§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

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

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

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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.

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

$CO2_{gpm} = 358.3628$