(ii) H = $(43.478)(48.2)(22.225)/[762 - (22.225 \times 48.2/100)]$ = 62 grains of water per pound of dry air.

(iii) K_H = $1/[1 - 0.0047(62 - 75)]$ = 0.9424.

(iv) CO_e = $[1 - (0.01 + 0.005 \times 3.14 \times 1.43) - 0.000323(48)] \times 306.6$ = 291.9 ppm.

(v) CO_d = $(1 - 0.000323(48)) \times 15.3$ = 15.1 ppm.

(vi) C_{CH3OHe} = $(3.813 \times 10^{-2})(71)(567)[(4460)(25.2) + (360)(24.9)] / (3660)(762)(1.18)$ = 56.60 ppm.

(vii) DF = $100(1/[1 + (3.14/2) + 3.76(1 + (3.14/4) - (0.6/2))])/1.43 + 10^{-4}[(81.6 + 291.9 + (1 - 0.75)(56.60)] + 8.350$

(viii) C_{CH3OHd} = $(3.813 \times 10^{-2})(71)(532)[(110)(25.0) + (10)(25.1)] / (3660)(762)(1.17)$ = 1.32 ppm.

(ix) CH_3OH_{conc}=$56.60 - 1.32(1 - 1/8.350)$=55.44 ppm.

(x) CH_3OH_{mass}=$2595.0 \times 37.71 \times (55.44/1,000,000)$=5.43 grams per test phase.

(xi) HC_{conc} = $[81.6 - (0.75)(56.60)] - [12.1 - (0.75)(1.32)](1 - 1/8.530)$ = 29.34 ppm.

(xii) HC_{mass}=(2594) (16.33) $(29.34/1,000,000)$=1.24 grams per test phase.

(xiii) C_{HCHOe} = $4.069 \times 10^{-2}(20)(5)(0.1429)(569)/(0.30)(762)$ = 1.4473 ppm.

(xiv) C_{HCHOd} = $4.069 \times 10^{-2}(1)(5)(0.1429)(532)/(0.31)(762)$ = 0.0655 ppm.

(xv) $HCHO_{conc}$=$1.4473 - 0.0655(1 - 1/8.350)$=1.3896 ppm.

(xvi) $HCHO_{mass}$=$(2595)(35.36)(1.3896/1,000,000)$=0.1275 grams per test phase.

(xvii) THCE = $1.24 + (13.8756/32.042)(5.43) + (13.8756/30.0262)(0.1275)$ = 3.65 grams per test phase.

(xviii) NOx_{conc}=$11.2 - (0.8)(1 - 1/8.350)$=10.50 ppm

(xix) NOx_{mass}=$(2595)(54.16)(10.50/1,000,000)(0.9424)$=1.390 grams per test phase.

(xx) CO_{conc}=$291.9 - 15.1$ $(1 - 1/8.350)$=278.61 ppm.

(xxi) CO_{mass}=$(2595.0)(32.97)(278.69/1,000,000)$=23.84 grams per test phase.

(xxii) CO_{2conc}=$1.43 - 0.032$ $(1 - 1/8.350)$=1.402 percent.

(xxiii) CO_{2mass}=$(2595.0)(51.85)(1.402/100)$=1886 grams per test phase.

(2) For the stabilized portion of the cold start test assume that similar calculations resulted in the following:

(i) THCE=0.55 grams per test phase.

(ii) NOx_{mass}=1.27 grams per test phase.

(iii) CO_{mass}=5.98 grams per test phase.

(iv) CO_{2mass}=2346 grams per test phase.

(v) D_s=3.902 miles.

(3) For the "transient" portion of the hot start test assume that similar calculations resulted in the following:

(i) THCE=0.67 grams as carbon equivalent per test phase.

(ii) NOx_{mass}=1.38 grams per test phase.

(iii) CO_{mass}=5.01 grams per test phase.

(iv) CO_{2mass}=1758 grams per test phase.

(v) D_{ht}=3.598 miles.

(4) Weighted emission results:

(i) $THCE_{wm}$=$0.43[(3.65+0.55)/(3.598+3.902)]+0.57[(0.67+0.55)/(3.598+3.902)]$=0.334 grams as carbon equivalent per mile.

(ii) NOx_{wm}=$0.43[(1.390+1.27)/(3.598+3.902)]+0.57[1.38+1.27)/(3.598+3.902)]$=0.354 grams per vehicle mile.

(iii) CO_{wm}=$0.43[(23.84+5.98)/(3.598+3.902)]+0.57[(5.01+5.98)/(3.598+3.902)]$=2.54 grams per vehicle mile.

(iv) CO_{2wm}+$0.43[(1886+2346)/(3.598+3.902)]+0.57[(1758+2346)/(3.598+3.902)]$=555 grams per vehicle mile.

