(8) Calculate combined cycle-weighted emissions of the four cycles as specified in paragraph (d) of this section.

(d) Calculate combined cycle-weighted emissions of the four cycles for vocational vehicles as follows:

(1) Calculate the g/ton-mile emission rate for the driving portion of the test specified in § 1037.510.

(2) Calculate the g/hr emission rate for the PTO portion of the test by dividing the total mass emitted over the cycle (grams) by the time of the test (hours). For testing where fractions of a cycle were run (for example, where three cycles are completed and the halfway point of a fourth PTO cycle is reached before the engine starts and shuts down again), use the following procedures to calculate the time of the test:

(i) Add up the time run for all complete tests.

(ii) For fractions of a test, use the following equation to calculate the time:

$$t_{test} = \frac{\sum_{i=1}^{N}\left(NP_{\text{circuit\_1,i}} \cdot NP_{\text{circuit\_2,i}}\right) \cdot \Delta t}{\sum_{i=1}^{N}\left(NP_{\text{circuit\_1,i}} \cdot NP_{\text{circuit\_2,i}}\right) \cdot \Delta t} \cdot t_{\text{cycle}}$$

Where:

t_{test} = time of the incomplete test.

i = the number of each measurement interval.

N = the total number of measurement intervals.

$NP_{\text{circuit—1}}$ = Normalized pressure command from circuit 1 of the PTO cycle.

$NP_{\text{circuit—2}}$ = Normalized pressure command from circuit 2 of the PTO cycle. Let $NP_{\text{circuit—2}}$ = 1 if there is only one circuit.

t_{cycle} = time of a complete cycle.

(iii) Sum the time from complete cycles (paragraph (d)(2)(i) of this section) and from partial cycles (paragraph (d)(2)(ii) of this section).

(3) Convert the g/hr PTO result to an equivalent g/mi value based on the assumed fraction of engine operating time during which the PTO is operating (28 percent) and an assumed average vehicle speed while driving (27.1 mph). The conversion factor is: Factor = (0.280)/(1.000 − 0.280)/(27.1 mph) = 0.0144 hr/mi. Multiply the g/hr emission rate by 0.0144 hr/mi.

(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.

§ 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 $t_{i-1} = 0$.

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

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

Where:

T_i = instantaneous measured torque at the transmission output shaft.

$f_{n,i}$ = 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:

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

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	$0.950 \leq a_1 \leq 1.030$	$0.950 \leq a_1 \leq 1.030$.
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.

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.