(4) Divide the g/mi PTO emission rate by the standard payload and add this value to the g/ton-mile emission rate for the driving portion of the test.

(e) Follow the provisions of § 1037.615 to calculate improvement factors and benefits for advanced technologies.

EFFECTIVE DATE NOTE: At 78 FR 36393, June 17, 2013, § 1037.525 was amended by revising the introductory text, effective Aug. 16, 2013. For the convenience of the user, the revised text is set forth as follows:

§ 1037.525 Special procedures for testing hybrid vehicles with power take-off.

This section describes the procedure for quantifying the reduction in greenhouse gas emissions as a result of running power take-off (PTO) devices with a hybrid powertrain. The procedures are written to test the PTO by ensuring that the engine produces all of the energy with no net change in stored energy. The full test for the hybrid vehicle is from a fully charged renewable energy storage system (RESS) to a depleted RESS and then back to a fully charged RESS. These procedures may be used for testing any hybrid architecture for which you are requesting a vehicle certificate using either chassis testing or powertrain testing. You must include all hardware for the PTO system. You may ask us to modify the provisions of this section to allow testing hybrid vehicles other than electric-battery hybrids, consistent with good engineering judgment.

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§ 1037.550 Special procedures for testing post-transmission hybrid systems.

This section describes the procedure for simulating a chassis test with a post-transmission hybrid system for A to B testing. The hardware that must be included in these tests is the engine, the transmission, the hybrid electric motor, the power electronics between the hybrid electric motor and the RESS, and the RESS. You may ask us to modify the provisions of this section to allow testing non-electric hybrid vehicles, consistent with good engineering judgment.

(a) Set up the engine according to 40 CFR 1065.110 to account for work inputs and outputs and accessory work.

(b) Collect CO_2 emissions while operating the system over the test cycles specified in § 1037.510.

(c) Collect and measure emissions as described in 40 CFR part 1066. Calculate emission rates in grams per ton-mile without rounding. Determine values for *A*, *B*, *C*, and *M* for the vehicle being simulated as specified in 40 CFR part 1066. If you will apply an improvement factor or test results to multiple vehicle configurations, use values of *A*, *B*, *C*, *M*, k_d, and *r* that represent the vehicle configuration with the smallest potential reduction in greenhouse gas emissions as a result of the hybrid capability.

(d) Calculate the transmission output shaft's angular speed target for the driver model, $f_{nref,driver}$, from the linear speed associated with the vehicle cycle using the following equation:

$$f_{\text{nrefi,driver}} = \frac{S_{i,cycle} \cdot k_{\text{d}}}{2 \cdot \pi \cdot r}$$

Where:

S_{cyclei} = vehicle speed of the test cycle for each point *i*.

k_d = final drive ratio (the angular speed of the transmission output shaft divided by the angular speed of the drive axle), as declared by the manufacturer.

r = radius of the loaded tires, as declared by the manufacturer.

(e) Use either speed control or torque control to program the dynamometer to follow the test cycle, as follows:

(1) *Speed control.* Program dynamometers using speed control as described in this paragraph (e)(1). We recommend speed control for automated manual transmissions or other designs where there is a power interrupt during shifts. Calculate the transmission output shaft's angular speed target for the dynamometer, $f_{nref,dyno}$, from the measured linear speed at the

dynamometer rolls using the following equation:

$$f_{\text{nrefi,dyno}} = \frac{S_{\text{i,ref}} \cdot k_{\text{d}}}{2 \cdot \pi \cdot r}$$

Where:

$$S_{\text{i,ref}} = \left(FR_{\text{meas,i}} - \left(A + B \cdot S_{\text{i}} + C \cdot S_{\text{i}}^{2}\right)\right)\frac{t_{\text{i}} - t_{\text{i-1}}}{M} + S_{\text{i,ref-1}}$$

t = elapsed time in the driving schedule as measured by the dynamometer, in seconds.

