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Proposal for 04 series of amendments to Regulation No. 96

DRAFT 3_1 (16 May 2012)

Uniform provisions concerning the approval of compression ignition (C.I.) engines to be installed in agricultural and forestry tractors and in non-road mobile machinery with regard to the emissions of pollutants by the engine

Note : Target of this proposal is to amend R96, such that
- the provisions of this Regulation are aligned with the 8 mode cycle of European Directive 2010/26/EU
- the provisions of this Regulation are aligned with the 2012 amendment of European Directive 97/68/EC

I. Proposal

Paragraph 2.1., amend to read:

2.1. For the purpose of this Regulation,

2.1.1. "*Adjustment factors*" mean additive (upward adjustment factor and downward adjustment factor) or multiplicative factors to be considered during the periodic (infrequent) regeneration;

2.1.2. "*Ageing cycle*" means the machine or engine operation (speed, load, power) to be executed during the service accumulation period;

2.1.3. "*Applicable emission limit*" means an emission limit to which an engine is subject;

2.1.4. "*Approval of an engine*" means the approval of an engine type or family with regard to the level of emission of gaseous and particulate pollutants by the engine;

2.1.5. "*Aqueous condensation*" means the precipitation of water-containing constituents from a gas phase to a liquid phase. Aqueous condensation is a function of humidity, pressure, temperature, and concentrations of other constituents such as sulphuric acid. These parameters vary as a function of engine intake-air humidity, dilution-air humidity, engine air-to-fuel ratio, and fuel composition - including the amount of hydrogen and sulphur in the fuel;

2.1.6. "*Atmospheric pressure*" means the wet, absolute, atmospheric static pressure. Note that if the atmospheric pressure is measured in a duct, negligible pressure losses shall be ensured between the atmosphere and the measurement location, and changes in the duct's static pressure resulting from the flow shall be accounted for;

2.1.7. "*Calibration*" means the process of setting a measurement system's response so that its output agrees with a range of reference signals. Contrast with "verification";

2.1.8. "*Calibration gas*" means a purified gas mixture used to calibrate gas analysers. Calibration gases shall meet the specifications of 9.5.1. Note that calibration gases and span gases are qualitatively the same, but differ in terms of their primary function. Various performance verification checks for gas analysers and sample handling components might refer to either calibration gases or span gases;

2.1.9. "*Compression ignition (C.I.) engine*" means an engine which works on the compression-ignition principle (e.g. diesel engine);

2.1.10. "*Confirmed and active DTC*" means a DTC that is stored during the time the NCD system concludes that a malfunction exists.

2.1.11. "*Constant-speed engine*" means an engine whose type approval or certification is limited to constant-speed operation. Engines whose constant-speed governor function is removed or disabled are no longer constant-speed engines;

2.1.12. "*Constant-speed operation*" means engine operation with a governor that automatically controls the operator's demand to maintain engine speed, even under

changing load. Governors do not always maintain exactly constant speed. Typically, speed can decrease (0.1 to 10) per cent below the speed at zero load, such that the minimum speed occurs near the engine's point of maximum power;

2.1.13. "*Continuous regeneration*" means the regeneration process of an exhaust after-treatment system that occurs either in a sustained manner or at least once over the applicable transient test cycle or ramped-modal cycle; in contrast to periodic (infrequent) regeneration;

2.1.14. "*Conversion efficiency of non-methane cutter (NMC) E*" means the efficiency of the conversion of a NMC that is used for removing the non-methane hydrocarbons from the sample gas by oxidizing all hydrocarbons except methane. Ideally, the conversion for methane is 0 per cent (E_{CH4} = 0) and for the other hydrocarbons represented by ethane is 100 per cent (E_{C2H6} = 100 per cent). For the accurate measurement of NMHC, the two efficiencies shall be determined and used for the calculation of the NMHC emission mass flow rate for methane and ethane. Contrast with "penetration fraction";

2.1.15. "*Critical emission-related components*" means the components which are designed primarily for emission control, that is, any exhaust after-treatment system, the electronic engine control unit and its associated sensors and actuators, and the EGR system including all related filters, coolers, control valves and tubing;

2.1.16. "*Critical emission-related maintenance*" means the maintenance to be performed on critical emission-related components;

2.1.17. "*Delay time*" means the difference in time between the change of the component to be measured at the reference point and a system response of 10 per cent of the final reading (t_{10}) with the sampling probe being defined as the reference point. For the gaseous components, this is the transport time of the measured component from the sampling probe to the detector (see Figure 3.1);

2.1.18. "*deNO_x system*" means an exhaust after-treatment system designed to reduce emissions of oxides of nitrogen (NO_x) (e.g. passive and active lean NO_x catalysts, NO_x adsorbers and selective catalytic reduction (SCR) systems);

2.1.19. "*Dew point*" means a measure of humidity stated as the equilibrium temperature at which water condenses under a given pressure from moist air with a given absolute humidity. Dew point is specified as a temperature in °C or K, and is valid only for the pressure at which it is measured;

2.1.20. "*Diagnostic trouble code (DTC)*" means a numeric or alphanumeric identifier which identifies or labels a NO_x Control Malfunction.

2.1.21. "*Discrete-mode*" means relating to a discrete-mode type of steady-state test, as described in paragraph 7.4.1.1. and Annex 5;

2.1.22. "*Drift*" means the difference between a zero or calibration signal and the respective value reported by a measurement instrument immediately after it was used in an emission test, as long as the instrument was zeroed and spanned just before the test;

2.1.23. "*Electronic control unit*" means an engine's electronic device that uses data from engine sensors to control engine parameters;

2.1.24. "*Emission control system*" means any device, system, or element of design that controls or reduces the emissions of regulated pollutants from an engine;

2.1.25. "*Emission control strategy*" means a combination of an emission control system with one base emission control strategy and with one set of auxiliary emission control strategies, incorporated into the overall design of an engine or non-road mobile machinery into which the engine is installed.

2.1.26 "*Emission durability period*" means the number of hours indicated in Annex 8 used to determine the deterioration factors.

2.1.27. "*Emission-related maintenance*" means the maintenance which substantially affects emissions or which is likely to affect emissions performance deterioration of the vehicle or the engine during normal in-use operation;

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

2.1.29. "*Engine family*" means a manufacturer's grouping of engines which, through their design, are expected to have similar exhaust emission characteristics and comply with the requirements in paragraph 7 of this Regulation;

2.1.30. "*Engine governed speed*" means the engine operating speed when it is controlled by the installed governor;

2.1.31. "*Engine system*" means the engine, the emission control system and the communication interface (hardware and messages) between the engine system electronic control unit(s) (ECU) and any other powertrain or vehicle control unit;

2.1.32. "*Engine type*" means a category of engines which do not differ in such essential engine characteristics as defined in paragraphs 1 to 4 of Annex 1A, Appendix 3 to this Regulation;

2.1.33. "*Exhaust after-treatment system*" means a catalyst, particulate filter, deNO_x system, combined deNO_x particulate filter or any other emission-reducing device that is installed downstream of the engine. This definition excludes exhaust gas recirculation (EGR) and turbochargers, which are considered an integral part of the engine;

2.1.34. "*Exhaust-gas recirculation*" means a technology that reduces emissions by routing exhaust gases that have been exhausted from the combustion chamber(s) back into the engine to be mixed with incoming air before or during combustion. The use of valve timing to increase the amount of residual exhaust gas in the combustion chamber(s) that is mixed with incoming air before or during combustion is not considered exhaust-gas recirculation for the purposes of this Regulation;

2.1.35. "*Full flow dilution method*" means the process of mixing the total exhaust flow with dilution air prior to separating a fraction of the diluted exhaust stream for analysis;

2.1.36. "*Gaseous pollutants*" means carbon monoxide, hydrocarbons (assuming a ratio of $C_1H_{1.85}$) and oxides of nitrogen, the last named being expressed in nitrogen dioxide (NO_2) equivalent;

2.1.37. "*Good engineering judgment*" means judgments made consistent with generally accepted scientific and engineering principles and available relevant information;

2.1.38. "*HEPA filter*" means high-efficiency particulate air filters that are rated to achieve a minimum initial particle-removal efficiency of 99.97 per cent using ASTM F 1471–93 or equivalent standard;

2.1.39. "*Hydrocarbon (HC)*" means THC, NMHC as applicable. Hydrocarbon generally means the hydrocarbon group on which the emission standards are based for each type of fuel and engine;

2.1.40. "*High speed (n_{hi})*" means the highest engine speed where 70 per cent of the rated power (Annex 4A) or the maximum power (Annex 4B) occurs;

2.1.41. "*Idle speed*" means the lowest engine speed with minimum load (greater than or equal to zero load), where an engine governor function controls engine speed. For engines without a governor function that controls idle speed, idle speed means the manufacturer-declared value for lowest engine speed possible with minimum load. Note that warm idle speed is the idle speed of a warmed-up engine;

2.1.42. "*Intermediate speed*" means that engine speed which meets one of the following requirements:

(a) For engines which are designed to operate over a speed range on a full load torque curve, the intermediate speed shall be the declared maximum torque speed if it occurs between 60 per cent and 75 per cent of the rated speed;

(b) If the declared maximum torque speed is less than 60 per cent of the rated speed, then the intermediate speed shall be 60 per cent of the rated speed;

(c) If the declared maximum torque speed is greater than 75 per cent of the rated speed then the intermediate speed shall be 75 per cent of the rated speed.

2.1.43. "*Linearity*" means the degree to which measured values agree with respective reference values. Linearity is quantified using a linear regression of pairs of measured values and reference values over a range of values expected or observed during testing;

2.1.44. "*Low speed (n_{lo})*" means the lowest engine speed where 50 per cent of the rated power (Annex 4A) or the maximum power (Annex 4B) occurs;

2.1.45. "*Maximum power*" means the maximum power in kW as designed by the manufacturer;

2.1.46. "*Maximum torque speed*" means the engine speed at which the maximum torque is obtained from the engine, as specified by the manufacturer;

2.1.47. "*Mean of a quantity*" based upon flow-weighted mean values means the mean level of a quantity after it is weighted proportionally to the corresponding flow rate;

2.1.48. "*NCD engine family*" means a manufacturer's grouping of engine systems having common methods of monitoring/diagnosing NCMs.

2.1.49. "*Net power*" means the power in "ECE kW" obtained on the test bench at the end of the crankshaft, or its equivalent, measured in accordance with the method described in Regulation No. 120 on the measurement of the net power, net torque and specific fuel consumption of internal combustion engines for agricultural and forestry tractors and non-road mobile machinery.

2.1.50. "*Non-emission-related maintenance*" means maintenance which does not substantially affect emissions and which does not have a lasting affect on the emissions performance deterioration of the machine or the engine during normal in-use operation once the maintenance is performed;

2.1.51. "*Non-methane hydrocarbons (NMHC)*" means the sum of all hydrocarbon species except methane;

2.1.52. "*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.

2.1.53. "*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.

2.1.54. "*Open crankcase emissions*" means any flow from an engine's crankcase that is emitted directly into the environment;

2.1.55. "*Operator demand*" means an engine operator's input to control engine output. The "operator" may be a person (i.e. manual), or a governor (i.e., automatic) that mechanically or electronically signals an input that demands engine output. Input may be from an accelerator pedal or signal, a throttle-control lever or signal, a fuel lever or signal, a speed lever or signal, or a governor setpoint or signal;

2.1.56. "*Oxides of nitrogen*" means compounds containing only nitrogen and oxygen as measured by the procedures specified in this Regulation. Oxides of nitrogen are expressed quantitatively as if the NO is in the form of NO_2, such that an effective molar mass is used for all oxides of nitrogen equivalent to that of NO_2;

2.1.57. "*Parent engine*" means an engine selected from an engine family in such a way that its emissions characteristics are representative for that engine family and that it complies with the requirements set out in Annex 1B of this Regulation;

2.1.58. "*Partial pressure*" means the pressure, *p*, attributable to a single gas in a gas mixture. For an ideal gas, the partial pressure divided by the total pressure is equal to the constituent's molar concentration, *x*;

2.1.59. "*Particulate after-treatment device*" means an exhaust after-treatment system designed to reduce emissions of particulate pollutants (PM) through a mechanical, aerodynamic, diffusional or inertial separation;

2.1.60. "*Partial flow dilution method*" means the process of separating a part from the total exhaust flow, then mixing it with an appropriate amount of dilution air prior to the particulate sampling filter;

2.1.61. "*Particulate matter (PM)*" means any material collected on a specified filter medium after diluting C.I. engine exhaust gas with clean filtered air so that the temperature does not exceed 325 K (52 °C);

2.1.62. "*Penetration fraction PF*" means the deviation from ideal functioning of a non-methane cutter (see Conversion efficiency of non-methane cutter (NMC) *E*). An ideal non-methane cutter would have a methane penetration factor, PF_{CH4}, of 1.000 (that is, a methane conversion efficiency E_{CH4} of 0), and the penetration fraction for all other hydrocarbons would be 0.000, as represented by PF_{C2H6} (that is, an ethane conversion efficiency E_{C2H6} of 1). The relationship is:

$PF_{CH4} = 1 - E_{CH4}$ and $PF_{C2H6} = 1 - E_{C2H6}$;

2.1.63. "*Per cent load*" means the fraction of the maximum available torque at an engine speed;

2.1.64. "*Periodic (or infrequent) regeneration*" means the regeneration process of an exhaust after-treatment system that occurs periodically in typically less than 100 hours of normal engine operation. During cycles where regeneration occurs, emission limits may be exceeded;

2.1.65. "*Placing on the market*" means the action of making available a product covered by this Regulation on the market of a country applying this Regulation, for payment or free of charge, with a view to distribution and/or use in the country;

2.1.66. "*Probe*" means the first section of the transfer line which transfers the sample to next component in the sampling system;

2.1.67. "*PTFE*" means polytetrafluoroethylene, commonly known as Teflon ™;

2.1.68. "*Ramped modal steady state test cycle*" means a test cycle with a sequence of steady state engine test modes with defined speed and torque criteria at each mode and defined speed and torque ramps between these modes;

2.1.69. "*Rated speed*" means the maximum full load speed allowed by the governor, as designed by the manufacturer, or, if such a governor is not present, the speed at which the maximum power is obtained from the engine, as designed by the manufacturer;

2.1.70. "*Reagent*" means any consumable or non-recoverable medium required and used for the effective operation of the exhaust after-treatment system.

