§ 600.114–12 Vehicle-specific 5-cycle fuel economy and carbon-related exhaust emission calculations.

Paragraphs (a) through (f) of this section apply to data used for fuel economy labeling under subpart D of this part. Paragraphs (d) through (f) of this section are used to calculate 5-cycle carbon-related exhaust emission values for the purpose of determining optional credits for CO₂-reducing technologies under §86.1866 of this chapter and to calculate 5-cycle CO₂ values for the purpose of fuel economy labeling under subpart D of this part.

(a) City fuel economy. For each vehicle tested under §600.010–08(a), (b), or (c), as applicable, determine the 5-cycle city fuel economy using the following equation:

\[
\text{CityFE} = \frac{0.905}{(\text{StartFC} + \text{RunningFC})}
\]

Where:

\[
\text{StartFC} = 0.33 \times \left( \frac{0.76 \times \text{StartFuel}_{\text{sc03}} + 0.24 \times \text{StartFuel}_{\text{us06}}}{4.1} \right)
\]

\[
\text{StartFuel}_{\text{us06}} = 3.6 \times \left( \frac{1}{\text{Bag 1 FE}_{\text{x}}} - \frac{1}{\text{Bag 3 FE}_{\text{x}}} \right)
\]

\[
\text{RunningFC} = 0.82 \times \left[ \frac{0.48}{\text{Bag 2 FE}_{75}} + \frac{0.41}{\text{Bag 3 FE}_{75}} + \frac{0.11}{\text{US06 City FE}} \right] + 0.18 \times \left[ \frac{0.5}{\text{Bag 2 FE}_{20}} + \frac{0.5}{\text{Bag 3 FE}_{20}} \right] + 0.133 \times 1.083 \times \left[ \frac{1}{\text{SC03 FE}} - \frac{0.61}{\text{Bag 3 FE}_{20}} + \frac{0.39}{\text{Bag 2 FE}_{20}} \right]
\]

(2) Terms used in the equations in this paragraph (a) are defined as follows:

Bag \( Y \) \( \text{FE}_x \) = the fuel economy in miles per gallon of fuel during bag \( Y \) of the FTP test conducted at an ambient temperature \( X \) of 75 °F or 20 °F.

SC03 \( \text{FE} \) = fuel economy in mile per gallon over the SC03 test.

US06 City \( \text{FE} \) = fuel economy in miles per gallon over the “city” portion of the US06 test.

(b) Highway fuel economy. (1) For each vehicle tested under §600.010–08(a), (b), or (c), as applicable, determine the 5-cycle highway fuel economy using the following equation:
(2) If the condition specified in §600.115-08(b)(2)(iii)(B) is met, in lieu of using the calculation in paragraph (b)(1) of this section, the manufacturer may optionally determine the highway fuel economy using the following modified 5-cycle equation which utilizes data from FTP, HFET, and US06 tests, and applies mathematic adjustments for Cold FTP and SC03 conditions:

(i) Perform a US06 test in addition to the FTP and HFET tests.
(ii) Determine the 5-cycle highway fuel economy according to the following formula:

\[
\text{HighwayFE} = \frac{0.905}{\text{StartFC} + \text{RunningFC}}
\]

Where:

\[
\text{StartFC} = 0.33 \times \left( \frac{0.76 \times \text{StartFuel}_{25} + 0.24 \times \text{StartFuel}_{35}}{60} \right)
\]

\[
\text{StartFuel}_{15} = 3.6 \times \left[ \frac{1}{\text{Bag1 FE}_{15}} - \frac{1}{\text{Bag3 FE}_{15}} \right]
\]

\[
\text{RunningFC} = 1.007 \times \left[ \frac{0.79 \times \text{US06 HighFE} + 0.21 \times \text{HFET FE}}{25} \right] + 0.133 \times 0.377 \times \left[ \frac{1}{\text{SC03 FE}} - \left( \frac{0.61}{\text{Bag3 FE}_{15}} + \frac{0.39}{\text{Bag2 FE}_{15}} \right) \right]
\]

(3) Terms used in the equations in this paragraph (b) are defined as follows:

Bag Y FE<sub>Y</sub> = the fuel economy in miles per gallon of fuel during bag Y of
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the FTP test conducted at an ambient temperature $X$ of $75$ °F or $20$ °F.

