OICA/Euromot Draft Proposal: NOx Control Requirements for REC

Version 1

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0. Definitions

0.1. "NOx Control Diagnostic system (NCD)" means a system of the REC which has the capability of

(a) detecting a NOx Control Malfunction;

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

0.2. "Scan-tool" means an external test equipment used for off-board communication with the NCD system.

0.3. "Generic scan-tool" means a scan-tool, which is publicly available, and which shall be capable to read failure messages.

0.4. "Proprietary scan-tool" means a scan-tool, which is used only by the REC manufacturer and its authorized dealership, and which shall be capable to read failure messages and to enable an engine start after activation of the operator inducement system.

7. General requirements

7.1. The REC shall be designed, constructed and capable of being mounted so as to enable the application to comply with the rules set out in this Regulation throughout the normal life of the REC under normal conditions of use.

7.2. The REC shall be durable. That is, it shall be designed, constructed and capable of being mounted so that reasonable resistance is obtained to phenomena such as the corrosion, oxidation, vibration and mechanical stress to which it will be exposed under normal conditions of use. Specific durability requirements are in paragraph 9.

7.3. Devices that by-pass or reduce the efficiency of the REC are not permitted.

7.4. Specific requirements for REC requiring a reagent

7.4.1. Each separate reagent tank installed on a vehicle or machine shall include means for taking a sample of any fluid inside the tank. The sampling point shall be easily accessible without the use of any specialised tool or device.

7.4.2. The driver or machine operator shall be informed of the level of reagent in the reagent storage tank on the vehicle or machine through a specific mechanical or electronic indication in accordance with Annex 9, paragraph 7.1. The reagent level indicator shall be placed in close proximity to the fuel level indicator.

7.4.3. The REC manufacturer shall demonstrate that the emission of ammonia over the applicable test cycle(s) at the type approval procedure does not exceed a mean value of 25 ppm.

7.4.4. The characteristics of the 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 REC manufacturer in Annex I.

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

7.4.6. The REC manufacturer shall provide installation documents that, when used by the driver or operator, will ensure that the REC, when installed in the vehicle or machine, will operate, in conjunction with the necessary machinery parts, in a manner that will comply with the requirements of this section. This documentation shall include the detailed technical requirements and the provisions of the REC (software, hardware, and communication) needed for the correct installation of the REC in the machine.

7.4.7. The approval shall be made conditional upon the following:

7.4.7.1. Providing to each driver or operator written maintenance instructions.

7.4.7.2. Providing to the workshop/driver/operator installation documents for the REC.

7.4.7.3. Providing to the workshop/driver/operator instructions for an operator warning system, an inducement system and reagent freeze protection (where applicable).

7.4.8. Maintenance requirements

7.4.8.1. The REC manufacturer shall furnish or cause to be furnished to all drivers or operators of vehicles or machines written instructions about the REC system and its correct operation.

These instructions shall state that if the REC system is not functioning correctly, the driver or operator will be informed of a problem by the operator warning system and that activation of the operator inducement system as a consequence of ignoring this warning will result in the vehicle or machine being unable to re-start.

7.4.8.2. The instructions shall indicate requirements for the proper use and maintenance of the REC in order to maintain its emissions performance, including the proper use of consumable reagents.

7.4.8.3. The instructions shall be written in a clear and non-technical manner using the same language as is used in the operator's manual on the vehicle or machine.

7.4.8.4. The instructions shall specify if consumable reagents have to be refilled by the driver or operator between normal maintenance intervals. The instructions shall also specify the required reagent quality. They shall indicate how the driver or operator should refill the reagent tank. The information shall also indicate a likely rate of reagent consumption and how often it should be replenished.

7.4.8.5. The instructions shall specify that use of, and refilling of, a required reagent of the correct specifications is essential in order for the vehicle or machine to comply with the requirements for the issuing of the approval of the REC for that vehicle or machine.

7.4.8.6. The instructions shall state that it may be a criminal offence to use a vehicle or machine that does not consume any reagent if the reagent is required for the reduction of emissions.

7.4.8.7. The instructions shall explain how the operator warning and inducement systems work. In addition, the consequences, in terms of performance and fault logging, of ignoring the warning system and not replenishing the reagent or rectifying the problem shall be explained.

