List of Annexes

ANNEX I

SCOPE, DEFINITIONS, SYMBOLS AND ABBREVIATIONS, ENGINE MARKINGS, SPECIFICATIONS AND TESTS, SPECIFICATION OF CONFORMITY OF PRODUCTION ASSESSMENTS, PARAMETERS DEFINING THE ENGINE FAMILY, CHOICE OF THE PARENT ENGINE

1. SCOPE

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2. DEFINITIONS, SYMBOLS AND ABBREVIATIONS

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2.1. . . . . .

2.2. . . . . .

2.3. . . . . .

2.4. . . . . .

2.5. . . . . .

2.6. . . . . .

2.7. . . . . .

2.8. . . . . .

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2.8a. . . . . .

2.8b. . . . . .

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2.8c. . . . . .

2.8d. . . . . .

2.9. . . . . .

3.6. . . . . .

3.7. . . . . .

4. SPECIFICATIONS AND TESTS

4.1. CI engines

4.1.1. General

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4.1.2. Specifications concerning the emissions of pollutants

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4.1.2.1. . . . . .

4.1.2.2. . . . . .

4.1.2.3. . . . . .

4.1.2.4. . . . . .

Engines for use in other applications than propulsion of inland waterway vessels, locomotives and railcars:

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Engines for propulsion of inland waterway vessels

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Engines for propulsion of locomotives

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Engines for propulsion of railcars

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4.1.2.5. . . . . .

Engines for use in other applications than propulsion of locomotives, railcars and inland waterway vessels

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Engines for propulsion of railcars

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Engines for propulsion of locomotives:

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4.1.2.6. . . . . .
Engines for use in other applications than propulsion of locomotives, railcars and inland waterway vessels

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4.1.2.7. . . . . .

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4.1.2.8. . . . . .

4.2. SI engines

4.2.1. General

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4.2.2. Specifications concerning the emissions of pollutants.

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4.2.2.1. . . . . .

4.2.2.2. . . . . .

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4.2.2.3. . . . . .

4.3. Installation on the mobile machinery

. . . . . .

4.3.1. . . . . .

4.3.2. . . . . .

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5.1. . . . . .

5.2. . . . . .

5.2.1. . . . . .

5.2.2. . . . . .

5.2.3. . . . . .

5.2.4. . . . . .

5.2.5. . . . . .

5.3. . . . . .

5.3.1. . . . . .

5.3.2. . . . . .

5.3.2.1. . . . . .

5.3.2.2. . . . . .

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5.3.3. . . . . .

5.3.4. . . . . .

6. PARAMETERS DEFINING THE ENGINE FAMILY

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6.1. . . . . .

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6.2. . . . . .

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6.3. . . . . .

6.4. . . . . .

6.5. . . . . .

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6.6. . . . . .

6.7. . . . . .

6.8. . . . . .

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6.9. . . . . .

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8.4.3. . . . . .

8.4.4. . . . . .

8.4.5. . . . . .

8.4.6. *Use and maintenance requirements*

8.4.6.1. . . . . .

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. . . . . .

8.4.7. *Reagent control (where applicable)*

8.4.7.1. . . . . .

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8.4.7.2. . . . . .

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8.5. **Requirements on NO_x control measures for Stage IV engines**

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8.5.3. . . . . .

8.5.4. . . . . .

8.5.5. . . . . .

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8.6. **Control area for stage IV**

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8.6.1. Demonstration requirements

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8.6.2. Test requirements

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8.7.1. . . . . .

8.7.2. . . . . .

8.7.3. . . . . .

8.7.3.1. Crankcase emissions

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9. SELECTION OF ENGINE POWER CATEGORY

9.1. . . . . .

9.2. . . . . .

Appendix 1

Requirements to ensure the correct operation of NO_x control measures

1. **Introduction**

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1.1. *Definitions and abbreviations*

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2. **General requirements**

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2.1. *Required information*

2.1.1. . . . . .

2.1.2. . . . . .

2.1.3. . . . . .

2.2. *Operating conditions*

2.2.1. . . . . .

. . . . . .

. . . . . .

2.3. *Reagent freeze protection*

2.3.1. . . . . .

2.3.1.1. . . . . .

2.3.2. . . . . .

2.3.2.1. . . . . .

2.3.2.2. Design criteria for a heated system

. . . . . .

2.3.2.2.1.. . . . . .

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:

. . . . . .

2.3.2.2.3.. . . . . .

2.3.2.3. . . . . .

2.3.3. . . . . .

2.3.3.1. . . . . .

2.3.3.2. . . . . .

2.4. *Diagnostic requirements*

2.4.1. . . . . .

2.4.2. Requirements for recording Diagnostic Trouble Codes (DTCs)

2.4.2.1. . . . . .

2.4.2.2. . . . . .

2.4.2.3. . . . . .

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

. . . . . .

2.4.4. . . . . .

2.4.5. . . . . .

2.4.6. NCD engine family

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2.4.6.1. Parameters defining an NCD engine family

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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.

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3.2. . . . . .

3.3. . . . . .

3.4. . . . . .

3.5. . . . . .

3.6. . . . . .

4. **Operator warning system**

4.1. . . . . .

4.2. . . . . .

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:

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4.4. . . . . .

4.5. . . . . .

4.6. . . . . .

4.7. . . . . .

4.8. . . . . .

4.9. . . . . .

5. **Operator inducement system**

5.1. . . . . .

. . . . . .

5.2. . . . . .

5.3. *Low-level inducement system*

5.3.1. . . . . .

5.3.2. . . . . .

5.3.3. . . . . .

5.4. *Severe inducement system*

5.4.1. . . . . .

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:

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5.5. . . . . .

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5.6. . . . . .

5.7. . . . . .

5.8. . . . . .

6. **Reagent availability**

6.1. *Reagent level indicator*

. . . . . .

6.2. *Activation of the operator warning system*

6.2.1. . . . . .

6.2.2. . . . . .

6.2.3. . . . . .

6.2.4. . . . . .

6.2.5. . . . . .

6.3. *Activation of the operator inducement system*

6.3.1. . . . . .

6.3.2. . . . . .

6.3.3. . . . . .

