Commission Delegated Regulation (EU) 2017/654 of 19 December 2016 supplementing Regulation (EU) 2016/1628 of the European Parliament and of the Council with regard to technical and general requirements relating to emission limits and type-approval for internal combustion engines for non-road mobile machinery

ANNEX 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.

[[F1]2.2.3.1. Notwithstanding point 2.2.3, in the case of engine (sub-)categories that are not subject to non-road transient test cycles for EU type-approval purposes, the base emission control strategy may identify when transient operating conditions occur and apply the corresponding emission control strategy. In this case, this emission control strategy shall be included in the overview of the base emission control strategy required by point 1.4 of Annex I to Implementing Regulation (EU) 2017/656 and in the confidential information on emission control strategy set out in Appendix 2 to that Annex.

Textual Amendments

F1 Inserted by Commission Delegated Regulation (EU) 2018/989 of 18 May 2018 amending and correcting Delegated Regulation (EU) 2017/654 supplementing Regulation (EU) 2016/1628 of the European Parliament and of the Council with regard to technical and general requirements relating to emission limits and type-approval for internal combustion engines for non-road mobile machinery (Text with EEA relevance).

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

2.3. Requirements for auxiliary emission control strategy

[F2 2.3.1. An auxiliary emission control strategy may be activated by an engine or a non-road mobile machinery, provided that the auxiliary emission control strategy:]

2.3.1.1. 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.

Textual Amendments

F2 Substituted by Commission Delegated Regulation (EU) 2018/989 of 18 May 2018 amending and correcting Delegated Regulation (EU) 2017/654 supplementing Regulation (EU) 2016/1628 of the European Parliament and of the Council with regard to technical and general requirements relating to emission limits and type-approval for internal combustion engines for non-road mobile machinery (Text with EEA relevance).

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: $IMT_c = P_{IM}/15{,}75 + 304{,}4$, where: IMT_c is the calculated intake manifold temperature, K and P_{IM} 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: $ECT_c = P_{IM}/14{,}004 + 325{,}8$, where: ECT_c is the calculated engine coolant temperature, K and P_{IM} 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 control 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 1 000 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: $T_c = – 0{,}4514 \times (101{,}3 – P_b) + 311$, where: T_c is the calculated ambient air temperature, K and P_b 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

[F3. . . . . .]

Textual Amendments

F3 Deleted by Commission Delegated Regulation (EU) 2018/989 of 18 May 2018 amending and correcting Delegated Regulation (EU) 2017/654 supplementing Regulation (EU) 2016/1628 of the European Parliament and of the Council with regard to technical and general requirements relating to emission limits and type-approval for internal combustion engines for non-road mobile machinery (Text with EEA relevance).

[F1 2.6.1. The manufacturer shall comply with the documentation requirements laid down in point 1.4 of Part A of Annex I to Implementing Regulation (EU) 2017/656 and Appendix 2 to that Annex.

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

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 Implementing Regulation (EU) 2017/656.

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:

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

(b) For engines of category NRE:

(i) 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

(ii) the requirements set out in Appendix 1 for engines not covered by subparagraph (i);

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

(d) 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 Implementing Regulation (EU) 2017/656.

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

[[F2]2.2.1. Monitoring for reagent level in the storage tank shall be conducted under all conditions where measurement is technically feasible (for instance, under all conditions when a liquid reagent is not frozen).**]**

[[F1]2.2.2. Reagent freeze protection shall apply at ambient temperatures at or below 266 K (– 7 °C).

2.2.3. All elements of the NO_x control diagnostic system other than those listed in points 2.2.1 and 2.2.2 shall, at a minimum, be operational at the applicable control conditions

set out in point 2.4 of this Annex for each engine category. The diagnostic system shall remain operational outside of this range where technically possible.**]**

2.3. Reagent freeze protection

[F2 2.3.1. It is permitted to use a heated or a non-heated reagent tank and dosing system. A heated system shall meet the requirements of points 2.3.2.2 to 2.3.2.2.4. A non-heated system shall meet the requirements of point 2.3.2.3.**]**

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.

[F2 2.3.2.2. Design criteria for a heated system

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

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.