§ 86.144–94 Calculations; exhaust emissions.

The final reported test results shall be computed by use of the following formula:

(a) For light-duty vehicles and light duty trucks:

$$Y_{wm} = 0.43\left(\frac{(Y_{ct} + Y_s)}{(D_{ct} + D_s)}\right) + 0.57\left(\frac{(Y_{ht} + Y_s)}{(D_{ht} + D_s)}\right)$$

Where:

(1) Y_{WM} = Weighted mass emissions of each pollutant, *i.e.*, THC, CO, THCE,

NMHC, NMHCE, CH_4, NO_X, or CO_2, in grams per vehicle mile.

(2) Y_{ct}=Mass emissions as calculated from the ''transient'' phase of the cold start test, in grams per test phase.

(3) Y_{ht}=Mass emissions as calculated from the ''transient'' phase of the hot start test, in grams per test phase.

(4) Y_s=Mass emissions as calculated from the ''stabilized'' phase of the cold start test, in grams per test phase.

(5) D_{ct}=The measured driving distance from the ''transient'' phase of the cold start test, in miles.

(6) D_{ht}=The measured distance from the ''transient'' phase of the hot start test, in miles.

(7) D_s=The measured driving distance from the ''stabilized'' phase of the cold start test, in miles.

(b) The mass of each pollutant for each phase of both the cold start test and the hot start test is determined from the following:

(1) Total hydrocarbon mass:

$$HC_{mass}=V_{mix} \times Density_{HC} \times (HC_{conc}/1,000,000)$$

(2) Oxides of nitrogen mass:

$$NOx_{mass}=V_{mix} \times Density_{NO2} \times K_H \times (NOx_{conc}/1,000,000)$$

(3) Carbon monoxide mass:

$$CO_{mass}=V_{mix} \times Density_{CO} \times (CO_{conc}/1,000,000)$$

(4) Carbon dioxide mass:

$$CO_{2mass}=V_{mix} \times Density_{CO2} \times (CO_{2conc}/100)$$

(5) Methanol mass:

$$CH_3OH_{mass}=V_{mix} \times Density_{CH3OH} \times (CH_3OH_{conc}/1,000,000)$$

(6) Formaldehyde mass:

$$HCHO_{mass}=V_{mix} \times Density_{HCHO} \times (HCHO_{conc}/1,000,000)$$

(7) Total hydrocarbon equivalent mass:

$$THCE_{mass} = HC_{mass} + 13.8756/32.042 \times (CH_3OH_{mass}) + 13.8756/32.0262 \times (HCHO_{mass})$$

(8) Non-methane hydrocarbon mass:

$$NMHC_{mass} = V_{mix} \times Density_{NMHC} \times (NMHC_{conc}/1,000,000)$$

(9) Non-methane hydrocarbon equivalent mass:

$$NMHCE_{mass} = NMHC_{mass} + 13.8756/32.042 \times (CH_3OH_{mass}) + 13.8756/30.0262 \times (HCHO_{mass})$$

(10) Methane mass:

$$CH_{4mass}=V_{mix}=Density_{CH4}=(CH_{4conc}/1,000,00)$$

(c) Meaning of symbols:

(1)(i) HC_{mass}=Total hydrocarbon emissions, in grams per test phase.

(ii) $Density_{HC}$=Density of total hydrocarbon.

(A) *For gasoline-fuel, diesel-fuel and methanol fuel;* $Density_{HC}$=16.33 g/ft^3−carbon atom (0.5768 kg/m^3−carbon atom), assuming an average carbon to hydrogen ratio of 1:1.85, at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(B) *For natural gas and liquefied petroleum gas-fuel;* $Density_{HC}$=1.1771 (12.011+H/C (1.008)) g/ft^3−carbon atom (0.04157(12.011+H/C (1.008))kg/m^3−carbon atom), where H/C is the hydrogen to carbon ratio of the hydrocarbon components of the test fuel, at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii)(A) HC_{conc}=Total hydrocarbon concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent, i.e., equivalent propane $\times 3$.

(B) $HC_{conc}=HC_e-HC_d(1-1/DF)$.

Where:

(iv)(A) HC_e=Total hydrocarbon concentration of the dilute exhaust sample or, for diesel-cycle (or methanol-fueled vehicles, if selected), average hydrocarbon concentration of the dilute exhaust sample as calculated from the integrated THC traces, in ppm carbon equivalent.

(B) HC_e=FID $HC_e-(r)C_{CH3OHe}$.

(v) FID HC_e=Concentration of total hydrocarbon plus methanol in dilute exhaust as measured by the FID, ppm carbon equivalent.

(vi) r=FID response to methanol.