HFET FE = fuel economy in miles per gallon over the HFET test.

SC03 FE = fuel economy in miles per gallon over the SC03 test.

US06 Highway FE = fuel economy in miles per gallon over the highway portion of the US06 test.

US06 FE = fuel economy in miles per gallon over US06 test.

(c) Fuel economy calculations for hybrid electric vehicles. Test hybrid electric vehicles as described in SAE J1711 (incorporated by reference in §600.011). For FTP testing, this generally involves emission sampling over four phases (bags) of the UDDS (cold-start, transient, warm-start, transient); however, these four phases may be combined into two phases (phases 1 + 2 and phases 3 + 4). Calculations for these sampling methods follow:

1) Four-bag FTP equations. If the 4-bag sampling method is used, manufacturers may use the equations in paragraphs (a) and (b) of this section to determine city and highway fuel economy estimates. If this method is chosen, it must be used to determine both city and highway fuel economy. Optionally, the following calculations may be used, provided that they are used to determine both city and highway fuel economy:

(i) City fuel economy.

\[ \text{City FE} = \frac{0.905}{(\text{StartFC} + \text{RunningFC})} \]

Where:

\[ \text{StartFC} = 0.33 \times \left( \frac{0.76 \times \text{StartFuel}_{75} + 0.24 \times \text{StartFuel}_{20}}{4.1} \right) \]

\[ \text{StartFuel}_{75} = 3.6 \times \left[ \frac{1}{\text{Bag1 FE}_{75}} - \frac{1}{\text{Bag3 FE}_{75}} \right] + 3.9 \times \left[ \frac{1}{\text{Bag2 FE}_{75}} - \frac{1}{\text{Bag4 FE}_{75}} \right] \]

\[ \text{StartFuel}_{20} = 3.6 \times \left( \frac{1}{\text{Bag1 FE}_{20}} - \frac{1}{\text{Bag3 FE}_{20}} \right) \]

\[ \text{RunningFC} = 0.82 \times \left( \frac{0.48}{\text{Bag4 FE}_{75}} + \frac{0.41}{\text{Bag3 FE}_{75}} + \frac{0.11}{\text{US06 City FE}} \right) \]

\[ + 0.18 \times \left( \frac{0.5}{\text{Bag2 FE}_{20}} + \frac{0.5}{\text{Bag3 FE}_{20}} \right) + 0.133 \times 1.083 \times \left[ \frac{1}{\text{SC03 FE}} - \left( \frac{0.61}{\text{Bag3 FE}_{75}} + \frac{0.39}{\text{Bag4 FE}_{75}} \right) \right] \]

(ii) Highway fuel economy.
(2) Two-bag FTP equations. If the 2-bag sampling method is used for the 75°F FTP test, it must be used to determine both city and highway fuel economy. The following calculations must be used to determine both city and highway fuel economy:

(i) City fuel economy.

\[
\text{City FE} = \frac{0.905}{\text{StartFC} + \text{Running FC}}
\]

Where:

\[
\text{StartFC} = 0.33 \times \left(\frac{0.76 \times \text{StartFuel}_{25} + 0.24 \times \text{StartFuel}_{20}}{60}\right)
\]

\[
\text{StartFuel}_{25} = 3.6 \times \left[\frac{1}{\text{Bag 1 FE}_{75}} - \frac{1}{\text{Bag 3 FE}_{75}}\right] + 3.9 \times \left[\frac{1}{\text{Bag 2 FE}_{75}} - \frac{1}{\text{Bag 4 FE}_{75}}\right]
\]

\[
\text{StartFuel}_{20} = 3.6 \times \left[\frac{1}{\text{Bag 1 FE}_{20}} - \frac{1}{\text{Bag 3 FE}_{20}}\right]
\]

\[
\text{Running FC} = 1.007 \times \left[\frac{0.79}{\text{US06 Highway FE}} + \frac{0.21}{\text{HFET FE}}\right] + 0.133 \times 0.377 \times \left[\frac{1}{\text{SC03 FE}} - \left(\frac{0.61}{\text{Bag 3 FE}_{75}} + \frac{0.39}{\text{Bag 4 FE}_{75}}\right)\right]
\]
\[ CityFE = \frac{0.905}{(\text{StartFC} + \text{RunningFC})} \]