2.1.71. "*Regeneration*" means an event during which emissions levels change while the aftertreatment performance is being restored by design. Two types of regeneration can occur: continuous regeneration (see paragraph 6.6.1.) and infrequent (periodic) regeneration (see paragraph 6.6.2.);

2.1.72. "*Response time*" means the difference in time between the change of the component to be measured at the reference point and a system response of 90 per cent of the

final reading (t_{90}) with the sampling probe being defined as the reference point, whereby the change of the measured component is at least 60 per cent full scale (FS) and the devices for gas switching shall be specified to perform the gas switching in less than 0.1 s. The system response time consists of the delay time to the system and of the rise time of the system;

2.1.73. "*Rise time*" means the difference in time between the 10 per cent and 90 per cent response of the final reading ($t_{90} - t_{10}$);

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

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

2.1.76. "*Shared atmospheric pressure meter*" means an atmospheric pressure meter whose output is used as the atmospheric pressure for an entire test facility that has more than one dynamometer test cell;

2.1.77. "*Shared humidity measurement*" means a humidity measurement that is used as the humidity for an entire test facility that has more than one dynamometer test cell;

2.1.78. "*Span*" means to adjust an instrument so that it gives a proper response to a calibration standard that represents between 75 per cent and 100 per cent of the maximum value in the instrument range or expected range of use;

2.1.79. "*Span gas*" means a purified gas mixture used to span gas analysers. Span gases shall meet the specifications of paragraph 9.5.1. Note that calibration gases and span gases are qualitatively the same, but differ in terms of their primary function. Various performance verification checks for gas analysers and sample handling components might refer to either calibration gases or span gases;

2.1.80. "*Specific emissions*" means the mass of emissions expressed in g/kWh;

2.1.81 "*Stand-alone*" means something that has no dependencies; it can "stand alone";

2.1.82. "*Steady-state*" means relating to emission tests in which engine speed and load are held at a finite set of nominally constant values. Discrete-mode tests or ramped-modal tests are steady-state tests;

2.1.83. "*Stoichiometric*" means relating to the particular ratio of air and fuel such that if the fuel were fully oxidized, there would be no remaining fuel or oxygen;

2.1.84. "*Storage medium*" means a particulate filter, sample bag, or any other storage device used for batch sampling;

2.1.85. "*Test (or duty) cycle*" means a sequence of test points each with a defined speed and torque to be followed by the engine under steady state or transient operating conditions. Duty cycles are specified in the Annex 5. A single duty cycle may consist of one or more test intervals;

2.1.86. "*Test interval*" means a duration of time over which brake-specific emissions are determined. In cases where multiple test intervals occur over a duty cycle, the Regulation may specify additional calculations that weigh and combine results to arrive at composite values for comparison against the applicable emission limits;

2.1.87. "*Tolerance*" means the interval in which 95 per cent of a set of recorded values of a certain quantity shall lie, with the remaining 5 per cent of the recorded values deviating from the tolerance interval. The specified recording frequencies and time intervals shall be used to determine if a quantity is within the applicable tolerance;

2.1.88. "*Total hydrocarbon (THC)*" means the combined mass of organic compounds measured by the specified procedure for measuring total hydrocarbon, expressed as a hydrocarbon with a hydrogen-to-carbon mass ratio of 1.85:1;

2.1.89. "*Transformation time*" means the difference in time between the change of the component to be measured at the reference point and a system response of 50 per cent of the final reading (t_{50}) with the sampling probe being defined as the reference point. The transformation time is used for the signal alignment of different measurement instruments. See Figure 3.1;

2.1.90. "*Transient test cycle*" means a test cycle with a sequence of normalized speed and torque values that vary relatively quickly with time (NRTC);

2.1.91. "*Type approval*" means the approval of an engine type with regard to its emissions measured in accordance with the procedures specified in this Regulation;

2.1.92. "*Updating-recording*" means the frequency at which the analyser provides new, current, values;

2.1.93. "*Useful life*" means the relevant period of distance and/or time over which compliance with the relevant gaseous and particulate emission limits has to be assured;

2.1.94. "*Variable-speed engine*" means an engine that is not a constant-speed engine;

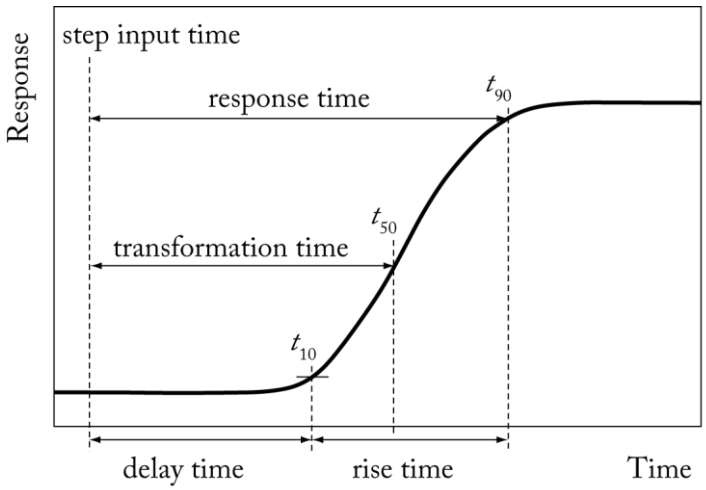
2.1.95. "*Verification*" means to evaluate whether or not a measurement system's outputs agree with a range of applied reference signals to within one or more predetermined thresholds for acceptance. Contrast with "calibration";

2.1.96. "*To zero*" means to adjust an instrument so it gives a zero response to a zero calibration standard, such as purified nitrogen or purified air for measuring concentrations of emission constituents;

2.1.97. "*Zero gas*" means a gas that yields a zero response in an analyser. This may either be purified nitrogen, purified air, a combination of purified air and purified nitrogen.

- Figure 1

Definitions of system response: delay time (paragraph 2.1.17.), response time (paragraph 2.1.72.), rise time (paragraph 2.1.73.) and transformation time (paragraph 2.1.89.)



Paragraph 4.4.3., amend to read:

4.4.3. an additional symbol consisting of two letters, the first of which shall be a letter from D to R indicating the emission level (paragraph 5.2.1.) according to which the engine or the engine family has been approved, the second of which shall be either the letter A if the engine family is certified for variable speed operation and the letter B if the engine family is certified for constant speed operation.

Insert new paragraph 5.2.3., to read:

5.2.3. In addition, the following requirements shall apply:

(a) durability requirements as set out in Annex 8;

(b) engine control area provisions as set out in paragraph 5.3.5. of this Regulation for tests of engines of power bands Q and R only;

(c) CO_2 reporting requirements as set out in Appendix 1 of Annex 10 for tests according to Annex 4A or Appendix 2 of Annex 10 for tests according to Annex 4B;

(d) the requirements set out in paragraph 5.3 for electronically controlled engines of power bands L to R.

Paragraph 5.3.2.2.2, amend to read:

5.3.2.2.2. The control conditions applicable for power bands L to P and power bands Q to R are the following:

(a) control conditions for engines of power bands L to P:

(i) an altitude not exceeding 1 000 metres (or equivalent atmospheric pressure of 90 kPa);

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

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

Where the auxiliary emission control strategy is activated when the engine is operating within the control conditions set out in points (i), (ii) and (iii), the strategy shall only be activated exceptionally.

(b) control conditions for engines of power bands Q to R :

(i) the atmospheric pressure greater than or equal to 82.5 kPa;

(ii) 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: $T_c = -0.4514 \cdot (101.3 - p_b) + 311$, where: T_c is the calculated ambient air temperature, K and P_b is the atmospheric pressure, kPa.

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

Where the auxiliary emission control strategy is activated when the engine is operating within the control conditions set out in points (i), (ii) and (iii), the strategy shall only be activated when demonstrated to be necessary for the purposes identified in paragraph 5.3.2.2.3. and approved by the Type Approval Authority.

(c) cold temperature operation

By derogation from the requirements of point (b), an auxiliary emission control strategy may be used on a engine equipped with exhaust gas recirculation (EGR) of power bands Q to R when the ambient temperature is below 275 K (2 °C) and if one of the two following criteria is met:

(i) 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;

(ii) 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.

Paragraph 5.3.2.2.3.(b), amend to read:

(b) for operational safety reasons;

Paragraph 5.3.3., amend title to read:

Requirements on NO_x control measures for engines of power bands L to P

Paragraph 5.3.3.3., amend to read:

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

Insert new paragraphs 5.3.4., 5.3.5. and 5.3.6. to read:

5.3.4. Requirements on NO_x control measures for engines of power bands Q to R

5.3.4.1. The manufacturer shall provide information that fully describes the functional operational characteristics of the NOx control measures using the documents set out in section 2 of Appendix 1 to Annex 1A and in section 2 of Appendix 3 to Annex 1A

5.3.4.2. The engine emission control strategy shall be operational under all environmental conditions regularly pertaining in the territory of the Contracting Parties especially at low ambient temperatures. This requirement is not restricted to the conditions under which a base emission control strategy must be used as specified in paragraph 5.3.2.2.2.

5.3.4.3. When a reagent is used, the manufacturer shall demonstrate that the emission of ammonia over the hot NRTC or NRSC at the type approval procedure does not exceed a mean value of 10 ppm.

5.3.4.4. If reagent containers are installed on or connected to a non-road mobile machine, 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.

5.3.4.5. The type approval shall be made conditional, in accordance with Paragraph 6.1., upon the following:

(a) providing to each operator of non-road mobile machinery written maintenance instructions, as specified in Annex 9;

(b) providing to the OEM installation documents for the engine, inclusive of the emission control system that is part of the approved engine type;

(c) providing to the OEM instructions for an operator warning system, an inducement system and (where applicable) reagent freeze protection;

(d) the application of provisions on operator instruction, installation documents, operator warning system, inducement system and reagent freeze protection that are set out in Annex 9.

5.3.5. Control area for power bands Q to R

For engines of power bands Q to R the emissions sampled within the control area defined in paragraph 5.3.5. shall not exceed by more than 100 % the limit values of the emissions in paragraph 5.2.1. of this Regulation.

5.3.5.1 Demonstration requirements

The technical service shall select up to three random load and speed points within the control area for testing. The technical service shall also determine a random running order of the test points. The test shall be run in accordance with the principal requirements of the NRSC, but each test point shall be evaluated separately. Each test point shall meet the limit values defined in paragraph 5.3.5.

5.3.5.2 Test requirements

The test shall be carried out as follows:

(a) The test shall be carried out immediately after the discrete mode test cycles as described in points (a) to (e) of paragraph 7.8.1.2. of Annex 4B but before the post test procedures (f) or alternatively after the Ramped Modal Cycle (RMC) test in points (a) to (d) of paragraph 7.8.2.2. of Annex 4B but before the post test procedures (e) as relevant;

(b) the tests shall be carried out as required in points (b) to (e) of paragraph 7.8.1.2. of Annex 4B using the multiple filter method (one filter for each test point) for each of the three chosen test points;

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

(d) emissions values may be calculated on a molar basis using Appendix A.7 or on a mass basis using Appendix A.8 of Annex 4B, but should be consistent with the method used for the discrete mode or RMC test;

(e) for gaseous summation calculations the N_{mode} shall be set to 1 and a weighting factor of 1 shall be used;

(f) for particulate calculations use the multiple filter method and for summation calculations the N_{mode} shall be set to 1 and a weighting factor of 1 shall be used.

5.3.5.3. Control area requirements

5.3.5.3.1. Engine control area

The control area (see Figure 1) is defined as follows:

speed range: speed A to high speed;

where:

speed A = low speed + 15% (high speed - low speed);

High speed and Low speed as defined in Annex 4B shall be used.

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

5.3.5.3.2. The following engine operating conditions shall be excluded from testing:

(a) points below 30% of maximum torque;

(b) points below 30 % of maximum power.

The manufacturer may request that the Technical Service excludes operating points from the control area defined in paragraph 5.5.1 and 5.5.2 during the certification/type approval. The Technical Service may grant this exclusion if the manufacturer can demonstrate that the engine is never capable of operating at such points when used in any machine combination.