[F1 2.3.2.2.4. Evaluation of the design criteria may be performed in a cold chamber test cell using an entire non-road mobile machinery or parts representative of those to be installed on a non-road mobile machinery or based on field tests.**]**

[F2 2.3.2.3. Activation of the operator warning and inducement system for a non-heated system.

[F1 2.3.2.3.1. The operator warning system described in points 4 to 4.9 shall be activated if no reagent dosing occurs at an ambient temperature ≤ 266 K (– 7 °C).

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

F3 2.3.3. Activation of the operator warning and inducement system for a non-heated system

2.3.3.1. . . . . .

2.3.3.2. . . . . .

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**

[[F2]3.1. The OEM shall provide to all end-users of new non-road mobile machinery written instructions about the emission control system and its correct operation in accordance with Annex XV.**]**

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 10.

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 minimum, 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;

(ea) **[**[F1]A description of the connection for, and method to read, the records referred to in point (e) shall be included in the information folder set out in Part A of Annex I to Implementing Regulation (EU) 2017/656;**]**

(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

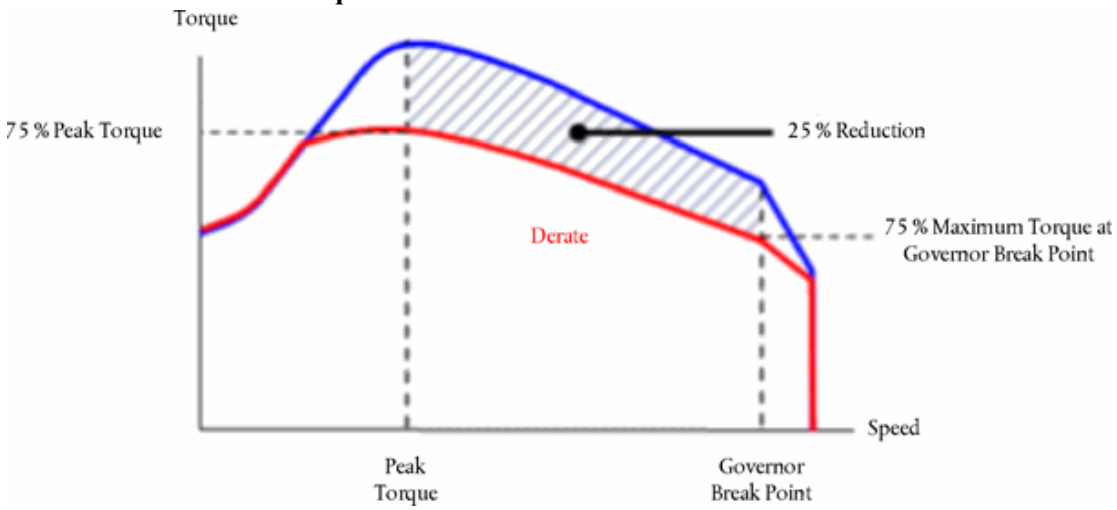
5.3.1. The low-level inducement system shall be activated after any of the conditions specified in points 6.3.1, 7.3.1, 8.4.1, and 9.4.1 has occurred.