7.4.9. The NOx control strategy of the REC shall be operational under all environmental conditions regularly pertaining in the territory of the Contracting Parties, especially at low ambient temperatures.

7.5. Reagent freeze protection

7.5.1. It is permitted to use a heated or a non heated reagent tank and dosing system. A heated system shall meet the requirements of paragraph 7.5.2. A non heated system shall meet the requirements of Annex 9, paragraph 6. The use of a non-heated reagent tank and dosing system shall be indicated in the written instructions to the driver or operator of the vehicle or machine.

7.5.2. Reagent tank and dosing system

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

7.5.2.2. Design criteria for a heated system

7.5.2.2.1. 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.

7.5.2.2.2. After the soak period in paragraph 7.5.2.2.1., the vehicle/machine/engine shall be started and operated at 266 K (- 7 °C) ambient temperature or lower as follows:

- 10 to 20 minutes idling, followed by

- up to 50 minutes at no more than 40 per cent of rated load.

7.5.2.2.3. At the conclusion of the test procedure in paragraph 2.3.2.2.2., the reagent dosing system shall be fully functional.

7.5.2.3. Evaluation of the design criteria may be performed in a cold chamber test cell using an entire vehicle or machine or parts representative of those to be installed on a vehicle or machine or based on field tests.

7.6. Requirements on NO_x control measures for REC requiring a reagent

7.6.1. The REC manufacturer shall provide information that fully describes the functional operational characteristics of the NOx control measures using the documents set out in Annex I.

7.6.2. The REC shall be equipped with a NOx Control Diagnostic system (NCD) able to identify the NOx control malfunctions. The NCD shall be designed, constructed and installed so as to be capable of meeting the requirements of this section during the normal life of the REC under normal conditions of use.

7.6.2.1. The NCD system shall be operational at

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

– all altitudes below 1600 m;

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

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

7.6.3. The NCD system shall meet the requirements in Annex 9.

Annex 9

Requirements of the NOx control diagnostic system of REC requiring a reagent

1. Introduction

This Annex sets out the requirements of the NO_x control diagnostic (NCD) system for RECs that rely on the use of a reagent in order to reduce emissions.

2. Diagnostic requirements

2.1. The NCD system shall be able to identify REC related malfunctions considered by this Annex by means of failure messages stored in the REC computer memory and to communicate that information off-board upon request.

2.2. The NCD system shall record a failure message for each distinct malfunction.

2.3. The NCD system shall conclude whether a malfunction is present.

2.3.1. The malfunction shall be detected within 60 minutes of operation, except for the cases laid down in paragraphs 2.3.1.1. and 2.3.2 of this Annex.

2.3.1.1. In cases where more than 60 minutes running time is required for the monitors to accurately detect and confirm a malfunction, the Approval Authority may permit a longer period for monitoring provided the REC manufacturer justifies the need for the longer period (for example by technical rationale, experimental results, in house experience, etc.).

2.3.2. The malfunction shall be detected within 10 minutes of operation for monitoring the reagent level and the dosing detection for a non-heated REC system.

2.4. Failures messages shall not be erased by the NCD system itself from the REC computer memory until the failure related to that message has been remedied, except for the case laid down in paragraph 6.1.4. of this Annex.

2.5. Any reprogrammable computer codes or operating parameters of the NCD system shall be resistant to tampering and afford a level of protection at least as good as the provisions in ISO 15031-7 (SAE J 2186) or SAE J1939-73

3. NCD family

3.1. The REC manufacturer is responsible for determining the composition of an NCD family. Grouping engines within an NCD family shall be based on good engineering judgement and be subject to approval by the Approval Authority.

Engines that do not belong to the same engine family incl. engines from different engine manufacturers may still belong to the same NCD family.

3.2. Parameters defining an NCD family

3.2.1. An NCD family is characterised by basic design parameters that shall be common to NCD systems within the family.

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

(a) NOx emission control systems

(b) methods of NCD monitoring

(c) criteria for NCD monitoring

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

3.2.3. These similarities shall be demonstrated by the REC 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.

4. Operator warning system

4.1. The REC shall include an operator warning system using visual and audible alarms that informs the driver or operator when a low reagent level, incorrect reagent quality, interruption of dosing or a malfunction according to paragraph 10 of this Annex have been detected in accordance with paragraph 2.3 of this Annex and that will lead to activation of the operator inducement system described in paragraph 5 of this Annex, if not rectified in a timely manner.

