**Name of Organisation submitting Amendment/Work Item**
Expert from Poland to GRPE

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**Regulation name and reference number:** Regulation 101

**Name of Amendment/Work Item:** Proposal for Draft Amendment to Regulation 101 – gas fuels

**Specific language for Amendment/Work Item:** English

**Rationale: (Why is it important/required?)**

There seem to be errors in provisions of Regulation 101 related to gas fuels. It is desirable that GFV gives attention to the matter.
Proposed amendments are in red.

Analysis/testing or data requirements to support the Amendment/Work item
(could be anticipated or existing supporting documentation)

**1. The main problem is as follows.** The first two indents in paragraph 5.2.4 of **Revision 1** of Regulation 101 read:
"5.2.4.    The appropriate reference fuels as defined in annex 10 to Regulation No. 83 must be used for testing.

For LPG and natural gas (NG) that reference fuel must be used which is chosen by the manufacturer for the measurement of the net power in accordance with  Regulation No. 85. The chosen fuel must be specified in the communication document as defined in annex 3 to this Regulation."

These indents have "vanished" in **Revision 2** for unknown reasons. Consequently, it is not clear whether one or two reference fuels must be used.

The interpretation that two fuels must be used is possible as according to paragraph 5.2.1:

"5.2.1.     The emissions of $CO_2$ and fuel consumption shall be measured according to the test procedure described in Annex 6."

and according to item 1.1 of annex 6:

"1.1.     Emissions of carbon dioxide ($CO_2$) and fuel consumption of vehicles powered by an internal combustion engine only shall be determined according to the procedure for the Type I test as defined in Annex 4 of Regulation No. 83 in force at the time of the approval of the vehicle."

It is desirable that GFV clarifies this problem. If two reference fuels were used, it would be required to correct the method of calculation of fuel consumption in item 1.4.3 of annex 6.

**2. Paragraph 5.2.4, amend to read:**

"5.2.4.     For the purpose of the calculation mentioned in paragraph 5.2.3., the fuel consumption shall be expressed in appropriate units and the following fuel characteristics shall be used:
(1) density: measured on the test fuel according to ISO 3675 or an equivalent method. For petrol and diesel fuel the density measured at 15 ºC will be used; for LPG and natural gas a reference density will be used, as follows:
0.538 kg/litre for LPG
0.654 [0.631] kg/m$^3$ for NG 3 /
(2) hydrogen-carbon ratio: fixed values will be used which are:
1.85 for petrol
1.86 for diesel fuel
2.525 [2.55] for LPG
4.00 for NG

3 / Mean value of G20 and G23 G25 reference fuels at 15 °C.

Justification.
(i) NG reference fuels are G20 and G25, but not G20 and G23. It seems that the mean density specified in Regulation 101 is calculated for G20 and G23 (for G20 – 16.042/23.63 = 0.679; for G23 – 0.6789*0.925 = 0.6280; (0.679+0.628)/2 ≈ 0,654) According to our simplified calculations the mean value for G20 and G25 is about 0.631 (for G20 – 16.042/23.63 = 0.679; for G25 – 0.6789*0.86 = 0.584; (0.679+0.584)/2 ≈ 0,631) instead of 0.654. To be confirmed.

(ii) H/C ratio for LPG – see the separate document "Regulations 49 and 83 – LPG reference fuel". It is proposed to use the average H/C ratio equal to 2.55.
(iii) Footnote – self-evident.

**3. Annex 6, item 1.4.3, (b), amend to read:**

"1.4.3.         ..................................

(b) for vehicles with a positive ignition engine fuelled with LPG:

$FC_{norm}$ = (0.1212 / 0.538) · [(0.825 · HC) + (0.429 · CO) + (0.273 · CO$_2$)]

$FC_{norm}$ = (0.1214 / 0.538) · [(0.824 · HC) + (0.429 · CO) + (0.273 · CO$_2$)]

If the composition of the fuel used for the test differs from the composition that is assumed for the calculation of the normalised consumption, on the manufacturer's request a correction factor cf may be applied, as follows:
$FC_{norm}$ = (0.1212 / 0.538) · (cf) · [(0.825 · HC) + (0.429 · CO) + (0.273 · CO$_2$)]
The correction factor cf, which may be applied, is determined as follows:
cf = 0.825 + 0.0693 · n$_{actual}$
where:
n$_{actual}$ = the actual H/C ratio of the fuel used

In the above formula the mean H/C ratio for reference fuels A and B is applied. On the manufacturer's request the actual H/C ratio of the fuel used for the test may be applied. In this case the fuel consumption is calculated by means of the following formula:

$FC_{norm}$ = [(0.1+0.008393 · n) / 0.538] · {[HC/(1+0.08393 · n)] + (0.429 · CO) + (0.273 · CO$_2$)}
where:
n = the actual H/C ratio of the fuel used;"

Justification and comment.
(i) It is assumed that one reference fuel is used. If two fuels were used, further changes would be required.
(ii) If the H/C ratio equal to 2.55 is applied instead of 2.525, small changes of coefficients in the formula are required.

(iii) The formula for calculation has a defect. The calculation is made for different fuel (mean A and B) that that used for the test. In my view it would be better to apply the formulae for the average reference fuel (A or B) actually used for the test i.e.

if LPG reference fuel A is used (average H/C ratio is assumed= 2.51):

$$FC_{norm} = (0.1207 / 0.538) \cdot [(0.826 \cdot HC) + (0.429 \cdot CO) + (0.273 \cdot CO_2)]$$

if LPG reference fuel B is used (average H/C ratio is assumed = 2.59):

$$FC_{norm} = (0.1217 / 0.538) \cdot [(0.821 \cdot HC) + (0.429 \cdot CO) + (0.273 \cdot CO_2)]$$

For consideration of GFV.
(iv) The composition of the fuel that is assumed for the calculation of the normalised consumption in the current version, is not directly known. In practice, the composition of the fuel used for the test always differs from the composition that is assumed for the calculation.
(v) The proposed formula for calculation at the request of the manufacturer is more accurate than the one currently specified.

## 4. Annex 6, item 1.4.3, (c), amend to read:

(c)          for vehicles with a positive ignition engine fuelled with NG:

$$\sout{Fc_{norm} = (0.1336 / 0.654) \cdot [(0.749 \cdot HC) + (0.429 \cdot CO) + (0.273 \cdot CO_2)]}$$

$$Fc_{norm} = (0.1336 / 0.631) \cdot [(0.749 \cdot HC) + (0.429 \cdot CO) + (0.273 \cdot CO_2)]$$

Justification.
(i) It is assumed that one reference fuel is used. If two fuels were used, further changes would be required.
(ii) The mean density is corrected – see item 2 above. The difference in fuel consumption is about 4%.