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

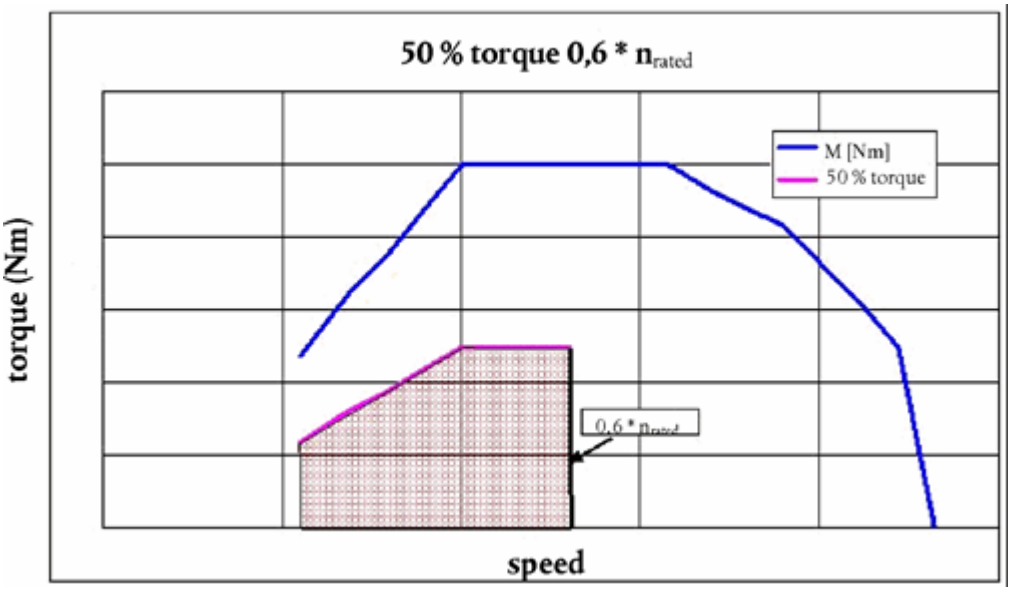
5.4.1. The severe inducement system shall be activated after any of the conditions specified in points 2.3.3.2, 6.3.2, 7.3.2, 8.4.2, and 9.4.2 has occurred.

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.

[[F2]7.1.1.1. The value of CD_{min} specified by the manufacturer shall be used during the demonstration set out in section 13 and recorded in Part C of the information document specified in Annex I to Implementing Regulation (EU) 2017/656.**]**

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.

[F29. **Other failures that may be attributed to tampering**

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

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

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

9.2. Monitoring requirements and counters

9.2.1. NCD system

9.2.1.1. The NO_x Control Diagnostic (NCD) system shall be monitored for electrical failures and for removal or deactivation of any sensor that prevents it from diagnosing any other failures set out in sections 6 to 8 (component monitoring).

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

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

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

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

9.2.2. Impeded EGR valve

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

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

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

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

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.

[[F2]9.5. As an alternative to the monitoring requirements set out in point 9.2, the manufacturer may monitor for failures using a NO_x sensor located in the exhaust system. In this case,

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

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

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

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

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.

[[F2]10.2.1. The demonstration that the monitoring systems for other members of the NCD engine family are similar may be performed by presenting to the approval authorities such elements as algorithms, functional analyses, etc.**]**

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.

[[F2]10.2.3. In the case where engines of an engine family belong to an NCD engine family that has already been EU type-approved, as referred to in point 10.2.1 (Figure 4.3), the compliance of that engine family is deemed to be demonstrated without further testing, provided the manufacturer demonstrates to the authority that the monitoring systems necessary for complying with the requirements of this Appendix are similar within the considered engine and NCD engine families.

