Appendix I-E-1

State of California
AIR RESOURCES BOARD

PROPOSED AMENDMENTS TO THE CALIFORNIA INTERIM CERTIFICATION PROCEDURES FOR 2004 AND SUBSEQUENT MODEL HYBRID-ELECTRIC AND OTHER HYBRID VEHICLES, IN THE URBAN BUS AND HEAVY-DUTY VEHICLE CLASSES

Adopted: October 24, 2002
Amended: [INSERT DATE OF AMENDMENT]

Note: The proposed amendments to this document are shown in underline to indicate additions and ~~strikeout~~ to indicate deletions compared to the test procedures as adopted October 24, 2002.

~~Note: The entire text of this document, which is incorporated by reference in sections 156.1 and 156.8, title 13, CCR, is new language.~~

Date of Release: October 23, 2013
Date of Hearing: December 12, 2013

PROPOSED AMENDMENTS TO THE CALIFORNIA INTERIM CERTIFICATION PROCEDURES FOR 2004 AND SUBSEQUENT MODEL HYBRID-ELECTRIC AND OTHER HYBRID VEHICLES, ~~,~~ IN THE URBAN BUS AND HEAVY-DUTY VEHICLE CLASSES

A. Applicability

The certification procedures in this document are applicable to new 2004 and subsequent model year heavy-duty, greater than 14,000 lbs gross vehicle weight rating (GVWR) hybrid-electric vehicles ~~and~~ including hybrid-electric urban ~~transit~~ buses ~~(HEBs)~~ and other hybrid vehicles. Requirements specified for hybrid-electric vehicles also apply to other hybrid vehicles, as appropriate.

General procedures and requirements necessary to certify a heavy-duty engine for sale in California are set forth in "California Exhaust Emission Standards and Test Procedures for ~~1985~~ 2004 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles" (hereinafter "HDD TPs"), as incorporated in title 13, CCR, section (§)1956.8(b), and "California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Heavy-Duty Otto-Cycle Engines," (hereinafter "HDO TPs"), as incorporated in title 13, CCR, ~~section~~ §1956.8(d), for testing and compliance of heavy-duty diesel and Otto-cycle engines with exhaust emission standards.

The interim certification procedures, as amended December 12, 2013, are optional for the 2004 ~~through 2006~~ and subsequent model year~~s~~ heavy-duty hybrid-electric and other hybrid vehicles. ~~The Executive Officer shall review test results and in-use data gathered from the 2004 through 2006 model years and make recommendations to the Board in 2006 for modifying certification procedures for 2007 and subsequent model year HEBs and heavy-duty hybrid-electric vehicles.~~

B. Definitions

These certification procedures incorporate by reference the definitions and abbreviations set forth in 40 CFR §86.001-2 (October 22, 1996) and §86.004-2 (~~January 18, 2001~~ June 8, 2012), the definitions and abbreviations set forth in the HDD TPs, the definitions set forth in the HDO TPs, and the definitions set forth in title 13, CCR, ~~sections~~ §1956.1 through 1956.8, title 13, CCR, §2023 (Jan. 31, 2006), 40 CFR, §86.1803-01 (October 15, 2012), and Society of Automotive Engineers (SAE) J2711, "Recommended Practice for Measuring Energy Consumption of Conventional and Hybrid Heavy-Duty Vehicles Using a Chassis Dynamometer" (Proposed Draft May 2012), unless otherwise amended below.

1. **“Auxiliary ~~p~~Power ~~u~~Unit (~~APU)~~”** means a device that converts consumable fuel energy into mechanical or electrical energy. Examples of auxiliary power units are internal combustion engines, turbines, flywheels, and fuel cells.

2. **“Average Loaded Vehicle Weight”** means the average between a vehicle’s curb and GVWR.

3. **“Baseline Conventional Engine”** means the heavy-duty engine in a specific heavy-duty engine family certified by the Executive Officer that will be used in a conventional vehicle. Certified engine emissions from the selected engine will be used in calculating a baseline emission factor for a conventional vehicle.

~~2~~4. **“Baseline ~~HEB~~ Hybrid-Electric Drive System ~~e~~ Engine”** means the ~~most representative~~ heavy-duty engine in a specific heavy-duty engine family certified by the Executive Officer that will be used in a hybrid-electric drive system for a specific ~~HEB~~ engine family. Certified emissions from the selected engine will be used in calculating an emission factor to determine the appropriate emission reduction for a particular hybrid-electric drive system.

~~3~~5. **“Baseline ~~urban transit bus~~ Vehicle”** means a representative, ~~non-hybrid-electric urban transit bus~~ conventional vehicle selected by the Executive Officer for chassis dynamometer testing. The Executive Officer will have the final discretion in determining a representative baseline vehicle for any specific hybrid-electric vehicle and/or for any groups of vehicles or vocations. Exhaust emissions from the selected ~~urban transit bus~~ baseline vehicle, as determined by the chassis dynamometer test procedure, will be used in conjunction with the certified emissions from the engine incorporated into the baseline ~~urban transit bus~~ vehicle to calculate a baseline emission factor.

~~4~~6. **“Battery”** means a device that stores chemical energy and releases electrical energy.

7. **“Battery Current Throughput ”** means the net change in integrated current of a battery at any given point in time relative to another point in time, expressed in Ampere-hours. The current throughput of the battery in a fully charged state (i.e., vehicle off charge and beginning the first cycle of a full charge test) may be defined as zero, or a value representing the measured current into the battery during recharge (where zero battery current throughput is the nominal level during charge-sustaining operation).

~~5~~8. **“Battery ~~r~~Rated Ampere-hour ~~c~~Capacity”** means the manufacturer-rated capacity of a battery in Ampere-hours obtained from a battery discharged at the manufacturer’s recommended discharge rate (C/1 – C/6) such that a specified minimum cut-off terminal voltage is reached.

~~6~~9. "Battery State of Charge ~~(SOC)~~" means the quantity of electric energy remaining in the battery relative to the maximum rated Ampere-hour ~~(Ah)~~ capacity of the battery expressed in percent.

~~7~~10. "Capacitor" means a device that stores energy electrostatically and releases electrical energy.

~~8~~11. "Capacitor ~~SOC~~ State of Charge" means the actual measured energy content of a capacitor and expressed as a percentage of the capacitor's maximum rated voltage squared (V^2).

~~9~~12. "CCR" means California Code of Regulations.

~~10~~13. "CFR" means Code of Federal Regulations.

