

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

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ANNEXES

ANNEX I

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

1. Requirements for engines fuelled with liquid fuels
  - 1.1. When applying for an EU type-approval, manufacturers may select one...
  - 1.2. Requirements for a standard fuel range (diesel, petrol) engine

**Changes to legislation:** There are currently no known outstanding effects for the Commission Delegated Regulation (EU) 2017/654. (See end of Document for details)

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- 1.2.1. The parent engine shall meet the applicable limit values set...
- 1.2.2. In the absence of either a standard from the European...
  - 1.2.2.1. The engine manufacturer shall not indicate at any time that...
- 1.2.3. If the manufacturer permits engines to run on additional market...
- 1.2.4. For SI engines, the fuel/oil mixture ratio must be the...
- 1.3. Requirements for a fuel-specific (ED 95 or E 85) engine...
  - 1.3.1. For ED 95, the parent engine shall meet the applicable...
  - 1.3.2. For E 85, the parent engine shall meet the applicable...
- 2. Requirements for engines fuelled with natural gas/biomethane (NG) or liquefied...
  - 2.1. When applying for an EU type-approval, manufacturers may select one...
  - 2.2. Tables summarizing the requirements for EU type-approval of natural gas/biomethane...
  - 2.3. Requirements for a universal fuel range engine
    - 2.3.1. For engines fuelled with natural gas/biomethane, including dual-fuel engines, the...
      - 2.3.1.1. For engines fuelled with compressed natural gas/biomethane (CNG) there are...
        - 2.3.1.1.1. The manufacturer may test the engine on a third fuel...
      - 2.3.1.2. For engines fuelled with liquefied natural gas/liquefied biomethane (LNG), the...
    - 2.3.2. For engines fuelled with compressed natural gas/biomethane (CNG) which are...
      - 2.3.2.1. The manufacturers may test the engine on a third fuel...
    - 2.3.3. For engines fuelled with natural gas/biomethane, the ratio of the...
    - 2.3.4. For engines fuelled with LPG the manufacturer shall demonstrate the...
      - 2.3.4.1. The ratio of emission results 'r' shall be determined for...
  - 2.4. Requirements for a restricted fuel range engine
    - 2.4.1. Engines fuelled with CNG and designed for operation on either...
      - 2.4.1.1. The parent engine shall be tested on the relevant reference...
      - 2.4.1.2. The manufacturers may test the engine on a third fuel...
      - 2.4.1.3. The ratio of emission results 'r' shall be determined for...
      - 2.4.1.4. ....
    - 2.4.2. For engines fuelled with natural gas or LPG and designed...
      - 2.4.2.1. The parent engine shall meet the emission requirements on the...
      - 2.4.2.2. For engines fuelled with CNG, the manufacturer may test the...
      - 2.4.2.3. On delivery to the customer the engine shall bear a...
  - 2.5. Requirements for a fuel-specific engine fuelled with liquefied natural gas/liquefied...
    - 2.5.1. Fuel-specific engine fuelled with liquefied natural gas/liquefied biomethane (LNG)
      - 2.5.1.1. The engine shall be calibrated for a specific LNG gas...
      - 2.5.1.2. If the requirements set out in point 2.5.1.1. are not fulfilled,...
    - 2.5.2. Fuel-specific dual-fuel engine fuelled with Liquefied Natural Gas (LNG)
      - 2.5.2.1. For a dual-fuel engine family where the engines are calibrated...
  - 2.6. EU type-approval of a member of a family
    - 2.6.1. With the exception of the case mentioned in point 2.6.2,...
    - 2.6.2. Where the technical service determines that, with regard to the...
  - 2.7. Additional requirements for dual-fuel engines

## Appendix 1

Summary of approval process for natural gas and LPG fuelled...

### ANNEX II

#### Arrangements with regard to conformity of production

1. Definitions
2. Purpose
  - 2.1. The conformity of production arrangements aim to ensure that each...
  - 2.2. Procedures include, inseparably, the assessment of quality management systems, referred...
3. Initial assessment
  - 3.1. Before granting EU type-approval, the approval authority shall verify the...
  - 3.2. Guidelines for quality and/or environmental management systems auditing set out...
  - 3.3. The approval authority shall be satisfied with the initial assessment...
    - 3.3.1. The initial assessment and/or verification of product conformity arrangements shall...
      - 3.3.1.1. When considering the extent of the initial assessment to be...
    - 3.3.2. The initial assessment and verification of product conformity arrangements may...
      - 3.3.2.1. In such a case, the approval authority of the other...
      - 3.3.2.2. On receiving an application for a compliance statement from the...
      - 3.3.2.3. The statement of compliance shall include at least the following:...
    - 3.3.3. The approval authority shall also accept the manufacturer's suitable certification...
4. Product conformity arrangements
  - 4.1. Every engine EU type-approved pursuant to Regulation (EU) 2016/1628, this...
  - 4.2. Before granting a EU type-approval pursuant to Regulation (EU) 2016/1628...
  - 4.3. The holder of the EU type-approval shall:
  - 4.4. If the further audit or check results referred to in...
5. Continued verification arrangements
  - 5.1. The authority which has granted EU type-approval may at any...
    - 5.1.1. The normal approach for such periodic audits shall be to...
      - 5.1.1.1. Surveillance activities carried out by the technical services (qualified or...
      - 5.1.1.2. The minimum frequency of verifications (other than those referred to...
  - 5.2. At every review, the records of tests, checks and production...
  - 5.3. The inspector may select random samples to be tested in...
  - 5.4. Where the level of control appears unsatisfactory, or when it...
  - 5.5. Where unsatisfactory results are found by the approval authority during...
6. Conformity of production test requirements in cases of an unsatisfactory...

- 6.1. In case of an unsatisfactory level of product conformity control...
- 6.2. Except otherwise provided in point 6.3, the following procedure shall...
  - 6.2.1. Three engines and, if applicable, three after-treatment systems shall randomly...
  - 6.2.2. After the inspector's selection of the engines, the manufacturer shall...
  - 6.2.3. Engines shall be subjected to emissions testing in accordance with...
    - 6.2.3.1. Notwithstanding point 6.2.3, in the case of engines of category...
  - 6.2.4. The limit values shall be those set out in Annex...
  - 6.2.5. The tests shall be carried out on newly manufactured engines....
    - 6.2.5.1. At the request of the manufacturer, the tests may be...
  - 6.2.6. On the basis of tests of the engine by sampling...
  - 6.2.7. When a pass decision has been reached for one pollutant,...
  - 6.2.8. If no decision is reached, the manufacturer may at any...
- 6.3. By derogation from point 6.2.1, the following procedure shall apply...
- 6.4. All these tests may be conducted with the applicable market...
- 6.5. Non-compliance of gaseous-fuelled engines

## Appendix 1

### Procedure for production conformity testing

1. This appendix describes the procedure to be used to verify...
2. With a minimum sample size of three engines, the sampling...
3. The following procedure is used for each of the emission...
4. Determine for the sample the test statistic quantifying the cumulative...
5. Then:

## ANNEX III

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

1. Definitions
2. General
  - 2.1. This Annex details the procedures for selecting engines to be...
  - 2.2. The service accumulation tests or the emissions tests performed to...
  - 2.3. This Annex also details the emission-related and non-emission-related maintenance that...
3. Engine categories NRE, NRG, IWP, IWA, RLL, RLR, SMB, ATS...
  - 3.1. Selection of engines for establishing emission durability period deterioration factors...
    - 3.1.1. Engines shall be selected from the engine family defined in...
    - 3.1.2. Engines from different engine families may be further combined into...
    - 3.1.3. The test engine shall represent the emission deterioration characteristics of...
    - 3.1.4. If the approval authority decides that the worst case emissions...
  - 3.2. Determination of emission durability period deterioration factors
    - 3.2.1. General

- 3.2.1.1. At the request of the manufacturer, the approval authority may...
- 3.2.2. Service accumulation schedule
  - 3.2.2.1. In-service and dynamometer service accumulation
    - 3.2.2.1.1. The manufacturer shall determine the form and duration of the...
    - 3.2.2.1.2. The manufacturer shall determine the test points where gaseous and...
    - 3.2.2.1.3. The emission values at the start point and at the...
    - 3.2.2.1.4. For engine categories or sub-categories to which a NRTC applies,...
    - 3.2.2.1.5. In the case of engine categories or sub-categories for which...
    - 3.2.2.1.6. Service accumulation schedules may be different for different engine-after-treatment system...
    - 3.2.2.1.7. Service accumulation schedules may be shorter than the emission durability...
    - 3.2.2.1.8. Accelerated ageing by adjusting the service accumulation schedule on a...
    - 3.2.2.1.9. The manufacturer may use, if agreed by the approval authority,...
    - 3.2.2.1.10. The service accumulation schedule shall be fully described in the...
  - 3.2.2.2. If the approval authority decides that additional measurements need to...
- 3.2.3. Engine testing
  - 3.2.3.1. Engine stabilisation
    - 3.2.3.1.1. For each engine-after-treatment system family, the manufacturer shall determine the...
    - 3.2.3.1.2. The end of the stabilisation period determined in point 3.2.3.1.1...
  - 3.2.3.2. Service accumulation testing
    - 3.2.3.2.1. After stabilisation, the engine shall be run over the service...
    - 3.2.3.2.2. During the service accumulation schedule, maintenance shall be carried out...
    - 3.2.3.2.3. During the service accumulation schedule, unscheduled maintenance on the engine...
- 3.2.4. Reporting
  - 3.2.4.1. The results of all emission tests (hot-start NRTC, LSI-NRTC and...
  - 3.2.4.2. The manufacturer shall retain records of all information concerning all...
- 3.2.5. Determination of deterioration factors
  - 3.2.5.1. When running a service accumulation schedule in accordance with point...
  - 3.2.5.2. The emission values for each pollutant at the start of...
  - 3.2.5.3. The deterioration factor (DF) for each pollutant is defined as...
- 3.2.6. Assigned deterioration factors
  - 3.2.6.1. As an alternative to using a service accumulation schedule to...
    - 3.2.6.1.1. Notwithstanding point 3.2.6.1, for PN, either an additive DF of...

