10.2 One of the following two emission test options must be performed.

(i) A three phase test that includes phase one as the first 505 seconds of the cold-start UDDS cycle, phase two as the remaining 867 seconds of the cold-start UDDS cycle, a 10 minute key-off soak period, and phase three as the first 505 seconds of the hot-start UDDS cycle. Emission weighting is as follows:

$$Y_{wm} = 0.43 * \left(\frac{Y_1 + Y_2}{D_1 + D_2} \right) + 0.57 * \left(\frac{Y_2 + Y_3}{D_2 + D_3} \right)$$

Where:

Y_{wm} = Weighted mass emissions of each pollutant, i.e., THC, CO, THCE, NMOG, NMHCE, CH_4, NO_x, or CO_2, in grams per vehicle mile.

Y_1 = Mass emissions as calculated from phase one of the three phase test.

Y_2 = Mass emissions as calculated from phase two of the three phase test.

Y_3 = Mass emissions as calculated from phase three of the three phase test.

D_1 = The measured driving distance from phase one of the three phase tests, in miles.

D_2 = The measured driving distance from phase two of the three phase tests, in miles.

D_3 = The measured driving distance from phase three of the three phase tests, in miles.

(ii) A two phase test that includes phase one as a UDDS cycle, a 10 minute key-off soak period, and phase two as a UDDS cycle. Emission weighting for the four phase test will follow the procedure outlined in section F.6.4.

G. Test Procedures for 2018 ~~and Subsequent~~through 2025 Model Off-Vehicle Charge Capable Hybrid Electric Vehicles.

The "as adopted or amended dates" of the 40 CFR Part 86 regulations and the 40 CFR Part 1066 regulations referenced by this document are the dates identified in the "California 2015 ~~and Subsequent~~through 2025 Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles," unless otherwise noted.

Migration of the test procedures for measuring exhaust emissions from 40 CFR Part 86 to 40 CFR Part 1066 shall be done in accordance with Part II, Subpart A, section 100.1 of the "California 2015 ~~and Subsequent~~through 2025 Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles."

1. Electric Dynamometer.

All off-vehicle charge capable HEVs must be tested using an electric dynamometer meeting the requirements of 40 CFR Part 1066 Subpart C.

2. Vehicle and Battery Break-In Period.

A manufacturer shall use good engineering judgment in determining the proper stabilized emissions mileage test point and report same according to the requirements of section D.2.11 above.

3. General Testing Requirements.

3.1 Recording requirements.

For off-vehicle charge capable hybrid electric vehicles: The following data shall be recorded for all tests and for each individual test cycle therein, except for the 20°F and 50°F tests, conducted in accordance with section G.8:

(a) mileage accumulated during the All-Electric Range portion of the test, where applicable;

(b) Net DC energy from the battery that was expended during the test (may be reported as the total DC battery energy output and the total DC battery energy input);

(c) AC energy required to fully charge the battery after a charge depleting or charge sustaining test from the point where electricity is introduced from the electric outlet to the battery charger;

(d) DC energy required to fully charge the battery after a charge depleting or charge sustaining test from the point where electricity is

introduced from the battery charger to the battery. As an alternative, DC energy required to fully charge the battery after a charge-depleting or charge-sustaining test from the point where electricity is introduced from the battery charger to the vehicle may be reported;

(e) Net DC amp-hrs from the battery that was expended during the test (may be reported as the total DC amp-hrs output and the total DC amp-hrs input); and

(f) Measured AC and DC watt hours and amp hours shall be reported to the nearest hundredths of a kilowatt hour and tenths of an amp hour.

3.2 **Regenerative braking**. Regenerative braking systems may be utilized during the range test. The braking level, if adjustable, shall be set according to the manufacturer's specifications for normal driving conditions prior to the commencement of the test. The driving schedule speed and time tolerances specified in 40 CFR §1066.425 shall not be exceeded due to the operation of the regenerative braking system.

3.3 **Measurement Accuracy**. The overall error in voltage and current recording instruments shall be NIST traceable with an accuracy as specified in 40 CFR §1066.501 subparagraph (a)(iv) [February 19, 2015]. Instruments measuring voltage and current shall be as specified in 40 CFR §1066.501 subparagraph (a)(iv)(4) [February 19, 2015].

3.4 **Watt Hour Calculation.**

DC energy (watt hours) shall be calculated as follows

DC energy = $\int v(t) * i(t)\, dt$
Wherev = vehicle DC main battery pack voltage
i = vehicle DC main battery pack current

AC energy (in watt-hours) shall be calculated as follows

AC energy = $\int v(t) * i(t)\, dt$ in watt-hours
Wherev = AC instantaneous voltage
i = AC instantaneous current

3.5 **Charger Requirements**

The standard charging apparatus (or equivalent) normally furnished with or specified for the vehicle shall be used for charging during vehicle testing.

4. Determination of the Emissions of the Fuel-fired Heater.

The exhaust emissions result of the fuel-fired heater shall be determined by operating at a maximum heating capacity with a cold start between 68°F and 86°F for

a period of 20 minutes and dividing the grams of emissions by 20. The resulting grams per minute shall be multiplied by 3.0 minutes per mile to obtain a grams per mile value.

5. Urban Emission Test Provisions for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

Alternative procedures may be used if shown to yield equivalent results and if approved in advance by the Executive Officer of the Air Resources Board.

For the purpose of determining Urban All-Electric Range and Urban Equivalent All-Electric Range, the vehicle shall be range tested in default mode or in normal mode if the vehicle does not have a default mode.

For the purpose of demonstrating compliance with exhaust emission standards, a vehicle must be emission tested in the vehicle operation (i.e., either charge-depleting, charge-sustaining, or charge-increasing operation) that represents the worst case urban NMOG + NOx emissions.

Vehicles with one or more driver-selectable modes (e.g., normal mode, economy mode, performance mode, battery charging mode, or any other operating mode available to the driver) for a given charge-depleting, charge-sustaining, or charge-increasing operation must be emission tested in the one driver-selectable mode and vehicle operation (i.e., charge-depleting, charge-sustaining, charge-increasing) which represents the worst case urban NMOG + NOx emissions. For example, if a vehicle has two driver-selectable modes that can be tested in charge-depleting, charge-sustaining, and charge-increasing operations, the manufacturer shall determine worst case urban NMOG + NOx emissions by comparing the following (1) mode 1 charge-depleting emissions, (2) mode 2 charge-depleting emissions, (3) mode 1 charge-sustaining emissions, (4) mode 2 charge-sustaining emissions, (5) mode 1 charge-increasing emissions, and (6) mode 2 charge-increasing emissions based on the Urban Charge-Depleting Emission Test and Urban Charge-Sustaining Emission Test. The exception to this would be for vehicles qualifying for the Alternative Urban Charge-Depleting Emission Test where the one driver-selectable mode representing the worst case urban NMOG + NOx emissions would be tested only on the Alternative Urban Charge-Depleting Emission Test. In addition, some driver-selectable modes are incompatible with testing of certain vehicle operations. For example, a charge-increasing driver-selectable mode is not compatible with a charge-depleting test.

In lieu of demonstrating the worst case urban NMOG + NOx emissions by certification testing in every urban charge-depleting driver-selectable mode, every urban charge-sustaining driver-selectable mode, and every charge-increasing driver-selectable mode, a manufacturer may determine the worst case operating mode by using non-certification emission data and/or an engineering evaluation. The manufacturer must report the data and/or engineering evaluation used to determine the worst case operating mode. The manufacturer must demonstrate compliance with

all applicable emission standards using test data for the worst case operating mode.

For vehicles that qualify for and are tested on the Alternative Urban Charge-Depleting Emission Test in section G.5.4.5, the urban worst case NMOG + NOx emissions may be determined for the Alternative Urban Charge-Depleting Emission Test alone. Therefore, a vehicle qualifying for the Alternative Urban Charge-Depleting Emission Test would not be required to be emission tested in charge-depleting, charge-sustaining, charge-increasing operations. If driver-selectable modes are available, each driver-selectable mode must still be considered for worst case NMOG + NOx emissions for the Alternative Urban Charge-Depleting Emission Test.

Confirmatory testing and/or in-use compliance testing may be performed in any driver-selectable mode in charge-depleting, charge-sustaining, or charge-increasing operation to ensure compliance with emission standards. For vehicles that qualify for and are certified on the Alternative Urban Charge-Depleting Emission Test, confirmatory testing and/or in-use compliance testing may be performed in any driver-selectable mode solely using the Alternative Urban Charge-Depleting Emission Test to ensure compliance with emission standards.

For the Urban Charge-Depleting Emission Test in section G.5.4.2, confirmatory and in-use compliance testing shall use two hot-start UDDS cycles to ensure that the vehicle has achieved full warm-up conditions in accordance with section G.5.4.2.1. If, based on the last cycle or series of cycles, the Additional End-of-Test criteria in section G.5.4.3.1 are not satisfied at the end of the second hot-start, then a third hot-start UDDS cycle shall be performed. If criteria are still not satisfied at the end of the third hot-start UDDS cycle, then additional hot-start UDDS cycles shall be performed until:

(1) based on the last cycle or series of cycles, the Additional End-of-Test criteria in section G.5.4.3.1 are satisfied; or
(2) the Additional End-of-Test criteria in section G.5.4.3.2 are satisfied.

For the Alternative Urban Charge-Depleting Emission Test, confirmatory and in-use compliance testing shall use one hot-start UDDS cycle as specified in section G.5.4.6.

5.1 Urban Test Applicability and General Provisions for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

To be conducted pursuant to 40 CFR §1066.801 with the following revisions:

5.1.1 Subparagraphs (a) through (b). [No change.]

5.1.2 Amend subparagraph (c)(1): The Urban Charge-Sustaining Emission Test and the Urban Charge-Depleting Emission Test.

5.1.3 Amend subparagraph (c)(1)(i): The Urban Charge-Sustaining Emission Test consists of an engine startup during the first UDDS cycle followed by a 10-

minute key-off soak. The Urban Charge-Depleting Emission Test consists of a series of charge-depleting UDDS cycles each followed by a 10-minute key-off soak until charge-sustaining operation is achieved. The Urban Charge-Depleting Emission Test begins with the vehicle at full state-of-charge with engine startup occurring during the driving of the series of charge-depleting UDDS cycles. The first engine startup (with all accessories turned off) that occurs during a UDDS cycle followed by a vehicle shutdown at the end of the UDDS cycle makes a complete cold-start UDDS cycle. After a 10-minute key-off soak, the subsequent UDDS cycle is a hot-start UDDS cycle. The UDDS cycle can be considered as a two phase cycle where the first 505 seconds of the UDDS cycle is the transient phase, and the remaining 867 seconds of the UDDS cycle is the stabilized phase. For the Urban Charge-Depleting Emission Test, additional hot-start UDDS cycles each followed by a 10-minute key-off soak may be needed to achieve charge-sustaining operation.

