

TABLE B-4—DUTY CYCLE FOR CONSTANT-SPEED AUXILIARY ENGINES

Mode No.	Engine speed <sup>1</sup>	Percent of maximum test torque <sup>2</sup>	Minimum time in mode (minutes)	Weighting factors
1 .....	Maximum Test Speed .....	100	5.0	0.05
2 .....	Maximum Test Speed .....	75	5.0	0.25
3 .....	Maximum Test Speed .....	50	5.0	0.30
4 .....	Maximum Test Speed .....	25	5.0	0.30
5 .....	Maximum Test Speed .....	10	5.0	0.10

<sup>1</sup> Engine speed: ±2 percent of point.  
<sup>2</sup> Torque: ±2 percent of engine maximum value.

(2) Variable speed auxiliary engines shall be tested using the duty cycle described in Table B-3 in paragraph (c)(2) of this section.

(e) *Recreational*. For the purpose of determining compliance with the emis-

sion standards of §94.8, recreational engines shall be tested using the duty cycle described in Table B-5, which follows:

TABLE B-5—RECREATIONAL MARINE DUTY CYCLE

Mode No.	Engine speed <sup>(1)</sup> (percent of maximum test speed)	Percent of maximum test power <sup>(2)</sup>	Minimum time in mode (minutes)	Weighting factors
1 .....	100	100	5.0	0.08
2 .....	91	75	5.0	0.13
3 .....	80	50	5.0	0.17
4 .....	63	25	5.0	0.32
5 .....	idle	0	5.0	0.30

<sup>1</sup> Engine speed: ±2 percent of point.  
<sup>2</sup> Power: ±2 percent of engine maximum value.

[64 FR 73331, Dec. 29, 1999, as amended at 67 FR 68343, Nov. 8, 2002]

**§ 94.106 Supplemental test procedures for Category 1 and Category 2 marine engines.**

This section describes the test procedures for supplemental testing conducted to determine compliance with the exhaust emission requirements of §94.8(e)(1). In general, the supplemental test procedures are the same as those otherwise specified by this subpart, except that they cover any speeds, loads, ambient conditions, and operating parameters that may be experienced in use. The test procedures specified by other sections in this subpart also apply to these tests, except as specified in this section.

(a) Notwithstanding other provisions of this subpart, testing conducted to determine compliance with the exhaust emission requirements of §94.8(e) may be conducted:

(1) At any speed and load (or any combination of speeds and loads that is nominally steady-state) within the applicable Not To Exceed Zone specified in paragraph (b) of this section;

(2)(i) Without correction, at any intake air temperature between 13°C and 35°C (or between 13°C and 30°C for engines not drawing intake air directly from a space that could be heated by the engine);

(ii) Without correction at any ambient water temperature (or equivalent) between 5°C and 27°C;

(iii) Without correction at any ambient humidity between 7.1 and 10.7 grams of moisture per kilogram of dry air; and

(3) With a continuous sampling period not less than 30 seconds in duration.

(b) The specified Not to Exceed Zones for marine engines are defined as follows. These Not to Exceed Zones apply, unless a modified zone is established under paragraph (c) of this section.

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(1) For commercial Category 1 engines certified using the duty cycle specified in §94.105(b), the Not to Exceed zones are defined as follows:

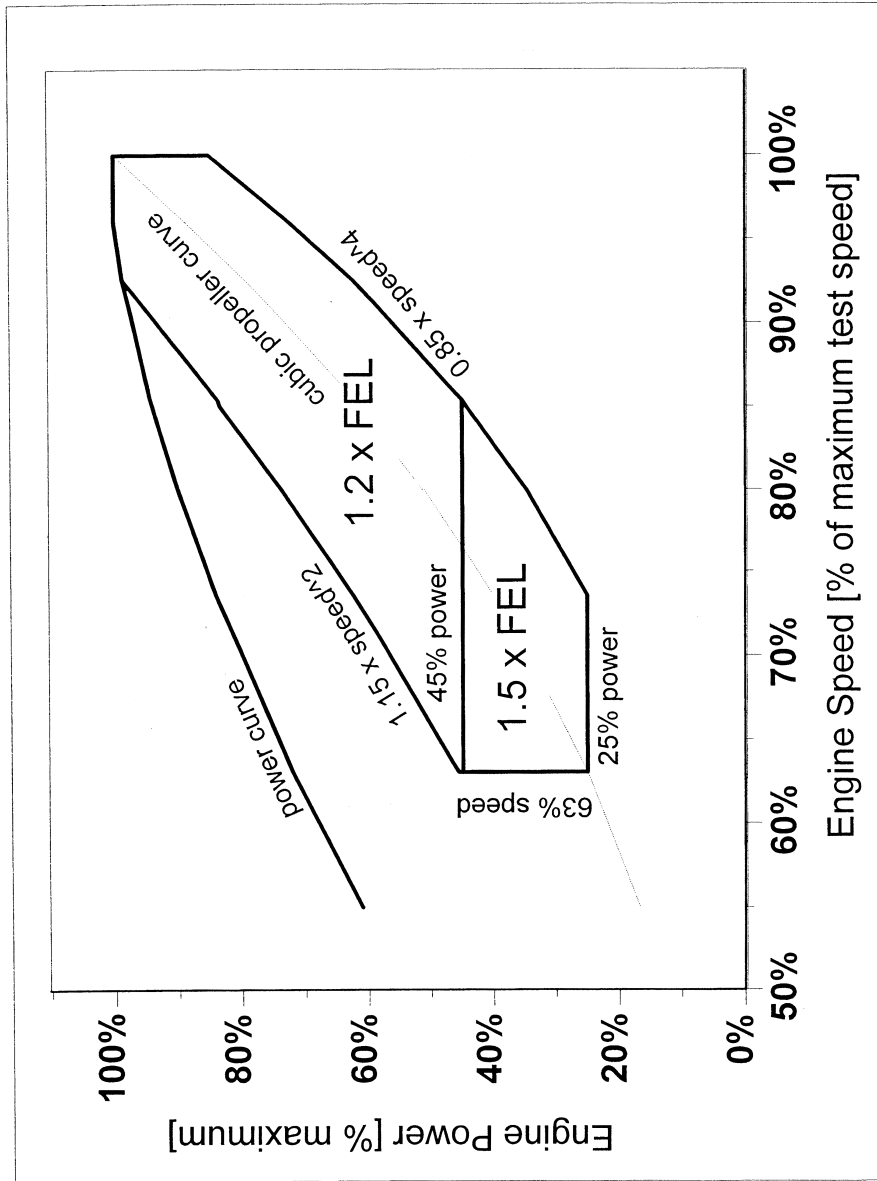
(i) The Not to Exceed zone is the region between the curves  $\text{power} = 1.15 \times \text{SPD}^2$  and  $\text{power} = 0.85 \times \text{SPD}^4$ , excluding all operation below 25% of maximum power at rated speed and excluding all operation below 63% of maximum test speed.

(ii) This zone is divided into two subzones, one above and one below 45% of maximum power at rated speed.

(iii) SPD in paragraph (b)(1)(i) of this section refers to percent of maximum test speed.

(iv) See Figure B-1 for an illustration of this Not to Exceed zone which follows:

Figure B-1



(2) For Category 2 engines certified using the duty cycle specified in § 94.105(b), the Not to Exceed zones are defined as follows:

(i) The Not to Exceed zone is the region between the curves  $\text{power} = 1.04 \times \text{SPD}^2$  and  $\text{power} = 0.76 \times \text{SPD}^4$ , excluding

all operation below 25% of maximum power at rated speed and excluding all operation below 63% of maximum test speed.