- 3.2.6.2. Where assigned DFs are used, the manufacturer shall present to...
- 3.2.7. Application of deterioration factors
  - 3.2.7.1. The engines shall meet the respective emission limits for each...
  - 3.2.7.2. For a multiplicative NO<sub>x</sub> + HC DF, separate HC and...
  - 3.2.7.3. The manufacturer may carry across the DFs determined for an...
  - 3.2.7.4. The DF for each pollutant for each applicable test cycle...
- 3.3. Checking of conformity of production
  - 3.3.1. Conformity of production for emissions compliance is checked on the...
  - 3.3.2. The manufacturer may measure the pollutant emissions before any exhaust...
  - 3.3.3. For the purposes of EU type-approval, only the DFs determined...
- 3.4. Maintenance
  - 3.4.1. Scheduled emission-related maintenance
    - 3.4.1.1. Scheduled emission-related maintenance during engine running, undertaken for the purpose...
    - 3.4.1.2. Any adjustment, disassembly, cleaning or exchange of critical emission-related components...
    - 3.4.1.3. Any scheduled maintenance requirements shall be subject to approval by...
    - 3.4.1.4. The engine manufacturer shall specify for the service accumulation schedules...
    - 3.4.1.5. Scheduled critical emission-related maintenance shall only be performed if it...
  - 3.4.2. Changes to scheduled maintenance
  - 3.4.3. Non-emission-related scheduled maintenance
- 3.5. Repair
  - 3.5.1. Repairs to the components of an engine selected for testing...
  - 3.5.2. If the engine, its emission control system or its fuel...
- 4. Engine categories and sub-categories NRSh and NRS, except for NRS-v-2b...
  - 4.1. The applicable EDP category and corresponding deterioration factor (DF) shall...
  - 4.2. An engine family shall be considered as compliant with the...
  - 4.3. DFs shall be determined as follows:
  - 4.4. EDP categories
    - 4.4.1. For those engine categories in Table V-3 or V-4 of...
    - 4.4.2. The manufacturer shall demonstrate to the satisfaction of the approval...

## ANNEX IV

### Requirements with regard to emission control strategies, NO<sub>x</sub> control measures and particulate control measures

- 1. Definitions abbreviations and general requirements
  - 1.1. For the purposes of this Annex, the following definitions and...
  - 1.2. Ambient temperature

2. Technical requirements relating to emission control strategies
  - 2.1. This section 2 shall apply for electronically controlled engines of...
  - 2.2. Requirements for base emission control strategy
    - 2.2.1. The base emission control strategy shall be designed as to...
    - 2.2.2. Base emission control strategies are, but not limited to, maps...
    - 2.2.3. Any base emission control strategy that can distinguish engine operation...
      - 2.2.3.1. Notwithstanding point 2.2.3, in the case of engine (sub-)categories that...
    - 2.2.4. The manufacturer shall demonstrate to the technical service at the...
  - 2.3. Requirements for auxiliary emission control strategy
    - 2.3.1. An auxiliary emission control strategy may be activated by an...
    - 2.3.2. Where the auxiliary emission control strategy is activated during the...
    - 2.3.3. Where the auxiliary emission control strategy is not activated during...
    - 2.3.4. Cold temperature operation
    - 2.3.5. Except as permitted by point 2.3.2, an auxiliary emission control...
    - 2.3.6. The manufacturer shall demonstrate to the technical service at the...
    - 2.3.7. Any operation of an auxiliary emission control strategy non-compliant with...
  - 2.4. Control conditions
    - 2.4.1. Control conditions for engines of categories IWP and IWA:
    - 2.4.2. Control conditions for engines of category RLL:
    - 2.4.3. Control conditions for engines of categories NRE, NRG and RLR:...
  - 2.5. Where the engine inlet air temperature sensor is being used...
  - 2.6. Documentation requirements
    - 2.6.1. The manufacturer shall comply with the documentation requirements laid down...
    - 2.6.2. The manufacturer shall ensure that all documents used for this...
3. Technical requirements relating to NO<sub>x</sub> control measures
  - 3.1. This section 3 shall apply to electronically controlled engines of...
  - 3.2. The manufacturer shall provide complete information on the functional operational...
  - 3.3. The NO<sub>x</sub> control strategy shall be operational under all environmental...
  - 3.4. The manufacturer shall demonstrate that the emission of ammonia during...
  - 3.5. If reagent containers are installed on or connected to a...
  - 3.6. In addition to the requirements set out in points 3.2...
4. Technical requirements relating to particulate pollutant control measures
  - 4.1. This section shall apply to engines of sub-categories subject to...
  - 4.2. The detailed technical requirements relating to particulate pollutant control measures...

## Appendix 1

### Additional technical requirements on NO<sub>x</sub> control measures for engines of...

1. Introduction
2. General requirements
  - 2.1. Required information
    - 2.1.1. If the emission control system requires a reagent, the type...

- 2.1.2. Detailed written information fully describing the functional operation characteristics of...
- 2.1.3. The manufacturer shall provide the OEM with documents with instructions...
- 2.2. Operating conditions
  - 2.2.1. Monitoring for reagent level in the storage tank shall be...
  - 2.2.2. Reagent freeze protection shall apply at ambient temperatures at or...
  - 2.2.3. All elements of the NO<sub>x</sub> control diagnostic system other...
- 2.3. Reagent freeze protection
  - 2.3.1. It is permitted to use a heated or a non-heated...
    - 2.3.1.1. The use of a non-heated reagent tank and dosing system...
  - 2.3.2. Reagent tank and dosing system
    - 2.3.2.1. If the reagent has frozen, the reagent shall be available...
    - 2.3.2.2. Design criteria for a heated system
      - 2.3.2.2.1. The reagent tank and dosing system shall be soaked at...
      - 2.3.2.2.2. After the soak period set out in point 2.3.2.2.1, the...
      - 2.3.2.2.3. At the conclusion of the test procedure set out in...
      - 2.3.2.2.4. Evaluation of the design criteria may be performed in a...
    - 2.3.2.3. Activation of the operator warning and inducement system for a...
      - 2.3.2.3.1. The operator warning system described in points 4 to 4.9...
      - 2.3.2.3.2. The severe inducement system as referred to in point 5.4...
  - 2.3.3. Activation of the operator warning and inducement system for a...
    - 2.3.3.1. ....
    - 2.3.3.2. ....
- 2.4. Diagnostic requirements
  - 2.4.1. The NO<sub>x</sub> Control Diagnostic system (NCD) shall be able to...
  - 2.4.2. Requirements for recording Diagnostic Trouble Codes (DTCs)
    - 2.4.2.1. The NCD system shall record a DTC for each distinct...
    - 2.4.2.2. The NCD system shall conclude within 60 minutes of engine...
    - 2.4.2.3. In cases where more than 60 minutes running time is...
  - 2.4.3. Requirements for erasing Diagnostic trouble codes (DTCs)
  - 2.4.4. An NCD system shall not be programmed or otherwise designed...
  - 2.4.5. Any reprogrammable computer codes or operating parameters of the NCD...
  - 2.4.6. NCD engine family
    - 2.4.6.1. Parameters defining an NCD engine family
- 3. Maintenance requirements
  - 3.1. The OEM shall provide to all end-users of new non-road...
- 4. Operator warning system



- 4.1. The non-road mobile machinery shall include an operator warning system...
- 4.2. The warning shall not be the same as the warning...
- 4.3. The operator warning system may consist of one or more...
- 4.4. At the choice of the manufacturer, the warning system may...
- 4.5. The operator warning system shall be activated as specified in...
- 4.6. The operator warning system shall be deactivated when the conditions...
- 4.7. The warning system may be temporarily interrupted by other warning...
- 4.8. Details of the operator warning system activation and deactivation procedures...
- 4.9. As part of the application for EU type-approval under this...
5. Operator inducement system
  - 5.1. The engine shall incorporate an operator inducement system based on...
  - 5.2. The engine may be fitted with a means to disable...
    - 5.2.1 The engine may be fitted with a means to temporarily...
      - 5.2.1.1 All of the following conditions shall apply when a means...
  - 5.3. Low-level inducement system
    - 5.3.1. The low-level inducement system shall be activated after any of...
    - 5.3.2. The low-level inducement system shall gradually reduce the maximum available...
    - 5.3.3. Other inducement measures that are demonstrated to the approval authority...
  - 5.4. Severe inducement system
    - 5.4.1. The severe inducement system shall be activated after any of...
    - 5.4.2. The severe inducement system shall reduce the non-road mobile machinery's...
  - 5.5. In order to account for safety concerns and to allow...
  - 5.6. The operator inducement system shall be deactivated when the conditions...
  - 5.7. Details of the operator inducement system activation and deactivation procedures...
  - 5.8. As part of the application for EU type-approval under this...
6. Reagent availability
  - 6.1. Reagent level indicator
  - 6.2. Activation of the operator warning system
    - 6.2.1. The operator warning system specified in section 4 shall be...
    - 6.2.2. The warning provided shall be sufficiently clear, in conjunction with...
    - 6.2.3. The operator warning system does not initially need to be...
    - 6.2.4. The continuous warning shall not be easily disabled or ignored....
    - 6.2.5. It shall not be possible to turn off the operating...
  - 6.3. Activation of the operator inducement system
    - 6.3.1 The low-level inducement system described in point 5.3 shall be...
    - 6.3.2. The severe inducement system described in point 5.4 shall be...
    - 6.3.3. Except to the extent permitted by point 5.5, it shall...
7. Reagent quality monitoring
  - 7.1. The engine or non-road mobile machinery shall include a means...

- 7.1.1. The manufacturer shall specify a minimum acceptable reagent concentration CD<sub>min</sub>,...
  - 7.1.1.1. The value of CD min specified by the manufacturer shall...
- 7.1.2. Any reagent concentration lower than CD<sub>min</sub> shall be detected and...
- 7.1.3. A specific counter ('the reagent quality counter') shall be attributed...
  - 7.1.3.1. Optionally, the manufacturer may group the reagent quality failure together...
- 7.1.4. Details of the reagent quality counter activation and deactivation criteria...
- 7.2. Activation of the operator warning system
- 7.3. Activation of the operator inducement system
  - 7.3.1. The low-level inducement system described in point 5.3 shall be...
  - 7.3.2. The severe inducement system described in point 5.4 shall be...
  - 7.3.3. The number of hours prior to activation of the inducement...
- 8. Reagent dosing activity
  - 8.1. The engine shall include a means of determining interruption of...
  - 8.2. Reagent dosing activity counter
    - 8.2.1. A specific counter shall be attributed to the dosing activity...
      - 8.2.1.1. Optionally, the manufacturer may group the reagent dosing failure together...
    - 8.2.2. Details of the reagent dosing activity counter activation and deactivation...
  - 8.3. Activation of the operator warning system
  - 8.4. Activation of the operator inducement system
    - 8.4.1. The low-level inducement system described in point 5.3 shall be...
    - 8.4.2. The severe inducement system described in point 5.4 shall be...
    - 8.4.3. The number of hours prior to activation of the inducement...
- 9. Other failures that may be attributed to tampering
  - 9.1. In addition to the level of reagent in the reagent...
  - 9.2. Monitoring requirements and counters
    - 9.2.1. NCD system
      - 9.2.1.1. The NO<sub>x</sub> Control Diagnostic (NCD) system shall be monitored...
      - 9.2.1.2. A counter shall be attributed to each of the monitoring...
        - 9.2.1.2.1. The manufacturer may group the NCD system failure together with...
      - 9.2.1.3. Details of the NCD system counter(s) activation and deactivation criteria...
    - 9.2.2. Impeded EGR valve
      - 9.2.2.1. The exhaust gas recirculation (EGR) system shall be monitored for...
      - 9.2.2.2. A counter shall be attributed to an impeded EGR valve...
        - 9.2.2.2.1. The manufacturer may group the impeded EGR valve failure together...
      - 9.2.2.3. Details of the EGR valve counter activation and deactivation criteria...

