

Environmental Protection Agency

§ 86.1360-2007

(20) For liquefied petroleum gas-fueled engines: Composition of the liquefied petroleum gas-fuel used during the test. Each hydrocarbon compound present, through C₄ compounds, shall be individually reported. C₅ 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_x, and, if applicable NMHC, NMHCE, THCE, CH₃OH, 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)(i) The following 13-mode cycle must be followed in dynamometer operation on the test engine:

Mode number	Engine speed	Percent load	Weighting factor	Mode length (minutes)
1	Idle	0.15	4
2	A	100	0.08	2
3	B	50	0.10	2
4	B	75	0.10	2
5	A	50	0.05	2
6	A	75	0.05	2
7	A	25	0.05	2
8	B	100	0.09	2
9	B	25	0.10	2
10	C	100	0.08	2
11	C	25	0.05	2
12	C	75	0.05	2
13	C	50	0.05	2

(ii) Upon Administrator approval, the manufacturer may use mode lengths other than those listed in paragraph (b)(1)(i) of this section.

(2) In addition to the 13 test points identified in paragraph (b)(1) of this section, for engines not certified to a NO_x standard or FEL less than 1.5 g/bhp-hr, EPA may select, and require the manufacturer to conduct the test using, up to 3 additional test points within the control area (as 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. Emissions sampling for the additional test modes must include all regulated gaseous pollutants. Particulate matter does not need to be measured.

(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) *Test requirements—(1) Engine warm-up.* Prior to beginning the test sequence, the engine must be warmed-up according to the procedures in § 86.1332–90(d)(3)(i) through (iv).

(2) *Test sequence.* The test must be performed in the order of the mode numbers in paragraph (b)(1) of this section. Where applicable, the EPA-selected test points identified under paragraph (b)(2) of this section must be performed immediately upon completion of mode 13. The engine must be operated for the prescribed time in each mode, completing engine speed and load changes in the first 20 seconds of each mode. The specified speed must be held to within ±50 rpm and the specified torque must be held to within plus or minus two percent of the maximum torque at the test speed.

(3) *Particulate sampling.* One filter shall be used for sampling PM over the 13-mode test procedure. The modal weighting factors specified in paragraph (b)(1) of this section shall be taken into account by taking a sample proportional to the exhaust mass flow during each individual mode of the cycle. This can be achieved by adjusting sample flow rate, sampling time, and/or dilution ratio, accordingly, so that the criterion for the effective weighting factors is met. The sampling time per mode must be at least 4 seconds per 0.01 weighting factor. Sampling must be conducted as late as possible within each mode. Particulate sampling shall be completed no earlier than 5 seconds before the end of each mode.

(4) The test must be conducted with all emission-related engine control variables in the highest brake-specific NO_x emissions state which could be encountered for a 30 second or longer averaging period at the given test point and for the conditions under which the engine is being tested.

(5) *Exhaust emissions measurements and calculations.* Manufacturers must

follow the exhaust emissions sample analysis procedures under § 86.1340, and the calculation formulas and procedures under § 86.1342, for the 13-mode cycle and the 3 EPA-selected test points as applicable for steady-state testing, including the NO_x correction factor for humidity.

(6) *Calculating the weighted average emissions.* (i) For each regulated gaseous pollutant, the weighted average emissions must be calculated as follows:

$$A_{WA} = \frac{\sum_{i=1}^n [A_{Mi} \times WF_i]}{\sum_{i=2}^n [A_{Pi} \times WF_i]}$$

Where:

A_{WA} = Weighted average emissions for each regulated gaseous pollutant, in grams per brake horse-power hour.

A_M = Modal average mass emissions level, in grams per hour. Mass emissions must be calculated as described in § 86.1342.

A_P = Modal average power, in brake horse-power. Any power measured during the idle mode (mode 1) is not included in this calculation.