(vii) C_{CH3OHe}=Concentration of methanol in dilute exhaust as determined from the dilute exhaust methanol sample in ppm carbon. For vehicles not fueled with methanol, C_{CH3OHe} equals zero.

(viii)(A) HC_d=Total hydrocarbon concentration of the dilution air as measured, in ppm carbon equivalent.

(B) HC_d=FID $HC_d-(r)C_{CH3OHd}$.

(ix) FID HC_d=Concentration of total hydrocarbon plus methanol in dilution

air as measured by the FID, ppm carbon equivalent.

(x) C_{CH3OHd}=Concentration of methanol in dilution air as determined from dilution air methanol sample in ppm carbon. For vehicles not fueled with methanol, C_{CH3OHd} equals zero.

(2)(i) NOx_{mass}=Oxides of nitrogen emissions, in grams per test phase.

(ii) $Density_{NO2}$=Density of oxides of nitrogen is 54.16 g/ft3 (1.913 kg/m³) assuming they are in the form of nitrogen dioxide, at 68 °F (20 °C) and 760 mm Hg (101.3kPa) pressure.

(iii)(A) NOx_{conc}=Oxides of nitrogen concentration of the dilute exhaust sample corrected for background, in ppm.

(B) $NOx_{conc}=NOx_e - NOx_d(1 - (1/DF))$.

Where:

(iv) NOx_e=Oxides of nitrogen concentration of the dilute exhaust sample as measured, in ppm.

(v) NOx_d=Oxides of nitrogen concentration of the dilution air as measured, in ppm.

(3)(i) CO_{mass}=Carbon monoxide emissions, in grams per test phase.

(ii) $Density_{CO}$ = Density of carbon monoxide is 32.97 g/ft³ (1.164 kg/m3), at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii)(A) CO_{conc} = Carbon monoxide concentration of the dilute exhaust sample corrected for background, water vapor, and CO_2 extraction, in ppm.

(B) $CO_{conc} = CO_e - CO_d(1 - (1/DF))$.

Where:

(iv)(A) CO_e = Carbon monoxide concentration of the dilute exhaust volume corrected for water vapor and carbon dioxide extraction, in ppm.

(B) $CO_e = (1 - 0.01925CO_{2e} - 0.000323R)CO_{em}$ for petroleum fuel with hydrogen to carbon ratio of 1.85:1.

(C) $CO_e=[1 - (0.01+0.005HCR) CO_{2e} - 0.000323R]CO_{em}$ for methanol-fuel or natural gas-fuel or liquefied petroleum gas-fuel, where HCR is hydrogen-to-carbon ratio as measured for the fuel used.

(v) CO_{em} = Carbon monoxide concentration of the dilute exhaust sample as measured, in ppm.

(vi) CO_{2e} = Carbon dioxide concentration of the dilute exhaust sample, in percent.

(vii) R = Relative humidity of the dilution air, in percent (see § 86.142(n)).

(viii)(A) CO_d = Carbon monoxide concentration of the dilution air corrected for water vapor extraction, in ppm.

(B) $CO_d = (1-0.000323R)CO_{dm}$.

Where:

(ix) CO_{dm} = Carbon monoxide concentration of the dilution air sample as measured, in ppm.

NOTE: If a CO instrument which meets the criteria specified in § 86.111 is used and the conditioning column has been deleted, CO_{em} must be substituted directly for CO_e and CO_{dm} must be substituted directly for CO_d.

(4)(i) CO_{2mass} = Carbon dioxide emissions, in grams per test phase.

(ii) Density CO_2 = Density of carbon dioxide is 51.81 g/ft³ (1.830 kg/m³), at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii)(A) CO_{2conc} = Carbon dioxide concentration of the dilute exhaust sample corrected for background, in percent.

(B) $CO_{2conc} = CO_{2e} - CO_{2d}(1 - (1/DF))$.

Where:

(iv) CO_{2d} = Carbon dioxide concentration of the dilution air as measured, in percent.

(5)(i) CH_3OH_{mass} = Methanol emissions corrected for background, in grams per test phase.

(ii) $Density_{CH3OH}$=Density of methanol is 37.71 g/ft³-carbon atom (1.332 kg/m³-carbon atom), at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii)(A) CH_3OH_{conc} = Methanol concentration of the dilute exhaust corrected for background, ppm.

(B) $CH_3OH_{conc} = C_{CH3OHe} - C_{CH3OHd}(1 - (1/DF))$.

Where:

(iv)(A) C_{CH3OHe}=Methanol concentration in the dilute exhaust, ppm.