- 9.3. Activation of the operator warning system
- 9.4. Activation of the operator inducement system
  - 9.4.1. The low-level inducement system described in point 5.3 shall be...
  - 9.4.2. The severe inducement system described in point 5.4 shall be...
  - 9.4.3. The number of hours prior to activation of the inducement...
- 9.5. As an alternative to the monitoring requirements set out in...
- 10. Demonstration requirements
  - 10.1. General
  - 10.2. Engine families and NCD engine families
    - 10.2.1. The demonstration that the monitoring systems for other members of...
    - 10.2.2. The test engine is selected by the manufacturer in agreement...
    - 10.2.3. In the case where engines of an engine family belong...
  - 10.3. Demonstration of the warning system activation
    - 10.3.1. The compliance of the warning system activation shall be demonstrated...
    - 10.3.2. Selection of the failure to be tested among those referred...
      - 10.3.2.1. The approval authority shall select one failure category. In the...
      - 10.3.2.2. For the purpose of demonstrating the activation of the warning...
      - 10.3.2.3. For the purpose of demonstrating the activation of the warning...
    - 10.3.3. Demonstration
      - 10.3.3.1. For the purpose of this demonstration, a separate test shall...
      - 10.3.3.2. During a test, no failure shall be present other than...
      - 10.3.3.3. Prior to starting a test, all DTC shall have been...
      - 10.3.3.4. At the request of the manufacturer, and with the agreement...
      - 10.3.3.5. Detection of failures other than lack of reagent.
      - 10.3.3.6. Detection in case of lack of reagent availability
        - 10.3.3.6.1. The demonstration shall start with a level of reagent in...
        - 10.3.3.6.2. The warning system is deemed to have performed in the...
      - 10.3.3.7. NCD test cycle
        - 10.3.3.7.1. The NCD test cycle considered in this section 10 for...
        - 10.3.3.7.2. On request of the manufacturer and with approval of the...
    - 10.3.4. The demonstration of the warning system activation is deemed to...
  - 10.4. Demonstration of the inducement system
    - 10.4.1. The demonstration of the inducement system shall be done by...
      - 10.4.1.1. Any components or sub-systems not physically mounted on the engine,...
      - 10.4.1.2. If the manufacturer chooses, and subject to the agreement of...
    - 10.4.2. The test sequence shall demonstrate the activation of the inducement...

- 10.4.3. For the purpose of this demonstration,
- 10.4.4. The manufacturer shall, in addition, demonstrate the operation of the...
  - 10.4.4.1 These additional demonstrations shall in particular demonstrate to the satisfaction...
- 10.4.5. Demonstration test of the low-level inducement system
  - 10.4.5.1 This demonstration starts when the warning system or when appropriate...
  - 10.4.5.2 When the system is being checked for its reaction to...
    - 10.4.5.2.1 The manufacturer may, with the agreement of the approval authority,...
  - 10.4.5.3 When the system is checked for its reaction in the...
  - 10.4.5.4 The demonstration of the low level inducement system shall be...
- 10.4.6. Demonstration test of the severe inducement system
  - 10.4.6.1 This demonstration shall start from a condition where the low-level...
  - 10.4.6.2 When the system is checked for its reaction in the...
    - 10.4.6.2.1 The manufacturer may, with the agreement of the approval authority,...
  - 10.4.6.3 When the system is checked for its reaction in the...
  - 10.4.6.4 The demonstration of the severe inducement system shall be deemed...
- 10.4.7. Alternatively, if the manufacturer chooses, and subject to the agreement...
  - 10.4.7.1 The non-road mobile machinery shall be operated until the counter...
- 10.5. Documentation of the demonstration
  - 10.5.1. A demonstration report shall document the demonstration of the NCD...
- 11. Description of the operator warning and inducement activation and deactivation...
  - 11.1 To complement the requirements specified in this Appendix concerning the...
  - 11.2. Activation and deactivation mechanisms of the warning system
    - 11.2.1. The operator warning system shall be activated when the diagnostic...
    - 11.2.2. The operator warning system shall be deactivated when the diagnosis...
      - 11.2.2.1 Requirements for erasing 'NOx control information'
        - 11.2.2.1.1 Erasing/resetting 'NOx control information' by a scan-tool
        - 11.2.2.1.2 NOx control information shall not be erased by disconnection of...
        - 11.2.2.1.3 The erasing of 'NOx control information' shall only be possible...
        - 11.2.2.1.4 When 'NOx control information' including DTCs are erased, any counter...
  - 11.3. Activation and deactivation mechanism of the operator inducement system
    - 11.3.1. The operator inducement system shall be activated when the warning...

- 11.3.2. The operator inducement system shall be deactivated when the system...
  - 11.3.3. The operator warning and inducement systems shall be immediately activated...
  - 11.4. Counter mechanism
    - 11.4.1. General
      - 11.4.1.1. To comply with the requirements of this Appendix, the system...
        - 11.4.1.1.1. The manufacturer may use one or more counters for grouping...
        - 11.4.1.1.2. Each of the counters shall count up to the maximum...
        - 11.4.1.1.3. A manufacturer may use a single or multiple NCD system...
          - 11.4.1.1.3.1. When the manufacturer decides to use multiple NCD system counters,...
      - 11.4.1.2. Each of the counters shall count up to the maximum...
      - 11.4.1.3. A manufacturer may use a single or multiple NCD system...
        - 11.4.1.3.1. When the manufacturer decides to use multiple NCD system counters,...
    - 11.4.2. Principle of counters mechanism
      - 11.4.2.1. Each of the counters shall operate as follows:
12. Illustration of the activation and deactivation and counter mechanisms
  - 12.1. This section 12 illustrates the activation and deactivation and counter...
  - 12.2. Figure 4.5 illustrates the operation of the activation and deactivation...
  - 12.3. Figure 4.6 illustrates three cases of wrong reagent quality:
  - 12.4. Figure 4.7 illustrates three cases of failure of the urea...
13. Demonstration of the minimum acceptable reagent concentration CD<sub>min</sub>
  - 13.1. The manufacturer shall demonstrate the correct value of CD<sub>min</sub> during...
  - 13.2. The test shall follow the appropriate NCD cycle(s) or manufacturer...
  - 13.3. The pollutant emissions resulting from this test shall not exceed...
  - 13.4. Documentation of the demonstration
    - 13.4.1. A demonstration report shall document the demonstration of the minimum...

## Appendix 2

### Additional technical requirements on NO<sub>x</sub> control measures for engines of...

- 1. Introduction
- 2. General requirements
- 3. Exceptions to the requirements of Appendix 1
- 4. Requirement for storing incidents of engine operation with inadequate reagent...
  - 4.1. The on-board computer log must record in non-volatile computer memory...
    - 4.1.1. It shall be possible for national inspection authorities to read...
    - 4.1.2. A description of the connection for, and method to read,...
  - 4.2. The duration of an incident of inadequate reagent level recorded...
  - 4.3. The duration of an incident recorded in the on-board computer...
  - 4.4. The duration of an incident recorded in the on-board computer...
  - 4.5. The duration of an incident recorded in the on-board computer...
  - 4.6. When conducting a demonstration pursuant to section 10.4 of Appendix...

### Appendix 3

Additional technical requirements on NOx control measures for engines of...

1. Introduction
2. Required information
  - 2.1. The manufacturer shall provide information that fully describes the functional...
  - 2.2. If the emission control system requires a reagent, the characteristics...
3. Reagent availability and operator warning system
4. Reagent quality

### Appendix 4

Technical requirements on particulate pollutant control measures, including the method...

1. Introduction
2. General requirements
  - 2.1. Required information
    - 2.1.1. If the emission control system requires a reagent e.g. fuel...
    - 2.1.2. Detailed written information fully describing the functional operation characteristics of...
    - 2.1.3. The manufacturer shall provide installation documents that, when used by...
  - 2.2. Operating conditions
    - 2.2.1. The PCD system shall, at a minimum, be operational at...
  - 2.3. Diagnostic requirements
    - 2.3.1. The PCD system shall be able to identify the particulate...
    - 2.3.2. Requirements for recording Diagnostic Trouble Codes (DTCs)
      - 2.3.2.1. The PCD system shall record a DTC for each distinct...
      - 2.3.2.2. The PCD system shall conclude within the periods of engine...
      - 2.3.2.3. In cases where more than the period of running time...
    - 2.3.3. Requirements for erasing Diagnostic trouble codes (DTCs):
    - 2.3.4. A PCD system shall not be programmed or otherwise designed...
    - 2.3.5. Any reprogrammable computer codes or operating parameters of the PCD...
    - 2.3.6. PCD engine family
      - 2.3.6.1. Parameters defining a PCD engine family
3. Maintenance requirements
  - 3.1. The OEM shall provide to all end-users of new non-road...
4. Operator warning system
  - 4.1. The non-road mobile machinery shall include an operator warning system...
  - 4.2. The operator warning system may consist of one or more...
  - 4.3. At the choice of the manufacturer, the warning system may...
  - 4.4. The operator warning system shall be activated as specified in...
  - 4.5. The operator warning system shall be deactivated when the conditions...
  - 4.6. The warning system may be temporarily interrupted by other warning...

