Proposal complementing working document ECE/TRANS/WP.29/GRPE/2012/13/Rev.1

in view of type-approving Heavy-Duty dual-fuel vehicles

Submitted by the chair of the informal GFV group

I. Proposal

"Annex 4, Equation (15), amend to read:

$$k_{\mathrm{w,e}} = \left(\frac{1}{1 + a \times 0{,}005 \times (c_{\mathrm{CO2}} + c_{\mathrm{CO}})} - k_{\mathrm{w1}} \right) \times 1{,}008 \qquad (15)$$

Annex 4, Equation (17), amend to read:

$$k_{\mathrm{w1}} = \frac{1{,}608 \times H_a}{1000 + (1{,}608 \times H_a)} \qquad (17)$$

Annex 4, Equation (18), amend to read:

$$k_{\mathrm{w,e}} = \left[\left(1 - \frac{\alpha \times c_{CO2w}}{200} \right) - k_{w2} \right] \times 1{,}008 \qquad (18)$$

Annex 4, Equation (19), amend to read:

$$k_{\mathrm{w,e}} = \left[\left(\frac{(1 - k_{w2})}{1 + \frac{\alpha \times c_{CO2d}}{200}} \right) \right] \times 1{,}008 \qquad (19)$$

Annex 4, Equation (20), amend to read:

$$k_{w2} = \frac{1{,}608 \times \left[H_d \times \left(1 - \frac{1}{D} \right) + H_a \times \left(\frac{1}{D} \right) \right]}{1000 + \left\{ 1{,}608 \times \left[H_d \times \left(1 - \frac{1}{D} \right) + H_a \times \left(\frac{1}{D} \right) \right] \right\}} \qquad (20)$$

Annex 4, Equation (21), amend to read:

$$k_{w,d} = (1 - k_{w3}) \times 1{,}008 \qquad (21)$$

Annex 4, Equation (22), amend to read:

$$k_{w2} = \frac{1{,}608 \times H_d}{1000 + (1{,}608 \times H_d)} \quad (22)$$

Annex 15, insert a new section, to read:

10.3 Additional dual-fuel specific CO_2 determination provisions

Section 3.1. of Annex 12 regarding the determination of CO_2 emissions in case of raw measurement is not applicable to dual-fuel engines. Instead the following provisions shall apply:

The measured test-averaged fuel consumption according to section 4.3. of Annex 12 shall be used as the base for calculating the test averaged CO_2 emissions.

The mass of each fuel consumed shall be used to determine, according to section A.6.4. of this Annex, the molar hydrogen ratio and the mass fractions of the fuel mix in the test.

The total fuel mass shall be determined according to equations 23 and 24.

$$m_{fuel,corr} = m_{fuel} - \left(m_{THC} + \frac{A_C + \alpha \times A_H}{M_{CO}} \times m_{CO} + \frac{w_{GAM} + w_{DEL} + w_{EPS}}{100} \times m_{fuel}\right) \quad (23)$$

$$m_{CO_2,fuel} = \frac{M_{CO_2}}{A_C + \alpha \times A_H} \times m_{fuel,corr} \quad (24)$$

where:

$m_{fuel,corr}$	is the corrected fuel mass of both fuels, g/test	
m_{fuel}	total fuel mass of both fuels, g/test	
m_{THC}	mass of total hydrocarbon emissions in the exhaust gas, g/test	
m_{CO}	mass of carbon monoxide emissions in the exhaust gas, g/test	
$m_{CO2,fuel}$	CO_2 mass emission coming from the fuel, g/test	
w_{GAM}	sulphur content of the fuels, per cent mass	
w_{DEL}	nitrogen content of the fuels, per cent mass	
w_{EPS}	oxygen content of the fuels, per cent mass	
α	molar hydrogen ratio of the fuels (H/C)	
A_C	is the Atomic mass of Carbon	12,011 g/mol
A_H	is the Atomic mass of Hydrogen	1,008 g/mol
M_{CO}	is the Molecular mass of Carbonmonoxide	28,011 g/mol
M_{CO2}	is the Molecular mass of Carbondioxide	44,01 g/mol