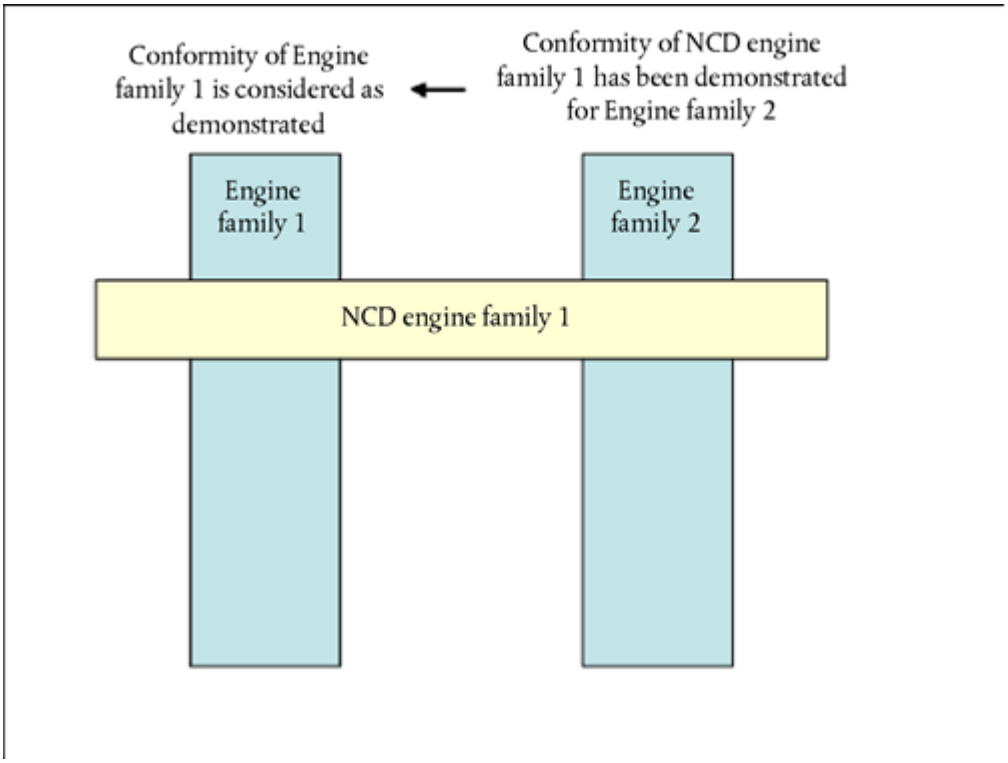
TABLE 4.1

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

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

Figure 4.3

Previously demonstrated conformity of an NCD engine family



10.3. Demonstration of the warning system activation

[F2 10.3.1. The compliance of the warning system activation shall be demonstrated by performing two tests: lack of reagent, and one failure category identified in sections 7, 8 or 9.

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

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

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

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

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

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

10.3.3. Demonstration

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

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. [F2 The demonstration of the warning system activation is deemed to be accomplished if, at the end of each demonstration test performed in accordance with point 10.3.3, the warning system has been properly activated and the DTC for the selected failure has got the ‘confirmed and active’ status.]

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.

[[F2] 10.4.2. The test sequence shall demonstrate the activation of the inducement system in case of the failure selected by the approval authority from the list as referred to in point 10.3.2.1 for the test of the warning system.

10.4.3. For the purpose of this demonstration,

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

(b) the achievement of the torque reduction required for low-level inducement may be demonstrated at the same time as the general engine performance approval process performed in accordance with this Regulation. A separate torque measurement during the inducement system demonstration is not required in this case,

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

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

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.

[[F1]10.5. Documentation of the demonstration

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

(a) identify the failures examined;

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

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

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

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

[F2 11.4.1.1. To comply with the requirements of this Appendix, the system shall contain counters to record the number of hours during which the engine has been operated while the system has detected any of the following NCM:

(a) an incorrect reagent quality;

(b) an interruption of reagent dosing activity;

(c) an impeded EGR valve;

(d) a failure of the NCD system.

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

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).

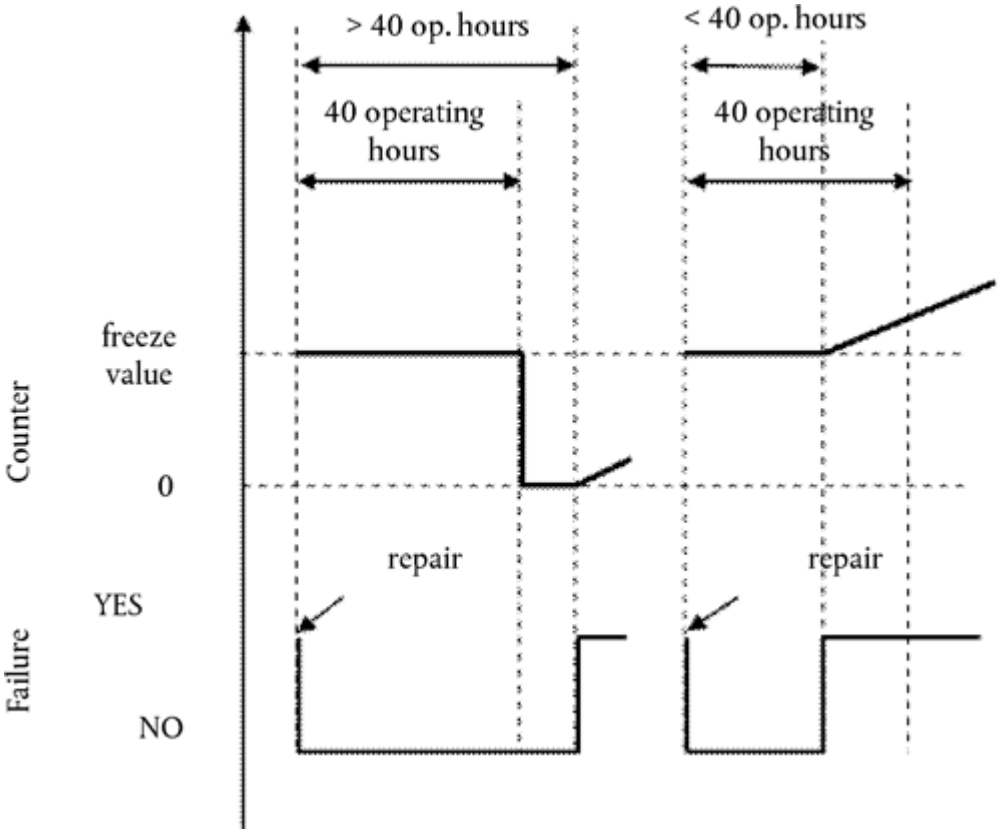
11.4.2.1.5. The counter shall continue counting from the point at which it had been held if a malfunction relevant to that counter is detected during a period when the counter is frozen (see Figure 4.4).

