GFV-20-05

INFORMAL GROUP ON GASEOUS FUEL VEHICLES
Within the UN GRPE (WP29)

Correction Factor for G-25 Weighting Process

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Regulation name and reference number
Regulations 115 & 83.

Name of Amendment/Work Item
Correction factor for G25 weighing process

Specific language for Amendment/Work Item
English

Rationale: (Why is it important/required?)
Documents ECE-TRANS-WP29-GRPE-2012-07 (referring to R115) and ECE-TRANS-WP29-GRPE-2012-06 (referring to R83) introduce the calculation of NG/biomethane energy ratio during a type I cycle by weighing the NG/biomethane mass consumed. The formulas introduced respectively in Annex 6B (ECE-TRANS-WP29-GRPE-2012-07) and Annex 12 - Appendix 2 (ECE-TRANS-WP29-GRPE-2012-06) are affected by an error when G25 reference fuel is used. The error is due to the presence of inert gas (N2) in the G25 reference fuel, varying from 12 to 16% in molar fraction units.
This proposal describes a modification to previous formulas in order to take into account the presence of inert gas and providing the correct energy ratio.

Analysis/testing or data requirements to support the Amendment/Work item

When G25 reference fuel is used and its composition is known, the mass of inert gas in it can be calculated.

In general, R83 fixes the allowed ranges for both CH4 molar fraction and N2 molar fraction in reference fuels. If we assume x_{CH4} the molar fraction of CH_4 and x_{N2} the molar fraction of N_2, we have:

$x_{CH4} = n_{CH4} / n_{TOT}$ (for G25: $0.84 \leq x_{CH4} \leq 0.88$)
$x_{N2} = n_{N2} / n_{TOT}$ (for G25: $0.12 \leq x_{N2} \leq 0.16$)

where:
n_{CH4} is the number of moles of CH_4
n_{N2} is the number of moles of N_2
n_{TOT} is the total number of moles

Since the mass of CH_4 and N_2 expressed in grams can be calculated as follows:

$m_{CH4} = n_{CH4} * PM_{CH4}$
$m_{N2} = n_{N2} * PM_{N2}$

where:
PM_{CH4} is the molar mass of CH_4 = 16.042 g/mol
PM_{N2} is the molar mass of N_2 = 28.02 g/mol

Combining previous equations:

$m_{CH4} = x_{CH4} * n_{TOT} * PM_{CH4}$
$m_{N2} = x_{N2} * n_{TOT} * PM_{N2}$

The weighing process will measure the total mass of G25 m_{TOT}:

$m_{TOT} = m_{CH4} + m_{N2}$
$m_{TOT} = n_{TOT} * (x_{CH4} * PM_{CH4} + x_{N2} * PM_{N2})$

but for the calculation of the energy ratio only the mass of CH_4 should be used. Thus the weighting process will overestimate the mass by a factor:

$m_{TOT} / m_{CH4} = (x_{CH4} * PM_{CH4} + x_{N2} * PM_{N2}) / (x_{CH4} * PM_{CH4})$

or vice versa the measured mass must be reduced by a factor:

$cf = m_{CH4} / m_{TOT} = (x_{CH4} * PM_{CH4}) / (x_{CH4} * PM_{CH4} + x_{N2} * PM_{N2})$.

For G25, in the worst case of minimum quantity of CH_4 and maximum quantity of N_2, the factor is $cf_{G25} = 0.75$.

(continue)

Proposal of modification of doc. ECE-TRANS-WP29-GRPE-2012-07

In annex 6B, replace par 2 with the following:

2. Calculation of the CNG energy ratio

The fuel consumption value shall be calculated from the emissions of hydrocarbons, carbon monoxide, and carbon dioxide determined from the measurement results assuming that only CNG is burned during the test.

The CNG ratio of the energy consumed in the cycle is then determined as follows:

$G_{CNG} = M_{CNG}$*__**cf ***__100/(FC_{mean}*dist*d)*100%

Where:

G_{CNG}: the CNG energy ratio;

M_{CNG}: the CNG mass consumed during the cycle (kg);

FC_{mean}: the mean fuel consumption calculated in accordance with paragraph. 6.2.2.4.3.2.;

dist: distance travelled during the cycle (km);

d: density d=0.654kg/m3.

cf: correction factor, assuming the following values:

cf = 1 in case of G20 reference fuel

cf = (x_{CH4} * PM_{CH4}) / (x_{CH4} * PM_{CH4} + x_{N2} * PM_{N2}) in case of G25 reference fuel

where:

x_{CH4} is the molar fraction of CH_4

x_{N2} is the molar fraction of N_2

PM_{CH4} is the molar mass of CH_4 = 16.042 g/mol

PM_{N2} is the molar mas of N_2 = 28.02 g/mol

If the exact composition of G25 is not known, a value of cf = 0.75 can be assumed.

Proposal of modification of doc. ECE-TRANS-WP29-GRPE-2012-06

In Annex 12 - Appendix 2, replace par. 2 with the following:

2. Calculation of the CNG energy ratio

The fuel consumption value shall be calculated from the emissions of hydrocarbons, carbon monoxide, and carbon dioxide determined from the measurement results assuming that only CNG is burned during the test.

The CNG ratio of the energy consumed in the cycle is then determined as follows:

$G_{CNG} = M_{CNG}$* __**cf ***__100/(FC_{norm}*dist*d)

Where:

G_{CNG}: the CNG energy ratio;

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M_{CNG}: the CNG mass consumed during the cycle (kg);

FC_{norm}: the fuel consumption calculated in accordance with Paragraph 1.4.3., letter (c), of Annex 6 to Regulation No. 101;

dist: distance travelled during the cycle (km);

d: density d = 0.654kg/m3.

cf: correction factor, assuming the following values:

cf = 1 **in case of G20 reference fuel**

$cf = (x_{CH4} * PM_{CH4}) / (x_{CH4} * PM_{CH4} + x_{N2} * PM_{N2})$ **in case of G25 reference fuel**

where:

x_{CH4} is the molar fraction of CH_4

x_{N2} is the molar fraction of N_2

PM_{CH4} is the molar mass of CH_4 = 16.042 g/mol

PM_{N2} is the molar mas of N_2 = 28.02 g/mol

If the exact composition of G25 is not known, a value of cf = 0.75 can be assumed.