(B)

$$C_{CH3OHe} = \frac{3.813 \times 10^{-2} \times T_{EM} \left[\left(C_{S1} \times AV_{S1} \right) + \left(C_{S2} \times AV_{S2} \right) \right]}{P_B \times V_{EM}}$$

(v)(A) C_{CH3OHd}=Methanol concentration in the dilution air, ppm.
(B)

$$C_{CH3OHd} = \frac{3.813 \times 10^{-2} \times T_{DM} \left[(C_{D1} \times AV_{D1}) + (C_{D2} \times AV_{D2}) \right]}{P_B \times V_{DM}}$$

(vi) T_{EM}=Temperature of methanol sample withdrawn from dilute exhaust, °R.

(vii) T_{DM}=Temperature of methanol sample withdrawn from dilution air, °R.

(viii) P_B=Barometric pressure during test, mm Hg.

(ix) V_{EM}=Volume of methanol sample withdrawn from dilute exhaust, ft³.

(x) V_{DM}=Volume of methanol sample withdrawn from dilution air, ft³.

(xi) C_S=GC concentration of sample drawn from dilute exhaust, µg/ml.

(xii) C_D=GC concentration of sample drawn from dilution air, µg/ml.

(xiii) AVS=Volume of absorbing reagent (deionized water) in impinger through which methanol sample from dilute exhaust is drawn, ml.

(xiv) AVD=Volume of absorbing reagent (deionized water) in impinger through which methanol sample from dilution air is drawn, ml.

(xv) 1=first impinger.
(xvi) 2=second impinger.
(xvii) 1 = first impinger.
(xviii) 2 = second impinger.
(6)(i) $HCHO_{mass}$ = Formaldehyde emissions corrected for background, in grams per test phase.

(ii) Density$_{HCHO}$=Density of formaldehyde is 35.36 g/ft³- carbon atom (1.249 kg/m³-carbon atom), at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii)(A) $HCHO_{conc}$ = Formaldehyde concentration of the dilute exhaust corrected for background, in ppm.

(B) $HCHO_{conc}$ = C_{HCHOe} − C_{HCHOd} (1 − (1/DF)).
Where:

(iv)(A) C_{HCHOe} = Formaldehyde concentration in dilute exhaust, in ppm.
(B)

$$C_{HCHOe} = \frac{4.069 \times 10^{-2} \times C_{FDE} \times V_{AE} \times Q \times T_{EF}}{V_{SE} \times P_B}$$

(v)(A) C_{HCHOd} = Formaldehyde concentration in dilution air in ppm.
(B)

$$C_{HCHOd} = \frac{4.069 \times 10^{-2} \times C_{FDA} \times V_{AA} \times Q \times T_{DF}}{V_{SA} \times P_B}$$

(vi) C_{FDE} = Concentration of DNPH derivative of formaldehyde from dilute exhaust sample in sampling solution, µg/ml.

(vii) V_{AE} = Volume of sampling solution for dilute exhaust formaldehyde sample, ml.

(viii)(A) Q = Ratio of molecular weights of formaldehyde to its DNPH derivative.

(B) Q = 0.1429.

(ix) T_{EF} = Temperature of formaldehyde sample withdrawn from dilute exhaust, °R.

(x) V_{SE} = Volume of formaldehyde sample withdrawn from dilute exhaust, ft³.

(xi) P_B = Barometric pressure during test, mm Hg.

(xii) C_{FDA} = Concentration of DNPH derivative of formaldehyde from dilution air sample in sampling solution, µg/ml.

(xiii) V_{AA} = Volume of sampling solution for dilution air formaldehyde sample, ml.

(xiv) T_{DF} = Temperature of formaldehyde sample withdrawn from dilution air, °R.

(xv) V_{SA} = Volume of formaldehyde sample withdrawn from dilution air, ft³.

(7)(i) DF = 13.4/[CO_{2e}+(HC_e+CO_e) 10^{-4}] for petroleum-fueled vehicles.

(ii) For methanol-fueled vehicles, where fuel composition is $C_x H_y O_z$ as measured, or calculated, for the fuel used:

$$DF = \frac{(100)\dfrac{x}{x + y/2 + 3.76\,(x + y/2 - z/2)}}{CO_{2e} + \left(HC_e + CO_e + CH_3OH_e + HCHO_e\right) \times 10^{-4}}$$

(iii)

$$DF = \frac{100 \times \dfrac{x}{x + y/2 + 3.76(x + y/4)}}{CO_{2e} + \left(NMHC_e + CH_{4e} + CO_e\right) \times 10^{-4}}$$

for natural gas-fueled or liquefied petroleum gas-fueled vehicles where fuel composition is $C_x H_y$ as measured for the fuel used.

(iv)(A) K_H=Humidity correction factor.

(B) $K_H = 1/[1 - 0.0047(H - 75)]$.

(C) *For SI units,* $K_H = 1 \times [1 - 0.0329(H \times 10.71)]$.

Where:

(v)(A) H=Absolute humidity in grains (grams) of water per pound (kilogram) of dry air.