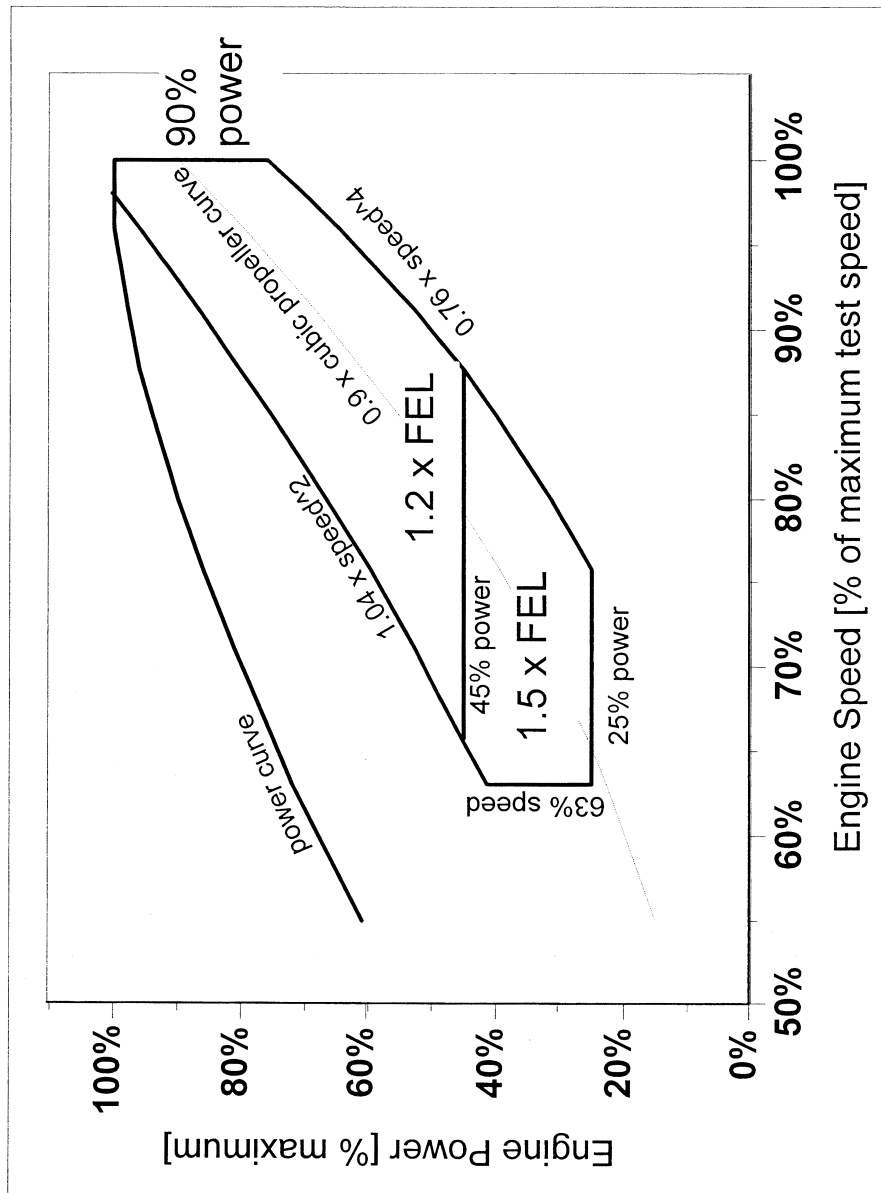
(ii) This zone is divided into two subzones, one above and one below 45% of maximum power at rated speed.

(iii) SPD in paragraph (b)(2)(i) of this section refers to percent of maximum test speed.

(iv) See Figure B-2 in paragraph (b)(3) of this section for an illustration of this Not to Exceed zone.

(3) For engines certified using the duty cycle specified in § 94.105(c)(2), the Not to Exceed zones are defined as follows:

Figure B-2



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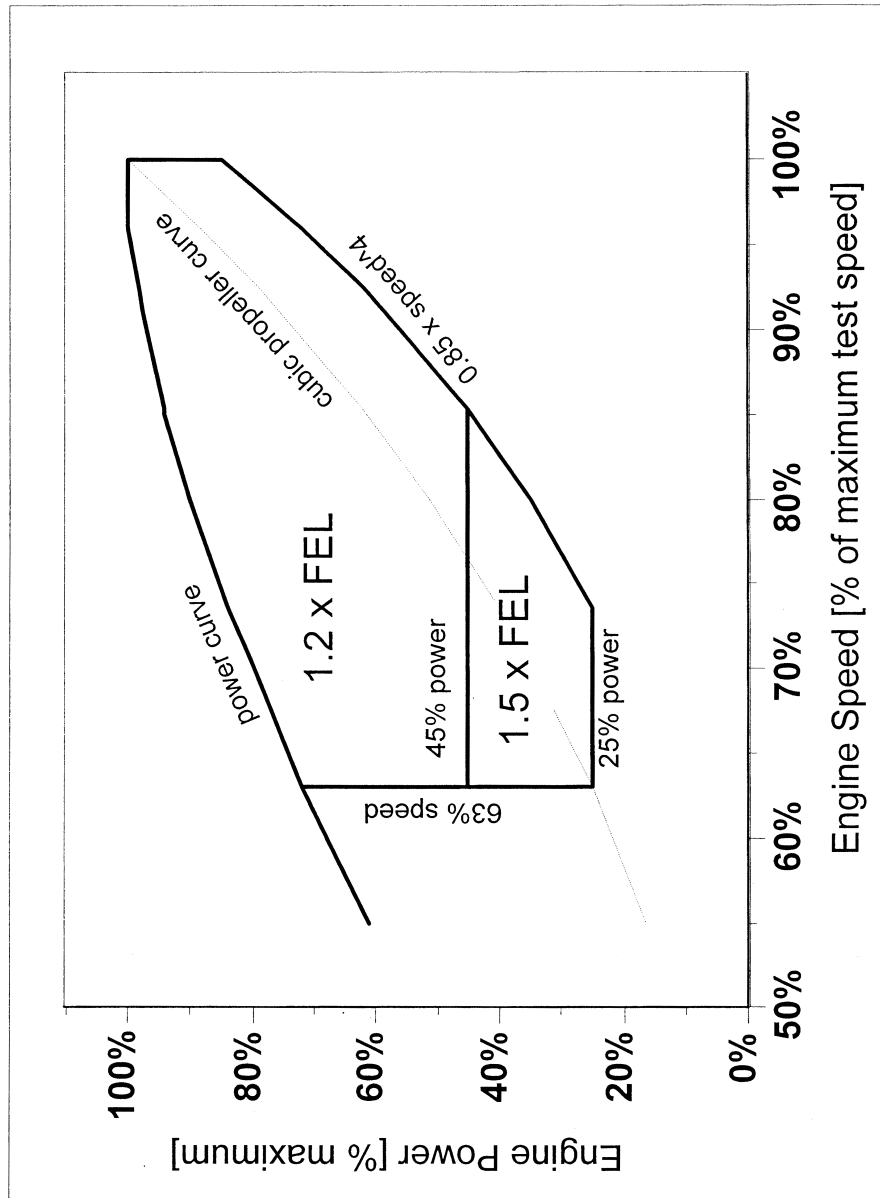
(i) The Not to Exceed zone is the region above the curve  $\text{power} = 0.85 \times \text{SPD}^2$ , excluding all operation below 25% of maximum power at rated speed and excluding all operation below 63% of maximum test speed.

(ii) This zone is divided into two subzones, one above and one below 45% of maximum power at rated speed.

(iii) SPD in paragraph (b)(3)(i) of this section refers to percent of maximum test speed.

(iv) See Figure B-3 for an illustration of this Not to Exceed zone:

Figure B-3



(4) For engines certified using the duty cycle specified in § 94.105(c)(1), the Not to Exceed zone is defined as any load greater than or equal to 25 percent of maximum power at rated speed, and

any speed at which the engine operates in use.

(5) For recreational marine engines certified using the duty cycle specified in § 94.105(e), the Not to Exceed zones are defined as follows:

(i) The Not to Exceed zone is the region between the curves  $\text{power} = 1.15 \times \text{SPD}^2$  and  $\text{power} = 0.85 \times \text{SPD}^4$ , excluding all operation below 25% of maximum power at rated speed and excluding all operation below 63% of maximum test speed.

