HFET FE = the HFET-based highway fuel economy determined under § 600.113–08(b), rounded to the nearest tenth.

(ii) The derived 5-cycle highway fuel economy calculated in paragraph (b)(2)(i)(B) of this section is multiplied by 0.95 and rounded to the nearest one tenth of a mile per gallon.

(iii) (A) If the vehicle-specific 5-cycle highway fuel economy of the vehicle tested in paragraph (b)(2)(i)(A) of this section is greater than or equal to the value determined in paragraph (b)(2)(ii) of this section, then the manufacturer may base the highway fuel economy estimates for the model types covered by the test group on the derived 5-cycle method specified in § 600.210–08(a)(2) or (b)(2) or § 600.210–12(a)(2) or (b)(2), as applicable.

(B) If the vehicle-specific 5-cycle highway fuel economy determined in paragraph (b)(2)(i)(A) of this section is less than the value determined in paragraph (b)(2)(ii) of this section, the manufacturer may determine the highway fuel economy for the model types covered by the test group on the modified 5-cycle equation specified in § 600.114–08(b)(2) or § 600.114–12(b)(2).

(c) The manufacturer will apply the criteria in paragraph (a) and (b) of this section to every test group for each model year.

(d) The tests used to make the evaluations in paragraphs (a) and (b) of this section will be the procedures for official test determinations under § 86.1835. Adjustments and/or substitutions to the official test data may be made with advance approval of the Administrator.

[76 FR 39547, July 6, 2011, as amended at 76 FR 57380, Sept. 15, 2011]

§ 600.116–12 Special procedures related to electric vehicles and hybrid electric vehicles.

(a) Determine fuel economy values for electric vehicles as specified in §§ 600.210 and 600.311 using the procedures of SAE J1634 (incorporated by reference in § 600.011), with the following clarifications and modifications:

(1) Use one of the following approaches to define end-of-test criteria for vehicles whose maximum speed is less than the maximum speed specified in the driving schedule, where the vehicle's maximum speed is determined, to the nearest 0.1 mph, from observing the highest speed over the first duty cycle (FTP, HFET, etc.):

(i) If the vehicle can follow the driving schedule within the speed tolerances specified in § 86.115 of this chapter up to its maximum speed, the end-of-test criterion is based on the point at which the vehicle can no longer meet the specified speed tolerances up to and including its maximum speed.

(ii) If the vehicle cannot follow the driving schedule within the speed tolerances specified in § 86.115 of this chapter up to its maximum speed, the end-of-test criterion is based on the following procedure:

(A) Measure and record the vehicle's speed (to the nearest 0.1 mph) while making a best effort to follow the specified driving schedule.

(B) This recorded sequence of driving speeds becomes the driving schedule for the test vehicle. Apply the end-of-test criterion based on the point at which the vehicle can no longer meet the specified speed tolerances over this new driving schedule. The driving to establish the new driving schedule may be done separately, or as part of the measurement procedure.

(2) Soak time between repeat duty cycles (four-bag FTP, HFET, etc.) may be up to 30 minutes. No recharging may occur during the soak time.

(3) Recharging the vehicle's battery must start within three hours after the end of testing.

(4) Do not apply the C coefficient adjustment specified in Section 4.4.2.

(5) We may approve alternate measurement procedures with respect to electric vehicles if they are necessary or appropriate for meeting the objectives of this part. For example, we may approve the use of an earlier version of SAE J1634 for carryover vehicles, or if you show that it is equivalent for your vehicle.

(6) All label values related to fuel economy, energy consumption, and range must be based on 5-cycle testing or on values adjusted to be equivalent to 5-cycle results.

(b) Determine performance values for hybrid electric vehicles that have no plug-in capability as specified in

§§ 600.210 and 600.311 using the procedures for charge-sustaining operation from SAE J1711 (incorporated by reference in § 600.011). We may approve alternate measurement procedures with respect to these vehicles if that is necessary or appropriate for meeting the objectives of this part. For example, we may approve alternate Net Energy Change tolerances for charge-sustaining operation as described in paragraph (c)(5) of this section.

(c) Determine performance values for hybrid electric vehicles that have plug-in capability as specified in §§ 600.210 and 600.311 using the procedures of SAE J1711 (incorporated by reference in § 600.011), with the following clarifications and modifications:

(1) To determine fuel economy and CREE values to demonstrate compliance with CAFE and GHG standards, calculate composite values representing combined operation during charge-depleting and charge-sustaining operation using the following utility factors except as specified in this paragraph (c):

TABLE 1 OF § 600.116–12—FLEET UTILITY FACTORS FOR URBAN "CITY" DRIVING

Schedule range for UDDS phases, miles	Cumulative UF	Sequential UF
3.59	0.125	0.125
7.45	0.243	0.117
11.04	0.338	0.095
14.90	0.426	0.088
18.49	0.497	0.071
22.35	0.563	0.066
25.94	0.616	0.053
29.80	0.666	0.049
33.39	0.705	0.040
37.25	0.742	0.037
40.84	0.772	0.030
44.70	0.800	0.028
48.29	0.822	0.022
52.15	0.843	0.021
55.74	0.859	0.017
59.60	0.875	0.016
63.19	0.888	0.013
67.05	0.900	0.012
70.64	0.909	0.010

TABLE 2 OF § 600.116–12—FLEET UTILITY FACTORS FOR HIGHWAY DRIVING

Schedule range for HFET, miles	Cumulative UF	Sequential UF
10.3	0.123	0.123
20.6	0.240	0.117
30.9	0.345	0.105
41.2	0.437	0.092
51.5	0.516	0.079
61.8	0.583	0.067
72.1	0.639	0.056

(2) To determine fuel economy and CO_2 emission values for labeling purposes, calculate composite values representing combined operation during charge-depleting and charge-sustaining operation using the following utility factors except as specified in this paragraph (c):

TABLE 3 OF § 600.116–12—MULTI-DAY INDIVIDUAL UTILITY FACTORS FOR URBAN "CITY" DRIVING

Schedule range for UDDS phases, miles	Equivalent 5-cycle distance, miles	Cumulative UF	Sequential UF
3.59	2.51	0.08	0.08
7.45	5.22	0.15	0.08
11.04	7.73	0.22	0.06
14.90	10.43	0.28	0.06
18.49	12.94	0.33	0.05
22.35	15.65	0.38	0.05
25.94	18.16	0.43	0.04
29.80	20.86	0.47	0.04
33.39	23.37	0.50	0.04
37.25	26.08	0.54	0.04
40.84	28.59	0.57	0.03
44.70	31.29	0.60	0.03
48.29	33.80	0.62	0.02
52.15	36.51	0.65	0.02
55.74	39.02	0.67	0.02
59.60	41.72	0.69	0.02
63.19	44.23	0.71	0.02
67.05	46.94	0.72	0.02
70.64	49.45	0.74	0.01
74.50	52.15	0.75	0.01
78.09	54.66	0.78	0.03

TABLE 3 OF § 600.116–12—MULTI-DAY INDIVIDUAL UTILITY FACTORS FOR URBAN "CITY" DRIVING—Continued

Schedule range for UDDS phases, miles	Equivalent 5-cycle distance, miles	Cumulative UF	Sequential UF
81.95	57.37	0.79	0.01
85.54	59.88	0.80	0.01
89.40	62.58	0.81	0.01
92.99	65.09	0.82	0.01

TABLE 4 OF § 600.116–12—MULTI-DAY INDIVIDUAL UTILITY FACTORS FOR HIGHWAY DRIVING

Schedule range for HFET phases, miles	Equivalent 5-cycle distance, miles	Cumulative UF	Sequential UF
10.30	7.21	0.21	0.21
20.60	14.42	0.36	0.16
30.90	21.63	0.48	0.12
41.20	28.84	0.57	0.09
51.50	36.05	0.64	0.07
61.80	43.26	0.70	0.06
72.10	50.47	0.75	0.04
82.40	57.68	0.78	0.04
92.70	64.89	0.81	0.03
103.00	72.10	0.83	0.02
113.30	79.31	0.85	0.02

(3) You may calculate performance values under paragraphs (b)(1) and (2) of this section by combining phases during FTP testing. For example, you may treat the first 7.45 miles as a single phase by adding the individual utility factors for that portion of driving and assigning emission levels to the combined phase. Do this consistently throughout a test run.

(4) Instead of the utility factors specified in paragraphs (b)(1) and (2) of this section, calculate utility factors using the following equation for vehicles whose maximum speed is less than the maximum speed specified in the driving schedule, where the vehicle's maximum speed is determined, to the nearest 0.1 mph, from observing the highest speed over the first duty cycle (FTP, HFET, etc.):

$$UF_i = 1 - \left[\exp\left(-\sum_{j=1}^{k} \left(\left(\frac{d_i}{ND} \right)^j \times C_j \right) \right) \right] - \sum_{i=1}^{n} UF_{i-1}$$

Where:

UF_i = the utility factor for phase i. Let $UF_0 = 0$.

j = a counter to identify the appropriate term in the summation (with terms numbered consecutively).

k = the number of terms in the equation (see Table 3 of this section).

d_i = the distance driven in phase i.

ND = the normalized distance. Use 399 for both FTP and HFET operation.

C_j = the coefficient for term j from the following table:

TABLE 5 OF § 600.116–12—CITY/HIGHWAY SPECIFIC UTILITY FACTOR COEFFICIENTS

Coefficient	Fleet values for CAFE and GHG values		Multi-day individual value for labeling
	City	Highway	City or highway
1	14.86	4.8	13.1
2	2.965	13	−18.7
3	−84.05	−65	5.22
4	153.7	120	8.15
5	−43.59	−100.00	3.53
6	−96.94	31.00	−1.34
7	14.47		−4.01

TABLE 5 OF §600.116–12—CITY/HIGHWAY SPECIFIC UTILITY FACTOR COEFFICIENTS—Continued

Coefficient	Fleet values for CAFE and GHG values		Multi-day individual value for labeling
	City	Highway	City or highway
8	91.70		−3.90
9	−46.36		−1.15
10			3.88

n = the number of test phases (or bag measurements) before the vehicle reaches the end-of-test criterion.

(5) The End-of-Test criterion is based on a 1 percent Net Energy Change as specified in Section 3.8 of SAE J1711. We may approve alternate Net Energy Change tolerances as specified in Section 3.9.1 or Appendix C of SAE J1711 if the 1 percent threshold is insufficient or inappropriate for marking the end of charge-depleting operation. For charge-sustaining tests, we may approve the use of alternate Net Energy Change tolerances as specified in Appendix C of SAE J1711 to correct final fuel economy values, CO_2 emissions, and carbon-related exhaust emissions. For charge-sustaining tests, do not use alternate Net Energy Change tolerances to correct emissions of criteria pollutants. Additionally, if we approve an alternate End-of-Test criterion or Net Energy Change tolerances for a specific vehicle, we may use the alternate criterion or tolerances for any testing we conduct on that vehicle.

(6) Use the vehicle's Actual Charge-Depleting Range, R_{cda}, as specified in Section 6.1.3 for evaluating the end-of-test criterion.

(7) Measure and record AC watt-hours throughout the recharging procedure. Position the measurement appropriately to account for any losses in the charging system.

(8) We may approve alternate measurement procedures with respect to plug-in hybrid electric vehicles if they are necessary or appropriate for meeting the objectives of this part.

(9) The utility factors described in this paragraph (c) are derived from equations in SAE J2841. You may alternatively calculate utility factors directly from the corresponding equations in SAE J2841.

(d) *Determining the proportion of recovered energy for hybrid electric vehicles.* Testing of hybrid electric vehicles under this part may include a determination of the proportion of energy recovered over the FTP relative to the total available braking energy required over the FTP. This determination is required for pickup trucks accruing credits for implementation of hybrid technology under §86.1870–12, and requires the measurement of electrical current (in amps) flowing into the hybrid system battery for the duration of the test. Hybrid electric vehicles are tested for fuel economy and GHG emissions using the 4-bag FTP as required by §600.114(c). Alternative measurement and calculation methods may be used with prior EPA approval.

(1) Calculate the theoretical maximum amount of energy that could be recovered by a hybrid electric vehicle over the FTP test cycle, where the test cycle time and velocity points are expressed at 10 Hz, and the velocity (miles/hour) is expressed to the nearest 0.01 miles/hour, as follows:

(i) For each time point in the 10 Hz test cycle (*i.e.*, at each 0.1 seconds):

(A) Determine the road load power in kilowatts using the following equation:

$$P_{roadload} = -\left(\frac{V_{mph} \times 0.44704 \times 4.448 \times \left(A + (B \times V_{mph}) + (C \times V_{mph}^{2})\right)}{1000}\right)$$

Where:

$P_{roadload}$ is the road load power in kilowatts, where road load is negative because it always represents a deceleration (*i.e.*, resistive) force on the vehicle;

A, B, and C are the vehicle-specific dynamometer road load coefficients in lb-force, lb-force/mph, and lb-force/mph^2, respectively;

V_{mph} = velocity in miles/hour, expressed to the nearest 0.01 miles/hour;

0.44704 converts speed from miles/hour to meters/second;

4.448 converts pound force to Newtons; and

1,000 converts power from Watts to kilowatts.

(B) Determine the applied deceleration power at each sampling point in time, t, in kilowatts, using the following equation. Positive values indicate acceleration and negative values indicate deceleration.

$$P_{accel} = \frac{ETW \times (V_t \times 0.44704) \times \left(0.44704 \times \frac{(V_t - V_{t-1})}{0.1}\right)}{2.205 \times 1000}$$

Where:

ETW = the vehicle Equivalent Test Weight (lbs);

V_t = velocity in miles/hour, rounded to the nearest 0.01 miles/hour, at each sampling point;

V_{t-1} = the velocity in miles/hour at the previous time point in the 10 Hz speed vs. time table, rounded to the nearest 0.01 miles/hour;

0.1 represents the time in seconds between each successive velocity data point;

0.44704 converts speed from miles/hour to meters/second;

2.205 converts weight from pounds to kilograms; and

1,000 converts power from Watts to kilowatts.