5.1.4 Subparagraphs (c)(1)(ii) through (c)(5). [Not applicable.]

5.1.5 Subparagraph (d). [No change.]

5.1.6 Subparagraph (e). [No change except the hot soak test temperature in the three-day diurnal emission test sequence is 105°F.]

5.2 Urban Vehicle Preconditioning for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

To be conducted pursuant to the "California Evaporative Emission Standards and Test Procedures for 2001 through 2025 Model Passenger Cars, Light-Duty trucks, Medium-Duty Vehicles, and Heavy-Duty Vehicles and 2021 and Subsequent Model ~~Motor Vehicles~~Motorcycles" with the following supplemental requirements:

5.2.1 The vehicle shall be preconditioned in charge-sustaining operation with the vehicle in default mode or in normal mode if the vehicle does not have default mode. If, however, the vehicle is to be tested in charge-increasing operation (this does not apply to a driver-selectable charge-increasing mode), then the initial SOC for the preconditioning drive shall be set at the lowest normal SOC level allowed by the vehicle when driving on the UDDS cycle.

5.2.2 The vehicle shall be pushed or towed to a work area for the initial fuel drain and fill according to section III.D.1.4 of the "California Evaporative Emission Standards and Test Procedures for 2001 through 2025 Model Passenger Cars, Light-Duty trucks, Medium-Duty Vehicles, and Heavy-Duty Vehicles and 2021 and Subsequent Model ~~Motor Vehicles~~Motorcycles."

5.2.3 Following the initial fuel drain and fill, the vehicle shall complete an initial soak period of a minimum of 6 hours.

5. 2.4 After completing the initial soak period, the vehicle shall be pushed or towed into position on a dynamometer and preconditioned.

5.2.5 For the Urban Charge-Depleting Emission Test and the Urban Charge-Sustaining Emission Test, the preconditioning cycle shall be the UDDS cycle and performed at this time. For the Urban Charge-Sustaining Emission Test, except as noted in sections G.5.2.8.1, G.5.2.8.2, and G.5.2.8.3, the initial SOC may be set after the preconditioning cycle by driving an additional distance on the chassis dynamometer such that the SOC Criterion is satisfied when applying the ±1% SOC Net Energy Change Tolerances in section G.10.

5.2.6 A fuel drain and fill shall be performed pursuant to the provisions of the "California Evaporative Emission Standards and Test Procedures for 2001 through 2025 Model Passenger Cars, Light-Duty trucks, Medium-Duty Vehicles, and Heavy-Duty Vehicles and 2021 and Subsequent Model ~~Motor Vehicles~~Motorcycles."

5.2.7 The vehicle shall be soaked for 12-36 hours. During this soak period, canister preconditioning shall be performed pursuant to the provisions of the "California Evaporative Emission Standards and Test Procedures for 2001 through 2025 Model Passenger Cars, Light-Duty trucks, Medium-Duty Vehicles, and Heavy-Duty Vehicles and 2021 and Subsequent Model ~~Motor Vehicles~~Motorcycles."

5.2.8 For the Urban Charge-Depleting Emission Test, charge the vehicle to full state-of-charge as specified by the vehicle manufacturer. For the Urban Charge-Sustaining Emission Test, except as noted in sections G.5.2.8.1, G.5.2.8.2, and G.5.2.8.3, initial SOC may be set during the soak period by discharging or charging the vehicle such that the SOC Criterion is satisfied when applying the ±1% SOC Net Energy Change Tolerances in section G.10. For the Alternative Urban Charge-Depleting Emission Test, only the initial dynamometer run to determine urban all-electric range as described in G.5.4.5 (ii) would require the vehicle to be charged to full state-of-charge prior to testing. For any subsequent dynamometer run to determine urban emissions for the Alternative Urban Charge-Depleting Emission Test, the initial SOC would be set according to G.5.4.5 (iv). The vehicle must be turned off during charging and charge time shall not exceed soak time.

5.2.8.1 If the alternative End-of-Test Criterion in section G.5.3.18 is used, then initial SOC setting shall not be permitted after the preconditioning cycle nor during the soak period prior to the Urban Charge-Sustaining Emission Test.

5.2.8.2 If testing a vehicle in a charge-increasing driver-selectable mode, then initial SOC setting shall not be permitted after the preconditioning cycle nor during the soak period prior to the Urban Charge-Sustaining Emission Test.

5.2.8.3 If testing a vehicle in charge-increasing operation, then the initial

SOC for the preconditioning drive shall be set at the lowest normal SOC level allowed by the vehicle when driving on the UDDS cycle.

5.3 Determination of Urban Charge-Sustaining Emissions –Dynamometer Test Run, Gaseous and Particulate Emissions for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

To be conducted pursuant to 40 CFR §1066.815 with the following revisions:

5.3.1 Amend subparagraph (a): *General*. The Urban Charge-Sustaining Emission Test consists of a cold-start UDDS cycle and a hot-start UDDS cycle as described in section G.5.1.3. If driver-selectable modes are available, activate the driver-selectable mode to be tested for the Urban Charge-Sustaining Emission Test to determine worst case emissions as described in the introductory paragraphs of section G.5. If a vehicle has a driver-selectable, charge-increasing mode, SOC shall be set in accordance with section G.5.4.5(iv) with the charge-increasing mode activated at the start of the cold-start UDDS cycle.

5.3.2 Amend subparagraph (b): *PM sampling options*. Collect PM using the procedures specified in subparagraphs (b)(1) or (b)(2) or (b)(5) of 40 CFR §1066.815 (subparagraphs (b)(3) and (b)(4) are not applicable) and use the corresponding equation in section G.5.6 to calculate composite PM emissions. Testing must meet the requirements related to filter face velocity as described in 40 CFR §1065.170(c)(1)(vi) [April 28, 2014], except as specified in paragraph (b)(5) of 40 CFR §1066.815 [February 19, 2015]. For procedures involving flow weighting, set the filter face velocity to a weighting target of 1.0 to meet the requirements of 40 CFR §1065.170(c)(1)(vi) [April 28, 2014]. Allow filter face velocity to decrease as a percentage of the weighting factor if the weighting factor is less than 1.0. Use the appropriate equations in 40 CFR §1066.610 to show that you meet the dilution factor requirements of 40 CFR §1066.110(b)(2)(iii)(B).

5.3.3 Amend subparagraphs (b)(1): A separate PM sample for transient and stabilized phases of the cold-start UDDS cycle and the hot-start UDDS cycle may be collected. This may be done by sampling with four filters.

5.3.4 Subparagraph (b)(2). [No change.]

5.3.5 Delete subparagraphs (b)(3) and (b)(4).

5.3.6 Subparagraphs (b)(5) through (c)(2). [No change.]

5.3.7 Delete subparagraph (c)(3).

5.3.8 Amend subparagraph (d): *Test sequence*. Follow the exhaust emission measurement procedures specified in 40 CFR §1066.410 through §1066.425, subject to the following exceptions and additional provisions:

5.3.9 Subparagraph (d)(1). [No change.]

5.3.10 Amend subparagraph (d)(1)(i): Precondition the vehicle as described in section G.5.2. Initiate the cold-start Urban Charge-Sustaining Emission Test in the driver-selectable mode to be tested following the 12 to 36 hour soak period.

5.3.11 Subparagraphs (d)(1)(ii) and (d)(1)(iii). [No change.]

5.3.12 Amend subparagraph (d)(1)(iv): Five seconds after the vehicle is turned off, stop all stabilized interval sampling and recording, including background sampling. Stop any integrating devices for the stabilized interval and indicate the end of the stabilized interval in the recorded data. Note that the 5 second delay is intended to account for sampling system transport.

5.3.13 Subparagraph (d)(2). [No change.]

5.3.14 Amend subparagraph (d)(2)(i): Initiate the hot-start UDDS cycle (9 to 11) minutes after the end of the sample period for the cold-start UDDS cycle.

5.3.15 Amend subparagraph (d)(2)(ii): Repeat the steps in paragraph (d)(1)(ii) of this section.

5.3.16 Amend subparagraph (d)(2)(iii): For bag 4 measurement or single bag per UDDS cycle measurement, operate the vehicle over the remainder of the UDDS and conclude the testing as described in paragraphs (d)(1)(iii) and (iv) of this section.

5.3.17 Amend subparagraph (3): **End-of-Test Criteria.** A valid test shall satisfy the SOC Net Energy Change Tolerances in section G.10. For PHEVs that use a battery as an energy storage device, $(\text{Amp-hr}_{initial})$ is the stored charge at the beginning of the cold-start UDDS cycle, and (Amp-hr_{final}) is the stored battery charge at the end of the subsequent hot-start UDDS cycle. The final stored battery charge, (Amp-hr_{final}), shall not exceed either $(\text{Amp-hr}_{final})_{max}$ or $(\text{Amp-hr}_{final})_{min}$ for a valid test. For PHEVs that use a capacitor as an energy storage device, $(V^2_{initial})$ is the square of the capacitor voltage stored at the beginning of the cold-start UDDS cycle, and (V_{final}) is the stored capacitor voltage at the end of the subsequent hot-start UDDS cycle. The final stored capacitor voltage, (V_{final}), shall not exceed either $(V_{final})_{max}$ or $(V_{final})_{min}$ for a valid test. For PHEVs that use an electro-mechanical flywheel as an energy storage device, $(\text{rpm}^2_{initial})$ is the squared flywheel rotational speed at the beginning of the cold-start UDDS cycle, and (rpm_{final}) is the flywheel rotational speed at the end of the subsequent hot-start UDDS cycle. The final flywheel rotational speed, (rpm_{final}), shall not exceed either $(\text{rpm}_{final})_{max}$ or $(\text{rpm}_{final})_{min}$ for a valid test.

5.3.18 **Additional End-of-Test Criteria.** With approval from the Executive

Officer, if the SOC Net Energy Change Tolerance is not satisfied after the hot-start UDDS cycle in section G.5.3.17, an Urban Charge-Sustaining Emission Test may be considered valid if:

5.3.18.1 The alternative End-of-Test criterion of ±5% SOC Net Energy Change Tolerance in Appendix C of SAE J1711 is satisfied (Note: Appendix C of SAE J1711 may not be used to correct measured values for any emissions.); or

5.3.18.2 The SOC at the end of the hot-start UDDS cycle is higher than the SOC at the beginning of the cold-start UDDS cycle.