The CO_2 emission resulting from urea shall be calculated with equation 25:

$$m_{CO_2,urea} = \frac{c_{urea}}{100} \times \frac{M_{CO_2}}{M_{CO(NH_2)_2}} \times m_{urea} \qquad (25)$$

where:

$m_{CO2,urea}$ CO_2 mass emission resulting from urea, g/test

c_{urea} urea concentration, per cent

m_{urea} total urea mass consumption, g/test

$M_{CO(NH2)2}$ is the Molecular mass of urea 60,056 g/mol

Then the total CO_2 emission shall be calculated with equation 26:

$$m_{CO_2} = m_{CO_2,fuel} + m_{CO_2,urea} \qquad (26)$$

The brake specific CO_2 emissions, e_{CO2} shall then be calculated according to section 3.3. of Annex 12.

Annex 15, Section 7.3. amend to read:

12. Appendices

Appendix 1 Types of HDDF engines and vehicles - illustration of the definitions and requirements

Appendix 2 Activation and deactivation mechanisms of the counter(s), warning system, operability restriction, service mode in case of HDDF engines and vehicles-Description and illustrations

Appendix 3 HDDF dual-fuel indicator, warning system, operability restriction - Demonstration requirements

Appendix 4 Additional emission test procedure requirements for dual-fuel engines

Appendix 5 Additional PEMS emission test procedure requirements for dual-fuel engines

Appendix 6 Determination of molar component ratios and u_{gas} values for dual-fuel engines

Annex 15, Appendix3. amend to read:

Annex 15 - Appendix 3

HDDF dual-fuel indicator, warning system, operability restriction - Demonstration requirements

A.3.1. Dual-fuel indicators

A.3.1.1. Dual-fuel mode indicator

In the case where a dual-fuel engine is type approved as a separate technical unit, the ability of the engine system to command the activation of the dual-fuel mode indicator when operating in dual-fuel mode shall be demonstrated at type-approval.

In the case where a dual-fuel vehicle is type approved as regards to its emissions, the activation of the dual-fuel mode indicator when operating in dual-fuel mode shall be demonstrated at type-approval.

Note: Installation requirements related to the dual-fuel mode indicator of an approved dual-fuel engine are specified in paragraph 6.2. of this Annex.

A.3.1.2. Diesel mode indicator

In the case where a dual-fuel engine of Type 1B, Type 2B, or Type 3B is type approved as a separate technical unit, the ability of the engine system to command the activation of the diesel mode indicator when operating in diesel mode shall be demonstrated at type-approval.

In the case where a dual-fuel vehicle of Type 1B, Type 2B, or Type 3B is type approved as regards to its emissions, the activation of the diesel mode indicator when operating in diesel mode shall be demonstrated at type-approval.

Note: Installation requirements related to the diesel mode indicator of an approved Type 1B, Type 2B, or Type 3B dual-fuel engine are specified in paragraph 6.2. of this Annex.

A.3.1.3. Service mode indicator

In the case where a dual-fuel engine is type approved as a separate technical unit, the ability of the engine system to command the activation of the service mode indicator when operating in service mode shall be demonstrated at type-approval.

In the case where a dual-fuel engine is type approved with regard to its emissions, the activation of the service mode indicator when operating in service mode shall be demonstrated at type-approval.

Note: Installation requirements related to the service mode indicator of an approved dual-fuel engine are specified in paragraph 6.2. of this Annex.

A.3.1.3.1. When so-equipped it is sufficient to perform the demonstration related to the service mode indicator by activating a service mode activation switch and to present the approval authority with evidence showing that the activation occurs when the service mode is commanded by the engine system itself (for example, through algorithms, simulations, result of in-house tests, etc …).

