UNITED
NATIONS

E

Economic and Social Council

Distr.
GENERAL

TRANS/WP.29/871
19 July 2002

ENGLISH
Original: ENGLISH
and FRENCH

**ECONOMIC COMMISSION FOR EUROPE**

INLAND TRANSPORT COMMITTEE

World Forum for Harmonization of Vehicle Regulations (WP.29)

DRAFT 04 SERIES OF AMENDMENTS TO REGULATION No. 49

(Emissions of C.I., NG and P.I. (LPG) engines)

Note: The text reproduced below was adopted by the Administrative Committee (AC.1) of the amended 1958 Agreement at its twenty-first session, following the recommendation by WP.29 at its one-hundred-and-twenty-seventh session. It is based on documents TRANS/WP.29/2002/37 and TRANS/WP.29/2002/37/Add.1 (English) not amended (TRANS/WP.29/861, para. 151).

___________

Paragraph 2.7., amend to read:

"2.7. "gaseous pollutants" means carbon monoxide, hydrocarbons (assuming a ratio of $CH_{1.85}$ for diesel, $CH_{2.525}$ for LPG and an assumed molecule $CH_3O_{0.5}$ for ethanol-fuelled diesel engines), non-methane hydrocarbons (assuming a ratio of $CH_{1.85}$ for diesel fuel, $CH_{2.525}$ for LPG and $CH_{2.93}$ for NG), methane (assuming a ratio of $CH_4$ for NG) and oxides of nitrogen, the last-named being expressed in nitrogen dioxide ($NO_2$) equivalent;

"particulate pollutants" means any material collected on a specified filter medium after diluting the exhaust with clean filtered air so that the temperature does not exceed 325 K (52°C);"

Paragraph 2.26., (French only).

Paragraph 2.28., amend to read:

"2.28. "Defeat Device" means a device which measures, senses or responds to operating variables (e.g. vehicle speed, engine speed, gear used, temperature, intake pressure or any other parameter) for the purpose of activating, modulating, delaying or deactivating the operation of any component or function of the emission control system such that the effectiveness of the emission control system is reduced under conditions encountered during normal vehicle use unless the use of such a device is substantially included in the applied emission certification test procedures."

Paragraphs 2.28.1. and 2.28.2., should be deleted.

Insert new paragraphs 2.29. and 2.30., to read:

"2.29. “Auxiliary control device” means a system, function or control strategy installed to an engine or on a vehicle, that is used to protect the engine and/or its ancillary equipment against operating conditions that could result in damage or failure, or is used to facilitate engine starting. An auxiliary control device may also be a strategy or measure that has been satisfactorily demonstrated not to be a defeat device.

2.30. “Irrational emission control strategy” means any strategy or measure that, when the vehicle is operated under normal conditions of use, reduces the effectiveness of the emission control system to a level below that expected on the applicable emission test procedures."

Paragraphs 2.29. and 2.29.1., renumber as paragraphs 2.31. and 2.31.1.

Paragraph 2.29.2., renumber as paragraph 2.31.2., and amend to read:

"2.31.2. Symbols for the Chemical Components

| | |
|---|---|
| $CH_4$ | Methane |
| $C_2H_6$ | Ethane |
| $C_2H_5OH$ | Ethanol |
| $C_3H_8$ | Propane |
| CO | Carbon monoxide |
| DOP | Di-octylphtalate |
| $CO_2$ | Carbon dioxide |
| HC | Hydrocarbons |
| NMHC | Non-methane hydrocarbons |
| NOx | Oxides of nitrogen |
| NO | Nitric oxide |

| | |
|---|---|
| $NO_2$ | Nitrogen dioxide |
| PT | Particulates" |

Paragraph 2.29.3., renumber as paragraph 2.31.3.

Paragraphs 4.1.1. and 4.1.2., amend to read:

"4.1.1. In the case of diesel fuel: if pursuant to paragraphs 3.1., 3.2. or 3.3. of this Regulation, the engine or vehicle meets the requirements of paragraphs 5, 6 and 7 below on the reference fuel specified in annex 5 of this Regulation, approval of that type of engine or vehicle must be granted.

4.1.2. In the case of natural gas the parent engine should demonstrate its capability to adapt to any fuel composition that may occur across the market. In the case of natural gas there are generally two types of fuel, high calorific fuel (H-gas) and low calorific fuel (L-gas), but with a significant spread within both ranges; they differ significantly in their energy content expressed by the Wobbe Index and in their $\lambda$-shift factor ($S_\lambda$). The formulae for the calculation of the Wobbe index and $S_\lambda$ are given in paragraphs 2.25. and 2.26. Natural gases with a $\lambda$-shift factor between 0.89 and 1.08 ($0.89 \leq S\lambda \leq 1.08$) are considered to belong to H-range, while natural gases with a $\lambda$-shift factor between 1.08 and 1.19 ($1.08 \leq S\lambda \leq 1.19$) are considered to belong to L-range. The composition of the reference fuels reflects the extreme variations of $S_\lambda$.

The parent engine must meet the requirements of this Regulation on the reference fuels GR (fuel 1) and G25 (fuel 2), as specified in annex 6, without any readjustment to the fuelling between the two tests. However, one adaptation run over one ETC cycle without measurement is permitted after the change of the fuel. Before testing, the parent engine must be run-in using the procedure given in paragraph 3 of appendix 2 to annex 4."

Insert new paragraph 4.1.2.1., to read:

"4.1.2.1. On the manufacturer's request the engine may be tested on a third fuel (fuel 3) if the $\lambda$-shift factor ($S_\lambda$) lies between 0.89 (i.e. the lower range of GR) and 1.19 (i.e. the upper range of G25), for example when fuel 3 is a market fuel. The results of this test may be used as a basis for the evaluation of the conformity of production."

Paragraphs 4.1.3. and 4.1.3.1., amend to read:

"4.1.3. In the case of an engine fuelled with natural gas which is self-adaptive for the range of H-gases on the one hand and the range of L-gases on the other hand, and which switches between the H-range and the L-range by means of a switch, the parent engine must be tested at each position of the switch on the reference fuel relevant for the respective position as specified in annex 6 for each range. The fuels are GR (fuel 1) and G23 (fuel 3) for the H-range of gases and G25 (fuel 2) and G23 (fuel 3) for the L-range of gases. The parent engine must meet the requirements of this Regulation at both positions of the switch without any readjustment to the fuelling between the two tests at the respective position of the switch. However, one adaptation run over one ETC cycle without measurement is permitted after the change of the fuel. Before testing the parent engine must be run-in using the procedure given in paragraph 3 of appendix 2 to annex 4.

4.1.3.1. On the manufacturer's request the engine may be tested on a third fuel instead of G23 (fuel 3) if the λ-shift factor ($S_\lambda$) lies between 0.89 (i.e the lower range of GR) and 1.19 (i.e. the upper range of G25), for example when fuel 3 is a market fuel. The results of this test may be used as a basis for the evaluation of the conformity of the production."

<u>Paragraph 4.1.3.2.</u>, renumber as paragraph 4.1.4., and amend to read:

"4.1.4. In the case of natural gas engines, the ratio of emission results "r" shall be determined...."

<u>Paragraph 4.1.4. (former)</u>, renumber as paragraph 4.1.5.

<u>Paragraph 4.1.4.1.</u>, renumber as paragraph 4.1.5.1., and amend to read:

"4.1.5.1. The ratio of emission results "r" must be determined for each pollutant as follows:

$$r = \frac{\text{emission result on reference fuel B}}{\text{emission result on reference fuel A}}$$

"

<u>Paragraphs 4.2. to 4.2.1.1.</u>, amend to read:

"4.2. <u>Granting of a fuel range restricted approval</u>

Fuel range restricted approval is granted subject to the following requirements:

4.2.1. Exhaust emissions approval of an engine running on natural gas and laid out for operation on either the range of H-gases or on the range of L-gases.

The parent engine must be tested on the relevant reference fuel as specified in annex 6 for the relevant range. The fuels are GR (fuel 1) and G23 (fuel 3) for the H-range of gases and G25 (fuel 2) and G23 (fuel 3) for the L-range of gases. The parent engine must meet the requirements of this Regulation without any readjustment to the fuelling between the two tests. However, one adaptation run over one ETC cycle without measurement is permitted after the change of the fuel. Before testing the parent engine must be run-in using the procedure defined in paragraph 3 of appendix 2 to annex 4.