5.4 Determination of Urban All-Electric Range, Urban Equivalent All-Electric Range, and Urban Charge-Depleting Emissions for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

5.4.1 The **Urban All-Electric Range** shall be defined as the distance that the vehicle is driven from the start of Urban Charge-Depleting Emission Test until the engine first starts in accordance with section G.5.4.2.1. Record the SOC when the engine first starts. The Urban Charge-Depleting Emission Test is performed with the vehicle initially at full state-of-charge. When emission testing a vehicle in a driver-selectable mode other than default mode or normal mode, the distance of the Urban All-Electric Range, which occurs during the first portion of the Urban Charge-Depleting Emission Test, shall not be considered as certification urban all-electric range for the purposes of compliance with the requirements in section C.

5.4.1.1 **Urban Equivalent All-Electric Range** shall be calculated in accordance with section G.11.

5.4.2 **Urban Charge-Depleting Emission Test.**

To be conducted pursuant to 40 CFR §1066.815 with the following revisions:

5.4.2.1 Amend subparagraph (a): *General*. The Urban Charge-Depleting Emission Test consists of the Urban All-Electric Range Test, a cold-start UDDS cycle when the engine starts followed by a 10-minute key off soak and hot-start UDDS cycle(s) as described in section G.5.1.3. The Continuous Urban Test Schedule is used for the Urban Charge-Depleting Emission Test. If driver-selectable modes are available that can be appropriately tested with charge-depleting operation, then test the appropriate driver-selectable mode(s) as required for the Urban Charge-Depleting Emission Test to determine worst case emissions as described in the introductory paragraphs of section G.5. The Alternative Continuous Urban Test Schedule may be substituted for the Continuous Urban Test Schedule if the test facility is unable to perform the

Continuous Urban Test Schedule. Refer to sections G.5.5, G.5.6, and G.11, for calculations of urban exhaust emissions, urban particulate emissions, and equivalent all-electric range, respectively. Emissions shall be measured for all test cycles when the engine is operating. For each test cycle during which emissions are not generated, emissions are not required to be sampled. However, the manufacturer must validate that the engine did not turn on at any time during the test cycle. If the engine starts operating toward the end of the cold-start UDDS cycle such that the vehicle does not achieve full warm-up conditions prior to the subsequent hot-start UDDS cycle, an additional hot-start UDDS cycle may be performed following the first hot-start UDDS cycle and be included in the hot-start mass summations Σm_h in the equation of section 5.5.1.2 and $\Sigma m_{PM\text{-}hUDDS}$ of the equation in section 5.6.1.2(1) along with the associated distance summations ΣD_h.

5.4.2.2 Amend subparagraph (b): *PM sampling options*. Collect PM using the procedures specified in subparagraphs (b)(1) or (b)(2) or (b)(5) of 40 CFR §1066.815 (subparagraphs (b)(3) and (b)(4) are not applicable) and use the corresponding equation in section G.5.6 to calculate composite PM emissions. Testing must meet the requirements related to filter face velocity as described in 40 CFR §1065.170(c)(1)(vi) [April 28, 2014], except as specified in paragraph (b)(5) of 40 CFR §1066.815. For procedures involving flow weighting, set the filter face velocity to a weighting target of 1.0 to meet the requirements of 40 CFR §1065.170(c)(1)(vi) [April 28, 2014]. Allow filter face velocity to decrease as a percentage of the weighting factor if the weighting factor is less than 1.0. Use the appropriate equations in 40 CFR §1066.610 to show that you meet the dilution factor requirements of 40 CFR §1066.110(b)(2)(iii)(B).

5.4.2.3 Amend subparagraphs (b)(1): A separate PM sample for transient and stabilized phases of the cold-start UDDS cycle and the hot-start UDDS cycle may be collected. This may be done by sampling with four filters.

5.4.2.4 Subparagraph (b)(2). [No change.]

5.4.2.5 Delete subparagraphs (b)(3) and (b)(4).

5.4.2.6 Subparagraphs (b)(5) through (c)(2). [No change.]

5.4.2.7 Delete subparagraph (c)(3).

5.4.2.8 Amend subparagraph (d): *Test sequence*. Follow the exhaust emission measurement procedures specified in 40 CFR §1066.410 through §1066.425, subject to the following exceptions and additional provisions:

5.4.2.9 Subparagraph (d)(1). [No change.]

5.4.2.10 Amend subparagraph (d)(1)(i): Precondition the vehicle as described in section G.5.2. Initiate the cold-start Urban Charge-Depleting Emission Test in the appropriate driver-selectable mode to be tested following the 12 to 36 hour soak period.

5.4.2.11 Subparagraphs (d)(1)(ii) and (d)(1)(iii). [No change.]

5.4.2.12 Amend subparagraph (d)(1)(iv): Five seconds after the vehicle is turned off, stop all stabilized interval sampling and recording, including background sampling. Stop any integrating devices for the stabilized interval and indicate the end of the stabilized interval in the recorded data. Note that the 5 second delay is intended to account for sampling system transport.

5.4.2.13 Subparagraph (d)(2). [No change.]

5.4.2.14 Amend subparagraph (d)(2)(i): Initiate the hot-start UDDS cycle (9 to 11) minutes after the end of the sample period for the cold-start UDDS cycle.

5.4.2.15 Amend subparagraph (d)(2)(ii): Repeat the steps in paragraph (d)(1)(ii) of this section.

5.4.2.16 Amend subparagraph (d)(2)(iii): For bag 4 measurement or single bag per UDDS cycle measurement, operate the vehicle over the remainder of the UDDS and conclude the testing as described in subparagraphs (d)(1)(iii) and (iv) of this section.

5.4.2.17 Amend subparagraph (3): **End-of-Test Criteria.** A valid test shall satisfy the SOC Net Energy Change Tolerances in section G.10. For PHEVs that use a battery as an energy storage device, $(\text{Amp-hr}_{initial})$ is the stored charge at the beginning of the cold-start UDDS cycle, and (Amp-hr_{final}) is the stored battery charge at the end of the next hot-start UDDS cycle immediately following the cold-start UDDS cycle. The final stored battery charge, (Amp-hr_{final}), shall not exceed either $(\text{Amp-hr}_{final})_{max}$ or $(\text{Amp-hr}_{final})_{min}$ for a valid test. For PHEVs that use a capacitor as an energy storage device, $(V^2_{initial})$ is the square of the capacitor voltage stored at the beginning of the cold-start UDDS cycle, and (V_{final}) is the stored capacitor voltage at the end of the next hot-start UDDS cycle immediately following the cold-start UDDS cycle. The final stored capacitor voltage, (V_{final}), shall not exceed either $(V_{final})_{max}$ or $(V_{final})_{min}$ for a valid test. For PHEVs that use an electro-mechanical flywheel as an energy storage device, $(\text{rpm}^2_{initial})$ is the squared flywheel rotational speed at the beginning of the cold-start UDDS cycle, and (rpm_{final}) is the flywheel rotational speed at the end of the next hot-start UDDS cycle immediately following the cold-start UDDS cycle. The final flywheel rotational speed, (rpm_{final}), shall not exceed either $(\text{rpm}_{final})_{max}$ or $(\text{rpm}_{final})_{min}$ for a valid test.

5.4.3 **Additional End-of-Test Criteria.** With approval from the Executive Officer, if the SOC Net Energy Change Tolerance is not satisfied after the hot-start UDDS cycle in section G.5.4.2.17, an Urban Charge-Depleting Emission Test may be considered valid if:

5.4.3.1 The alternative End-of-Test criteria in Section 3.9 or Section 3.9.1 of SAE J1711 are satisfied; or

5.4.3.2 The SOC at the end of the hot-start UDDS cycle is higher than the SOC at the beginning of the cold-start UDDS cycle.

5.4.4 **Vehicle charging after testing.** Vehicle charging shall begin within three hours after the charge depleting emission test, and the vehicle shall be charged to the manufacturer specified full state-of-charge. During charging, all applicable requirements in section G.3 must be met, and energy consumption shall be calculated pursuant to the requirements in section G.11.7.

5.4.5 **Alternative Urban Charge-Depleting Emission Test.**

A vehicle with an Urban All-Electric Range that is equal to or greater than four UDDS cycles and has an AER/EAER ratio that is equal to or greater than 0.98 may demonstrate compliance with applicable exhaust emission standards using this section G.5.4.5 in lieu of sections G.5.3 and G.5.4.2. The AER and EAER values used to calculate the AER/EAER ratio must each contain three significant figures after the decimal point. Rounding the calculated AER/EAER ratio up to 0.98 is prohibited. Use of the Alternative Urban Charge-Depleting Emission Test must be approved in advance by the Executive Officer.

For the purpose of measuring vehicle emissions, subparagraphs 5.4.5(i) and (ii) must be performed during the initial Alternative Urban Charge-Depleting Emission Test to determine urban all-electric range; these sections may be omitted during any subsequent Alternative Urban Charge-Depleting Emission Tests.

(i) The vehicle shall be charged to full state-of-charge.

(ii) **Dynamometer run to determine Urban All-Electric Range.** The vehicle shall be placed or pushed onto a chassis dynamometer and operated through the Continuous Urban Test Schedule or the Alternative Continuous Urban Test Schedule with the vehicle in default mode or in normal mode if the vehicle does not have default mode. When the engine first starts, record SOC, and continue driving until charge-sustaining operation is achieved. As an option, emissions may be measured so the full Urban Charge-Depleting Emission Test as described in section G.5.4.2 may be used to determine urban charge-depleting emissions for vehicles operating in default or normal mode. If this option is used, vehicle preconditioning

according to section G.5.2 must be performed prior to this section G.5.4.5(ii). To determine the Urban Equivalent All-Electric Range for the TZEV Allowance in section C.3.3(a), the full Urban Charge-Depleting Emission Test option shall be performed and the Urban Equivalent All-Electric Range calculated in accordance with section G.11.

(iii) **Vehicle preconditioning.** The vehicle shall be preconditioned according to section G.5.2.