(B) $H = [(43.478)R_a \times P_d]/[P_B - (P_d \times R_a/100)]$.

(C) *For SI units,* $H = [(6.211)R_a \times P_d]/[P_B \times (P_d \times R_a/100)]$.

(vi) R_a=Relative humidity of the ambient air, percent.

(vii) P_d=Saturated vapor pressure, mm Hg (kPa) at the ambient dry bulb temperature.

(viii) P_B=Barometric pressure, mm Hg (kPa).

(ix)(A) V_{mix}=Total dilute exhaust volume in cubic feet per test phase corrected to standard conditions (528°R (293 °K) and 760 mm Hg (101.3 kPa)).

(B) For PDP–CVS, V_{mix} is:

$$V_{mix} = \frac{V_O \times N \times \left(P_B - P_4\right) \times 528}{760 \times T_P}$$

(C) *For SI units,*

$$V_{mix} = \frac{V_o \times N \times \left(P_B - P_4\right) \times 293}{101.3 \times T_p}$$

Where:

(x) V_o=Volume of gas pumped by the positive displacement pump, in cubic feet (m³) per revolution. This volume is dependent on the pressure differential across the positive displacement pump.

(xi) N=Number of revolutions of the positive displacement pump during the test phase while samples are being collected.

(xii) P_B=Barometric pressure, mm Hg (kPa).

(xiii) P_4=Pressure depression below atmospheric measured at the inlet to the positive displacement pump, in mm Hg (kPa) (during an idle mode).

(xiv) T_p=Average temperature of dilute exhaust entering positive displacement pump during test, °R(°K).

(8)(i) $NMHC_{conc} = HC_{conc} - (r_{CH4} \times CH_{4conc})$.

(ii) $Density_{NMHC}$=The density of non-methane hydrocarbon.

(A) *For gasoline-fuel and diesel-fuel;* $Density_{NMHC}$=16.33 g/ft³-carbon atom (0.5768 kg/m³-carbon atom), assuming an average carbon to hydrogen ratio of 1:1.85 at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(B) For natural gas and liquefied petroleum gas fuel; $Density_{NMHC}$=1.1771(12.011+H/C(1.008))g/ft³-carbon atom (0.04157(12.011+H/C(1.008))kg/m³-carbon atom), where H/C is the hydrogen to carbon ratio of the non-methane hydrocarbon components of the test fuel, at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii)(A) CH_{4conc} = Methane concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent.

(B) $CH_{4conc} = CH_{4e} - CH_{4d}(1 - 1/DF)$

Where:

(iv) CH_{4e} = Methane exhaust bag concentration in ppm carbon equivalent.

(v) CH_{4d} = Methane concentration of the dilution air in ppm carbon equivalent.

(vi) r_{CH4}=HC FID response to methane for natural gas-fueled vehicles as measured in §86.121(d). For all other vehicles r_{CH4}=1.

(9)(i) CH_{4mass}=Methane emissions, in grams per test phase.

(ii) $Density_{CH4}$=Density of methane is 18.89 g/ft³-carbon atom (0.6672 kg/m³-carbon atom), at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(d) For petroleum-fueled vehicles, example calculation of mass values of exhaust emissions using positive displacement pump:

(1) For the "transient" phase of the cold start test assume the following: V_o = 0.29344 ft³rev; N = 10,485; R = 48.0 pct; R_a = 48.2 percent; P_B = 762 mm Hg; P_d = 22.225 mm Hg; P_4 = 70 mm Hg; T_p = 570 °R; HC_e = 105.8 ppm, carbon equivalent; NOx_e = 11.2 ppm; CO_{em} = 306.6 ppm; CO_{2e} = 1.43 percent; CH_{4e} = 10.74 ppm; HC_d = 12.1 ppm; NOx_d = 0.8 ppm; CO_{dm} = 15.3 ppm; CO_{2d} = 0.032 percent; CH_{4d} = 2.20 ppm; D_{ct} = 3.598 miles.

Then:

(i) V_{mix} = (0.29344)(10,485)(762-70)(528)/(760)(570) = 2595.0 ft³ per test phase.

(ii) H = (43.478)(48.2)(22.225)/762 − (22.225)(48.2/100) = 62 grains of water per pound of dry air.

(iii) K_H = 1/[1 − 0.0047(62-75)] = 0.9424.

(iv) CO_e = [1-0.01925(1.43) − 0.000323(48)](306.6) = 293.4 ppm.

(v) CO_d = [1 − 0.000323(48)](15.3) = 15.1 ppm.

(vi) DF = 13.4/[1.43+10⁻⁴(105.8+293.4)] = 9.116.

(vii) HC_{conc} = 105.8-12.1(1 − 1/9.116) = 95.03 ppm.

