

(c) Use the fuels specified in 40 CFR part 1065, subpart C, to perform valid tests for all the testing we require in this part, except as noted in §1048.515. For service accumulation, use the test fuel or any commercially available fuel that is representative of the fuel that in-use engines will use.

(d) In place of the provisions of 40 CFR 1065.405, you may consider emission levels stable without measurement after 50 hours of engine operation.

(e) To test engines for evaporative emissions, use the equipment and procedures specified for testing diurnal emissions in 40 CFR 86.107-96 and 86.133-96 with fuel meeting the specifications in 40 CFR part 1065, subpart C. Measure emissions from a test engine with a complete fuel system. Reported emission levels must be based on the highest emissions from three successive 24-hour periods of cycling temperatures. Note that you may omit testing for evaporative emissions during certification if you certify by design, as specified in §1048.245.

(f) You may use special or alternate procedures to the extent we allow them under 40 CFR 1065.10.

(g) This subpart is addressed to you as a manufacturer, but it applies equally to anyone who does testing for you, and to us when we perform testing to determine if your engines meet emission standards.

(h) Map all engines (including constant-speed engines) using the procedures specified in 40 CFR part 1065 for variable-speed engines. For constant-speed engines, continue the mapping procedure until you reach the high-idle speed (the highest speed at which the engine produces zero torque).

[70 FR 40476, July 13, 2005]

**§ 1048.505 How do I test engines using steady-state duty cycles, including ramped-modal testing?**

This section describes how to test engines under steady-state conditions. In some cases, we allow you to choose the appropriate steady-state duty cycle for an engine. In these cases, you must use the duty cycle you select in your appli-

cation for certification for all testing you perform for that engine family. If we test your engines to confirm that they meet emission standards, we will use the duty cycles you select for your own testing. We may also perform other testing as allowed by the Clean Air Act.

(a) You may perform steady-state testing with either discrete-mode or ramped-modal cycles, as follows:

(1) For discrete-mode testing, sample emissions separately for each mode, then calculate an average emission level for the whole cycle using the weighting factors specified for each mode. Calculate cycle statistics for the sequence of modes and compare with the specified values in 40 CFR 1065.514 to confirm that the test is valid. Operate the engine and sampling system as follows:

(i) *Engines with lean NO<sub>x</sub> aftertreatment.* For lean-burn engines that depend on aftertreatment to meet the NO<sub>x</sub> emission standard, operate the engine for 5-6 minutes, then sample emissions for 1-3 minutes in each mode.

(ii) *Engines without lean NO<sub>x</sub> aftertreatment.* For other engines, operate the engine for at least 5 minutes, then sample emissions for at least 1 minute in each mode. Calculate cycle statistics for the sequence of modes and compare with the specified values in 40 CFR part 1065 to confirm that the test is valid.

(2) For ramped-modal testing, start sampling at the beginning of the first mode and continue sampling until the end of the last mode. Calculate emissions and cycle statistics the same as for transient testing.

(b) Measure emissions by testing the engine on a dynamometer with one or more of the following sets of duty cycles to determine whether it meets the steady-state emission standards in §1048.101(b):

(1) For engines from an engine family that will be used only in variable-speed applications, use one of the following duty cycles:

(i) The following duty cycle applies for discrete-mode testing:

TABLE 1 OF § 1048.505

C2 Mode No.	Engine speed <sup>1</sup>	Observed torque <sup>2</sup>	Minimum time in mode (minutes)	Weighting factors
1 .....	Maximum test speed	25	3.0	0.06
2 .....	Intermediate test speed	100	3.0	0.02
3 .....	Intermediate test speed	75	3.0	0.05
4 .....	Intermediate test speed	50	3.0	0.32
5 .....	Intermediate test speed	25	3.0	0.30
6 .....	Intermediate test speed	10	3.0	0.10
7 .....	Idle	0	3.0	0.15

<sup>1</sup> Speed terms are defined in 40 CFR part 1065.

<sup>2</sup> The percent torque is relative to the maximum torque at the given engine speed.

(ii) The following duty cycle applies for ramped-modal testing:

TABLE 2 OF § 1048.505

RMC mode	Time in mode (seconds)	Engine speed <sup>1,2</sup>	Torque (percent) <sup>2,3</sup>
1a Steady-state .....	119	Warm Idle .....	0
1b Transition .....	20	Linear Transition .....	Linear Transition.
2a Steady-state .....	29	Intermediate Speed .....	100
2b Transition .....	20	Intermediate Speed .....	Linear Transition.
3a Steady-state .....	150	Intermediate Speed .....	10
3b Transition .....	20	Intermediate Speed .....	Linear Transition.
4a Steady-state .....	80	Intermediate Speed .....	75
4b Transition .....	20	Intermediate Speed .....	Linear Transition.
5a Steady-state .....	513	Intermediate Speed .....	25
5b Transition .....	20	Intermediate Speed .....	Linear Transition.
6a Steady-state .....	549	Intermediate Speed .....	50
5b Transition .....	20	Linear Transition .....	Linear Transition.
6a Steady-state .....	96	Maximum test speed .....	25
6b Transition .....	20	Linear Transition .....	Linear Transition.
7 Steady-state .....	124	Warm Idle .....	0

<sup>1</sup> Speed terms are defined in 40 CFR part 1065.

<sup>2</sup> Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode.

<sup>3</sup> The percent torque is relative to maximum torque at the commanded engine speed.

(2) For engines from an engine family that will be used only at a single, rated speed, use one of the following duty cycles:

(i) The following duty cycle applies for discrete-mode testing:

TABLE 3 OF § 1048.505

D2 mode No.	Engine speed	Torque <sup>1</sup>	Minimum time in mode (minutes)	Weighting factors
1 .....	Maximum test .....	100	3.0	0.05
2 .....	Maximum test .....	75	3.0	0.25
3 .....	Maximum test .....	50	3.0	0.30
4 .....	Maximum test .....	25	3.0	0.30
5 .....	Maximum test .....	10	3.0	0.10

<sup>1</sup> The percent torque is relative to the maximum torque at maximum test speed.

§ 1048.505

40 CFR Ch. I (7-1-06 Edition)

(ii) The following duty cycle applies for ramped-modal testing:

TABLE 4 OF § 1048.505

RMC mode	Time in mode (seconds)	Engine speed	Torque (percent) <sup>1,2</sup>
1a Steady-state .....	53	Engine Governed .....	100
1b Transition .....	20	Engine Governed .....	Linear transition.
2a Steady-state .....	101	Engine Governed .....	10
2b Transition .....	20	Engine Governed .....	Linear transition.
3a Steady-state .....	277	Engine Governed .....	75
3b Transition .....	20	Engine Governed .....	Linear transition.
4a Steady-state .....	339	Engine Governed .....	25
4b Transition .....	20	Engine Governed .....	Linear transition.
5 Steady-state .....	350	Engine Governed .....	50

<sup>1</sup> The percent torque is relative to maximum test torque.  
<sup>2</sup> Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode.

(3) Use a duty cycle from both paragraphs (b)(1) and (b)(2) of this section if you will not restrict an engine family to constant-speed or variable-speed applications.

(4) Use a duty cycle specified in paragraph (b)(2) of this section for all severe-duty engines.

(5) For high-load engines, use one of the following duty cycles:

(i) The following duty cycle applies for discrete-mode testing:

TABLE 5 OF § 1048.505

D1 mode No.	Engine speed	Torque <sup>1</sup>	Minimum time in mode (minutes)	Weighting factors
1 .....	Maximum test .....	100	3.0	0.50
2 .....	Maximum test .....	75	3.0	0.50

<sup>1</sup> The percent torque is relative to the maximum torque at maximum test speed.

(ii) The following duty cycle applies for discrete-mode testing:

TABLE 6 OF § 1048.505

RMC modes	Time in mode (seconds)	Engine speed (percent)	Torque (percent) <sup>1,2</sup>
1a Steady-state .....	290	Engine Governed .....	100
1b Transition .....	20	Engine Governed .....	Linear Transition.
2 Steady-state .....	290	Engine Governed .....	75

<sup>1</sup> The percent torque is relative to maximum test torque.  
<sup>2</sup> Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode.

(c) If we test an engine to confirm that it meets the duty-cycle emission standards, we will use the steady-state duty cycles that apply for that engine family.

(d) During idle mode, operate the engine with the following parameters:

(1) Hold the speed within your specifications.

(2) Set the engine to operate at its minimum fueling rate.

(3) Keep engine torque under 5 percent of maximum test torque.

(e) For full-load operating modes, operate the engine at wide-open throttle.

(f) See 40 CFR part 1065 for detailed specifications of tolerances and calculations.

(g) For those cases where transient testing is not necessary, perform the

## Environmental Protection Agency

## § 1048.515

steady-state test according to this section after an appropriate warm-up period, consistent with 40 CFR part 1065, subpart F.

[70 FR 40476, July 13, 2005]

### § 1048.510 Which duty cycles do I use for transient testing?

(a) Starting with the 2007 model year, measure emissions by testing the engine on a dynamometer with one of the following transient duty cycles to determine whether it meets the transient emission standards in §1048.101(a):

(1) For constant-speed engines and severe-duty engines, use the transient duty-cycle described in Appendix I of this part.

(2) For all other engines, use the transient duty cycle described in Appendix II of this part.

(b) If we test an engine to confirm that it meets the duty-cycle emission standards, we will use the transient duty cycle that applies for that engine family.

(c) Warm up the test engine as follows:

(1) Operate the engine for the first 180 seconds of the appropriate duty cycle from Appendix I or Appendix II of this part, then allow it to idle without load for 30 seconds. At the end of the 30-second idling period, start measuring emissions as the engine operates over the prescribed duty cycle. For severe-duty engines, this engine warm-up procedure may include up to 15 minutes of operation over the appropriate duty cycle.

(2) If the engine was already operating before a test, use good engineering judgment to let the engine cool down enough so measured emissions during the next test will accurately represent those from an engine starting at room temperature. For example, if an engine starting at room temperature warms up enough in three minutes to start closed-loop operation and achieve full catalyst activity, then minimal engine cooling is necessary before starting the next test.

(3) You are not required to measure emissions while the engine is warming up. However, you must design your emission-control system to start working as soon as possible after engine starting. In your application for cer-

tification, describe how your engine meets this objective (see §1048.205(b)).

[67 FR 68347, Nov. 8, 2002, as amended at 70 FR 40478, July 13, 2005]

### § 1048.515 What are the field-testing procedures?

(a) This section describes the procedures to determine whether your engines meet the field-testing emission standards in §1048.101(c). These procedures may include any normal engine operation and ambient conditions that the engines may experience in use. Paragraph (b) of this section defines the limits of what we will consider normal engine operation and ambient conditions. Use the test procedures we specify in §1048.501, except for the provisions we specify in this section. Measure emissions with one of the following procedures:

(1) Remove the selected engines for testing in a laboratory. You may use an engine dynamometer to simulate normal operation, as described in this section.

(2) Test the selected engines while they remain installed in the equipment. In 40 CFR part 1065, subpart J, we describe the equipment and sampling methods for testing engines in the field. Use fuel meeting the specifications of 40 CFR part 1065, subpart H, or a fuel typical of what you would expect the engine to use in service.

(b) An engine's emissions may not exceed the levels we specify in §1048.101(c) for any continuous sampling period of at least 120 seconds under the following ranges of operation and operating conditions:

(1) Engine operation during the emission sampling period may include any normal operation, subject to the following restrictions:

(i) Average power must be over 5 percent of maximum brake power.

(ii) Continuous time at idle must not be greater than 120 seconds.

(iii) The sampling period may not begin until the engine has reached stable operating temperatures. For example, this would exclude engine operation after starting until the thermostat starts modulating coolant temperature.

(iv) The sampling period may not include engine starting.