(iv) **Dynamometer run to determine Urban Emissions.** After the cold soak period, using the engine start SOC data from the previous section G.5.4.5(ii), set the SOC so that the engine starts at or before the first 45 seconds of the cold-start UDDS cycle. The SOC shall not be set below the normal operating SOC threshold of the vehicle as observed during the UDDS cycle when driving in default mode or in normal mode if the vehicle does not have default mode. If testing a vehicle in driver-selectable, charge-increasing mode: first set SOC in accordance with the conditions set forth in the first two sentences of this section G.5.4.5(iv) with the vehicle in default mode or in normal mode if the vehicle does not have default mode, then activate the charge-increasing mode at the start of the cold-start UDDS cycle. For all tests, the engine must start at or before the first 45 seconds of the cold-start UDDS cycle to be valid.

(v) The vehicle shall be placed or pushed onto a dynamometer and operated through a cold-start UDDS cycle followed by a 10 minute key-off soak and then a hot-start UDDS cycle. At the completion of the hot-start UDDS cycle, the test is completed. For additional testing information, the testing parameters for the Urban Charge-Sustaining Emission Test in section G.5.3 are applicable. However, the Alternative Urban Charge-Depleting Emission Test does not require satisfying the SOC Net Energy Change Tolerance to be a valid test.

(vi) Refer to sections G.5.5 and G.5.6, for calculating urban gaseous emissions and urban particulate emissions, respectively.

(vii) **Optional vehicle charging after testing.** Vehicle may be fully charged following the Urban All-Electric Range Test in section G.5.4.5(ii). If this option is performed, vehicle charging shall begin within three hours after completing the Urban All-Electric Range Test in section G.5.4.5(ii), and the vehicle shall be charged to the manufacturer specified full state-of-charge. During charging, all applicable requirements in section G.3 must be met, and energy consumption shall be calculated pursuant to the requirements in section G.11.7.

5.5 Calculations – Urban Gaseous Emissions for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

5.5.1 Urban Charge-Depleting Gaseous Emissions Calculations.

To be conducted pursuant to 40 CFR §1066.820 [April 28, 2014] with the following revisions:

5.5.1.1 Subparagraph (a). [No change.]

5.5.1.2 Amend subparagraph (b): Calculate the final composite gaseous test results as a mass-weighted value, $e_{[\text{emission}]\text{-FTPcomp}}$, in grams per mile using the following equation:

$$e_{[\text{emission }]-\text{FTPcomp}} = 0.43\left(\frac{m_{\text{c}}}{D_{\text{c}}}\right) + 0.57\left(\frac{\Sigma m_{\text{h}}}{\Sigma D_{\text{h}}}\right)$$

Where:

m_c = the mass emissions determined from the cold-start UDDS cycle, in grams. If the cold-start UDDS cycle consists of phase 1 cold transient emissions and phase 2 cold stabilized emissions, then sum phase 1 and phase 2 emissions to determine m_c.

D_c = the measured driving distance from the cold-start UDDS cycle, in miles. If the cold-start UDDS cycle consists of phase 1 distance and phase 2 distance, then sum phase 1 and phase 2 distances to determine D_c.

Σm_h = the summation of the mass emissions determined from each hot-start UDDS cycle, in grams. If a hot-start UDDS cycle consists of phase 3 hot transient emissions and phase 4 hot stabilized emissions, then sum phase 3 and phase 4 emissions to determine m_h for the each hot-start UDDS cycle.

ΣD_h = the summation of the driving distances from each hot-start UDDS cycle, in miles. If a hot-start UDDS cycle consists of phase 3 distance and phase 4 distance, then sum phase 3 and phase 4 distances to determine D_h for each hot-start UDDS cycle.

5.5.1.3 Subparagraphs (c). [Not applicable.]

5.5.2 Urban Charge-Sustaining Gaseous Emissions Calculations.

To be conducted pursuant to 40 CFR §1066.820 [April 28, 2014] with the following revisions:

5.5.2.1 Subparagraph (a). [No change.]

5.5.2.2 Amend subparagraph (b): Calculate the final composite gaseous test results as a mass-weighted value, $e_{[\text{emission}]\text{-FTPcomp}}$, in grams per mile using the following equation:

$$e_{[\text{emission }]-\text{FTPcomp}} = 0.43\left(\frac{m_{\text{c}}}{D_{\text{c}}}\right) + 0.57\left(\frac{m_{\text{h}}}{D_{\text{h}}}\right)$$

Where:

m_c = the mass emissions determined from the cold-start UDDS cycle, in grams. If the cold-start UDDS cycle consists of phase 1 cold transient emissions and phase 2 cold stabilized emissions, then sum phase 1 and phase 2 emissions to determine m_c.

D_c = the measured driving distance from the cold-start UDDS cycle, in miles. If the cold-start UDDS cycle consists of phase 1 distance and phase 2 distance, then sum phase 1 and phase 2 distances to determine D_c.

m_h = the mass emissions determined from the hot-start UDDS cycle, in grams. If the hot-start UDDS cycle consists of phase 3 hot transient emissions and phase 4 hot stabilized emissions, then sum phase 3 and phase 4 emissions to determine m_h.

D_h = the driving distance from the hot-start UDDS cycle, in grams. If the hot-start UDDS cycle consists of phase 3 distance and phase 4 distance, then sum phase 3 and phase 4 distances to determine D_h.

5.5.2.3 Subparagraph (c). [Not applicable.]

5.6 Calculations - Urban Particulate Emissions for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

5.6.1 Urban Charge-Depleting Particulate Emissions Calculations.

To be conducted pursuant to 40 CFR §1066.820 with the following revisions:

5.6.1.1 Subparagraph (a) to (b). [Not applicable.]

5.6.1.2 Amend subparagraphs (c) through (c)(1): Calculate the final composite PM test results as a mass-weighted value, $e_{\text{PM-FTPcomp}}$, in grams per mile as follows:

(1) Use the following equation for PM measured as described in §1066.815(b)(1) or (2):

$$e_{\mathrm{PM-FTPcomp}} = 0.43\left(\frac{m_{\mathrm{PM-cUDDS}}}{D_{\mathrm{c}}}\right) + 0.57\left(\frac{\Sigma m_{\mathrm{PM-hUDDS}}}{\Sigma D_{\mathrm{h}}}\right)$$

Where:

$m_{\mathrm{PM\text{-}cUDDS}}$ = the combined PM mass emissions determined from the cold-start UDDS cycle (phase 1 and phase 2), in grams, as calculated using Eq. 1066.605-2.

D_{c} = the measured driving distance from the cold-start UDDS cycle, in miles. If the cold-start UDDS cycle consists of phase 1 distance and phase 2 distance, then sum phase 1 and phase 2 distances to determine D_{c}.

$\Sigma m_{\mathrm{PM\text{-}hUDDS}}$ = the summation of the PM mass emissions determined from each hot-start UDDS cycle, in grams, as calculated using Eq. 1066.605-2. If a hot-start UDDS cycle consists of phase 3 hot transient emissions and phase 4 hot stabilized emissions, then sum phase 3 and phase 4 emissions to determine $m_{\mathrm{PM\text{-}hUDDS}}$ for the each hot-start UDDS cycle.

ΣD_{h} = the summation of the driving distances from each hot-start UDDS cycle, in miles. If a hot-start UDDS cycle consists of phase 3 distance and phase 4 distance, then sum phase 3 and phase 4 distances to determine D_{h} for each hot-start UDDS cycle.

5.6.1.3 Subparagraph (c)(2). [Not applicable.]

5.6.1.4 Amend subparagraph (c)(3): Use the following equation for PM measured as described in §1066.815(b)(5):

$$e_{\mathrm{PM-FTPcomp}} = \frac{m_{\mathrm{PM}}}{0.43(D_{\mathrm{c}}) + 0.57(D_{\mathrm{h}})}$$

Where:

m_{PM} = the combined PM mass emissions determined from the cold-start UDDS cycle and the hot-start UDDS cycle (phase 1, phase 2, phase 3, and phase 4), in grams, as calculated using Eq. 1066.605-4.

D_c = the measured driving distance from the cold-start UDDS cycle, in miles. If the cold-start UDDS cycle consists of phase 1 distance and phase 2 distance, then sum phase 1 and phase 2 distances to determine D_c.

D_h = the driving distance from the hot-start UDDS cycle, in grams. If the hot-start UDDS cycle consists of phase 3 distance and phase 4 distance, then sum phase 3 and phase 4 distances to determine D_h.

5.6.2 Urban Charge-Sustaining Particulate Emissions Calculations.

To be conducted pursuant to 40 CFR §1066.820 with the following revisions:

5.6.2.1 Subparagraphs (a) to (b). [Not applicable.]

5.6.2.2 Amend subparagraphs (c) through (c)(1): Calculate the final composite PM test results as a mass-weighted value, $e_{\mathrm{PM-FTPcomp}}$, in grams per mile as follows:

(1) Use the following equation for PM measured as described in §1066.815(b)(1) or (2):

$$e_{\mathrm{PM-FTPcomp}} = 0.43\left(\frac{m_{\mathrm{PM-cUDDS}}}{D_c}\right) + 0.57\left(\frac{m_{\mathrm{PM-hUDDS}}}{D_h}\right)$$

Where:

$m_{\mathrm{PM\text{-}cUDDS}}$ = the combined PM mass emissions determined from the cold-start UDDS cycle (phase 1 and phase 2), in grams, as calculated using Eq. 1066.605-2.

D_c = the measured driving distance from the cold-start UDDS cycle, in miles. If the cold-start UDDS cycle consists of phase 1 distance and phase 2 distance, then sum phase 1 and phase 2 distances to determine D_c.

$m_{\mathrm{PM\text{-}hUDDS}}$ = the combined PM mass emissions determined from the hot-start UDDS cycle (phase 3 and phase 4), in grams, as calculated using Eq. 1066.605-2.

D_h = the driving distance from the hot-start UDDS cycle, in grams. If the hot-start UDDS cycle consists of phase 3 distance and phase 4 distance, then sum phase 3 and phase 4 distances to determine D_h.

5.6.2.3 Subparagraph (c)(2). [Not applicable.]

5.6.2.4 Amend subparagraph (c)(3): Use the following equation for PM measured as described in §1066.815(b)(5):

$$e_{\mathrm{PM-FTPcomp}} = \frac{m_{\mathrm{PM}}}{0.43(D_{\mathrm{c}}) + 0.57(D_{\mathrm{h}})}$$

Where:

m_{PM} = the combined PM mass emissions determined from the cold-start UDDS cycle and the hot-start UDDS cycle (phase 1, phase 2, phase 3, and phase 4), in grams, as calculated using Eq. 1066.605-4.

D_c = the measured driving distance from the cold-start UDDS cycle, in miles. If the cold-start UDDS cycle consists of phase 1 distance and phase 2 distance, then sum phase 1 and phase 2 distances to determine D_c.

D_h = the driving distance from the hot-start UDDS cycle, in grams. If the hot-start UDDS cycle consists of phase 3 distance and phase 4 distance, then sum phase 3 and phase 4 distances to determine D_h.

6. Highway Emission Test Provisions for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

To be conducted pursuant to 40 CFR §1066.801, except as noted.

Alternative procedures may be used if shown to yield equivalent results and if approved in advance by the Executive Officer of the Air Resources Board.

For the purpose of determining Highway All-Electric Range and Highway Equivalent All-Electric Range, the vehicle shall be range tested in default mode or in normal mode if the vehicle does not have a default mode.

For the purpose of demonstrating compliance with exhaust emission standards, a vehicle must be emission tested in the vehicle operation (i.e., either charge-sustaining or charge-increasing operation) that represents the worst case highway NMOG + NOx emissions.

Vehicles with one or more driver-selectable modes (e.g., normal mode, economy mode, performance mode, battery charging mode, or any other operating mode available to the driver) for a given charge-sustaining or charge-increasing operation (if available) must be emission tested in the one driver-selectable mode and

vehicle operation (i.e., charge-sustaining, charge-increasing) which represents the worst case highway NMOG + NOx emissions. For example, if a vehicle has two driver-selectable modes that can be tested in charge-sustaining and charge-increasing operations, the manufacturer shall determine worst case highway emissions of NMOG + NOx by comparing the following (1) mode 1 charge-sustaining emissions, (2) mode 2 charge-sustaining emissions, (3) mode 1 charge-increasing emissions, and (4) mode 2 charge-increasing emissions based on the Highway Emission Test.

In lieu of demonstrating the worst case highway NMOG + NOx emissions by certification testing in every highway charge-sustaining driver-selectable mode and every highway charge-increasing (if available) driver-selectable mode, a manufacturer may determine the worst case operating mode by using non-certification emission data and/or an engineering evaluation. The manufacturer must report the data and/or engineering evaluation used to determine the worst case operating mode. The manufacturer must demonstrate compliance with all applicable emission standards using test data for the worst case operating mode.

Confirmatory testing and/or in-use compliance testing may be performed in any driver-selectable mode charge-sustaining or charge-increasing operation (if available) to ensure compliance with emission standards.

6.1 Determination of Highway All-Electric Range, Highway Equivalent All-Electric Range, and Highway Emissions for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

6.1.1 The **Highway All-Electric Range** shall be defined as the distance that the vehicle is driven from the start of the Highway Charge-Depleting Range Test until the engine first starts. The Highway Charge-Depleting Range Test is performed with the vehicle initially at full state-of-charge and in default mode or in normal mode if the vehicle does not have a default mode.

6.1.2 **Highway Charge Depleting Range Test.**

(i) **Dynamometer run.** Starting at full state-of-charge, the vehicle shall be placed or pushed, onto a dynamometer and operated through the Continuous Highway Test Schedule until the SOC Net Energy Change Tolerances (specified in section G.10 of these test procedures) that indicate charge sustaining operation are met for one HFEDS cycle. Additional End-of-Test Criteria as provided for in the Urban Charge-Depleting Emission Test in sections G.5.4.3.1 and G.5.4.3.2 may be used for the Highway Charge-Depleting Range Test with approval from the Executive Officer. The Alternative Continuous Highway Test Schedule may be substituted for the Continuous Highway Test Schedule if the test facility is unable to perform the Continuous Highway Test Schedule. Emissions shall be measured for all test cycles when the engine is operating. For each test cycle during which emissions are not generated, emissions are not required to be sampled. However, the

manufacturer must validate that the engine did not turn on at any time during the test cycle.

(ii) **Vehicle charging after testing.** Vehicle charging shall begin within three hours after the Highway Charge Depleting Range Test and the vehicle shall be charged to the manufacturer specified full state-of-charge. During charging, all applicable requirements in section G.3 must be met, and energy consumption shall be calculated according to the requirements in section G.11.7.

6.1.3 **Equivalent All-Electric Range** shall be calculated in accordance with section G.11.

6.1.4 **Highway Emission Test.**

To be conducted pursuant to 40 CFR §1066.840 with the following revisions:

6.1.4.1 Amend subparagraph (a): Perform the Highway Emission Test immediately following any of the urban emission tests, the Highway Charge-Depleting Range Test, or a previous Highway Emission Test when this is practical. If the Highway Emission Test starts more than 3 hours after any of the urban emission tests (including evaporative emission measurements, if applicable), Highway Charge-Depleting Range Test, or a previous Highway Emission Test, operate the vehicle over one UDDS cycle in charge-sustaining operation to precondition the vehicle. If driver-selectable modes are available, do not activate the driver-selectable mode to be tested for the UDDS preconditioning drive, but set the vehicle in default mode or normal mode for the UDDS preconditioning drive with the vehicle in charge-sustaining operation. Additional preconditioning UDDS cycles may be approved in advance by Executive Officer if the need for additional preconditioning is demonstrated by the manufacturer.

6.1.4.2 Amend subparagraph (b): Operate the vehicle over the HFEDS cycle in charge-sustaining operation for preconditioning. If driver-selectable modes are available, do not activate the driver-selectable mode to be tested for the preconditioning drive, but set the vehicle in default mode or normal mode for the preconditioning drive with the vehicle in charge-sustaining operation. If, however, the vehicle is to be tested in charge-increasing operation (this does not apply to a driver-selectable charge-increasing mode), then the initial SOC shall be set at the lowest normal SOC level allowed by the vehicle when driving on the UDDS cycle. After the preconditioning drive, allow the vehicle to idle for 15 seconds (with the vehicle in gear), then start a repeat run of the HFEDS cycle and simultaneously start sampling and recording. If a driver-selectable mode is to be tested after the preconditioning drive, allow the vehicle to idle for 15 seconds (with the vehicle in gear), activate the driver-selectable mode to be tested, then start a repeat run of the HFEDS cycle and simultaneously start

sampling and recording. End-of-Test Criterion: A valid test shall satisfy the SOC Net Energy Change Tolerances in section G.10 for the HFEDS cycle with emission sampling. For PHEVs that use a battery as an energy storage device, ($Amp\text{-}hr_{initial}$) is the stored charge at the beginning of the HFEDS cycle with emission sampling, and ($Amp\text{-}hr_{final}$) is the stored battery charge at the end of the same HFEDS cycle with emission sampling. The final stored battery charge, ($Amp\text{-}hr_{final}$), shall not exceed either $(Amp\text{-}hr_{final})_{max}$ or $(Amp\text{-}hr_{final})_{min}$ for a valid test. For PHEVs that use a capacitor as an energy storage device, ($V^2_{initial}$) is the square of the capacitor voltage stored at the beginning of the HFEDS cycle with emission sampling, and (V_{final}) is the stored capacitor voltage at the end of the same HFEDS cycle with emission sampling. The final stored capacitor voltage, (V_{final}), shall not exceed either $(V_{final})_{max}$ or $(V_{final})_{min}$ for a valid test. For PHEVs that use an electro-mechanical flywheel as an energy storage device, ($rpm^2_{initial}$) is the squared flywheel rotational speed at the beginning of the HFEDS cycle with emission sampling, and (rpm_{final}) is the flywheel rotational speed at the end of the same HFEDS cycle with emission sampling. The final flywheel rotational speed, (rpm_{final}), shall not exceed either $(rpm_{final})_{max}$ or $(rpm_{final})_{min}$ for a valid test.

6.1.4.3 Amend subparagraph (c): Turn the vehicle off at the end of the final HFEDS cycle and stop all sampling and recording, including background. Stop any integrating devices and indicate the end of the test cycle in the recorded data.

6.1.5 **Additional End-of-Test Criterion.** With approval from the Executive Officer, if the SOC Net Energy Change Tolerance is not satisfied for the HFEDS cycle with emission sampling in section G.6.1.4.2, a Highway Emission Test may be considered valid if:

6.1.5.1 The alternative End-of-Test criterion of ±5% SOC Net Energy Change Tolerance in Appendix C of SAE J1711 is satisfied (Note: Appendix C of SAE J1711 may not be used to correct measured values for any emissions.); or

6.1.5.2 The SOC at the end of the HFEDS cycle with emission sampling is higher than the SOC at the beginning of the same HFEDS cycle with emission sampling.

7. SFTP Emission Test Provisions for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

To be conducted pursuant to 40 CFR §1066.801, except as noted.

Alternative procedures may be used if approved in advance by the Executive Officer of the Air Resources Board.

For the purpose of determining US06 all electric range capability as required in

section C.3.3(a)(1), a vehicle shall be range tested in default mode or in normal mode if the vehicle does not have a default mode in accordance with section G.7.3.

For the purpose of demonstrating compliance with exhaust emission standards, a vehicle must be emission tested in the vehicle operation (i.e., either charge-sustaining or charge-increasing operation) that represents the worst case SFTP NMOG + NOx emissions.

Vehicles with one or more driver-selectable modes (e.g., normal mode, economy mode, performance mode, battery charging mode, or any other operating mode available to the driver) for a given charge-sustaining or charge-increasing operation (if available) must be emission tested in the one driver-selectable mode and vehicle operation (i.e., charge-sustaining, charge-increasing) which represents the worst case SFTP NMOG + NOx emissions. For example, if a vehicle has two driver-selectable modes that can be tested in charge-sustaining and charge-increasing operations, the manufacturer shall determine worst case SFTP NMOG + NOx emissions by comparing the following (1) mode 1 charge-sustaining emissions, (2) mode 2 charge-sustaining emissions, (3) mode 1 charge-increasing emissions, and (4) mode 2 charge-increasing emissions based on the US06 Emission Test and SC03 Emission Test.

In lieu of demonstrating the worst case SFTP NMOG + NOx emissions by certification testing in every SFTP charge-sustaining driver-selectable mode and every SFTP charge-increasing (if available) driver-selectable mode, a manufacturer may determine the worst case operating mode by using non-certification emission data and/or an engineering evaluation. The manufacturer must report the data and/or engineering evaluation used to determine the worst case operating mode. The manufacturer must demonstrate compliance with all applicable emission standards using test data for the worst case operating mode.

Confirmatory testing and/or in-use compliance testing may be performed in any driver-selectable mode in charge-sustaining or charge-increasing operation to ensure compliance with emission standards.

7.1 US06 Emission Test.

To be conducted pursuant to 40 CFR §1066.831 with the following revisions:

7.1.1 Subparagraphs (a) through (b)(1). [No change.]

7.1.2 Amend subparagraph (b)(1)(i): For aggressive-driving tests that do not follow any urban emission test or the Highway Emission Test.

7.1.3 Amend subparagraph (b)(1)(ii): For a test element that starts more than 72 hours after any most recent urban emission test or the Highway Emission Test (with or without evaporative emission measurements).

7.1.4 Amend subparagraph (b)(1)(iii): For testing in which the test vehicle has not remained in an area where ambient temperatures were within the range specified for testing since any previous urban emission test or the Highway Emission Test.

7.1.5 Subparagraphs (b)(2) through (b)(3)(i). [No change.]

7.1.6 Amend subparagraph(b)(3)(ii): Operate the vehicle one time over one of the driving schedules specified in this paragraph (b)(3)(ii). A particular preconditioning driving schedule that is related to fuel effects on adaptive memory systems may be requested. The vehicle shall be in charge-sustaining operation for this preconditioning drive. If driver-selectable modes are available, do not activate the driver-selectable mode to be tested for the preconditioning drive, but set the vehicle in default mode or normal mode for the preconditioning drive with the vehicle in charge-sustaining operation. If, however, the vehicle is to be tested in charge-increasing operation (this does not apply to a driver-selectable charge-increasing mode), then the initial SOC shall be set at the lowest normal SOC level allowed by the vehicle when driving on the UDDS cycle. Sampling equipment may be exercised, but emissions may not be determined during preconditioning. Choose from the following driving schedules:

7.1.7 Subparagraphs (b)(3)(ii)(A) through (b)(3)(ii)(B). [No change.]

7.1.8 Amend subparagraph (b)(3)(ii)(C): The HFEDS cycle.

7.1.9 Subparagraphs (b)(3)(ii)(D) through (e). [No change.]

7.1.10 Amend subparagraph (e)(1): Following the preconditioning specified in paragraph (b) of this section, place the vehicle in gear and simultaneously start sampling and recording. If a driver-selectable mode is to be tested following the preconditioning, activate the driver-selectable mode, place the vehicle in gear, and simultaneously start sampling and recording. Begin the first acceleration 5 seconds after placing the vehicle in gear.

7.1.11 Subparagraphs (e)(2) through (e)(2)(iii). [No change.]

7.1.12 Amend subparagraph (e)(3): Turn the vehicle off 2 seconds after the end of the last deceleration. Five seconds after the vehicle stops running, stop all sampling and recording, including background sampling. Stop any integrating devices and indicate the end of the test cycle in the recorded data. Note that the 5 second delay is intended to account for sampling system transport. End-of-Test Criterion: A valid test shall satisfy the SOC Net Energy Change Tolerances in section G.10 for the US06 cycle with emission sampling. For PHEVs that use a battery as an energy storage device, (Amp-$hr_{initial}$) is the stored charge at the beginning of the US06 cycle with emission sampling, and (Amp-hr_{final}) is the stored

battery charge at the end of the same US06 cycle with emission sampling. The final stored battery charge, $(Amp\text{-}hr_{final})$, shall not exceed either $(Amp\text{-}hr_{final})_{max}$ or $(Amp\text{-}hr_{final})_{min}$ for a valid test. For PHEVs that use a capacitor as an energy storage device, $(V^2_{initial})$ is the square of the capacitor voltage stored at the beginning of the US06 cycle with emission sampling, and (V_{final}) is the stored capacitor voltage at the end of the same US06 cycle with emission sampling. The final stored capacitor voltage, (V_{final}), shall not exceed either $(V_{final})_{max}$ or $(V_{final})_{min}$ for a valid test. For PHEVs that use an electro-mechanical flywheel as an energy storage device, $(rpm^2_{initial})$ is the squared flywheel rotational speed at the beginning of the US06 cycle with emission sampling, and (rpm_{final}) is the flywheel rotational speed at the end of the same US06 cycle with emission sampling. The final flywheel rotational speed, (rpm_{final}), shall not exceed either $(rpm_{final})_{max}$ or $(rpm_{final})_{min}$ for a valid test.

7.1.13 Subparagraph (e)(4). [No change.]

7.1.14 **Additional End-of-Test Criterion.** With approval from the Executive Officer, if the SOC Net Energy Change Tolerance is not satisfied for the US06 cycle with emission sampling in section G.7.1.12, a US06 Emission Test may be considered valid if:

7.1.14.1 The alternative End-of-Test criterion of ±5% SOC Net Energy Change Tolerance in Appendix C of SAE J1711 is satisfied (Note: Appendix C of SAE J1711 may not be used to correct measured values for any emissions.); or

7.1.14.2 The SOC at the end of the US06 cycle with emission sampling is higher than the SOC at the beginning of the same US06 cycle with emission sampling.

7.2 SC03 Emission Test.

To be conducted pursuant to 40 CFR §1066.835 with the following revisions:

7.2.1 Subparagraphs (a) through (c)(4). [No change.]

7.2.2 Amend subparagraph (c)(5): Perform a preconditioning drive by operating the test vehicle in charge-sustaining operation over the first 505 seconds of the UDDS cycle (phase 1), the last 867 seconds of the UDDS cycle (phase 2), or the SC03 driving schedule. If driver-selectable modes are available, do not activate the driver-selectable mode to be tested for the preconditioning drive, but set the vehicle in default mode or normal mode for the preconditioning drive with the vehicle in charge-sustaining operation. If, however, the vehicle is to be tested in charge-increasing operation (this does not apply to a driver-selectable charge-increasing mode), then the initial SOC shall be set at the lowest normal SOC level allowed by the vehicle when driving on the UDDS cycle. If the air conditioning test sequence starts more than 2 hours after a different exhaust emission test, the

vehicle may be driven over one full UDDS cycle for the preconditioning drive instead of over one of the cycles listed previously in this section (c)(5).

7.2.3 Subparagraphs (c)(6) through (d). [No change.]

7.2.4 Amend subparagraph (d)(1): Place the vehicle in gear 15 seconds after starting vehicle, which is 3 seconds before the first acceleration. If a driver-selectable mode is to be tested, start the vehicle, activate the driver-selectable mode, and place the vehicle in gear 15 seconds after starting vehicle. Follow the SC03 driving schedule.

7.2.5 Amend subparagraph (d)(2): Turn the vehicle off 2 seconds after the end of the last deceleration. Five seconds after the vehicle stops running, stop all sampling and recording, including background sampling. Stop any integrating devices and indicate the end of the test cycle in the recorded data. Note that the 5 second delay is intended to account for sampling system transport. End-of-Test Criterion: A valid test shall satisfy the SOC Net Energy Change Tolerances in section G.10 for the SC03 cycle with emission sampling. For PHEVs that use a battery as an energy storage device, $(\text{Amp-hr}_{initial})$ is the stored charge at the beginning of the SC03 cycle with emission sampling, and (Amp-hr_{final}) is the stored battery charge at the end of the same SC03 cycle with emission sampling. The final stored battery charge, (Amp-hr_{final}), shall not exceed either $(\text{Amp-hr}_{final})_{max}$ or $(\text{Amp-hr}_{final})_{min}$ for a valid test. For PHEVs that use a capacitor as an energy storage device, $(V^2_{initial})$ is the square of the capacitor voltage stored at the beginning of the SC03 cycle with emission sampling, and (V_{final}) is the stored capacitor voltage at the end of the same SC03 cycle with emission sampling. The final stored capacitor voltage, (V_{final}), shall not exceed either $(V_{final})_{max}$ or $(V_{final})_{min}$ for a valid test. For PHEVs that use an electro-mechanical flywheel as an energy storage device, $(\text{rpm}^2_{initial})$ is the squared flywheel rotational speed at the beginning of the SC03 cycle with emission sampling, and (rpm_{final}) is the flywheel rotational speed at the end of the same SC03 cycle with emission sampling. The final flywheel rotational speed, (rpm_{final}), shall not exceed either $(\text{rpm}_{final})_{max}$ or $(\text{rpm}_{final})_{min}$ for a valid test.

7.2.6 Subparagraphs (d)(3) through (f)(3)(iv). [No change.]

7.2.7 **Additional End-of-Test Criterion.** With approval from the Executive Officer, if the SOC Net Energy Change Tolerance is not satisfied for the SC03 cycle with emission sampling in section G.7.2.5, an SC03 Emission Test may be considered valid if:

7.2.7.1 The alternative End-of-Test criterion of ±5% SOC Net Energy Change Tolerance in Appendix C of SAE J1711 is satisfied (Note: Appendix C of SAE J1711 may not be used to correct measured values for any emissions.); or

7.2.7.2 The SOC at the end of the SC03 cycle with emission sampling is

higher than the SOC at the beginning of the same SC03 cycle with emission sampling.

7.3 Optional Cold Start US06 All-Electric Range Test.

7.3.1 **Cold soak and vehicle charging.** The vehicle shall be stored at an ambient temperature not less than 68°F (20°C) and not more than 86°F (30°C) for 12 to 36 hours. During this time, the vehicle battery shall be charged to a full state-of-charge. The vehicle must be turned off during charging. Charge time shall not exceed soak time.

7.3.2 At the end of the cold soak period with the vehicle in default mode or in normal mode if the vehicle does not have a default mode, place or push the vehicle onto a dynamometer, and drive the vehicle on a continuous US06 test cycle until either:

(a) the auxiliary power unit starts, or

(b) the vehicle can no longer meet the speed trace limits of the US06 driving schedule as specified in CFR 86 Appendix I to within 2 mph higher than the highest point on the trace within 1 second for the upper limit or within 2 mph lower than the lowest point on the trace within 1 second for the lower limit.

When either of these conditions is met, the test shall be ended. The range for this test, in miles, shall be the distant driven from the start of the test to when condition (a) or (b) is met. Emission sampling is not required for this test.

8. 50°F and 20°F Test Provision for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

50°F testing shall be conducted pursuant to section G.5 with the modifications in Part II, Section D of the "California 2015 ~~and Subsequent~~through 2025 Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" and the additional following revisions.

20°F testing shall be conducted pursuant to section G.5 with the modifications in Part II Section B or Part II Section C, as applicable, of the "California 2015 ~~and Subsequent~~through 2025 Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" and the additional following revisions.