(viii) HC_{mass} = (2595)(16.33)(95.03/1,000,000) = 4.027 grams per test phase.

(ix) NOx_{conc} = 11.2 − 0.8(1 − 1/9.116) = 10.49 ppm.

(x) NOx_{mass} = (2595)(54.16)(10.49/1,000,000)(0.9424) = 1.389 grams per test phase.

(xi) CO_{conc} = 293.4 − 15.1(1 − 1/9.116) = 280.0 ppm.

(xii) CO_{mass} = (2595)(32.97)(280/1,000,000) = 23.96 grams per test phase.

(xiii) CO_{2conc} = 1.43 − 0.032(1 − 1/9.116) = 1.402 percent.

(xiv) CO_{2mass} = (2595.0)(51.85)(1.402/100) = 1886 grams per test phase.

(xv) CH_{4conc} = 10.74 − 2.2 (1 − 1/9.116) = 8.78 ppm.

(xvi) $NMHC_{conc}$ = 95.03 − 8.78 = 86.25 ppm.

(xvii) $NMHC_{mass}$ = (2595)(16.33)(86.25)/1,000,000 = 3.655 grams per test phase.

(2) For the stabilized portion of the cold start test assume that similar calculations resulted in the following:

(i) HC_{mass} = 0.62 gram per test phase.

(ii) NOx_{mass} = 1.27 grams per test phase.

(iii) CO_{mass} = 5.98 grams per test phase.

(iv) CO_{2mass} = 2346 grams per test phase.

(v) D_s = 3.902 miles.

(vi) $NMHC_{mass}$ = 0.50 gram per test phase.

(3) For the "transient" portion of the hot start test assume that similar calculations resulted in the following:

(i) HC_{mass} = 0.51 gram per test phase.

(ii) NOx_{mass} = 1.38 grams per test phase.

(iii) CO_{mass} = 5.01 grams per test phase.

(iv) CO_{2mass} = 1758 grams per test phase.

(v) D_{ht} = 3.598 miles.

(vi) $NMHC_{mass}$ = 0.44 grams per test phase.

(4) Weighted mass emission results:

(i) HC_{wm} = 0.43[(4.027+0.62)/(3.598+3.902)]+0.57[(0.51+0.62)/(3.598+3.902)] = 0.352 gram per vehicle mile.

(ii) NOx_{wm} = 0.43[(1.389+1.27)/(3.598+3.902)] + 0.57[(1.38+1.27)/(3.598+3.902)] = 0.354 gram per vehicle mile.

(iii) CO_{wm} = 0.43[(23.96+5.98)/(3.598+3.902)] + 0.57[(5.01+5.98)/(3.598+3.902)] = 2.55 grams per vehicle mile.

(iv) CO_{2wm} = 0.43[(1886+2346)/(3.598+3.902)+0.57[(1758+2346)/(3.598+3.902)] = 555 gram per vehicle mile.

(v) $NMHC_{wm}$ = 0.43[(3.655 + 0.50)/(3.598 + 3.902)] + 0.57[(0.44 + 0.50)/(3.598 + 3.902)] = 0.310 gram per vehicle mile.

(e) For methanol-fueled vehicles with measured fuel composition of $CH_{3.487}O_{0.763,}$ example calculation of exhaust emissions using positive displacement pump:

(1) For the ''transient'' phase of the cold start test assume the following: V_0=0.29344 ft^3 rev; N=25,801; R=37.5 pct; Ra=37.5 percent; P_B=725.42 mm Hg; P_d=22.02 mm Hg; P_4=70 mm Hg; T_p 570 deg.R; FID HC_e=14.65 ppm, carbon equivalent; r=0.788; T_{EM}=527.67 deg.R; V_{EM}=0.2818 ft^3; C_{S1}=7.101; AV_{S1}=15.0 ml; C_{S2}=0.256; AV_{S2}=15.0 ml; T_{DM}=527.67 deg.R; V_{DM}=1.1389 ft^3; C_{D1}=0.439; AV_{D1}=15.0 ml; C_{D2}=0.0; AV_{D2}=15.0 ml; C_{FDE}=8.970 µ g/ml; V_{AE}=5.0 ml; Q=0.1429; T_{EF}=527.67 deg.R; V_{SE}=0.2857 ft^3; C_{FDA}=0.39 µ g/ml; V_{AA}=5.0 ml; T_{DF}=527.67 deg.R; V_{SA}=1.1043 ft^3; NO_{Xe}=5.273 ppm; CO_{em}=98.8 ppm; CO_{2e}=0.469 pct; CH_{4e}=2.825 ppm; FID HC_d=2.771 ppm; NO_{Xd}=0.146 ppm; CO_{dm}=1.195 ppm; CO_{2d}=0.039 percent; CH_{4d}=2.019 ppm; Dct=3.583 miles. (Q P='04'≤

Then:

(i) V_{mix}=(0.29344)(25,801)(725.42−70)(528)/(760)(570)=6048.1.0 ft^3 per test phase.

