

## §CFR 600.113-93(h) EPA Natural Gas Fuel Economy

Read Input Data

$i := 1 \dots 62$                        $input_i := READ(hwyinput)$

Testnumber := input<sub>1</sub>              Testnumber = 199702              Numeric test identifier              Testnumber = 199702

Procedure := input<sub>2</sub>              Procedure = 3              Numeric test procedure identifier

### §538.7 - DOT Gallon Equivalents for Gaseous Fuels

The gallon equivalent of gaseous fuels, for purposes of calculations.

gegf<sub>CNG</sub> = 0.823                      Compressed Natural Gas Gallon Equivalent Measurement

gegf<sub>LNG</sub> = 0.823                      Liquefied Natural Gas Gallon Equivalent Measurement

### Natural Gas Fuel Property Determination

$x := input_{49}$                        $x = 1$                       Carbon-to-carbon ratio as measured for the fuel used.

$y_{THC} := input_{50}$                        $y_{THC} = 3.97$                       Hydrogen-to-carbon ratio as measured for the fuel used.

$y_{NMHC} := input_{52}$                        $y_{NMHC} = 2.596$                       Hydrogen-to-carbon ratio as measured for the fuel used.

$z := input_{53}$                        $z = 0$                       Oxygen-to-carbon ratio as measured for the fuel used.

$CWF_{NG} := input_{54}$                        $CWF_{NG} = 0.72$                       Carbon weight fraction of the gaseous fuel

$CWF_{HCNG} := input_{55}$                        $CWF_{HCNG} = 0.703$                       Carbon weight fraction derived from the weight of carbon in HC constituents divided by the total weight of the fuel

$WF_{CO_2} := input_{56}$                        $WF_{CO_2} = 0.063$                       Carbon Dioxide Weight Fraction

$NHV_{B.t.u.per.lb} := input_{57}$                        $NHV_{B.t.u.per.lb} = 20432$                       Net (lower) heating value of the fuel per ASTM D-3588, B.t.u. per pound

$SG_{fuel.AIR} := input_{58}$                        $SG_{fuel.AIR} = 0.584$                       Specific gravity of the fuel per ASTM D-3588, relative to Air.

### Weighted Mass Emissions, Grams per Mile

$CH_4 := input_{59}$                        $CH_4 = 0$                       Methane, grams per mile

$NMHC := input_{60}$                        $NMHC = 0.158$                       Non-MethaneHydrocarbon, grams per mile

$CO := input_{61}$                        $CO = 0.198$                       Carbon Monoxide, grams per mile

$CO_2 := input_{62}$                        $CO_2 = 358$                       Carbon Dioxide, grams per mile

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Natural Gas Fuel Property Derivation

Testnumber = 199702

Density HC in NG, grams per cubic foot

$$D_{HC} := 1.1771 \cdot (12.011 + y_{THC} \cdot 1.008)$$

$$D_{HC} = 18.849$$

Density NMHC in NG, grams per cubic foot

$$D_{NMHC} := 1.1771 \cdot (12.011 + y_{NMHC} \cdot 1.008)$$

$$D_{NMHC} = 17.218$$

Carbon Weight Graction of the NMHC in the NG

$$CWF_{NMHC} := \frac{12.011}{(y_{NMHC} \cdot 1.008 + 12.011)}$$

$$CWF_{NMHC} = 0.821$$

Density of Natural Gas @ 60°F and 1 atm, grams per cubic foot

$$D_{NG.1} := SG_{fuel.AIR} \cdot 28.316847 \cdot 1.2047$$

Note: @ 68°F & 1 atm  
28.316847 is liters per cu ft  
1.2047 is Density Air, gr per liter

$$D_{NG.1} = 19.922$$

Cubic feet of natural gas fuel consumed per mile.

$$FC_{NG} := \frac{0.749 \cdot CH_4 + CWF_{NMHC} \cdot NMHC + 0.429 \cdot CO + 0.273 \cdot CO_2}{CWF_{NG} \cdot D_{NG.1}}$$

$$FC_{NG} = 6.829$$

Grams of Carbon Dioxide in natural gas fuel consumed per mile of travel.

$$CO_{2.NG} := FC_{NG} \cdot D_{NG.1} \cdot WF_{CO2}$$

$$CO_{2.NG} = 8.571$$

§CFR 600.113-93(h) EPA Natural Gas Fuel economy, mile per gallon equivalent

$$mpg_{e.NG} := \frac{CWF_{HCNG} \cdot D_{NG.1} \cdot 121.5}{0.749 \cdot CH_4 + CWF_{NMHC} \cdot NMHC + 0.429 \cdot CO + 0.273 \cdot (CO_2 - CO_{2.NG})}$$

$$mpg_{e.NG} = 17.798$$

Note:  $\frac{100}{\text{gegf}_{CNG}} = 121.5$  and  $\frac{100}{\text{gegf}_{LNG}} = 121.5$

## §CFR 600.510-93 Alternative Fuel Energy Efficiency

Net Heating Value of the Fuel, B.t.u.'s per pound

$$NHV_{fuel} := NHV_{B.t.u.per.lb}$$

$$NHV_{fuel} = 20432$$

Density of the Natural Gas Fuel, lbs per 100 cubic feet

$$D_{NG.100} := 100 \cdot \left[ \frac{D_{NG.1}}{453.6} \right]$$

$$D_{NG.100} = 4.392$$

Natural Gas Fuel Economy while operated on the alternative fuel, miles per gallon

$$FE_{alt} := mpg_{e.NG}$$

$$FE_{alt} = 17.798$$

Density of the alternative fuel, pounds per gallon

$$D_{alt} := D_{NG.100}$$

$$D_{alt} = 4.392$$

Energy Efficiency while operating on alternative fuel, miles per million B.t.u.

$$E_{alt} := \left[ \frac{FE_{alt}}{NHV_{fuel} \cdot D_{alt}} \right] \cdot 10^6$$

$$E_{alt} = 198.33$$