14. "Charge-Depleting Actual Range (Rcda)" means the distance traveled at which the off-board electrical energy was exhausted and charge-sustaining operation began. The total distance, measured from the start of the full charge test, through any subsequent charge-depleting test cycles, and ending at a point in the Transitional Cycle proportional to the change in state of charge of the Transitional Cycle compared to the cycle previous to the Transitional Cycle. This range shall be reported to the nearest 0.1 miles.

15. "Charge-Depleting Cycle Range (Rcdc)" for a given test full charge test, the total distance traveled in the full charge test until the end of the last cycle before the net off-board electrical energy has been exhausted. Typically, all subsequent cycles are charge-sustaining. Rcdc range includes the Transitional Cycle where vehicle may have operated in both depleting and sustaining modes. If the full charge test possesses a Transitional Range, then the Rcdc is the total distance traveled until the end of the last cycle that does not satisfy the Net Energy Change tolerance. This range shall be reported to the nearest 0.1 miles.

1~~1~~6. "Charge-~~d~~Depleting ~~HEB~~ Hybrid-Electric Vehicle" means a~~n~~ ~~HEB~~ hybrid-electric vehicle that is designed to be recharged off-board under normal conditions. Under conditions of continuous operation, the rechargeable energy storage system ~~(RESS)~~ of a charge-depleting ~~HEB~~ hybrid-electric vehicle ultimately fully discharges and impairs vehicle operation when no off-board charging is performed and the consumable fuel is regularly replenished.

17. "Charge-Depleting Mode" means an operating mode of a hybrid-electric vehicle in which the vehicle runs by consuming only the electric energy from the main batteries or along with the fuel energy simultaneously or sequentially until the Charge-Sustaining Mode starts.

1~~2~~8. "Charge-~~s~~Sustaining ~~HEB~~ Hybrid-Electric Vehicle" means a~~n~~ ~~HEB~~ hybrid-electric vehicle that derives all of its energy from on-board consumable fuel under normal usage. Under conditions of continuous operation, the ~~RESS~~ rechargeable energy storage system of a charge-sustaining ~~HEB~~ hybrid-electric vehicle does not fully discharge and impair vehicle operation when no off-board charging is performed and the consumable fuel is regularly replenished.

19. "**Charge-Sustaining Mode"** means an operating mode where the hybrid-electric vehicle runs by consuming the fuel energy while sustaining the electric energy of the rechargeable energy storage system at a certain level while the vehicle is driven.

20. "Consumable Fuel" means any solid, liquid, or gaseous matter that releases energy when consumed by an auxiliary power unit.

21. "Curb Weight" means the total weight of the vehicle with all standard equipment, including batteries/capacitors, lubricants at nominal capacity, and the weight of optional equipment. Incomplete trucks shall have the curb weight specified by the manufacturer.

~~13~~22. "Electric ~~d~~Drive ~~c~~Components" means the electric motor, system controller, generator, on board charge, and energy storage system (batteries, capacitors, and flywheels).

~~14~~23. "Electromechanical ~~f~~Flywheel" means a device that stores rotational kinetic energy and releases that kinetic energy to an electric motor-generator system, thereby producing electrical energy.

~~15~~24. "Electromechanical ~~f~~Flywheel ~~SOC~~State of Charge" means a percentage of the flywheel's maximum-rated revolutions per minute squared (rpm^2), which is based on the actual measured energy content of an electromechanical flywheel.

~~16~~25. "Emission ~~f~~Factor" means the number calculated from exhaust emissions chassis dynamometer test results and engine dynamometer test results for a ~~HEB~~ hybrid-electric vehicle or conventional ~~urban transit bus~~ vehicle. The number, expressed in units of bhp-hr/mi, is used to calculate an emission factor ratio.

~~17~~26. "Emission Factor Ratio" means the number resulting from dividing the emission factor for a ~~HEB~~ hybrid-electric vehicle by the emission factor for a baseline ~~urban transit bus~~ vehicle, and reflects the emission reduction capability of a hybrid-electric drive system.

27. "End of Test " means the portion of the full charge test where charge-sustaining behavior is observed. Charge-sustaining operation is validated if the difference in state of charge of the last cycle or last series of cycles is less than 2% of the total depleted capacity or the net energy change tolerance, whichever is larger.

28. "Flywheel" See "Electromechanical Flywheel"

29. "Full Charge Test" means test cycles are repeated until the vehicle has exhausted the energy designed to be consumed during charge-depleting mode.

30. "Gross Vehicle Weight Rating (GVWR)" means the value specified by the manufacturer as the maximum design loaded weight of a single vehicle.

~~18~~31. "Hybrid-~~e~~Electric ~~d~~Drive ~~s~~System" means the propulsion system comprised of the ~~APU~~ auxiliary power unit and the corresponding electric drive components connected with that ~~APU~~ auxiliary power unit.

~~19~~32. "Hybrid-~~e~~Electric ~~u~~Urban ~~t~~Transit ~~b~~Bus (HEB)" ~~means an urban bus equipped with at least two sources of energy stored on board; this energy is converted to motive power using an electric drive motor and an APU. The electric drive motor must be used partially or fully to drive the vehicle's wheels.~~ See "Hybrid-Electric Vehicle".

~~20~~33. "HEB Family" means the basic classification unit of a manufacturer's product line used for the purpose of test fleet selection, based on gross vehicle weight (either 24,000 lbs to 44,000 lbs, or greater than 44,000 lbs). A family may include any engine that certifies to the same standard as the HEB test vehicle.

34. "Hybrid-Electric Vehicle" means a heavy-duty vehicle, including urban bus that can draw propulsion energy from both of the following sources of stored energy: 1) a consumable fuel and 2) a rechargeable energy storage system that is recharged by an electric motor-generator system, an external electric energy source, or both.

35. "Hybrid Engine Family" means the grouping of engines and hybrid drive system, based on similar emission characteristics that are used in hybrid vehicles with gross vehicle weight greater than 14,000 lbs.

~~21~~36. "Net Energy Change ~~(NEC)~~" means the net change in energy level of a ~~RESS~~ rechargeable energy storage system expressed in Joules (watt-seconds).

37. "Plug-In Hybrid-Electric Vehicle" means a hybrid-electric vehicle that has the capability to charge the battery from an off-vehicle electric source, such that the off-vehicle source cannot be connected to the vehicle while the vehicle is in motion.

~~22~~38. "Propulsion ~~e~~Energy" means energy that is derived from the vehicle's consumable fuel and/or ~~RESS~~ rechargeable energy storage system to drive the wheels. If an energy source is supplying energy only to vehicle accessories (e.g., a 12-volt battery on a conventional vehicle), it is not acting as a source of propulsion energy.