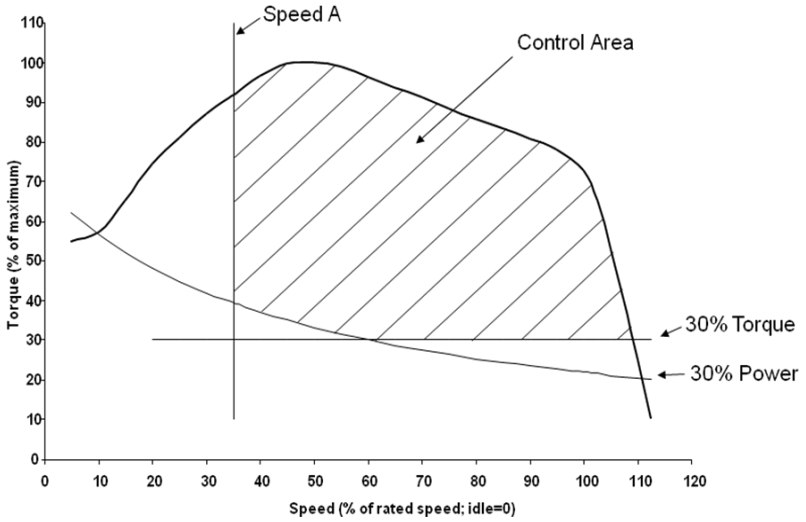


Figure 1. Control area

5.3.6 Verifying Emissions of Crankcase Gases for engines of power bands Q to R

5.3.6.1. No crankcase emissions shall be discharged directly into the ambient atmosphere, with the exception given in paragraph 5.3.6.3.

5.3.6.2. Engines may discharge crankcase emissions into the exhaust upstream of any after treatment device during all operation.

5.3.6.3. Engines equipped with turbochargers, pumps, blowers, or superchargers for air induction may discharge crankcase emissions to the ambient atmosphere. In this case

the crankcase emissions shall be added to the exhaust emissions (either physically or mathematically) during all emission testing in accordance with paragraph 6.10. of Annex 4B.

Insert a new paragraph 5.4. to read:

5.4. SELECTION OF ENGINE POWER CATEGORY

5.4.1. For the purposes of establishing the conformity of variable speed engines defined by paragraph 1.1 and 1.2 of this Regulation with the emission limits given in paragraph 5.2.1. of this Regulation, they shall be allocated to power bands on the basis of the highest value of the net power measured in accordance with paragraph 2.1.49 of this Regulation.

5.4.2. For other engine types rated net power shall be used.

Paragraph 6.1.1., 6.1.2. and 6.1.3., amend to read:

6.1.1. Intake depression shall not exceed that specified for the approved engine in Annex 1A, Appendix 1 or 3 as applicable.

6.1.2. Exhaust back pressure shall not exceed that specified for the approved engine in Annex 1A, Appendix 1 or 3 as applicable.

6.1.3. The operator shall be informed on the reagent control as defined in paragraph 5.3.3.7.1. or Annex 9, if applicable.

Insert a new paragraph 6.1.4. to read:

6.1.4. The OEM shall be provided with the installation documents and instructions as defined in paragraph 5.3.4.5., if applicable.

Annex 1A, Appendix 1, paragraph 4., amend to read:

4. Reserved

Annex 1A, Appendix 1, insert new paragraphs 5., 6., 7. to read:

5. VALVE TIMING

5.1. Maximum lift and angles of opening and closing in relation to dead centres or equivalent data:

……

5.2. Reference and/or setting ranges (*)

5.3. Variable valve timing system (if applicable and where intake and/or exhaust) (*)

5.3.1. Type: continuous or on/off (*)

5.3.2. Cam phase shift angle: . . . . . .

6. Reserved

7. Reserved

_____

(*) Strike out what does not apply.

Annex 1A, Appendix 2, paragraph 1.8, amend to read:

1.8. Exhaust after-treatment system (*): . . . . . .

_____

(*) If not applicable mark n.a.

Annex 1A, Appendix 2, table in paragraph 2.2., amend to read:

	Parent Engine (*)	Engines within family (**)			
Engine Type					
No. of cylinders					
Rated speed (min^{-1})					
Fuel delivery per stroke (mm^3) at rated net power					
Rated net power (kW)					
Maximum power speed (min^{-1})					
Maximum net power (kW)					
Maximum torque speed (min^{-1})					

Fuel delivery per stroke (mm^3) at maximum torque					
Maximum torque (Nm)					
Low idle speed (min^{-1})					
Cylinder displacement (in % of parent engine)	100				

(*) For full details see Appendix 1.

(**) For full details see Appendix 3.

Annex 1A, Appendix 3, paragraph 4., amend to read:

4. Reserved

Annex 1A, Appendix 3, insert new paragraphs 5., 6., 7. to read:

5. VALVE TIMING

5.1. Maximum lift and angles of opening and closing in relation to dead centres or equivalent data:

…….

5.2. Reference and/or setting ranges (*)

5.3. Variable valve timing system (if applicable and where intake and/or exhaust) (*)

5.3.1. Type: continuous or on/off (*)

5.3.2. Cam phase shift angle: . . . . . .

6. Reserved

7. Reserved

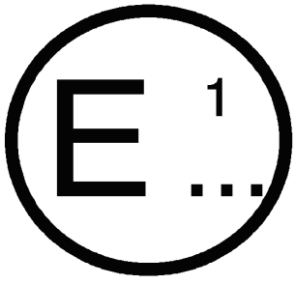
(*) Strike out what does not apply.

Annex 2, amend to read:

Annex 2

Communication

(Maximum format: A4 (210 x 297 mm) issued by : Name of administration:
.....
.....
.....



concerning[2]: Approval granted

Approval extended

Approval refused

Approval withdrawn

Production definitively discontinued

of a compression-ignition engine type or family of engine types as separate technical units with regard to the emission of pollutants pursuant to Regulation No. 96

Approval No.: ..... Extension No.: .....

1. Trade name or mark of the engine: .....
2. Engine type(s):
2.1. Engine family:.....
2.2. Power band of engine family: ……
2.3. Variable speed/constant speed[2]
2.4. Types included in the engine family: .....
2.5. Tested type of engine or the representative of the engine family:.....
3. Manufacturer's name and address: .....
4. If applicable, name and address of manufacturer's representative: .....
5. Maximum allowable intake depression:..... kPa
6. Maximum allowable back pressure:..... kPa
7. Restriction of use (if any):.....

[1] Distinguishing number of the country which has granted/extended/refused/withdrawn an approval (see approval provisions in the Regulation).

2 [2] Strike out what does not apply.

8. Emission levels - final test results with DF:

	NRSC	*NRTC*
CO (g/kWh)		
HC (g/kWh)		
NO_x (g/kWh)		
PM (g/kWh)		

9. Engine submitted for test on: .....

10. Technical Service responsible for conducting the approval test: .....

11. Date of test report issued by that service: .....

12. Number of test report issued by that service: .....

13. Site of approval mark on the engine: .....

14. Place: .....

15. Date: .....

16. Signature: .....

17. The following documents, bearing the approval number shown above, are annexed to this communication:

One copy of Annex 1A and Appendix 1 of Annex 2 to this Regulation completed and with drawings and diagrams referred to attached.

ANNEX 2, Appendix 1, amend to read:

Appendix 1

TEST REPORT FOR COMPRESSION IGNITION ENGINES

TEST RESULTS ([3])

Information concerning the test engine

Engine type: . . . . . .

Engine identification number: . . . . . .

1. Information concerning the conduct of the test: . . . . . .

1.1. Reference fuel used for test

[3] For the case of several parent engines, the following is to be indicated for each of them

1.1.1. Cetane number: . . . . . .

1.1.2. Sulphur content: . . . . . .

1.1.3. Density: . . . . . .

1.2. Lubricant

1.2.1. Make(s): . . . . . .

1.2.2. Type(s): . . . . . .

(state percentage of oil in mixture if lubricant and fuel are mixed)

1.3. Engine driven equipment (if applicable)

1.3.1. Enumeration and identifying details: . . . . . .

1.3.2. Power absorbed at indicated engine speeds (as specified by the manufacturer):

	Power absorbed by engine driven equipment at various engine speeds ([4],[5]), taking into account Annex 7		
Equipment	Intermediate speed (if applicable)	Maximum power speed (if different from rated)	Rated speed ([6])
Total:			

1.4. Engine performance

1.4.1. Engine speeds:

Idle: . . . . . min^{-1}

Intermediate: . . . . . min^{-1}

---

[4] delete as appropriate

[5] shall not be greater than 10 per cent of the power measured during the test.

[6] Insert values at engine speed corresponding to 100% normalised speed if NRSC test uses this speed.

Maximum Power: . . . . . min^{-1}

Rated ([7]): . . . . . min^{-1}

1.4.2. Engine power ([8])

	Power setting (kW) at various engine speeds		
Condition	Intermediate speed (if applicable)	Maximum power speed (if different from rated)	Rated speed ([9])
Maximum power measured at specified test speed (kW) (*a*)			
Total power absorbed by engine driven equipment as per paragraph 1.3.2. of this Appendix taking into account Annex 7 (kW) (*b*)			
Net engine power as specified in paragraph 2.1.49 (kW) (*c*)			
$c = a + b$			

2. Information concerning the conduct of the NRSC test:

2.1. Dynamometer setting (kW)

[7] Insert engine speed corresponding to 100% normalised speed if NRSC test uses this speed.

[8] Uncorrected power measured in accordance with paragraph 2.1.49.

[9] Replace with values at engine speed corresponding to 100% normalised speed if NRSC test uses this speed.

	Dynamometer setting (kW) at various engine speeds	
Per cent Load	Intermediate speed (if applicable)	Rated speed ([10])
10 (if applicable)		
25 (if applicable)		
50		
75		
100		

2.2. Emission results of the engine/parent engine ([11])

Deterioration Factor (DF): calculated/fixed ([9])

Specify the DF values and the emission results in the following table ([9]):

[10] Replace with values at engine speed corresponding to 100% normalised speed if NRSC test uses this speed.

[11] Delete as appropriate.

NRSC Test						
DF mult/add[3]	CO	HC	NO_x	$HC+NO_x$	PM	
Emissions	CO (g/kWh)	HC (g/kWh)	NO_x (g/kWh)	$HC+NO_x$ (g/kWh)	PM (g/kWh)	CO_2 (g/kWh)
Test result						
Final test result with DF						

Additional control area test points (if applicable)						
Emissions at test point	Engine Speed	Load (%)	CO (g/kWh)	HC (g/kWh)	NO_x (g/kWh)	PM (g/kWh)
Test result 1						
Test result 2						
Test result 3						

2.3. Sampling system used for the NRSC test:

2.3.1. Gaseous emissions ([12]): . . . . . .

2.3.2. PM ([10]): . . . . . .

2.3.2.1. Method ([13]): single/multiple filter

3. Information concerning the conduct of the NRTC test (if applicable):

3.1. Emission results of the engine/parent engine ([13])

---

[12] Indicate figure number of system used as defined in of Annex 4A, Appendix 4, or section 9 of Annex 4B, as applicable

[13] Delete as appropriate.

Deterioration Factor (DF): calculated/fixed ([14])

Specify the DF values and the emission results in the following table ([12]):

Regeneration related data shall be reported for engines of power bands Q and R.

NRTC Test						
	CO	HC	NO_x	$HC+NO_x$	PM	
DF mult/add ([14])						
Emissions	CO (g/kWh)	HC (g/kWh)	NO_x (g/kWh)	$HC+NO_x$ (g/kWh)	PM (g/kWh)	
Cold start						
Emissions	CO (g/kWh)	HC (g/kWh)	NO_x (g/kWh)	$HC+NO_x$ (g/kWh)	PM (g/kWh)	CO_2 (g/kWh)
Hot start w/o regeneration						
Hot start with regeneration ([14])						
kr,u (mult/add) ([14]) kr,d (mult/add) ([14])						
Weighted test result						
Final test result with DF						

Cycle work for hot start w/o regeneration kWh

3.2. Sampling system used for the NRTC test:

[14] Delete as appropriate.

Gaseous emissions ([15]): . . . . . .

PM ([13]): . . . . . .

Method ([16]): single/multiple filter

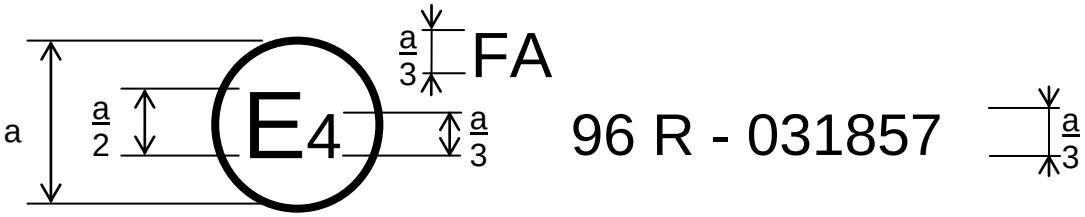
Annex 3, amend to read:

Annex 3

Arrangements of approval marks

Model A

(See paragraph 4.4. of this Regulation)



a = 8 mm min

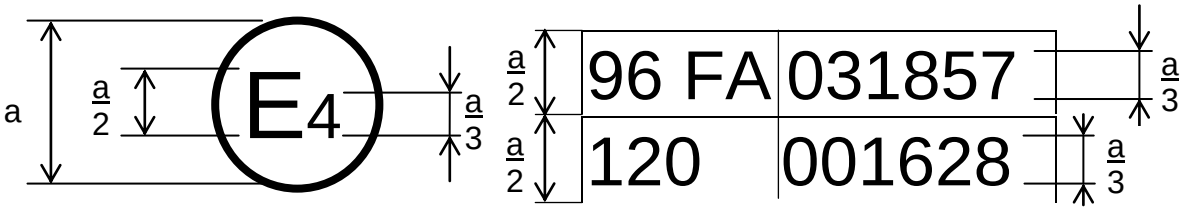
The above approval mark affixed to an engine shows that the engine type concerned has been approved in the Netherlands (E4) pursuant to Regulation No. 96 (according to the level corresponding to power band F as a variable speed engine) and under approval number 031857. The first two digits of the approval number indicate that Regulation No. 96 was in its amended form (03 series of amendments) when the approval was granted.