Let $t_{\text{i-1}} = 0$.

$$FR_{\text{meas,i}} = \frac{k_{\text{d}} \cdot T_{\text{i}}}{r}$$

$$S_{\text{i}} = \frac{2 \cdot \pi \cdot r \cdot f_{\text{n,i}}}{k_{\text{d}}}$$

Where:

T_{i} = instantaneous measured torque at the transmission output shaft.

$f_{\text{n,i}}$ = instantaneous measured angular speed of the transmission output shaft.

(2) *Torque control.* Program dynamometers using torque control as described in this paragraph (e)(2).

(i) Calculate the transmission output shaft's torque target, T_{refi}, using the following equation:

$$T_{\text{ref,i}} = \frac{r \cdot FR_{\text{i}}}{k_{\text{d}}}$$

Where:

FR_{i} = total road load force at the surface of the roll, calculated using the equation in 40 CFR 1066.210(d)(4), as specified in paragraph (e)(2)(ii) of this section.

(ii) Calculate the total road load force based on instantaneous speed values, S_{i}, calculated from the equation in paragraph (e)(1) of this section.

(3) For each test, validate the measured transmission output shaft's speed or torque with the corresponding reference values according to 40 CFR 1065.514(e). You may delete points when the vehicle is braking or stopped. Perform the validation based on speed and torque values at the transmission output shaft. For steady-state tests (55 mph and 65 mph cruise), apply cycle-validation criteria by treating the sampling periods from the two tests as a continuous sampling period. Perform

this validation based on the following parameters for either speed-control or torque-control, as applicable:

TABLE 1 OF § 1037.550—STATISTICAL CRITERIA FOR VALIDATING DUTY CYCLES

Parameter	Speed control	Torque control
Slope, a_1	$0.950 \le a_1 \le 1.030$	$0.950 \le a_1 \le 1.030$.
Absolute value of intercept, a_0	≤2.0% of maximum test speed	≤2.0% of maximum torque.
Standard error of estimate, *SEE*	≤5% of maximum test speed	≤10% of maximum torque.
Coefficient of determination, r^2	≥0.970	≥0.850.

(f) Send a brake signal when throttle position is equal to zero and vehicle speed is greater than the reference vehicle speed from the test cycle. The brake signal should be turned off when the torque measured at the transmission output shaft is less than the reference torque. Set a delay before changing the brake state using good engineering judgment to prevent the brake signal from dithering.

(g) The driver model should be designed to follow the cycle as closely as possible and must meet the requirements of 40 CFR 1066.430(e) for transient testing and § 1037.510 for steady-state testing.

(h) Correct for the net energy change of the energy storage device as described in 40 CFR 1066.501.

(i) Follow the provisions of § 1037.510 to weight the cycle results and § 1037.615 to calculate improvement factors and benefits for advanced technologies.

EFFECTIVE DATE NOTE: At 78 FR 36393, June 17, 2013, § 1037.550 was amended by revising the section heading, the introductory text and paragraphs (d) through (g), effective Aug. 16, 2013. For the convenience of the user, the revised text is set forth as follows:

§ 1037.550 Special procedures for testing hybrid systems.

This section describes the procedure for simulating a chassis test with a pre-transmission or post-transmission hybrid system for A to B testing. These procedures may also be used to perform A to B testing with non-hybrid systems.

* * * * *

(d) Calculate the transmission output shaft's angular speed target for the driver model, $f_{nref,driver,}$ from the linear speed associated with the vehicle cycle using the following equation:

$$f_{\mathrm{nrefi,driver}} = \frac{v_{cyclei} \cdot k_{\mathrm{d}}}{2 \cdot \pi \cdot r}$$

Where:

v_{cyclei} = vehicle speed of the test cycle for each point, *i*, starting from *i*=1.

k_d = final drive ratio (the angular speed of the transmission output shaft divided by the angular speed of the drive axle), as declared by the manufacturer.

r = radius of the loaded tires, as declared by the manufacturer.