~~23~~39. "Propulsion ~~s~~System" means a system that, when started, provides propulsion for the vehicle in an amount proportional to what the driver commands.

~~25~~40. “Rechargeable Energy Storage System ~~(RESS)~~” means a component, or system of components, that stores energy and for which the supply of energy is rechargeable by an electric motor-generator system, an off-vehicle electric energy source, or both. Examples of ~~RESS~~ rechargeable energy storage system for ~~HEBs~~ hybrid-electric vehicles include batteries, capacitors, and electromechanical flywheels.

~~24~~41. “Regenerative ~~b~~Braking” means ~~deceleration of the bus caused by operating an electric motor-generator system. This act returns energy to the vehicle propulsion system and provides charge to the RESS or to operate on-board accessories.~~ the partial recovery of the energy normally dissipated into friction braking that is returned as electrical current to an energy storage device.

~~26~~42. “~~SOC~~ State of Charge” See “Battery ~~SOC~~ State of Charge”, “Capacitor State of Charge”, and “Electromechanical Flywheel State of Charge”.

~~27~~43. “~~SOC~~ State of Charge $_{\mathrm{delta}}$” means ~~delta~~ the change in ~~a~~Ampere-hours, V^2, or rpm^2 measured during a test.

~~28~~44. “~~SOC~~ State of Charge $_{\mathrm{final}}$” means state of charge at the end of a test run (Ampere-hours ~~Ah~~, V^2, or rpm^2).

~~29~~45. “~~SOC~~ State of Charge $_{\mathrm{initial}}$” means state of charge at the beginning of a test run (Ampere-hours ~~Ah~~, V^2, or rpm^2).

46. “Urban Bus” means a passenger-carrying vehicle powered by a heavy heavy-duty diesel engine, or of a type normally powered by a heavy heavy-duty diesel engine, with a load capacity of fifteen or more passengers and intended primarily for intra-city operation, i.e., within the confines of a city or greater metropolitan area. Urban bus operation is characterized by short rides and frequent stops. To facilitate this type of operation, more than one set of quick-operating entrance and exit doors would normally be installed. Since fares are usually paid in cash or token, rather than purchased in advance in the form of tickets, urban buses would normally have equipment installed for the collection of fares. Urban buses are also typically characterized by the absence of equipment and facilities for long distance travel, e.g., restrooms, large luggage compartments, and facilities for stowing carry-on luggage.

~~30~~47. “Total Fuel Energy” means the total energy content of the fuel, in British Thermal Units (Btu) or Kilowatt-Hour (kWh), consumed during a test as determined by carbon balance or other standard method and calculated based on the lower heating value of the fuel.

C. Heavy-Duty Hybrid-Electric ~~Drive System~~ Vehicle Certification Requirements

Compliance with the heavy-duty hybrid-electric vehicle criteria pollutant standards requires the development of an emission factor ratio for a heavy-duty hybrid-electric drive system with a certified baseline engine and comparison of the corresponding emissions with the applicable (e.g., urban bus or heavy-duty diesel or Otto-cycle engine) exhaust emission standards for a given engine by model year.

For model years 2004 through 2006, no more than two parties (i.e. the engine/turbine/fuel cell manufacturer and the hybrid-electric drive system manufacturer) shall be granted an individual Executive Order identifying the emission standard achieved by the engine/turbine/fuel cell and the hybrid-electric drive system. For 2007 and subsequent model years, only one Executive Order shall be granted identifying the emission standard achieved by the hybrid-electric drive system or vehicle.

1. One Party Responsibility. Where one party is responsible for emissions, an Executive Order shall be granted identifying the emission standard achieved by the ~~HEB~~ hybrid-electric vehicle.

1.1 Certification Standards. All 2004 and subsequent model year HEBs shall, by model year, meet the exhaust emission standards or optional emission standards set forth in title 13, CCR, ~~section~~ §1956.1. All 2007 and subsequent model year hybrid-electric vehicles shall, by model year, meet the exhaust emission standards set forth in title 13, CCR, §1956.8. The criteria pollutant exhaust emissions for the hybrid-electric drive system of the ~~HEB~~ hybrid-electric vehicle shall be determined in accordance with section D of this document. The criteria pollutant certification standard for the hybrid-electric drive system shall be determined in accordance with section E of this document.

2. Two Party Responsibility. For model years 2004 through 2006, ~~W~~where two parties are responsible for emissions, two Executive Orders shall be granted. One Executive Order shall be granted to the engine/turbine/fuel cell manufacturer identifying the emission standard achieved and one Executive Order shall be granted to a second party identifying the emission standard of the hybrid-electric drive system.

2.1 Certification Standards. For model years 2004 through 2006, the heavy-duty engine, turbine, or fuel cell used as a motive source in an HEB shall, by model year and size, meet the exhaust emission standards or optional emission standards set forth in title 13, CCR, ~~section~~ §1956, 1956.1, 1956.7, or 1956.8. ~~All 2004 and subsequent model year hybrid-electric drive systems shall, by model year, meet the exhaust emission standards or optional emission standards set forth in title 13, CCR, section 1956.1~~. The exhaust emissions for a hybrid-electric drive system shall be determined in accordance with section D of this document. The certification standard for the hybrid-electric drive system shall be determined in accordance with section E of this document.

3. 25 Percent Reduction Claim. For the 2004 through 2006 model years, hybrid-electric drive system manufacturers may claim a 25 percent reduction from the NOx certification standard of the engine or turbine incorporated as part of the hybrid-electric drive system in lieu of following the test procedures set forth in sections ~~E~~D and ~~F~~E. During that period, the Executive Officer may request the manufacturer to perform chassis testing of an HEB selecting this option in accordance with the test procedures in sections D and E. If testing data indicate a reduction of exhaust emissions of less than 25 percent, the HEB family shall receive that smaller reduction.

4. Useful Life. For the 2004 through 2006 model years, the useful life of the hybrid-electric drive system shall be 5 years or 150,000 miles, whichever comes first. ~~After that time~~ For the 2007 and subsequent model years, the useful life of the engine and hybrid~~-electric~~ drive system in a hybrid engine family shall meet the useful life requirements as required for a conventional engine certified for use in the same vehicle service class as the hybrid engine family ~~for urban transit buses as~~ set forth in title 13, CCR, ~~section~~ §2112(l)(19),(20),(21), or (22) as last amended ~~October 24, 2002~~ August 7, 2012.

5. Emissions Warranty. For the 2004 and subsequent model years, the hybrid-electric drive system shall, by model year, meet the warranty requirements listed in title 13, CCR, ~~section~~ §2035 and 2036, as last amended ~~December 26, 1990~~ November 9, 2007 and ~~May~~ April 15, 1999, respectively.

6. Durability and Emission Testing. An HEB family with less than 50 HEBs sold for the 2004 through 2006 model years shall be exempt from durability-data vehicle and emission-data vehicle testing. An HEB family in California with 50 or more HEBs sold, and any 2007 and subsequent model year ~~HEB~~ hybrid engine families shall meet the durability-data vehicle and emission-data vehicle testing as required in title 13, CCR, ~~section~~ §2111 et seq., as last amended ~~December~~ November ~~2~~8, 2010~~0~~.

7. Labeling Requirements. The hybrid-electric drive system shall meet labeling requirements as set forth in title 13, CCR, ~~section~~ §1965, as amended by the HDD TPs and the HDO TPs. In addition to the information required by those labeling requirements, the hybrid-electric drive system manufacturer shall also include the following information on the hybrid-electric drive system label:

7.1 An unconditional statement of compliance with the appropriate model year California regulations; for example:

"This vehicle (engine or hybrid-electric drive system, as applicable) conforms to California regulations applicable to [insert MY date] model year new, ___(for 2004 and subsequent model years, specify heavy-duty Otto-cycle engines, heavy-duty diesel engines, or urban ~~transit~~ bus engine, as applicable)."

For federally certified vehicles certified for sale in California, the statement must include the phrase "conforms to U.S. EPA regulations and is certified for sale in California."

For 2004-2006 ~~and later~~ model years hybrid-electric drive systems to be used in urban buses that incorporate an on-road heavy-duty diesel engine and are certified to the optional reduced-emission standards, the label shall contain the following statement in lieu of the above:

"This hybrid-electric drive system conforms to California regulations applicable to [insert MY date] model year new urban bus engines and is certified to a NOx plus NMHC optional reduced-emission standard of [insert appropriate number] g/bhp-hr (for optional reduced-emission standards specify between 0.3 and 1.8, inclusive, at 0.3 g/bhp-hr increments), and a particulate matter standard of [insert appropriate number] g/bhp-hr (specify 0.03 g/bhp-hr, 0.02 g/bhp-hr, or 0.01 g/bhp-hr)."

7.2 For 2004 and subsequent model year hybrid-electric drive systems used in urban ~~transit~~ buses, if the manufacturer is assigned an alternative useful life period by the Executive Officer, the label shall contain the statement:

"This hybrid-electric drive system has been certified to meet California standards for a useful life period of [specify] years or [specify] miles of operation, whichever occurs first. This hybrid-electric drive system's actual life may vary depending on its service application."

The manufacturer may alter this statement only to express the assigned alternate useful life in terms other than years or miles (e.g., hours or miles only).

7.3 For 2004 and subsequent model year hybrid-electric drive systems used in urban ~~transit~~ buses, the label shall contain the statement:

"This hybrid-electric drive system has a primary intended service application as an urban ~~transit~~ bus engine. It is certified to the emission standards applicable to an urban ~~transit~~ bus."

7.4 For 2015 and subsequent model year hybrid-electric drive systems used in heavy-duty vehicles, the label shall contain the statement:

"This hybrid-electric drive system has a primary intended service application as [specify application] engine. It is certified to the emission standards applicable to [specify an urban bus or a heavy-duty vehicle weight category]"

8. Engine Service Manuals and Equipment Maintenance Signals. The hybrid-electric drive system manufacturer shall meet service manual and maintenance signal requirements as set forth in 40 CFR, §86.004-38 (~~October 21, 1997~~June 27, 2003) and §86.007-38 (~~January 18, 2001~~ June 29, 2004) as amended by the HDD TPs and the HDO TPs.

9. Rebuild Provisions and Recordkeeping Requirement. The heavy-duty engine rebuilding practices set forth in 40 CFR, §86.004-40 (~~October 21, 1997~~ January 18, 2001) as amended in the HDD TPs and HDO TPs shall also apply to the hybrid-electric drive system.

10. Information Requirements. In addition to the requirements set forth in 40 CFR, §86.1843-01(c), the HDD TPs and the HDO TPs, the certification application shall include the following:

10.1 Identification of California certified engine, engine family name, and model code.

10.~~1~~2 Identification and description of the hybrid-electric drive system covered by the application.

10.3 Description of any modification of hardware and/or software to accommodate the hybrid-electric drive system.

10.~~2~~4 Identification of the heavy-duty vehicle weight category to which the vehicle is certifying: light heavy-duty, medium heavy-duty, heavy heavy-duty, heavy-duty Otto, or urban ~~transit~~ bus; and the curb weight and ~~gross vehicle weight rating~~ GVWR of the vehicle.

10.~~3~~5 Identification and description of the propulsion system for the vehicle.

10.~~4~~6 Identification and description of the climate control system used on the vehicle.

10.~~5~~7 Projected number of heavy-duty hybrid-electric vehicles produced and delivered for sale in California.

10.~~6~~8 All information necessary for the proper and safe operation of the vehicle, including information on the safe handling of the battery system, emergency procedures to follow in the event of battery leakage, or other malfunctions that may affect the safety of the vehicle operator or laboratory personnel.

10.~~7~~9 Method for determining battery state-of-charge ~~and any other relevant information as determined by the Executive Officer~~.

10.10 Any other relevant information as determined by the Executive Officer.

11. Safety Procedures. For 2004 and subsequent model years, a manufacturer shall conform to the requirements specified in title 13, CCR, division 2, chapter 6.5, articles 1, 3, and 8, inclusive.

12. Hydraulic, Turbine, Flywheel, or Fuel Cell Hybrid Vehicles. The certification application will be considered by the Executive Officer on a case-by-case basis. Upon approval of the Executive Officer, the stated certification requirements on section C shall be followed for these hybrid vehicles, as applicable.

D. Heavy-Duty Hybrid-Electric ~~Drive System~~ Vehicle Test Procedures

These test procedures incorporate by reference SAE J2711, "~~Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy-Duty Vehicles~~" "Recommended Practice for Measuring Energy Consumption of Conventional and Hybrid Heavy-Duty Vehicles Using a Chassis Dynamometer" (~~April 2002)~~ (Proposed Draft May 2012), as modified in these test procedures to apply to HEBs and hybrid-electric vehicles sold in California. For ~~2004 through 2006~~ 2015 and subsequent model years, heavy-duty hybrid-electric vehicles may follow these or equivalent procedures provided the manufacturer obtains prior written approval from the Executive Officer ~~(EO)~~.

