Equation development:

Evaporative Emissions Calculations adjusted for ethanol containing fuel

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I. 40 CFR 86.143-96 methanol concentration equation derived for ethanol:

$$M_{EtOH} = (n_{Mix})(C_{EtOH})(MW_{EtOH})$$

$$n_{Mix} = \frac{(M_{EtOH})}{(C_{EtOH})(MW_{EtOH})}$$

$$|PV = nRT|_{Mix}$$

$$\left| n = \frac{PV}{RT} \right|_{Mix}$$

Combine above equations to yield:

$$\left| \frac{PV}{RT} \right|_{Mix} = \frac{(M_{EtOH})}{(C_{EtOH})(MW_{EtOH})}$$

$$C_{EtOH} = \frac{(R)(T)}{(MW_{EtOH})(P_{Mix})(V_{Mix})} \times M_{EtOH}$$ *(“mix” = sample of enclosure air)*

$$C_{C\ EtOH} = 2(C_{EtOH})$$ (*concentration in terms of carbon)*

$$PPM_{C\ EtOH} = 10^6 \times (C_{C\ EtOH})$$ *(PPM concentration in terms of carbon)*

$$C_{EtOH} = \frac{PPM_{C\ EtOH}}{2\times10^6}$$

$$PPM_{C\ EtOH} = \frac{(2)(10^6)(R)(T)}{(MW_{EtOH})(P_{Mix})(V_{Mix})} \times M_{EtOH}$$

$$M_{EtOH}(in\ \mu g) = [(C_{S1} \times AV_1) + (C_{S2} \times AV_2)]$$ *(from 86.143-96 conc. eqn.)*

$$M_{EtOH}(in\ g) = [(C_{S1} \times AV_1) + (C_{S2} \times AV_2)] \times 10^{-6}$$

$$PPM_{C\ EtOH} = \frac{(2)(R)(T)}{(MW_{eth})(P_{Mix})(V_{Mix})} \times [(C_{S1} \times AV_1) + (C_{S2} \times AV_2)]$$

$$MW_{EtOH} = 46.07 \frac{grams}{mole}$$

$$R = .0481\frac{(inHg)(ft^3)}{(mole)(°R)}$$

$$PPM_{C\ EtOH} = \frac{2.088 \times 10^{-3} \times T}{P_{Mix} \times V_{Mix}} \times [(C_{S1} \times AV_1) + (C_{S2} \times AV_2)]$$

II. California Evaporative Emission Test Procedure diurnal mass equation derived for ethanol:

$M_{di} = M_{HCd} + (OMHCE_{EtOH})(10^{-6})(M_{EtOH})$ *(reported diurnal emissions)*

Where:

$$OMHCE_{EtOH} = \frac{available\ HC\ mass\ of\ an\ ethanol\ molecule\ (assuming\ a\ hydrocarbon\ H:C\ ratio^*\ of\ 2.3:1)}{total\ mass\ of\ an\ ethanol\ molecule}$$

$$OMHCE_{EtOH} = \frac{28.66}{46.07}$$

$M_{di} = M_{HCd} + \left(\frac{28.66}{46.07}\right)(10^{-6})(M_{EtOH})$ *(reported diurnal emissions)*

III. California Evaporative Emission Test Procedure hot soak and running loss mass equations derived for ethanol:

$M_{hs} = M_{HChs} + (OMHCE_{EtOH})(10^{-6})(M_{EtOH})$ *(reported hot soak emissions)*

Where:

$$OMHCE_{EtOH} = \frac{available\ HC\ mass\ of\ an\ ethanol\ molecule\ (assuming\ a\ hydrocarbon\ H:C\ ratio^*\ of\ 2.2:1)}{total\ mass\ of\ an\ ethanol\ molecule}$$

$$OMHCE_{EtOH} = \frac{28.44}{46.07}$$

$M_{hs} = M_{HChs} + \left(\frac{28.44}{46.07}\right)(10^{-6})(M_{EtOH})$ *(reported hot soak emissions)*

$M_{rl} = M_{HCrl} + \left(\frac{28.44}{46.07}\right)(10^{-6})(M_{EtOH})$ *(reported running loss emissions)*

** Hydrocarbon H:C (hydrogen to carbon) ratio obtained from 40 CFR 86.143-96 (diurnal) and 40 CFR 86.143-90 (hot soak and running loss)*

IV. California Evaporative Emission Test Procedure ethanol vapor density calculation (in running loss emission mass equation)

Assumptions:
Density of air at NTP (Normal temperature and pressure = 68^oF and 1 atm) is $34.12\ g/ft^3$
Vapor density of ethanol at NTP = 1.59 x Vapor density of air at NTP

Therefore:
Ethanol vapor density at NTP = 1.59 x $34.12\ g/ft^3$ = $54.25\ g/ft^3$