- 4.7. In the application for EU type-approval under Regulation (EU) 2016/1628,...
5. System to store information on operator warning system activation
  - 5.1. The PCD system shall include a non-volatile computer memory or...
  - 5.2. The PCD shall store in the non-volatile memory the total...
  - 5.3. It shall be possible for national authorities to read these...
  - 5.4. A description of the connection for, and method to read,...
6. Monitoring for removal of the particulate after-treatment system
  - 6.1. The PCD system shall detect the complete removal of the...
7. Additional requirements in the case of a particulate after-treatment system...
  - 7.1. In the case of a confirmed and active DTC for...
  - 7.2. The warning system shall be activated if the reagent level...
8. Monitoring failures that may be attributed to tampering
  - 8.1. In addition to monitoring for removal of the particulate after-treatment...
  - 8.2. Monitoring of loss of the particulate after-treatment system function
  - 8.3. Monitoring of failures of the PCD system
    - 8.3.1. The PCD system shall be monitored for electrical failures and...
    - 8.3.2. Where the failure, removal or deactivation of a single sensor...
9. Demonstration requirements
  - 9.1. General
  - 9.2. Engine families and PCD engine families
    - 9.2.1. In the case where engines of an engine family belong...
  - 9.3. Demonstration of the warning system activation
    - 9.3.1. The compliance of the warning system activation shall be demonstrated...
    - 9.3.2. Selection of the failures to be tested
      - 9.3.2.1. The manufacturer shall provide the approval authority with a list...
      - 9.3.2.2. The failure to be considered in the test shall be...
    - 9.3.3. Demonstration
      - 9.3.3.1. For the purpose of this demonstration, a separate test shall...
      - 9.3.3.2. During a test, no failure shall be present other than...
      - 9.3.3.3. Prior to starting a test, all DTC shall have been...
      - 9.3.3.4. At the request of the manufacturer, and with the agreement...
      - 9.3.3.5. Detection of failures
        - 9.3.3.5.1. The PCD system shall respond to the introduction of a...
      - 9.3.3.6. PCD test cycle
        - 9.3.3.6.1. The PCD test cycle considered in this Section 9 for...
        - 9.3.3.6.2. On request of the manufacturer and with approval of the...
      - 9.3.3.7. Configuration for demonstration of the warning system activation
        - 9.3.3.7.1. The demonstration of the warning system activation shall be done...
        - 9.3.3.7.2. Any components or subsystems not physically mounted on the engine,...

9.3.3.7. If the manufacturer chooses, and subject to the agreement of...

9.3.4. The demonstration of the warning system activation is deemed to...

9.3.5. Where a particulate after-treatment system that uses a reagent is...

9.3.6. Documentation of the demonstration

9.3.6.1. A demonstration report shall document the demonstration of the PCD...

## ANNEX V

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

1. General requirements
2. Engine control area
  - 2.1. Control area for engines tested on NRSC cycle C1
    - 2.1.1. Variable-speed engines of category NRE with maximum net power  $\geq$ ...
    - 2.1.2. Variable-speed engines of category NRE with maximum net power  $<$ ...

Key  
Key
  - 2.2. Control area for engines tested on NRSC cycles D2, E2...
  - 2.3. Control area for engines tested on NRSC cycle E3
 

Key:
3. Demonstration requirements
  - 3.1. For the purpose of the random selections required in point...
4. Test requirements
5. Regeneration

## ANNEX VI

Conduct of emission tests and requirements for measurement equipment

1. Introduction
2. General overview
3. Related annexes
4. General requirements
5. Performance requirements
  - 5.1. Emissions of gaseous and particulate pollutants and of CO<sub>2</sub> and...
    - 5.1.1. Equivalency
  - 5.2. General requirements on the test cycles
    - 5.2.1. The EU type-approval test shall be conducted using the appropriate...
    - 5.2.2. The technical specifications and characteristics of the NRSC are set...



- 5.2.3. The technical specifications and characteristics of the NRTC and LSI-NRTC...
  - 5.2.4. The test cycles specified in point 7.4 and in Annex...
  - 5.2.5. Test speeds
    - 5.2.5.1. Maximum test speed (MTS)
      - 5.2.5.1.1. Calculation of MTS
      - 5.2.5.1.2. Use of a declared MTS
      - 5.2.5.1.3. Use of an adjusted MTS
    - 5.2.5.2. Rated speed
    - 5.2.5.3. Maximum torque speed for variable-speed engines
    - 5.2.5.4. Intermediate speed
    - 5.2.5.5. Idle speed
    - 5.2.5.6. Test speed for constant-speed engines
  - 5.2.6. Torque and Power
    - 5.2.6.1. Torque
    - 5.2.6.2. Power
6. Test Conditions
- 6.1. Laboratory test conditions
    - 6.1.1. For the test to be considered valid both the following...
    - 6.1.2. Where the altitude of the laboratory in which the engine...
    - 6.1.3. Where the power of the engine being tested is greater...
    - 6.1.4. Where the altitude of the laboratory in which the engine...
    - 6.1.5. In the case of an engine family of category NRS...
    - 6.1.6. For engines of category SMB the temperature of the intake...
      - 6.1.6.1. For engines of category SMB fitted with electronically controlled fuel...
    - 6.1.7. It is allowed to use:
  - 6.2. Engines with charge-air cooling
  - 6.3. Engine power
    - 6.3.1. Basis for emission measurement
    - 6.3.2. Auxiliaries to be fitted
    - 6.3.3. Auxiliaries to be removed
    - 6.3.4. Determination of auxiliary power
    - 6.3.5. Engine cycle work
  - 6.4. Engine intake air
    - 6.4.1. Introduction
    - 6.4.2. Intake air pressure restriction
  - 6.5. Engine exhaust system
  - 6.6. Engine with exhaust after-treatment system
    - 6.6.1. Continuous regeneration
    - 6.6.2. Infrequent regeneration
      - 6.6.2.1. Requirement for establishing adjustment factors using NRTC, LSI-NRTC or RMC...
      - 6.6.2.2. Requirement for establishing adjustment factors using discrete-mode NRSC testing
      - 6.6.2.3. General procedure for developing infrequent regeneration adjustment factors (IRAFs)
        - Figure 6 Scheme of infrequent regeneration with n number of measurements and...
      - 6.6.2.4. Application of adjustment factors
  - 6.7. Cooling system
  - 6.8. Lubricating oil

- 6.9. Specification of the reference fuel
- 6.10. Crankcase emissions
- 7. Test procedures
  - 7.1. Introduction
  - 7.2. Principle of emission measurement
    - 7.2.1. Mass of constituent
      - 7.2.1.1. Continuous sampling
      - 7.2.1.2. Batch sampling
      - 7.2.1.3. Combined sampling
    - 7.2.2. Work determination
  - 7.3. Verification and calibration
    - 7.3.1. Pre-test procedures
      - 7.3.1.1. General requirements for preconditioning the sampling system and the engine...
        - 7.3.1.1.1. Preconditioning for cold-start run of NRTC
        - 7.3.1.1.2. Preconditioning for hot-start run of NRTC or for LSI-NRTC
        - 7.3.1.1.3. Preconditioning for discrete-mode NRSC
        - 7.3.1.1.4. Preconditioning for RMC
        - 7.3.1.1.5. Engine cool-down (NRTC)
      - 7.3.1.2. Engine cool-down (NRTC)
      - 7.3.1.3. Verification of HC contamination
      - 7.3.1.4. Preparation of measurement equipment for sampling
      - 7.3.1.5. Calibration of gas analyzers
      - 7.3.1.6. PM filter preconditioning and tare weighing
    - 7.3.2. Post-test procedures
      - 7.3.2.1. Verification of proportional sampling
      - 7.3.2.2. Post-test PM conditioning and weighing
      - 7.3.2.3. Analysis of gaseous batch sampling
      - 7.3.2.4. Drift verification
  - 7.4. Test cycles
    - 7.4.1. Steady-state test cycles
      - 7.4.1.1. Discrete-mode NRSC
      - 7.4.1.2. Ramped modal NRSC
    - 7.4.2. Transient (NRTC and LSI-NRTC) test cycles
      - 7.4.2.1. Test sequence for NRTC
        - Figure 6 NRTC normalized dynamometer schedule
      - 7.4.2.2. Test sequence for LSI-NRTC
  - 7.5. General test sequence
    - Figure 6 Test sequence
    - 7.5.1. Engine starting, and restarting
      - 7.5.1.1. Engine start
      - 7.5.1.2. Engine stalling
      - 7.5.1.3. Engine operation
  - 7.6. Engine mapping
    - 7.6.1. Engine mapping for variable-speed NRSC
    - 7.6.2. Engine mapping for NRTC and LSI-NRTC
    - 7.6.3. Engine mapping for constant-speed NRSC
      - 7.6.3.1. Rated power check for engines to be tested on cycles...
      - 7.6.3.2. Mapping procedure for constant-speed NRSC
  - 7.7. Test cycle generation

- 7.7.1. Generation of NRSC
  - 7.7.1.1. Generation of NRSC test speeds for engines tested with both...
  - 7.7.1.2. Generation of NRSC test speeds for engines only tested with...
  - 7.7.1.3. Generation of NRSC load for each test mode
- 7.7.2. Generation of NRTC & LSI-NRTC speed and load for each...
  - 7.7.2.1. Reserved
  - 7.7.2.2. Denormalization of engine speed
  - 7.7.2.3. Denormalization of engine torque
    - (a) Declared minimum torque
    - (b) Adjustment of engine torque due to auxiliaries fitted for the...
  - 7.7.2.4. Example of denormalization procedure
- 7.8. Specific test cycle running procedure
  - 7.8.1. Emission test sequence for discrete-mode NRSC
    - 7.8.1.1. Engine warming-up for steady state discrete-mode NRSC
    - 7.8.1.2. Performing discrete-mode NRSC
    - 7.8.1.3. Validation criteria
  - 7.8.2. Emission test sequence for RMC
    - 7.8.2.1. Engine warming-up
    - 7.8.2.2. Performing an RMC
    - 7.8.2.3. Emission test sequence
    - 7.8.2.4. Validation criteria
  - 7.8.3. Transient (NRTC and LSI-NRTC) test cycles
    - 7.8.3.1. Performing an NRTC test
    - 7.8.3.2. Performing an LSI-NRTC test
    - 7.8.3.3. Cycle validation criteria for transient (NRTC and LSI-NRTC) test cycles...
    - 7.8.3.4. Calculation of cycle work
    - 7.8.3.5. Validation statistics (see Appendix 2 of Annex VII)
- 8. Measurement procedures
  - 8.1. Calibration and performance checks
    - 8.1.1. Introduction
    - 8.1.2. Summary of calibration and verification
    - 8.1.3. Verifications for accuracy, repeatability, and noise
    - 8.1.4. Linearity verification
      - 8.1.4.1. Scope and frequency
      - 8.1.4.2. Performance requirements
      - 8.1.4.3. Procedure
      - 8.1.4.4. Reference signals
      - 8.1.4.5. Measurement systems that require linearity verification
    - 8.1.5. Continuous gas analyser system-response and updating-recording verification
      - 8.1.5.1. Scope and frequency
      - 8.1.5.2. Measurement principles
      - 8.1.5.3. System requirements
      - 8.1.5.4. Procedure
      - 8.1.5.5. Performance evaluation
    - 8.1.6. Response time verification for compensation type analysers
      - 8.1.6.1. Scope and frequency
      - 8.1.6.2. Measurement principles
      - 8.1.6.3. System requirements
      - 8.1.6.4. Procedure

- 8.1.7. Measurement of engine parameters and ambient conditions
  - 8.1.7.1. Torque calibration
    - 8.1.7.1.1. Scope and frequency
    - 8.1.7.1.2. Dead-weight calibration
    - 8.1.7.1.3. Strain gage or proving ring calibration
  - 8.1.7.2. Pressure, temperature, and dew point calibration
- 8.1.8. Flow-related measurements
  - 8.1.8.1. Fuel flow calibration
  - 8.1.8.2. Intake air flow calibration
  - 8.1.8.3. Exhaust gas flow calibration
  - 8.1.8.4. Diluted exhaust gas flow (CVS) calibration
    - 8.1.8.4.1. Overview
    - 8.1.8.4.2. PDP calibration
    - 8.1.8.4.3. CFV calibration
    - 8.1.8.4.4. SSV calibration
    - 8.1.8.4.5. Ultrasonic calibration (reserved)
  - Figure 6 Schematic diagrams for diluted exhaust gas flow CVS calibration
  - 8.1.8.5. CVS and batch sampler verification (propane check)
    - 8.1.8.5.1. Introduction
    - 8.1.8.5.2. Method of introducing a known amount of propane into the...
    - 8.1.8.5.3. Preparation of the propane check
    - 8.1.8.5.4. Preparation of the HC sampling system for the propane check...
    - 8.1.8.5.5. Propane check performance
    - 8.1.8.5.6. Evaluation of the propane check
    - 8.1.8.5.7. PM secondary dilution system verification
    - 8.1.8.5.8. Sample dryer verification
  - 8.1.8.6. Periodic calibration of the partial flow PM and associated raw...
    - 8.1.8.6.1. Specifications for differential flow measurement
    - 8.1.8.6.2. Calibration of differential flow measurement
    - 8.1.8.6.3. Special requirements for differential flow measurement
      - 8.1.8.6.3.1. Pre-test check
      - 8.1.8.6.3.2. Determination of the transformation time
  - 8.1.8.7. Vacuum-side leak verification
    - 8.1.8.7.1. Scope and frequency
    - 8.1.8.7.2. Measurement principles
    - 8.1.8.7.3. Low-flow leak test
    - 8.1.8.7.4. Dilution-of-span-gas leak test
    - 8.1.8.7.5. Vacuum-decay leak test
- 8.1.9. CO and CO<sub>2</sub> measurements
  - 8.1.9.1. H<sub>2</sub>O interference verification for CO<sub>2</sub> NDIR analyzers
    - 8.1.9.1.1. Scope and frequency
    - 8.1.9.1.2. Measurement principles
    - 8.1.9.1.3. System requirements
    - 8.1.9.1.4. Procedure
  - 8.1.9.2. H<sub>2</sub>O and CO<sub>2</sub> interference verification for CO NDIR analyzers
    - 8.1.9.2.1. Scope and frequency
    - 8.1.9.2.2. Measurement principles

- 8.1.9.2.3 System requirements
- 8.1.9.2.4 Procedure
- 8.1.10. Hydrocarbon measurements
  - 8.1.10.1 FID optimization and verification
    - 8.1.10.1.1 Scope and frequency
    - 8.1.10.1.2 Calibration
      - 8.1.10.1.2.1 HC FID response optimization
      - 8.1.10.1.2.2 HC FID CH<sub>4</sub> response factor determination
      - 8.1.10.1.2.3 HC FID methane (CH<sub>4</sub>) response verification
  - 8.1.10.2 Non-stoichiometric raw exhaust gas FID O<sub>2</sub> interference verification
    - 8.1.10.2.1 Scope and frequency
    - 8.1.10.2.2 Measurement principles
    - 8.1.10.2.3 System requirements
    - 8.1.10.2.4 Procedure
  - 8.1.10.3 Non-methane cutter penetration fractions (Reserved)
- 8.1.11. NO<sub>x</sub> measurements
  - 8.1.11.1 CLD CO<sub>2</sub> and H<sub>2</sub>O quench verification
    - 8.1.11.1.1 Scope and frequency
    - 8.1.11.1.2 Measurement principles
    - 8.1.11.1.3 System requirements
    - 8.1.11.1.4 CO<sub>2</sub> quench verification procedure
    - 8.1.11.1.5 H<sub>2</sub>O quench verification procedure
  - 8.1.11.2 CLD quench verification calculations
    - 8.1.11.2.1 Amount of water expected during testing
    - 8.1.11.2.2 Amount of CO<sub>2</sub> expected during testing
    - 8.1.11.2.3 Combined H<sub>2</sub>O and CO<sub>2</sub> quench calculations
  - 8.1.11.3 NDUV analyzer HC and H<sub>2</sub>O interference verification
    - 8.1.11.3.1 Scope and frequency
    - 8.1.11.3.2 Measurement principles
    - 8.1.11.3.3 System requirements
    - 8.1.11.3.4 Procedure
  - 8.1.11.4 Sample dryer NO<sub>2</sub> penetration
    - 8.1.11.4.1 Scope and frequency
    - 8.1.11.4.2 Measurement principles
    - 8.1.11.4.3 System requirements
    - 8.1.11.4.4 Procedure
  - 8.1.11.5 NO<sub>2</sub>-to-NO converter conversion verification
    - 8.1.11.5.1 Scope and frequency
    - 8.1.11.5.2 Measurement principles
    - 8.1.11.5.3 System requirements
    - 8.1.11.5.4 Procedure
- 8.1.12. Sample dryer verification
  - 8.1.12.1 PM balance verifications and weighing process verification
    - 8.1.12.1.1 Scope and frequency
    - 8.1.12.1.2 Independent verification
    - 8.1.12.1.3 Zeroing and spanning
    - 8.1.12.1.4 Reference sample weighing
  - 8.1.12.2 PM sample filter buoyancy correction
    - 8.1.12.2.1 General
    - 8.1.12.2.2 PM sample filter density
    - 8.1.12.2.3 Air density
    - 8.1.12.2.4 Calibration weight density

**Changes to legislation:** There are currently no known outstanding effects for the Commission Delegated Regulation (EU) 2017/654. (See end of Document for details)

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- 8.1.12.2 Correction calculation
- 8.1.13. PM measurements
  - 8.1.13.1 PM balance verifications and weighing process verification
    - 8.1.13.1.1 Scope and frequency
    - 8.1.13.1.2 Independent verification
    - 8.1.13.1.3 Zeroing and spanning
    - 8.1.13.1.4 Reference sample weighing
  - 8.1.13.2 PM sample filter buoyancy correction
    - 8.1.13.2.1 General
    - 8.1.13.2.2 PM sample filter density
    - 8.1.13.2.3 Air density
    - 8.1.13.2.4 Calibration weight density
    - 8.1.13.2.5 Correction calculation
- 8.2. Instrument validation for test
  - 8.2.1. Validation of proportional flow control for batch sampling and minimum...
    - 8.2.1.1. Proportionality criteria for CVS
      - 8.2.1.1.1 Proportional flows
      - 8.2.1.1.2 Constant flows
      - 8.2.1.1.3 Demonstration of proportional sampling
    - 8.2.1.2. Partial flow dilution system validation
  - 8.2.2. Gas analyzer range validation, drift validation and drift correction
    - 8.2.2.1. Range validation
      - 8.2.2.1.1 Batch sampling
      - 8.2.2.1.2 Continuous sampling
    - 8.2.2.2. Drift validation and drift correction
  - 8.2.3. PM sampling media (e.g. filters) preconditioning and tare weighing
    - 8.2.3.1. Periodic verifications
    - 8.2.3.2. Visual Inspection
    - 8.2.3.3. Grounding
    - 8.2.3.4. Unused sample media
    - 8.2.3.5. Stabilization
    - 8.2.3.6. Weighing
    - 8.2.3.7. Buoyancy correction
    - 8.2.3.8. Repetition
    - 8.2.3.9. Tare-weighing
    - 8.2.3.10 Substitution weighing
  - 8.2.4. Post-test PM sample conditioning and weighing
    - 8.2.4.1. Periodic verification
    - 8.2.4.2. Removal from sealed containers
    - 8.2.4.3. Electrical grounding
    - 8.2.4.4. Visual inspection
    - 8.2.4.5. Stabilisation of PM samples
    - 8.2.4.6. Determination of post-test filter mass
    - 8.2.4.7. Total mass
- 9. Measurement equipment
  - 9.1. Engine dynamometer specification
    - 9.1.1. Shaft work
    - 9.1.2. Transient (NRTC and LSI-NRTC) test cycles
    - 9.1.3. Engine accessories
    - 9.1.4. Engine fixture and power transmission shaft system (category NRSh)
  - 9.2. Dilution procedure (if applicable)

- 9.2.1. Diluent conditions and background concentrations
- 9.2.2. Full flow system
  - Figure 6 Examples of full-flow dilution sampling configurations
- 9.2.3. Partial flow dilution (PFD) system
  - 9.2.3.1. Description of partial flow system
    - Figure 6 Schematic of partial flow dilution system (total sampling type).
  - 9.2.3.2. Dilution
  - 9.2.3.3. Applicability
  - 9.2.3.4. Calibration
- 9.3. Sampling procedures
  - 9.3.1. General sampling requirements
    - 9.3.1.1. Probe design and construction
      - 9.3.1.1.1. Mixing chamber (category NRSh)
    - 9.3.1.2. Transfer lines
    - 9.3.1.3. Sampling methods
  - 9.3.2. Gas sampling
    - 9.3.2.1. Sampling probes
      - 9.3.2.1.1. Mixing chamber (Category NRSh)
    - 9.3.2.2. Transfer lines
    - 9.3.2.3. Sample-conditioning components
      - 9.3.2.3.1. Sample dryers
        - 9.3.2.3.1.1. Requirements
        - 9.3.2.3.1.2. Type of sample dryers allowed and procedure to estimate moisture...
      - 9.3.2.3.2. Sample pumps
      - 9.3.2.3.3. Ammonia scrubbers
    - 9.3.2.4. Sample storage media
  - 9.3.3. PM sampling
    - 9.3.3.1. Sampling probes
      - Figure 6 Scheme of a sampling probe with a hat-shaped pre-classifier
    - 9.3.3.2. Transfer lines
    - 9.3.3.3. Pre-classifier
    - 9.3.3.4. Sample filter
      - 9.3.3.4.1. Filter specification
      - 9.3.3.4.2. Filter size
      - 9.3.3.4.3. Dilution and temperature control of PM samples
      - 9.3.3.4.4. Filter face velocity
      - 9.3.3.4.5. Filter holder
  - 9.3.4. PM-stabilization and weighing environments for gravimetric analysis
    - 9.3.4.1. Environment for gravimetric analysis
    - 9.3.4.2. Cleanliness
    - 9.3.4.3. Temperature of the chamber
    - 9.3.4.4. Verification of ambient conditions
    - 9.3.4.5. Installation of balance
    - 9.3.4.6. Static electric charge
- 9.4. Measurement instruments
  - 9.4.1. Introduction
    - 9.4.1.1. Scope
    - 9.4.1.2. Instrument types
    - 9.4.1.3. Redundant systems
  - 9.4.2. Data recording and control

