# §86.144 Calculations; exhaust emissions

Read Input Data

$i := 1 .. 54$ $input_i := READ(hwyinput)$

Testnumber := $input_1$ Numeric test identifier Testnumber = 199702

Procedure := $input_2$ Procedure = 3 Numeric Test Procedure

§86.144-94(e)
For Phase II California fueled vehicle with measured fuel composition of CxHyOz:

| | | |
|---|---|---|
| $x := input_{49}$ | x = 1 | Carbon-to-carbon ratio as measured for the fuel used. |
| $y := input_{50}$ | y = 3.97 | Hydrogen-to-carbon ratio as measured for thefuel used. |
| $y_{HC} := y$ | $y_{HC}$ = 3.97 | Hydrogen-to-carbon ratio as measured for the fuel used. |
| $y_{NMHC} := input_{52}$ | $y_{NMHC}$ = 2.596 | Non-Methane Hydrocarbon Hydrogen-to-carbon ratio as measured for the Non-Methane Hydrocarbon components of the fuel used. |
| $z := input_{53}$ | z = 0 | Oxygen-to-carbon ratio as measured for the fuel used. |

FID response to methane

| | | |
|---|---|---|
| $r_{CH4} := input_7$ | $r_{CH4}$ = 1.114 | FID response to methane. |

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The analyzer concentrations were as follows:

| | | |
|---|---|---|
| $FIDHC_e := input_{10}$ | $FIDHC_e = 104.295$ | Concentration of hydrocarbon plus methane in dilute exhaust as measured by the FID, ppm carbon equivalent. |
| $NOx_e := input_{11}$ | $NOx_e = 29.477$ | Oxides of nitrogen concentration of the dilute exhaust sample as measured, in ppm. |
| $CO_e := input_{12}$ | $CO_e = 15.774$ | Carbon monoxide concentration of the dilute exhaust sample as measured, in ppm. |
| $CO2_e := input_{13}$ | $CO2_e = 1.845$ | Carbon dioxide concentration of the dilute exhaust sample as measured, in percent. |
| $CH4_e := input_{14}$ | $CH4_e = 0$ | Concentration of methane in dilute exhaust sample as measured, ppm carbon equivalent. |

| | | |
|---|---|---|
| $FIDHC_d := input_{15}$ | $FIDHC_d = 99.794$ | Concentration of hydrocarbon plus methane in dilution air as measured by the FID, ppm carbon equivalent. |
| $NOx_d := input_{16}$ | $NOx_d = 0.153$ | Oxides of nitrogen concentration of the dilution air sample as measured, in ppm. |
| $CO_d := input_{17}$ | $CO_d = 0.094$ | Carbon monoxide concentration of the dilution air sample as measured, in ppm. |
| $CO2_d := input_{18}$ | $CO2_d = 0.045$ | Carbon dioxide concentration of the dilution air as measured, in percent. |
| $CH4_d := input_{19}$ | $CH4_d = 0$ | Concentration of methane in dilution air as measured, ppm carbon equivalent. |

| | | |
|---|---|---|
| $D := input_{20}$ | $D = 10.293$ | The measured driving distance from the "transient" phase of the cold start test, in miles. |
| $V_{mix} := input_{21}$ | $V_{mix} = 3937$ | Volume of dilute exhaust collected during the transient phase of the cold-start test, in scf. |
| $K_H := input_{22}$ | $K_H = 0.865$ | NOx Humidity Correction Factor |

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CONSTANTS

| | |
|---|---|
| $Density_{HC} := 16.33$ | Density is grams per cubic foot, at 68ïF and 760 mm Hg pressure. |
| $Density_{THC} := 16.33$ | Density is grams per cubic foot, at 68ïF and 760 mm Hg pressure. |
| $Density_{NMHC} := 16.33$ | Density is grams per cubic foot, at 68ïF and 760 mm Hg pressure. |
| $Density_{CH4} := 18.89$ | Density is grams per cubic foot, at 68ïF and 760 mm Hg pressure. |
| $Density_{NOx} := 54.16$ | Density is grams per cubic foot, at 68ïF and 760 mm Hg pressure. |
| $Density_{CO} := 32.97$ | Density is grams per cubic foot, at 68ïF and 760 mm Hg pressure. |
| $Density_{CO2} := 51.81$ | Density is grams per cubic foot, at 68ïF and 760 mm Hg pressure. |

DERIVED DENSITIES

$Density_{HC} := 1.1771 \cdot \left(12.011 + y_{HC} \cdot 1.008\right)$ $Density_{HC} = 18.849$

$Density_{NMHC} := 1.1771 \cdot \left(12.011 + y_{NMHC} \cdot 1.008\right)$ $Density_{NMHC} = 17.218$

# §86.144 Calculations; exhaust emissions

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EPA and CARB - Non-methane hydrocarbon concentration of the dilute exhaust sample as measured, in ppm carbon equivalent.

$$NMHC_e := FIDHC_e - r_{CH4} \cdot CH4_e$$

$NMHC_e = 104.295$

EPA and CARB - Non-methane hydrocarbon concentration of the dilution air as measured, in ppm carbon equivalent.

$$NMHC_d := FIDHC_d - r_{CH4} \cdot CH4_d$$

$NMHC_d = 99.794$

Total hydrocarbon (non-methanol) concentration of the dilute exhaust sample as measured, ppm carbon equivalent, i.e., equivalent propane X 3.