Where:

\[ \text{StartFC} = 0.33 \times \left( \frac{0.76 \times \text{StartFuel}_{75} + 0.24 \times \text{StartFuel}_{20}}{4.1} \right) \]

\[ \text{StartFuel}_{75} = 7.5 \times \left( \frac{1}{\text{Bag1/2 FE}_{75}} - \frac{1}{\text{Bag3/4 FE}_{75}} \right) \]

\[ \text{StartFuel}_{20} = 3.6 \times \left( \frac{1}{\text{Bag1 FE}_{20}} - \frac{1}{\text{Bag3 FE}_{20}} \right) \]

\[ \text{RunningFC} = 0.82 \times \left( \frac{0.90}{\text{Bag3/4 FE}_{75}} + \frac{0.10}{\text{US06 City FE}} \right) \\
+ 0.18 \times \left( \frac{0.5}{\text{Bag2 FE}_{20}} + \frac{0.5}{\text{Bag3 FE}_{20}} \right) + 0.133 \times 1.083 \times \left( \frac{1}{\text{SC03 FE}} - \left( \frac{1.0}{\text{Bag3/4 FE}_{75}} \right) \right) \]

(ii) Highway fuel economy.
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HighwayFE = \frac{0.905}{(\text{StartFC} + \text{Running FC})}

Where:

\text{StartFC} = 0.33 \times \left( \frac{(0.76 \times \text{StartFuel}_{75}) + (0.24 \times \text{StartFuel}_{20})}{60} \right)

\text{StartFuel}_{75} = 7.5 \times \left[ \frac{1}{\text{Bag1/2 FE}_{75}} - \frac{1}{\text{Bag3/4 FE}_{75}} \right]

\text{StartFuel}_{20} = 3.6 \times \left[ \frac{1}{\text{Bag1 FE}_{20}} - \frac{1}{\text{Bag3 FE}_{20}} \right]

\text{RunningFC} = 1.007 \times \left[ \frac{0.79}{\text{US06HighwayFE}} + \frac{0.21}{\text{HFETFE}} \right] + 0.133 \times 0.377 \times \left[ \frac{1}{\text{SC03FE} - \left( \frac{1.0}{\text{Bag3/4 FE}_{75}} \right)} \right]

(3) For hybrid electric vehicles using the modified 5-cycle highway calculation in paragraph (b)(2) of this section, the equation in paragraph (b)(2)(ii)(A) of this section applies except that the equation for \text{StartFuel}_{75} will be replaced with one of the following:

(i) The equation for \text{StartFuel}_{75} for hybrids tested according to the 4-bag FTP is:

\text{StartFuel}_{75} = 3.6 \times \left[ \frac{1}{\text{Bag1 FE}_{75}} - \frac{1}{\text{Bag3 FE}_{75}} \right] + 3.9 \times \left[ \frac{1}{\text{Bag2 FE}_{75}} - \frac{1}{\text{Bag4 FE}_{75}} \right]

(ii) The equation for \text{StartFuel}_{75} for hybrids tested according to the 2-bag FTP is:

\text{StartFuel}_{75} = 7.5 \times \left[ \frac{1}{\text{Bag1/2 FE}_{75}} - \frac{1}{\text{Bag3/4 FE}_{75}} \right]

(4) Terms used in the equations in this paragraph (b) are defined as follows:

Bag X/Y FE_{75} = fuel economy in miles per gallon of fuel during combined phases X and Y of the FTP test conducted at an ambient temperature of 75 °F.

Bag Y FE_{x} = the fuel economy in miles per gallon of fuel during bag Y of the FTP test conducted at an ambient temperature X of 75 °F or 20 °F.
BPET FE = fuel economy in miles per gallon over the HFET test.

SC03 FE = fuel economy in mile per gallon over the SC03 test.

