VEHICLE STANDARD (AUSTRALIAN DESIGN RULE 80/01 — EMISSION CONTROL FOR HEAVY VEHICLES) 2005

APPENDIX B

Commission of the European Communities Directive 2001/27/EC of 10 April 2001 adapting to technical progress Council Directive 88/77/EC, on the approximation of the laws of the Member States relating to measures to be taken against the emission of gaseous and particulate pollutants from compression ignition engines for use in vehicles, and the emission of gaseous pollutants from positive ignition engines fuelled with natural gas or liquefied petroleum gas for use in vehicles.

ANNEX

AMENDMENTS TO ANNEX I TO DIRECTIVE 88/77/EEC

1. Sections 2.7 and 2.28 are replaced by the following:

'2.7. *"gaseous pollutants"* means carbon monoxide, hydrocarbons (assuming a ratio of $CH_{1,85}$ for diesel, $CH_{2,525}$ for LPG and $CH_{2,93}$ for NG (NMHC), and an assumed molecule $CH_3O_{0,5}$ for ethanol-fuelled diesel engines), 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);'.

'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.'

2. Sections 2.29 and 2.30 are introduced as follows:

'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.'

3. Section 2.29 is renumbered as 2.31. The table in section 2.31.2 is replaced by the following table:

'2.31.2. Symbols for 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.'

4. Section 4 is replaced by the following:

'4. EC TYPE-APPROVAL

4.1. **Granting of a universal fuel EC type-approval**

A universal fuel EC type-approval is granted subject to the following requirements.

4.1.1. In the case of diesel fuel the parent engine meets the requirements of this Directive on the reference fuel specified in Annex IV.

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 λ-shift factor (S_λ). The formulae for the calculation of the Wobbe index and S_λ are given in sections 2.25 and 2.26. Natural gases with a λ-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 λ-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_λ.

The parent engine shall meet the requirements of this Directive on the reference fuels G_R (fuel 1) and G_{25} (fuel 2), as specified in Annex IV, 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 shall be run-in using the procedure given in paragraph 3 of Appendix 2 to Annex III.

4.1.2.1. On the manufacturer's request the engine may be tested on a third fuel (fuel 3) if the λ-shift factor (S_λ) lies between 0,89 (i.e. the lower range of G_R) and 1,19 (i.e. the upper range of G_{25}), 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.

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 shall be tested on the relevant reference fuel as specified in Annex IV for each range, at each position of the switch. The fuels are G_R (fuel 1) and G_{23} (fuel 3) for the H-range of gases and G_{25} (fuel 2) and G_{23} (fuel 3) for the L-range of gases. The parent engine shall meet the requirements of this Directive at both positions of the switch without any readjustment to the fuelling between the two tests at each 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 shall be run-in using the procedure given in paragraph 3 of Appendix 2 to Annex III.

4.1.3.1. At the manufacturer's request the engine may be tested on a third fuel instead of G_{23} (fuel 3) if the λ-shift factor (S_λ) lies between 0,89 (i.e. the lower range of G_R) and 1,19 (i.e. the upper range of G_{25}), 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.

4.1.4. In the case of natural gas engines, the ratio of the emission results "r" shall be determined for each pollutant as follows:

$$r = \frac{\text{emission result on reference fuel 2}}{\text{emission result on reference fuel 1}}$$

or,

$$ra = \frac{\text{emission result on reference fuel 2}}{\text{emission result on reference fuel 3}}$$

and,

$$rb = \frac{\text{emission result on reference fuel 1}}{\text{emission result on reference fuel 3}}$$

4.1.5. In the case of LPG the parent engine should demonstrate its capability to adapt to any fuel composition that may occur across the market. In the case of LPG there are variations in C_3/C_4 composition. These variations are reflected in the reference fuels. The parent engine should meet the emission requirements on the reference fuels A and B as specified in Annex IV 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 shall be run-in using the procedure defined in paragraph 3 of Appendix 2 to Annex III.

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

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

4.2. **Granting of a fuel range restricted EC type-approval**

Fuel range restricted EC type-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 shall be tested on the relevant reference fuel, as specified in Annex IV, for the relevant range. The fuels are G_R (fuel 1) and G_{23} (fuel 3) for the H-range of gases and G_{25} (fuel 2) and G_{23} (fuel 3) for the L-range of gases. The parent engine shall meet the requirements of this Directive 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 shall be run-in using the procedure defined in paragraph 3 of Appendix 2 to Annex III.

4.2.1.1. At the manufacturer's request the engine may be tested on a third fuel instead of G_{23} (fuel 3) if the λ-shift factor (S_λ) lies between 0,89 (i.e. the lower range of G_R) and 1,19 (i.e. the upper range of G_{25}), 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.

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

$$r = \frac{\text{emission result on reference fuel 2}}{\text{emission result on reference fuel 1}}$$

or,

$$ra = \frac{\text{emission result on reference fuel 2}}{\text{emission result on reference fuel 3}}$$

and,

$$rb = \frac{\text{emission result on reference fuel 1}}{\text{emission result on reference fuel 3}}$$

4.2.1.3. On delivery to the customer the engine shall bear a label (see paragraph 5.1.5) stating for which range of gases the engine is approved.

4.2.2. Exhaust emissions approval of an engine running on natural gas or LPG and laid out for operation on one specific fuel composition

4.2.2.1. The parent engine shall meet the emission requirements on the reference fuels G_R and G_{25} in the case of natural gas, or the reference fuels A and B in the case of LPG, as specified in Annex IV. 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. At the manufacturer's request the engine may be tested on the reference fuels G_R and G_{23}, or on the reference fuels G_{25} and G_{23}, in which case the type-approval is only valid for the H-range or the L-range of gases respectively.

4.2.2.3. On delivery to the customer the engine shall bear a label (see paragraph 5.1.5) stating for which fuel composition the engine has been calibrated.

4.3. **Exhaust emissions approval of a member of a family**

4.3.1. With the exception of the case mentioned in paragraph 4.3.2, the approval of a parent engine shall be extended to all family members without further testing, for any fuel composition within the range for which the parent engine has been approved (in the case of engines described in paragraph 4.2.2) or the same range of fuels (in the case of engines described in either paragraphs 4.1 or 4.2) for which the parent engine has been approved.

4.3.2. Secondary test engine

In case of an application for type-approval of an engine, or a vehicle in respect of its engine, that engine belonging to an engine family, if the technical service determines that, with regard to the selected parent engine the submitted application does not fully represent the engine family defined in Annex I, Apppendix 1, an alternative and if necessary an additional reference test engine may be selected by the technical service and tested.

4.4. **Type-approval certificate**

A certificate conforming to the model specified in Annex VI shall be issued for approval referred to under sections 3.1, 3.2 and 3.3.'

5. Section 6 is replaced by the following:

'6. SPECIFICATIONS AND TESTS

6.1. **General**

6.1.1. Emission control equipment

6.1.1.1. 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 Directive.

6.1.2. Functions of emission control equipment

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

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

— operates only outside the conditions specified in paragraph 6.1.2.4, or

— is activated only temporarily under the conditions specified in paragraph 6.1.2.4 for such purposes as engine damage protection, air-handling device protection [1], smoke management [1], cold start or warming-up, or

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

6.1.2.3. An engine control device, function, system or measure that operates during the conditions specified in section 6.1.2.4 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 sections 6.1.3 and/or 6.1.4, 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.

6.1.2.4. For the purposes of point 6.1.2.2, the defined conditions of use under steady state and transient conditions [1] are:

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

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

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

6.1.3. Special requirements for electronic emission control systems

6.1.3.1. 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 indentified. This information shall be attached to the documentation required in Annex I, section 3;

(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.

6.1.4. 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 sections 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

[1] To be subject to further evaluation by the Commission before 31 December 2001.

6.1.4.1. As an alternative to the requirements of Appendix 4 to Annex III to Directive 88/77/EEC, the emissions of NO_x during the ETC screening test may be sampled using the raw exhaust gas and the technical prescriptions of ISO DIS 16183, dated 15 October 2000, shall be followed.

6.1.4.2. 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 sections 2.28 and 2.30, an additional margin of 10 %, related to the appropriate NO_x limit value, shall be accepted.

6.1.5. Transitional provisions for extension of type-approval

6.1.5.1. This section shall only be applicable to new compression-ignition engines and new vehicles propelled by a compression-ignition engine that have been type-approved to the requirements of row A of the tables in section 6.2.1 of Annex I to Directive 88/77/EEC.

6.1.5.2. As an alternative to sections 6.1.3 and 6.1.4, 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 II, and taking into account the provisions of sections 6.1.4.1 and 6.1.4.2. 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 section 2 of this Annex.

6.1.5.3. 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 section 6.1.4, are also applicable to all engine types within the engine family described in Annex II.'

6. Section 9.1.1.2.4 and section 9.1.1.2.5 are replaced by the following:

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

— for H marked engines with a commercial fuel within the H-range ($0{,}89 \leq S\lambda \leq 1{,}00$),

— for L marked engines with a commercial fuel within the L-range ($1{,}00 \leq S\lambda \leq 1{,}19$),

— for HL marked engines with a commercial fuel within the extreme range of the λ-shift factor ($0{,}89 \leq S\lambda \leq 1{,}19$).

However, at the manufacturer's request, the reference fuels described in Annex IV may be used. This implies tests, as described in section 4 of this Annex.

9.1.1.2.5. In the case of dispute caused by the non-compliance of gas fuelled engines when using a commercial fuel, the tests shall be performed with a reference fuel on which the parent engine has been tested, or whith 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 4.1.4, 4.1.5.1 and 4.2.1.2. If r, ra or rb are less than 1 no correction shall 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).'

AMENDMENTS TO ANNEX II TO DIRECTIVE 88/77/EEC

7. — Section 0.5 is amended to read:

'0.5. Category of engine: diesel/NG fuelled/LPG fuelled/ethanol fuelled (1):',

— Section 1.14 of Appendix 1 to Annex II is amended to read:

'1.14. *Fuel*: diesel/LPG/NG-H/NG-L/NG-HL/ethanol (2)',

— Section 1.14 of Appendix 3 to Annex II is amended to read:

'1.14. *Fuel*: diesel/LPG/NG-H/NG-L/NG-HL/ethanol (2)'.

AMENDMENTS TO APPENDIX 2 OF ANNEX III TO DIRECTIVE 88/77/EEC

8. Table 6 in section 3.9.3 is modified as follows:

'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^2	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

(*) Until 1 October 2005, the figures shown in brackets may be used for the type-approval testing of gas engines. (Before 1 October 2004, the Commission shall report on the development of gas engine technology to confirm or modify the regression line tolerances applicable to gas engines given in this table.)'

AMENDMENTS TO ANNEX IV TO DIRECTIVE 88/77/EEC

9. — Section 1 is renumbered to be section 1.1,

— a new section 1.2 is added, as follows:

'1.2. **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	ADTM 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

Parameter	Unit	Limits (2)		Test method (3)
		Minimum	Maximum	
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 ethyl-acetate	% m/m	—	0,1	ASSTM 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.'

10. Sections 2 and 3 are replaced by the following:

'2. NATURAL GAS (NG)

European market fuels are available in two ranges:

— the H-range, whose extreme reference fuels are G_R and G_{23},

— the L-range, whose extreme reference fuels are G_{23} and G_{25}.

The characteristics of G_R, G_{23} and G_{25} reference fuels are summarised below:

Reference fuel G_R

Characteristics	Units	Basis	Limits		Test method
			Minimum	Maximum	
Composition:					
Methane		87	84	89	
Ethane		13	11	15	
Balance (*)	%-mole	—	—	1	ISO 6974
Sulphur content	mg/m³ (**)	—	—	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 G_{23}

Characteristics	Units	Basis	Limits		Test method
			Minimum	Maximum	
Composition:					
Methane		92,5	91,5	93,5	
Balance (*)	%-mole	—	—	1	ISO 6974
N_2		7,5	6,5	8,5	
Sulphur content	mg/m³ (**)	—	—	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 G_{25}

Characteristics	Units	Basis	Limits		Test method
			Minimum	Maximum	
Composition					
Methane		86	84	88	
Balance (*)	%-mole	—	—	1	ISO 6974
N_2		14	12	16	
Sulphur content	mg/m³ (**)	—	—	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).