15 Indicate figure number of system used as defined in section 1of Annex 4A, Appendix 4, or section 9 of Annex 4B, as applicable

16 Delete as appropriate.

Model B

(See paragraph 4.5. of this Regulation)



a = 8 mm min

The above approval mark affixed to an engine shows that the engine type concerned has been approved in the Netherlands (E4) pursuant to Regulations Nos. 96 (according to the level corresponding to power band F as a variable speed engine) and 120. The first two digits of the approval number indicate that, at the dates when the respective approvals were granted, Regulation No. 96 was in its amended form (03 series of amendments) and 120 in its original version.

Annex 4A, paragraph 1.4, symbol P_{AE}, amend to read:

P_{AE}	kW	Declared total power absorbed by auxiliaries fitted for the test which are not required by paragraph 2.1.49. of this Regulation.

footnotes in paragraph 3.7.1.1. and 3.7.1.2. Annex 4A, and in paragraphs 1.1(a) und 1.1(b) Annex 5, amend to read:

ISO 8178-4: 2007 (corr. 2008)

Annex 4B, paragraph 7.7.1., amend title to read:

7.7.1. Generation of steady-state test cycles (NRSC)

Annex 4B, paragraph 7.7.1.1., amend to read:

7.7.1.1. Rated and denormalization speed

For engines that are tested with the NRSC and also the NRTC, the denormalization speed shall be calculated according to the transient procedure (paragraphs 7.6.2. and 7.7.2.1. and Figure 7.3.). In case of the steady state cycle the denormalization speed (n_{denorm}) shall be used in place of the rated speed.

If the calculated denormalization speed (n_{denorm}) is within ±2.5 per cent of the denormalization speed as declared by the manufacturer, the declared denormalization

speed (n_{denorm}) may be used for the emission test. If the tolerance is exceeded, the calculated denormalization speed (n_{denorm}) shall be used for the emissions test.

For variable speed engines that are not tested with the NRTC, the rated speed of tables in Annex 5 for the 8-mode discrete and the derived ramped mode cycle shall be calculated according to the steady state procedure (paragraphs 7.6.1. and Figure 7.3.). The rated speed is defined in paragraph 2.1.69.

For constant speed engines the rated speed and engine governed speed of tables in Annex 5 for the 5-mode discrete and the derived ramped mode cycle shall be that defined in paragraphs 2.1.30. and 2.1.69.

Annex 4B, paragraph 7.7.1.2., amend first paragraph to read:

The intermediate speed shall be determined from the calculations according to its definition (see paragraph 2.1.42.). Consistent with paragraph 7.7.1.1., for engines that are tested with the NRSC and also the NRTC the denormalization speed (n_{denorm}) shall be used in place of rated speed when determining the intermediate speed.

footnotes in paragraph 7.7.1.3. Annex 4B, and in paragraph 1.1(b) Annex 5, amend to read:

ISO 8528-1: 2005

Annex 4B, paragraph 7.7.2.1(a)., amend to read:

(a) $n_{denorm} = n_{lo} + 0.95 \cdot (n_{hi} - n_{lo})$ (7-2)

Where:

n_{denorm} = denormalization speed

n_{hi} = high speed (see paragraph 2.1.40.)

n_{lo} = low speed (see paragraph 2.1.44.)

Annex 4B, paragraph 9.4.6., amend to read:

9.4.6. CO and CO_2 measurements

A Non-dispersive infrared (NDIR) analyser shall be used to measure CO and CO_2 concentrations in raw or diluted exhaust for either batch or continuous sampling.

The NDIR-based system shall meet the calibration and verifications in paragraph 8.1.9.1.

Annex 5, paragraph 1.1.(a), amend to read

(a) For variable-speed engines the following 8-mode cycle ([17]) shall be followed in dynamometer operation on the test engine:

Mode Number	*Engine Speed*	*Torque [per cent]*	*Weighing Factor*
1	Rated(*) or reference(**)	100	0.15
2	Rated(*) or reference(**)	75	0.15
3	Rated(*) or reference(**)	50	0.15
4	Rated(*) or reference(**)	10	0.10
5	Intermediate	100	0.10
6	Intermediate	75	0.10
7	Intermediate	50	0.10
8	Idle	---	0.15

(*) Denormalization speed (n_{denorm}) shall be used in place of rated speed for engines tested according to Annex 4B and is defined in paragraph 7.7.1.1. of Annex 4B. In this case (n_{denorm}) shall also be used in place of rated speed when determining the intermediate speed.

(**) Reference speed is only optionally applicable for engines tested according to Annex 4A and is defined in paragraph 4.3.1. of Annex 4A

Annex 8, amend to read:

Annex 8

DURABILITY REQUIREMENTS

1. VERIFYING THE DURABILITY OF CI ENGINES OF POWER BANDS H to P

This Appendix shall apply to CI engines of power bands H to P only.

1.1. Manufacturers shall determine a Deterioration Factor (DF) value for each regulated pollutant for all engine families of power bands H to P. Such DFs shall be used for type approval and production line testing.

1.1.1. Test to establish DFs shall be conducted as follows:

[17] Identical to C1 cycle as described in paragraph 8.3. of ISO 8178-4: 2007 (corr.2008).

1.1.1.1. The manufacturer shall conduct durability tests to accumulate engine operating hours according to a test schedule that is selected on the basis of good engineering judgement to be representative of in-use engine operation in respect to characterising emission performance deterioration. The durability test period should typically represent the equivalent of at least one quarter of the emission durability period (EDP).

Service accumulation operating hours may be acquired through running engines on a dynamometer test bed or from actual infield machine operation. Accelerated durability tests can be applied whereby the service accumulation schedule is performed at a higher load factor than typically experienced in the field. The acceleration factor relating the number of engine durability test hours to the equivalent number of EDP hours shall be determined by the engine manufacturer based on good engineering judgement.

During the period of the durability test, no emission sensitive components can be serviced or replaced other than to the routine service schedule recommended by the manufacturer.

The test engine, subsystems, or components to be used to determine exhaust emission DFs for an engine family, or for engine families of equivalent emission control system technology, shall be selected by the engine manufacturer on the basis of good engineering judgement. The criterion is that the test engine should represent the emission deterioration characteristics of the engine families that will apply the resulting DF values for type approval. Engines of different bore and stroke, different configuration, different air management systems, different fuel systems can be considered as equivalent in respect to emissions deterioration characteristics if there is a reasonable technical basis for such determination.

DF values from another manufacturer can be applied if there is a reasonable basis for considering technology equivalence with respect to emissions deterioration, and evidence that the tests have been carried according to the specified requirements. Emissions testing shall be performed according to the procedures defined in this Regulation for the test engine after initial run-in but before any service accumulation test, and at the completion of the durability test. Emission tests can also be performed at intervals during the service accumulation test period and applied in determining the deterioration trend.

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

1.1.1.3. Determination of DF values from durability tests

An additive DF is defined as the value obtained by subtraction of the emission value determine at the beginning of the EDP from the emissions value determined to represent the emission performance at the end of the EDP.

A multiplicative DF is defined as the emission level determined for the end of the EDP divided by the emission value recorded at the beginning of the EDP.

Separate DF values shall be established for each of the pollutants covered by the legislation. In the case of establishing a DF value relative to the NOx+HC standard,

for an additive DF, this is determined based on the sum of the pollutants notwithstanding that a negative deterioration for one pollutant may not offset deterioration for the other. For a multiplicative NOx+HC DF, separate HC and NOx DFs shall be determined and applied separately when calculating the deteriorated emission levels from an emissions test result before combining the resultant deteriorated NOx and HC values to establish compliance with the standard.

In cases where the testing is not conducted for the full EDP, the emission values at the end of the EDP is determined by extrapolation of the emission deterioration trend established for the test period, to the full EDP.

When emissions test results have been recorded periodically during the service accumulation durability testing, standard statistical processing techniques based on good practice shall be applied to determine the emission levels at the end of the EDP; statistical significance testing can be applied in the determination of the final emissions values.

If the calculation results in a value of less than 1.00 for a multiplicative DF, or less than 0.00 for an additive DF, then the DF shall be 1.0 or 0.00, respectively.

1.1.1.4. A manufacturer may, with the approval of the type approval authority, use DF values established from results of durability tests conducted to obtain DF values for certification of on-road HD CI engines. This will be allowed if there is technological equivalency between the test on-road engine and the non-road engine families applying the DF values for certification. The DF values derived from on-road engine emission durability test results, must be calculated on the basis of EDP values defined in section 3.

1.1.1.5. In the case where an engine family uses established technology, an analysis based on good engineering practices may be used in lieu of testing to determine a deterioration factor for that engine family subject to approval of the type approval authority.

1.2. DF information in approval applications

1.2.1. Additive DFs shall be specified for each pollutant in an engine family approval application for CI engines not using any aftertreatment device.

1.2.2. Multiplicative DFs shall be specified for each pollutant in an engine family approval application for CI engines using an aftertreatment device.

1.2.3. The manufacture shall furnish the type-approval authority on request with information to support the DF values. This would typically include emission test results, service accumulation schedule, maintenance procedures together with information to support engineering judgements of technological equivalency, if applicable.

2. VERIFYING THE DURABILITY OF CI ENGINES OF POWER BANDS Q TO R

2.1 General

2.1.1. This section shall apply to CI engines of power band Q to R. At the request of the manufacturer it may also be applied to CI engines of power bands H to P as an alternative to the requirements in section 1 of this Annex.

2.1.2. This section 2 details the procedures for selecting engines to be tested over a service accumulation schedule for the purpose of determining deterioration factors for stage IV engine type approval and conformity of production assessments. The deterioration factors shall be applied in accordance with paragraph 2.4.7. to the emissions measured according to Annex 4B of this Regulation.

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

2.1.4. This section 2 also details the emission-related and non-emission-related maintenance that should be or may be carried out on engines undergoing a service accumulation schedule. Such maintenance shall conform to the maintenance performed on in-service engines and communicated to owners of new engines.

2.1.5. At the request of the manufacturer, the type-approval authority may allow the use of deterioration factors that have been established using alternative procedures to those specified in paragraphs 2.4.1. to 2.4.5. In this case, the manufacturer must demonstrate to the satisfaction of the approval authority that the alternative procedures that have been used are no less rigorous than those contained in paragraphs 2.4.1 to 2.4.5.

2.2. Reserved

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

2.3.1. Engines shall be selected from the engine family defined in Annex 1B of this Regulation for emission testing to establish emission durability period deterioration factors.

2.3.2. Engines from different engine families may be further combined into families based on the type of exhaust after-treatment system utilised. In order to place engines with different cylinder configuration but having similar technical specifications and installation for the exhaust after-treatment systems into the same engine after-treatment system family, the manufacturer shall provide data to the approval authority that demonstrates that the emissions reduction performance of such engine systems is similar.

2.3.3. One engine representing the engine-after-treatment system family, as determined in accordance with paragraph 2.3.2., shall be selected by the engine manufacturer for testing over the service accumulation schedule defined in paragraph 2.4.2, and shall be reported to the type-approval authority before any testing commences.

2.3.3.1. If the type-approval authority decides that the worst case emissions of the engine-after-treatment system family can be characterised better by another engine then the test engine shall be selected jointly by the type-approval authority and the engine manufacturer.

2.4. Establishing emission durability period deterioration factors

2.4.1. General

Deterioration factors applicable to an engine-after-treatment system family are developed from the selected engines based on a service accumulation schedule that

includes periodic testing for gaseous and particulate emissions over the NRSC and NRTC tests.

2.4.2. Service accumulation schedule

Service accumulation schedules may be carried out at the choice of the manufacturer by running a machine equipped with the selected engine over an “in-service" accumulation schedule or by running the selected engine over a “dynamometer service" accumulation schedule.

2.4.2.1. In-service and dynamometer service accumulation

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

2.4.2.1.2. The manufacturer shall determine the test points where gaseous and particulate emissions will be measured over the hot NRTC and NRSC cycles. The minimum number of test points shall be three, one at the beginning, one approximately in the middle and one at the end of the service accumulation schedule.

2.4.2.1.3. The emission values at the start point and at the emission durability period endpoint calculated in accordance with paragraph 2.4.5.2. shall be within the limit values applicable to the engine family, but individual emission results from the test points may exceed those limit values.

2.4.2.1.4. At the request of the manufacturer and with the agreement of the type-approval authority, only one test cycle (either the hot NRTC or NRSC cycle) needs to be run at each test point, with the other test cycle run only at the beginning and at the end of the service accumulation schedule.