7. **Reagent quality monitoring**

7.1. . . . . .

7.1.1. . . . . .

7.1.1.1. . . . . .

7.1.2. . . . . .

7.1.3. . . . . .

7.1.3.1. . . . . .

7.1.4. . . . . .

7.2. *Activation of the operator warning system*

. . . . . .

7.3. *Activation of the operator inducement system*

7.3.1. . . . . .

7.3.2. . . . . .

7.3.3. . . . . .

8. **Reagent dosing activity**

8.1. . . . . .

8.2. *Reagent dosing activity counter*

8.2.1. . . . . .

8.2.1.1. . . . . .

8.2.2. . . . . .

8.3. *Activation of the operator warning system*

. . . . . .

8.4. *Activation of the operator inducement system*

8.4.1. . . . . .

8.4.2. . . . . .

8.4.3. . . . . .

9. **Monitoring failures that may be attributed to tampering**

9.1. . . . . .

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9.2. *Monitoring requirements*

9.2.1. . . . . .

. . . . . .

9.2.2. EGR valve counter

9.2.2.1. . . . . .

9.2.2.1.1. . . . . .

9.2.2.2. . . . . .

9.2.3. NCD system counter(s)

9.2.3.1. . . . . .

9.2.3.1.1. . . . . .

9.2.3.2. . . . . .

9.3. *Activation of the operator warning system*

. . . . . .

9.4. *Activation of the operator inducement system*

9.4.1. . . . . .

9.4.2. . . . . .

9.4.3. . . . . .

9.5. . . . . .

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10. **Demonstration requirements**

10.1. *General*

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10.2. *Engine families And NCD engine families*

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10.2.1. . . . . .

10.2.2. . . . . .

10.2.3. . . . . .

10.3. *Demonstration of the warning system activation*

10.3.1. . . . . .

10.3.2. Selection of the failures to be tested

10.3.2.1. . . . . .

10.3.2.2. . . . . .

. . . . . .

10.3.3. Demonstration

10.3.3.1. . . . . .

10.3.3.2. . . . . .

10.3.3.3. . . . . .

10.3.3.4. . . . . .

10.3.3.5. Detection of failures other than lack of reagent

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10.3.3.6. Detection in case of lack of reagent

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10.3.3.6.1. . . . . .

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

. . . . . .

10.3.3.7. NCD test cycle

10.3.3.7.1. . . . . .

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

. . . . . .

10.3.4. . . . . .

10.4. *Demonstration of the inducement system activation*

10.4.1. . . . . .

10.4.1.1. . . . . .

10.4.1.2. . . . . .

10.4.2. . . . . .

10.4.3. . . . . .

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10.4.4. . . . . .

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10.4.4.1. . . . . .

10.4.5. Demonstration test of the low level inducement system

10.4.5.1. . . . . .

10.4.5.2. . . . . .

10.4.5.2.1. . . . . .

10.4.5.3. . . . . .

10.4.5.4. . . . . .

10.4.6. Demonstration test of the severe inducement system

10.4.6.1. . . . . .

10.4.6.2. . . . . .

10.4.6.2.1. . . . . .

10.4.6.3. . . . . .

10.4.6.4. . . . . .

10.4.7. . . . . .

10.4.7.1. . . . . .

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

11.1. . . . . .

11.2. *Activation and deactivation mechanisms of the warning system*

11.2.1. . . . . .

. . . . . .

11.2.2. . . . . .

11.2.2.1. Requirements for erasing 'NO_x control information'

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

. . . . . .

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11.2.2.1.2. . . . . .

11.2.2.1.3. . . . . .

11.2.2.1.4. . . . . .

11.3. *Activation and deactivation mechanism of the operator inducement system*

11.3.1. . . . . .

11.3.2. . . . . .

11.3.3. . . . . .

11.4. *Counter mechanism*

11.4.1. General

11.4.1.1. . . . . .

. . . . . .

11.4.1.1.1. . . . . .

11.4.1.2. . . . . .

11.4.1.3. . . . . .

11.4.1.3.1. . . . . .

11.4.2. Principle of counters mechanism

11.4.2.1. . . . . .

. . . . . .

11.5. *Illustration of the activation and deactivation and counter mechanisms*

11.5.1. . . . . .

11.5.2. . . . . .

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11.5.3. . . . . .

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11.5.4. . . . . .

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

12.1. . . . . .

12.2. . . . . .

12.3. . . . . .

Appendix 2

Control Area requirements for stage IV engines

1. **Engine control area**

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ANNEX II

INFORMATION DOCUMENT No. …

relating to type-approval and referring to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery

(Directive 97/68/EC as last amended by Directive ../…/EC)

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Appendix 1

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2. MEASURES TAKEN AGAINST AIR POLLUTION

2.1. . . . . .

2.2. . . . . .

2.2.1. . . . . .

2.2.1.1. . . . . .

2.2.1.2. . . . . .

2.2.1.3. . . . . .

2.2.1.4. . . . . .

2.2.1.5. . . . . .

2.2.1.6. . . . . .

2.2.1.7. . . . . .

2.2.1.8. . . . . .

2.2.1.9. . . . . .

2.2.1.10. . . . . .

2.2.1.11. . . . . .

2.2.1.12. . . . . .

2.2.1.13. . . . . .

2.2.1.13.1. . . . . .

2.2.1.13.2. . . . . .

2.2.1.13.3. . . . . .

2.2.1.14. . . . . .

2.2.2. . . . . .

2.2.2.1. . . . . .

2.2.2.2. . . . . .

2.2.2.3. . . . . .

2.2.3. . . . . .

2.2.3.1. . . . . .

2.2.4. . . . . .

2.2.4.1. . . . . .

2.2.5. . . . . .

2.2.5.1. . . . . .

2.2.5.2. . . . . .

2.2.5.3. . . . . .

2.2.5.4. . . . . .

2.2.5.5. . . . . .

2.2.6. . . . . .

2.2.6.1. . . . . .

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5. VALVE TIMING

5.1. . . . . .

5.2. Reference and/or setting ranges

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

5.3.1. . . . . .

5.3.2. . . . . .

6. PORTING CONFIGURATION

6.1. . . . . .