4.2.1.1. On the manufacturer's request the engine may be tested on a third fuel instead of G23 (fuel 3) if the λ-shift factor ($S_\lambda$) lies between 0.89 (i.e. the lower range of GR) and 1.19 (i.e. the upper range of G25), for example when fuel 3 is a market fuel. The results of this test may be used as a basis for the evaluation of the conformity of the production."

Paragraphs 4.2.2.1. to 4.2.2.3., amend to read:

"4.2.2.1. The parent engine must meet the emission requirements on the reference fuels GR and G25 in the case of natural gas, or the reference fuels A and B in the case of LPG, as specified in annex 7.

Between the tests fine-tuning of the fuelling system is allowed. This fine-tuning will consist of a recalibration of the fuelling database, without any alteration to either the basic control strategy or the basic structure of the database. If necessary the exchange of parts that are directly related to the amount of fuel flow (such as injector nozzles) is allowed.

4.2.2.2. On the manufacturer’s request the engine may be tested on the reference fuels GR and G23, or on the reference fuels G25 and G23, in which case the approval is only valid for the H-range or the L-range of gases respectively.

4.2.2.3. Upon delivery to the customer the engine must bear a label (see paragraph 4.11.) stating for which fuel composition the engine has been calibrated."

Insert new tables concerning approval of NG-fuelled and LPG-fuelled engines, after paragraph 4.2.2.3., to read as follows:

"APPROVAL OF NG-FUELLED ENGINES

| | **Para. 4.1.**<br>**Granting of a universal fuel approval** | **Number of test runs** | **Calculation of "r"** | **Para. 4.2.**<br>**Granting of a fuel restricted approval** | **Number of test runs** | **Calculation of "r"** |
|---|---|---|---|---|---|---|
| refer to para. 4.1.2. NG-engine adaptable to any fuel composition | GR (1) and G25 (2)<br>at manufacturerís request engine may be tested on an additional market fuel (3), if $S_\lambda$ = 0.89 ñ 1.19 | 2<br><br>(max. 3) | $r = \frac{\text{fuel 2(G25)}}{\text{fuel 1(GR)}}$<br>and, if tested with an <u>additional fuel</u><br>$ra = \frac{\text{fuel 2(G25)}}{\text{fuel 3(market fuel)}}$<br>and<br>$rb = \frac{\text{fuel 1(GR)}}{\text{fuel 3(G23 or market fuel)}}$ | | | |
| refer to para. 4.1.3. NG-engine which is self adaptive by a switch | GR (1) and G23 (3) for H<br><u>and</u><br>G25 (2) and G23 (3) for L<br>at manufacturerís request engine may be tested on a market fuel (3) instead of G23, if $S_\lambda$ = 0.89 ñ 1.19 | 2 for the H-range, and<br>2 for the L-range at respective position of switch<br><br>4 | $rb = \frac{\text{fuel 1(GR)}}{\text{fuel 3(G23 or market fuel)}}$<br>and<br>$ra = \frac{\text{fuel 2(G25)}}{\text{fuel 3(G23 or market fuel)}}$ | | | |
| refer to para. 4.2.1. NG-engine laid out for operation on either H-range gas or L-range gas | | | | GR (1) and G23 (3) for H<br><u>or</u><br>G25 (2) and G23 (3) for L<br>at manufacturerís request engine may be tested on a market fuel (3) instead of G23, if $S_\lambda$ = 0.89 ñ 1.19 | 2 for the H-range<br>or<br>2 for the L-range<br><br>2 | $rb = \frac{\text{fuel 1(GR)}}{\text{fuel 3(G23 or market fuel)}}$<br>for the H-range<br><u>or</u><br>$ra = \frac{\text{fuel 2(G25)}}{\text{fuel 3(G23 or market fuel)}}$<br>for the L-range |
| refer to para. 4.2.2. NG-engine laid out for operation on one specific fuel composition | | | | GR (1) and G25 (2), fine-tuning between the tests allowed<br><br>at manufacturerís request engine may be tested on<br>GR (1) and G23 (3) for H<br>or<br>G25 (2) and G23 (3) for L | 2<br>or<br>2 for the H-range<br>or<br>2 for the L-range<br><br>2 | |

APPROVAL OF LPG-FUELLED ENGINES

| | **Para. 4.1.<br>Granting of a universal fuel approval** | **Number of test runs** | **Calculation of "r"** | **Para. 4.2.<br>Granting of a fuel restricted approval** | **Number of test runs** | **Calculation of "r"** |
|---|---|---|---|---|---|---|
| refer to<br>para. 4.1.5<br>LPG-engine adaptable to any fuel composition | fuel A and fuel B | 2 | $r = \frac{\text{fuel B}}{\text{fuel A}}$ | | | |
| refer to<br>para. 4.2.2<br>LPG-engine laid out for operation on one specific fuel composition | | | | fuel A and fuel B,<br>fine-tuning between the tests allowed | 2 | |

"

Paragraph 4.4., amend to read:

"4.4. An approval number shall be assigned to each type approved. Its first two digits (at present 04, corresponding to 04 series of amendments) shall indicate the series ...."

Paragraphs 5.1. and 5.1.1., amend to read:

"5.1. General

5.1.1. Emission control equipment"

Insert new paragraphs 5.1.1.1. to 5.1.4.2., to read:

"5.1.1.1. The components liable to affect the emission of gaseous and particulate pollutants from diesel engines and the emission of gaseous pollutants from gas engines shall be so designed, constructed, assembled and installed as to enable the engine, in normal use, to comply with the provisions of this Regulation.

5.1.2. Functions of emission control equipment

5.1.2.1. The use of a defeat device and/or an irrational emission control strategy is forbidden.

5.1.2.2. An auxiliary control device may be installed to an engine, or on a vehicle, provided that the device:

5.1.2.2.1. operates only outside the conditions specified in paragraph 5.1.2.4., or

5.1.2.2.2. is activated only temporarily under the conditions specified in paragraph 5.1.2.4. for such purposes as engine damage protection, air-handling device protection, smoke management, cold start or warming-up, or

5.1.2.2.3. is activated only by on-board signals for purposes such as operational safety and limp-home strategies;

5.1.2.3. An engine control device, function, system or measure that operates during the conditions specified in paragraph 5.1.2.4 and which results in the use of a different or modified engine control strategy to that normally employed during the applicable emission test cycles will be permitted if, in complying with the requirements of paragraphs 5.1.3. and/or 5.1.4., it is fully demonstrated that the measure does not reduce the effectiveness of the emission control system. In all other cases, such devices shall be considered to be a defeat device.

5.1.2.4. For the purposes of paragraph 5.1.2.2., the defined conditions of use under steady state and transient conditions are:

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

(ii) an ambient temperature within the range 283 to 303 K (10 to 30°C),

(iii) engine coolant temperature within the range 343 to 368 K (70 to 95°C).

5.1.3. Special requirements for electronic emission control systems

5.1.3.1. Documentation requirements

The manufacturer shall provide a documentation package that gives access to the basic design of the system and the means by which it controls its output variables, whether that control is direct or indirect.

The documentation shall be made available in two parts:

(a) The formal documentation package, which shall be supplied to the technical service at the time of submission of the type-approval application, shall include a full description of the system. This documentation may be brief, provided that it exhibits evidence that all outputs permitted by a matrix obtained from the range of control of the individual unit inputs have been identified. This information shall be attached to the documentation required in paragraph 3 of this Regulation.

(b) Additional material that shows the parameters that are modified by any auxiliary control device and the boundary conditions under which the device operates. The additional material shall include a description of the fuel system control logic, timing strategies and switch points during all modes of operation.

The additional material shall also contain a justification for the use of any auxiliary control device and include additional material and test data to demonstrate the effect on exhaust emissions of any auxiliary control device installed to the engine or on the vehicle.

This additional material shall remain strictly confidential and be retained by the manufacturer, but be made open for inspection at the time of type-approval or at any time during the validity of the type-approval.

5.1.4. To verify whether any strategy or measure should be considered a defeat device or an irrational emission control strategy according to the definitions given in paragraphs 2.28. and 2.30., the type-approval authority and/or the technical service may additionally request a $NO_X$ screening test using the ETC which may be carried out in combination with either the type-approval test or the procedures for checking the conformity of production.

5.1.4.1. As an alternative to the requirements of appendix 4 to annex 4 to this Regulation, the emissions of $NO_X$ during the ETC screening test may be sampled using the raw exhaust gas and the technical prescriptions of ISO FDIS 16183, dated 15 September 2001, shall be followed.

5.1.4.2. In verifying whether any strategy or measure should be considered a defeat device or an irrational emission control strategy according to the definitions given in paragraphs 2.28.

and 2.30., an additional margin of 10 per cent, related to the appropriate $NO_X$ limit value, shall be accepted."

Paragraphs 8.3.2.4. and 8.3.2.5., amend to read:

"8.3.2.4. For NG fuelled engines, all these tests may be conducted with commercial fuel in the following way:

(i) for H marked engines with a commercial fuel within the H range ($0.89 \leq S_\lambda \leq 1.00$);

(ii) for L marked engines with a commercial fuel within the L range ($1.00 \leq S_\lambda \leq 1.19$);

(iii) for HL marked engines with a commercial fuel within the extreme range of the 8-shift factor ($0.89 \leq S_\lambda \leq 1.19$).

However, at the manufacturer's request, the reference fuels described in annex 6 may be used. This implies tests, as described in paragraph 4. of this Regulation.

8.3.2.5. In the case of dispute caused by the non-compliance of gas fuelled engines when using a commercial fuel, the tests must be performed with a reference fuel on which the parent engine has been tested, or with the possible additional fuel 3 as referred to in paragraphs 4.1.3.1. and 4.2.1.1., on which the parent engine may have been tested. Then, the result has to be converted by a calculation applying the relevant factor(s) "r", "ra" or "rb" as described in paragraphs 4.1.3.2., 4.1.5.1. and 4.2.1.2. If r, ra or rb are less than 1 no correction must take place. The measured results and the calculated results must demonstrate that the engine meets the limit values with all relevant fuels (fuels 1, 2 and, if applicable, fuel 3 in the case of natural gas engines and fuels A and B in the case of LPG engines)."

Paragraphs 12 to 12.4.1., amend to read:

"12. TRANSITIONAL PROVISIONS

Amend these provisions to read:

12.1. General

12.1.1. As from the official date of entry into force of the 04 series of amendments, no Contracting Party applying this Regulation must refuse to grant ECE approval under this Regulation as amended by the 04 series of amendments.

12.1.2. As from the date of entry into force of the 04 series of amendments, Contracting Parties applying this Regulation must grant ECE approvals only if the engine meets the requirements of this Regulation as amended by the 04 series of amendments.

The engine must be subject to the relevant tests set out in paragraph 5.2. to this Regulation and must, in accordance with paragraphs 12.2.1., 12.2.2. and 12.2.3. below, satisfy the relevant emission limits detailed in paragraph 5.2.1. of this Regulation.

12.2. New type approvals

12.2.1. Subject to the provisions of paragraph 12.4.1., Contracting Parties applying this Regulation must, from the date of entry into force of the 04 series of amendments to this Regulation, grant an ECE approval to an engine only if that engine satisfies the relevant emission limits of Rows A, B1, B2 or C in the tables to paragraph 5.2.1. of this Regulation.

12.2.2. Subject to the provisions of paragraph 12.4.1., Contracting Parties applying this Regulation must, from 1 October 2005, grant an ECE approval to an engine only if that engine satisfies the relevant emission limits of Rows B1, B2 or C in the tables to paragraph 5.2.1. of this Regulation.

12.2.3. Subject to the provisions of paragraph 12.4.1., Contracting Parties applying this Regulation must, from 1 October 2008, grant an ECE approval to an engine only if that engine satisfies the relevant emission limits of Rows B2 or C in the tables to paragraph 5.2.1. of this Regulation.

12.3. Limit of validity of old type approvals

12.3.1. With the exception of the provisions of paragraphs 12.3.2. and 12.3.3., as from the official date of entry into force of the 04 series of amendments, type approvals granted to this Regulation as amended by the 03 series of amendments must cease to be valid, unless the Contracting Party which granted the approval notifies the other Contracting Parties applying this Regulation that the engine type approved meets the requirements of this Regulation as amended by the 04 series of amendments, in accordance with paragraph 12.2.1. above.

12.3.2. Extension of type-approval

12.3.2.1. Paragraphs 12.3.2.2 and 12.3.2.3 below shall only be applicable to new compression-ignition engines and new vehicles propelled by a compression-ignition engine that have been approved to the requirements of row A of the tables in paragraph 5.2.1. of this Regulation.

12.3.2.2. As an alternative to paragraphs 5.1.3. and 5.1.4., the manufacturer may present to the technical service the results of a $NO_x$ screening test using the ETC on the engine conforming to the characteristics of the parent engine described in annex 1, and taking into account the provisions of paragraphs 5.1.4.1 and 5.1.4.2. The manufacturer shall also provide a written statement that the engine does not employ any defeat device or irrational emission control strategy as defined in paragraph 2 of this Regulation.

12.3.2.3. The manufacturer shall also provide a written statement that the results of the $NO_X$ screening test and the declaration for the parent engine, as referred to in paragraph 5.1.4., are also applicable to all engine types within the engine family described in annex 1.

12.3.3. Gas engines

As from the 1 October 2003, type approvals granted to gas engines to this Regulation as amended by the 03 series of amendments must cease to be valid, unless the Contracting Party which granted the approval notifies the other Contracting Parties applying this Regulation that the engine type approved meets the requirements of this Regulation as amended by the 04 series of amendments, in accordance with paragraph 12.2.1. above.

12.3.4. As from 1 October 2006, type approvals granted to this Regulation as amended by the 04 series of amendments must cease to be valid, unless the Contracting Party which granted the approval notifies the other Contracting Parties applying this Regulation that the engine type approved meets the requirements of this Regulation as amended by the 04 series of amendments, in accordance with paragraph 12.2.2. above.

12.3.5. As from 1 October 2009, type approvals granted to this Regulation as amended by the 04 series of amendments must cease to be valid, unless the Contracting Party which granted the approval notifies the other Contracting Parties applying this Regulation that the engine type approved meets the requirements of this Regulation as amended by the 04 series of amendments, in accordance with paragraph 12.2.3. above.

12.4. Replacement parts for vehicles in use

12.4.1. Contracting Parties applying this Regulation may continue to grant approvals to those engines which comply with the requirements of this Regulation as amended by any previous series of amendments, or to any level of the Regulation as amended by the 04 series of amendments, provided that the engine is intended as a replacement for a vehicle in-use and for which that earlier standard was applicable at the date of that vehicle's entry into service."

Annex 1, item 1.14, amend to read:

"1.14. Fuel: Diesel/LPG/NG-H/NG-L/NG-HL/Ethanol 1/"

Annex 1 - Appendix 3, item 1.14, amend to read:

"1.14. Fuel: Diesel/LPG/NG-H/NG-L/NG-HL/Ethanol 1/"

Annex 2A, item 10, amend to read:

"10. Emission levels of the engine/parent engine

10.1. ESC-test (if applicable):
CO:.............. g/kWh
THC:............. g/kWh
$NO_x$: ............. g/kWh
PT:.............. g/kWh

10.2. ELR-test (if applicable):
Smoke value:.............. $m^{-1}$

10.3. ETC-test (if applicable):
CO:.............. g/kWh
THC:............. g/kWh
NMHC:............ g/kWh
$CH_4$: ............. g/kWh
$NO_x$: ............. g/kWh
PT:.............. g/kWh"

Annex 2B, item 9., amend to read:

"9. Emission levels of the engine/parent engine

9.1. ESC-test (if applicable):
CO:.............. g/kWh
THC:............. g/kWh
$NO_x$: ............. g/kWh
PT:.............. g/kWh

9.2. ELR-test (if applicable):
Smoke value:............. $m^{-1}$

9.3. ETC-test (if applicable):
CO:.............. g/kWh
THC:............. g/kWh
NMHC:............ g/kWh
$CH_4$: ............. g/kWh
$NO_x$: ............. g/kWh
PT:.............. g/kWh"

Annex 3, amend to read:

"Annex 3

ARRANGEMENTS OF APPROVAL MARKS
(See paragraph 4.6. of this Regulation)

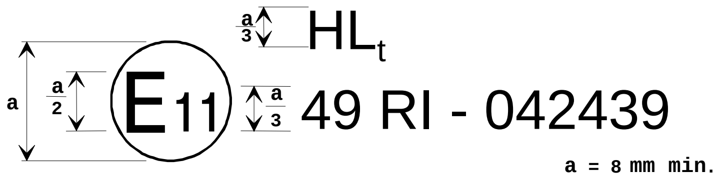
I. APPROVAL “I” (Row A).
(See paragraph 4.6.3. of this Regulation)

Model A

Engines approved to Row A emission limits and operating on diesel or liquefied petroleum gas (LPG) fuel.

Model B

Engines approved to Row A emission limits and operating on natural gas (NG) fuel.  The suffix after the national symbol indicates the fuel qualification determined in accordance with paragraph 4.6.3.1. of this Regulation.




The above approval marks affixed to an engine/vehicle show that the engine/vehicle type concerned has been approved in the United Kingdom (E11) pursuant to Regulation No. 49 and under approval number 042439. This approval indicates that the approval was given in accordance with the requirements of Regulation No. 49 with the 04 series of amendments incorporated and satisfying the relevant limits detailed in paragraph 5.2.1. of this Regulation.

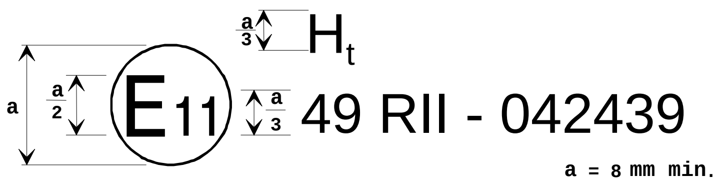
II. APPROVAL “II” (Row B1).
(See paragraph 4.6.3. of this Regulation)

Model C

Engines approved to Row B1 emission limits and operating on diesel or liquefied petroleum gas (LPG) fuel.


Model D

Engines approved to Row B1 emission limits and operating on natural gas (NG) fuel.  The suffix after the national symbol indicates the fuel qualification determined in accordance with paragraph 4.6.3.1. of this Regulation.




The above approval mark affixed to an engine/vehicle shows that the engine/vehicle type concerned has been approved in the United Kingdom (E11) pursuant to Regulation No. 49 and under approval number 042439. This approval indicates that the approval was given in accordance with the requirements of Regulation No. 49 with the 04 series of amendments incorporated and satisfying the relevant limits detailed in paragraph 5.2.1. of this Regulation.

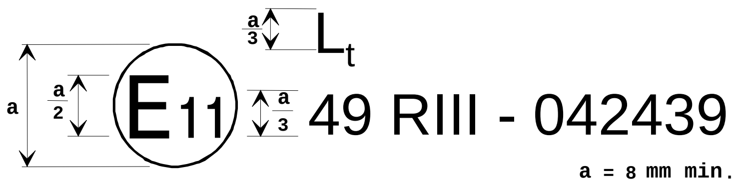
III. APPROVAL "III" (Row B2).
(See paragraph 4.6.3. of this Regulation)

Model E

Engines approved to Row B2 emission limits and operating on diesel or liquefied petroleum gas (LPG) fuel.


Model F

Engines approved to Row B2 emission limits and operating on natural gas (NG) fuel. The suffix after the national symbol indicates the fuel qualification determined in accordance with paragraph 4.6.3.1. of this Regulation.




The above approval mark affixed to an engine/vehicle shows that the engine/vehicle type concerned has been approved in the United Kingdom (E11) pursuant to Regulation No. 49 and under approval number 042439. This approval indicates that the approval was given in accordance with the requirements of Regulation No. 49 with the 04 series of amendments incorporated and satisfying the relevant limits detailed in paragraph 5.2.1. of this Regulation.

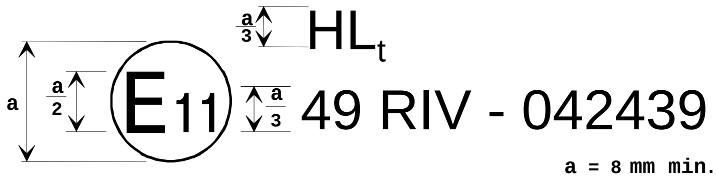
IV. APPROVAL "IV" (Row C).
(See paragraph 4.6.3. of this Regulation)

Model G

Engines approved to Row C emission limits and operating on diesel or liquefied petroleum gas (LPG) fuel.

Model H

Engines approved to Row C emission limits and operating on natural gas (NG) fuel. The suffix after the national symbol indicates the fuel qualification determined in accordance with paragraph 4.6.3.1. of this Regulation.




The above approval mark affixed to an engine/vehicle shows that the engine/vehicle type concerned has been approved in the United Kingdom (E11) pursuant to Regulation No. 49 and under approval number 042439. This approval indicates that the approval was given in accordance with the requirements of Regulation No. 49 with the 04 series of amendments incorporated and satisfying the relevant limits detailed in paragraph 5.2.1. of this Regulation.

V. ENGINE/VEHICLE APPROVED TO ONE OR MORE REGULATIONS
(See paragraph 4.7. of this Regulation)

Model I


The above approval mark affixed to an engine/vehicle shows that the engine/vehicle type concerned has been approved in the United Kingdom (E11) pursuant to Regulation No. 49 (emission level IV) and Regulation No. 24 1/. The first two digits of the approval numbers indicate that, at the dates when the respective approvals were given, Regulation No. 49 included the 04 series of amendments, and Regulation No. 24 the 03 series of amendments.

---

1/ The second Regulation number is given merely as an example.

"

Annex 4,

Paragraph 1.3., amend to read:

"1.3. Measurement principle

The emissions to be measured from the exhaust of the engine include the gaseous components (carbon monoxide, total hydrocarbons for diesel engines on the ESC test only; non-methane hydrocarbons for diesel and gas engines on the ETC test only; methane for gas engines on the ETC test only and oxides of nitrogen), the particulates (diesel engines, gas engines at stage C only) and smoke (diesel engines on the ELR test only). Additionally, carbon dioxide is often used as a tracer gas for determining the dilution ratio of partial and full flow dilution systems. Good engineering practice recommends the general measurement of carbon dioxide as an excellent tool for the detection of measurement problems during the test run."

Annex 4 - Appendix 1, paragraph 1.2., amend to read:

"1.2. Determination of dynamometer settings

The torque curve at full load must be determined by experimentation to calculate the torque values for the specified test modes under net conditions, as specified in annex 1, appendix 1, paragraph 8.2. The power absorbed by engine-driven equipment, if applicable, must be taken into account. The dynamometer setting for each test mode except idle must be calculated using the formula:
......"

Annex 4 - Appendix 2,

Paragraph 3.1., amend to read:

"3.1. Preparation of the sampling filters (if applicable)

At least one hour ...."

Paragraph 3.4., amend to read:

"3.4. Starting the particulate sampling system (if applicable)

The particulate sampling ....."

Paragraph 3.8.3., amend to read:

"3.8.3. Particulate sampling (if applicable)

At the start of the engine ....."

Paragraph 3.9.3, table 6, amend to read

"Table 6: Regression line tolerances

| | Speed | Torque | Power |
|---|---|---|---|
| Standard error of estimate (SE) of Y on X | max 100 $min^{-1}$ | max 13 % (15 %) of power map maximum engine torque | max 8% (15 %) of power map maximum engine power |
| Slope of the regression line, m | 0.95 to 1.03 | 0.83 - 1.03 | 0.89 - 1.03 (0.83 - 1.03) |
| Coefficient of determination, r≤ | min 0.9700 (min 0.9500) | min 0.8800 (min 0.7500) | min 0.9100 (min 0.7500) |
| Y intercept of the regression line, b | ± 50 $min^{-1}$ | ± 20 Nm or ± 2 % (± 20 Nm or ± 3 %) of max torque whichever is greater | ± 4 kW or ± 2 % (± 4 Kw or ± 3 %) of max power whichever is greater |

The figures shown in brackets may be used for the type-approval testing of gas engines until 1 October 2005."

Paragraph 4.3.1., amend to read:

"4.3.1. Systems with constant mass flow

For systems with heat exchanger, the mass of the pollutants (g/test) must be determined from the following equations:

(1) $NO_x$ mass = 0.001587 * NOx conc * $K_{H,D}$ * $M_{TOTW}$ (diesel engines)

(2) $NO_x$ mass = 0.001587 * NOx conc * $K_{H,G}$ * $M_{TOTW}$ (gas engines)

(3) CO mass = 0.000966 * CO conc * $M_{TOTW}$

(4) HC mass = 0.000479 * HC conc * $M_{TOTW}$' (diesel engines)

(5) HC mass = 0.000502 * HC conc * $M_{TOTW}$' (LPG fuelled engines)

(6) HC mass = 0.000552 * HC conc * $M_{TOTW}$' (NG fuelled engines)

(7) NMHC mass = 0.000479 * NMHC conc * $M_{TOTW}$' (diesel engines)

(8) NMHC mass = 0.000502 * NMHC conc * $M_{TOTW}$' (LPG fuelled engines)

(9) NMHC mass = 0.000516 * NMHC conc * $M_{TOTW}$' (NG fuelled engines)

(10) $CH_4$ mass = 0.000552 * $CH_4$ conc * $M_{TOTW}$ (NG fuelled engines)

where:

$NO_x$ conc, CO conc, HC conc, 1/ NMHC conc, $CH_4$ conc = average background corrected concentrations over the cycle from integration (mandatory for $NO_x$ and HC) or bag measurement, ppm

---

1/ Based on C1 equivalent

$M_{TOTW}$ = total mass of diluted exhaust gas over the cycle as determined in paragraph 4.1., kg

$K_{H,D}$ = humidity correction factor for diesel engines as determined in paragraph 4.2., based on cycle averaged intake air humidity

$K_{H,G}$ = humidity correction factor for gas engines as determined in paragraph 4.2., based on cycle averaged intake air humidity

Concentrations measured on a dry basis must be converted to a wet basis in accordance with annex 4, appendix 1, paragraph 4.2.

The determination of $NMHC_{conc}$ and $CH_{4\ conc}$ depends on the method used (see annex 4, appendix 4, paragraph 3.3.4.). Both concentrations must be determined as follows, whereby $CH_4$ is subtracted from HC for the determination of $NMHC_{conc}$:

(a) GC method

$$NMHC_{conc} = HC_{conc} - CH_{4\ conc}$$

$$CH_{4\ conc} = \text{as measured}$$

(b) NMC method

$$NMHC_{conc} = \frac{HC(w/o\ Cutter) * (1 - CE_M) - HC(w/Cutter)}{CE_E - CE_M}$$

$$CH_{4,conc} = \frac{HC(w/\ Cutter) - HC(w/o\ \ Cutter) \times (1 - CE_E)}{CE_E - CE_M}$$

where:

HC(w/ Cutter) = HC concentration with the sample gas flowing through the NMC

HC(w/o Cutter) = HC concentration with the sample gas bypassing the NMC

$CE_M$ = methane efficiency as determined per annex 4, appendix 5, paragraph 1.8.4.1.

$CE_E$ = ethane efficiency as determined per annex 4, appendix 5, paragraph 1.8.4.2."

Paragraph 4.3.1.1., amend to read (calculation of the dilution factor for NG-fuelled gas engines deleted):

"4.3.1.1. Determination of the background corrected concentrations

The average background concentration of the gaseous pollutants in the dilution air must be subtracted from measured concentrations to get the net concentrations of the pollutants. The average values of the background concentrations can be determined by the sample bag method or by continuous measurement with integration.  The following formula must be used.

$$conc = conc_e - conc_d * (1 - (1/DF))$$

where:

conc = concentration of the respective pollutant in the diluted exhaust gas, corrected by the amount of the respective pollutant contained in the dilution air, ppm

$conc_e$ = concentration of the respective pollutant measured in the diluted exhaust gas, ppm

$conc_d$ = concentration of the respective pollutant measured in the dilution air, ppm

DF = dilution factor

The dilution factor shall be calculated as follows:

$$DF = \frac{F_S}{CO_{2,conce} + (HC_{conce} + CO_{conce}) * 10^{-4}}$$

where:

$CO_{2,conce}$ = concentration of $CO_2$ in the diluted exhaust gas, % vol

$HC_{conce}$ = concentration of HC in the diluted exhaust gas, ppm C1

$CO_{conce}$ = concentration of CO in the diluted exhaust gas, ppm

$F_S$ = stoichiometric factor

Concentrations measured on dry basis must be converted to a wet basis in accordance with annex 4, appendix 1, paragraph 4.2.

The stoichiometric factor must be calculated as follows:

$$F_S = 100 * \frac{x}{x + \frac{y}{2} + 3.76 * \left(x + \frac{y}{4}\right)}$$

where:

x,y = fuel composition $C_xH_y$

Alternatively, if the fuel composition is not known, the following stoichiometric factors may be used:

$F_S$ (diesel) = 13.4
$F_S$ (LPG) = 11.6
$F_S$ (NG) = 9.5"

Paragraph 4.3.2., amend to read:

"4.3.2. Systems with flow compensation

For systems without heat exchanger, the mass of the pollutants (g/test) must be determined by calculating the instantaneous mass emissions and integrating the instantaneous values over the cycle. Also, the background correction must be applied directly to the instantaneous concentration value. The following formulae must be applied:

(1) $NO_{x\ mass}$ =

$$\sum_{i=1}^{n}(M_{TOTW,i} \times NOx_{conce,i} \times 0.001587 \times K_{H,D}) - (M_{TOTW} \times NOx_{concd} \times (1 - 1/DF) \times 0.001587 \times K_{H,D})$$

(diesel engines)

(2) $NO_{x\ mass}$ =

$$\sum_{i=1}^{n}(M_{TOTW,i} \times NOx_{conce,i} \times 0.001587 \times K_{H,G}) - (M_{TOTW} \times NOx_{concd} \times (1 - 1/DF) \times 0.001587 \times K_{H,G})$$

(gas engines)

(3) $CO_{mass} = \sum_{i=1}^{n}(M_{TOTW,i} \times CO_{conce,i} \times 0.000966) - (M_{TOTW} \times CO_{concd} \times (1 - 1/DF) \times 0.000966)$

(4) $HC_{mass} = \sum_{i=1}^{n}(M_{TOTW,i} \times HC_{conce,i} \times 0.000479) - (M_{TOTW} \times HC_{concd} \times (1 - 1/DF) \times 0.000479)$

(diesel engines)

(5) $HC_{mass} = \sum_{i=1}^{n}(M_{TOTW,i} \times HC_{conce,i} \times 0.000502) - (M_{TOTW} \times HC_{concd} \times (1 - 1/DF) \times 0.000502)$

(LPG engines)

(6) $HC_{mass}$ =

$$\sum_{i=1}^{n}(M_{TOTW,i} \times HC_{conce,i} \times 0.000552) - (M_{TOTW} \times HC_{concd} \times (1 - 1/DF) \times 0.000552)$$

(NG engines)

(7) $NMHC_{mass}$ =

$$\sum_{i=1}^{n}(M_{TOTW,i} \times NMHC_{conce,i} \times 0.000479) - (M_{TOTW} \times NMHC_{concd} \times (1 - 1/DF) \times 0.000479)$$

(diesel engines)

(8) $NMHC_{mass}$ =

$$\sum_{i=1}^{n}(M_{TOTW,i} \times NMHC_{conce,i} \times 0.000502) - (M_{TOTW} \times NMHC_{concd} \times (1 - 1/DF) \times 0.000502)$$

(LPG engines)

(9) $NMHC_{mass}$ =

$$\sum_{i=1}^{n}(M_{TOTW,i} \times NMHC_{conce,i} \times 0.000516) - (M_{TOTW} \times NMHC_{concd} \times (1 - 1/DF) \times 0.000516)$$

(NG engines)

(10) $CH_{4\ mass}$ =

$$\sum_{i=1}^{n}(M_{TOTW,i} \times CH_{4\ conce,i} \times 0.000552) - (M_{TOTW} \times CH_{4\ concd} * (1 - 1/DF) \times 0.000552)$$

(NG engines)

where:

$conc_e$ = concentration of the respective pollutant measured in the diluted exhaust gas, ppm

$conc_d$ = concentration of the respective pollutant measured in the dilution air, ppm

$M_{TOTW,I}$ = instantaneous mass of the diluted exhaust gas (see paragraph 4.1.), kg

$M_{TOTW}$ = total mass of diluted exhaust gas over the cycle (see paragraph 4.1.), kg

$K_{H,D}$ = humidity correction factor for diesel engines as determined in paragraph 4.2., based on cycle averaged intake air humidity

$K_{H,G}$ = humidity correction factor for gas engines as determined in paragraph 4.2., based on cycle averaged intake air humidity

DF = dilution factor as determined in paragraph 4.3.1.1."

Paragraph 4.4., amend to read:

"4.4. Calculation of the specific emissions

The emissions (g/kWh) must be calculated for the individual components, as required according to paragraphs 5.2.1. and 5.2.2. for the respective engine technology, in the following way:

$\overline{NO_x} = NOx_{mass}/W_{act}$ (diesel and gas engines)

$\overline{CO} = CO_{mass}/W_{act}$ (diesel and gas engines)

$\overline{HC} = HC_{mass}/W_{act}$ (diesel and gas engines)

$\overline{NMHC} = NMHC_{mass}/W_{act}$ (diesel and gas engines)

$\overline{CH_4} = CH_{4mass}/W_{act}$ (NG fuelled gas engines)

where:

$W_{act}$ = actual cycle work as determined in paragraph 3.9.2., kWh."

Paragraph 5., amend to read:

"5. CALCULATION OF THE PARTICULATE EMISSION (IF APPLICABLE)"

Annex 4 - Appendix 5, paragraph 1.8.2., amend to read:

"1.8.2. Hydrocarbon response factors

The analyser must be calibrated using propane in air and purified synthetic air, according to paragraph 1.5.

Response factors must be determined when introducing an analyser into service and after major service intervals. The response factor ($R_f$) for a particular hydrocarbon species is the ratio of the FID C1 reading to the gas concentration in the cylinder expressed by ppm C1.

The concentration of the test gas must be at a level to give a response of approximately 80 per cent of full scale. The concentration must be known to an accuracy of ± 2 per cent in reference to a gravimetric standard expressed in volume. In addition, the gas cylinder must be preconditioned for 24 hours at a temperature of 298 K ± 5 K (25°C ± 5°C).

The test gases to be used and the recommended relative response factor ranges are as follows:

Methane and purified synthetic air $1.00 \leq R_f \leq 1.15$ (diesel and LPG engines)

Methane and purified synthetic air $1.00 \leq R_f \leq 1.07$ (NG engines)

Propylene and purified synthetic air $0.90 \leq R_f \leq 1.1$

Toluene and purified synthetic air $0.90 \leq R_f \leq 1.10$

These values are relative to the response factor ($R_f$) of 1.00 for propane and purified synthetic air."

Annex 5,

Insert a new paragraph 2., to read:

"2. ETHANOL FOR DIESEL ENGINES [(1)]

| Parameter | Unit | Limits [(2)] | | Test Method [(3)] |
|---|---|---|---|---|
| | | Minimum | Maximum | |
| Alcohol, mass | % m/m | 92.4 | - | ASTM D 5501 |
| Other alcohol than ethanol contained in total alcohol, mass | % m/m | - | 2 | ASTM D 5501 |
| Density at 15°C | kg/m$^3$ | 795 | 815 | ASTM D 4052 |
| Ash content | % m/m | | 0.001 | ISO 6245 |
| Flash point | °C | 10 | | ISO 2719 |
| Acidity, calculated as acetic acid | % m/m | - | 0.0025 | ISO 1388-2 |
| Neutralisation (strong acid) number | KOH mg/1 | - | 1 | |
| Colour | According to scale | - | 10 | ASTM D 1209 |
| Dry residue at 100°C | mg/kg | | 15 | ISO 759 |
| Water content | % m/m | | 6.5 | ISO 760 |
| Aldehydes calculated as acetic acid | % m/m | | 0.0025 | ISO 1388-4 |
| Sulphur content | mg/kg | - | 10 | ASTM D 5453 |
| Esters, calculated as ethylacetate | % m/m | - | 0.1 | ASTM D 1617 |

(1) Cetane improver, as specified by the engine manufacturer, may be added to the ethanol fuel. The maximum allowed amount is 10 % m/m.

(2) The values quoted in the specification are “true values”. In establishment of their limit values the terms of ISO 4259, Petroleum products – Determination and application of precision data in

relation to methods of test, have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R – reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the manufacturer of a fuel should nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specification, the terms of ISO 4259 should be applied.

(3) Equivalent ISO methods will be adopted when issued for all properties listed above."

Annex 6, amend to read:

"Annex 6

TECHNICAL CHARACTERISTICS OF REFERENCE N.G. FUEL PRESCRIBED FOR APPROVAL TESTS AND TO VERIFY CONFORMITY OF PRODUCTION

Type: NATURAL GAS (NG)

European market fuels are available in two ranges:

– the H range, whose extreme reference fuels are GR and G23;
– the L range, whose extreme reference fuels are G23 and G25.

The characteristics of GR, G23 and G25 reference fuels are summarised below:

Reference fuel GR

| Characteristics | Units | Basis | Limits | | Test Method |
|---|---|---|---|---|---|
| | | | Min. | Max. | |
| Composition: | | | | | |
| Methane | % mole | 87 | 84 | 89 | |
| Ethane | % mole | 13 | 11 | 15 | |
| Balance (*) | % mole | - | - | 1 | ISO 6974 |
| Sulphur content | $mg/m^3$ (**) | - | - | 10 | ISO 6326-5 |

(*) Inerts $+C_{2+}$
(**) Value to be determined at standard conditions (293.2 K (20°C) and 101.3 kPa)

Reference fuel G23

| Characteristics | Units | Basis | Limits | | Test Method |
|---|---|---|---|---|---|
| | | | Min. | Max. | |
| Composition: | | | | | |
| Methane | % mole | 92.5 | 91.5 | 93.5 | |
| Balance (*) | % mole | - | - | 1 | ISO 6974 |
| $N_2$ | % mole | 7.5 | 6.5 | 8.5 | |
| Sulphur content | $mg/m^3$ (**) | - | - | 10 | ISO 6326-5 |

(*) Inerts (different from $N_2$) $+C_2/C_{2+}$
(**) Value to be determined at standard conditions (293.2 K (20°C) and 101.3 kPa).

Reference fuel G25

| Characteristics | Units | Basis | Limits | | Test Method |
|---|---|---|---|---|---|
| | | | Min | Max. | |
| Composition: | | | | | |
| Methane | % mole | 86 | 84 | 88 | |
| Balance (*) | % mole | - | - | 1 | ISO 6974 |
| $N_2$ | % mole | 14 | 12 | 16 | |
| Sulphur content | $mg/m^3$ (**) | - | - | 10 | ISO 6326-5 |

(*) Inerts (different from $N_2$) $+C_2/C_{2+}$
(**) Value to be determined at standard conditions (293.2 K (20°C) and 101.3 kPa).

"

Annex 7, amend to read:

"Annex 7

Type: LIQUEFIED PETROLEUM GAS (LPG)

| Parameter | Unit | Limits Fuel A | | Limits Fuel B | | Test Method |
|---|---|---|---|---|---|---|
| | | Minimum | Maximum | Minimum | Maximum | |
| Motor Octane Number | | 92.5 (1) | | 92.5 | | EN 589 Annex B |
| Composition: | | | | | | |
| C3 content | % vol | 48 | 52 | 83 | 87 | |
| C4 content | % vol | 48 | 52 | 13 | 17 | ISO 7941 |
| Olefins | % vol | | 12 | | 14 | |
| Evaporation Residue | mg/kg | | 50 | | 50 | NFM 41015 |
| Total sulphur content | ppm mass (1) | | 50 | | 50 | EN 24260 |
| Hydrogen sulphide | --- | | None | | None | ISO 8819 |
| Copper strip corrosion | rating | | class 1 | | class 1 | ISO 6251(2) |
| Water at 0°C | | | free | | free | visual inspection |

(1) Value to be determined at standard conditions 293.2 K (20 °C) and 101.3 kPa.

(2) This method may not accurately determine the presence of corrosive materials if the sample contains corrosion inhibitors or other chemicals, which diminish the corrosivity of the sample to the copper strip. Therefore, the addition of such compounds for the sole purpose of biasing the test method is prohibited.

"

Annex 8,

Paragraph 3.1, amend to read:

"3.1. Gaseous emissions (diesel engine)

Assume the following test results for a PDP-CVS system

| | | |
|---|---|---|
| $V_0$ | ($m^3$/rev) | 0.1776 |
| $N_p$ | (rev) | 23073 |
| $p_B$ | (kPa) | 98.0 |
| $p_1$ | (kPa) | 2.3 |
| T | (K) | 322.5 |
| $H_a$ | (g/kg) | 12.8 |
| $NO_{x\ conce}$ | (ppm) | 53.7 |
| $NO_{x\ concd}$ | (ppm) | 0.4 |
| $CO_{conce}$ | (ppm) | 38.9 |
| $CO_{concd}$ | (ppm) | 1.0 |
| $HC_{conce}$ | (ppm) without cutter | 9.00 |
| $HC_{concd}$ | (ppm) without cutter | 3.02 |
| $HC_{conce}$ | (ppm) with cutter | 1.20 |
| $HC_{concd}$ | (ppm) with cutter | 0.65 |
| $CO_{2,conce}$ | (%) | 0.723 |
| $W_{act}$ | (kWh) | 62.72 |

Calculation of the diluted exhaust gas flow (annex 4, appendix 2, paragraph 4.1.):

$M_{TOTW}$ = 1.293 * 0.1776 * 23073 * (98.0 - 2.3) * 273 / (101.3 * 322.5)
= 4237.2 kg

Calculation of the $NO_x$ correction factor (annex 4, appendix 2, paragraph 4.2.):

$$K_{H,D} = \frac{1}{1 - 0.0182 \times (12.8 - 10.71)} = 1.039$$

Calculation of the NMHC concentration by NMC method (annex 4, appendix 2, paragraph 4.3.1.), assuming a methane efficiency of 0.04 and an ethane efficiency of 0.98:

$$NMHC_{conce} = \frac{9.0 \times (1 - 0.04) - 1.2}{0.98 - 0.04} = 7.91 \text{ ppm}$$

$$NMHC_{concd} = \frac{3.02 \times (1 - 0.04) - 0.65}{0.98 - 0.04} = 2.39 \text{ ppm}$$

Calculation of the background corrected concentrations (annex 4, appendix 2, paragraph 4.3.1.1.):

Assuming a diesel fuel of the composition $C_1H_{1.8}$

$$F_S = 100 * \frac{1}{1+(1.8/2)+(3.76*(1+(1.8/4)))} = 13.6$$

$$DF = \frac{13.6}{0.723+(9.00+38.9)*10^{-4}} = 18.69$$

$NO_{x\ conc}$ = 53.7 - 0.4 * (1 - (1/18.69)) = 53.3 ppm

$CO_{conc}$ = 38.9 - 1.0 * (1 - (1/18.69)) = 37.9 ppm

$HC_{conc}$ = 9.00 - 3.02 * (1 - (1/18.69)) = 6.14 ppm

$NMHC_{conc}$ = 7.91 - 2.39 * (1 - (1/18.69)) = 5.65 ppm

Calculation of the emissions mass flow (annex 4, appendix 2, paragraph 4.3.1.):

$NO_{x\ mass}$ = 0.001587 * 53.3 * 1.039 * 4237.2 = 372.391 g

$CO_{mass}$ = 0.000966 * 37.9 * 4237.2 = 155.129 g

$HC_{mass}$ = 0.000479 * 6.14 * 4237.2 = 12.462 g

$NMHC_{mass}$ = 0.000479 * 5.65 * 4237.2 = 11.467 g

Calculation of the specific emissions (annex 4, appendix 2, paragraph 4.4.):

$\overline{NO_x}$ = 372.391 / 62.72 = 5.94 g/kWh

$\overline{CO}$ = 155.129 / 62.72 = 2.47 g/kWh

$\overline{HC}$ = 12.462 / 62.72 = 0.199 g/kWh

$\overline{NMHC}$ = 11.467 / 62.72 = 0.183 g/kWh "

Paragraph 3.3., amend to read (deleting also words "with double dilution" in the first sentence):

"3.3. Gaseous emissions (CNG engine)

Assume the following test results for a PDP-CVS system

| | | |
|---|---|---|
| $M_{TOTW}$ | (kg) | 4237.2 |
| $H_a$ | (g/kg) | 12.8 |
| $NO_{x\ conce}$ | (ppm) | 17.2 |
| $NO_{x\ concd}$ | (ppm) | 0.4 |
| $CO_{\ conce}$ | (ppm) | 44.3 |
| $CO_{\ concd}$ | (ppm) | 1.0 |
| $HC_{\ conce}$ | (ppm) without cutter | 27.0 |
| $HC_{\ concd}$ | (ppm) without cutter | 2.02 |
| $HC_{\ conce}$ | (ppm) with cutter | 18.0 |
| $HC_{\ concd}$ | (ppm) with cutter | 0.65 |
| $CH_{4\ conce}$ | (ppm) | 18.0 |
| $CH_{4\ concd}$ | (ppm) | 1.1 |
| $CO_{2,conce}$ | (%) | 0.723 |
| $W_{act}$ | (kWh) | 62.72 |

Calculation of the NOx correction factor (annex 4, appendix 2, paragraph 4.2.):

$$K_{H,G} = \frac{1}{1 - 0.0329 \times (12.8 - 10.71)} = 1.074$$

Calculation of the NMHC concentration (annex 4, appendix 2, paragraph 4.3.1.):

a) GC method

$$NMHC_{conce} = 27.0 - 18.0 = 9.0 \text{ ppm}$$

b) NMC method

Assuming a methane efficiency of 0.04 and an ethane efficiency of 0.98 (see annex 4, appendix 5, paragraph 1.8.4.)

$$NMHC_{conce} = \frac{27.0 \times (1 - 0.04) - 18.0}{0.98 - 0.04} = 8.4 \text{ ppm}$$

$$NMHC_{concd} = \frac{2.02 \times (1 - 0.04) - 0.65}{0.98 - 0.04} = 1.37 \text{ ppm}$$

Calculation of the background corrected concentrations (annex 4, appendix 2, paragraph 4.3.1.1.):

Assuming a 100 % methane fuel of the composition $C_1H_4$

$$F_S = 100 \times \frac{1}{1 + (4/2) + (3.76 \times (1 + (4/4)))} = 9.5$$

$$DF = \frac{9.5}{0.723 + (27.0 + 44.3) \times 10^{-4}} = 13.01$$

For NMHC with GC method, the background concentration is the difference between $HC_{concd}$ and $CH_{4\ concd}$

$NO_{x\ conc}$ = 17.2 - 0.4 * (1 - (1/13.01)) = 16.8 ppm

$CO_{conc}$ = 44.3 - 1.0 * (1 - (1/13.01)) = 43.4 ppm

$NMHC_{conc}$ = 8.4 - 1.37 * (1 - (1/13.01)) = 7.13 ppm (NMC method)

$NMHC_{conc}$ = 9.0 - 0.92 * (1 - (1/13.01)) = 8.15 ppm (GC method)

$CH_{4\ conc}$ = 18.0 - 1.1 * (1 - (1/13.01)) = 17.0 ppm (GC method)

Calculation of the emissions mass flow (annex 4, appendix 2, paragraph 4.3.1.):

$NO_{x\ mass}$ = 0.001587 * 16.8 * 1.074 * 4237.2 =121.330 g

$CO_{mass}$ = 0.000966 * 43.4 * 4237.2 = 177.642 g

$NMHC_{mass}$ = 0.000516 * 7.13 * 4237.2 = 15.589 g (NMC method)

$NMHC_{mass}$ = 0.000516 * 8.15 * 4237.2 = 17.819 g (GC method)

$CH_{4\ mass}$ = 0.000552 * 17.0 * 4237.2 = 39.762 g (GC method)

Calculation of the specific emissions (annex 4, appendix 2, paragraph 4.4.):

$\overline{NO_x}$ = 121.330/62.72 = 1.93 g/kWh

$\overline{CO}$ = 177.642/62.72 = 2.83 g/kWh

$\overline{NMHC}$ = 15.589/62.72 = 0.249 g/kWh (NMC method)

$\overline{NMHC}$ = 17.819/62.72 = 0.284 g/kWh (GC Method)

$\overline{CH_4}$ = 39.762/62.72 = 0.634 g/kWh (GC method)"

Paragraph 4.2., example 2, amend the title line to read:

"Example 2: GR: $CH_4$ = 87 %, $C_2H_6$ = 13 % (by vol)"

Add a new annex 9, to read:

"Annex 9

SPECIFIC TECHNICAL REQUIREMENTS RELATING TO
ETHANOL-FUELLED DIESEL ENGINES

In the case of ethanol-fuelled diesel engines, the following specific modifications to the appropriate paragraphs, equations and factors will apply to the test procedures defined in annex 4 to this Regulation.

In annex 4, appendix 1

4.2. Dry/wet correction

$$F_{FH} = \frac{1.877}{\left(1 + 2.577x \frac{G_{FUEL}}{G_{AIRW}}\right)}$$

4.3. $NO_X$ correction for humidity and temperature

$$K_{H,D} = \frac{1}{1 + A * (H_a - 10.71) + B * (T_a - 298)}$$

with:
A = 0.181 $G_{FUEL}/G_{AIRD}$ - 0.0266
B = - 0.123 $G_{FUEL}/G_{AIRD}$ + 0.00954
$T_a$ = temperature of the air, K
$H_a$ = humidity of the intake air, g water per kg dry air

4.4. Calculation of the emission mass flow rates

The emission mass flow rates (g/h) for each mode shall be calculated as follows, assuming the exhaust gas density to be 1.272 kg/$m^3$ at 273 K (O°C) and 101.3 kPa:

(1) $NO_{x\ mass} = 0.001613 * NO_{x\ conc} * K_{H,D} * G_{EXHW}$

(2) $CO_{mass} = 0.000982 * CO_{conc} * G_{EXHW}$

(3) $HC_{mass} = 0.000809 * HC_{conc} * K_{H,D} * G_{EXHW}$

where $NO_{x\ conc}$, $CO_{conc}$, $HC_{conc}$ 1/ are the average concentrations (ppm) in the raw exhaust gas, as determined in paragraph 4.1.

1/ Based on C1 equivalent.

If, optionally, the gaseous emissions are determined with a full flow dilution system, the following formulae must be applied:

(1) $NO_{x\ mass} = 0.001587 * NO_{x\ conc} * K_{H,D} * G_{TOTW}$

(2) $CO_{mass} = 0.000966 * CO_{conc} * G_{TOTW}$

(3) $HC_{mass} = 0.000795 * HC_{conc} * G_{TOTW}$

where $NO_{x\ conc}$, $CO_{conc}$, $HC_{conc}$ 1/ are the average background corrected concentrations (ppm) of each mode in the diluted exhaust gas, as determined in annex 4, appendix 2, paragraph 4.3.1.1.

In annex 4, appendix 2

Paragraphs 3.1., 3.4., 3.8.3. and 5. of appendix 2 do not apply solely to diesel engines. They also apply to ethanol-fuelled diesel engines.

4.2. The conditions for the test should be arranged so that the air temperature and the humidity measured at the engine intake is set to standard conditions during the test run. The standard should be 6 " 0.5 g water per kg dry air at a temperature interval of 298 " 3 K. Within these limits no further $NO_X$ correction should be made. The test is void if these conditions are not met.

4.3. Calculation of the emission mass flow

4.3.1. Systems with constant mass flow

For systems with heat exchanger, the mass of the pollutants (g/test) must be determined from the following equations:

(1) $NO_{X\ mass} = 0.001587 * NO_{X\ conc} * K_{H,D} * M_{TOTW}$ (ethanol fuelled engines)

(2) $CO_{mass} = 0.000966 * CO_{conc}\ M_{TOTW}$ (ethanol fuelled engines)

(3) $HC_{mass} = 0.000794 * HC_{conc} * M_{TOTW}'$ (ethanol fuelled engines)

where:

$NO_{x\ conc}$, $CO_{conc}$, $HC_{conc}$ 1/, $NMHC_{conc}$ = average background corrected concentrations over the cycle from integration (mandatory for $NO_X$ and HC) or bag measurement, ppm.

$M_{TOTW}$ = total mass of diluted exhaust gas over the cycle as determined in paragraph 4.1., kg.

4.3.1.1. Determination of the background corrected concentrations

The average background concentration of the gaseous pollutants in the dilution air must be subtracted from measured concentrations to get the net concentrations of the pollutants. The average values of the background concentrations can be determined by the sample bag method or by continuous measurement with integration. The following formula must be used.

---

1/ Based on C1 equivalent.

$$conc = conc_e - conc_d * (1 - (1/DF))$$

where:

conc = concentration of the respective pollutant in the diluted exhaust gas, corrected by the amount of the respective pollutant contained in the dilution air, ppm

$conc_e$ = concentration of the respective pollutant measured in the diluted exhaust gas, ppm

$conc_d$ = concentration of the respective pollutant measured in the dilution air, ppm

DF = dilution factor

The dilution factor must be calculated as follows:

$$DF = \frac{F_S}{CO_{2,conce} + (HC_{conce} + CO_{conce}) * 10^{-4}}$$

where:

$CO_{2,conce}$ = concentration of $CO_2$ in the diluted exhaust gas, % vol
$HC_{conce}$ = concentration of HC in the diluted exhaust gas, ppm C1
$CO_{conce}$ = concentration of CO in the diluted exhaust gas, ppm
$F_S$ = stoichiometric factor

Concentrations measured on dry basis must be converted to a wet basis in accordance with annex 4, appendix 1, paragraph 4.2.

The stoichiometric factor must, for the general fuel composition $CH_\alpha O_\beta N_\gamma$, be calculated as follows:

$$F_S = 100 * \frac{1}{1 + \frac{\alpha}{2} + 3.76 * \left(1 + \frac{\alpha}{4} - \frac{\beta}{2}\right) + \frac{\gamma}{2}}$$

Alternatively, if the fuel composition is not known, the following stoichiometric factors may be used:

$F_S$ (ethanol) = 12.3

4.3.2. Systems with flow compensation

For systems without heat exchanger, the mass of the pollutants (g/test) must be determined by calculating the instantaneous mass emissions and integrating the instantaneous values over the cycle. Also, the background correction must be applied directly to the instantaneous concentration value. The following formulae must be applied:

(1) $NO_{x\ mass}$ =

$$\sum_{i=1}^{n}(M_{TOTW,i} * NO_{x\ conce,i} * 0.001587) - (M_{TOTW} * NO_{x\ concd} * (1 - 1/DF) * 0.001587)$$

(2) $CO_{mass}$ =

$$\sum_{i=1}^{n}(M_{TOTW,i} * CO_{conce,i} * 0.000966) - (M_{TOTW} * CO_{concd} * (1 - 1/DF) * 0.000966)$$

(3) $HC_{mass}$ =

$$\sum_{i=1}^{n}(M_{TOTW,i} * HC_{conce,i} * 0.000479) - (M_{TOTW} * HC_{concd} * (1 - 1/DF) * 0.000479)$$

where:

$conc_e$ = concentration of the respective pollutant measured in the diluted exhaust gas, ppm

$conc_d$ = concentration of the respective pollutant measured in the dilution air, ppm

$M_{TOTW,I}$ = instantaneous mass of the diluted exhaust gas (see paragraph 4.1.), kg

$M_{TOTW}$ = total mass of diluted exhaust gas over the cycle (see paragraph 4.1.), kg

DF = dilution factor as determined in paragraph 4.3.1.1.

4.4. Calculation of the specific emissions

The emissions (g/kWh) must be calculated for all individual components in the following way:

$$\overline{NO_x} = NO_{x\ mass} / W_{act}$$

$$\overline{CO} = CO_{mass} / W_{act}$$

$$\overline{HC} = HC_{mass} / W_{act}$$

where:

$W_{act}$ = actual cycle work as determined in paragraph 3.9.2., kWh

____________"