**Changes to legislation:** There are currently no known outstanding effects for the Commission Delegated Regulation (EU) 2017/654. (See end of Document for details)

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- 9.4.3. Performance specifications for measurement instruments
  - 9.4.3.1. Overview
  - 9.4.3.2. Component requirements
- 9.4.4. Measurement of engine parameters & ambient conditions
  - 9.4.4.1. Speed and torque sensors
    - 9.4.4.1.1Application
    - 9.4.4.1.2Shaft work
  - 9.4.4.2. Pressure transducers, temperature sensors, and dew point sensors
- 9.4.5. Flow-related measurements
  - 9.4.5.1. Fuel flow meter
  - 9.4.5.2. Intake-air flow meter
  - 9.4.5.3. Raw exhaust flow meter
    - 9.4.5.3.1Component requirements
    - 9.4.5.3.2Flow meter response time
    - 9.4.5.3.3Exhaust gas cooling
  - 9.4.5.4. Dilution air and diluted exhaust flow meters
    - 9.4.5.4.1Application
    - 9.4.5.4.2Component requirements
    - 9.4.5.4.3Exhaust gas cooling
  - 9.4.5.5. Sample flow meter for batch sampling
  - 9.4.5.6. Gas divider
- 9.4.6. CO and CO<sub>2</sub> measurements
- 9.4.7. Hydrocarbon measurements
  - 9.4.7.1. Flame-ionization detector
    - 9.4.7.1.1Application
    - 9.4.7.1.2Component requirements
    - 9.4.7.1.3FID fuel and burner air
    - 9.4.7.1.4Reserved
    - 9.4.7.1.5Reserved
  - 9.4.7.2. Reserved
- 9.4.8. NO<sub>x</sub> measurements
  - 9.4.8.1. Chemiluminescent detector
    - 9.4.8.1.1Application
    - 9.4.8.1.2Component requirements
    - 9.4.8.1.3NO<sub>2</sub>-to-NO converter
    - 9.4.8.1.4Humidity effects
    - 9.4.8.1.5Response time
  - 9.4.8.2. Non-dispersive ultraviolet analyzer
    - 9.4.8.2.1Application
    - 9.4.8.2.2Component requirements
    - 9.4.8.2.3NO<sub>2</sub>-to-NO converter
    - 9.4.8.2.4Humidity effects
- 9.4.9. O<sub>2</sub> measurements
- 9.4.10. Air-to-fuel ratio measurements
- 9.4.11. PM measurements with gravimetric balance
- 9.4.12. Ammonia (NH<sub>3</sub>) measurements
- 9.5. Analytical gases and mass standards
  - 9.5.1. Analytical gases
    - 9.5.1.1. Gas specifications
    - 9.5.1.2. Concentration and expiration date
    - 9.5.1.3. Gas transfer
  - 9.5.2. Mass standards



## Appendix 1

### Particle number emissions measurement equipment

1. Measurement test procedure
  - 1.1. Sampling
    - 1.1.1. Diluent filtration
  - 1.2. Compensating for particle number sample flow — full flow dilution...
  - 1.3. Compensating for particle number sample flow — partial flow dilution...
    - 1.3.1. For partial flow dilution systems the mass flow extracted from...
    - 1.3.2. The instantaneous exhaust gas flow rate into the dilution system...
    - 1.3.3. Correction of PM measurement
    - 1.3.4. Proportionality of partial flow dilution sampling
    - 1.3.5. Particle number calculation
2. Measurement equipment
  - 2.1. Specification
    - 2.1.1. System overview
      - 2.1.1.1. The particle sampling system shall consist of a probe or...
      - 2.1.1.2. It is recommended that a particle size pre-classifier (e.g. cyclone,...
    - 2.1.2. General requirements
      - 2.1.2.1. The particle sampling point shall be located within a dilution...
      - 2.1.2.2. The VPR shall include devices for sample dilution and for...
      - 2.1.2.3. All parts of the dilution system and the sampling system...
      - 2.1.2.4. The particle sampling system shall incorporate good aerosol sampling practice...
    - 2.1.3. Specific requirements
      - 2.1.3.1. The particle sample shall not pass through a pump before...
      - 2.1.3.2. A sample pre-classifier is recommended.
      - 2.1.3.3. The sample preconditioning unit shall:
      - 2.1.3.4. The PNC shall:
      - 2.1.3.5. Where they are not held at a known constant level...
      - 2.1.3.6. The sum of the residence time of the PTS, VPR...
      - 2.1.3.7. The transformation time of the entire particle number sampling system...
    - 2.1.4. Recommended system description
      - Figure 6 Schematic of recommended particle sampling system – Full flow sampling...
      - 2.1.4.1. Sampling system description
      - 2.1.4.2. Particle transfer system
      - 2.1.4.3. Particle pre-classifier
      - 2.1.4.4. Volatile particle remover (VPR)
        - 2.1.4.4.1. First particle number dilution device (PND1)
        - 2.1.4.4.2. Evaporation Tube (ET)
        - 2.1.4.4.3. Second particle number dilution device (PND2)
      - 2.1.4.5. Particle number counter (PNC)
  - 2.2. Calibration/Validation of the particle sampling system
    - 2.2.1. Calibration of the particle number counter
      - 2.2.1.1. The Technical Service shall ensure the existence of a calibration...

- 2.2.1.2. The PNC shall also be recalibrated and a new calibration...
- 2.2.1.3. Calibration shall be traceable to a standard calibration method:
- 2.2.1.4. Calibration shall also include a check, against the requirements in...
- 2.2.2. Calibration/Validation of the volatile particle remover
  - 2.2.2.1. Calibration of the VPR's particle concentration reduction factors across its...
  - 2.2.2.2. The test aerosol for these measurements shall be solid particles...
  - 2.2.2.3. The Technical Service shall ensure the existence of a validation...
- 2.2.3. Particle number system check procedures
  - 2.2.3.1. Prior to each test, the particle counter shall report a...
  - 2.2.3.2. On a monthly basis, the flow into the particle counter...
  - 2.2.3.3. Each day, following the application of a HEPA filter of...
  - 2.2.3.4. Prior to the start of each test it shall be...
  - 2.2.3.5. Prior to the start of each test it shall be...

## Appendix 2

Installation requirements for equipment and auxiliaries

## Appendix 3

Verification of torque signal broadcast by electronic control unit

1. Introduction
2. ECU torque signal
3. Verification procedure

## Appendix 4

Procedure for the measurement of ammonia

1. This appendix describes the procedure for measurement of ammonia (NH<sub>3</sub>)...
2. Three measurement principles are specified for NH<sub>3</sub> measurement and either...
  - 2.1. Fourier Transform Infrared (hereinafter 'FTIR') analyser
    - 2.1.1. Measurement principle
    - 2.1.2. Installation and sampling
    - 2.1.3. Cross interference
  - 2.2. Non Dispersive Ultra Violet Resonance Absorption analyser (hereinafter 'NDUV')
    - 2.2.1. Measurement Principle
    - 2.2.2. Installation
    - 2.2.3. Cross Sensitivity
  - 2.3. Laser Infrared analyser
    - 2.3.1. Measurement principle
    - 2.3.2. Installation
    - 2.3.3. Interference verification for NH<sub>3</sub> laser infrared analyzers (cross interference)

- 2.3.3.1. Scope and frequency
- 2.3.3.2. Measurement principles for interference verification
- 3. Emissions test procedure
  - 3.1. Checking the analysers
  - 3.2. Collection of emission relevant data
  - 3.3. Operations after test
  - 3.4.Analyser drift
    - 3.4.1. As soon as practical but no later than 30 minutes...
    - 3.4.2. Determination of analyser drift is not required in the following...
- 4. Analyser specification and verification
  - 4.1. Linearity requirements
  - 4.2. Analyser specifications
    - 4.2.1. Minimum detection limit
    - 4.2.2. Accuracy
    - 4.2.3. Zero drift
    - 4.2.4. Span drift
    - 4.2.5. System response time
    - 4.2.6. Rise time
    - 4.2.7. NH<sub>3</sub> calibration gas
    - 4.2.8. Interference verification procedure
- 5. Alternative systems

## Appendix 5

### Description of system responses

- 1. This appendix describes the times used to express the response...
- 2. The following times apply, as shown in figure 6-11:  
Figure 6-11 Illustration of system responses

## ANNEX VII

### Method for data evaluation and calculation

- 1. General requirements
  - 1.1. General symbols
  - 1.2. Subscripts
  - 1.3. Symbols and abbreviations for the chemical components (used also as...
  - 1.4. Symbols and abbreviations for the fuel composition
- 2. Mass based emissions calculations
  - 2.1. Measurement of gaseous emissions in raw exhaust gas
    - 2.1.1. Discrete-mode NRSC tests
    - 2.1.2. Transient (NRTC and LSI-NRTC) test cycles and RMC tests
    - 2.1.3. Dry-to-wet concentration conversion
    - 2.1.4. NO<sub>x</sub> correction for humidity and temperature
    - 2.1.5. Component specific factor u
      - 2.1.5.1. Tabulated values
      - 2.1.5.2. Calculated values
    - 2.1.6. Mass flow rate of the exhaust gas
      - 2.1.6.1. Air and fuel measurement method

