. System to store information on operator warning system activation

5.1 The PCD system shall include a non-volatile computer memory or counters to store incidents of engine operation with a DTC confirmed and active in a manner to ensure that the information cannot be intentionally deleted.

5.2 The PCD shall store in the non-volatile memory the total number and duration of all incidents of engine operation with a DTC confirmed and active where the operator warning system has been active for 20 hours of engine operation, or a shorter period at the choice of the manufacturer.

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

6. Monitoring for removal of the particulate after-treatment system

6.1 The PCD 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.

7. Additional requirements in the case of a particulate after-treatment system that uses a reagent (eg fuel borne catalyst)

7.1 In the case of a confirmed and active DTC for either removal of the particulate after-treatment system or loss of the particulate after-treatment system function the reagent dosing shall be immediately interrupted. Dosing shall re-commence when the DTC is no longer active.

7.2 The warning system shall be activated if the reagent level in the additive tank falls below the minimum value specified by the manufacturer.

8. Monitoring failures that may be attributed to tampering

8.1. In addition to monitoring for removal of the particulate after-treatment system the following failures shall be monitored because they may be attributed to tampering:

(a) loss of the particulate after-treatment system function,

(b) failures of the PCD system, as described in point 8.3..

8.2 Monitoring of loss of the particulate after-treatment system function

The PCD shall detect the complete removal of the particulate after-treatment system substrate ("empty can"). In this case the particulate after-treatment system housing and sensors used to monitor, activate, de-activate or modulate its operation are still present.

8.3. Monitoring of failures of the PCD system

8.3.1. The PCD system shall be monitored for electrical failures and for removal or deactivation of any sensor or actuator that prevents it from diagnosing any other failures mentioned in point 6.1. and 8.1(a) (component monitoring).

A non-exhaustive list of sensors that affect the diagnostic capability are those directly measuring differential pressures over the particulate after-treatment system and exhaust gas temperature sensors for controlling the particulate after-treatment system regeneration.

8.3.2. Where the failure, removal or deactivation of a single sensor or actuator of the PCD system does not prevent the diagnosis within the required time period of the failures mentioned in point 6.1. and 8.1(a) (redundant system), the activation of the warning system and storage of information on operator warning system activation shall not be required unless additional sensor or actuator failures are confirmed and active.

9. Demonstration requirements

9.1. General

The compliance to the requirements of this Appendix shall be demonstrated during EU type-approval by performing, as illustrated in Table 4.6. and specified in this section 9. a demonstration of the warning system activation.

Table 4.6.

Illustration of the content of the demonstration process in accordance with the provisions in point 9.3.

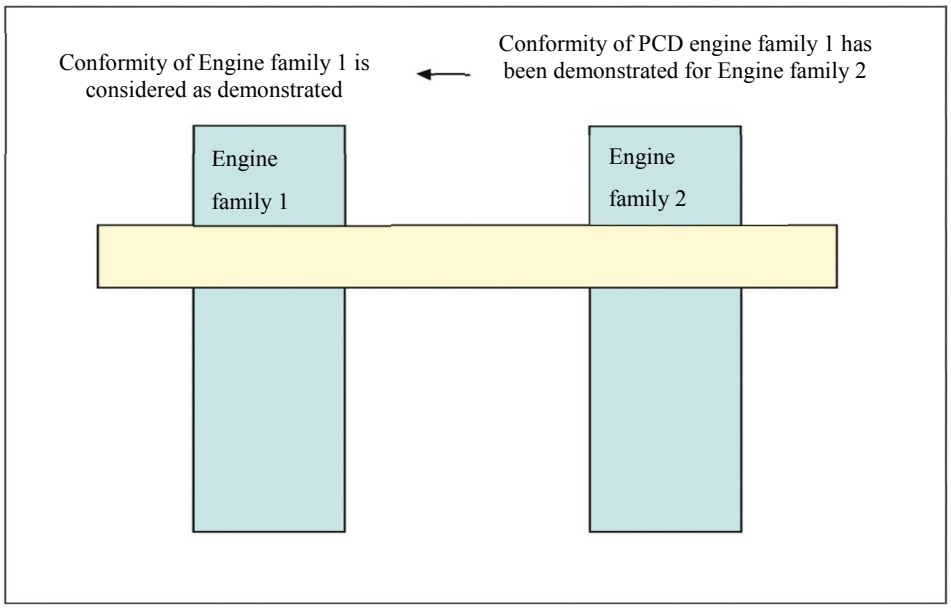
Mechanism	demonstration elements
Warning system activation specified in point 4.4.	• 2 activation tests (incl. loss of the particulate after-treatment system function) • Supplementary demonstration elements, as appropriate