W_F = Weighting factor corresponding to each mode of the steady-state test cycle, as defined in paragraph (b)(1) of this section.

i = The modes of the steady-state test cycle, as defined in paragraph (b)(1) of this section.

n = 13, corresponding to the 13 modes of the steady-state test cycle, as defined in paragraph (b)(1) of this section.

(ii) For PM measurements, a single filter must be used to measure PM over the 13 modes. The brake-specific PM emission level for the test must be calculated as described for a transient hot start test in § 86.1343. Only the power measured during the sampling period shall be used in the calculation.

(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

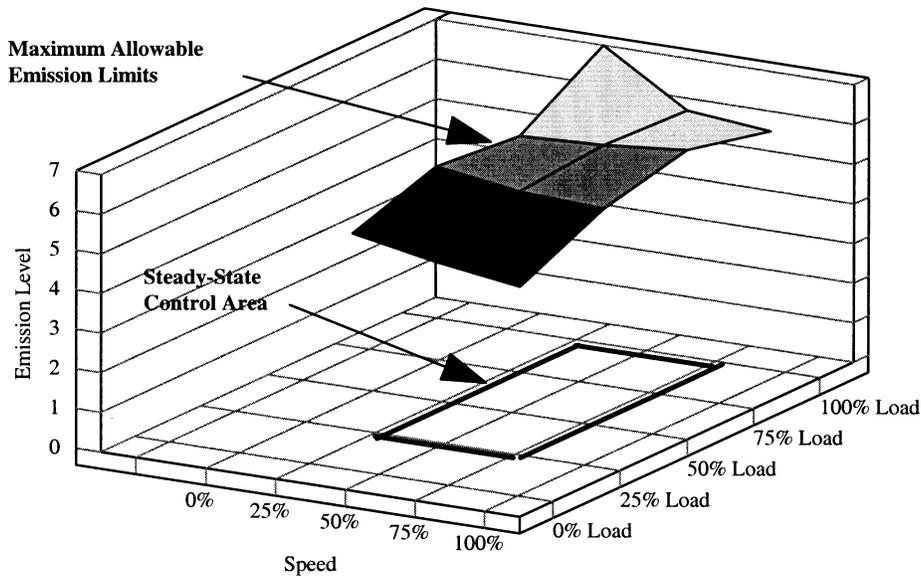
non-idle supplemental steady state test points from that engine. The control area extends from the 25% to the 75% engine speeds, at engine loads of 25% to 100%, as defined in paragraph (d) of this

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(EZ) 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).

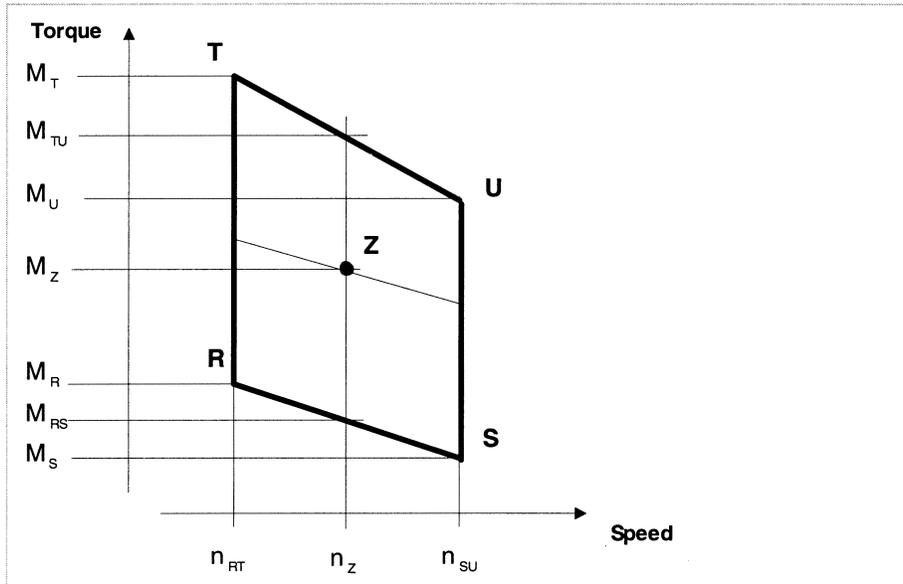
M_R, M_S, M_T, M_U = engine torque of the enveloping modes.