The test procedure for determining compliance with standards applicable to the hydraulic, turbine, flywheel, or fuel cell used as the motive power in a hybrid-electric ~~bus~~ vehicle shall be determined by the Executive Officer on a case-by-case basis.

1. Chassis Dynamometer Test Preparations

1.1 Test Site. The ambient temperature levels encountered by the test vehicle shall be no less than 20 ºC (68 ºF) and no greater than 30 ºC (86 ºF). Ambient temperatures shall be recorded at the beginning and end of the test period. Adequate test site capabilities for safe venting and cooling of batteries representative of in-use operation, protection from exposure to high voltage, and any other necessary precaution shall be provided during testing. Test conditions specified in 40 CFR, Part 86 and Part 1065 shall apply, as appropriate. A fixed-speed fan shall direct cooling air to the vehicle to maintain the engine operating temperature as specified by the manufacturer during testing, and shall be operated only when the vehicle is in operation and shall be switched off for all key off dwell periods. Fans for brake cooling may be utilized during testing.

1.2 Pre-Test Data Collection. Vehicle demographics shall be recorded prior to testing including the vehicle identification number, gross vehicle weight (from vehicle data plate), curb weight (from vehicle data plate or by weighing), engine manufacturer, model year and type, certified engine family, engine serial number, engine displacement and number of cylinders, engine rated power/torque and speed, tire size, transmission type, manufacturer, model, number of speeds, presence or absence of retarder, lock up torque converter, exhaust gas aftertreatment type, and rear axle ratio. Pre-test data shall also include details of the type, power, and speed of the electric motor(s); and type and capacity of the ~~RESS~~ rechargeable energy storage system. The chassis test laboratory shall be used to measure actual cycle distance during a test.

1.3 Fuel Specifications. The test fuel shall meet the certification specifications set forth in the HDD TPs and HDO TPs.

1.4 Vehicle Preparation. Vehicle preparation and preconditioning shall be conducted in accordance with 40 CFR, §86.1231-90 (April 11, 1989) and 40 CFR, §86.1232-96~~0~~ (~~April 11, 1989~~December 8, 2005), respectively.

1.4.1 Prior to testing, the vehicle shall be stabilized to a manufacturer-determined distance or to 4,000 miles. Charge-depleting vehicles, for which regular, off-vehicle charging is recommended, shall have their rechargeable energy storage system fully recharged prior to testing. This recharge should occur at least once between each refilling of consumable fuel; however, charging frequency for the rechargeable energy storage system shall not be greater than is anticipated during normal vehicle use.

1.4.2 Vehicles shall be tested at ~~curb weight plus driver weight and one half seated passenger load using a weight of 150 lbs per passenger~~ the prescribed test weight presented in Table 1.

Table 1

Vehicle Class	**Prescribed Test Weight**
Light Heavy-Duty (14,001 to 19,500 lbs)	Average Loaded Vehicle Weight
Medium Heavy-Duty (19,501 to 33,000 lbs)	Average Loaded Vehicle Weight
Heavy Heavy-Duty (Greater than 33,000 lbs)	Average Loaded Vehicle Weight
Buses	Driver + ½ seated passenger capacity @ 150 lbs/person

1.4.3 Manufacturer's recommended tires and pressures shall be used. For dynamometer testing, t~~T~~ire pressures shall be set at the beginning of the test at the pressure used to establish the dynamometer road-load coefficients and shall not exceed levels necessary for safe operation. Tires shall be conditioned as recommended by the vehicle manufacturer and shall be the same size as would be used in service.

1.4.4 The vehicle lubricants normally specified by the manufacturer shall be used.

1.4.5 Vehicles shall be tested with normal appendages (mirrors, bumpers, etc.). Certain items (e.g., hub caps) may be removed where necessary for safety on the dynamometer.

1.4.~~5~~6 The vehicle shall be driven with appropriate accelerator pedal movement to achieve the time-versus-speed relationship prescribed by the driving cycle. If test vehicles are equipped with manual transmission, the transmission shall be shifted in accordance with procedures that are representative of shift patterns that may reasonably be expected to be followed by vehicles in use.

1.4.~~6~~7 If the vehicle has a regenerative braking system, the vehicle shall be tested on the dynamometer with the identical control strategy as used in service. Vehicles equipped with an antilock braking system or traction control system may require modifications (i.e. defeat) to those systems during dynamometer testing to achieve normal operation of the regenerative braking system.

1.4.~~7~~8 ~~If necessary,~~ ~~v~~Vehicles with air suspension ~~may~~ shall be aired up from an external source prior to testing. After the vehicle has reached sufficient air pressure to achieve proper suspension leveling and service brake operation, external air shall be disconnected from the vehicle and shall not be reconnected during emissions testing or between testing events during the key-off period.

1.4.~~8~~9 Off-vehicle charging shall be allowed only for the battery conditioning of charge-sustaining hybrid-electric vehicles ~~HEVs~~.

1.4.10 In the event that the rechargeable energy storage system is damaged or has an energy storage capability below the manufacturer's specified rating, the rechargeable energy storage system shall be repaired or replaced and stabilized, and then the test procedure should be repeated. Data from tests with a faulty rechargeable energy storage system shall be considered invalid.

1.5 Chassis Dynamometer Specifications. The chassis dynamometer shall be capable of mimicking the transient inertial load, aerodynamic drag and rolling resistance associated with normal operations of heavy-duty vehicles. The transient inertial load shall be simulated using appropriately sized flywheels or electronically controlled power absorbers. It is recommended to use a 40 CFR, §1066 compliant chassis dynamometer, if available. The driver shall be provided a visual display of the desired and actual vehicle speed to allow the driver to operate the vehicle on the prescribed cycle.

1.5.1. Coastdown analysis. The drag and rolling resistance shall be established as a function of vehicle speed as referenced in 40 CFR, §86.1229-85 (October 6, 2000) or another appropriate method approved by the Executive Officer. The vehicle weight for the on-road coastdown shall be the same as the anticipated vehicle testing weight as simulated on the dynamometer. Vehicles equipped with regenerative braking systems that are activated at least in part when the brake pedal is not depressed shall have their regenerative braking systems disabled during the deceleration portion of coastdown testing, preferably through temporary software changes in the vehicle's control system.