9.2. Engine families and PCD engine families

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 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



9.3. Demonstration of the warning system activation

9.3.1. The compliance of the warning system activation shall be demonstrated by performing two tests: loss of the particulate after-treatment system function and one failure category considered in point 6. or point 8.3. of this Annex.

9.3.2. Selection of the failures to be tested

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

9.3.2.2. The failure to be considered in the test shall be selected by the approval authority from this list referred to in point 9.3.2.1..

9.3.3. Demonstration

9.3.3.1. For the purpose of this demonstration, a separate test shall be performed for the loss of the particulate after-treatment system function set out in point 8.2. and for the failures laid down in points 6. and 8.3.. The loss of the particulate after-treatment system function shall be created by a complete removal of the substrate from the particulate after-treatment system housing.

9.3.3.2. During a test, no failure shall be present other than the one addressed by the test.

9.3.3.3. Prior to starting a test, all DTC shall have been erased.

9.3.3.4. At the request of the manufacturer, and with the agreement of the approval authority, the failures subject to testing may be simulated.

9.3.3.5. Detection of failures

9.3.3.5.1. The PCD system shall respond to the introduction of a failure selected as appropriate by the approval authority in accordance to the provisions of this Appendix. This is considered to be demonstrated if activation occurs within the number of consecutive PCD test-cycles given in Table 4.7..

When it has been specified in the monitoring description and agreed by the approval authority that a specific monitor needs more PCD test-cycles to complete its monitoring than indicated in Table 4.7., the number of PCD test-cycles may be increased by up to 50 %.

Each individual PCD test-cycle in the demonstration test may be separated by an engine shut-off. The time until the next start-up shall take into consideration any monitoring that may occur after engine shut- off and any necessary condition that must exist for monitoring to occur at the next start-up.

Table 4.7.

Monitor types and corresponding number of PCD test cycles within which a "confirmed and active" DTC shall be stored

Monitor type	Number of PCD test cycles within which a "confirmed and active" DTC shall be stored
Removal of the particulate after-treatment system	2
Loss of function of the particulate after-treatment system	8
Failures of the PCD system	2

9.3.3.6. PCD test cycle

9.3.3.6.1. The PCD test cycle considered in this Section 9. for demonstrating the correct performance of the particulate after-treatment system monitoring system is the hot-start NRTC cycle for engines of sub-category NRE-v-3, NRE-v-4, NRE-v-5, NRE-v-6 and the applicable NRSC for all other categories.

9.3.3.6.2. On request of the manufacturer and with approval of the approval authority, an alternative PCD test- cycle (e.g. other than the NRTC or the NRSC) can be used for a specific monitor. The request shall contain elements (technical considerations, simulation, test results, etc.) demonstrating:

(a) the requested test-cycle results in a monitor that will run in real world driving, and

(b) the applicable PCD test-cycle specified in point 9.3.3.6.1. is less appropriate for the considered monitoring.

9.3.3.7 Configuration for demonstration of the warning system activation

9.3.3.7.1. The demonstration of the warning system activation shall be done by tests performed on an engine test bench.

9.3.3.7.2. Any components or subsystems not physically mounted on the engine, such as, but not limited to, ambient temperature sensors, level sensors, and operator warning and information systems, that are required in order to perform the demonstrations shall be connected to the engine for that purpose, or shall be simulated, to the satisfaction of the approval authority.