7. IGNITION SYSTEM

7.1. Ignition coil

7.1.1. . . . . .

7.1.2. . . . . .

7.1.3. . . . . .

7.2. . . . . .

7.2.1. . . . . .

7.2.2. . . . . .

7.3. . . . . .

7.3.1. . . . . .

7.3.2. . . . . .

7.4. . . . . .

7.4.1. . . . . .

7.4.2. . . . . .

Appendix 2

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Appendix 3

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2. MEASURES TAKEN AGAINST AIR POLLUTION

2.1. . . . . .

2.2. . . . . .

2.2.1. . . . . .

2.2.1.1. . . . . .

2.2.1.2. . . . . .

2.2.1.3. . . . . .

2.2.1.4. . . . . .

2.2.1.5. . . . . .

2.2.1.6. . . . . .

2.2.1.7. . . . . .

2.2.1.8. . . . . .

2.2.1.9. . . . . .

2.2.1.10. . . . . .

2.2.1.11. . . . . .

2.2.1.12. . . . . .

2.2.1.13. . . . . .

2.2.1.13.1. . . . . .

2.2.1.13.2. . . . . .

2.2.1.13.3. . . . . .

2.2.1.14. . . . . .

2.2.2. . . . . .

2.2.2.1. . . . . .

2.2.2.2. . . . . .

2.2.2.3. . . . . .

2.2.3. . . . . .

2.2.3.1. . . . . .

2.2.4. . . . . .

2.2.4.1. . . . . .

2.2.5. . . . . .

2.2.5.1. . . . . .

2.2.5.2. . . . . .

2.2.5.3. . . . . .

2.2.5.4. . . . . .

2.2.5.5. . . . . .

2.2.6. . . . . .

2.2.6.1. . . . . .

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ANNEX III

TEST PROCEDURE FOR C.I. ENGINES

1. INTRODUCTION

1.1. . . . . .

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1.2. *Selection of test procedure*

. . . . . .

1.2.1. Test procedure for stages I, II, IIIA, IIIB and IV

. . . . . .

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. . . . . .

1.2.1.1. . . . . .

1.3. Measurement principle:

. . . . . .

1.3.1. NRSC test:

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1.3.2. *NRTC test*

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2. TEST CONDITIONS

2.1. General requirements

. . . . . .

2.2. Engine test conditions

2.2.1. . . . . .

. . . . . .

2.2.2. Test validity

. . . . . .

. . . . . .

2.2.3. Engines with charge air cooling

. . . . . .

. . . . . .

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2.3. Engine air inlet system

. . . . . .

2.4. Engine exhaust system

. . . . . .

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2.5. Cooling system

. . . . . .

2.6. Lubricating oil

. . . . . .

2.7. Test fuel

. . . . . .

. . . . . .

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2.8. Determination of dynamometer settings

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3. TEST RUN (NRSC TEST)

3.1. Determination of dynamometer settings

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3.2. Preparation of the sampling filters

. . . . . .

3.3. Installation of the measuring equipment

. . . . . .

3.4. Starting the dilution system and engine

. . . . . .

3.5. Adjustment of the dilution ratio

. . . . . .

. . . . . .

. . . . . .

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. . . . . .

. . . . . .

3.6. Checking the analysers

. . . . . .

3.7. Test cycle

3.7.1. . . . . .

3.7.1.1. *Specification A*

. . . . . .

. . . . . .

3.7.1.2. *Specification B*

. . . . . .

. . . . . .

. . . . . .

3.7.1.3. *Specification C*

. . . . . .

. . . . . .

. . . . . .

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3.7.1.4. *Specification D*

. . . . . .

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3.7.2. Conditioning of the engine

. . . . . .

3.7.3. Test sequence

. . . . . .

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3.7.4. Analyser response

. . . . . .

3.7.5. Particulate sampling

. . . . . .

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. . . . . .

3.7.6. Engine conditions

. . . . . .

. . . . . .

. . . . . .

3.8. Re-checking the analysers

. . . . . .

4. TEST RUN (NRTC TEST)

4.1. Introduction

. . . . . .

4.1.1. . . . . .

4.2. Engine mapping procedure

. . . . . .

4.2.1. Determination of the mapping speed range

. . . . . .

. . . . . .

4.2.2. Engine mapping curve

. . . . . .

4.2.2.1. Transient map

. . . . . .

4.2.2.2. Step map

. . . . . .

4.2.3. Mapping curve generation

. . . . . .

4.2.4. Alternate mapping

. . . . . .

4.2.5. Replicate tests

. . . . . .

. . . . . .

4.3. Generation of the reference test cycle

4.3.1. *Reference speed*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

4.3.2. Denormalisation of engine speed

. . . . . .

4.3.3. Denormalisation of engine torque

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4.3.4. Example of denormalisation procedure

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4.4. Dynamometer

4.4.1. . . . . .

4.4.2. . . . . .

4.5. **Emissions test run**

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4.5.1. *Preparation of the sampling filters*

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4.5.2. *Installation of the measuring equipment*

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4.5.3. *Starting the dilution system*

. . . . . .

4.5.4. *Starting the particulate sampling system*

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4.5.5. *Checking the analysers*

. . . . . .

4.5.6. *Cool-down requirements*

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4.5.7. *Cycle run*

4.5.7.1. *Cold start cycle*

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4.5.7.2. *Analyser response*

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4.5.7.3. *Particulate sampling*

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4.5.7.4. *Engine stalling during the cold start test cycle*

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4.5.7.5. *Operations after cold start cycle*

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4.5.7.6. *Hot soak*

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4.5.7.7. *Hot start cycle*

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4.5.7.8. *Engine stalling during the hot start cycle*

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4.5.7.9. *Operations after hot start cycle*

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4.6. Verification of the test run

4.6.1. Data shift

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4.6.2. Calculation of the cycle work

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4.6.3. Validation statistics of the test cycle

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Table 1 — Regression line tolerances

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Table 2 — Permitted point deletions from regression analysis (points to which the point deletion is applied have to be specified)

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Appendix 1

MEASUREMENT AND SAMPLING PROCEDURES

1. MEASUREMENT AND SAMPLING PROCEDURES (NRSC TEST)

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1.1. Dynamometer specification