4.1.1. The operator warning system shall not be easily disabled or ignored.

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

- the remaining time before activation of the inducement,

- the amount of inducement, for example the amount of time for restart,

- the conditions under which vehicle or machine disablement can be cleared.

4.3. Upon detection of the malfunction in accordance with paragraph 2.3. of this Annex, a visual warning in accordance with paragraph 4.2. of this Annex shall be activated.

4.4. 10 hours after detection of the malfunction, an audible warning shall be activated in addition to the visual warning.

4.5. Between 10 hours and 19 hours after detection of the malfunction, the visual and audible warnings shall escalate in intensity.

4.6. 19 hours after detection of the malfunction, the driver or operator shall be informed that after an additional hour of operation without having remedied the malfunction, the engine will not start after engine shut off.

4.6.1. This warning shall be clearly displayed by

- activating a second lamp, whose meaning is described in the REC manual, or

- display a message, e.g. "engine will not start after shut-off"

4.7. 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.

4.8. As part of the application for type-approval, the REC manufacturer shall demonstrate the operation of the operator warning system, as specified in paragraph 11 of this Annex.

5. Operator inducement system

5.1. The REC shall incorporate an operator inducement system that shall be activated, if failures of the REC system have not been rectified in a timely manner.

5.2. The operator inducement system shall be activated 20 hours after detection of the malfunction, unless otherwise noted in paragraphs 6.2 and 7.3. of this Annex.

5.3. The direct current to the engine starter (terminal 30 in accordance with DIN 72552) shall be interrupted, as follows:

5.3.1. An interruptor switch shall be installed between battery and engine starter, whose operation shall be controlled by the NCD system.

5.3.2. The connectors of the interruptor switch shall be made of breakaway safety devices, such as shear bolt, breakaway valve or similar.

5.4. After engine shut-off, an engine re-start shall not be possible for 5 hours.

5.5. As part of the application for type-approval, the REC manufacturer shall demonstrate the operation of the operator inducement system, as specified in paragraph 11 of this Annex.

5.6. Upon prior approval of the type approval authority, the REC may be fitted with a means to disable the operator inducement system during an emergency declared by a national or regional government, their emergency services or their armed services.

6. Specific requirements of the operator warning and inducement system

6.1. If a malfunction has not been remedied after engine re-start in accordance with paragraph 5.4. of this Annex, the following provisions apply:

6.1.1. The operator warning system shall be activated in accordance with paragraph 4.3. of this Annex.

6.1.2. The operator inducement system shall be activated in accordance with paragraph 5.3. of this Annex 2 hours after detection of the malfunction in paragraph 6.1.1. of this Annex.

6.1.3. After engine shut-off, an engine re-start shall not be possible for 48 hours.

6.1.4. Non-erasable failure messages identifying the reason of failures of the REC system shall be stored by the NCD system for at least 400 days.

6.1.4.1. The failures messages shall be accessible via a generic scantool, as defined in paragraph 0.3.

6.1.5. If the failure has been remedied after the engine shut-off, the NCD system may enable an engine re-start prior to the 48 hours period upon request of a proprietary scan-tool, as defined in paragraph 0.4., using a pass code provided by the REC manufacturer or an authorized dealer upon request,

6.1.5.1. The REC manufacturer shall ensure that adequate tools are available on market for service or dealers.

6.1.5.2. The provision in paragraph 6.1.5. of this Annex shall not be used more than one time.

6.1.5.3. The provisions of paragraph 6.1.4. of this Annex apply.

6.2. Non-heated REC system

6.2.1. The operator warning system described in paragraph 4.3. of this Annex shall be activated if no reagent dosing occurs at an ambient temperature ≤ 266 K (- 7°C) in accordance with paragraph 2.3.2.

6.2.2. The operator inducement system described in paragraphs 5.3. to 5.7. of this Annex 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).

7. Reagent availability

7.1. Reagent level indicator

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 paragraph 4 of this Annex 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.