2.4.2.1.5. In the case of constant speed engines only the NRSC cycle shall be run at each test point.

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

2.4.2.1.7. Service accumulation schedules may be shorter than the emission durability period, but shall not be shorter than the equivalent of at least one quarter of the relevant emission durability period specified in section 3 of this Annex.

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

2.4.2.1.9. At the request of the manufacturer and with the agreement of the type-approval authority, alternative methods of accelerated ageing may be permitted.

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

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

2.4.3. Engine testing

2.4.3.1. Engine system stabilisation

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

2.4.3.1.2. The end of the stabilisation period determined in paragraph 2.4.3.1.1 shall be deemed to be the start of the service accumulation schedule.

2.4.3.2. Service accumulation testing

2.4.3.2.1. After stabilisation, the engine shall be run over the service accumulation schedule selected by the manufacturer, as described in paragraph 2.3.2. At the periodic intervals in the service accumulation schedule determined by the manufacturer, and, where appropriate, also stipulated by the type-approval authority in accordance with paragraph 2.4.2.2, the engine shall be tested for gaseous and particulate emissions over the hot NRTC and NRSC cycles.

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

In accordance with paragraph 2.4.2.1.4., if it has been agreed that only one test cycle (hot NRTC or NRSC) be run at each test point, the other test cycle (hot NRTC or NRSC) shall be run at the beginning and end of the service accumulation schedule.

In accordance with paragraph 2.4.2.1.5., in the case of constant speed engines only the NRSC cycle shall be run at each test point.

2.4.3.2.2. During the service accumulation schedule, maintenance shall be carried out on the engine according to paragraph 2.5.

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

2.4.4. Reporting

2.4.4.1. The results of all emission tests (hot NRTC and NRSC) conducted during the service accumulation schedule shall be made available to the type-approval authority. If any emission test is declared to be void, the manufacturer shall provide an explanation of

why the test has been declared void. In such a case, another series of emission tests shall be carried out within the following 100 hours of service accumulation.

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

2.4.5. Determination of deterioration factors

2.4.5.1. For each pollutant measured over the hot NRTC and NRSC cycles at each test point during the service accumulation schedule, a “best fit” linear regression analysis shall be made on the basis of all test results. The results of each test for each pollutant shall be expressed to the same number of decimal places as the limit value for that pollutant, as applicable to the engine family, plus one additional decimal place.

In accordance with paragraph 2.4.2.1.4. or paragraph 2.4.2.1.5., if only one test cycle (hot NRTC or NRSC) has been run at each test point, the regression analysis shall be made only on the basis of the test results from the test cycle run at each test point.

At the request of the manufacturer and with the prior approval of the type approval authority, non linear regression is permitted.

2.4.5.2. The emission values for each pollutant at the start of the service accumulation schedule and at the emission durability period end point that is applicable for the engine under test shall be calculated from the regression equation. If the service accumulation schedule is shorter than the emission durability period, the emission values at the emission durability period end point shall be determined by extrapolation of the regression equation as determined in paragraph 2.4.5.1.

In the case that emission values are used for engine families in the same engine-after-treatment family but with different emission durability periods, then the emission values at the emission durability period end point shall be recalculated for each emission durability period by extrapolation or interpolation of the regression equation as determined in paragraph 2.4.5.1.

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

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

An example for determination of DFs by using linear regression is shown in figure 1 for NOx emission.

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

If the calculation results in a value of less than 1.00 for a multiplicative DF, or less than 0.00 for an additive DF, then the deterioration factor shall be 1.0 or 0.00, respectively.

In accordance with paragraph 2.4.2.1.4., if it has been agreed that only one test cycle (hot NRTC or NRSC) be run at each test point and the other test cycle (hot NRTC or NRSC) run only at the beginning and end of the service accumulation schedule, the deterioration factor calculated for the test cycle that has been run at each test point shall be applicable also for the other test cycle.

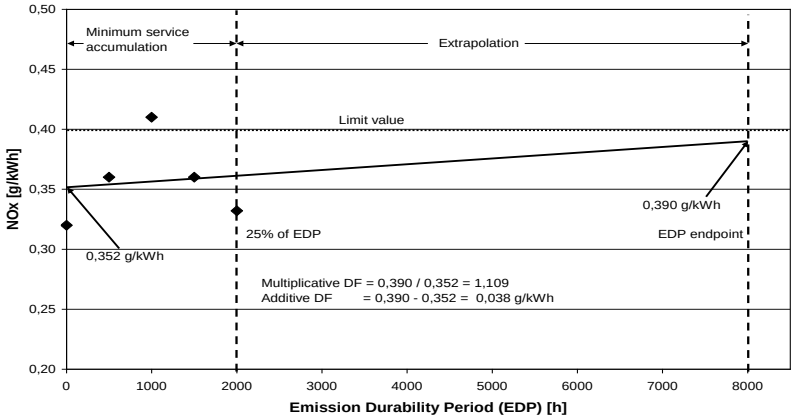


Figure 1: Example of DF determination

2.4.6. Assigned deterioration factors

2.4.6.1. As an alternative to using a service accumulation schedule to determine DFs, engine manufacturers may select to use the following assigned multiplicative DFs:

Test cycle	CO	HC	NO_x	PM
NRTC	1.3	1.3	1.15	1.05
NRSC	1.3	1.3	1.15	1.05

Assigned additive DFs are not given. It is not permitted to transform the assigned multiplicative DFs into additive DFs.

Where assigned DFs are used, the manufacturer shall present to the Type Approval Authority robust evidence that the emission control components can reasonably be expected to have the emission durability associated with those assigned factors. This evidence may be based upon design analysis, or tests, or a combination of both.

2.4.7. Application of deterioration factors

2.4.7.1. The engines shall meet the respective emission limits for each pollutant, as applicable to the engine family, after application of the deterioration factors to the test result as measured in accordance with Annex 4B (cycle-weighted specific emission for particulate and each individual gas). Depending on the type of DF, the following provisions apply:

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

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

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

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

In the case that DFs are carried across to an engine system with a different emission durability period, then the DFs shall be recalculated for the applicable emission durability period by extrapolation or interpolation of the regression equation as determined in paragraph 2.4.5.1.

2.4.7.4. The DF for each pollutant for each applicable test cycle shall be recorded in the test result document set out in Appendix 1 to Annex 2.

2.4.8. Checking of conformity of production

2.4.8.1. Conformity of production for emissions compliance is checked on the basis of section 7 of this Regulation.

2.4.8.2. The manufacturer may select to measure the pollutant emissions before any exhaust after-treatment system at the same time as the type-approval test is being performed. In so doing, the manufacturer may develop informal DFs separately for the engine and for the after-treatment system that may be used by the manufacturer as an aid to end of production line auditing.

2.4.8.3. For the purposes of type-approval, only the DFs determined in accordance with paragraph 2.4.5 or 2.4.6 shall be recorded in the test result document set out in Appendix 1 to Annex 2.

2.5. Maintenance

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

2.5.1. Emission-related scheduled maintenance

2.5.1.1. Emission-related scheduled maintenance during engine running, undertaken for the purpose of conducting a service accumulation schedule, must occur at equivalent intervals to those that will be specified in the manufacturer's maintenance instructions to the owner of the machine or engine. This maintenance schedule may

be updated as necessary throughout the service accumulation schedule provided that no maintenance operation is deleted from the maintenance schedule after the operation has been performed on the test engine.

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

– Filters and coolers in the exhaust gas re-circulation system

– Positive crankcase ventilation valve, if applicable

– Fuel injector tips (only cleaning is permitted)

– Fuel injectors

– Turbocharger

– Electronic engine control unit and its associated sensors and actuators

– Particulate after-treatment system (including related components)

– NO_x after-treatment system (including related components)

– Exhaust gas re-circulation system, including all related control valves and tubing

– Any other exhaust after-treatment system.

2.5.1.3. Critical emission-related scheduled maintenance shall only be performed if intended to be performed in-use and the requirement to perform such maintenance is to be communicated to the owner of the machine.

2.5.2. Changes to scheduled maintenance

2.5.2.1. The manufacturer shall submit a request to the type-approval authority for approval of any new scheduled maintenance that it wishes to perform during the service accumulation schedule and subsequently to recommend to owners of machines and engines. The request shall be accompanied by data supporting the need for the new scheduled maintenance and the maintenance interval.

2.5.3. Non-emission-related scheduled maintenance

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

2.5.4. Repair

2.5.4.1. Repairs to the components of an engine system selected for testing over a service accumulation schedule shall be performed only as a result of component failure or engine system malfunction. Repair of the engine itself, the emission control system or the fuel system is not permitted except to the extent defined in paragraph 2.5.4.2.

2.5.4.2. If the engine itself, the emission control system or the fuel system fail during the service accumulation schedule, the service accumulation shall be considered void, and a new service accumulation shall be started with a new engine system, unless the failed components are replaced with equivalent components that have been subject to a similar number of hours of service accumulation.

3. EMISSION DURABILITY PERIOD FOR ENGINES OF POWER BANDS H TO R

3.1. Manufacturers shall use the emission durability period in Table 1 of this section.

Table 1: Emission durability period for CI Engines (hours) of power bands H to R

Category (power band)	Emission durability period (hours)
≤ 37 kW (constant speed engines)	3000
≤ 37 kW (variable speed engines)	5000
> 37 kW	8000

Insert new Annex 9 to read:

Annex 9

REQUIREMENTS TO ENSURE THE CORRECT OPERATION OF NOx CONTROL MEASURES

1. Introduction

This Annex sets out the 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.

2. General requirements

The engine system shall be equipped with a NO_x Control Diagnostic system (NCD) able to identify the NOx control malfunctions (NCMs) considered by this Annex. Any engine system covered by this section 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 useful life period as specified in paragraph 3.1 of Annex 8 show some deterioration in the performance and the sensitivity of the NOx 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 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 paragraph 2.2.1.13. of Appendix 1 and in paragraph 2.2.1.13. of Appendix 3 to Annex 1A.

2.1.2. 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.

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, when installed in the machine, 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 system (software, hardware, and communication) needed for the correct installation of the engine system in the machine.

2.2. Operating conditions

2.2.1. The NOx control diagnostic system shall be operational at the following conditions:

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

(b) all altitudes below 1600 m;

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

This section shall 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).

2.3. Reagent freeze protection

2.3.1. It is permitted to use a heated or a non heated reagent tank and dosing system. A heated system shall meet the requirements of paragraph 2.3.2. A non heated system shall meet the requirements of paragraph 2.3.3.

2.3.1.1. The use of a non-heated reagent tank and dosing system shall be indicated in the written instructions to the owner of the machine.

2.3.2. Reagent tank and dosing system

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

2.3.2.2. Design criteria for a heated system

A heated system shall be so designed that it meets the performance requirements set out in this section 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 in paragraph 2.3.2.2.1., the machine/engine shall be started and operated at 266 K (- 7 °C) ambient temperature or lower as follows:

(a) 10 to 20 minutes idling,

(b) followed by up to 50 minutes at no more than 40 per cent of rated load.

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

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

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

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

2.3.3.2. The severe inducement system described in paragraph 5.4. shall be activated if no reagent dosing occurs within a maximum of 70 minutes after engine start at an ambient temperature ≤ 266 K (- 7°C).

2.4. Diagnostic requirements

2.4.1 The NOx Control Diagnostic system (NCD) shall be able to identify the NOx control malfunctions (NCMs) 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.

2.4.2 Requirements for recording Diagnostic Trouble Codes (DTCs)

2.4.2.1 The NCD system shall record a DTC for each distinct NOx 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 paragraph 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 machine), 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 machine 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 engine systems 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 engine systems within the family.

In order that engine systems 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 system 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 flow, etc.); or their similarities are based on good engineering judgment.

3. Maintenance requirements

3.1. The manufacturer shall furnish or cause to be furnished to all owners of new engines or machines written instructions about the emission control system and its correct operation.

These instructions shall state that if the emission control system is not functioning correctly, the 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 machine being unable to conduct its mission.

3.2. The instructions shall indicate requirements for the proper use and maintenance of engines in order to maintain their emissions performance, including where relevant the proper use of consumable reagents.

3.3. 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 non-road mobile machinery or engine.

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

3.5. The instructions shall state that use of, and refilling of, a required reagent of the correct specifications is essential in order for the engine to comply with the requirements for the issuing of the type approval for that engine type.

3.6. 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.

4. Operator warning system

4.1. The machine 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 of the type specified in paragraph 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 paragraph 5. has been activated.

4.2. The warning shall not be the same as the warning used for the purposes of signalling a 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:

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

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

- the conditions under which machine 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 paragraphs 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 Appendix 2 of this Annex.

4.9. As part of the application for type-approval under this Regulation, the manufacturer shall demonstrate the operation of the operator warning system, as specified in Appendix 2 of this Annex.

5. Operator inducement system

5.1. The machine 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 machine operation);

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

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

5.3. Low-level inducement system

5.3.1. The low-level inducement system shall be activated after any of the conditions specified in paragraphs 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 per cent between the peak torque speed and the governor breakpoint as shown in figure 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 type approval authority as having the same or greater level of severity may be used.