US06 City FE = fuel economy in miles per gallon over the city portion of the US06 test.

US06 Highway FE = fuel economy in miles per gallon over the highway portion of the US06 test.

(d) City CO\textsubscript{2} emissions and carbon-related exhaust emissions. For each vehicle tested, determine the 5-cycle city CO\textsubscript{2} emissions and carbon-related exhaust emissions using the following equation:

\[
\text{City CREE} = \frac{(\text{Start CREE} + \text{Running CREE})}{0.905}
\]

Where:

\[
\text{Start CREE} = 0.33 \times \left(\frac{0.76 \times \text{Start CREE}_{2} + 0.24 \times \text{Start CREE}_{3}}{4.1}\right)
\]

\[
\text{Start CREE}_{X} = 3.6 \times (\text{Bag 1 CREE}_{X} - \text{Bag 3 CREE}_{X})
\]

\[
\text{Running CREE} = 0.82 \times \left(0.48 \times \text{Bag 2 CREE}_{15} + 0.41 \times \text{Bag 3 CREE}_{15} + 0.11 \times \text{US06 City CREE}\right) + 0.18 \times \left(0.5 \times \text{Bag 2 CREE}_{20} + 0.5 \times \text{Bag 3 CREE}_{20}\right) + 0.133 \times 1.083 \times \text{SC03 CREE} - \left((0.61 \times \text{Bag 3 CREE}_{15} + 0.39 \times \text{Bag 2 CREE}_{15})\right)
\]

(2) To determine the City CO\textsubscript{2} emissions, use the appropriate CO\textsubscript{2} grams/mile values instead of CREE values in the equations in this paragraph (d).

(3) Terms used in the equations in this paragraph (d) are defined as follows:

Bag Y CREE\textsubscript{X} = the carbon-related exhaust emissions in grams per mile during bag Y of the FTP test conducted at an ambient temperature X of 75 °F or 20 °F.

US06 City CREE = carbon-related exhaust emissions in grams per mile over the city portion of the US06 test.

SC03 CREE = carbon-related exhaust emissions in grams per mile over the SC03 test.

(e) Highway CO\textsubscript{2} emissions and carbon-related exhaust emissions. (1) For each vehicle tested, determine the 5-cycle highway carbon-related exhaust emissions using the following equation:
Highway CREE = \( \frac{(\text{Start CREE} + \text{Running CREE})}{0.905} \)

Where:

\[
\text{Start CREE} = 0.33 \times \left( \frac{(0.76 \times \text{Start CREE}_{75}) + (0.24 \times \text{Start CREE}_{20})}{60} \right)
\]

\[
\text{Start CREE}_x = 3.6 \times (\text{Bag 1CREE}_x - \text{Bag 3CREE}_x)
\]

Running CREE =

\[
1.007 \times \left[ (0.79 \times \text{US06 Highway CREE}) + (0.21 \times \text{HFET CREE}) \right] + 0.133 \times 0.377 \times \left[ \text{SC03 CREE} - \left( (0.61 \times \text{Bag3CREE}_{75}) + (0.39 \times \text{Bag2CREE}_{75}) \right) \right]
\]

(2) If the condition specified in §600.115-08(b)(2)(iii)(B) is met, in lieu of using the calculation in paragraph (e)(1) of this section, the manufacturer may optionally determine the highway carbon-related exhaust emissions using the following modified 5-cycle equation which utilizes data from FTP, HFET, and US06 tests, and applies mathematic adjustments for Cold FTP and SC03 conditions:

(i) Perform a US06 test in addition to the FTP and HFET tests.