$$HC_e := FIDHC_e$$

$HC_e = 104.295$

Total hydrocarbon (non-methanol) concentration of the dilution air as measured, in ppm carbon equivalent.

$$HC_d := FIDHC_d$$

$HC_d = 99.794$

Dilution factor for Natural Gas fueled vehicles where fuel composition is CxHyOz as measured for the fuel used.

$$DF := \frac{100 \cdot \left[ \frac{x}{x + \frac{y}{2} + 3.76 \cdot \left[ x + \frac{y}{4} \right]} \right]}{CO2_e + \left( NMHC_e + CH4_e + CO_e \right) \cdot 10^{-4}}$$

$DF = 5.14$

Non-methane concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent.

$$NMHC_{conc} := NMHC_e - NMHC_d \cdot \left[ 1 - \frac{1}{DF} \right]$$

$NMHC_{conc} = 23.92$

Non-methane hydrocarbon mass, in grams per test phase.

$$NMHC_{mass} := \frac{V_{mix} \cdot Density_{NMHC} \cdot NMHC_{conc}}{10^6}$$

$NMHC_{mass} = 1.621$

Methane concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent.

$$CH4_{conc} := CH4_e - CH4_d \cdot \left[ 1 - \frac{1}{DF} \right]$$

$CH4_{conc} = 0$

Methane hydrocarbon mass, in grams per test phase.

$$CH4_{mass} := \frac{V_{mix} \cdot Density_{CH4} \cdot CH4_{conc}}{10^6}$$

$CH4_{mass} = 0$

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Hydrocarbon concentration of the dilute exhaust sample, in ppm carbon equivalent.

$$HC_{conc} := HC_e - HC_d \cdot \left(1 - \frac{1}{DF}\right) \qquad HC_{conc} = 23.916$$

Total hydrocarbon emissions, in grams per test phase.

$$HC_{mass} := \frac{V_{mix} \cdot Density_{HC} \cdot HC_{conc}}{10^6} \qquad HC_{mass} = 1.775$$

Oxides of nitrogen concentration of the dilute exhaust sample corrected for background, ppm.

$$NOx_{conc} := NOx_e - NOx_d \cdot \left(1 - \frac{1}{DF}\right) \qquad NOx_{conc} = 29.35$$

Oxides of nitrogen emissions, in grams per test phase.

$$NOx_{mass} := \frac{V_{mix} \cdot Density_{NOx} \cdot K_H \cdot NOx_{conc}}{10^6} \qquad NOx_{mass} = 5.412$$

Carbon monoxide concentration of the dilute exhaust sample corrected for background, ppm.

$$CO_{conc} := CO_e - CO_d \cdot \left(1 - \frac{1}{DF}\right) \qquad CO_{conc} = 15.7$$

Carbon monoxide emissions, in grams per test phase.

$$CO_{mass} := \frac{V_{mix} \cdot Density_{CO} \cdot CO_{conc}}{10^6} \qquad CO_{mass} = 2.04$$

Carbon dioxide concentration of the dilute exhaust sample corrected for background, percent.

$$CO2_{conc} := CO2_e - CO2_d \cdot \left(1 - \frac{1}{DF}\right) \qquad CO2_{conc} = 1.808$$

Carbon dioxide emissions, in grams per test phase.

$$CO2_{mass} := \frac{V_{mix} \cdot Density_{CO2} \cdot CO2_{conc}}{10^2} \qquad CO2_{mass} = 3689$$

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(1) The above calculations resulted in the following:

| | | |
|---|---|---|
| $HC := HC_{mass}$ | Total hydrocarbon equivalent, in grams per test phase. | HC = 1.775 |
| $CH4 := CH4_{mass}$ | Total hydrocarbon equivalent, in grams per test phase. | CH4 = 0 |
| $NMHC := NMHC_{mass}$ | Total hydrocarbon equivalent, in grams per test phase. | NMHC = 1.621 |
| $NOx := NOx_{mass}$ | Oxides of nitrogen, in grams per test phase. | NOx = 5.412 |
| $CO := CO_{mass}$ | Carbon monoxide, in grams per test phase. | CO = 2.038 |
| $CO2 := CO2_{mass}$ | Carbon dioxide in grams per test phase. | CO2 = 3689 |

(4) Emission results:

Total hydrocarbon, in grams per vehicle mile.

$$HC_{gpm} := \frac{HC}{D}$$

$HC_{gpm} = 0.1724$

Methane hydrocarbon, in grams per vehicle mile.

$$CH4_{gpm} := \frac{CH4}{D}$$

$CH4_{gpm} = 0$

Non-methane hydrocarbon, in grams per vehicle mile.

$$NMHC_{gpm} := \frac{NMHC}{D}$$

$NMHC_{gpm} = 0.1575$

Oxides of nitrogen, in grams per vehicle mile.

$$NOx_{gpm} := \frac{NOx}{D}$$

$NOx_{gpm} = 0.5258$

Carbon monoxide, in grams per vehicle mile.

$$CO_{gpm} := \frac{CO}{D}$$

$CO_{gpm} = 0.198$

Carbon dioxide, in grams per vehicle mile.

$$CO2_{gpm} := \frac{CO2}{D}$$

$CO2_{gpm} = 358.3628$