(ii) H=(43.478)(37.5)(22.02)/[725.42-(22.02x37.5/100)]=50 grains of water per pound of dry air.

(iii) K_H=1/[1−0.0047(50−75)]=0.8951.

(iv) CO_e=[1-(0.01+0.005×3.487)×0.469)−0.000323(37.5)) ×98.8=96.332 ppm.

(v) CO_d=(1−0.000323(37.5))×1.195=1.181 ppm.

(vi) C_{CH3OHe} = (3.813×10^{-2})(527.67)[(7.101)(15.0) + (0.256)(15.0)]/(725.42)(0.2818) = 10.86 ppm.

(vii) HC_e=14.65−(0.788)(10.86)=6.092.

(viii) DF = 100(1/[1 + (3.487/2) + 3.76(1 + (3.487/4) − (0.763/2)])])/0.469 + (6.092 + 96.332 + 10.86 + 0.664)(10^{-4}) = 24.939.

(ix) C_{CH3OHd} = (3.813 × 10^{-2})(527.67)[(0.439)(15.0) + (0.0)(15.0)]/(725.42)(1.1389) = 0.16 ppm.

(x) CH_3OH_{conc}=10.86−0.16(1–1/24.939)=10.71 ppm.

(xi) CH_3OH_{mass}=6048.1×37.71×(10.71/1,000,000)=2.44 grams per test phase.

(xii) HC_{conc}=[14.65 − (0.788)(10.86)] − [2.771 − (0.788)(0.16)] (1–1/24.94)=3.553 ppm.

(xiii) HC_{mass}=(6048.1)(16.33)(3.553/1,000,000)=0.35 grams per test phase.

(xiv) C_{HCHOe} = 4.069 × 10^{-2}(8.970)(5.0)(0.1429)(527.67)/(0.2857)(725.42) = 0.664 ppm.

(xv) C_{HCHOd} = 4.069 × 10^{-2}(0.39)(5.0)(0.1429)(527.67)/(1.1043)(725.42) = 0.0075 ppm.

(xvi) $HCHO_{conc}$=0.664−0.0075(1–1/24.939)=0.6568 ppm.

(xvii) $HCHO_{mass}$=(6048.1)(35.36)(0.6568/1,000,000)=0.1405 grams per test phase.

(xviii) THCE=0.35+(13.8756/32.042)(2.44)+(13.8756/ 30.0262)(0.1405)=1.47 grams per test phase.

(xix) NO_{Xconc}=5.273−(0.146)(1–1/24.939)=5.13 ppm.

(xx) NO_{Xmass}=(6048.1)(54.16)(5.13/1,000,000)(0.8951)=1.505 grams per test phase.

(xxi) CO_{conc}=96.332−1.181(1–1/24.939)=95.2 ppm.

(xxii) CO_{mass}=(6048.1)(32.97)(95.2/1,000,000)=18.98 grams per test phase.

(xxiii) $CO2_{conc}$=0.469−0.039(1–1/24.939)=0.432 percent.

(xxiv) $CO2_{mass}$=(6048.1)(51.85)(0.432/100)=1353 grams.

(xxv) $CH4_{conc}$=2.825−2.019(1–1/24.939)=0.89 ppm.

(xxvi) $NMHC_{conc}$=3.553 ppm−0.89 ppm=2.67 ppm.

(xxvii) $NMHC_{mass}$=(6048.1)(16.33)(2.67/1,000,000)=0.263 grams per test phase.

(xxviii) $NMHCE_{mass}$=0.263+(13.8756/32.042)(2.44) + (13.8756/30.0262)(0.1405)=1.39 grams per test phase.

(2) For the stabilized portion of the cold start test assume that similar calculations resulted in the following:

(i) THCE=0.143 grams per test phase.

(ii) NO_{Xmass}=0.979 grams per test phase.

(iii) CO_{mass}=0.365 grams per test phase.

(iv) CO_{2mass}=1467 grams per test phase.

(v) D_s=3.854 miles.

(vi) NMHCE=0.113 grams per test phase.

(3) For the ''transient'' portion of the hot start test assume that similar calculations resulted in the following:

(i) THCE=0.488 grams as carbon equivalent per test phase.

(ii) NO_{Xmass}=1.505 grams per test phase.

(iii) CO_{mass}=3.696 grams per test phase.

(iv) CO_{2mass}=1179 grams per test phase.

(v) D_{ht}=3.577 miles.

(vi) NMHCE=0.426 grams per test phase.