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;

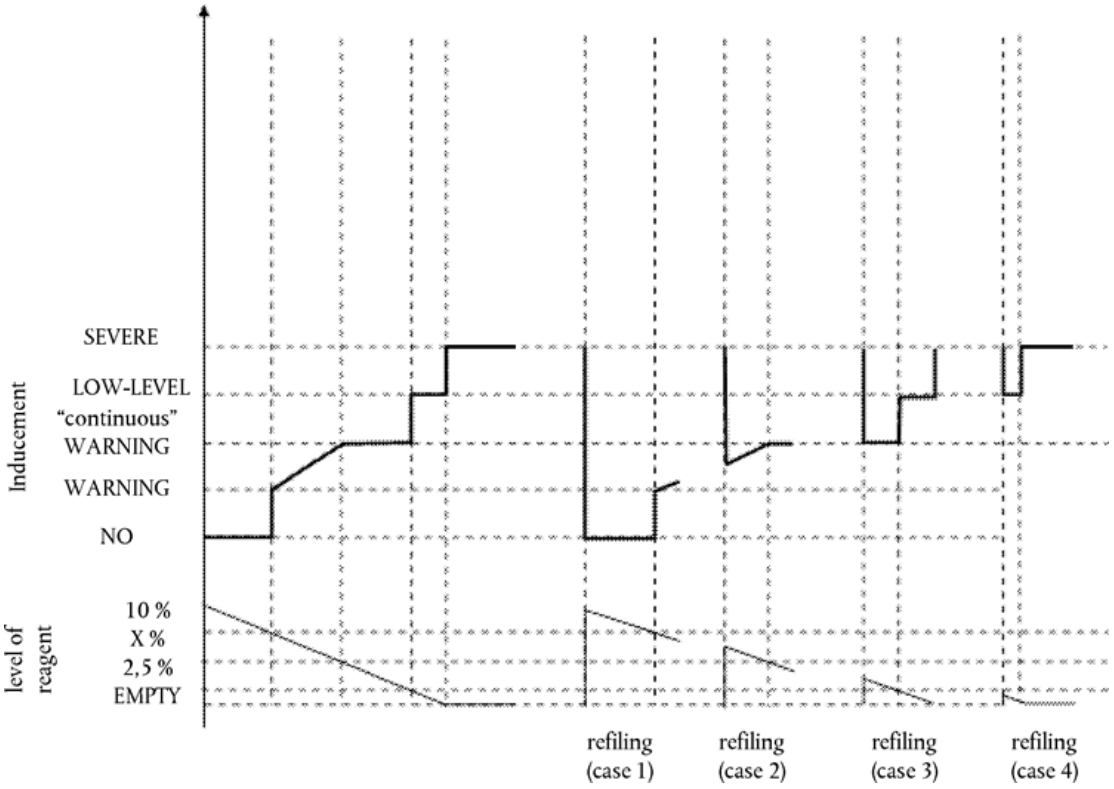
(b) refilling case 1 (‘adequate’ refilling): the operator refills the reagent tank so that a level above the 10 % threshold is reached. Warning and inducement are de-activated;