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**



(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).

(h) *Test fuel specifications.* The test fuel used for supplemental steady-state testing under this section must meet the requirements of § 86.1313.

(i) *General requirements.* Ambient conditions, charge cooling specifications, and intake and exhaust restrictions for supplemental steady-state testing and maximum allowable emission limit testing under this section must meet the requirements of § 86.1330.

[65 FR 59958, Oct. 6, 2000, as amended at 66 FR 5188, Jan. 18, 2001]

§ 86.1370-2007 Not-To-Exceed test procedures.

(a) *General.* The purpose of this test procedure is to measure in-use emissions of heavy-duty diesel engines while operating within a broad range of speed and load points (the Not-To-Exceed Control Area) and under conditions which can reasonably be expected to be encountered in normal vehicle operation and use. Emission results from this test procedure are to be compared to the Not-To-Exceed Limits specified in § 86.007-11 (a)(4), or to later Not-To-Exceed limits. The Not-To-Exceed Limits do not apply for engine starting conditions.

(b) *Not-to-exceed control area for diesel heavy-duty engines.* The Not-To-Exceed Control Area for diesel heavy-duty engines consists of the following engine speed and load points:

(1) All operating speeds greater than the speed calculated using the following formula, where n_{hi} and n_{lo} are determined according to the provisions in § 86.1360(c):

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

(2) All engine load points greater than or equal to 30% or more of the maximum torque value produced by the engine.

(3) Notwithstanding the provisions of paragraphs (b)(1) and (b)(2) of this section, all operating speed and load points with brake specific fuel consumption (BSFC) values within 5% of the minimum BSFC value of the engine. For the purposes of this requirement, BSFC must be calculated under the general test cell conditions specified in § 86.1330. The manufacturer may

petition the Administrator at certification to exclude such points if the manufacturer can demonstrate that the engine is not expected to operate at such points in normal vehicle operation and use. Engines equipped with drivelines with multi-speed manual transmissions or automatic transmissions with a finite number of gears are not subject to the requirements of this paragraph (b)(3).

(4) Notwithstanding the provisions of paragraphs (b)(1) through (b)(3) of this section, speed and load points below 30% of the maximum power value produced by the engine shall be excluded from the Not-To-Exceed Control Area for all emissions.

(5) [Reserved]

(6)(i) For petroleum-fueled diesel cycle engines, the manufacturer may identify particular engine-vehicle combinations and may petition the Administrator at certification to exclude operating points from the Not-to-Exceed Control Area defined in § 86.1370(b)(1) through (5) if the manufacturer can demonstrate that the engine is not capable of operating at such points when used in the specified engine-vehicle combination(s).

(ii) For diesel cycle engines that are not petroleum-fueled, the manufacturer may petition the Administrator at certification to exclude operating points from the Not-to-Exceed Control Area defined in § 86.1370(b)(1) through (5) if the manufacturer can demonstrate that the engine is not expected to operate at such points in normal vehicle operation and use.

(7) Manufacturers may petition the Administrator to limit NTE testing in a single defined region of speeds and loads. Such a defined region must generally be of elliptical or rectangular shape, and must share some portion of its boundary with the outside limits of the NTE zone. Under this provision testing would not be allowed with sampling periods in which operation within that region constitutes more than 5.0 percent of the time-weighted operation within the sampling period. Approval of this limit by the Administrator is contingent on the manufacturer satisfactorily demonstrating that operation at the speeds and loads within that region accounts for less than 5.0 percent