(4) Weighted emission results:

(i) $THCE_{wm}$ = (0.43) × (1.473 + 0.143)/(3.583 + 3.854) + (0.57) × (0.488 + 0.143)/(3.577 + 3.854) = 0.142 grams as carbon equivalent per mile.

(ii) NOx_{wm} = (0.43) × (1.505 + 0.979)/(3.583 + 3.854) + (0.57) × (1.505 + 0.979)/3.577 + 3.854) = 0.344 grams per mile.

(iii) $CO_{wm} = (0.43) \times (18.983 + 0.365)/(3.583 = 3.854) + (0.57) \times (3.696 + 0.365)/(3.577 + 3.854) = 1.43$ grams per mile.

(iv) $CO2_{wm} = (0.43) \times (1353 + 1467)/(3.583 + 3.854) + (0.57) \times (1179 + 1467)/(3.577 + 3.854) = 366$ grams per mile.

(v) $NMHCE_{wm} = (0.43) \times (1.386 + 0.113)/(3.583 + 3.854) + (0.57) \times (0.426 = 0.113)/(3.577 + 3.854) = 0.128$ grams per mile.

[56 FR 25777, June 5, 1991, as amended at 59 FR 39649, Aug. 3, 1994; 59 FR 48511, Sept. 21, 1994; 60 FR 34349, June 30, 1995; 62 FR 47122, Sept. 5, 1997]

§86.145–82 Calculations; particulate emissions.

(a) The final reported test results for the mass particulate (M_p) in grams/mile shall be computed as follows.

$M_p = 0.43(M_{p1} + M_{p2})/(D_{ct} + D_s) + 0.57(M_{p3} + M_{p2})/(D_{ht} = D_s)$

where:

(1) M_{p1} = Mass of particulate determined from the "transient" phase of the cold start test, in grams per test phase. (See §86.110–82(c)(1) for determination.)

(2) M_{p2} = Mass of particulate determined from the "stabilized" phase of the cold start test, in grams per test phase. (See §86.110–82(c)(1) for determination.)

(3) M_{p3} = Mass of particulate determined from the "transient" phase of the hot start test, in grams per test phase. (See §86.110–82(c)(1) for determination).

(4) D_{ct} = The measured driving distance from the "transient" phase of the cold start test, in miles.

(5) D_s = The measured driving distance from the "stabilized" phase of the cold start test, in miles.

(6) D_{ht} = The measured driving distance from the "transient" phase of the hot start test, in miles.

(b) The mass of particulate for each phase of testing is determined as follows:

$$M_{pj} = \left[V_{mix} + V_{epi}\right]\left[\frac{P_{ei}}{V_{epi}} - \frac{P_b}{V_{bp}}(1 - 1/DF)\right]$$

where:

(1) j = 1, 2 or 3 depending on which phase the mass of particulate is being determined for (i.e., the "transient" phase of the cold start test, the "sta-

bilized" phase of the cold start test, or the "transient" phase of the hot start test).

(2) V_{mix} = Total dilute exhaust volume in cubic meters per test, corrected to standard conditions 528°R (293K) and 29.92 in Hg (101.3 kPa). V_{mix} is further defined in §86.144.

(3) P_e = mass of particulate per test on the exhaust filter(s), grams.

(4) P_b = mass of particulate on the "background" filter, grams.

(i) The background particulate level, P_b, inside the dilution air filter box at EPA is very low. P_b will be assumed = 0, and background particulate samples will not be taken with each exhaust sample. It is recommended that background particulate checks be made periodically to verify the low level.

(ii) Any manufacturer may make the same assumption without prior EPA approval.

(iii) If P_b is assumed = 0, then no background correction is made. The equation for particulate mass emissions then reduces to:

$$M_{pj} = \frac{V_{mix_i} + V_{ep_i} \times P_{e_i}}{V_{ep_i}}$$

(6) V_{ep} = total volume of sample pulled through the filter, cubic feet at standard conditions.

$$V_{ep} = \frac{V_{ap} \times \left(P_{bar} + P_{ip}\right) \times 528}{T_{ip} \times 29.92}$$

where:

(i) V_{ap} = corrected (according to procedure specified in §85.120) dilute exhaust sample volume, cubic feet.

(ii) P_{bar} = barometric pressure, in Hg.

(iii) P_{ip} = pressure elevation above ambient measured at the inlet to the dilute exhaust sample gas meter or flow instrument, in Hg. (For most gas meters with unrestricted discharge P_{ip} is negligible and can be assumed = 0.)

(iv) T_{ip} = average temperature of the dilute exhaust sample at the inlet to the gas meter or flow instrument, °R.

(7) V_{bp} = total volume of the background sample, cubic feet at standard conditions. (V_{bp} is not required if P_b is assumed = 0.) It is calculated using the following formula: