
40 C.F.R. § 1036.535

Determining steady-state engine fuel maps and fuel consumption at idle.

The procedures in this section describe how to determine an engine's steady-state fuel map and fuel consumption at idle for model year 2021 and later vehicles; these procedures apply as described in § 1036.505. Vehicle manufacturers may need these values to demonstrate compliance with emission standards under 40 CFR part 1037.

(a) *General test provisions.* Perform fuel mapping using the procedure described in paragraph (b) of this section to establish measured fuel-consumption rates at a range of engine speed and load settings. Measure fuel consumption at idle using the procedure described in paragraph (c) of this section. Paragraph (d) of this section describes how to apply the steady-state mapping from paragraph (b) of this section for the special case of cycle-average mapping for highway cruise cycles as described in § 1036.540. Use these measured fuel-consumption values to declare fuel-consumption rates for certification as described in paragraph (g) of this section.

(1) Map the engine's torque curve and declare engine idle speed as described in § 1036.505(c)(1) and (3). Perform emission measurements as described in 40 CFR 1065.501 and 1065.530 for discrete-mode steady-state testing. This section uses engine parameters and variables that are consistent with 40 CFR part 1065.

(2) Measure NO_x emissions as described in paragraph (f) of this section. Include these measured NO_x values any time you report to us your fuel consumption values from testing under this section.

(3) You may use shared data across engine configurations to the extent that the fuel-consumption rates remain valid.

(4) 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.

(5) Correct fuel mass flow rate to a mass-specific net energy content of a reference fuel as described in paragraph (e) of this section.

(b) *Steady-state fuel mapping.* Determine steady-state fuel-consumption rates for each engine configuration over a series of paired engine speed and torque setpoints as described in this paragraph (b). For example, if you test a high-output (parent) configuration and create a different (child) configuration that uses the same fueling strategy but limits the engine operation to be a subset of that from the high-output configuration, you may use the fuel-consumption rates for the reduced number of mapped points for the low-output configuration, as long as the narrower map includes at least 70 points. Perform fuel mapping as follows:

(1) Generate the fuel-mapping sequence of engine speed and torque setpoints as follows:

(i) Select the following required speed setpoints: warm idle speed, f_{idle} the highest speed above maximum power at which 70% of maximum power occurs, n_{hi} , and eight (or more) equally spaced points between f_{idle} and n_{hi} . (See 40 CFR 1065.610(c)). For engines with adjustable warm idle speed, replace f_{idle} with minimum warm idle speed f_{idlemin} .

(ii) Determine the following default torque setpoints at each of the selected speed setpoints: zero ($T = 0$), maximum mapped torque, $T_{\text{max mapped}}$, and eight (or more) equally spaced points between $T = 0$ and $T_{\text{max mapped}}$. Select the maximum torque setpoint at each speed to conform to the torque map as follows:

(A) Calculate 5 percent of $T_{\text{max mapped}}$. Subtract this result from the mapped torque at each speed setpoint, T_{max} .

(B) Select T_{max} at each speed setpoint as a single torque value to represent all the default torque setpoints above the value determined in paragraph (b)(1)(ii)(A) of this section. All the default torque setpoints less than T_{max} at a given speed setpoint are required torque setpoints.

(iii) You may select any additional speed and torque setpoints consistent with good engineering judgment. For example you may need to select additional points if the engine's fuel consumption is nonlinear across the torque map. Avoid creating a problem with interpolation between narrowly spaced speed and torque setpoints near T_{max} . For each additional speed setpoint, we recommend including a torque setpoint of T_{max} ; however, you may select torque setpoints that properly represent in-use operation. Increments for torque setpoints between these minimum and maximum values at an additional speed setpoint must be no more than one-ninth of $T_{\text{max,mapped}}$. Note that if the test points were added for the child rating, they should still be reported in the parent fuel map. We will test with at least as many points as you. If you add test points to meet testing requirements for child ratings, include those same test points as reported values for the parent fuel map. For our testing, we will use the same normalized speed and torque test points you use, and we may select additional test points.

(iv) Start fuel-map testing at the highest speed setpoint and highest torque setpoint, followed by decreasing torque setpoints at the highest speed setpoint. Continue testing at the next lowest speed setpoint and the highest torque setpoint at that speed setpoint, followed by decreasing torque setpoints at that speed setpoint. Follow this pattern through all the speed and torque points, ending with the lowest speed (f_{idle} or f_{idlemin}) and torque setpoint ($T = 0$). The following figure illustrates an array of test points and the corresponding run order.

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