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World Forum for Harmonization of Vehicle Regulations

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Item 4.9.3 of the provisional agenda
1958 Agreement:
Consideration of draft amendments to existing UN Regulations submitted by GRPE

Proposal for Supplement 2 to the 05 series of amendments to UN Regulation No. 96 (Uniform provisions concerning the approval of engines to be installed in agricultural and forestry tractors and in nonroad mobile machinery with regard to the emissions of pollutants by the engine)

Submitted by the Working Party on Pollution and Energy*

The text reproduced below was adopted by the Working Party on Pollution and Energy (GRPE) at its ninety-first session (ECE/TRANS/WP.29/GRPE/91, para. 43.). It is based on ECE/TRANS/WP.29/GRPE/2024/24. It is submitted to the World Forum for Harmonization of Vehicle Regulations (WP.29) and to the Administrative Committee (AC.1) for consideration at their March 2025 sessions.

* In accordance with the programme of work of the Inland Transport Committee for 2025 as outlined in proposed programme budget for 2025 (A/79/6 (Sect. 20), table 20.6), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

Annex 2 Appendix A.1, paragraph 10.3.1., amend to read:

"10.3.1. Hot cycle CO_2 (g/kWh) (7):"

Annex 2 Appendix A.1, paragraph 10.3.4., amend to read:

"10.3.4. Cycle CO_2 for hot start test (g) (7):"

Annex 5, Appendix A.1, paragraph A.1.1.3., amend to read:

"A.1.1.3. Dry-to-wet concentration conversion

If the emissions are measured on a dry basis, the measured concentration c_d on dry basis shall be converted to the concentration c_w on a wet basis by means of equation (A.5-3). If water injection is used, Equations (A.5-4) and (A.5-7) are not applicable.:

$$c_w = k_w \cdot c_d \qquad \text{(A.5-3)}$$

where:

k_w = dry-to-wet conversion factor [-]

c_d = emission concentration on a dry basis [ppm] or [% vol]

For complete combustion, the dry-to-wet conversion factor for raw exhaust gas is written as $k_{w,a}$ [-] and shall be calculated by means of equation (A.5-4):

$$k_{w,a} = \frac{\left(1 - \dfrac{1.2442 \cdot H_a + 111.19 \cdot w_H \cdot \dfrac{q_{mf,i}}{q_{mad,i}}}{773.4 + 1.2442 \cdot H_a + \dfrac{q_{mf,i}}{q_{mad,i}} \cdot k_f \cdot 1000}\right)}{\left(1 - \dfrac{p_r}{p_b}\right)} \qquad \text{(A.5-4)}$$

where:

H_a = intake air humidity [g H_2O/kg dry air]

$q_{mf,i}$ = instantaneous fuel flow rate [kg/s]

$q_{mad,i}$ = instantaneous dry intake air flow rate [kg/s]

p_r = water pressure after cooler [kPa]

p_b = total barometric pressure [kPa]

w_H = hydrogen content of the fuel [% mass]

k_f = combustion additional volume [m^3/kg fuel]

with:

$$k_f = 0.055594 \cdot w_H + 0.0080021 \cdot w_N + 0.0070046 \cdot w_O \qquad \text{(A.5-5)}$$

where:

w_H = hydrogen content of fuel [% mass]

w_N = nitrogen content of fuel [% mass]

w_O = oxygen content of fuel [% mass]

In equation (A.5-4), the ratio p_r / p_b may be assumed:

$$\frac{1}{\left(1-\frac{p_r}{p_b}\right)}=1.008 \tag{A.5-6}$$

For incomplete combustion (rich fuel air mixtures) and also for emission tests without direct air flow measurements, a second method of $k_{w,a}$ calculation is preferred:

$$k_{w,a}=\frac{\frac{1}{1+\alpha\cdot 0.005\cdot\left(c_{CO2}+c_{CO}\right)}-k_{w1}}{1-\frac{p_r}{p_b}} \tag{A.5-7}$$

where:

c_{CO2} = concentration of CO_2 in the raw exhaust gas, on a dry basis [% vol]

c_{CO} = concentration of CO in the raw exhaust gas, on a dry basis [ppm]

p_r = water pressure after cooler [kPa]

p_b = total barometric pressure [kPa]

α = molar to carbon hydrogen ratio [-]

k_{w1} = intake air moisture [-]

$$k_{w1}=\frac{1.608\cdot H_a}{1000+1.608\cdot H_a}$$

(A.5-8)”

Annex 11, Title of Table A.11.1., amend to read:

“Table A.11.1.
Raw exhaust gas u and component densities (for emission concentration expressed in ppm) for engines operated solely on hydrogen”