A.3.2. Warning system

In the case where a dual-fuel engine is type approved as a separate technical unit, the ability of the engine system to command the activation of the warning system in the case that the amount of gas in the tank is below the warning level, shall be demonstrated at type-approval.

In the case where a dual-fuel vehicle is type-approved as regards to its emissions the activation of the warning system in the case that the amount of gas in the tank is below the warning level, shall be demonstrated at type-approval. For that purpose, at the request of the manufacturer and with the approval of the approval authority, the actual amount of gas may be simulated.

Note: Installation requirements related to the warning system of an approved dual-fuel engine are specified in paragraph 6.2. of this Annex.

A.3.3. Operability restriction

In the case where a Type 1A or Type 2A dual-fuel engine is type approved as a separate technical unit, the ability of the engine system to command the activation of the operability restriction upon detection of an empty gaseous fuel tank, of a malfunctioning gas supply system, and of an abnormality of gas consumption in dual-fuel shall be demonstrated at type-approval.

In the case where a Type 1A or Type 2A dual-fuel vehicle is type approved as regards to its emissions, the activation of the operability restriction upon detection of an empty gaseous fuel tank, of a malfunctioning gas supply system, and of an abnormality of gas consumption in dual-fuel mode shall be demonstrated at type-approval.

Note: Installation requirements related to the operability restriction of an approved dual-fuel engine are specified in paragraph 6.2. of this Annex.

A.3.3.1. The malfunctioning of the gas supply and the abnormality of gas consumption may be simulated at the request of the manufacturer and with the approval of the approval authority.

In the case where a Type 1A or Type 2A dual-fuel engine is type approved as a separate technical unit, the ability of the engine system to command the activation of the operability restriction upon detection of an empty gaseous fuel tank, of a malfunctioning gas supply system, and of an abnormality of gas consumption in dual-fuel shall be demonstrated at type-approval.

In the case where a Type 1A or Type 2A dual-fuel vehicle is type approved as regards to its emissions, the activation of the operability restriction upon detection of an empty gaseous fuel tank, of a malfunctioning gas supply system, and of an abnormality of gas consumption in dual-fuel mode shall be demonstrated at type-approval.

Note: Installation requirements related to the operability restriction of an approved dual-fuel engine are specified in paragraph 6.2. of this Annex.

A.3.3.1. The malfunctioning of the gas supply and the abnormality of gas consumption may be simulated at the request of the manufacturer and with the approval of the approval authority.

A.3.3.2. It is sufficient to perform the demonstration in a typical use-case selected with the agreement of the Approval Authority and to present that authority with evidence showing that the operability restriction occurs in the other possible use-cases (for example, through algorithms, simulations, result of in-house tests, etc …

Annex 15, Appendix4. amend to read:

Annex 15 - Appendix 4

Additional emission test procedure requirements for dual-fuel engines

A.4.1. General

This appendix defines the additional requirements and exceptions to Annex 4 of this regulation to enable emission testing of dual-fuel engines independent whether these emissions are solely exhaust emissions or also crankcase emissions added to the exhaust emissions according to paragraph 6.10. of Annex 4.

Emission testing of a dual-fuel engine is complicated by the fact that the fuel used by the engine can vary between pure diesel fuel and a combination of mainly gaseous fuel with only a small amount of diesel fuel as an ignition source. The ratio between the fuels used by a dual-fuel engine can also change dynamically depending of the operating condition of the engine. As a result special precautions and restrictions are necessary to enable emission testing of these engines.

A.4.2. Test conditions (Annex 4, section 6.)

A.4.2.1. Laboratory test conditions (Annex 4, paragraph 6.1.)

The parameter f_a for dual-fuel engines shall be determined with formula (a)(2) in paragraph 6.1. of Annex 4 to this regulation.

A.4.3. Test procedures (Annex 4, section 7.)