(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:

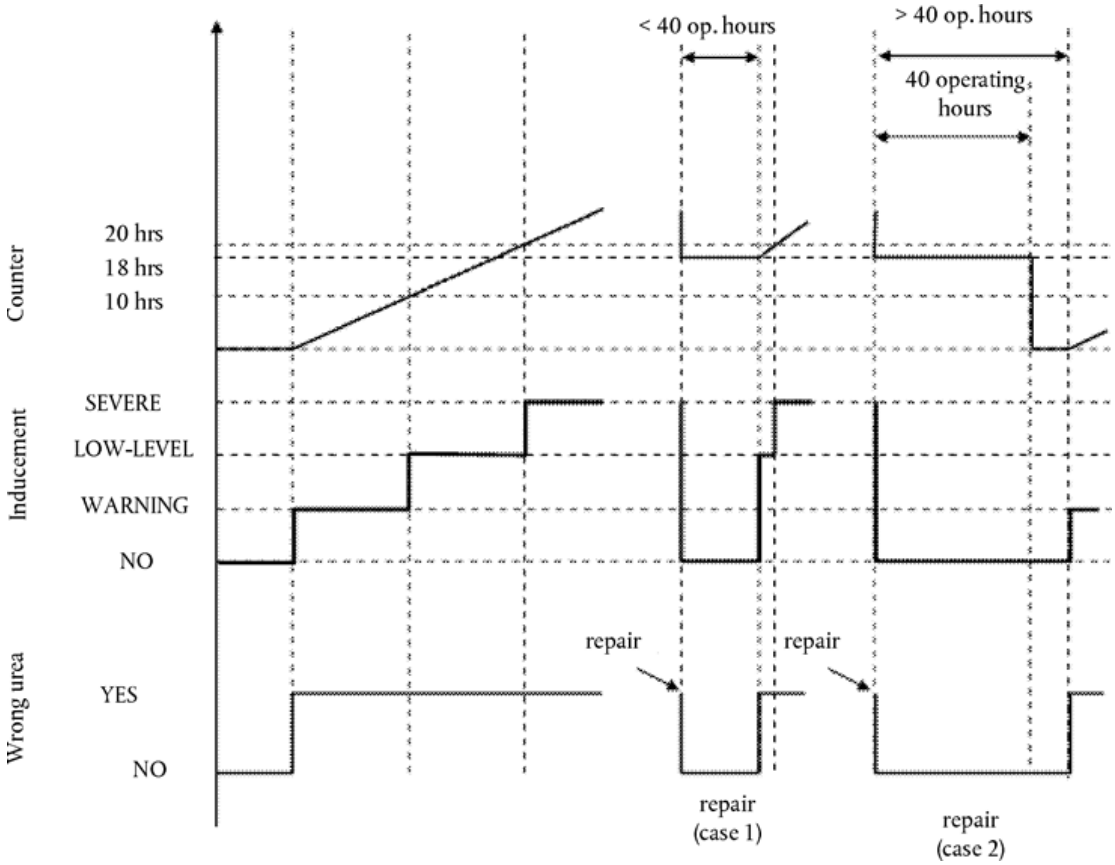
(a) use case 1: the operator continues operating the non-road mobile machinery in spite of the warning until non-road mobile machinery operation is disabled.

(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:

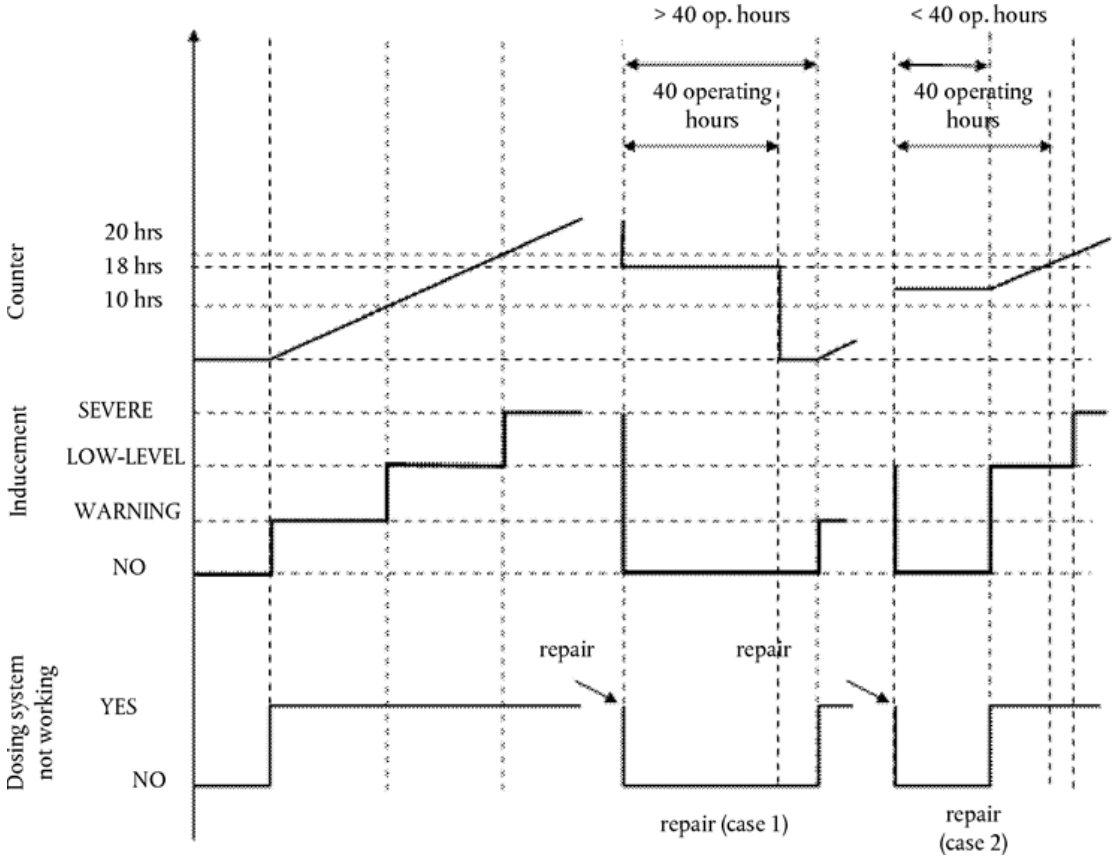
(a) use case 1: the operator continues operating the non-road mobile machinery in spite of the warning until non-road mobile machinery operation is disabled.

(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}.

[[F2]13.3. The pollutant emissions resulting from this test shall not exceed the NO_x threshold specified in point 7.1.1.**]**

[[F1]13.4. Documentation of the demonstration

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

(a) identify the failures examined;

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

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

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

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.

[F2 2. General requirements

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

3. Exceptions to the requirements of Appendix 1

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

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

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

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

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

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

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

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

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

[F1 4.6. When conducting a demonstration pursuant to section 10.4 of Appendix 1, the demonstration shall be conducted in accordance with the requirements applicable to demonstration of the severe inducement system, but the demonstration of severe

inducement system shall be replaced by a demonstration of the storage of an incident of engine operation with inadequate reagent injection or reagent quality.**]]**

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 Implementing Regulation (EU) 2017/656.

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 Implementing Regulation (EU) 2017/656.

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 Implementing Regulation (EU) 2017/656, 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 Implementing Regulation (EU) 2017/656.

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

[[F2]2.2.1. The PCD system shall, at a minimum, be operational at the applicable control conditions set out in point 2.4 of Annex IV for each engine category. The diagnostic system shall remain operational outside of this range where technically possible.**]**

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.

[F2 2.3.2.3. In cases where more than the period of running time indicated in Table 4.5 is required for the monitors to accurately detect and confirm a PCM (e.g. monitors using statistical models or with respect to fluid consumption on the non-road mobile machinery), the approval authority may permit a longer period for monitoring provided the manufacturer justifies the need for the longer period (for example by technical rationale, experimental results, in-house experience, etc.).**]**

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**

[[F2]3.1. The OEM shall provide to all end-users of new non-road mobile machinery written instructions about the emission control system and its correct operation as required in Annex XV.**]**

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.