1.6 Test Instrumentation. Equipment referenced in 40 CFR, §86.130~~1~~5-90 (April 11, 1989) to 40 CFR, §86.1326-90 (April 11, 1989) (including exhaust emissions sampling and analytical systems) shall be required for emissions measurements. All instrumentation shall be NIST-traceable (National Institute of Standards and Technology). The following instruments shall be required for as-needed usage:

a) A DC wideband voltage, Ampere, and Watt-hour meter (power analyzer): This is the preferred electrical measurement system when possible since voltage and current of the rechargeable energy storage system are measured directly with this meter. It shall be installed in such a way as to measure all current leaving and entering the rechargeable energy storage system (no other connections upstream of the measurement point). Ampere-hour meters using an integration technique shall have an integration period of less than 0.05 seconds if an integration technique is used, so that abrupt changes of current can be accommodated without introducing significant integration errors. Total accuracy of current measurements shall be 1% of the reading or 1% of full scale, whichever is larger. Instruments shall not be susceptible to offset errors measuring current, because very small current offsets can be integrated throughout the cycle and provide erroneous net energy change results.

b) A DC wideband Ampere-hour meter: If voltage sensing is not available, then one should optionally measure ampere-hours without directly sensing voltage. In this case, the voltage shall be monitored (logged) from vehicle network data or some other means. Good engineering judgment should be used in order to ensure the voltage signal used is representative of the actual battery terminal voltage.

c) An instrument to measure a capacitor's voltage (if applicable).

d) An instrument to measure an electromechanical flywheel's rotational speed (if applicable).

e) An AC Watt-hour meter to measure AC recharge energy (if applicable): It shall be installed in such a way as to measure all AC electrical energy entering the charger. The AC Watt-hour meter shall have a total accuracy of 1% or better. In the event that the AC energy side of a particular charging setup is difficult or impossible to obtain, engineering judgment may be used to provide an estimated correction factor given the measured DC energy into the battery.

f) A voltmeter and ammeter for as-needed usage.

g) A means to verify and record engine operation for the purpose of determining the dynamometer distance traveled before initial engine startup.

h) An instrument to measure throttle or pedal position (or an equivalent indicator of the driver's acceleration demands).

The accuracy of each instrument shall be as specified in 40 CFR, §86.1309-90 and SAE J1634, as applicable. Instrument accuracy for coastdown measurements shall be as specified in SAE J2263 and SAE J2265, as applicable. ~~a DC wideband Ampere-hour meter with an integration period of less than 0.05 seconds if an integration technique is used; an instrument to measure a capacitor's voltage; an instrument to measure an electromechanical flywheel's rotational speed; an AC Watt-hour meter to measure AC Recharge Energy; and a voltmeter and ammeter.~~ As specified in 40 CFR, Part 1065, where applicable, dilution ~~T~~tunnel flow volume shall be set at the minimum level possible for vehicles such that a carbon balance for fuel efficiency and a hydrocarbon balance for tunnel integrity can be performed accurately and the lowest possible detection limits can be determined. Where possible, laboratories shall determine and submit estimated lower detection limits with all test data. The detection limits shall be expressed in the same units as the data (e.g., grams per mile for emission data). The detection limit for a laboratory, based on good engineering judgment, shall be determined by one of two methods. For laboratories with a large base of repeat run data, the measurement error may be determined statistically from run-to-run variations, and the detection limit may be equated to the measurement error. In other cases, the measurement error must be determined by considering the stated accuracy of the analyzers, calibration gases, balance (for PM) and assigning these potential errors as a root-mean-square error to detection limit. These errors must be considered twice, since they are also applied to the background measurement, and introduce error into the background correction. Emission levels that are determined to be below detection limit shall be cited as less than the detection limit value.

2. Chassis Dynamometer Test Procedure

2.1 Vehicle Propulsion System Starting and Restarting. The vehicle's propulsion system shall be started according to the manufacturer's recommended starting procedures in the owner's manual. Only equipment necessary to the primary propulsion of the vehicle during normal service shall be operated.

2.2 Driving cycles. Chassis testing shall include two separate test cycles as follows: one cold start and three hot start tests using the Orange County bus cycle; and one cold start and three hot start tests using the heavy-duty Urban Dynamometer Driving Schedule (UDDS) (40 CFR, §86 Appendix I(d)) (~~April 29, 1998~~July 13, 2005).

~~**2.2.1** During the interim certification period, the Executive Officer may request data from one cold start and three hot starts using the Central Business District (CBD) cycle which will not be used for certification~~.

2.2.~~2~~1 The applicant may request a substitution of one test cycle with one representative of specific ~~transit fleet~~ vocational operation for approval ~~of~~ by the Executive Officer.

2.2.~~3~~2 The test vehicle shall be operated through at least one preliminary run of the desired test cycles to familiarize the driver with vehicle operation and verify function of laboratory instrumentation.

2.2.~~4~~3 A cycle length of approximately 30 minutes shall be used for all chassis tests. For driving cycles less than 30 minutes in duration, repetitions of the cycle shall be run back-to-back for a total cycle length of approximately 30 minutes. Chassis tests shall also consist of a normalized condition prior to the test, including either a 12-hour cold soak or a warm-up followed by a 20- to 30-minute key-off period.

~~**2.2.5** If at any point during the test vehicle propulsion is not possible or the driver is warned by the vehicle to discontinue driving because the RESS energy supply is too low, the test shall be considered invalid.~~

2.3 Charge-Sustaining Vehicle Evaluation Procedure. Reference: SAE J2711, "Recommended Practice for Measuring Energy Consumption of Conventional and Hybrid Heavy-Duty Vehicles Using a Chassis Dynamometer" (Proposed Draft May 2012).

2.4 Charge-Depleting Vehicle Evaluation Procedure (Plug-In Hybrid-Electric Vehicles). Reference: SAE J2711, "Recommended Practice for Measuring Energy Consumption of Conventional and Hybrid Heavy-Duty Vehicles Using a Chassis Dynamometer" (Proposed Draft May 2012).

2.~~3~~5 Cold and Hot Emission Tests

2.~~3~~5.1 Cold start test cycles shall include all emission data from the moment the vehicle is started, including the actual start event. The vehicle shall be cold soaked for a minimum of 12 hours at no less than 20 ºC (68 ºF) and no greater than 30 ºC (86 ºF) to ensure that all components are at ambient temperature. The vehicle shall remain in the key-off position for 30 minutes until testing begins. A separate vehicle or other equipment (e.g., electric heaters) as necessary, based on good engineering judgment, shall be utilized to bring the dynamometer to operating temperature, where possible. The vehicle shall be started and idled for one minute, after which time the 30-minute test cycle shall commence. Emission measurements shall be taken from one minute before the vehicle is started through test cycle completion. At the end of the test cycle the vehicle shall be returned to the key-off condition.