For 50°F and 20°F charge depleting testing, vehicle charging, prior to emissions testing, shall be performed during the soak period at 50°F and 20°F, respectively.

8.1 To satisfy test requirements for the 50°F emission test, a vehicle shall be emission tested in the vehicle operation and driver-selectable mode (if available) that represents the worst case urban NMOG + NOx emissions as determined in section G.5. To satisfy test requirements for the 20°F emission test, a vehicle shall be emission tested in the vehicle operation and driver-selectable mode (if available) that represents the worst case CO emissions of the urban charge-depleting emission test or urban charge-sustaining emission test following the procedure outlined in section G.5. For the 20°F and 50°F emission tests, a vehicle is not required to meet SOC net energy change tolerances. If a vehicle qualifies for the Urban Alternative Charge-Depleting Emission Test, the 50°F and 20°F emission test shall be performed using the Alternative Charge-Depleting Emission Test in lieu of the urban charge-depleting emission test or urban charge-sustaining emission test.

8.2 If the worst case for emissions is charge sustaining operation, the vehicle shall be preconditioned, and one of the following two emission test options must be performed.

(i) A three phase test that includes phase one as the first 505 seconds of the UDDS cycle, phase two as 506 seconds to the end of the UDDS cycle, a 10 minute key-off soak period, and phase three the first 505 seconds of the UDDS cycle. The first two phases test shall be counted as the first UDDS cycle and the second and third phases will constitute the second UDDS cycle. Emission weighting is as follows:

$$Y_{wm} = 0.43 * \left(\frac{Y_1 + Y_2}{D_1 + D_2} \right) + 0.57 * \left(\frac{Y_2 + Y_3}{D_2 + D_3} \right)$$

Where:

Y_{wm} = Weighted mass emissions of each pollutant, i.e., THC, CO, THCE, NMOG, NMHCE, CH_4, NO_x, or CO_2, in grams per vehicle mile.

Y_1 = Mass emissions as calculated from phase one of the three phase test.

Y_2 = Mass emissions as calculated from phase two of the three phase test.

Y_3 = Mass emissions as calculated from phase three of the three phase test.

D_1 = The measured driving distance from phase one of the three phase tests, in miles.

D_2 = The measured driving distance from phase two of the three phase tests, in miles.

D_3 = The measured driving distance from phase three of the three phase tests, in miles.

(ii) A two phase test that includes phase one as a UDDS cycle, a 10 minute key-off soak period, and phase two as a UDDS cycle. Emission weighting for the four phase test will follow the procedure outlined in section G.5.5.

8.3 If measurement of worst case emissions requires the urban charge depleting emission test to be performed, the vehicle shall be preconditioned and fully charged. The continuous urban test schedule shall then be performed. The UDDS cycle, in which the auxiliary power unit first starts, shall be the cold UDDS cycle. Emissions shall be sampled according to one of the options in section G.8.2. For the three phase test option, if the auxiliary power unit starts in phase two of the UDDS cycle, phase one emissions are considered zero for emission calculation purposes. Emissions are weighted according to section G.8.2.

9. Additional Provisions.

9.1 Confirmatory testing may be performed on all tests to establish if higher emissions occur at different states-of-charge in charge depleting mode. This is to ensure that cold start and other emissions standards are not exceeded at other operating SOCs.

9.2 For an example of an off-vehicle charge capable hybrid electric vehicle with all-electric range and blended operation that has charge depleting actual range and charge depleting cycle range, please see section I, Figure 1.

9.3 For an example of charge depleting to charge sustaining range with and without transitional range and end of test conditions, please see section I, Figure 2.

9.4 When determining the SOC Net Energy Change tolerance during testing, the current drive cycle may be aborted if the SOC Net Energy Change tolerance is met for previous drive cycle.

9.5 If the manufacturer determines there is insufficient fuel to run the subsequent test, the manufacturer may perform a fuel drain and fill or add fuel pursuant to the provisions of the "California Evaporative Emission Standards and Test Procedures for 2001 through 2025 Model Passenger Cars, Light-Duty trucks, Medium-Duty Vehicles, and Heavy-Duty Vehicles and 2021 and Subsequent Model ~~Motor Vehicles."~~Motorcycles"

10. State-of-Charge Net Energy Change Tolerances for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

10.1 For vehicles that use a battery as an energy storage device, the following state-of-charge net energy change tolerance shall apply:

$$(\text{Amp-hr}_{final})_{max} = (\text{Amp-hr}_{initial}) + 0.01 * \left(\frac{NHV_{fuel} * m_{fuel}}{V_{system} * K_1} \right)$$

$$(\text{Amp-hr}_{final})_{min} = (\text{Amp-hr}_{initial}) - 0.01 * \left(\frac{NHV_{fuel} * m_{fuel}}{V_{system} * K_1} \right)$$

Where:

$(\text{Amp-hr}_{final})_{max}$ = Maximum allowed Amp-hr stored in battery at the end of the test

$(\text{Amp-hr}_{final})_{min}$ = Minimum allowed Amp-hr stored in battery at the end of the test

$(\text{Amp-hr}_{initial})$ = Battery Amp-hr stored at the beginning of the test

NHV_{fuel} = Net heating value of consumable fuel, in Joules/kg

m_{fuel} = Total mass of fuel consumed during test, in kg

K_1 = Conversion factor, 3600 seconds/hour

V_{system} = Open circuit voltage (OCV) that corresponds to the SOC of the target SOC during charge sustaining operation. This value shall be submitted for testing purposes, and it shall be subject to confirmation by the Air Resources Board.

10.2 For vehicles that use a capacitor as an energy storage device, the following state-of-charge net energy change tolerance shall apply:

$$(V_{final})_{max} = \sqrt{V_{initial}^2 + 0.01 * \frac{\left(2 * NHV_{fuel} * m_{fuel}\right)}{C}}$$

$$(V_{final})_{min} = \sqrt{V_{initial}^2 - 0.01 * \frac{\left(2 * NHV_{fuel} * m_{fuel}\right)}{C}}$$

Where:

$(V_{final})_{max}$ = The maximum stored capacitor voltage allowed at the end of the test

$(V_{final})_{min}$ = The minimum stored capacitor voltage allowed at the end of the test

$V_{initial}^2$ = The square of the capacitor voltage stored at the beginning of the test

NHV_{fuel} = Net heating value of consumable fuel, in Joules/kg

m_{fuel} = Total mass of fuel consumed during test, in kg

C = Rated capacitance of the capacitor, in Farads

10.3 For vehicles that use an electro-mechanical flywheel as an energy storage device, the following state-of-charge net energy change tolerance shall apply:

$$(rpm_{final})_{max} = \sqrt{rpm_{initial}^2 + 0.01 * \frac{\left(2 * NHV_{fuel} * m_{fuel}\right)}{I * K_3}}$$

$$(rpm_{final})_{min} = \sqrt{rpm_{initial}^2 - 0.01 * \frac{\left(2 * NHV_{fuel} * m_{fuel}\right)}{I * K_3}}$$

Where:

$(rpm_{final})_{max}$ = The maximum flywheel rotational speed allowed at the end of the test

$(rpm_{final})_{min}$ = The minimum flywheel rotational speed allowed at the end of the test

$rpm_{initial}^2$ = The squared flywheel rotational speed at the beginning of the test

NHV_{fuel} = Net heating value of consumable fuel, in Joules/kg

m_{fuel} = Total mass of fuel consumed during test, in kg

K_3 = Conversion factor, $\frac{4\pi^2}{3600\,\mathrm{sec}^2 - rpm^2}$

I = Rated moment of inertia of the flywheel, in kg-m^2

11. Calculations – Equivalent All-Electric Range for Off-Vehicle Charge Capable Hybrid Electric Vehicles.

11.1 Charge Depleting CO_2 Produced means the cumulative tailpipe CO_2 emissions produced, M_{cd}, in grams per mile during the charge depleting cycle range.

$$M_{cd} = \Sigma\, Y_i$$

where:

Y_i = The sum of the CO_2 grams per mile in the charge depleting mode from each test cycle (UDDS cycles or HFEDS cycles)

i = Number (UDDS cycles or HFEDS cycles) of the test over the charge depleting cycle range, R_{cdc}

11.2 Charge Sustaining CO_2 Produced - urban means the cumulative tailpipe CO_2 emissions produced, M_{cs}, in grams per mile, during the cold start charge sustaining urban test.

$$M_{cs} = Y_c + Y_h * \left[\frac{(R_{cdcu} - D_c)}{D_c} \right]$$

where:

R_{cdcu} = Urban Charge Depleting Cycle Range, in miles

D_c = The measured driving distance from the cold start UDDS cycle, in miles

Y_c = Grams per mile CO_2 emissions as calculated from the cold start UDDS cycle

Y_h = Grams per mile CO_2 emissions as calculated from the hot start UDDS cycle

11.3 Charge Sustaining CO_2 Produced - highway means the grams per mile tailpipe CO_2 emissions produced, M_{cs}, during the cold start charge sustaining highway test.

$$M_{cs} = \left(\frac{R_{cdch}}{D_h} \right) * Y_h$$

where:

R_{cdch} = Highway Charge Depleting Cycle Range, in miles

D_h = The measured driving distance from the hot start HFEDS cycle, in miles

Y_h = Grams per mile emissions as calculated from the hot start HFEDS cycle

11.4 Urban Equivalent All-Electric Range ($EAER_u$) shall be calculated as follows:

$$EAER_u = \left(\frac{M_{cs} - M_{cd}}{M_{cs}} \right) * R_{cdcu}$$

where:

M_{cs} is as defined in G.11.2.

M_{cd} is as defined in G.11.1, using the UDDS test cycle.

11.5 Highway Equivalent All-Electric Range ($EAER_h$) shall be calculated as follows:

$$EAER_h = \left[\frac{M_{cs} - M_{cd}}{M_{cs}} \right] * R_{cdch}$$

where:

M_{cs} is as defined in G.11.3.
M_{cd} is as defined in G.11.1, using the HFEDS test cycle.
R_{cdch} is as defined in G.11.3

11.6 Electric Range Fraction (%).

The Electric Range Fraction means fraction of the total miles driven electrically (with the engine off) for blended operation hybrid electric vehicles.

