

natural gas-fuel used during the test. C<sub>1</sub> and C<sub>2</sub> compounds shall be individually reported. C<sub>3</sub> and heavier compounds, and C<sub>6</sub> and heavier compounds may be reported as a group.

(20) For liquefied petroleum gas-fueled engines: Composition of the liquefied petroleum gas-fuel used during the test. Each hydrocarbon compound present, through C<sub>4</sub> compounds, shall be individually reported. C<sub>5</sub> and heavier hydrocarbons may be reported as a group.

(21) The stabilized pre-test weight and post-test weight of each particulate sample and back-up filter or pair of filters.

(22) Brake specific emissions (g/BHP-hr) for HC, CO, NO<sub>x</sub>, and, if applicable NMHC, NMHCE, THCE, CH<sub>3</sub>OH, and HCHO for each test phase (cold and hot).

(23) The weighted (cold and hot) brake specific emissions (g/BHP-hr) for the total test.

(24) The weighted (cold and hot) carbon balance or mass-measured brake specific fuel consumption for the total test.

(25) The number of hours of operation accumulated on the engine after completing the test sequences described in Figure N84-10.

[59 FR 48535, Sept. 21, 1994, as amended at 60 FR 34376, June 30, 1995; 62 FR 54730, Oct. 21, 1997]

#### § 86.1360-2007 Supplemental emission test; test cycle and procedures.

The test procedures of this subpart N apply for supplemental emission testing, except as specified otherwise in this section.

(a) *Applicability.* This section applies to 2007 and later diesel heavy duty engines.

(b) *Test cycle.* (1) Perform testing as described in § 86.1362-2007 for determining whether an engine meets the applicable standards when measured over the supplemental emission test.

(2) For engines not certified to a NO<sub>x</sub> standard or FEL less than 1.5 g/bhp-hr, EPA may select, and require the manufacturer to conduct the test using, up to three discrete test points within the control area defined in paragraph (d) of this section. EPA will notify the manufacturer of these supplemental test

points in writing in a timely manner before the test. Emission sampling for these discrete test modes must include all regulated pollutants except particulate matter.

(3) For engines certified using the ramped-modal cycle specified in § 86.1362, perform the three discrete test points described in paragraph (b)(2) of this section as follows:

(i) Allow the engine to idle as needed to complete equipment checks following the supplemental emission test described in this section, then operate the engine over the three additional discrete test points.

(ii) Validate the additional discrete test points as a composite test separate from the supplemental emission test, but in the same manner.

(iii) Use the emission data collected during the time interval from 35 to 5 seconds before the end of each mode (excluding transitions) to perform the MAEL calculations in paragraph (f) of this section.

(c) *Determining engine speeds.* (1) The engine speeds A, B and C, referenced in the table in paragraph (b)(1) of this section, and speeds D and E, referenced in § 86.1380, must be determined as follows:

Speed A =  $n_{lo} + 0.25 \times (n_{hi} - n_{lo})$

Speed B =  $n_{lo} + 0.50 \times (n_{hi} - n_{lo})$

Speed C =  $n_{lo} + 0.75 \times (n_{hi} - n_{lo})$

Speed D =  $n_{hi}$

Speed E =  $n_{lo} + 0.15 \times (n_{hi} - n_{lo})$

Where:  $n_{hi}$  = High speed as determined by calculating 70% of the maximum power. The highest engine speed where this power value occurs on the power curve is defined as  $n_{hi}$ .

$n_{lo}$  = Low speed as determined by calculating 50% of the maximum power. The lowest engine speed where this power value occurs on the power curve is defined as  $n_{lo}$ . Maximum power = the maximum observed power calculated according to the engine mapping procedures defined in § 86.1332.

(d) *Determining the control area.* The control area extends from the engine speed A to C, as defined in paragraph (c) of this section, and extends from 25 to 100 percent load.

(e) [Reserved]