A.4.3.1. Measurement procedures (Annex 4, paragraph 7.1.3.)

The recommended measurement procedure for dual-fuel engines is procedure (b) listed in paragraph 7.1.3. of Annex 4 (CVS system).

This measurement procedure ensures that the variation of the fuel composition during the test will only influence the hydrocarbon measurement results. This shall be compensated via one of the methods described in section 4.4.

Other measurement methods such as method (a) listed in paragraph 7.1.3 of Annex 4 (raw gaseous/partial flow measurement) can be used with some precautions regarding exhaust mass flow determination and calculation methods. Fixed values for fuel parameters and u_{gas}-values shall be applied as described in Appendix 6.

A.4.4. Emission calculation (Annex 4, section 8.)

The emissions calculation on a molar basis, in accordance with Annex 7 of gtr No. 11 concerning the exhaust emission test protocol for Non-Road Mobile Machinery (NRMM), is not permitted.

A.4.4.1. Dry/wet correction (Annex 4, section 8.1.)

A.4.4.1.1. Raw exhaust gas (Annex 4, paragraph 8.1.1.)

Equations 15 and 17 in Annex 4 paragraph 8.1.1. shall be used to calculate the dry/wet correction.

The fuel specific parameters shall be determined according to sections A.6.2 and A.6.3. of Appendix 6.

A.4.4.1.2. Diluted exhaust gas (Annex 4, paragraph 8.1.2.)

Equations 19 and 20 in Annex 4 paragraph 8.1.2. shall be used to calculate the wet/dry correction.

The molar hydrogen ratio α of the combination of the two fuels shall be used for the dry/wet correction. This molar hydrogen ratio shall be calculated from the fuel consumption measurement values of both fuels according to section A.6.4. of Appendix 6.

A.4.4.2. NO_x correction for humidity (Annex 4, section 8.2.)

The NO_x humidity correction for compression ignition engines as specified in paragraph 8.2.1 of Annex 4 shall be used to determine the NO_x humidity correction for dual-fuel engines.

$$k_{h,D} = \frac{15{,}698 \times H_a}{1\,000} + 0{,}832 \qquad \text{(A4.1)}$$

where:

H_a is the intake air humidity, g water per kg dry air

A.4.4.3. Partial flow dilution (PFS) and raw gaseous measurement (Annex 4, section 8.4.)

A.4.4.3.1. Determination of exhaust gas mass flow (Annex 4, section 8.4.1.)

The exhaust mass flow shall be determined according to the direct measurement method as described in section 8.4.1.3.

Alternatively the airflow and air to fuel ratio measurement method according to section 8.4.1.6. (equations30, 31 and 32) may be used only if α, γ, δ and ε values are determined according to sections A.6.2. and A.6.3. of Appendix 6. The use of a zirconia-type sensor to determine the air fuel ratio is not allowed.

A.4.4.3.2. Determination of the gaseous components (Annex 4, section 8.4.2.)

The calculations shall be performed according to Annex 4, section 8. but the u_{gas}-values and molar ratios as described in sections A.6.2. and A.6.3. of Appendix 6 shall be used.

A.4.4.3.3. Particulate determination (Annex 4, section 8.4.3.)

For the determination of particulate emissions with the partial dilution measurement method the calculation shall be performed according to Annex 4, section 8.4.3.2.

For controlling the dilution ratio one of the following two methods may be used:

- The direct mass flow measurement as described in section 8.4.1.3.
- The airflow and air to fuel ratio measurement method according to section 8.4.1.6. (Equations 30, 31 and 32) may only be used when this is combined with the look ahead method described in section 8.4.1.2. and if α, γ, δ and ε values are determined according to sections A.6.2. and A.6.3. of Appendix 6.

The quality check according to section 9.4.6.1. shall be performed for each measurement.

