**GTR11 Extracts - Emissions calculations for transient cycles**

In yellow: parts which could be relevant for RDE GTR, to accommodate other fuel compositions and/or to substitute the tabulated values

A.7.1.3. Fuel properties

 The general chemical formula of fuel is CH*α*O*β*S*γ*N*δ* with *α* atomic hydrogen-to-carbon ratio (H/C), *β* atomic oxygen-to-carbon ratio (O/C), *γ* atomic sulphur-to-carbon ratio (S/C) and *δ* atomic nitrogen-to-carbon ratio (N/C). Based on this formula the carbon mass fraction of fuel *w*C can be calculated. In case of diesel fuel the simple formula CH**O** may be used. Default values for fuel composition may be derived from table A.7.1:

|  |  |  |
| --- | --- | --- |
| Fuel | Atomic hydrogen and oxygen-to-carbon ratiosCHO | Carbon mass concentration, *w*C[g/g] |
| N. 2 Diesel | CH1.80O0 | 0.869 |
| N. 1 Diesel | CH1.93O0 | 0.861 |

 Table A.7.1 - Default values of atomic hydrogen-to-carbon ratio, **, atomic oxygen-to-carbon ratio, **, and carbon mass fraction of fuel, *w*C for diesel fuels

A.7.1. Basic parameters and relationships

A.7.1.1. Dry air and chemical species

 This annex uses the following values for dry air composition:

 

 This annex uses the following molar masses or effective molar masses of chemical species:

 *M*air = 28.96559 g/mol (dry air)

 *M*Ar = 39.948 g/mol (argon)

 *M*C = 12.0107 g/mol (carbon)

 *M*CO = 28.0101 g/mol (carbon monoxide)

 *M*CO2 = 44.0095 g/mol (carbon dioxide)

 *M*H = 1.00794 g/mol (atomic hydrogen)

 *M*H2 = 2.01588 g/mol (molecular hydrogen)

 *M*H2O = 18.01528 g/mol (water)

 *M*He = 4.002602 g/mol (helium)

 *M*N = 14.0067 g/mol (atomic nitrogen)

 *M*N2 = 28.0134 g/mol (molecular nitrogen)

 *M*NMHC = 13.875389 g/mol (non-methane hydrocarbon1)

 *M*NOx = 46.0055 g/mol (oxides of nitrogen2)

 *M*O = 15.9994 g/mol (atomic oxygen)

 *M*O2 = 31.9988 g/mol (molecular oxygen)

 *M*C3H8 = 44.09562 g/mol (propane)

 *M*S = 32.065 g/mol (sulphur)

 *M*THC = 13.875389 g/mol (total hydrocarbon2)

 (a) The effective molar masses of THC and NMHC are defined by an atomic hydrogen-to-carbon ratio, α, of 1.85;

 (b) The effective molar mass of NOx is defined by the molar mass of nitrogen dioxide, NO2.

 This annex uses the following molar gas constant *R* for ideal gases:

 

 This annex uses the following ratios of specific heats *γ*  for dilution air and diluted exhaust:

 *γ*air = 1.399 (ratio of specific heats for intake air or dilution air)

 *γ*dil = 1.399 (ratio of specific heats for diluted exhaust)

 *γ*dil = 1.385 (ratio of specific heats for raw exhaust)

A.8.2.1.2. Transient and ramped modal cycles tests

 The total mass per test of a gaseous emission mgas [g/test] shall be calculated by multiplication of the time aligned instantaneous concentrations and exhaust gas flows and integration over the test cycle according to the following equation:

  (A.8-4)

 Where:

 *f* = data sampling rate [Hz]

 *k*h = NOx correction factor [-], only to be applied for the NOx emission calculation

 *k* = 1 for cgasr,w,i in [ppm] and *k* = 10,000 for cgasr,w,*i* in [per cent vol]

 *u*gas = component specific factor [-] (see paragraph A.8.2.4.)