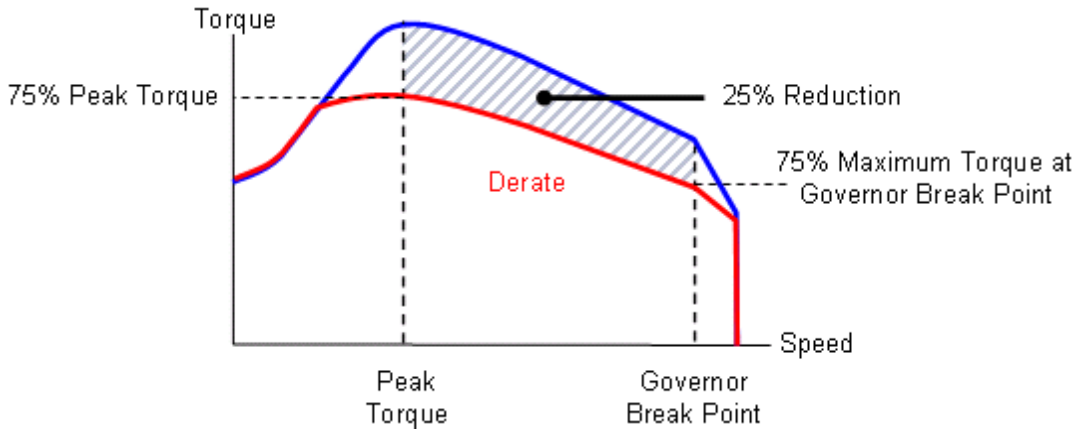


Figure 1: Low-level inducement torque reduction scheme

5.4. Severe inducement system

5.4.1. The severe inducement system shall be activated after any of the conditions specified in paragraphs 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 machine'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 1 by a minimum of 1 per cent per minute to 50 per cent of maximum torque or lower and engine speed shall be gradually reduced to 60 per cent of rated speed or lower within the same time period as the torque reduction, as shown in figure 2.

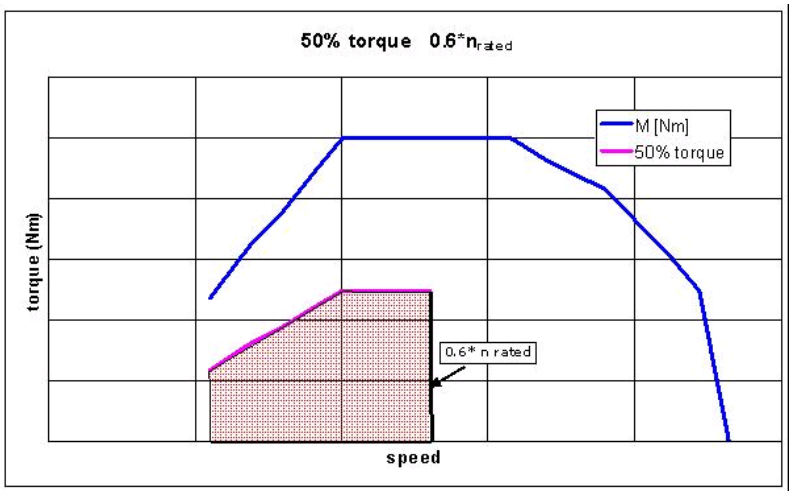


Figure 2: Severe inducement torque reduction scheme

5.4.2.2. Other inducement measures that are demonstrated to the type 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

- is active for no longer than 30 minutes, and
- 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 Appendix 2 of this Annex.

5.8. As part of the application for type-approval under this Regulation, the manufacturer shall demonstrate the operation of the operator inducement system, as specified in Appendix 2 of this Annex.

6. Reagent availability

6.1. Reagent level indicator

The machine 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 paragraph 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 paragraph 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 paragraph 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 paragraph 5.3. shall be activated if the reagent tank level goes below 2.5 per cent of its nominally full capacity or a higher percentage at the choice of the manufacturer.

6.3.2. The severe inducement system described in paragraph 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 per cent of its nominally full capacity at the discretion of the manufacturer.

6.3.3. Except to the extent permitted by paragraph 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 machine shall include a means of determining the presence of an incorrect reagent on board a machine.

7.1.1. The manufacturer shall specify a minimum acceptable reagent concentration CD_{min}, which results in tailpipe NOx emissions not exceeding a threshold of 0.9 g/kWh.

7.1.1.1. The correct value of CD_{min} shall be demonstrated during type approval by the procedure defined in Appendix 3 of this Annex and recorded in the extended documentation package as specified in 5.3 of this Regulation.

7.1.2. Any reagent concentration lower than CD_{min} shall be detected and be regarded, for the purpose of paragraph 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 Appendix 2 of this Annex.

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 paragraph 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 paragraph 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 described in paragraph 7.2.

7.3.2. The severe inducement system described in paragraph 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 in described paragraph 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 Appendix 2 of this Annex.

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 machine operating conditions are such that the machine'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 Appendix 2 of this Annex.

8.3. Activation of the operator warning system

The operator warning system described in paragraph 4. shall be activated in the case of interruption of dosing which sets the dosing activity counter in accordance with paragraph 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 paragraph 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 paragraph 8.3.

8.4.2. The severe inducement system described in paragraph 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 paragraph 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 Appendix 2 of this Annex.

9. Monitoring failures that may be attributed to tampering

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

(i) impeded EGR valve;

(ii) failures of the NOx Control Diagnostic (NCD) system, as described in paragraph 9.2.1.

9.2. Monitoring requirements

9.2.1. The NOx 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 mentioned in paragraphs 6. to 8. (component monitoring).

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.

9.2.2. EGR valve counter

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

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

9.2.2.2. Details of the EGR valve counter activation and deactivation criteria and mechanisms are described in Appendix 2 of this Annex.

9.2.3. NCD system counter(s)

9.2.3.1. A specific counter shall be attributed to each of the monitoring failures considered in paragraph 9.1 (ii). The NCD system counters shall count the number of engine operating hours when the DTC associated to a malfunction of the NCD system is confirmed to be active. Grouping of several faults into a single counter is permitted.

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

9.2.3.2. Details of the NCD system counter(s) activation and deactivation criteria and mechanisms are described in Appendix 2 of this Annex.

9.3. Activation of the operator warning system

The operator warning system described in paragraph 4. shall be activated in case any of the failures specified in paragraph 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 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 paragraph 5.3. shall be activated if a failure specified in paragraph 9.1. is not rectified within a maximum of 36 engine operating hours after the activation of the operator warning system in paragraph 9.3.

9.4.2. The severe inducement system described in paragraph 5.4. shall be activated if a failure specified in paragraph 9.1. is not rectified within a maximum of 100 engine operating hours after the activation of the operator warning system in paragraph 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 Appendix 2 of this Annex.

9.5. As an alternative to the requirements in paragraph 9.2., the manufacturer may use a NOx sensor located in the exhaust gas. In this case,

- the NO_x value shall not exceed a threshold of 0.9 g/kWh,

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

- paragraph 9.4.1. shall read "within 10 engine hours",
- paragraph 9.4.2. shall read "within 20 engine hours".

Appendix 1

DEMONSTRATION REQUIREMENTS

1. GENERAL

The compliance to the requirements of this Annex shall be demonstrated during type-approval by performing, as illustrated in table 1 and specified in this section:

(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

Table 1: Illustration of the content of the demonstration process according to the provisions in sections 3. and 4.

Mechanism	demonstration elements
Warning system activation specified in section 3. of this Appendix	• 2 activation tests (incl. lack of reagent) • Supplementary demonstration elements, as appropriate
Low-level inducement activation specified in section 4. of this Appendix	• 2 activation tests (incl. lack of reagent) • Supplementary demonstration elements, as appropriate • 1 torque reduction test
Severe inducement activation specified in section 4.6. of this Appendix	• 2 activation tests (incl. lack of reagent) • Supplementary demonstration elements, as appropriate

2. ENGINE FAMILIES AND NCD ENGINE FAMILIES

The compliance of an engine family or an NCD engine family with the requirements of this Appendix 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 Annex are similar within the family.

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

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.

2.3. In the case where engines of an engine family belong to an NCD engine family that has already been type-approved according to paragraph 2.1 (Figure 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 Annex are similar within the considered engine and NCD engine families.

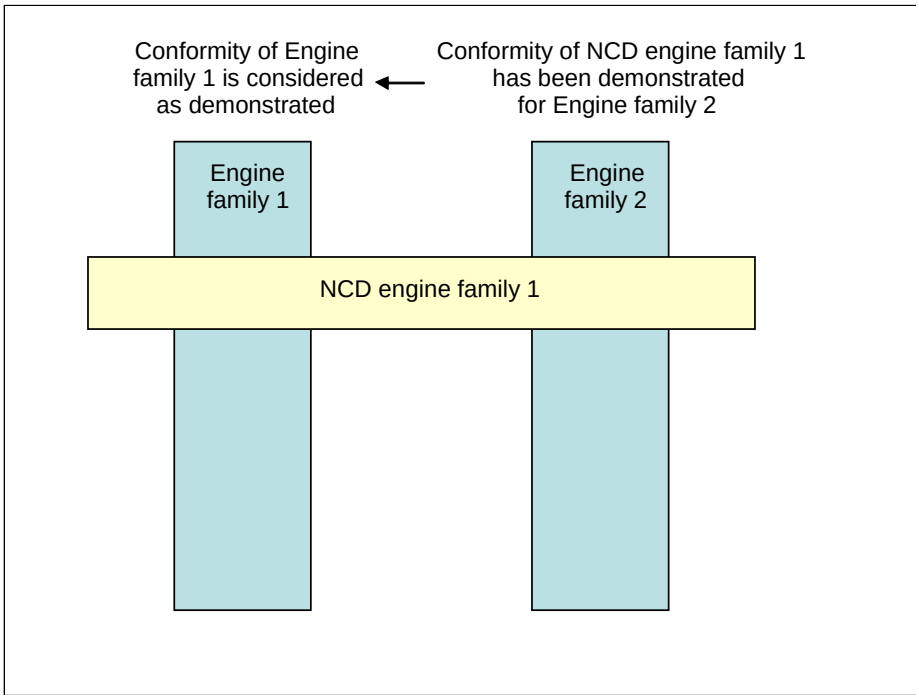


Figure 3: Previously demonstrated conformity of an NCD engine family

3. DEMONSTRATION OF THE WARNING SYSTEM ACTIVATION

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

3.2. Selection of the failures to be tested

3.2.1. For the purpose of demonstrating the activation of the warning system in case of a wrong reagent quality, a reagent shall be selected with a dilution of the active ingredient at least as dilute as that communicated by the manufacturer according to the requirements of section 7. of this Annex

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

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

3.2.2.2. The failure to be considered in the test shall be selected by the approval authority from this list referred to in paragraph 3.2.2.1.

3.3. Demonstration

3.3.1. For the purpose of this demonstration, a separate test shall be performed for each of the failures considered in paragraph 3.1.

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

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

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.

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:

3.3.5.1. The NCD system shall respond to the introduction of a failure selected as appropriate by the type 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 paragraph 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.

3.3.5.2. The demonstration of the warning system activation is deemed to be accomplished if, at the end of each demonstration test performed according to paragraph 3.2.1, the warning system has been properly activated and the DTC for the selected failure has got the “confirmed and active” status.

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 system shall be operated over one or more NCD test cycles at the discretion of the manufacturer.

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 per cent of the nominal capacity of the tank.

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 per cent 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 according to the provisions of section 6. of this Annex.

3.3.7. NCD test cycle

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 NRTC cycle.

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. 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 driving, and

(b) the applicable NCD test-cycle specified in paragraph 3.3.7.1 is shown to be less appropriate for the considered monitoring.

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 paragraph 3.3, the warning system has been properly activated.

4. DEMONSTRATION OF THE INDUCEMENT SYSTEM ACTIVATION

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

4.1.1. Any components or sub-systems not physically mounted on the engine system, 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 system for that purpose, or shall be simulated, to the satisfaction of the approval authority.

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 machine or machinery either by mounting the machine on a suitable test bed or by running it on a test track under controlled conditions.

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

4.3. For the purpose of this demonstration,

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

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

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

(d) the severe inducement shall be demonstrated according to the requirements of paragraph 4.6 of this Appendix.

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. of this Annex which have not been chosen for use in demonstration tests described in paragraphs 4.1. to 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.

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.

4.5. Demonstration test of the low level inducement system

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.

4.5.2. When the system is being checked for its reaction to the case of lack of reagent in the tank, the engine system shall be run until the reagent availability has reached a value of 2.5 per cent of the nominal full capacity of the tank or the value declared by the manufacturer in accordance with paragraph 6.3.1 of this Annex at which the low-level inducement system is intended to operate.

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.

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 system shall be run for the relevant number of operating hours indicated in Table 3 of this Appendix or, at the choice of the manufacturer, until the relevant counter has reached the value at which the low-level inducement system is activated.

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 paragraphs 4.5.2. and 4.5.3, the manufacturer has demonstrated to the approval authority that the engine ECU has activated the torque reduction mechanism.

4.6. Demonstration test of the severe inducement system

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.

4.6.2. When the system is checked for its reaction in the case of lack of reagent in the tank, the engine system shall be run until the reagent tank is empty, or has reached the level below 2.5 per cent of the nominal full capacity of the tank at which the manufacturer has declared to activate the severe inducement system.

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.

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 system shall then be run for the relevant number of operating hours indicated in Table 3 of this Appendix or, at the choice of the manufacturer, until the relevant counter has reached the value at which the severe inducement system is activated.