(ii) Determine the 5-cycle highway carbon-related exhaust emissions according to the following formula:

Highway CREE = \( \frac{(\text{Start CREE} + \text{Running CREE})}{0.905} \)

Where:

\[
\text{Start CREE}_{75} = 3.6 \times (\text{Bag 1CREE}_{75} - \text{Bag 3CREE}_{75})
\]

\[
\text{Running CREE} = 1.007 \times \left[ (0.79 \times \text{US06 Highway CREE}) + (0.21 \times \text{HFET CREE}) \right] + 0.133 \times 0.377 \times \left( (0.005515 \times A) + 1.13637 \times \text{StartCREE}_{75} \right)
\]

(3) To determine the Highway CO₂ emissions, use the appropriate CO₂...
(f) CO₂ and carbon-related exhaust emissions calculations for hybrid electric vehicles. Test hybrid electric vehicles as described in SAE J1711 (incorporated by reference in §600.011). For FTP testing, this generally involves emission sampling over four phases (bags) of the UDDS (cold-start, transient, warm-start, transient); however, these four phases may be combined into two phases (phases 1 + 2 and phases 3 + 4). Calculations for these sampling methods follow:

(1) Four-bag FTP equations. If the 4-bag sampling method is used, manufacturers may use the equations in paragraphs (a) and (b) of this section to determine city and highway CO₂ and carbon-related exhaust emissions values. If this method is chosen, it must be used to determine both city and highway CO₂ emissions and carbon-related exhaust emissions. Optionally, the following calculations may be used, provided that they are used to determine both city and highway CO₂ and carbon-related exhaust emissions values:

(i) City CO₂ emissions and carbon-related exhaust emissions.

City CREE = \( \frac{(\text{Start CREE} + \text{Running CREE})}{0.905} \)

Where:

\[
\text{Start CREE} = 0.33 \times \left( \frac{0.76 \times \text{Start CREE}_{75} + 0.24 \times \text{Start CREE}_{20}}{4.1} \right)
\]

\[
\text{Start CREE}_{75} = 3.6 \times (\text{Bag 1 CREE}_{75} - \text{Bag 3 CREE}_{75}) + 3.9 \times (\text{Bag 2 CREE}_{75} - \text{Bag 4 CREE}_{75})
\]

\[
\text{Start CREE}_{20} = 3.6 \times (\text{Bag 1 CREE}_{20} - \text{Bag 3 CREE}_{20})
\]

Running CREE = \( 0.82 \times [(0.48 \times \text{Bag 4 CREE}_{75}) + (0.41 \times \text{Bag 3 CREE}_{75}) + (0.11 \times \text{US06 City CREE})] + 0.18 \times [(0.5 \times \text{Bag 2 CREE}_{20}) + (0.5 \times \text{Bag 3 CREE}_{20})] + 0.133 \times 1.083 \times \left( \text{SC03 CREE} - (0.61 \times \text{Bag 3 CREE}_{75}) + (0.39 \times \text{Bag 4 CREE}_{75}) \right) \)
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(1) Highway CO₂ emissions and carbon-related exhaust emissions.

Highway CREE = \( \frac{(\text{Start CREE} + \text{Running CREE})}{0.905} \)

Where:

\[
\text{Start CREE} = 0.33 \times \left( \frac{0.76 \times \text{Start CREE}_{75} + 0.24 \times \text{Start CREE}_{20}}{60} \right)
\]

\[
\text{Start CREE}_{75} = 3.6 \times (\text{Bag 1 CREE}_{75} - \text{Bag 3 CREE}_{75}) + 3.9 \times (\text{Bag 2 CREE}_{75} - \text{Bag 4 CREE}_{75})
\]

\[
\text{Start CREE}_{20} = 3.6 \times (\text{Bag 1 CREE}_{20} - \text{Bag 3 CREE}_{20})
\]

\[
\text{Running CREE} = 1.007 \times \left[ (0.79 \times \text{US06 Highway CREE}) + (0.21 \times \text{HFET CREE}) \right] + 0.133 \times 0.377 \times \left[ \text{SC03 CREE} - \left( (0.61 \times \text{Bag 3 CREE}_{75}) + (0.39 \times \text{Bag 4 CREE}_{75}) \right) \right]
\]

(2) Two-bag FTP equations. If the 2-bag sampling method is used for the 75 °F FTP test, it must be used to determine both city and highway CO₂ emissions and carbon-related exhaust emissions. The following calculations must be used to determine both city and highway CO₂ emissions and carbon-related exhaust emissions:

(1) City CO₂ emissions and carbon-related exhaust emissions.
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\[ \text{City CREE} = \left( \frac{\text{Start CREE} + \text{Running CREE}}{0.905} \right) \]