(f) *Maximum allowable emission limits.*

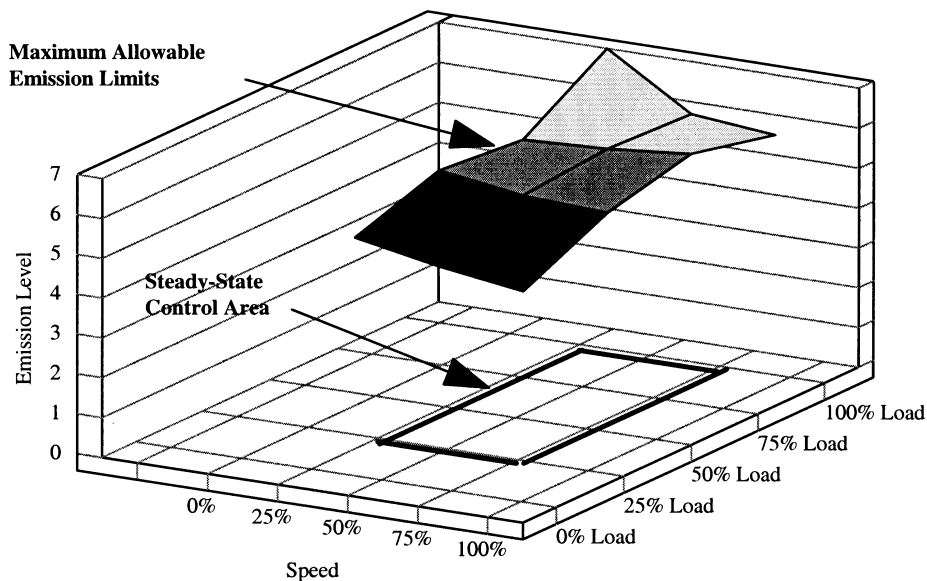
(1) For gaseous emissions, the 12 non-idle test point results and the four-point linear interpolation procedure specified in paragraph (g) of this section for intermediate conditions, shall

define Maximum Allowable Emission Limits for purposes of § 86.007-11(a)(3) except as modified under paragraph (f)(3) of this section. Each engine shall have its own Maximum Allowable Emission Limits generated from the 12 non-idle supplemental steady state test points from that engine. The control

area extends from the 25% to the 75% engine speeds, at engine loads of 25% to 100%, as defined in paragraph (d) of this section. Figure 1 of this paragraph (f)(1) depicts a sample Maximum Allowable Emission Limit curve, for illustration purposes only, as follows:

**Figure 1**

**Maximum Allowable Emission Limits**  
Sample - For Illustration Only



(2) If the weighted average emissions, calculated according to paragraph (e)(6) of this section, for any gaseous pollutant is equal to or lower than required by § 86.007-11(a)(3), each of the 13 test values for that pollutant shall first be multiplied by the ratio of the applicable emission standard (under § 86.007-11(a)(3)) to the weighted average emissions value, and then by 1.10 for interpolation allowance, before determining the Maximum Allowable

Emission Limits under paragraph (f)(1) of this section.

(3) If the Maximum Allowable Emission Limit for any point, as calculated under paragraphs (f)(1) and (2) of this section, is greater than the applicable Not-to-Exceed limit (if within the Not-to-Exceed control area defined in § 86.1370-2007(b)), then the Maximum Allowable Emission Limit for that point shall be defined as the applicable Not-to-Exceed limit.

(g) *Calculating intermediate test points.*

(1) For the three test points selected by EPA under paragraph (b)(2) of this section, the emissions must be measured and calculated as described in paragraph (e)(6)(i) of this section (except that  $n = 1$  and  $WF = 1$ ). The measured values then must be compared to the interpolated values according to paragraph (g)(3) of this section. The interpolated values are determined from the modes of the test cycle closest to the respective test point according to paragraph (g)(2) of this section.

(2) Interpolating emission values from the test cycle. The gaseous emissions for each regulated pollutant for each of the control points (Z) must be interpolated from the four closest modes of the test cycle that envelop the selected control point Z as shown in Figure 2 of this paragraph (g)(2).

(i) For these modes (R, S, T, U), the following definitions apply:

(A) Speed (R) = Speed(T) =  $n_{RT}$ .

(B) Speed (S) = Speed(U) =  $n_{SU}$ .

(C) Per cent load (R) = Per cent load (S).

(D) Per cent load (T) = Per cent load (U).

(ii) The interpolated value of the brake specific gaseous emissions of the selected control point Z ( $E_Z$ ) must be calculated as follows:

$$E_Z = E_{RS} + (E_{TU} - E_{RS}) * (M_Z - M_{RS}) / (M_{TU} - M_{RS})$$

$$E_{TU} = E_T + (E_U - E_T) * (n_Z - n_{RT}) / (n_{SU} - n_{RT})$$

$$E_{RS} = E_R + (E_S - E_R) * (n_Z - n_{RT}) / (n_{SU} - n_{RT})$$

$$M_{TU} = M_T + (M_U - M_T) * (n_Z - n_{RT}) / (n_{SU} - n_{RT})$$

$$M_{RS} = M_R + (M_S - M_R) * (n_Z - n_{RT}) / (n_{SU} - n_{RT})$$

Where:

$E_R, E_S, E_T, E_U$  = for each regulated pollutant, brake specific gaseous emissions of the enveloping modes adjusted according to the factors in (f)(2).