 N = number of measurements [-]

 *qm*ew,*i* = instantaneous exhaust gas mass flow rate on a wet basis [kg/s]

 *c*gas,*i* = instantaneous emission concentration in the raw exhaust gas, on a wet basis [ppm] or [per cent vol]

 The following chapters show how the needed quantities (*c*gas,*i*, *u*gas and *qm*ew,*i*) shall be calculated.

A.8.2.4.2. Calculated values

 The component specific factor, *u*gas,i, can be calculated by the density ratio of the component and the exhaust or alternatively by the corresponding ratio of molar masses:

  (A.8-12)

 or

  (A.8-13)

 Where:

 *M*gas = molar mass of the gas component [g/mol]

 *M*e,*i* = instantaneous molar mass of the wet raw exhaust gas [g/mol]

 **gas = density of the gas component [kg/m3]

 **e,*i* = instantaneous density of the wet raw exhaust gas [kg/m3]

 The molar mass of the exhaust, *M*e,i shall be derived for a general fuel composition CH**O*ε*N*δ*S*γ*under the assumption of complete combustion, as follows:



 (A.8-14)

 Where:

 *qm*f,*i* = instantaneous fuel mass flow rate on wet basis [kg/s]

 *qm*aw,*i* = instantaneous intake air mass flow rate on wet basis [kg/s]

 ** = molar hydrogen-to-carbon ratio [-]

 ** = molar nitrogen-to-carbon ratio [-]

 ** = molar oxygen-to-carbon ratio [-]

 *γ* = atomic sulphur-to-carbon ratio [-]

 *H*a = intake air humidity [g H2O/kg dry air]

 *M*a = dry intake air molecular mass = 28.965 g/mol

 The instantaneous raw exhaust density *ρ*e,*i* [kg/m3] shall be derived as follows:

  (A.8-15)

 Where:

 *qm*f,*i* = instantaneous fuel mass flow rate [kg/s]

 *qm*ad,*i* = instantaneous dry intake air mass flow rate [kg/s]

 *H*a = intake air humidity [g H2O/kg dry air]

 *k*f = combustion additional volume [m3/kg fuel] (see equation A.8-7)

**GTR15 Extract (From Amendment 6 entries started at IWG26 April 2019)**

3.1.2. The mass $M$ of gaseous compounds emitted by the vehicle during the test shall be determined by the product of the volumetric concentration of the gas in question and the volume of the diluted exhaust gas with due regard for the following densities under the reference conditions of 273.15 K (0 °C) and 101.325 kPa:

Carbon monoxide (CO) $ρ=1.25$ g/l

Carbon dioxide (CO2) $ρ=1.964$ g/l

Hydrocarbons:

 for petrol (E0) (C1H1.85) $ρ=0.619$ g/1

 for petrol (E5) (C1H1.89O0.016) $ρ=0.632$ g/1

 for petrol (E10) (C1H1.93 O0.033) $ρ=0.646$ g/l

 for diesel (B0) (C1Hl.86) $ρ=0.620$ g/1

 for diesel (B5) (C1Hl.86O0.005) $ρ=0.623$ g/1

 for diesel (B7) (C1H1.86O0.007) $ρ=0.625$ g/l

 for LPG (C1H2.525) $ρ=0.649$ g/l

 for NG/biomethane (CH4) $ρ=0.716$ g/l

 for ethanol (E85) (C1H2.74O0.385) $ρ=0.934$ g/l

Formaldehyde (if applicable) $ρ=1.34$

Acetaldehyde (if applicable) $ρ=1.96$

Ethanol (if applicable) $ρ=2.05$

Nitrogen oxides (NOx) $ρ=2.05$ g/1

Nitrogen dioxide (NO2) (if applicable) $ρ=2.05$ g/1

Nitrous oxide (N2O) (if applicable) $ρ=1.964$ g/1

The density for NMHC mass calculations shall be equal to that of total hydrocarbons at 273.15 K (0 °C) and 101.325 kPa, and is fuel-dependent. The density for propane mass calculations (see paragraph 3.5. of Annex 5) is 1.967 g/l at standard conditions.

If a fuel type is not listed in this paragraph, the density of that fuel shall be calculated using the equation given in paragraph 3.1.3. of this annex.