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 paragraphs 4.6.2. and 4.6.3, the manufacturer has demonstrated to the type-approval authority that the severe inducement mechanism considered in this Annex has been activated.

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 machine in accordance with the requirements of paragraph 5.4, either by mounting the machine on a suitable test bed or by running it on a test track under controlled conditions.

4.7.1. The machine shall be operated until the counter associated with the selected failure has reached the relevant number of operating hours indicated in Table 3 of this Appendix or, as appropriate, until either the reagent tank is empty or, has reached the level below 2.5 per cent of the nominal full capacity of the tank at which the manufacturer has chosen to activate the severe inducement system.

Appendix 2

DESCRIPTION OF THE OPERATOR WARNING AND INDUCEMENT ACTIVATION AND DEACTIVATION MECHANISMS

1. To complement the requirements specified in this Annex concerning the warning and inducement activation and deactivation mechanisms, this Appendix 2 specifies the

technical requirements for an implementation of those activation and deactivation mechanisms.

2. Activation and deactivation mechanisms of the warning system

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 2 of this Appendix.

Table 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
NOx threshold, if applicable	confirmed and active

2.2. The operator warning system shall be deactivated when the diagnostic 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.

2.2.1 Requirements for erasing "NOx control information"

2.2.1.1. Erasing / resetting "NOx 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 3).

Table 3: Erasing / resetting "NOx 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

2.2.1.2. NO_x control information shall not be erased by disconnection of the machine's battery(s).

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

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

3. Activation and deactivation mechanism of the operator inducement system

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 its activation has reached the value specified in Table 4 of this Appendix.

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.

3.3. The operator warning and inducement systems shall be immediately activated or deactivated as appropriate according to the provisions of section 6 of this Annex 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.

4. Counter mechanism

4.1. General

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

(a) an incorrect reagent quality;

(b) an interruption of reagent dosing activity;

(c) an impeded EGR valve;

(d) a failure of the NCD system according to paragraph 9.1 (ii) of this Annex.

4.1.1.1. Optionally, the manufacturer may use one or more counters for grouping the failures indicated in paragraph 4.1.1.

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.

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.

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 Annex to that type of counters.

4.2. Principle of counters mechanism

4.2.1. Each of the counters shall operate as follows:

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 2.

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

(i) 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 of this Appendix or a value of greater than or equal to the counter value for severe inducement minus 30 minutes.

(ii) The counter shall be kept frozen at the value defined in Table 4 of this Appendix or a value greater than or equal to the counter value for severe inducement minus 30 minutes.

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 paragraph 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: 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	≤ 10 hours	≤ 20 hours	≥ 90% of counter value for severe

	active			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
NOx threshold, if applicable	confirmed and active	≤ 10 hours	≤ 20 hours	≥ 90% of counter value for severe inducement

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).

4.2.1.5. 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).

5. Illustration of the activation and deactivation and counter mechanisms

5.1. This paragraph illustrates the activation and deactivation and counter mechanisms for some typical cases. The figures and descriptions given in paragraphs 5.2., 5.3. and 5.4. are provided solely for the purposes of illustration in this Annex 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 6 and 7 refer to the maximum severe inducement values in Table 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.

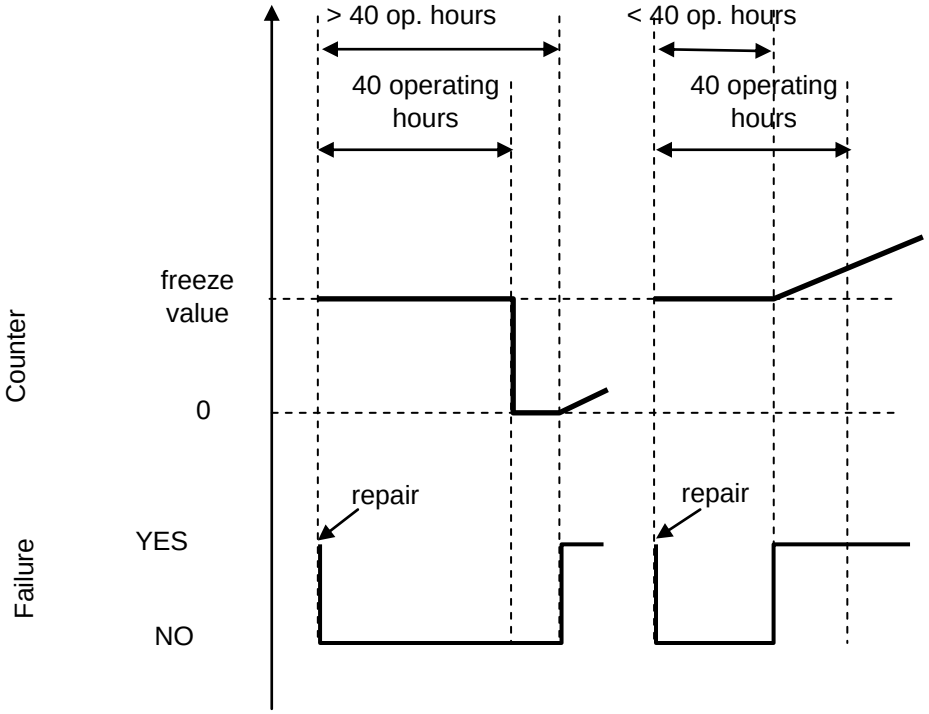


Figure 4: Reactivation and resetting to zero of a counter after a period when its value has been frozen.

5.2. Figure 5 illustrates the operation of the activation and deactivation mechanisms when monitoring the reagent availability for five cases:

– use case 1: the operator continues operating the machine in spite of the warning until machine operation is disabled;

– 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;

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

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

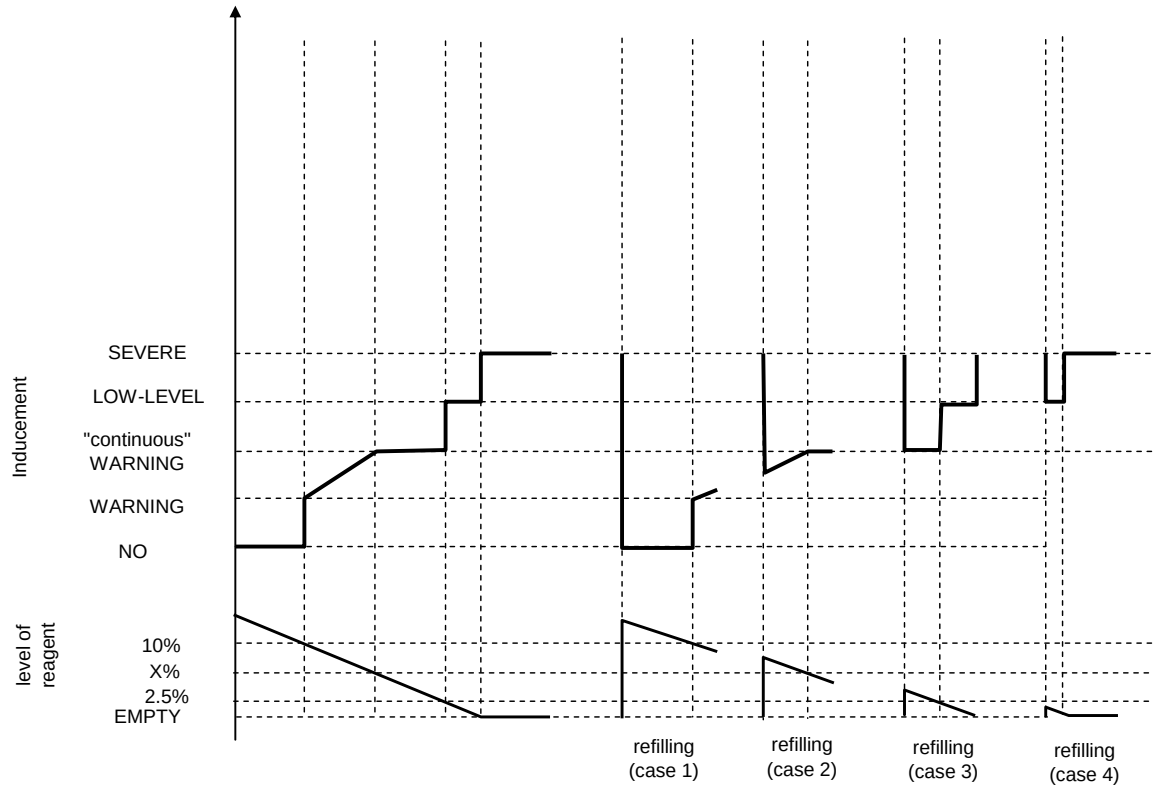


Figure 5 - Reagent availability

5.3. Figure 6 illustrates three cases of wrong reagent quality:

– use case 1: the operator continues operating the machine in spite of the warning until machine operation is disabled.

– repair case 1 ("bad" or "dishonest" repair): after disablement of the machine, 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 machine operation is disabled after 2 engine operating hours.

– repair case 2 ("good" repair): after disablement of the machine, 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.

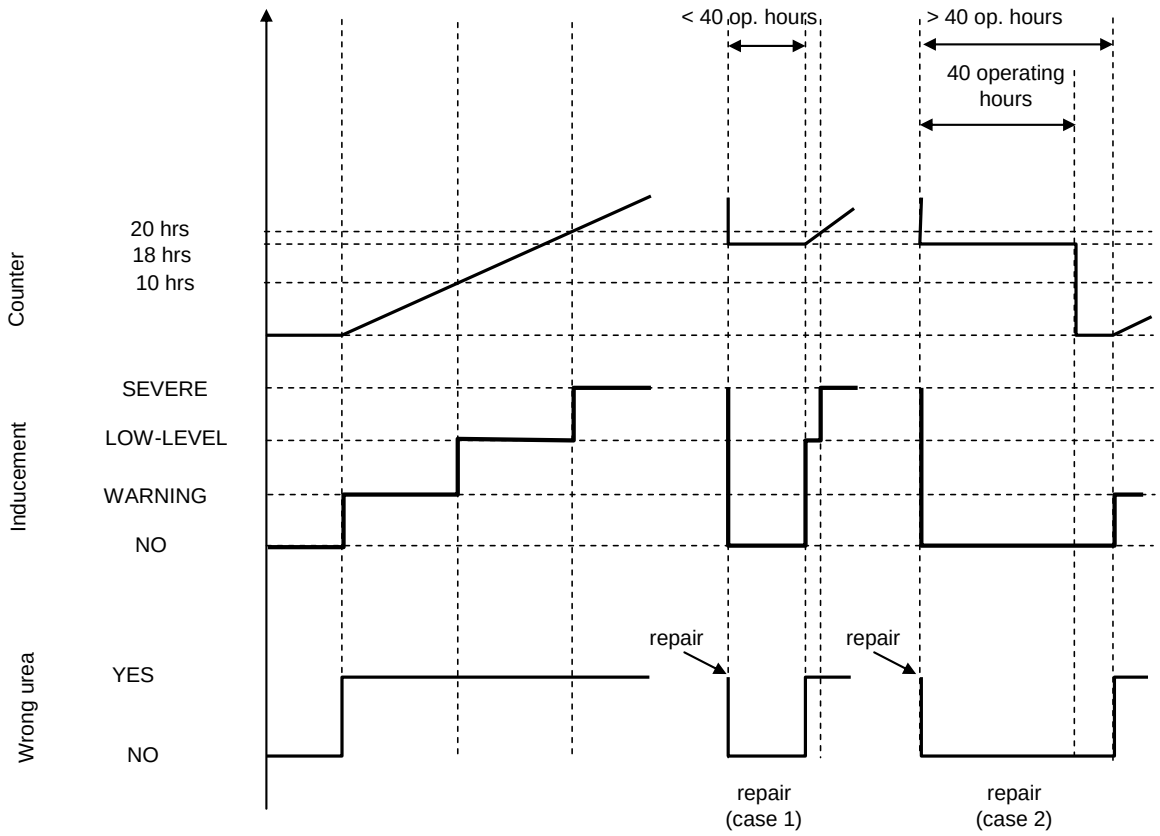


Figure 6 - Filling with poor reagent quality

5.4. Figure 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. of this Annex.

– use case 1: the operator continues operating the machine in spite of the warning until machine operation is disabled.

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

– 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.