(C) Determine braking power in kilowatts using the following equation. Note that during braking events, P_{brake}, P_{accel}, and $P_{roadload}$ will all be negative (*i.e.*, resistive) forces on the vehicle.

$$P_{brake} = P_{accel} - P_{roadload}$$

Where:

P_{accel} = the value determined in paragraph (c)(1)(i)(B) of this section;

$P_{roadload}$ = the value determined in paragraph (c)(1)(i)(A) of this section; and

P_{brake} = 0 if P_{accel} is greater than or equal to $P_{roadload}$.

(ii) The total maximum braking energy (E_{brake}) that could theoretically be recovered is equal to the absolute value of the sum of all the values of P_{brake} determined in paragraph (c)(1)(i)(C) of this section, divided by 36000 (to convert 10 Hz data to hours) and rounded to the nearest 0.01 kilowatt hours.

(2) Calculate the actual amount of energy recovered (E_{rec}) by a hybrid electric vehicle when tested on the FTP according to the provisions of this part, as follows:

(i) Measure the electrical current in Amps to and from the hybrid electric vehicle battery during the FTP. Measurements should be made directly upstream of the battery at a 10 Hz sampling rate.

(ii) At each sampling point where current is flowing into the battery, calculate the current flowing into the battery, in Watt-hours, as follows:

$$E_t = \frac{V_{nominal} \times I_t}{36{,}000}$$

Where:

E_t = the current flowing into the battery, in Watt-hours, at time t in the test;

I_t = the electrical current, in Amps, at time t in the test; and

$V_{nominal}$ = the nominal voltage of the hybrid battery system determined according to paragraph (c)(4) of this section.

(iii) The total energy recovered (E_{rec}) is the absolute value of the sum of all values of E_t that represent current flowing into the battery, divided by 1000 (to convert Watt-hours to kilowatt-hours).

(3) The percent of braking energy recovered by a hybrid system relative to the total available energy is determined by the following equation, rounded to the nearest one percent:

$$Energy\ Recovered\ \% = \frac{E_{rec}}{E_{brake}} \times 100$$

Where:

E_{rec} = The actual total energy recovered, in kilowatt hours, as determined in paragraph (c)(2) of this section; and

E_{brake} = The theoretical maximum amount of energy, in kilowatt hours, that could be recovered by a hybrid electric vehicle over the FTP test cycle, as determined in paragraph (c)(1) of this section.

(4)(i) Determination nominal voltage ($V_{nominal}$) using the following equation:

$$V_{nominal} = \frac{V_S + V_F}{2}$$

Where:

V_S is the battery voltage measured at the start of the FTP test, where the measurement is made after the key-on event but not later than 10 seconds after the key-on event; and

V_F is the battery voltage measured at the conclusion of the FTP test, where the measurement is made before the key-off event but not earlier than 10 seconds prior to the key-off event.

(ii) If the absolute value of the measured current to and from the battery during the measurement of either V_S or V_F exceeds three percent of the maximum absolute value of the current measured over the FTP, then that V_S or V_F value is not valid. If no valid voltage measurement can be made using this method, the manufacturer must develop an alternative method of determining nominal voltage. The alternative must be developed using good engineering judgment and is subject to EPA approval.

[76 FR 39548, July 6, 2011, as amended at 76 FR 57380, Sept. 15, 2011; 77 FR 63182, Oct. 15, 2012; 79 FR 23747, Apr. 28, 2014]

§ 600.117 Interim provisions.

The following provisions apply instead of other provisions specified in this part through model year 2019:

(a) Except as specified in paragraph (e) of this section, manufacturers must demonstrate compliance with greenhouse gas emission standards and determine fuel economy values using gasoline test fuel as specified in 40 CFR 86.113–04(a), regardless of any testing with Tier 3 test fuel under paragraph (b) of this section.

(b) Manufacturers may demonstrate that vehicles comply with Tier 3 emission standards as specified in 40 CFR part 86, subpart S, during fuel economy measurements using the gasoline test fuel specified in 40 CFR 86.113–04(a), as long as this test fuel is used for all the duty cycles specified in 40 CFR part 86, subpart S. If a vehicle fails to meet a Tier 3 emission standard using the gasoline test fuel specified in 40 CFR 86.113–04(a), the manufacturer must retest the vehicle using the Tier 3 test fuel specified in 40 CFR 1065.710(b) to demonstrate compliance with all applicable emission standards over that test cycle.

(c) If a manufacturer demonstrates compliance with emission standards for criteria pollutants over all five test cycles using the Tier 3 test fuel specified in 40 CFR 1065.710(b), the manufacturer may use the derived five-cycle calculations to demonstrate compliance with greenhouse gas emission standards and