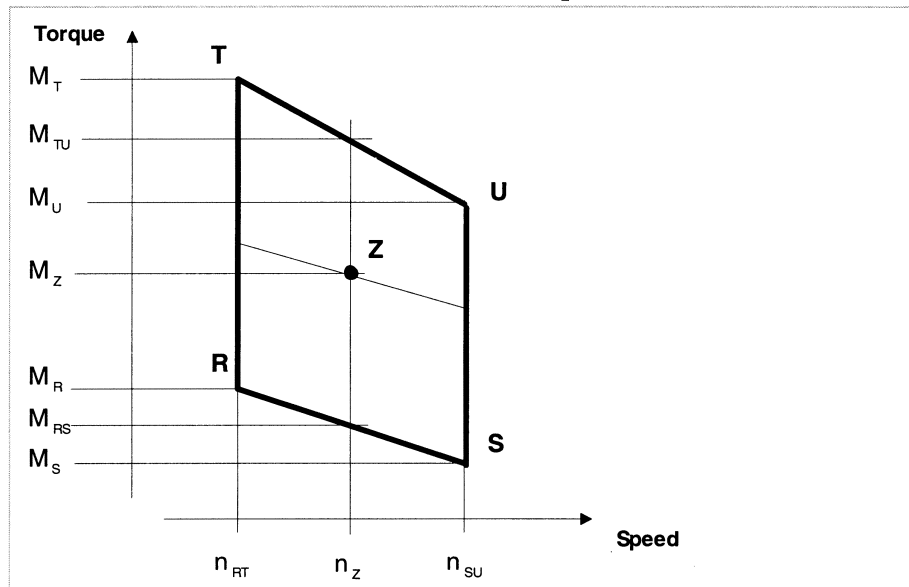
$M_R, M_S, M_T, M_U$  = engine torque of the enveloping modes.

$M_Z$  = engine torque of the selected control point Z.

$n_Z$  = engine speed of the selected control point Z.

(iii) Figure 2 follows:

**Figure 2**  
**Four-Point Linear Interpolation**



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(3) *Comparing calculated and interpolated emission values.* The measured brake specific gaseous emissions of the control point Z ( $X_Z$ ) must be less than or equal to the interpolated value ( $E_Z$ ).

[65 FR 59958, Oct. 6, 2000, as amended at 66 FR 5188, Jan. 18, 2001; 70 FR 40439, July 13, 2005; 71 FR 51487, Aug. 30, 2006; 73 FR 37192, June 30, 2008]

### § 86.1362–2007 Steady-state testing with a ramped-modal cycle.

This section describes how to test engines under steady-state conditions.

Manufacturers may alternatively use the procedures specified in § 86.1363–2007 through the 2009 model year.

(a) Start sampling at the beginning of the first mode and continue sampling until the end of the last mode. Calculate emissions as described in 40 CFR 1065.650 and cycle statistics as described in 40 CFR 1065.514.

(b) Measure emissions by testing the engine on a dynamometer with the following ramped-modal duty cycle to determine whether it meets the applicable steady-state emission standards:

RMC mode	Time in mode (seconds)	Engine speed <sup>1,2</sup>	Torque (percent) <sup>2,3</sup>
1a Steady-state .....	170	Warm Idle .....	0
1b Transition .....	20	Linear Transition .....	Linear Transition
2a Steady-state .....	170	A .....	100
2b Transition .....	20	A .....	Linear Transition
3a Steady-state .....	102	A .....	25
3b Transition .....	20	A .....	Linear Transition
4a Steady-state .....	100	A .....	75
4b Transition .....	20	A .....	Linear Transition
5a Steady-state .....	103	A .....	50
5b Transition .....	20	Linear Transition .....	Linear Transition
6a Steady-state .....	194	B .....	100
6b Transition .....	20	B .....	Linear Transition
7a Steady-state .....	219	B .....	25
7b Transition .....	20	B .....	Linear Transition
8a Steady-state .....	220	B .....	75
8b Transition .....	20	B .....	Linear Transition
9a Steady-state .....	219	B .....	50
9b Transition .....	20	Linear Transition .....	Linear Transition
10a Steady-state .....	171	C .....	100
10b Transition .....	20	C .....	Linear Transition
11a Steady-state .....	102	C .....	25
11b Transition .....	20	C .....	Linear Transition
12a Steady-state .....	100	C .....	75
12b Transition .....	20	C .....	Linear Transition
13a Steady-state .....	102	C .....	50
13b Transition .....	20	Linear Transition .....	Linear Transition
14 Steady-state .....	168	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 speed or torque setting of the current mode to the speed or torque setting of the next mode.

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

(c) 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.

(d) [Reserved]

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

(f) Perform the ramped-modal test with a warmed-up engine. If the ramped-modal test follows directly after testing over the Federal Test Pro-

cedure, consider the engine warm. Otherwise, operate the engine to warm it up as described in 40 CFR part 1065, subpart F.

[70 FR 40439, July 13, 2005, as amended 73 FR 37193, June 30, 2008]

### § 86.1362–2010 Steady-state testing with a ramped-modal cycle.

This section describes how to test engines under steady-state conditions. For model years through 2009, manufacturers may use the mode order described in this section or in § 86.1362–