2.~~3~~5.2 Hot test cycles shall include all emission data from the moment the vehicle is started, excluding the actual start event. The vehicle shall be started and warmed to operating temperature utilizing the same test cycle that will be used for emission characterization. Multiple back-to-back hot test events must include a 20- to 30- minute key-off condition in between each test event. Once the vehicle is at operating temperature the vehicle shall be turned off and will remain in the key-off position for approximately 20 to 30 minutes. The vehicle shall be restarted and idled for one minute, at which time the 30-minute test cycle shall begin and emission measurements will be taken. At the end of the test cycle the vehicle shall be returned to the key-off condition.

2.~~4~~6 Intra-test Pauses. Between two test events, the vehicle shall remain with the key switch in the key-off position for 20 to 30 minutes, with the engine enclosure closed, cooling fans switched off, and the brake pedal not depressed.

2.~~5~~7 Test Termination. The test shall be terminated at the conclusion of the test run. If necessary, a one-minute idle may be added at the end of the test cycle before termination for collection of emissions remaining in the sampling train.

2.~~6~~8 Data Recording.

2.~~6~~8.1 The emissions from the vehicle exhaust shall be ducted to a full-scale dilution tunnel where the gaseous emissions of hydrocarbons, carbon monoxide, oxides of nitrogen (both nitric oxide and nitrogen dioxide) and carbon dioxide shall be measured on a continual basis at a frequency of 5 Hz or greater. An integrated bag sample of the dilution tunnel may be collected and analyzed for carbon monoxide and carbon dioxide levels, and these may be compared to the continuous measurements for carbon monoxide and carbon dioxide as a quality assurance check. Modal results must be within five percent of bag sample results for modal results to be used. Alternatively, the measured values for carbon monoxide and carbon dioxide may be obtained from the integrated bag sample. Particulate matter shall be measured gravimetrically using fluorocarbon-coated glass fiber filters by weighing the filters before and after testing. Filters shall be conditioned to temperature and humidity conditions as specified in 40 CFR, §86.1312-88 (September 5, 1997).

2.~~6~~8.2 For each constituent, a background sample using the same sampling train as used during the emission testing shall be measured before and after the emission test, and the background correction shall be performed as specified by 40 CFR, §86.1343-88 (September 5, 1997). For a compressed natural gas-fueled vehicle, and in cases where non-methane hydrocarbons are a species of interest, the integrated methane and non-methane content of hydrocarbons shall be measured, using gas chromatography analysis of integrated bag samples for each run. If necessary, the tunnel inlet may be filtered for PM with a HEPA filter to aid in lowering the detection limits.

2.~~6~~8.3 Fuel consumed shall be determined by carbon balance from the analytical instruments, and the number of dynamometer roll revolutions shall be used to determine the distance traveled during the driving cycles.

2.~~6~~8.4 ~~SOC~~ State of Charge of the vehicle shall be measured continuously (at a rate of 1Hz or greater) and recorded throughout the entire test. Recorded data shall then be time integrated against the emission measurement data at the beginning and end of the test to coincide with the emission measurement portion of the chassis test. Provided the ~~SOC~~ state of charge is measured, time sequenced and integrated in accordance with the procedures in this document, only the beginning and ending ~~SOC~~ state of charge values are necessary in the final test report. Both Ampere-hours ~~Ah~~ and system voltage shall be recorded during the test, as outlined in the method for determining ~~NEC~~ net energy change.

3. Final Report

3.1 Exhaust Emissions and Fuel Economy. The exhaust emissions and fuel economy of the hybrid-electric vehicle shall be reported in grams per mile and miles per diesel equivalent gallon, respectively. Total fuel energy shall be reported in ~~British Thermal Units (~~Btu~~)~~. The total exhaust emissions of the hybrid-electric vehicle shall be reported as the sum of the emissions from the charge-sustaining portion and the emissions from the non-charge-sustaining portion of the full charge test. For the purpose of this section, the “non-charge-sustaining portion of the full charge test” is defined as the sum of the charge-depleting portion of the full charge test and the transition portion of the full charge test.

3.1.1 Calculations for exhaust emissions are referenced in 40 CFR, §86.1342-90 (September 5, 1997) with the following revision to paragraph (a):

$$A_{WM} = (1/7)(Y_C/D_C) + (6/7)(Y_H/D_H)$$

Where:

A_{WM} = Weighted mass emission level for each drive cycle in grams per vehicle mile

Y_C = Mass emissions from the cold start test in grams

Y_H =	Averaged mass emissions from the hot start tests in grams
D_C =	Measured driving distance from the cold start test in miles
D_H =	Averaged measured driving distance from the hot start tests in miles

3.2 Fuel Consumption Calculations. Reference: SAE J2711, "Recommended Practice for Measuring Energy Consumption of Conventional and Hybrid Heavy-Duty Vehicles Using a Chassis Dynamometer" (Proposed Draft May 2012).

3.~~2~~3 ~~SOC~~ State of Charge Difference. The state of charge difference of the ~~RESS~~ rechargeable energy storage system shall be measured during the test and reported along with the ~~RESS~~ rechargeable energy storage system ~~NEC~~ net energy change.

3.~~3~~4 Net Energy Change ~~(NEC).~~ ~~NEC~~ Net energy change calculations for batteries, capacitors, and electromechanical flywheels are listed below.

3.~~3~~4.1 Batteries. Either of two equations may be used to calculate the ~~NEC~~ net energy change for batteries:

(1) **~~NEC~~ Net Energy Change = [~~SOC~~ State of Charge $_{final}$ – ~~SOC~~ State of Charge $_{initial}$] * V_{system} * K_1**

where

~~SOC~~ State of Charge =	Battery ~~SOC~~ State of Charge at the beginning and end of the test run, in Ampere-hours ~~(Ah)~~. If the ~~SOC~~ State of Charge $_{final}$ and ~~SOC~~ State of Charge $_{initial}$ values are in ampere-seconds, the conversion factor is not used.
V_{system} =	Battery's DC nominal system voltage as specified by the manufacturer, in volts (V)
K1 =	Conversion factor = 3600 (seconds/hour; not used if ~~SOC~~ State of Charge $_{final}$ and ~~SOC~~ State of Charge $_{initial}$ values are in ampere-seconds)

or,

(2) **~~NEC~~ Net Energy Change = ~~SOC~~ State of Charge $_{delta}$ * V_{system} * K_1**

where

~~SOC~~ State of Charge $_{delta}$ = ~~Delta~~ Change in Ampere-hours during a test