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

[[F1]5.4. A description of the connection for, and method to read, these records shall be included in the information folder as set out in Part A of Annex I of Implementing Regulation (EU) 2017/656.**]**

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

[[F2]6.1. The PCD system shall detect the complete removal of the particulate after-treatment system inclusive of the removal of any sensors used to monitor, activate, de-activate or modulate its operation.**]**

7. **Additional requirements in the case of a particulate after-treatment system that uses a reagent (e.g. 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.

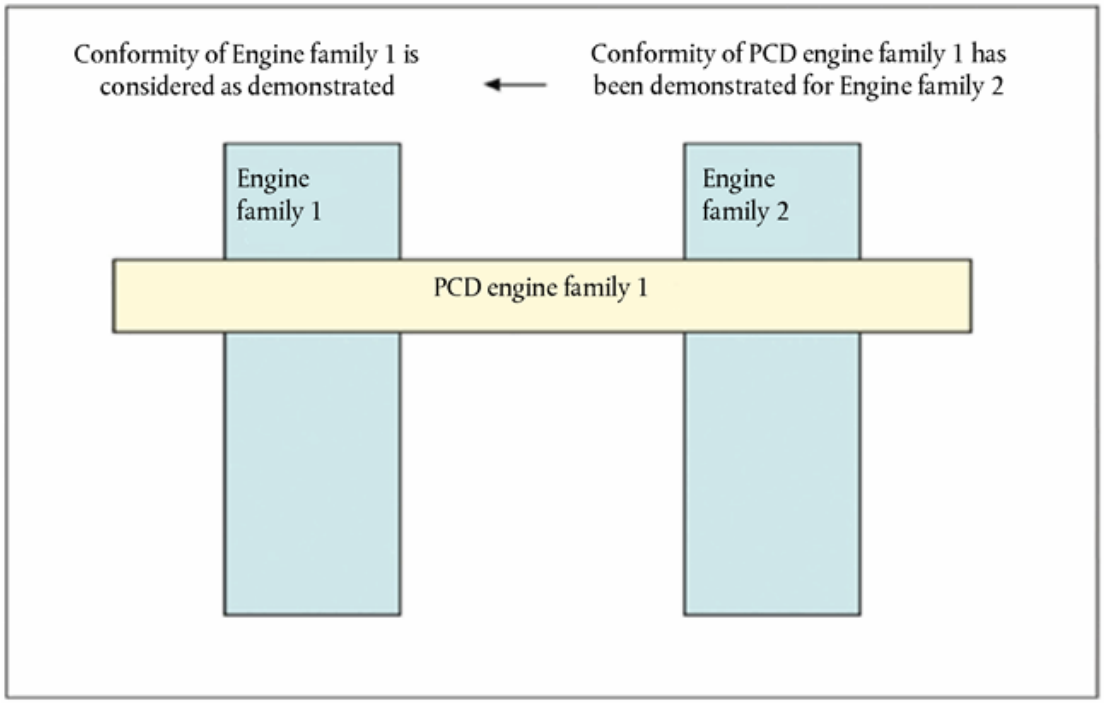
Mechanism	Demonstration elements
Warning system activation specified in point 4.4.	— 2 activation tests (incl. loss of the particulate after-treatment system function) — Supplementary demonstration elements, as appropriate

9.2. Engine families and PCD engine families

[F2 9.2.1. In the case where engines of an engine family belong to a PCD engine family that has already been EU type-approved, in accordance with point 2.3.6 (Figure 4.8), the compliance of that engine family is deemed to be demonstrated without further testing, provided the manufacturer demonstrates to the authority that the monitoring systems necessary for complying with the requirements of this Appendix are similar within the considered engine and PCD engine families.

Figure 4.8

Previously demonstrated conformity of a PCD engine family]



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) **[**[F2]the requested test-cycle results in a monitor that will run in real world operation conditions; 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 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.

[[F1]9.3.6. Documentation of the demonstration

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

(a) identify the failures examined;

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

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

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

Changes to legislation:
There are currently no known outstanding effects for the Commission Delegated Regulation (EU) 2017/654, ANNEX IV.