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1.2. Exhaust gas flow

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1.2.1. Direct measurement method

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1.2.2. Air and fuel measurement method

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1.2.3. Carbon balance method

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1.2.4. Tracer measurement method

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1.2.5. Air flow and air to fuel ratio measurement method

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1.2.6. Total dilute exhaust gas flow

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1.3. Accuracy

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Table 3 — Accuracy of measuring instruments

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1.4. Determination of the gaseous components

1.4.1. General analyser specifications

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1.4.1.1. Measurement error

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1.4.1.2. Repeatability

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1.4.1.3. Noise

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1.4.1.4. Zero drift

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1.4.1.5. Span drift

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1.4.2. Gas drying

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1.4.3. Analysers

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1.4.3.1. Carbon monoxide (CO) analysis

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1.4.3.2. Carbon dioxide (CO_2) analysis

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1.4.3.3. Hydrocarbon (HC) analysis

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1.4.3.4. Oxides of nitrogen (NO_x) analysis

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1.4.4. Air to fuel measurement

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1.4.5. Sampling for gaseous emissions

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1.5. Determination of the particulates

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1.5.1. Particulate sampling filters

1.5.1.1. Filter specification

. . . . . .

1.5.1.2. Filter size

. . . . . .

1.5.1.3. Primary and back-up filters

. . . . . .

1.5.1.4. Filter face velocity

. . . . . .

1.5.1.5. Filter loading

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1.5.2. Weighing chamber and analytical balance specifications

1.5.2.1. Weighing chamber conditions

. . . . . .

1.5.2.2. Reference filter weighing

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1.5.2.3. Analytical balance

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1.5.2.4. Elimination of static electricity effects

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1.5.3. Additional specifications for particulate measurement

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2. MEASUREMENT AND SAMPLING PROCEDURES (NRTC TEST)

2.1. Introduction

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2.2. Dynamometer and test cell equipment

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2.2.1. Engine dynamometer

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2.2.2. Other instruments

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Table 3 — Accuracy of measuring instruments

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2.2.3. Raw exhaust gas flow

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Direct measurement method

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Air and fuel measurement method

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Tracer measurement method

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Air flow and air to fuel ratio measurement method

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2.2.4. Diluted exhaust gas flow

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2.3. Determination of the gaseous components

2.3.1. General analyser specifications

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2.3.1.1. Measurement error

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2.3.1.2. Repeatability

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2.3.1.3. Noise

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2.3.1.4. Zero drift

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2.3.1.5. Span drift

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2.3.1.6. Rise time

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2.3.2. Gas drying

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2.3.3. Analysers

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2.3.3.1. Carbon monoxide (CO) analysis

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2.3.3.2. Carbon dioxide (CO_2) analysis

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2.3.3.3. Hydrocarbon (HC) analysis

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2.3.3.4. Oxides of nitrogen (NO_x) analysis

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2.3.4. Air to fuel measurement

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2.3.5. Sampling of gaseous emissions

2.3.5.1. Raw exhaust gas flow

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2.3.5.2. Diluted exhaust gas flow

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2.4. Determination of the particulates

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2.4.1. Particulate sampling filters

2.4.1.1. Filter specification

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2.4.1.2. Filter size

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2.4.1.3. Primary and back-up filters

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2.4.1.4. Filter face velocity

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2.4.1.5. Filter loading

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2.4.2. Weighing chamber and analytical balance specifications

2.4.2.1. Weighing chamber conditions

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2.4.2.2. Reference filter weighing

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2.4.2.3. Analytical balance

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2.4.2.4. Elimination of static electricity effects

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2.4.3. Additional specifications for particulate measurement

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Appendix 2

CALIBRATION PROCEDURE (NRSC, NRTC)

1. CALIBRATION OF THE ANALYTICAL INSTRUMENTS

1.1. Introduction

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1.2. Calibration gases

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1.2.1. Pure gases

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1.2.2. Calibration and span gases

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1.3. Operating procedure for analysers and sampling system

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1.4. Leakage test

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1.5. Calibration procedure

1.5.1. Instrument assembly

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1.5.2. Warming-up time

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1.5.3. NDIR and HFID analyser

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1.5.4. Calibration

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1.5.5. Establishment of the calibration curve

1.5.5.1. General guidelines

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1.5.5.2. Calibration below 15 % of full scale

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1.5.5.3. Alternative methods

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1.6. Verification of the calibration

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1.7. Efficiency test of the NO_x converter

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1.7.1. Test set-up

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1.7.2. Calibration

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1.7.3. Calculation

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1.7.4. Adding of oxygen

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1.7.5. Activation of the ozonator

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1.7.6. NO_x mode

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1.7.7. De-activation of the ozonator

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1.7.8. NO mode

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1.7.9. Test interval

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1.7.10. Efficiency requirement

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1.8. Adjustment of the FID

1.8.1. Optimization of the detector response

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1.8.2. Hydrocarbon response factors

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1.8.3. Oxygen interference check

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1.8.3.1. Oxygen interference gases

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1.8.3.2. Procedure

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1.9. Interference effects with NDIR and CLD analysers

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1.9.1. CO analyser interference check

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1.9.2. NO_x analyser quench checks

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1.9.2.1. CO_2 quench check

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1.9.2.2. Water quench check

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1.10. Calibration intervals

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1.11. Additional calibration requirements for raw exhaust measurements over NRTC test

1.11.1. Response time check of the analytical system

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1.11.2. Calibration of tracer gas analyser for exhaust flow measurement

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2. CALIBRATION OF THE PARTICULATE MEASURING SYSTEM

2.1. Introduction

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2.2. Flow measurement

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2.3. Checking the dilution ratio

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2.4. Checking the partial flow conditions

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2.5. Calibration intervals

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2.6. Additional calibration requirements for partial flow dilution systems

2.6.1 Periodical calibration

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2.6.2. Carbon flow check

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2.6.3. Pre-test check

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2.6.4. Determination of the transformation time

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3. CALIBRATION OF THE CVS SYSTEM

3.1. General

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3.2. Calibration of the positive displacement pump (PDP)