- 2.1.6.2. Tracer measurement method
    - 2.1.6.3. Air flow and air to fuel ratio measurement method
    - 2.1.6.4. Carbon balance method, 1-step procedure
  - 2.2. Diluted gaseous emissions
    - 2.2.1. Mass of the gaseous emissions
    - 2.2.2. Dry-to-wet concentration conversion
      - 2.2.2.1. Diluted exhaust gas
      - 2.2.2.2. Dilution factor
      - 2.2.2.3. Dilution air
      - 2.2.2.4. Determination of the background corrected concentration
    - 2.2.3. Component specific factor u
    - 2.2.4. Exhaust gas mass flow calculation
      - 2.2.4.1. PDP-CVS system
      - 2.2.4.2. CFV-CVS system
      - 2.2.4.3. SSV-CVS system
  - 2.3. Calculation of particulate emission
    - 2.3.1. Transient (NRTC and LSI-NRTC) test cycles and RMC
      - 2.3.1.1. Partial flow dilution system
        - 2.3.1.1.1. Calculation based on sample ratio
        - 2.3.1.1.2. Calculation based on dilution ratio
      - 2.3.1.2. Full flow dilution system
        - 2.3.1.2.1. Background correction
    - 2.3.2. Calculation for discrete-mode NRSC
      - 2.3.2.1. Dilution system
      - 2.3.2.2. Calculation of the particulate mass flow rate
  - 2.4. Cycle work and specific emissions
    - 2.4.1. Gaseous emissions
      - 2.4.1.1. Transient (NRTC and LSI-NRTC) test cycles and RMC
      - 2.4.1.2. Discrete-mode NRSC
    - 2.4.2. Particulate emissions
      - 2.4.2.1. Transient (NRTC and LSI-NRTC) test cycles and RMC
      - 2.4.2.2. Discrete-mode NRSC
    - 2.4.3. Adjustment for emission controls that are regenerated on an infrequent...
    - 2.4.4. Adjustment for deterioration factor
  - 2.5. Diluted Exhaust Flow (CVS) Calibration and Related Calculations
    - 2.5.1. Positive displacement pump (PDP)
    - 2.5.2. Critical flow venturi (CFV)
    - 2.5.3. Subsonic venturi (SSV)
  - 2.6. Drift Correction
    - 2.6.1. General procedure
    - 2.6.2. Calculation procedure
- 3. Molar based emissions calculation
  - 3.1. Subscripts
  - 3.2. Symbols for chemical balance
  - 3.3. Basic parameters and relationships
    - 3.3.1. Dry air and chemical species
      - (\*\*) The effective molar mass of HC is defined by an...
      - (\*) The effective molar mass of NO<sub>x</sub> is defined by the...
    - 3.3.2. Wet air
      - 3.3.2.1. Vapour pressure of water
      - 3.3.2.2. Dew point

- 3.3.2.3. Relative humidity
- 3.3.2.4. Dew point determination from relative humidity and dry bulb temperature...
- 3.3.3. Fuel properties
  - 3.3.3.1. Calculation of carbon mass concentration wC
- 3.3.4. Total HC (THC) concentration initial contamination correction
- 3.3.5. Flow-weighted mean concentration
- 3.4. Chemical balances of fuel, intake air, and exhaust gas
  - 3.4.1. General
  - 3.4.2. Procedures that require chemical balances
  - 3.4.3. Chemical balance procedure
  - 3.4.4. NOx correction for humidity
- 3.5. Measurement of gaseous emissions in raw exhaust gas
  - 3.5.1. Mass of gaseous emissions
  - 3.5.2. Dry-to-wet concentration conversion
  - 3.5.3. Exhaust gas molar flow rate
- 3.6. Diluted gaseous emissions
  - 3.6.1. Emission mass calculation and background correction
  - 3.6.2. Dry-to wet concentration conversion
  - 3.6.3. Exhaust gas molar flow rate
- 3.7. Determination of particulates
  - 3.7.1. Sampling
  - 3.7.2. Background correction
- 3.8. Cycle work and specific emissions
  - 3.8.1. Gaseous emissions
    - 3.8.1.1. Transient (NRTC and LSI-NRTC) test cycles and RMC
    - 3.8.1.2. Discrete-mode NRSC
  - 3.8.2. Particulate emissions
    - 3.8.2.1. Transient (NRTC and LSI-NRTC) test cycles and RMC
    - 3.8.2.2. Discrete-mode NRSC
      - 3.8.2.2.1. For the single-filter method by means of equation (7-133):
      - 3.8.2.2.2. For the multiple-filter method by means of equation (7-134):
  - 3.8.3. Adjustment for emission controls that are regenerated on an infrequent...
  - 3.8.4. Adjustment for deterioration factor
- 3.9. Diluted Exhaust Flow (CVS) Calibration and Related Calculations
  - 3.9.1. Reference meter conversions
  - 3.9.2. PDP calibration calculations
  - 3.9.3. Venturi governing equations and permissible assumptions
  - 3.9.4. SSV calibration
    - (a) Molar based approach. To calibrate an SSV flow meter the...
  - 3.9.5. CFV calibration

## Appendix 1

### Drift Correction

1. Scope and frequency
2. Correction principles
3. Drift validation

#### 4. Drift correction

### Appendix 2

#### Carbon Flow Check

1. Introduction
2. Carbon flow rate into the engine (location 1)
3. Carbon flow rate in the raw exhaust gas (location 2)...
  - 3.1. Based on CO<sub>2</sub>
  - 3.2. Based on CO<sub>2</sub>, HC and CO
4. Carbon flow rate in the dilution system (location 3)
  - 4.1. Based on CO<sub>2</sub>
  - 4.2. Based on CO<sub>2</sub>, HC and CO
5. Calculation of the molar mass of the exhaust gas

### Appendix 3

#### Statistics

1. Arithmetic mean
2. Standard deviation
3. Root mean square
4. t-test
5. F-test
6. Slope
7. Intercept
8. Standard estimate of error
9. Coefficient of determination

### Appendix 4

#### 1980 INTERNATIONAL GRAVITY FORMULA

### Appendix 5

#### Particle number calculation

1. Determination of particle numbers
  - 1.1. Time alignment
  - 1.2. Determination of particle numbers for transient (NRTC and LSI-NRTC) test...
  - 1.3. Determination of particle numbers for transient (NRTC and LSI-NRTC) test...
  - 1.4. Determination of particle numbers for discrete-mode NRSC with a partial...
  - 1.5. Determination of particle numbers for discrete-mode cycles with a full...
2. Test result
  - 2.1. Calculation of the specific emissions for transient (NRTC and LSI-NRTC)...

- 2.1.1. Weighted average NRTC test result
- 2.2. Calculation of the specific emissions for discrete-mode NRSC tests
- 2.3. Rounding of final results
- 2.4. Determination of particle number background
  - 2.4.1. At the engine manufacturer's request, dilution tunnel background particle number...
  - 2.4.2. Subtraction of particle number tunnel background concentrations shall not be...

## Appendix 6

### Ammonia emission calculation

- 1. Calculation of the mean concentration for transient (NRTC and LSI-NRTC)...
- 2. Calculation of the mean concentration for discrete-mode NRSC

## ANNEX VIII

### Performance requirements and test procedures for dual-fuel engines

- 1. Scope
- 2. Definitions and abbreviations
- 3. Dual-fuel specific additional approval requirements
  - 3.1. Engines with operator-adjustable control of GERcycle.
- 4. General requirements
  - 4.1. Operating modes of dual-fuel engines
    - 4.1.1. Conditions for a dual-fuel engine to operate in liquid mode...
    - 4.1.2. Conditions for a dual-fuel engine to idle using liquid fuel...
      - 4.1.2.1. Dual-fuel Type 1A engines shall not idle using liquid fuel...
      - 4.1.2.2. Dual-fuel Type 1B engines shall not idle using liquid fuel...
      - 4.1.2.3. Dual-fuel Types 2A, 2B and 3B engines may idle using...
    - 4.1.3. Conditions for a dual-fuel engine to warm-up or start using...
      - 4.1.3.1. A Type 1B, Type 2B, or Type 3B dual-fuel engine...
      - 4.1.3.2. A Type 1A or Type 2A dual-fuel engine may warm-up...
        - 4.1.3.2.1. The strategy shall cease to be active when the coolant...
        - 4.1.3.2.2. The service mode shall be activated while the strategy is...
  - 4.2. Service mode
    - 4.2.1. Conditions for dual-fuel engines to operate in service mode
    - 4.2.2. Operability restriction in service mode
      - 4.2.2.1. Requirement for engine categories other than IWP, IWA, RLL and...
      - 4.2.2.2. Requirement for engine categories IWP, IWA, RLL and RLR
      - 4.2.2.3. Activation of the operability restriction
      - 4.2.2.4. Deactivation of the operability restriction
    - 4.2.3. Unavailability of gaseous fuel when operating in a dual-fuel mode...
      - 4.2.3.1. Unavailability of gaseous fuel — empty gaseous fuel tank
      - 4.2.3.2. Unavailability of gaseous fuel — malfunctioning gas supply

- 4.3. Dual-fuel indicators
    - 4.3.1. Dual-fuel operating mode indicator
      - 4.3.1.1. The dual-fuel mode indicator shall be set to service mode...
      - 4.3.1.2. The dual-fuel mode indicator shall be set for at least...
    - 4.3.2. Empty gaseous fuel tank warning system (dual-fuel warning system)
      - 4.3.2.1. Characteristics of the dual-fuel warning system
  - 4.4. Communicated torque
    - 4.4.1. Communicated torque when a dual-fuel engine operates in dual-fuel mode...
    - 4.4.2. Communicated torque when a dual-fuel engine operates in liquid-fuel mode...
  - 4.5. Additional requirements
    - 4.5.1. Where used for a dual-fuel engine, adaptive strategies shall, in...
  - 4.6. The type-approval shall be conditional upon providing to the OEM...
5. Performance requirements
    - 5.1. The performance requirements, including emission limit values, and the requirements...
    - 5.2. The hydrocarbon (HC) limit for operation in dual-fuel mode shall...
    - 5.3. The technical requirements on emission control strategies, including documentation required...
    - 5.4. The detailed technical requirements on the area associated with the...
  6. Demonstration requirements
    - 6.1. The demonstration requirements applicable to dual-fuel engines are identical to...
    - 6.2. Compliance with the applicable limit values shall be demonstrated in...
    - 6.3. For dual-fuel engine types with a liquid-fuel mode (i.e. types...
    - 6.4. Additional demonstration requirements in case of a Type 2 engine...
      - 6.4.1. The manufacturer shall present the approval authority with evidence showing...
    - 6.5. Additional demonstration requirements in case of an engine with an...
      - 6.5.1. Compliance with the applicable limit values shall be demonstrated at...
    - 6.6. Requirements for demonstrating the durability of a dual-fuel engine
      - 6.6.1. Provisions of Annex III shall apply.
    - 6.7. Demonstration of the dual-fuel indicators, warning and operability restriction
      - 6.7.1. As part of the application for EU type-approval under this...
    - 6.8. Documentation of the demonstration
  7. Requirements to ensure the correct operation of NO<sub>x</sub> control measures...
    - 7.1. Annex IV (technical requirements on NO<sub>x</sub> control measures) shall apply...
    - 7.2. Additional NO<sub>x</sub> control requirements in case of Type 1B, Type...
      - 7.2.1. The torque considered to apply to the severe inducement defined...
      - 7.2.2. A possible influence of the mode of operation on the...
      - 7.2.3. In the case of malfunctions the detection of which does...
      - 7.2.4. In the case of malfunctions where the detection depends on...
      - 7.2.5. A change of the mode of operation (dual-fuel to liquid...



## Appendix 1

Dual-fuel engine dual-fuel indicator, warning system, operability restriction — Demonstration...

1. Dual-fuel indicators
  - 1.1. Dual-fuel mode indicator
  - 1.2. Liquid-fuel mode indicator
  - 1.3. Service mode indicator
    - 1.3.1. When so-equipped it is sufficient to perform the demonstration related...
2. Warning system
3. Operability restriction
  - 3.1. It is sufficient to perform the demonstration in a typical...