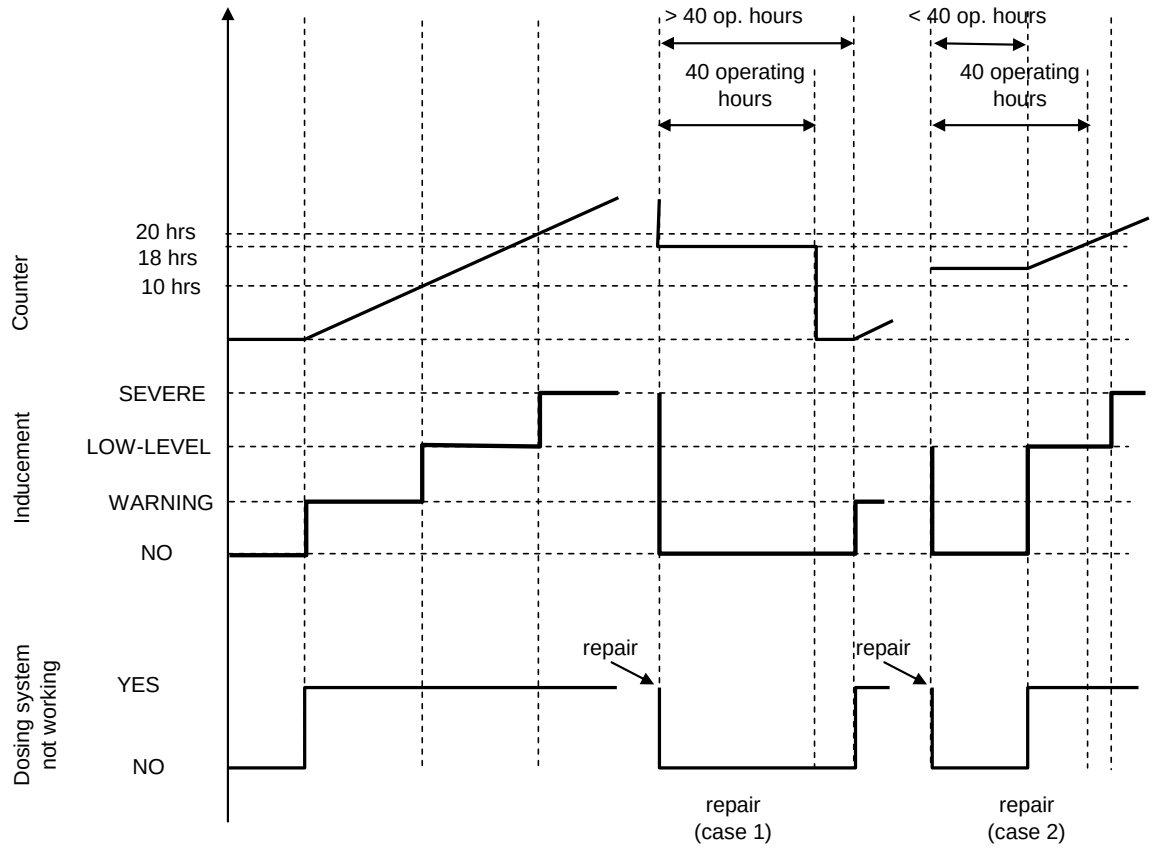


Figure 7 - Failure of the reagent dosing system

Appendix 3

DEMONSTRATION OF THE MINIMUM ACCEPTABLE REAGENT CONCENTRATION CD_{min}

1. The manufacturer shall demonstrate the correct value of CD_{min} during type approval by performing the hot part of the NRTC cycle using a reagent with the concentration CD_{min}.

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}.

3. The pollutant emissions resulting from this test shall be lower than the NOx threshold specified in paragraph 7.1.1. of this Annex.

Insert a new Annex 10 to read:

Annex 10

Appendix 1

DETERMINATION OF CO_2 EMISSIONS FOR ENGINES OF POWER BANDS UP TO P

1. Introduction

1.1. This Appendix sets out the provisions and test procedures for reporting CO_2 emissions for all power bands up to P. If the manufacturer, based on the option indicated in paragraph 5.2. of this Regulation, chooses to use the procedure of Annex 4B, Appendix 2 of this Annex shall apply.

2. General requirements

2.1. CO_2 emissions shall be determined over the applicable test cycle specified in paragraph 1.1 of Annex 4A in accordance with section 3 (NRSC) or section 4 (hot start NRTC), respectively, of Annex 4A. For power bands L to P CO_2 emissions shall be determined over the hot start NRTC test cycle.

2.2. The test results shall be reported as cycle averaged brake specific values and expressed in the unit of g/kWh.

2.3. If, at the choice of the manufacturer, the NRSC is operated as a ramped modal cycle, either the references to the NRTC laid down in this Appendix or the requirements of Appendix 2 of this Annex shall apply.

3. Determination of CO_2 emissions

3.1. Raw measurement

This section applies, if CO_2 is measured in the raw exhaust gas.

3.1.1. Measurement

CO_2 in the raw exhaust gas emitted by the engine submitted for testing shall be measured with a non-dispersive infrared (NDIR) analyser in accordance with paragraph 1.4.3.2. (NRSC) or paragraph 2.3.3.2. (NRTC), respectively, of Appendix 1 to Annex 4A.

The measurement system shall meet the linearity requirements of paragraph 1.5. of Appendix 2 to Annex 4A.

The measurement system shall meet the requirements of paragraph 1.4.1. (NRSC) or paragraph 2.3.1. (NRTC), respectively, of Appendix 1 to Annex 4A.

3.1.2. Data evaluation

The relevant data shall be recorded and stored in accordance with paragraph 3.7.4. (NRSC) or paragraph 4.5.7.2. (NRTC), respectively, of Annex 4A.

3.1.3. Calculation of cycle averaged emission

If measured on a dry basis, the dry/wet correction in accordance with paragraph 1.3.2. (NRSC) or paragraph 2.1.2.2. (NRTC), respectively, of Appendix 3 to Annex 4A shall be applied.

For the NRSC, the mass of CO_2 (g/h) shall be calculated for each individual mode in accordance with paragraph 1.3.4. of Appendix 3 to Annex 4A. The exhaust gas flows shall be determined in accordance with paragraphs 1.2.1. to 1.2.5. of Appendix 1 to Annex 4A.

For the NRTC, the mass of CO_2 (g/test) shall be calculated in accordance with paragraph 2.1.2.1. of Appendix 3 to Annex 4A. The exhaust gas flow shall be determined in accordance with paragraph 2.2.3. of Appendix 1 to Annex 4A.

3.2. Dilute measurement

This section applies, if CO_2 is measured in the dilute exhaust gas.

3.2.1. Measurement

CO_2 in the dilute exhaust gas emitted by the engine submitted for testing shall be measured with a non-dispersive infrared (NDIR) analyser in accordance with paragraph 1.4.3.2. (NRSC) or paragraph 2.3.3.2. (NRTC), respectively, of Appendix 1 to Annex 4A. Dilution of the exhaust shall be done with filtered ambient air, synthetic air or nitrogen. The flow capacity of the full flow system shall be large enough to completely eliminate water condensation in the dilution and sampling systems.

The measurement system shall meet the linearity requirements of paragraph 1.5. of Appendix 2 to Annex 4A.

The measurement system shall meet the requirements of paragraph 1.4.1. (NRSC) or paragraph 2.3.1. (NRTC), respectively, of Appendix 1 to Annex 4A.

3.2.2. Data evaluation

The relevant data shall be recorded and stored in accordance with paragraph 3.7.4. (NRSC) or paragraph 4.5.7.2. (NRTC), respectively, of Annex 4A.

3.2.3. Calculation of cycle averaged emission

If measured on a dry basis, the dry/wet correction in accordance with paragraph 1.3.2. (NRSC) or paragraph 2.1.2.2. (NRTC), respectively, of Appendix 3 to Annex 4A shall be applied.

For the NRSC, the mass of CO_2 (g/h) shall be calculated for each individual mode in accordance with paragraph 1.3.4. of Appendix 3 to Annex 4A. The diluted exhaust gas flows shall be determined in accordance with paragraph 1.2.6. of Appendix 1 to Annex 4A.

For the NRTC, the mass of CO_2 (g/test) shall be calculated in accordance with paragraph 2.2.3. of Appendix 3 to Annex 4A. The diluted exhaust gas flow shall be determined in accordance with paragraph 2.2.1. of Appendix 3 to Annex 4A.

Background correction shall be applied in accordance with paragraph 2.2.3.1.1. of Appendix 3 to Annex 4A.

3.3. Calculation of brake specific emissions

3.3.1. NRSC

The brake specific emissions e_{CO2} (g/kWh) shall be calculated as follows:

$$e_{CO2} = \frac{\sum_{i=1}^{i=n}\left(CO2_{mass,i} \times W_{F,i}\right)}{\sum_{i=1}^{i=n}\left(P_i \times W_{F,i}\right)}$$

where

$$P_i = P_{m,i} + P_{AE,i}$$

and

$CO_{2\ mass,i}$ is the mass of CO_2 of the individual mode (g/h)

$P_{m,i}$ is the measured power of the individual mode (kW)

$P_{AE,i}$ is the power of the auxiliaries of the individual mode (kW)

$W_{F,i}$ is the weighting factor of the individual mode

3.3.2. NRTC

The cycle work needed for the calculation of brake specific CO_2 emissions shall be determined in accordance with paragraph 4.6.2. of Annex 4A.

The brake specific emissions e_{CO2} (g/kWh) shall be calculated as follows:

$$e_{CO2} = \frac{m_{CO2,hot}}{W_{act,hot}}$$

where

$m_{CO2,\ hot}$ is the CO_2 mass emissions of the hot start NRTC (g)

$W_{act,\ hot}$ is the actual cycle work of the hot start NRTC (kWh)

Appendix 2

DETERMINATION OF CO_2 EMISSIONS FOR POWER BANDS Q AND R

1. Introduction

The provisions and test procedures for reporting CO_2 emissions for power bands Q to R set out in this Appendix shall apply. If the manufacturer, based on the option indicated in paragraph 5.2. of this Regulation, chooses to use the procedure of Annex 4B, the provisions and test procedures for reporting CO_2 emissions set out in this Appendix 2 shall apply.

2. General requirements

2.1. CO_2 emissions shall be determined over the hot start NRTC test cycle in accordance with paragraph 7.8.3 of Annex 4B.

2.2. The test results shall be reported as cycle averaged brake specific values and expressed in the unit of g/kWh.

3. Determination of CO_2 emissions

3.1. Raw measurement

This section applies, if CO_2 is measured in the raw exhaust gas.

3.1.1. Measurement

CO_2 in the raw exhaust gas emitted by the engine submitted for testing shall be measured with a non-dispersive infrared (NDIR) analyser in accordance with paragraph 9.4.6. of Annex 4B.

The measurement system shall meet the linearity requirements of paragraph 8.1.4. of Annex 4B.

The measurement system shall meet the requirements of paragraph 8.1.9. of Annex 4B.

3.1.2. Data evaluation

The relevant data shall be recorded and stored in accordance with paragraph 7.8.3.2. of Annex 4B.

3.1.3. Calculation of cycle averaged emission

If measured on a dry basis, the dry/wet correction in accordance with paragraph A.8.2.2. of Appendix 8 or paragraph A.7.3.2. of Appendix 7 to Annex 4B shall be applied to the instantaneous concentration values before any further calculation is done.

The mass of CO_2 (g/test) shall be calculated by multiplication of the time aligned instantaneous CO_2 concentrations and exhaust gas flows and integration over the test cycle in accordance with either of the following:

(a) paragraph A.8.2.1.2. and paragraph A.8.2.5. of Appendix 8 to Annex 4B, by using the u values of CO_2 from table A.8.1. or calculating the u values in accordance with paragraph A.8.2.4.2. of Appendix 8 to Annex 4B;

(b) paragraph A.7.3.1. and paragraph A.7.3.3. of Appendix 7 to Annex 4B.

3.2. Dilute measurement

This section applies, if CO_2 is measured in the dilute exhaust gas.

3.2.1. Measurement

CO_2 in the dilute exhaust gas emitted by the engine submitted for testing shall be measured with a non-dispersive infrared (NDIR) analyser in accordance with paragraph 9.4.6. of Annex 4B. Dilution of the exhaust shall be done with filtered ambient air, synthetic air or nitrogen. The flow capacity of the full flow system shall be large enough to completely eliminate water condensation in the dilution and sampling systems.

The measurement system shall meet the linearity requirements of paragraph 8.1.4. of Annex 4B.

The measurement system shall meet the requirements of paragraph 8.1.9. of Annex 4B.

3.2.2. Data evaluation

The relevant data shall be recorded and stored in accordance with paragraph 7.8.3.2. of Annex 4B.

3.2.3. Calculation of cycle averaged emission

If measured on a dry basis, the dry/wet correction in accordance with paragraph A.8.3.2. of Appendix 8 or paragraph A.7.4.2. of Appendix 7 to Annex 4B shall be applied to the instantaneous concentration values before any further calculation is done.

The mass of CO_2 (g/test) shall be calculated by multiplication of the CO_2 concentrations and the diluted exhaust gas flows in accordance with either of the following:

(a) paragraph A.8.3.1. and paragraph A.8.3.4. of Appendix 8 to Annex 4B, by using the u values of CO_2 from table A.8.2. or calculating the u values in accordance with paragraph A.8.3.3. of Appendix 8 to Annex 4B;

(b) paragraph A.7.4.1. and paragraph A.7.4.3. of Appendix 7 to Annex 4B.

Background correction shall be applied in accordance with paragraph A.8.3.2.4. of Appendix 8 or paragraph A.7.4.1. of Appendix 8 to Annex 4B.

3.3. Calculation of brake specific emissions

The cycle work needed for the calculation of brake specific CO_2 emissions shall be determined in accordance with paragraph 7.8.3.4. of Annex 4B.

The brake specific emissions e_{CO2} (g/kWh) shall be calculated as follows:

$$e_{CO2} = \frac{m_{CO2,hot}}{W_{act,hot}}$$

where

$m_{CO2,\ hot}$ is the CO_2 mass emissions of the hot start NRTC (g)

$W_{act,\ hot}$ is the actual cycle work of the hot start NRTC (kWh).

II. Justification

Aligning R96 with European Directive 97/68/EC as amended in 2012 and aligning table of 8 mode cycle with 2010/26/EU.