The Urban Electric Range Fraction (ERF_u) is calculated as follows:

$$ERF_u\ (\%) = \left(\frac{EAER_u}{R_{cda}}\right) * 100$$

The Highway Electric Range Fraction (ERF_h) is calculated as follows:

$$ERF_h\ (\%) = \left(\frac{EAER_h}{R_{cdah}}\right) * 100$$

11.7 Equivalent All-Electric Range Energy Consumption.

The Urban Equivalent All-Electric Range Energy Consumption ($EAEREC_u$) shall be calculated as follows:

$$EAEREC_u\ (wh/mi) = \frac{E_{cd}}{EAER_u}$$

where:
E_{cd} = Total electrical energy used to fully charge the vehicle battery from an external power source after the charge depleting test has been completed. This shall be calculated for both AC and DC energy.

The Highway Equivalent All-Electric Range Energy Consumption ($EAEREC_h$) shall be calculated as follows:

$$EAEREC_h\ (wh/mi) = \frac{E_{cd}}{EAER_h}$$

where:
E_{cd} = Total electrical energy used to fully charge the vehicle battery from an external power source after the charge depleting test has been completed. This shall be calculated for both AC and DC energy.

11.8 The Urban Charge Depleting Cycle Range, R_{cdcu}, (see section H for an illustration of R_{cdcu}) shall be defined as the distance traveled on the Urban Charge

Depleting Procedure up to the UDDS cycle prior to where the state-of-charge is above the lower bound state-of-charge tolerance for one test cycle given by:

$$(\text{Amp-hr}_{final})_{min} = (\text{Amp-hr}_{initial}) - 0.01 * \left(\frac{NHV_{fuel} * m_{fuel}}{V_{system} * K_1} \right)$$

Where:

$(\text{Amp-hr}_{final})_{min}$ = Minimum allowed Amp-hr stored in battery at the end of the test

$(\text{Amp-hr}_{initial})$ = Battery Amp-hr stored at the beginning of the test

NHV_{fuel} = Net heating value of consumable fuel, in Joules/kg

m_{fuel} = Total mass of fuel consumed during test, in kg

K_1 = Conversion factor, 3600 seconds/hour

V_{system} = Open circuit voltage (OCV) that corresponds to the SOC of the target SOC during charge sustaining operation. This value shall be submitted for testing purposes, and it shall be subject to confirmation by the Air Resources Board.

11.9 The Charge Depleting Actual Range, R_{cda}, shall be defined as the range at which the state-of-charge is first equal to the average state-of-charge of the one or two UDDS cycles used to end the Urban Charge Depleting Test. This range must be reported to the nearest 0.1 miles. For an illustration of R_{cda} see section I.

11.10 The Charge Depleting to Charge Sustaining Urban Range shall be defined as the distance driven in miles from the start of the Urban Charge Depleting Test through the UDDS cycle preceding the one or two UDDS cycles used to end the Urban Charge Depleting Test.

11.11 The Highway Charge Depleting Cycle Range, R_{cdch}, shall be defined as the sum of the distance traveled on the Highway Charge Depleting Range Test up to the HFEDS cycle prior to where the state-of-charge is above the lower bound state-of-charge tolerance for one test cycle given by:

$$(\text{Amp-hr}_{final})_{min} = (\text{Amp-hr}_{initial}) - 0.01 * \left(\frac{NHV_{fuel} * m_{fuel}}{V_{system} * K_1} \right)$$

Where:

$(\text{Amp-hr}_{final})_{min}$ = Minimum allowed Amp-hr stored in battery at the end of the test

$(\text{Amp-hr}_{initial})$ = Battery Amp-hr stored at the beginning of the test

NHV_{fuel} = Net heating value of consumable fuel, in Joules/kg

m_{fuel} = Total mass of fuel consumed during test, in kg

K_1 = Conversion factor, 3600 seconds/hour

V_{system} = Open circuit voltage (OCV) that corresponds to the SOC of the target SOC during charge sustaining operation. This

value shall be submitted for testing purposes, and it shall be subject to confirmation by the Air Resources Board.

11.12 he Charge Depleting to Charge Sustaining Highway Range shall be defined as the distance driven in miles from the start of the Highway Charge Depleting Range Test through the HFEDS cycle preceding the final HFEDS cycle.

11.13 The Urban Equivalent All Electric Range for vehicles with an urban charge depleting actual range greater than 40 miles, $EAER_{u40}$, is determined through the following equation:

$$EAER_{u40}\ (\text{miles}) = \left(\frac{ERF_u \times 40\,mi}{100}\right)$$

12. The Calculations of the Combined Greenhouse Gas Regulatory Rating of Off-vehicle Charge Capable Hybrid Electric Vehicles

12.1 The combined Greenhouse Gas (GHG) emissions value is determined by the following equation.

$$GHG_{PHEV,\,combined} = 0.55 * (GHG_{urban}) + 0.45 * (GHG_{highway}) \quad \text{(Eq. 1)}$$

12.2 The urban GHG emissions value for off-vehicle charge capable hybrid electric vehicles is calculated using the following equations.

12.2.1 The urban GHG emissions value is determined by the following equation.

$$GHG_{urban} = \sum_{i=1}^{N_{urban}} (UF_i) * \left(\frac{Y_{CD.i}}{D_i} + GHG_{cd.AC.i}\right) - \sum_{i=1}^{N_{urban}} (UF_i) * G_{upstream} + \left(1 - \sum_{i=1}^{N_{urban}} (UF_i)\right) * (Y_{cs.urban})$$

(Eq. 2)

Where,

GHG_{urban} = Rated urban GHG emissions for PHEV, in gCO_2e/mile
i = Number of charge-depleting urban test cycle
N_{urban} = Total number of urban test cycles in charge depleting to charge sustaining range (R_{cdtcs})
UF_i = Utility factor for urban test cycle i
$Y_{CD.i}$ = Mass emissions of CO_2 in grams per vehicle mile, for the "i"th test in the charge depleting test
$D_{.i}$ = Distance of the "i"th urban test cycle, in miles.
$GHG_{cd.AC.i}$ = Rated GHG emissions for test cycle i, in gCO_2e/mile
$Y_{cs.urban}$ = Weighted mass emissions of CO_2 in grams/mi of the charge sustaining test.
$G_{upstream}$ = Gasoline upstream factor = $0.25 * GHG_{target}$.

12.2.2 The Charge Depleting to Charge Sustaining Range (R_{cdtcs}) is the

total number of cycles driven at least partially in charge depleting mode times the cycle distance. Cycles meets charge sustaining criterion are not included in the R_{cdtcs}. The R_{cdtcs} includes the transitional cycle, where the vehicle may have operated in both depleting and sustaining modes.

12.2.3 The utility factors for urban and highway cycles are provided in the following table.

Utility factors for each PHEV drive cycle test with charge-depletion operation

Test cycle number	Test cycle utility factor	
	Urban, UF_i	Highway, UF_j
1	0.176	0.233
2	0.141	0.172
3	0.112	0.127
4	0.091	0.095
5	0.074	0.071
6	0.059	0.054
7	0.049	0.041
8	0.039	0.032
9	0.033	0.025
10	0.027	0.020
11	0.023	0.017
12	0.019	0.013

12.2.4 This charge-depleting GHG rate from electricity use in each test cycle is defined by the following equation:

$$GHG_{cd.AC.i} = GHG_{grid} * E_{cd.AC.i} \quad \text{(Eq. 3)}$$

Where,

$GHG_{cd.AC.i}$ = Rated GHG emissions for charge-depleting PHEV, in gCO_2e/mile

$E_{cd.AC.i}$ = Urban or highway charge depleting electricity use, in kWh/mile

GHG_{grid} = Lifecycle California electricity GHG intensity, 270 gCO_2e/kWh

12.2.5 The urban or highway charge depleting electricity use is defined by the following formula:

$$E_{cd.AC.i} = \frac{E_{cd.DC.i}}{\sum_{i=1}^{N} E_{cd.DC.i}} * E_{cd.AC.total} \quad \text{(Eq. 4)}$$

Where,

N = Total number of test cycles in the charge depleting to charge sustaining range (R_{cdtcs}) of the urban or highway charge depleting range test.

$E_{cd.AC.i}$ = AC kWh consumed in the "i"th cycle of the charge depleting test.

$E_{cd.DC.i}$ = Depleted DC energy for the "i"th cycle in the charge depleting test. It is defined in section F.3.4 of these test procedures.

$E_{cd.AC.total}$ = Charge-depleting net AC energy consumption is determined according to section F.3.4 of these test procedures.

12.2.6 The $Y_{cs.urban}$, which is the weighted CO_2 mass emissions of the charge-sustaining test, is determined by the following equation, which can be found in section F.5.5 of these test procedures.

$$Y_{CS.Urban} = 0.43 * \frac{Y_C}{D_C} + 0.57 * \frac{Y_H}{D_H} \quad \text{(Eq. 5)}$$

Where,

$Y_{CS.Urban}$ = Weighted mass emissions of CO_2 in grams/mi of the charge sustaining test.

Y_C = Mass emissions as calculated from the cold start UDDS cycle, in grams per cycle.

Y_H = Mass emissions as calculated from the hot start UDDS cycle, in grams per cycle.

D_C = The measured driving distance from the cold start UDDS cycle, in miles.

D_H = The measured driving distance from the hot start UDDS cycle, in miles.

12.3 The highway GHG emissions value for off-vehicle charge capable hybrid electric vehicles is calculated using the following equation.

$$GHG_{highway} = \sum_{j=1}^{N_{highwayn}} (UF_j\} * (\frac{Y_{CD.j}}{D_j} + GHG_{cd.AC.j}) - \sum_{j=1}^{N_{highway}} (UF_i) * G_{upstream} + (1 - \sum_{j=1}^{N_{highway}} (UF_j)) * (Y_{cs.highway})$$

(Eq. 7)

Where,

$GHG_{highway}$= Rated highway GHG emissions for PHEV, in gCO_2e/mile

j = Number of charge-depleting highway test cycle

$N_{highway}$ = Total number of highway test cycles in charge depleting to charge sustaining range (R_{cdtcs})

UF_j = Utility factor for highway test cycle j (see Table 1)

$Y_{CD.j}$ = Mass emissions of CO_2 in grams per vehicle mile, for the "j"th test in the charge depleting test

D_j = Distance of the HFEDS cycle, in miles.

$GHG_{cd.AC.j}$ = Rated GHG emissions for test cycle *j*, in gCO_2e/mile (see Eq. 3)
$Y_{cs.highway}$ = Mass emissions of CO_2 in grams/mi of the highway charge sustaining emission test, which can be found in section F.6.3.3 of these test procedures.
$G_{upstream}$ = Gasoline upstream factor $0.25 * GHG_{target}$

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