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3.2.1. Data analysis

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3.3. Calibration of the critical flow venturi (CFV)

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3.3.1. Data analysis

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3.4. Calibration of the subsonic venturi (SSV)

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3.4.1. Data analysis

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3.5. Total system verification

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3.5.1. Metering with a critical flow orifice

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3.5.2. Metering by means of a gravimetric technique

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Appendix 3

DATA EVALUATION AND CALCULATIONS

1. DATA EVALUATION AND CALCULATIONS — NRSC TEST

1.1. Gaseous emissions data evaluation

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1.2. Particulate emissions

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1.3. Calculation of the gaseous emissions

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1.3.1. Determination of the exhaust gas flow

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1.3.2. Dry/wet correction

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1.3.3. Humidity correction for NO_x

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1.3.4. Calculation of emission mass flow rates

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Table 4: Values of the coefficients u - wet for various exhaust components

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1.3.5. Calculation of the specific emissions

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1.4. Calculation of the particulate emission

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1.4.1. Humidity correction factor for particulates

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1.4.2. Partial flow dilution system

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1.4.2.1. Isokinetic systems

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1.4.2.2. Systems with measurement of CO_2 or NO_x concentration

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1.4.2.3. Systems with CO2 measurement and carbon balance method

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1.4.2.4. Systems with flow measurement

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1.4.3. Full flow dilution system

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1.4.4. Calculation of the particulate mass flow rate

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1.4.5. Calculation of the specific emissions

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1.4.6. Effective weighting factor

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2. DATA EVALUATION AND CALCULATIONS (NRTC TEST)

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2.1. Calculation of gaseous emissions in the raw exhaust gas and of the particulate emissions with a partial flow dilution system

2.1.1. Introduction

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2.1.2. Determination of the gaseous components

2.1.2.1. Calculation of mass emission

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Table 4: Values of the coefficients u — wet for various exhaust components

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2.1.2.2. Dry/wet correction

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2.1.2.3. NO_x correction for humidity and temperature

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2.1.2.4. *Calculation of the specific emissions*

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2.1.3. Particulate determination

2.1.3.1. *Calculation of mass emission*

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2.1.3.2. Particulate correction factor for humidity

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2.1.3.3. *Calculation of the specific emissions*

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2.2. Determination of gaseous and particulate components with a full flow dilution system

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2.2.1. Determination of the diluted exhaust gas flow

PDP-CVS system

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CFV-CVS system

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SSV-CVS system

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2.2.2. NO_x correction for humidity

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2.2.3. Calculation of the emission mass flow

2.2.3.1. Systems with constant mass flow

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2.2.3.1.1. Determination of the background corrected concentrations

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2.2.3.2. Systems with flow compensation

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2.2.4. *Calculation of the specific emissions*

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2.2.5. Calculation of the particulate emission

2.2.5.1. *Calculation of the mass flow*

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2.2.5.2. Particulate correction factor for humidity

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2.2.5.3. *Calculation of the specific emissions*

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Appendix 4

NRTC ENGINE DYNAMOMETER SCHEDULE

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Appendix 5

Durability requirements

1. VERIFYING THE DURABILITY OF STAGE IIIA AND STAGE IIIB CI ENGINES

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1.1. . . . . .

1.1.1. . . . . .

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1.2. **DF information in approval applications**

1.2.1. . . . . .

1.2.2. . . . . .

1.2.3. . . . . .

2. VERIFYING THE DURABILITY OF STAGE IV CI ENGINES

2.1. **General**

2.1.1. . . . . .

2.1.2. . . . . .

2.1.3. . . . . .

2.1.4. . . . . .

2.1.5. . . . . .

2.2. **Definitions**

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2.2.1. . . . . .

2.2.2. . . . . .

2.2.3. . . . . .

2.2.4. . . . . .

2.2.5. . . . . .

2.2.6. . . . . .

2.2.7. . . . . .

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

2.3.1. . . . . .

2.3.2. . . . . .

2.3.3. . . . . .

2.3.3.1. . . . . .

2.4. **Establishing emission durability period deterioration factors**

2.4.1. *General*

. . . . . .

2.4.2. *Service accumulation schedule*

. . . . . .

2.4.2.1. In-service and dynamometer service accumulation

2.4.2.1.1. . . . . .

2.4.2.1.2. . . . . .

2.4.2.1.3. . . . . .

2.4.2.1.4. . . . . .

2.4.2.1.5. . . . . .

2.4.2.1.6. . . . . .

2.4.2.1.7. . . . . .

2.4.2.1.8. . . . . .

2.4.2.1.9. . . . . .

2.4.2.1.10. . . . . .

2.4.2.2. . . . . .

2.4.3. *Engine testing*

2.4.3.1. Engine system stabilisation

2.4.3.1.1. . . . . .

2.4.3.1.2. . . . . .

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 Section 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 Section 2.4.2.2, the engine shall be tested for gaseous and particulate emissions over the hot NRTC and NRSC cycles.

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2.4.3.2.2. . . . . .

2.4.3.2.3. . . . . .

2.4.4. *Reporting*

2.4.4.1. . . . . .

2.4.4.2. . . . . .

2.4.5. *Determination of deterioration factors*

2.4.5.1. . . . . .

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2.4.5.2. . . . . .

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2.4.5.3. . . . . .

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2.4.6. *Assigned deterioration factors*

2.4.6.1. . . . . .

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2.4.7. *Application of deterioration factors*

2.4.7.1. . . . . .

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2.4.7.2. . . . . .

2.4.7.3. . . . . .

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2.4.7.4. . . . . .

2.4.8. *Checking of conformity of production*

2.4.8.1. . . . . .

2.4.8.2. . . . . .

2.4.8.3. . . . . .

2.5. **Maintenance**

. . . . . .

2.5.1. *Emission-related scheduled maintenance*

2.5.1.1. . . . . .

2.5.1.2. . . . . .

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2.5.1.3. . . . . .

2.5.2. *Changes to scheduled maintenance*

2.5.2.1. . . . . .

2.5.3. *Non-emission-related scheduled maintenance*

2.5.3.1. . . . . .

2.5.4. *Repair*

2.5.4.1. . . . . .

2.5.4.2. . . . . .