7.2. Activation of the operator warning system

7.2.1. The operator warning system shall be activated in accordance with paragraph 4.3. of this Annex when the level of reagent goes below

(a) 10 % of the capacity of the reagent tank or a higher percentage at the choice of the REC manufacturer or

(b) a level corresponding to 12 hours of usage of the vehicle or machine under average conditions of operation.

7.2.2. The warning provided shall be sufficiently clear, in conjunction with the reagent indicator, for the driver or 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”).

7.2.3. Paragraphs 4.4. to 4.6. of this Annex do not apply.

7.2.4. The operator warning system shall escalate in intensity when the level of reagent goes below

(a) 2.5 % of the capacity of the reagent tank or a higher percentage at the choice of the REC manufacturer or

(b) a level corresponding to 3 hours of usage of the vehicle or machine under average conditions of operation.

This warning shall be clearly displayed by

- activating a second lamp, whose meaning is described in the REC manual, or
- display a message, for example “fill up urea”, “fill up AdBlue”, or “fill up reagent”.

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

7.3 Activation of the operator inducement system

7.3.1. The operator inducement system described in paragraphs 5.3. to 5.7. of this Annex shall be activated if the reagent tank is empty, or at any level below 2.5% of its nominally full capacity at the discretion of the REC manufacturer.

7.3.2. It shall not be possible to turn off the operator inducement system until the reagent has been replenished to a level not requiring their respective activation.

8. Reagent quality monitoring

8.1. The REC shall include a means of determining the presence of an incorrect reagent in the tank, for example NOx sensor, reagent quality sensor, or equivalent.

8.2. The manufacturer shall specify a minimum acceptable reagent concentration CD_{min}, which results in tailpipe NOx emissions not exceeding a threshold of xxx g/kWh.

8.2.1. The correct value of CD_{min} shall be demonstrated during type approval as follows and recorded in the documentation package as specified in Annex 1.

8.2.1.1. The test shall be conducted by performing the hot part of the WHTC or NRTC cycle, whichever applies, using a reagent with the concentration CD_{min}.

8.2.1.2. A WHTC or NRTC preconditioning cycle or REC manufacturer defined pre-conditioning cycle may be conducted, permitting a closed loop NO_x control system to perform adaptation to the quality of the reagent with the concentration CD_{min}.

8.2.1.3. The NOx emission resulting from this test shall be lower than the NOx threshold specified in paragraph 8.2. of this Annex.

8.2.2. Any reagent concentration lower than CD_{min} shall be detected and be regarded, for the purpose of paragraph 8.1. of this Annex, as being incorrect reagent.

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

8.3.1. Optionally, the manufacturer may group the reagent quality failure together with the failures listed in paragraphs 9 and 10 of this Annex into a single counter.

8.4. Activation of the operator warning system

8.4.1. The operator warning system shall be activated in accordance with paragraph 4 of this Annex.

8.4.2. When the operator warning system includes a message display system, it shall display a message indicating the reason of the warning if technically feasible (for example “incorrect urea detected”, “incorrect AdBlue detected”, or “incorrect reagent detected”).

8.5. Activation of the operator inducement system

8.5.1. The operator inducement system shall be activated in accordance with paragraph 5 of this Annex.

9. Reagent dosing activity

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

9.2. A specific counter shall be attributed to the dosing activity (the "dosing activity counter"). The counter shall count the number of operating hours which occur with an interruption of the reagent dosing activity. This is not required where such interruption is demanded because vehicle or machine operating conditions are such that their emission performance does not require reagent dosing.

9.2.1. Optionally, the REC manufacturer may group the reagent dosing failure together with the failures listed in paragraphs 8 and 10 of this Annex into a single counter.

9.3. Activation of the operator warning system

9.3.1. The operator warning system shall be activated in accordance with paragraph 4 of this Annex.

9.3.2. 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”).

9.4. Activation of the operator inducement system

9.4.1. The operator inducement system shall be activated in accordance with paragraph 5 of this Annex.

10. Monitoring failures that may be attributed to tampering

10.1. 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:

(i) disconnect reagent dosing valve;

(ii) disconnect reagent pump;

(iii) failures or disconnect of the NCD system, as described in paragraph 10.1.1. of this Annex.

10.1.1. The NCD system shall be monitored for electrical failures and for removal or deactivation of any sensor that prevents it from diagnosing any other failures mentioned in paragraphs 7 to 9 of this Annex..