Where:

\[ \text{Start CREE} = 0.33 \times \left( \frac{0.76 \times \text{Start CREE}_{75} + 0.24 \times \text{Start CREE}_{20}}{4.1} \right) \]

\[ \text{Start CREE}_{75} = 7.5 \times (\text{Bag1/2 CREE}_{75} - \text{Bag3/4 CREE}_{75}) \]

\[ \text{Start CREE}_{20} = 3.6 \times (\text{Bag1 CREE}_{20} - \text{Bag3 CREE}_{20}) \]

Running CREE = 0.82 \times \left[ (0.90 \times \text{Bag3/4 CREE}_{75}) + (0.10 \times \text{US06 City CREE}) \right] + 0.18 \times \left[ (0.5 \times \text{Bag2 CREE}_{20}) + (0.5 \times \text{Bag3 CREE}_{20}) \right] + 0.133 \times 1.083 \times [ \text{SC03 CREE} - (\text{Bag3/4 CREE}_{75}) ]

(ii) Highway CO₂ emissions and carbon-related exhaust emissions.

\[ \text{Highway CREE} = \left( \frac{\text{Start CREE} + \text{Running CREE}}{0.905} \right) \]

Where:

\[ \text{Start CREE} = 0.33 \times \left( \frac{0.76 \times \text{Start CREE}_{75} + 0.24 \times \text{Start CREE}_{20}}{60} \right) \]

\[ \text{Start CREE}_{75} = 7.5 \times (\text{Bag1/2 CREE}_{75} - \text{Bag3/4 CREE}_{75}) \]

\[ \text{Start CREE}_{20} = 3.6 \times (\text{Bag1 CREE}_{20} - \text{Bag3 CREE}_{20}) \]

Running CREE = 1.007 \times \left[ (0.79 \times \text{US06 Highway CREE}) + (0.21 \times \text{HFET CREE}) \right] + 0.133 \times 0.377 \times [ \text{SC03 CREE} - \text{Bag3/4}_{75} \text{ CREE} ]
(3) For hybrid electric vehicles using the modified 5-cycle highway calculation in paragraph (e)(2) of this section, the equation in paragraph (e)(2)(ii)(A) of this section applies except that the equation for \( \text{Start CREE}_{75} \) will be replaced with one of the following:

(i) The equation for \( \text{Start CREE}_{75} \) for hybrids tested according to the 4-bag FTP is:

\[
\text{Start CREE}_{75} = 3.6 \times (\text{Bag 1 CREE}_{75} - \text{Bag 3 CREE}_{75} + 3.9 \times (\text{Bag 2 CREE}_{75} - \text{Bag 4 CREE}_{75}))
\]

(ii) The equation for \( \text{Start CREE}_{75} \) for hybrids tested according to the 2-bag FTP is:

\[
\text{Start CREE}_{75} = 7.5 \times (\text{Bag ½ CREE}_{75} - \text{Bag ¾ CREE}_{75})
\]

(4) To determine the City and Highway \( \text{CO}_2 \) emissions, use the appropriate \( \text{CO}_2 \) grams/mile values instead of CREE values in the equations in paragraphs (f)(1) through (3) of this section.

(5) Terms used in the equations in this paragraph (e) are defined as follows:

- Bag \( Y \) \( \text{CREE}_X \) = the carbon-related exhaust emissions in grams per mile during bag \( Y \) of the FTP test conducted at an ambient temperature \( X \) of 75 °F or 20 °F.
- US06 City \( \text{CREE} \) = carbon-related exhaust emissions in grams per mile over the City portion of the US06 test.
- SC03 \( \text{CREE} \) = carbon-related exhaust emissions in grams per mile over the SC03 test.
- US06 Highway \( \text{CREE} \) = carbon-related exhaust emissions in grams per mile over the Highway portion of the US06 test.
- HFET \( \text{CREE} \) = carbon-related exhaust emissions in grams per mile over the HFET test.

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\( \text{[76 FR 39538, July 6, 2011, as amended at 76 FR 57379, Sept. 15, 2011]} \)