3. 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						
C_3 content	% vol	48	52	83	87	
C_4 content	% vol	48	52	13	17	ISO 7941
Olefins	% vol		12		14	
Evaporation residue	mg/kg		50		50	NFM 41015

Parameter	Unit	Limits fuel A		Limits fuel B		Test method
		Minimum	Maximum	Minimum	Maximum	
Total sulphur content	ppm weight (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.'

AMENDMENTS TO ANNEX VI TO DIRECTIVE 88/77/EEC

11. — Section 0.5 is amended to read:

'0.5. Category of engine: diesel/NG fuelled/LPG fuelled/ethanol fuelled (1):',

— Section 1.1.5 of the Appendix to Annex VI is amended to read:

'1.1.5. Category of engine: diesel/NG fuelled/LPG fuelled/ethanol fuelled (8):'.

AMENDMENTS TO ANNEX VII TO DIRECTIVE 88/77/EEC

12. In section 4.2, the title line of example 2 is replaced by the following:

'**Example 2**: G_R: CH_4 = 87 %, C_2H_6 = 13 % (by vol)'.

13. A new Annex VIII is added as follows:

'*ANNEX VIII*

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 III to this Directive.

In Annex III, Appendix 1:

4.2. Dry/wet correction

$$F_{FH} = \frac{1{,}877}{\left(1 + 2{,}577 \times \frac{G_{FUEL}}{G_{AIRW}}\right)}$$

4.3. NO_x correction for humidity and temperature

$$K_{H,D} = \frac{1}{1 + A \times (H_a - 10{,}71) + B \times (T_a - 298)}$$

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/m³ at 273 K (0 °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} [5] are the average concentrations (ppm) in the raw exhaust gas, as determined in section 4.1.

If, optionally, the gaseous emissions are determined with a full flow dilution system, the following formulae shall 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} [5] are the average background corrected concentrations (ppm) of each mode in the diluted exhaust gas, as determined in Annex III, Appendix 2, section 4.3.1.1.

[5] Based on C1 equivalent.

In Annex III, Appendix 2:

Sections 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) shall be determined from the following equations:

(1) $NO_{x\,mass} = 0{,}001587 * No_{x\,conc} * K_{H,D} * M_{TOTW}$ (ethanol fuelled engines)

(2) $CO_{mass} = 0{,}000966 * CO_{conc}\ M_{MTOTW}$ (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 section 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 shall 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 shall 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:

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

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 shall be converted to a wet basis in accordance with Annex III, Appendix 1, section 4.2.

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

$$F_s = 100 \times \frac{1}{1 + \frac{\alpha}{2} + 3{,}76 \times \left(1 + \frac{\alpha}{4} - \frac{\beta}{2}\right) + \frac{\gamma}{2}}$$

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) shall be determined by calculating the instantaneous mass emissions and integrating the instantaneous values over the cycle. Also, the background correction shall be applied directly to the instantaneous concentration value. The following formulae shall be applied:

(1) NO_{xmas} =

$$\sum_{i=1}^{n} (M_{TOTW,i} \times NO_{Xconce,i} \times 0{,}001587) - (M_{TOTW} \times NO_{Xconcd} \times (1-1/DF) \times 0{,}001587)$$

(2) CO_{mass} =

$$\sum_{i=1}^{n} (M_{TOTW,i} \times CO_{conce,i} \times 0{,}000966) - (M_{TOTW} \times CO_{concd} \times (1-1/DF) \times 0{,}000966)$$

(3) HC_{mass} =

$$\sum_{i=1}^{n} (M_{TOTW,i} \times HC_{conce,i} \times 0{,}000749) - (M_{TOTW} \times HC_{concd} \times (1-1/DF) \times 0{,}000749)$$

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 section 4.1), kg;

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

DF = dilution factor as dertermined in section 4.3.1.1.

4.4. Calculation of the specific emissions

The emissions (g/kWh) shall 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 section 3.9.2, kWh.'