3. EMISSION DURABILITY PERIOD FOR STAGE IIIA, IIIB AND IV ENGINES

3.1. . . . . .

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Appendix 6

Determination of CO_2 Emissions for Stage I, II, IIIA, IIIB and IV Engines

1. **Introduction**

1.1. . . . . .

2. **General requirements**

2.1. . . . . .

2.2. . . . . .

2.3. . . . . .

3. **Determination of CO_2 emissions**

3.1. *Raw measurement*

. . . . . .

3.1.1. Measurement

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3.1.2. Data evaluation

. . . . . .

3.1.3. Calculation of cycle averaged emission

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3.2. *Dilute measurement*

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3.2.1. Measurement

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3.2.2. Data evaluation

. . . . . .

3.2.3. Calculation of cycle averaged emission

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3.3. *Calculation of brake specific emissions*

3.3.1. NRSC

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3.3.2. NRTC

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Appendix 7

Alternative determination of CO_2 emissions

1. **Introduction**

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2. **General requirements**

2.1. . . . . .

2.2. . . . . .

3. **Determination of CO_2 emissions**

3.1. *Raw measurement*

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3.1.1. Measurement

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. . . . . .

3.1.2. Data evaluation

. . . . . .

3.1.3. Calculation of cycle averaged emission

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. . . . . .

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3.2. *Dilute measurement*

. . . . . .

3.2.1. Measurement

. . . . . .

. . . . . .

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3.2.2. Data evaluation

. . . . . .

3.2.3. Calculation of cycle averaged emission

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3.3. *Calculation of brake specific emissions*

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ANNEX IV

TEST PROCEDURE FOR SPARK IGNITION ENGINES

1. INTRODUCTION

1.1. . . . . .

1.2. . . . . .

2. TEST CONDITIONS

2.1. Engine test conditions

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2.1.1. Test validity

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2.1.2. Engines with charge air-cooling

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2.2. Engine air inlet system

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2.3. Engine exhaust system

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2.4. Cooling system

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2.5. Lubricating oil

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2.6. Adjustable carburettors

. . . . . .

2.7. Test fuel

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2.8. Determination of dynamometer settings

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3. TEST RUN

3.1. Installation of the measuring equipment

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3.2. Starting the dilution system and engine

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3.3. Adjustment of the dilution ratio

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3.4. Checking the analysers

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3.5. Test cycle

3.5.1. . . . . .

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3.5.1.1. Test modes and weighting factors

3.5.1.2. Choosing an appropriate test cycle

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3.5.1.3. Examples (the list is not exhaustive)

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3.5.2. Conditioning of the engine

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3.5.3. Test sequence

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3.5.4. Analyser response

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3.5.5. Engine conditions

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3.6. Rechecking the analysers

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Appendix 1

1. MEASUREMENT AND SAMPLING PROCEDURES

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1.1. Dynamometer specification

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1.2. Fuel flow and total diluted flow

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1.3. Accuracy

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1.4. Determination of the gaseous components

1.4.1. General analyser specifications

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1.4.1.1. Accuracy

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1.4.1.2. Repeatability

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1.4.1.3. Noise

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1.4.1.4. Zero drift

. . . . . .

1.4.1.5. Span drift

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1.4.2. Gas drying

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1.4.3. Analysers

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1.4.3.1. Carbon monoxide (CO) analysis

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1.4.3.2. Carbon dioxide (CO_2) analysis

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1.4.3.3. Oxygen (O_2) analysis

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1.4.3.4. Hydrocarbon (HC) analysis

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1.4.3.5. Oxides of nitrogen (NO_x) analysis

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1.4.4. Sampling for gaseous emissions

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Appendix 2

1. CALIBRATION OF THE ANALYTICAL INSTRUMENTS

1.1. Introduction

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1.2. Calibration gases

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1.2.1 Pure gases

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1.2.2 Calibration and span gases

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1.2.3 Oxygen interference check

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1.3. Operating procedure for analysers and sampling system

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1.4. Leakage test

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1.5. Calibration procedure

1.5.1 Instrument assembly

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1.5.2. Warming-up time

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1.5.3. NDIR and HFID analyser

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1.5.4. GC and HPCL

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1.5.5. Establishment of the calibration curves

1.5.5.1. General guidelines

. . . . . .

1.5.5.2. Alternative methods

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1.6. Verification of the calibration

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1.7. Calibration of tracer gas analyser for exhaust flow measurement

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1.8. Efficiency test of the NO_x converter

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1.8.1. Test set-up

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1.8.2. Calibration

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1.8.3. Calculation

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1.8.4. Adding of oxygen

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1.8.5 Activation of the ozonator

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1.8.6 NO_x mode

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1.8.7. Deactivation of the ozonator

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1.8.8. NO mode

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1.8.9. Test interval

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1.8.10. Efficiency requirement

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1.9. Adjustment of the FID

1.9.1. Optimisation of the detector response

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1.9.2. Hydrocarbon response factors

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1.9.3. Oxygen interference check

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1.10. Interference effects with CO, CO_2, NO_X and O_2 analysers

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1.10.1. CO analyser interference check

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1.10.2. NO_x analyser quench checks

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1.10.2.1. CO_2 quench check

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1.10.2.2. Water quench check

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1.10.3. O_2 analyser interference

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1.11. Calibration intervals

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Appendix 3

1. DATA EVALUATION AND CALCULATIONS

1.1. Gaseous emissions evaluation

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1.2. Calculation of the gaseous emissions

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1.2.1. Dry/wet correction

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1.2.2. Humidity correction for NO_x

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1.2.3. Calculation of emission mass flow rate

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1.2.4. Calculation of specific emissions

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2. EXAMPLES

2.1. Raw exhaust gas data from a four-stroke SI engine

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2.1.1. Dry/wet correction factor k_w

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2.1.2. HC emissions

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2.1.3. NO_x emissions

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2.1.4 CO emissions

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2.1.5. CO_2 emissions

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2.1.6. Specific emissions

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2.2. Raw exhaust gas data from a two-stroke SI engine

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2.2.1 Dry/wet correction factor k_w

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2.2.2. HC emissions

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2.2.3. NO_x emissions

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2.2.4. CO emissions

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2.2.5. CO_2 emissions

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2.2.6. Specific emissions

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2.3. Diluted exhaust gas data from a four-stroke SI engine

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2.3.1. Dry/wet correction factor k_w

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2.3.2. HC emissions

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2.3.3. NO_x emissions

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2.3.4. CO emissions

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2.3.5. CO_2 emissions

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2.3.6. Specific emissions

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Appendix 4

1. COMPLIANCE WITH EMISSION STANDARDS

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1.1. . . . . .