V_{system} = Battery's DC nominal system voltage as specified by the manufacturer, in ~~volts (~~V~~)~~

K_1 = Conversion factor = 3600 (seconds/hour; not used if ~~SOC~~ State of Charge $_{final}$ and ~~SOC~~ State of Charge $_{initial}$ values are in ampere-seconds)

3.~~3~~4.2 Capacitors. The following equation shall be used to calculate~~s~~ ~~NEC~~ net energy change for capacitors:

~~NEC~~ Net Energy Change = (C/2) * [~~SOC~~ State of Charge $_{final}$ – ~~SOC~~ State of Charge $_{initial}$]

where

~~SOC~~ State of Charge = The capacitor ~~SOC~~ State of Charge at the beginning and end of the test run, in $(V)^2$

C = Rated capacitance of the capacitor as specified by the manufacturer, in Farads (F)

3.~~3~~4.3 Electromechanical Flywheels. The following equation shall be used to calculate ~~NEC~~ net energy change for electromechanical flywheels:

~~NEC~~ Net Energy Change = (1/2) * I * [~~SOC~~ State of Charge $_{final}$ – ~~SOC~~ State of Charge $_{initial}$] * K_2

where

~~SOC~~ State of Charge = Flywheel state-of-charge at the beginning and end of the test run, in $(rpm)^2$

I = Rated moment of inertia of the flywheel system, in kilogram-meter^2 (kg-m^2)

K_2= Conversion factor = $4\pi^2/3600$ (rad^2/sec^2/rpm^2)

3.~~4~~5 ~~NEC~~ Net Energy Change Variance Determination.

3.~~4~~5.1 Total Fuel Energy. Total fuel energy is the energy value of the fuel consumed by the internal combustion engine, hydraulic, turbine, flywheel, or fuel cell during the test and shall be calculated using the following equation:

Total Fuel Energy = NHV_{fuel} * m_{fuel}

where

NHV_{fuel} = Net heating value (per consumable fuel analysis as specified by ASTM) in Joules per kilogram (J/kg)

~~M~~m $_{fuel}$ = Total mass of fuel consumed over test, in kilograms (kg)

~~**3.4.2 Total Cycle Energy.** The total cycle energy shall be reported in watt-seconds or converted to kWh.~~

~~**Total Cycle Energy = Total Fuel Energy – NEC**~~

3.4~~5.3~~2 Determination Procedure. To determine if a test run has an acceptable ~~NEC~~ net energy change variance, divide ~~NEC~~ net energy change of rechargeable energy storage system by total ~~cycle~~ fuel energy. If the absolute value of the calculation yields a number less than or equal to ~~2~~1%, as shown in the equation below, the ~~NEC~~ net energy change variance is within tolerance levels.

(~~NEC~~ Net Energy Change /~~t~~Total ~~cycle~~Fuel ~~e~~Energy) * 100% ≤ ~~2~~1%

If the absolute value of the calculation yields a number greater 1%, but less than or equal to 5%, emissions and fuel economy values from the test run need to be corrected for state of charge as described in SAE J2711. Test runs with ~~NEC~~ net energy change variance greater than +/- ~~2~~5% shall be considered invalid.

3.~~5~~6 Final Test Report. The final test report shall include all measured parameters, including vehicle configuration, vehicle statistics, test cycles, measured parameters and calculated test results.

4. Charge-Depleting Hybrid-Electric Vehicles

Modifications to this procedure for measuring fuel economy and emissions of charge-depleting heavy-duty hybrid-electric vehicles may be made upon approval of the Executive Officer.

5. Conventional Drivetrain ~~Urban Transit Buses~~ Vehicles

Modifications to this hybrid-electric drive system procedure for measuring fuel economy and emissions of conventional drivetrain ~~urban transit buses~~ vehicles may be made upon approval of the Executive Officer.

E. Certification by Emission Factor Ratio Application

The applicant shall provide both engine and vehicle test results when using the following procedure. Engine test results shall be obtained from an engine manufacturer who has complied with the HDD TPs, HDO TPs, or alternative procedures approved by the Executive Officer. Vehicle test results shall be obtained from the party certifying the hybrid-electric drive system in accordance with the procedures set forth in ~~S~~section D of this document. An emission factor shall be calculated ~~from~~ using the larger value of two results to determine the emissions reduction achieved by the hybrid-electric drive system.

1. Emission Factor. An emissions factor shall be calculated by following equation:

$$\mathbf{EF} = \frac{\textbf{Vehicle NOx (g/mi)}}{\textbf{Engine NOx (g/bhp-hr)}}$$

where

EF = emission factor of the vehicle in bhp-hr/mi

Vehicle NOx = weighted mass emissions level of NOx determined from chassis dynamometer testing in g/mi

Engine NOx = weighted mass emissions level of NOx determined from engine dynamometer testing in g/bhp-hr

Emission factors shall be calculated for ~~HEBs~~ hybrid-electric vehicles and for baseline ~~urban transit buses~~ vehicles. The baseline ~~urban transit bus~~ vehicle shall be selected by the Executive Officer and tested by the Air Resources Board. The resulting data will be available for use by manufacturers applying for certification.

2. Emission Factor Ratio. An emission factor ratio shall be calculated by the following equation:

$$\mathbf{EFR} = \frac{\mathbf{EF_{hybrid}}}{\mathbf{EF_{baseline}}}$$

where

EFR = emission factor ratio

EF_{hybrid} = emission factor calculated for a hybrid-electric ~~urban~~ ~~transit~~ ~~bus~~ vehicle

$EF_{baseline}$ = emission factor calculated for a baseline ~~urban transit~~ ~~bus~~ vehicle

3. Application of Emission Factor Ratio for Hybrid-Electric- ~~**Bus**~~ **Vehicle Certification.** The NOx certification value for a hybrid-electric- ~~bus~~ vehicle shall be calculated by applying the following equation:

~~HEB~~ Hybrid-Electric Vehicle$_{cert}$ = EFR * Engine NOx

where

~~HEB~~ Hybrid-Electric Vehicle$_{cert}$ = hybrid-electric ~~bus~~ vehicles (include urban buses) NOx certification value in g/bhp-hr

EFR =	emission factor ratio
Engine NOx =	weighted mass emissions level of NOx determined from engine dynamometer testing in g/bhp-hr