9.3.3.7.3. If the manufacturer chooses, and subject to the agreement of the approval authority, the demonstration tests may be performed, notwithstanding point 9.3.3.7.1., on a complete non-road mobile machinery or machinery either by mounting the non-road mobile machinery on a suitable test bed or by running it on a test track under controlled conditions.

9.3.4. The demonstration of the warning system activation is deemed to be accomplished if, at the end of each demonstration test performed in accordance with to point 9.3.3. the warning system has been properly activated and the DTC for the selected failure has a “confirmed and active” status.

9.3.5 Where a particulate after-treatment system that uses a reagent is subjected to a demonstration test for loss of the particulate after-treatment system function or removal of the particulate after-treatment system it shall also be confirmed that reagent dosing has been interrupted.

ANNEX V

Measurements and tests with regard to the area associated with the non-road steady-state test cycle

1. General requirements

This Annex shall apply for electronically controlled engines of categories NRE, NRG, IWP, IWA, and RLR, complying with "Stage V" emission limits set out in Annex II to Regulation (EU) 2016/1628 and using electronic control to determine both the quantity and timing of injecting fuel or using electronic control to activate, de-activate or modulate the emission control system used to reduce NO_x.

This Annex sets out the technical requirements relating to the area associated with the relevant NRSC, within which the amount by which that the emissions shall be permitted to exceed the emission limits set out in Annex II is controlled.

When an engine is tested in the manner set out in test requirements of section 4. the emissions 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.

Section 3. sets out the selection by the technical service of additional measurement points from within the control area during the emission bench test, in order to demonstrate that the requirements of this section 1. have been met.

The manufacturer may request that the Technical Service excludes operating points from any of the control areas set out in section 2. during the demonstration set out in section 3. The Technical Service may grant this exclusion if the manufacturer can demonstrate that the engine is never capable of operating at such points when used in any non-road mobile non-road mobile machinery combination.

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 speed and load points outside of the control area for the torque curve corresponding to the approved engine type or engine family.

2. Engine control area

The applicable control area for conducting the engine test shall be the area identified in this section 2. that corresponds to the applicable NRSC for the engine being tested.

2.1. Control area for engines tested on NRSC cycle C1

These engines operate with variable-speed and load. Different control area exclusions apply depending upon the (sub-)category and operating speed of the engine.

2.1.1. Variable-speed engines of category NRE with maximum net power ≥ 19 kW, variable-speed engines of category IWA with maximum net power ≥ 300 kW, variable-speed engines of category RLR and variable-speed engines of category NRG.

The control area (see Figure 5.1.) is defined as follows:

upper torque limit: full load torque curve;

speed range: speed A to n_{hi};

where:

speed A = $n_{lo} + 0{,}15 \cdot (n_{hi} - n_{lo})$;

n_{hi} = high speed [see Article 3(26) of Regulation (EU) 2016/1628],

n_{lo} = low speed [see Article 3(31) of Regulation (EU) 2016/1628].

The following engine operating conditions shall be excluded from testing:

(a) points below 30 % of maximum torque;

(b) points below 30 % of maximum net power.

If the measured engine speed A is within ± 3 % of the engine speed declared by the manufacturer, the declared engine speeds shall be used. If the tolerance is exceeded for any of the test speeds, the measured engine speeds shall be used.

Intermediate test points within the control area shall be determined as follows:

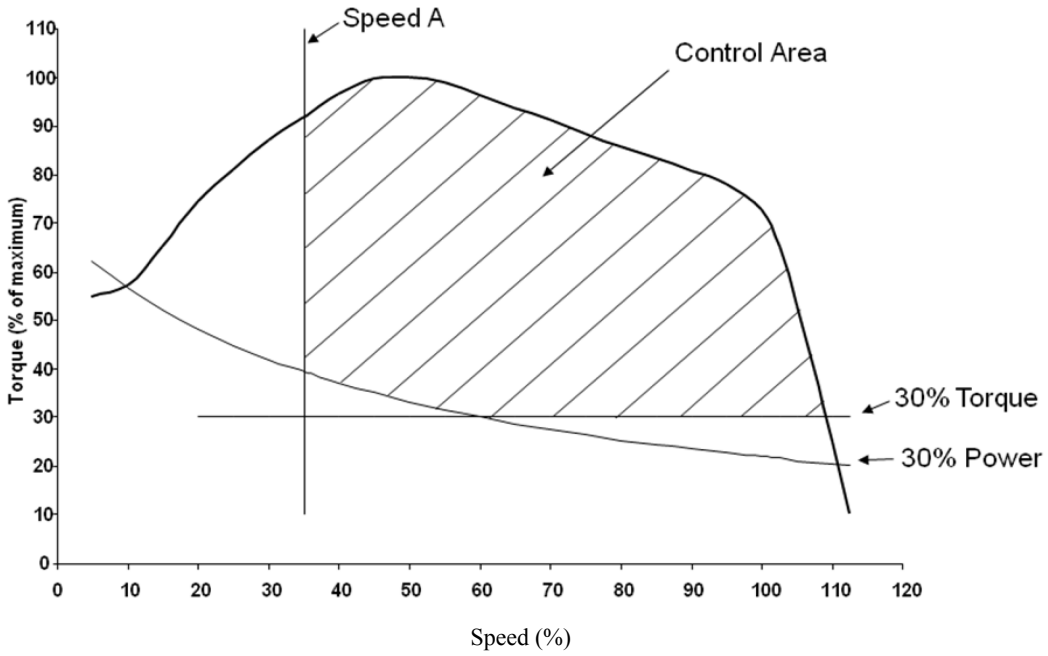
%torque = % of maximum torque;

$$\%\text{speed} = \frac{(n - n_{idle})}{(n_{100\%} - n_{idle})} \cdot 100 \text{ ;¶}$$

where: $n_{100\%}$ is the 100% speed for the corresponding test cycle.

Figure 5.1.

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



2.1.2. 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

The control area specified in point 2.1.1. shall apply but with the additional exclusion of the engine operating conditions given in this point and illustrated in Figures 5.2. and 5.3..

(a) for particulate matter only, if the C speed is below 2400 r/min, points to the right of or below the line formed by connecting the points of 30 % of maximum torque or 30 % of maximum net power, whichever is greater, at the B speed and 70 % of maximum net power at the high speed;

(b) for particulate matter only, if the C speed is at or above 2400 r/min, points to the right of the line formed by connecting the points of 30 % of maximum torque or 30 % of maximum net power, whichever is greater, at the B speed, 50 % of

maximum net power at 2400 r/min, and 70 % of maximum net power at the high speed.

where:

speed B = $n_{lo} + 0{,}5 \cdot (n_{hi} - n_{lo})$;

speed C = $n_{lo} + 0{,}75 \cdot (n_{hi} - n_{lo})$.

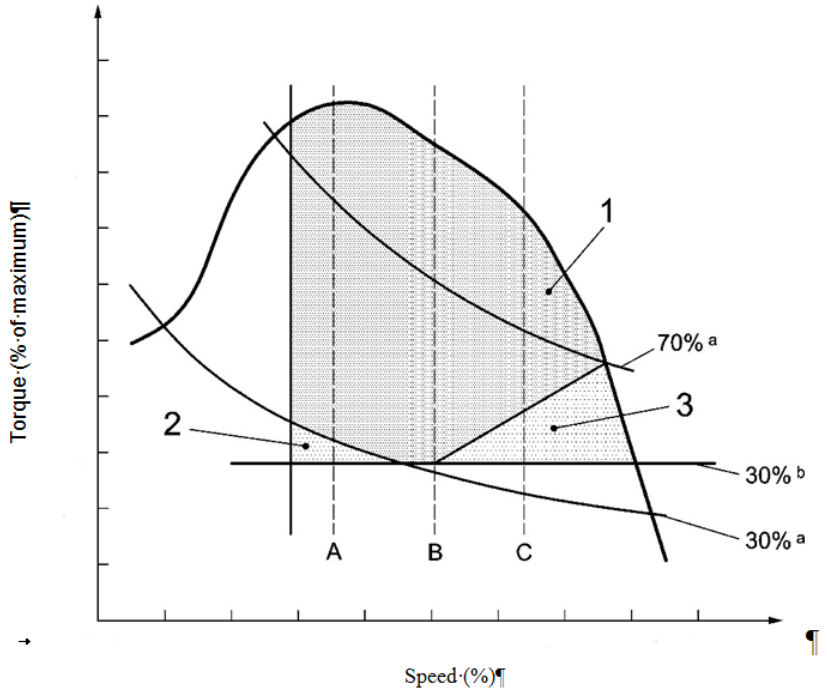
n_{hi} = high speed [see Article 3(26) of Regulation (EU) 2016/1628],