1.2. . . . . .

1.3. . . . . .

1.3.1. . . . . .

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1.4. . . . . .

1.4.1. . . . . .

1.4.1.1. . . . . .

1.4.1.2 . . . . . .

1.4.1.3 . . . . . .

1.4.1.4. . . . . .

1.4.1.5. . . . . .

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1.4.1.6. . . . . .

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2. EMISSION DURABILITY PERIODS FOR STAGE 2 ENGINES

2.1. . . . . .

2.1.1. . . . . .

2.1.2. . . . . .

2.1.3. . . . . .

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ANNEX V

TECHNICAL CHARACTERISTICS OF REFERENCE FUEL PRESCRIBED FOR APPROVAL TESTS AND TO VERIFY CONFORMITY OF PRODUCTION
NON-ROAD MOBILE MACHINERY REFERENCE FUEL FOR CI ENGINES TYPE APPROVED TO MEET STAGE I and II LIMIT VALUES AND FOR ENGINES TO BE USED IN INLAND WATERWAY VESSELS

. . . . . .
NON-ROAD MOBILE MACHINERY REFERENCE FUEL FOR CI ENGINES TYPE APPROVED TO MEET STAGE IIIA LIMIT VALUES.

. . . . . .
NON-ROAD MOBILE MACHINERY REFERENCE FUEL FOR CI ENGINES TYPE APPROVED TO MEET STAGE IIIB AND IV LIMIT VALUES.

. . . . . .
NON-ROAD MOBILE MACHINERY REFERENCE FUEL FOR SI ENGINES

ANNEX VI

ANALYTICAL AND SAMPLING SYSTEM

1. GASEOUS AND PARTICULATE SAMPLING SYSTEMS

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1.1. Determination of the gaseous emissions

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1.1.1. Gaseous exhaust components CO, CO_2, HC, NO_x

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Descriptions — Figures 2 and 3

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— SP1 raw exhaust gas sampling probe (Figure 2 only)

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— SP2 dilute exhaust gas HC sampling probe (Figure 3 only)

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— SP3 dilute exhaust gas CO, CO_2, NO_x sampling probe (Figure 3 only)

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— HSL1 heated sampling line

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— HSL2 heated NO_x sampling line

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— SL sampling line for CO (CO_2)

. . . . . .

— BK background bag (optional; Figure 3 only)

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— BG sample bag (optional; Figure 3 CO and CO_2 only)

. . . . . .

— F1 heated pre-filter (optional)

. . . . . .

— F2 heated filter

. . . . . .

— P heated sampling pump

. . . . . .

— HC

. . . . . .

— CO, CO_2

. . . . . .

— NO_2

. . . . . .

— C converter

. . . . . .

— B cooling bath

. . . . . .

. . . . . .

— T1, T2, T3 temperature sensor

. . . . . .

— T4 temperature sensor

. . . . . .

— T5 temperature sensor

. . . . . .

— G1, G2, G3 pressure gauge

. . . . . .

— R1, R2 pressure regulator

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— R3, R4, R5 pressure regulator

. . . . . .

— FL1, FL2, FL3 flow meter

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— FL4 to FL7 flow meter (optional)

. . . . . .

— V1 to V6 selector valve

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— V7, V8 solenoid valve

. . . . . .

— V9 needle valve

. . . . . .

— V10, V11 needle valve

. . . . . .

— V12, V13 toggle valve

. . . . . .

— V14 selector valve

. . . . . .

1.2. Determination of the particulates

. . . . . .

1.2.1. Dilution system

1.2.1.1. Partial flow dilution system (Figures 4 to 12)

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— isokinetic systems (Figures 4 and 5)

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— flow controlled systems with concentration measurement (Figures 6 to 10)

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— flow controlled systems with flow measurement (Figures 11 and 12)

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Description - Figures 4 to 12

— EP exhaust pipe

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— SP sampling probe (Figures 6 to 12)

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— ISP isokinetic sampling probe (Figures 4 and 5)

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— FD1, FD2 flow divider (Figure 9)

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— FD3 flow divider (Figure 10)

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— EGA exhaust gas analyser (Figures 6 to 10)

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— TT transfer tube (Figures 4 to 12)

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— DPT differential pressure transducer (Figures 4, 5 and 10)

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— FC1 flow controller (Figures 4, 5 and 10)

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— PCV1, PCV2 pressure control valve (Figure 9)

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— DC damping chamber (Figure 10)

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— VN venturi (Figure 8)

. . . . . .

— FC2 flow controller (Figures 6, 7, 11 and 12; optional)

. . . . . .

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— FM1 flow measurement device (Figures 6, 7, 11 and 12)

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— FM2 flow measurement device (Figure 12)

. . . . . .

— PB pressure blower (Figures 4, 5, 6, 7, 8, 9 and 12)

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— SB suction blower (Figures 4, 5, 6, 9, 10 and 12)

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— DAF dilution air filter (Figures 4 to 12)

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— PSP particulate sampling probe (Figures 4, 5, 6, 8, 9, 10 and 12)

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— DT dilution tunnel (Figures 4 to 12)

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1.2.1.2. Full flow dilution system (Figure 13)

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Descriptions (Figure 13)

— EP exhaust pipe

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— PDP positive displacement pump

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— CFV critical flow venturi

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— SSV subsonic venturi

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— HE heat exchanger (optional if EFC is used)

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— EFC electronic flow compensation (optional if HE is used)

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— DT dilution tunnel

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— DAF dilution air filter

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— PSP particulate sampling probe

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1.2.2. Particulate sampling system (Figures 14 and 15)

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Descriptions - Figures 14 and 15

— PSP particulate sampling probe (Figures 14 and 15)

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— PTT particulate transfer tube (Figures 14 and 15)

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— SDT secondary dilution tunnel (Figure 15)

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— FH filter holder(s) (Figures 14 and 15)

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— P sampling pump (Figures 14 and 15)

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— DP dilution air pump (Figure 15) (full flow double dilution only)

. . . . . .