## Appendix 2

Emission test procedure requirements for dual-fuel engines

1. General
2. Test conditions
3. Test procedures
4. Measurement procedures
5. Measurement equipment
6. Particle number emissions measurement
7. Emission calculation
  - 7.1. Mass-based emission calculation
    - 7.1.1. Dry/wet correction
      - 7.1.1.1. Raw exhaust gas
      - 7.1.1.2. Diluted exhaust gas
    - 7.1.2. NO<sub>x</sub> correction for humidity
    - 7.1.3. Partial flow dilution (PFS) and raw gaseous measurement
      - 7.1.3.1. Determination of exhaust gas mass flow
      - 7.1.3.2. Determination of the gaseous components
        - 7.1.3.2.1. Mass per test of a gaseous emission
      - 7.1.3.3. Particulate determination
      - 7.1.3.4. Additional requirements regarding the exhaust gas mass flow meter
    - 7.1.4. Full flow dilution measurement (CVS)
      - 7.1.4.1. Determination of the background corrected concentrations
    - 7.1.5. Determination of molar component ratios
      - 7.1.5.1. General
      - 7.1.5.2. Calculation of the fuel mixture components
      - 7.1.5.3. Calculation of the molar ratios of H, C, S, N...
  - 7.2. Molar-based emission calculation
    - 7.2.1. NO<sub>x</sub> correction for humidity
    - 7.2.2. Determination of exhaust gas mass flow when not using a...
    - 7.2.3. Molar component ratios for determination of the gaseous components
      - 7.2.3.1. Determination of molar component ratios
  - 7.3. CO<sub>2</sub> determination

### 7.3.1 CO<sub>2</sub> determination when testing on transient (NRTC and LSI-NRTC) test...

## Appendix 3

Types of dual-fuel engines operated on natural gas/biomethane or LPG...

## ANNEX IX

### Reference Fuels

1. Technical data on fuels for testing compression-ignition engines
  - 1.1. Type: Diesel (non-road gas-oil)
  - 1.2. Type: Ethanol for dedicated compression ignition engines (ED95) (1)
2. Technical data on fuels for testing spark ignition engines
  - 2.1. Type: Petrol (E10)
  - 2.2. Type: Ethanol (E85)
3. Technical data on gaseous fuels for single-fuel and dual-fuel engines...
  - 3.1. Type: LPG
  - 3.2. Type: Natural Gas/ Biomethane
    - 3.2.1. Specification for reference fuels supplied with fixed properties (e.g. from...)
    - 3.2.2. Specification for reference fuel supplied from a pipeline with admixture...
      - 3.2.2.1. The basis of each pipeline reference fuel (GR, G20, ...)
      - 3.2.2.2. The value of  $S\lambda$  of the resulting blend of pipeline...
      - 3.2.2.3. The engine test report for each test run shall include...
      - 3.2.2.4. The requirements of Appendices 1 and 2 shall be met...
      - 3.2.2.5. In the case that one or more of the gas...

## Appendix 1

Supplementary requirements for conducting emission testing using gaseous reference fuels...

1. Method of gas analysis and gas flow measurement
  - 1.1. For the purpose of this Appendix, where required the composition...
  - 1.2. For the purpose of this Appendix, where required the measurement...
2. Analysis and flowrate of incoming utility gas supply
  - 2.1. The composition of the utility gas supply shall be analysed...
  - 2.2. The flowrate of the utility gas entering the admixture blending...
3. Analysis and flowrate of admixture
  - 3.1. When an applicable certificate of analysis is available for an...
  - 3.2. Where an applicable certificate of analysis is not available for...
  - 3.3. The flowrate of each admixture entering the admixture blending system...
4. Analysis of blended gas
  - 4.1. The analysis of the composition of the gas supplied to...

5. Calculation of  $S\lambda$  and MN of the blended gas
  - 5.1. The results of the gas analysis according to point 2.1,...
6. Control and verification of gas blend during the test
  - 6.1 The control and verification of the gas blend during the...
  - 6.2 Open loop blend control system
    - 6.2.1 In this case the gas analysis, flow measurements and calculations...
    - 6.2.2 The proportion of utility gas and admixture(s) shall be set...
    - 6.2.3 When the relative proportions have been set they shall be...
    - 6.2.4 When the emission test has been completed the analysis of...
  - 6.3 Closed loop blend control system
    - 6.3.1 In this case the analysis of gas composition, flow measurements...
    - 6.3.2 The results from the periodic measurements and calculations shall be...
    - 6.3.3 In order for the test to be considered valid the...

## Appendix 2

### Calculation of $\lambda$ -Shift factor ( $S\lambda$ )

1. Calculation
2. Examples for the calculation of the  $\lambda$ -shift factor  $S\lambda$ :

## Appendix 3

### Correction for CO<sub>2</sub> in the exhaust gas arising from CO<sub>2</sub>...

1. Instantaneous mass flow rate of CO<sub>2</sub> in the gaseous fuel...
  - 1.1. Gas composition and gas flow shall be determined according to...
  - 1.2. The instantaneous mass flow rate of CO<sub>2</sub> in a stream...
  - 1.3. In order to determine the total mass flow rate of...
2. Calculation of specific CO<sub>2</sub> emissions for transient (NRTC and LSI-NRTC)...
  - 2.1. The total mass per test of CO<sub>2</sub> emission from the...
  - 2.2. The total mass of CO<sub>2</sub> emission  $m_{CO_2}$  [g/test] used...
3. Calculation of specific CO<sub>2</sub> emissions for discrete-mode NRSC
  - 3.1. The mean mass flow of CO<sub>2</sub> emission from the CO<sub>2</sub>...
  - 3.2. The mean mass flow rate of CO<sub>2</sub> emission  $q_{m,CO_2}$ ...

## ANNEX X

### Detailed technical specifications and conditions for delivering an engine separately from its exhaust after-treatment system

1. Separate shipment, as set out in Article 34(3) of Regulation...
2. In this case, the manufacturer shall:
  - 2.1. Be considered responsible for the placing on the market of...
  - 2.2. Place all orders for the parts shipped separately before shipping...
  - 2.3. Make available to the OEM the instructions for installation of...
  - 2.4. Keep records of:

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- 2.4.1. keep these records for at least 10 years;
  - 2.4.2. Make the records available to the approval authority, the European...
  - 2.5. Ensure that, in addition to the statutory marking required by...
  - 2.6. Ensure that the parts shipped separately from the engines have...
  - 2.7. Ensure that in the case of a transition engine, the...
    - 2.7.1. The records set out in point 2.4 shall include evidence...
3. The OEM shall:
- 3.1. Confirm to the manufacturer that the engine has been brought...
  - 3.2. Where an OEM receives a regular supply of engines from...

#### ANNEX XI

Detailed technical specifications and conditions for the temporary placing on the market for the purposes of field testing

The following conditions shall apply for the temporary placing on...

1. The ownership of the engine shall remain with the manufacturer...
2. Before placing the engine on the market, the manufacturer shall...
3. The engine shall be accompanied by a statement of conformity...
4. The engine shall bear the statutory marking set out in...
5. When the tests have been completed and in any case...
6. Notwithstanding point 5, the manufacturer may apply for an extension...
  - 6.1. The approval authority may authorise the extension, if deemed justified...

#### ANNEX XII

Detailed technical specifications and conditions for special purpose engines

The following conditions shall apply for placing on the market...

1. Before placing the engine on the market, the manufacturer shall...
2. For the purposes of point 1, a written statement from...
3. The manufacturer shall:
4. The engine shall be accompanied by a statement of conformity...
5. The engine shall bear the statutory marking set out in...

### ANNEX XIII

#### Acceptance of equivalent engine type-approvals

1. For engine families or engines types of category NRE the...

### ANNEX XIV

#### Details of the relevant information and instructions for OEMs

1. As required by Article 43(2) of Regulation (EU) 2016/1628, the...
2. The instructions may be provided on paper or a commonly...
3. Where a number of engines requiring the same instructions are...
4. The information and instructions to the OEM shall include at...
5. As required by Article 43(3) of Regulation (EU) 2016/1628, the...
6. As required by Article 43(4) of Regulation (EU) 2016/1628, the...

### ANNEX XV

#### Details of the relevant information and instructions for end-users

1. The OEM shall provide to the end-users all information and...
2. The instructions to the end-users shall be:
  - 2.1. written in a clear and non-technical manner using the same...
  - 2.2. be provided on paper or, alternatively, a commonly used electronic...
  - 2.3. be part of the instructions to end-users for the non-road...
    - 2.3.1. when delivered separately from the instructions to end-users for the...
3. The information and instructions to the end-users shall include at...
4. As required by Article 43(4) of Regulation (EU) 2016/1628, the...

### ANNEX XVI

#### Performance standards and assessment of technical services

1. General Requirements
2. Standards with which the technical services have to comply
  - 2.1. Technical services of the different categories set out in Article...
  - 2.2. Reference to Article 41 of Directive 2007/46/EC in that Appendix...
  - 2.3. Reference to Annex IV of Directive 2007/46/EC in that Appendix...
3. Procedure for the assessment of the technical services
  - 3.1. The compliance of the Technical services with the requirements of...
  - 3.2. References to Article 42 of Directive 2007/46/EC in Appendix 2...

## ANNEX XVII

### Characteristics of the steady-state and transient test cycles

1. Tables of test modes and weighting factors for the discrete-mode...
2. Tables of test modes and weighting factors for the RMC...
3. Tables of engine dynamometer schedules for transient (NRTC and LSI-NRTC)...

#### Appendix 1

##### Steady-state discrete-mode NRSC

- Test cycles type C
- Test cycles type D
- Test cycles type E
- Test cycle type F
- Test cycle type G
- Test cycle type H

#### Appendix 2

##### Steady-state ramped modal cycles (RMC)

- Test cycles type C
- Test cycles type D
- Test cycles type E
- Test cycle type F
- Test cycles type G
- Test cycle type H

#### Appendix 3

- 2.4.2.1 Transient (NRTC and LSI-NRTC) test cycles
  - NRTC engine dynamometer schedule
  - LSI-NRTC engine dynamometer schedule

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- (1) [OJ L 252, 16.9.2016, p. 53.](#)
- (2) Council Decision of 27 November 1997 with a view to accession by the European Community to the Agreement of the United Nations Economic Commission for Europe concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted to and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions ('Revised 1958 Agreement') ([OJ L 346, 17.12.1997, p. 78](#)).
- (3) [http://www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29glob\\_registry.html](http://www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29glob_registry.html)
- (4) [OJ L 88, 22.3.2014, p. 1.](#)

**Changes to legislation:**

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