A.4.4.3.4. Additional requirements regarding the exhaust gas mass flow meter

The flow meter referred to in sections A.4.4.3.1 and A.4.4.3.3. shall not be sensitive to the changes in exhaust gas composition and density. The small errors of e.g. pitot tube or orifice-type of measurement (equivalent with the square root of the exhaust density) may be neglected.

A.4.4.4. Full flow dilution measurement (CVS) (Annex 4, section 8.5.)

The possible variation of the fuel composition will only influence the hydrocarbons measurement results calculation. For all other components the appropriate equations from section 8.5.2. of Annex 4 shall be used.

The exact equations shall be applied for the calculation of the hydrocarbon emissions using the molar component ratios determined from the fuel consumption measurements of both fuels according to section A.6.4. of Appendix 6.

A.4.4.4.1. Determination of the background corrected concentrations (Annex 4, paragraph 8.5.2.3.2.)

To determine the stoïchiometric factor, the molar hydrogen ratio α of the fuel shall be calculated as the average molar hydrogen ratio of the fuel mix during the test according to section A.6.4. of Appendix 6.

Alternatively the F_s value of the gaseous fuel may be used in equation 59 or 60 of Annex 4.

A.4.5. Equipment specification and verification (Annex 4, section 9.)

A.4.5.1. Oxygen interference check gases (Annex 4, paragraph 9.3.3.4.)

The oxygen concentrations required for dual-fuel engines are equal to those required for compression ignition engines listed in table 8 in paragraph 9.3.3.4. of Annex 4.

A.4.5.2. Oxygen interference check (Annex 4, paragraph 9.3.7.3.)

Instruments used to measure dual-fuel engines shall be checked using the same procedures as those used to measure compression ignition engines. The 21 per cent oxygen blend shall be used under item (b) in paragraph 9.3.7.3. of Annex 4.

A.4.5.3. Water quench check (Annex 4, paragraph 9.3.9.2.2.)

The water quench check in paragraph 9.3.9.2.2. of Annex 4 to this regulation applies to wet NO_x concentration measurements only. For dual-fuel engines fuelled with natural gas this check should be performed with an assumed H/C ratio of 4 (Methane). In that case $H_m = 2 \times A$. For dual-fuel engines fuelled with LPG this check should be performed with an assumed H/C ratio of 2.525. In that case $H_m = 1.25 \times A$.

Annex 15, Appendix5. amend to read:

Annex 15 - Appendix 5

Additional PEMS emission test procedure requirements for dual-fuel engines

A.5.1 General

This appendix defines the additional requirements and exceptions to Annex 8 of this regulation to enable PEMS emission testing of dual-fuel engines.

Emission testing of a dual-fuel engine is complicated by the fact that the fuel used by the engine can vary between pure diesel fuel and a combination of mainly gaseous fuel with only a small amount of diesel fuel as an ignition source. The ratio between the fuels used by a dual-fuel engine can also change dynamically depending of the operating condition of the engine. As a result special precautions and restrictions are necessary to enable emission testing of these engines.

A.5.2. The following amendments to Appendix 1 of Annex 8 shall apply:

A.5.2.1. Note (2) of Table 1 in paragraph A.1.2.2. shall read:

(2) Only for engines fuelled with natural gas

A.5.2.2. Paragraph A.1.3.3. "Dry-Wet correction" shall read:

If the concentration is measured on a dry basis, it shall be converted to a wet basis according to paragraph 8.1. of Annex 4 and paragraph 4.1.1. of Appendix 4 to this Annex.

A.5.2.3. Paragraph A.1.3.5. "Calculation of the instantaneous gaseous emissions" shall read:

The mass emissions shall be determined as described in paragraph 8.4.2.3. of Annex 4. The u_{gas} values shall be determined according to appendix 6 of Annex 15.

