
40 C.F.R. § 1036.540

Determining cycle-average engine fuel maps.

(a) *Overview.* This section describes how to determine an engine's cycle-average fuel maps for model year 2021 and later vehicles. Vehicle manufacturers may need cycle-average fuel maps for transient duty cycles, highway cruise cycles, or both to demonstrate compliance with emission standards under 40 CFR part 1037. Generate cycle-average engine fuel maps as follows:

- (1) Determine the engine's torque maps as described in § 1036.505(c).
- (2) Determine the engine's steady-state fuel map and fuel consumption at idle as described in § 1036.535. If you are applying cycle-average fuel mapping for highway cruise cycles, you may instead use GEM's default fuel map instead of generating the steady-state fuel map in § 1036.535(b).
- (3) Simulate several different vehicle configurations using GEM (see 40 CFR 1037.520) to create new engine duty cycles as described in paragraph (c) of this section. The transient vehicle duty cycles for this simulation are in 40 CFR part 1037, appendix A; the highway cruise cycles with grade are in 40 CFR part 1037, appendix D. Note that GEM simulation relies on vehicle service classes as described in 40 CFR 1037.140.
- (4) Test the engines using the new duty cycles to determine fuel consumption, cycle work, and average vehicle speed as described in paragraph (d) of this section and establish GEM inputs for those parameters for further vehicle simulations as described in paragraph (e) of this section.

(b) *General test provisions.* The following provisions apply for testing under this section:

- (1) To perform fuel mapping under this section for hybrid engines, make sure the engine and its hybrid features are appropriately configured to represent the hybrid features in your testing.
 - (2) Measure NO_x emissions for each specified sampling period in grams. You may perform these measurements using a NO_x emission-measurement system that meets the requirements of 40 CFR part 1065, subpart J. Include these measured NO_x values any time you report to us your fuel-consumption values from testing under this section. If a system malfunction prevents you from measuring NO_x emissions during a test under this section but the test otherwise gives valid results, you may consider this a valid test and omit the NO_x emission measurements; however, we may require you to repeat the test if we determine that you inappropriately voided the test with respect to NO_x emission measurement.
 - (3) The provisions related to carbon balance error verification in § 1036.543 apply for all testing in this section. These procedures are optional, but we will perform carbon balance error verification for all testing under this section.
 - (4) Correct fuel mass to a mass-specific net energy content of a reference fuel as described in paragraph (d)(13) of this section.
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(5) This section uses engine parameters and variables that are consistent with 40 CFR part 1065.

(c) *Create engine duty cycles.* Use GEM to simulate your engine operation with several different vehicle configurations to create transient and highway cruise engine duty cycles corresponding to each vehicle configuration as follows:

(1) Set up GEM to simulate your engine's operation based on your engine's torque maps, steady-state fuel maps, warm-idle speed as defined in 40 CFR 1037.520(h)(1), and fuel consumption at idle as described in paragraphs (a)(1) and (2) of this section.

(2) Set up GEM with transmission parameters for different vehicle service classes and vehicle duty cycles. Specify the transmission's torque limit for each gear as the engine's maximum torque as determined in 40 CFR 1065.510. Specify the transmission type as Automatic Transmission for all engines and for all engine and vehicle duty cycles, except that the transmission type is Automated Manual Transmission for Heavy HDE operating over the highway cruise cycles or the SET duty cycle. For automatic transmissions set neutral idle to “Y” in the vehicle file. Select gear ratios for each gear as shown in the following table:

Table 1 to Paragraph (c)(2) of § 1036.540—GEM Input for Gear Ratio

Gear number	Spark-ignition HDE, light HDE, and medium HDE— all engine and vehicle duty cycles	Heavy HDE— transient and FTP duty cycles	Heavy HDE— cruise and SET duty cycles
1	3.10	3.51	12.8
2	1.81	1.91	9.25
3	1.41	1.43	6.76
4	1.00	1.00	4.90
5	0.71	0.74	3.58
6	0.61	0.64	2.61
7			1.89
8			1.38
9			1.00
10			0.73
Lockup Gear	3	3	

(3) Run GEM for each simulated vehicle configuration and use the GEM outputs of instantaneous engine speed and engine flywheel torque for each vehicle configuration to generate a 10 Hz transient duty cycle corresponding to each vehicle configuration operating over each vehicle duty cycle. Run GEM for the specified number of vehicle configurations. You may run additional vehicle configurations to represent a wider range of in-use vehicles. Run GEM as follows:

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