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

10.2. A specific counter shall be attributed to each of the monitoring failures considered in paragraph 10.1. of this Annex. The NCD system counters shall count the number of operating hours when the diagnostic capability of the NCD system is not available. Grouping of several faults into a single counter is permitted.

10.2.1. Optionally, the manufacturer may group the NCD system failure together with the failures listed in paragraphs 8 and 9 of this Annex into a single counter.

10.3. As an alternative to the requirements in paragraph 10.1. of this Annex, the manufacturer may use a NOx sensor located in the exhaust gas. In this case,

- the NOx value shall not exceed a threshold of x.xx g/kWh,

- use of a single failure "high NOx - root cause unknown" may be used,

10.4. Activation of the operator warning system

10.4.1. The operator warning system shall be activated in accordance with paragraph 4 of this Annex.

10.4.2. 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").

10.5. Activation of the operator inducement system

10.5.1. The operator inducement system shall be activated in accordance with paragraph 5 of this Annex.

11. Demonstration requirements

11.1. The compliance to the requirements of this Annex shall be demonstrated during type-approval by performing:

(a) a demonstration of the operator warning system activation;

(b) a demonstration of the operator inducement system activation.

11.2. Demonstration of the operator warning system activitation

11.2.1. The compliance of the warning system activation shall be demonstrated by performing two tests: lack of reagent, and one failure category considered in paragraphs 8 to 10 of this Annex.

11.2.2. 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 according to the requirements of paragraph 8.2. of this Annex

11.2.3. For the purpose of demonstrating the activation of the warning system, the selection shall be performed on the basis of a list of potential failures provided by the REC manufacturer to the type approval authority, and agreed by the type approval authority.

11.2.4. For the purpose of this demonstration, a separate test shall be performed for each of the failures considered in paragraph 11.2.1. of this Annex.

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

11.2.6. Prior to starting a test, all failure messages shall have been erased.

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

11.2.8. Demonstration test procedure for failures other than lack of reagent

11.2.8.1. Once the failure has been installed or simulated, the NCD system shall respond to the introduction of a failure within three consecutive hot WHTC or hot NRTC cycles, as applicable.

11.2.8.2. Each individual test cycle in the demonstration test may be separated by an engine shut-off.

11.2.9. Demonstration test procedure in case of lack of reagent

11.2.9.1. The REC system shall be operated over one or more hot WHTC or hot NRTC cycles, as applicable, at the discretion of the REC manufacturer.

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

11.2.10. The demonstration of the warning system activation is deemed to be accomplished if, at the end of each demonstration test performed according to paragraphs 11.2.8. and 11.2.9. of this Annex, the warning system has been properly activated in accordance with paragraph 4 of this Annex..

11.2.11. The manufacturer shall be permitted to simulate, in agreement with the approval authority, the achievement of a certain number of operating hours.

11.3. Demonstration of the operator inducement system activitation

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

11.3.2. If the REC manufacturer chooses, and subject to the agreement of the approval authority, the demonstration tests may be performed on a complete vehicle or machine either by mounting the vehicle or machine on a suitable test bed or by running it on a test track under controlled conditions.

11.3.3. The compliance of the inducement system activation shall be demonstrated by performing two tests: lack of reagent, and one failure category considered in paragraphs 8 to 10 of this Annex.

11.3.4. For the purpose of this demonstration, the failures selected for the warning system activation shall be used.

11.3.5. The demonstration starts when the warning system has been activated as a result of the detection of a failure selected by the type approval authority.

11.3.6. 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 tank is empty, or has reached the level of 2.5 per cent of the nominal full capacity of the tank or the value declared by the manufacturer in accordance with paragraph 7.3.1. of this Annex

11.3.6.1. 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.

11.3.7. 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 hours indicated in paragraph 5.2. of this Annex.

11.3.8. The manufacturer shall be permitted to simulate, in agreement with the approval authority, the achievement of a certain number of operating hours.

11.3.9. The demonstration of the inducement system activation is deemed to be accomplished if, at the end of each demonstration test performed according to paragraphs 11.3.4. and 11.3.5. of this Annex, the inducement system has been properly activated in accordance with paragraph 5 of this Annex.