Annex 15, Appendix 6. amend to read:

Annex 15 - Appendix 6

Determination of molar component ratios and u_{gas} values for dual-fuel engines

A.6.1. General

This appendix defines the determination of molar component ratios and u_{gas} values for the dry-wet factor and emissions calculations for emission testing of dual-fuel engines.

A.6.2. Operation in dual-fuel mode

A.6.2.1. For Type 1A or 1B dual-fuel engines operating in dual-fuel mode the molar component ratios and the u_{gas} values of the gaseous fuel shall be used.

A.6.2.2. For Type 2A or 2B dual-fuel engines operating in dual-fuel mode the molar component ratios and the u_{gas} values from tables A6.1 and A6.2 shall be used.

Table A6.1: Molar component ratios for a mixture of 50% gaseous fuel and 50% diesel fuel (mass %)

Table A6.2: Molar component ratios for a mixture of 50% gaseous fuel and 50% diesel fuel (mass %)

Gaseous Fuel	α	γ	δ	ε
CH_4	2,8681	2.3341E-06	0	0.00402236
CNG	2,7676	2.3182E-06	0	0.00399502
G_{23}	2,7986	2.4774E-06	0.07032933	0.00426934
G_{25}	2,7542	2.5689E-06	0.1151987	0.00442692
Propane	[tbd]	[tbd]	[tbd]	[tbd]
Butane	[tbd]	[tbd]	[tbd]	[tbd]
LPG A	[tbd]	[tbd]	[tbd]	[tbd]
LPG B	2,17	[tbd]	[tbd]	[tbd]

Table A6.2: Raw exhaust gas u_{gas} values and component densities for a mixture of 50% gaseous fuel and 50% diesel fuel (mass %)

Gaseous Fuel	ρ_e	Gas					
		NO_x	CO	HC	CO_2	O_2	CH_4
		ρ_{gas} [kg/m^3]					
		2.053	1.250	a)	1.9636	1.4277	0.716
		u_{gas} b)					
CH_4	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]
CNG c)	[tbd]	[tbd]	[tbd]	[tbd] d)	[tbd]	[tbd]	[tbd]
Propane	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]
Butane	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]
LPG e)	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]	[tbd]

a) depending on fuel

b) at $\lambda = 2$, dry air, 273 K, 101.3 kPa

c) u accurate within 0.2 % for mass composition of: C = 66 - 76 %; H = 22 - 25 %; N = 0 - 12 % (including G25)

d)	NMHC on the basis of $CH_{2.93}$ (for total HC the u_{gas} coefficient of CH_4 shall be used)
e)	u accurate within 0.2 % for mass composition of: C3 = 70 - 90 %; C4 = 10 - 30 % (LPG Fuel B)

A.6.2.3. For Type 3B dual-fuel engines operating in dual-fuel mode the molar component ratios and the u_{gas} values of diesel fuel shall be used.

A.6.2.4. For the calculation of the hydrocarbon emissions of all types of dual-fuel engines operating in dual-fuel mode, the following shall apply:

- For the calculation of the THC emissions, the u_{gas} value of the gaseous fuel shall be used.
- For the calculation of the NMHC emissions, the u_{gas} value on the basis of $CH_{2.93}$ shall be used.
- For the calculation of the CH_4 emissions, the u_{gas} value of CH_4 shall be used.

A.6.3. Operation in diesel mode

For Type 1B, 2B or 3B dual-fuel engines operating in diesel mode, the molar component ratios and the u_{gas} values of diesel fuel shall be used.