— FC3 flow controller (Figures 14 and 15)

. . . . . .

— FM3 flow measurement device (Figures 14 and 15) (particulate sample flow)

. . . . . .

— FM4 flow measurement device (Figure 15) (dilution air, full flow double dilution only)

. . . . . .

— BV ball valve (optional)

. . . . . .

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1.a. . . . . .

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ANNEX VII

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Appendix 1

Test report for compression ignition engines test results
Information concerning the test engine

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. . . . . .

1. . . . . .

1.1. Reference fuel used for test

1.1.1. . . . . .

1.1.2. . . . . .

1.1.3. . . . . .

1.2. Lubricant

1.2.1. . . . . .

1.2.2. . . . . .

. . . . . .

1.3. Engine driven equipment (if applicable)

1.3.1. . . . . .

1.3.2. . . . . .

. . . . . .

1.4. Engine performance

1.4.1. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

1.4.2. Engine power

. . . . . .

2. . . . . .

2.1. Dynamometer setting (kW)

. . . . . .

2.2. Emission results of the engine/parent engine

. . . . . .

. . . . . .

. . . . . .

. . . . . .

2.3. . . . . .

2.3.1. . . . . .

2.3.2. . . . . .

2.3.2.1. . . . . .

3. . . . . .

3.1. Emission results of the engine/parent engine

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. . . . . .

3.2. . . . . .

. . . . . .

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Appendix 2

TEST RESULTS FOR SPARK IGNITION ENGINES

1. INFORMATION CONCERNING THE CONDUCT OF THE TEST(S):

1.1. Octane number

1.1.1. . . . . .

1.1.2. . . . . .

1.1.3. . . . . .

1.2. Lubricant

1.2.1. . . . . .

1.2.2. . . . . .

1.3. Engine driven equipment (if applicable)

1.3.1. . . . . .

1.3.2. . . . . .

1.4. Engine performance

1.4.1. . . . . .

. . . . . .

. . . . . .

. . . . . .

1.4.2. . . . . .

1.5. Emission levels

1.5.1. . . . . .

1.5.2. . . . . .

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Appendix 3

EQUIPMENT AND AUXILIARIES TO BE INSTALLED
FOR THE TEST TO DETERMINE ENGINE POWER

ANNEX VIII

APPROVAL CERTIFICATE NUMBERING SYSTEM

(see Article 4 (2))

1. . . . . .

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2. . . . . .

. . . . . .

3. . . . . .

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ANNEX IX

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ANNEX X

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ANNEX XI

DATA SHEET OF TYPE-APPROVED ENGINES

1. **SI Engines**

. . . . . .

2. **CI Engines**

2.1. *General engine information*

. . . . . .

2.2. *Final emission result*

. . . . . .

2.3. *NRSC deterioration factors and emission test results*

. . . . . .

2.4. *NRTC deterioration factors and emission test results*

. . . . . .

2.5. *NRTC hot start emission test results*

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ANNEX XII

RECOGNITION OF ALTERNATIVE TYPE-APPROVALS

1. The following type-approvals and, where applicable, the pertaining approval marks are recognised as being equivalent to an approval to this Directive for engines of categories A, B and C as defined in Article 9(2):

. . . . . .

2. For engines categories D, E, F and G (stage II) as defined in Article 9(3), the following type-approvals and, where applicable, the pertaining approval marks are recognised as being equivalent to an approval to this Directive:

. . . . . .

3. For engines categories H, I, J and K (stage IIIA) as defined in Article 9(3a) and Article 9(3b), the following type-approvals and, where applicable, the pertaining approval marks are recognised as being equivalent to an approval to this Directive:

. . . . . .

4. For engines categories L, M, N and P (stage IIIB) as defined in Article 9(3c), the following type-approvals and, where applicable, the pertaining approval marks are recognised as being equivalent to an approval to this Directive:

. . . . . .

5. For engines categories Q and R (stage IV) as defined in Article 9(3d), the following type-approvals and, where applicable, the pertaining approval marks are recognised as being equivalent to an approval to this Directive:

. . . . . .

ANNEX XIII

PROVISIONS FOR ENGINES PLACED ON THE MARKET UNDER A ‘FLEXIBLE SCHEME’

. . . . . .

1. ACTIONS BY THE OEM

1.1. . . . . .

1.1.1. . . . . .

1.1.2. As an optional alternative to Section 1.1.1 and with the exception of engines for the propulsion of railcars and locomotives, the OEM may seek permission for the OEM's engine manufacturers to place on the market a fixed number of engines for the OEM's exclusive use. The number of engines in each engine category shall not exceed the following ceilings:

1.2. . . . . .

1.2.1. . . . . .

1.2.2. As an optional alternative to Section 1.2.1, the OEM may seek permission for the OEM's engine manufacturers to place on the market a fixed number of engines for the OEM's exclusive use. The number of engines in each engine category shall not exceed the following ceilings:

1.3. As regards engines for use in the propulsion of locomotives, during Stage III B, but for a period no longer than 3 years from the beginning of that stage, an OEM may seek permission for the OEM's engine manufacturers to place on the market a maximum of 16 engines for the OEM's exclusive use. The OEM may also seek permission for his engine manufacturers to place on the market a maximum of 10 additional engines with rated powers greater than 1 800 kW to be installed in locomotives designed exclusively for use on the United Kingdom network. Locomotives will be considered to meet this requirement only if they have, or are able to be issued with, a safety certificate for operation on the United Kingdom network.

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1.4. The OEM shall include in the application to an approval authority the following information:

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1.5. . . . . .

1.6. . . . . .

2. ACTIONS BY THE ENGINE MANUFACTURER

2.1. . . . . .

2.2. . . . . .

3. ACTIONS BY THE APPROVAL AUTHORITY

3.1. . . . . .

ANNEX XIV

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ANNEX XV

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