n_{lo} = low speed [see Article 3(31) of Regulation (EU) 2016/1628],

If the measured engine speeds A, B and C are within ± 3 % of the engine speed declared by the manufacturer, the declared engine speeds shall be used. If the tolerance is exceeded for any of the test speeds, the measured engine speeds shall be used.

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



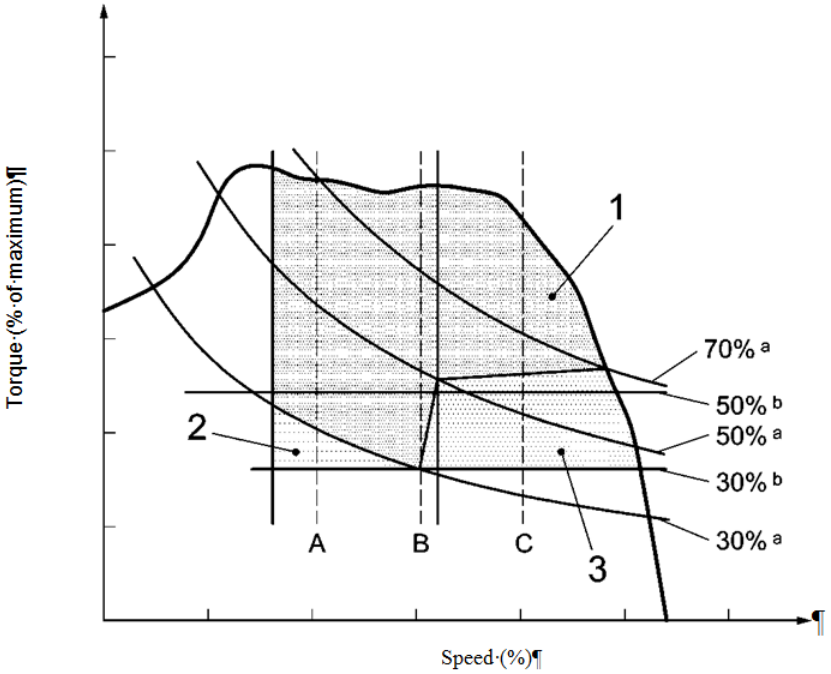
Key

1	Engine Control Area	2	All Emissions Carve-Out

3	PM Carve-Out	[a]	% of maximum net power
[b]	% of maximum torque		

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		

2.2. Control area for engines tested on NRSC cycles D2, E2 and G2

These engines are mainly operated very close to their designed operating speed, hence the control area is defined as:

speed: 100 %

torque range: 50 % to the torque corresponding to maximum power.

2.3. Control area for engines tested on NRSC cycle E3

These engines are mainly operated slightly above and below a fixed pitch propeller curve. The control area is related to the propeller curve and has exponents of mathematical equations defining the boundaries of the control area. The control area is defined as follows:

Lower speed limit: $0{,}7 \cdot n_{100\%}$

Upper boundary curve: $\%power = 100 \cdot \cdot (\%speed/90)^{3.5}$;

Lower boundary curve: $\%power = 70 \cdot \cdot (\%speed/100)^{2.5}$;

Upper power limit: Full load power curve

Upper speed limit: Maximum speed permitted by governor

where:

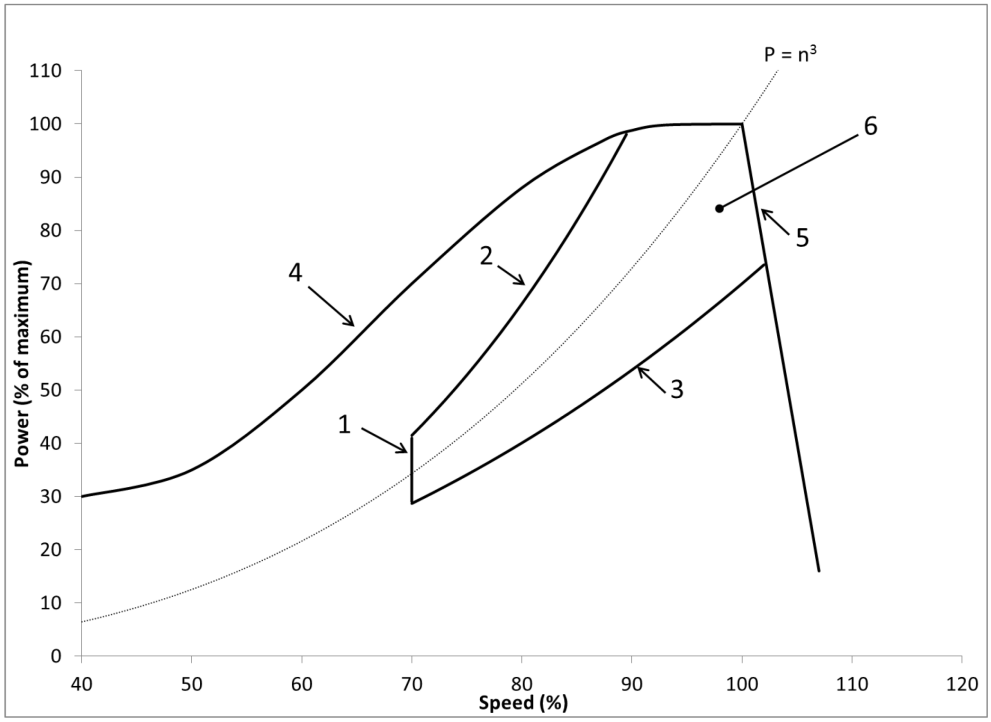
%power is % of maximum net power;

%speed is % of $n_{100\%}$

$n_{100\%}$ is the 100% speed for the corresponding test cycle.

Figure 5.4.

Control area for engines tested on NRSC cycle E3



Key

1	Lower speed limit	2	Upper boundary curve
3	Lower boundary curve	4	Full load power curve
5	Governor maximum speed curve	6	Engine Control Area

3. Demonstration requirements

The technical service shall select random load and speed points within the control area for testing. For engines subject to point 2.1. up to three points shall be selected. For engines subject to point 2.2. one point shall be selected. For engines subject to points 2.3. or 2.4. up to two points shall be selected. The technical service shall also determine a random running order of the test points. The test shall be run in accordance with the principal requirements of the NRSC, but each test point shall be evaluated separately.

4. Test requirements

The test shall be carried out immediately after the discrete mode NRSC as follows:

(a) the test shall be carried out immediately after the discrete-mode NRSC as 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 in points (a) to (d) of point 7.8.2.3. of Annex VI but before the post test procedures (e) as relevant;

(b) the tests shall be carried out as required in points (b) to (e) of point 7.8.1.2. of Annex VI using the multiple filter method (one filter for each test point) for each of the test points chosen in accordance with section 3.;

(c) a specific emission value shall be calculated (in g/kWh or #/kWh as applicable) for each test point;

(d) emissions values may be calculated on a mass basis using section 2. of Annex VII or on a molar basis using section 3. of Annex VII, but shall be consistent with the method used for the discrete-mode NRSC or RMC test;

(e) for gaseous and PN, if applicable, summation calculations, N_{mode} in equation (7-63) shall be set to 1 and a weighting factor of 1 shall be used;

(f) for particulate calculations the multiple filter method shall be used; for summation calculations, N_{mode} in equation (7-64) shall be set to 1 and a weighting factor of 1 shall be used.