(e) Use speed control with a loop rate of at least 100 Hz to program the dynamometer to follow the test cycle, as follows:

(1) Calculate the transmission output shaft's angular speed target for the dynamometer, $f_{nref,dyno,}$ from the measured linear speed at the dynamometer rolls using the following equation:

$$f_{\mathrm{nrefi,dyno}} = \frac{v_{\mathrm{refi}} \cdot k_{\mathrm{d}}}{2 \cdot \pi \cdot r}$$

Where:

$$v_{\text{refi}} = \left(\frac{k_{\text{d}} \cdot T_{\text{i-1}}}{r} - \left(A + B \cdot v_{\text{ref,i-1}} + C \cdot v_{\text{ref,i-1}}^{2} \right) - F_{\text{brake,i-1}} \right) \frac{t_{\text{i}} - t_{\text{i-1}}}{M} + v_{\text{ref,i-1}}$$

T = instantaneous measured torque at the transmission output shaft.

F_{brake} = instantaneous brake force applied by the driver model to add force to slow down the vehicle.

t = elapsed time in the driving schedule as measured by the dynamometer, in seconds.

(2) For each test, validate the measured transmission output shaft's speed with the corresponding reference values according to 40 CFR 1065.514(e). You may delete points when the vehicle is stopped. Perform the validation based on speed values at the transmission output shaft. For steady-state tests (55 mph and 65 mph cruise), apply cycle-validation criteria by treating the sampling periods from the two tests as a continuous sampling period. Perform this validation based on the following parameters:

TABLE 1 OF § 1037.550—STATISTICAL CRITERIA FOR VALIDATING DUTY CYCLES

Parameter	Speed control
Slope, a_1	$0.950 \leq a_1 \leq 1.030$.
Absolute value of intercept, $\lvert a_0 \rvert$.	≤ 2.0% of maximum test speed.
Standard error of estimate, *SEE*.	≤ 5% of maximum test speed.
Coefficient of determination, r^2.	≥ 0.970.

(f) Send a brake signal when throttle position is equal to zero and vehicle speed is greater than the reference vehicle speed from the test cycle. Set a delay before changing the brake state to prevent the brake signal from dithering, consistent with good engineering judgment.

(g) The driver model should be designed to follow the cycle as closely as possible and must meet the requirements of § 1037.510 for steady-state testing and 40 CFR 1066.430(e) for transient testing. The driver model should be designed so that the brake and throttle are not applied at the same time.

Subpart G—Special Compliance Provisions

§ 1037.601 What compliance provisions apply to these vehicles?

(a) Engine and vehicle manufacturers, as well as owners and operators of vehicles subject to the requirements of this part, and all other persons, must observe the provisions of this part, the provisions of the Clean Air Act, and the following provisions of 40 CFR part 1068:

(1) The exemption and importation provisions of 40 CFR part 1068, subparts C and D, apply for vehicles subject to this part 1037, except that the hardship exemption provisions of 40 CFR 1068.245, 1068.250, and 1068.255 do not apply for motor vehicles.

(2) Manufacturers may comply with the defect reporting requirements of 40 CFR 1068.501 instead of the defect reporting requirements of 40 CFR part 85.

(b) Vehicles exempted from the applicable standards of 40 CFR part 86 are exempt from the standards of this part without request. Similarly, vehicles are exempt without request if the installed engine is exempted from the applicable standards in 40 CFR part 86.

(c) The prohibitions of 40 CFR 86.1854 apply for vehicles subject to the requirements of this part. The actions prohibited under this provision include the introduction into U.S. commerce of a complete or incomplete vehicle subject to the standards of this part where the vehicle is not covered by a valid certificate of conformity or exemption.

(d) Except as specifically allowed by this part, it is a violation of section 203(a)(1) of the Clean Air Act (42 U.S.C. 7522(a)(1)) to introduce into U.S. commerce a tractor containing an engine not certified for use in tractors; or to introduce into U.S. commerce a vocational vehicle containing a light heavy-duty or medium heavy-duty engine not certified for use in vocational vehicles. This prohibition applies especially to the vehicle manufacturer.

(e) A vehicle manufacturer that completes assembly of a vehicle at two or more facilities may ask to use as the date of manufacture for that vehicle the date on which manufacturing is