A.6.4. Determination of the molar component ratios when the fuel mix is known

A.6.4.1. Calculation of the fuel mixture components

$$w_{ALF} = \frac{w_{ALF1} \times q_{mf1} + w_{ALF2} \times q_{mf2}}{q_{mf1} + q_{mf2}} \qquad \text{(A6.1)}$$

$$w_{BET} = \frac{w_{BET1} \times q_{mf1} + w_{BET2} \times q_{mf2}}{q_{mf1} + q_{mf2}} \qquad \text{(A6.2)}$$

$$w_{GAM} = \frac{w_{GAM1} \times q_{mf1} + w_{GAM2} \times q_{mf2}}{q_{mf1} + q_{mf2}} \qquad \text{(A6.3)}$$

$$w_{DEL} = \frac{w_{DEL1} \times q_{mf1} + w_{DEL2} \times q_{mf2}}{q_{mf1} + q_{mf2}} \qquad \text{(A6.4)}$$

$$w_{EPS} = \frac{w_{EPS1} \times q_{mf1} + w_{EPS2} \times q_{mf2}}{q_{mf1} + q_{mf2}} \qquad \text{(A6.5)}$$

where:

q_{mf1} fuel mass flow rate of fuel1, kg/s

q_{mf2} fuel mass flow rate of fuel2, kg/s

w_{ALF} hydrogen content of fuel, per cent mass

w_{BET} carbon content of fuel, per cent mass

w_{GAM} sulphur content of fuel, per cent mass

w_{DEL} nitrogen content of fuel, per cent mass

w_{EPS} oxygen content of fuel, per cent mass

A.6.4.2. Calculation of the molar ratios of H, C, S, N and O related to C for the fuel mixture (according to ISO8178-1, Annex A-A.2.2.2).

$$\alpha = 11.9164 \times \frac{w_{ALF}}{w_{BET}} \quad \text{(A6.6)}$$

$$\gamma = 0.37464 \times \frac{w_{GAM}}{w_{BET}} \quad \text{(A6.7)}$$

$$\delta = 0.85752 \times \frac{w_{DEL}}{w_{BET}} \quad \text{(A6.8)}$$

$$\varepsilon = 0.75072 \times \frac{w_{EPS}}{w_{BET}} \quad \text{(A6.9)}$$

where:

w_{ALF} hydrogen content of fuel, per cent mass

w_{BET} carbon content of fuel, per cent mass

w_{GAM} sulphur content of fuel, per cent mass

w_{DEL} nitrogen content of fuel, per cent mass

w_{EPS} oxygen content of fuel, per cent mass

α molar hydrogen ratio (H/C)

γ molar sulphur ratio (S/C)

δ molar nitrogen ratio (N/C)

ε molar oxygen ratio (O/C)

referring to a fuel $CH_{\alpha}O_{\varepsilon}N_{\delta}S_{\gamma}$

A.6.4.3. Calculation of the u_{gas} values for a fuel mixture

The raw exhaust gas u_{gas} values for a fuel mixture can be calculated with the exact equations in section 8.4.2.4. of Annex 4 and the molar ratios calculated according to this section.

For systems with constant mass flow, equation 57 in section 8.5.2.3.1. of Annex 4 is needed to calculate the diluted exhaust gas u_{gas} values.

II. Justification

The text reproduced above was prepared by the chairmen of the informal group on Gaseous Fuelled Vehicles (GFV) – Heavy Duty Dual-Fuel –Task-Force (HDDF-TF), to introduce complementary specifications to the 06 series of amendments of Regulation No. 49 and to working document ECE/TRANS/WP.29/GRPE/2012/13/Rev.1.

GFV presented in March 2012 to the attention of GRPE working document **GRPE/2012/13/Rev.1.** that contains all the major amendments to Regulation No. 49 that are considered necessary to type approve Heavy-Duty dual-fuel engines and vehicles., except appendixes 3, 4, 5 and 6 of the dual-fuel dedicated annex (Annex 15) that were not finalized at the time when the working document was published.

Accordingly, the working document announced that these appendices would be submitted as an informal document to the GRPE once they are finalized and approved by the experts of the GFV. In addition, some necessary amendments and typographic corrigenda to rev.6 of Regulation No 49 were considered by the GFV-HDDF experts as worth to be proposed. These appendices and additional proposals are included in this document (Document **GRPE-64-xx1).**