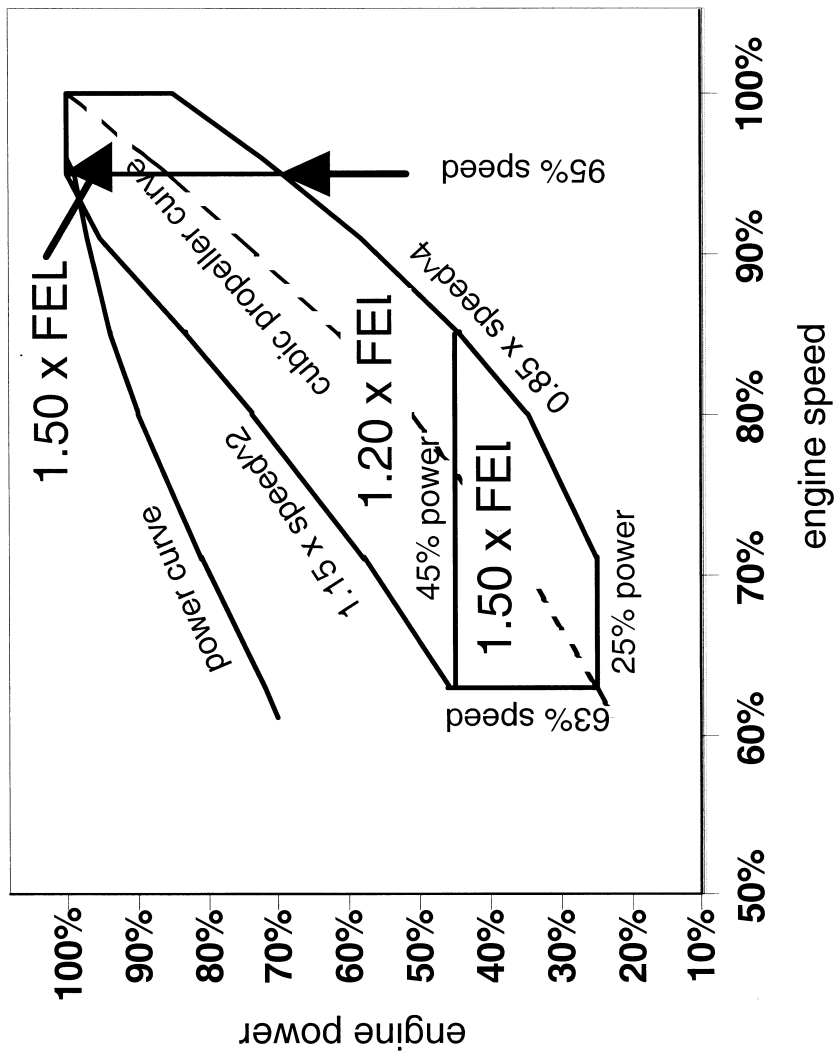
(ii) This zone is divided into three subzones, one below 45% of maximum

power at maximum test speed; one above 95% of maximum test speed; and a third area including all of the remaining area of the NTE zone.

(iii) SPD in paragraph (b)(5)(i) of this section refers to percent of maximum test speed.

(iv) See Figure B-4 for an illustration of this Not to Exceed zone as follows:

Figure B-4



(c)(1) Upon request by the manufacturer, the Administrator may specify a narrower Not to Exceed Zone for an engine family at the time of certification, provided that the narrower Not to Exceed Zone includes all speeds greater than 63 percent of maximum test speed and loads greater than 25 percent of maximum power at rated speed at which the engines are expected to normally operate in use.

(2) At the time of certification, the Administrator may specify, or require the manufacturer to specify, a broader Not to Exceed Zone for an engine family, provided that the broader Not to Exceed Zone includes only speeds greater than 63 percent of maximum test speed and loads greater than 25 percent of maximum power at rated speed at which the engines are expected to normally operate in use.

(d) Testing conducted to determine compliance with the exhaust emission requirements of § 94.8(e) may be conducted at any ambient air temperature or humidity outside the ranges specified in paragraph (a)(2) of this section, provided that emission measurements are corrected to be equivalent to measurements within the ranges specified in paragraph (a)(2) of this section. Correction of emission measurements made in accordance with this paragraph (d) shall be made in accordance with good engineering practice. The measurements shall be corrected to be within the range using the minimum possible correction.

(e) Testing conducted under this section may not include engine starting.

[64 FR 73331, Dec. 29, 1999, as amended at 67 FR 68344, Nov. 8, 2002; 68 FR 9784, Feb. 28, 2003]

**§ 94.107 Determination of maximum test speed.**

(a) *Overview.* This section specifies how to determine maximum test speed from a lug curve. This maximum test speed is used in §§ 94.105, 94.106, and § 94.109 (including the tolerances for engine speed specified in § 94.105).

(b) *Generation of lug curve.* Prior to beginning emission testing, generate maximum measured brakepower versus engine speed data points using the applicable method specified in 40 CFR 86.1332. These data points form the lug

curve. It is not necessary to generate the entire lug curve. For the portion of the curve where power increases with increasing speed, it is not necessary to generate points with power less than 90 percent of the maximum power value. For the portion of the curve where power decreases with increasing speed, it is not necessary to generate points with power less than 75 percent of the maximum power value.

(c) *Normalization of lug curve.* (1) Identify the point (power and speed) on the lug curve at which maximum power occurs.

(2) Normalize the power values of the lug curve by dividing them by the maximum power value identified in paragraph (b)(1) of this section, and multiplying the resulting values by 100.

(3) Normalize the engine speed values of the lug curve by dividing them by the speed at which maximum power occurs, which is identified in paragraph (b)(1) of this section, and multiplying the resulting values by 100.

(4) Maximum engine power is located on the normalized lug curve at 100 percent power and 100 percent speed.

(d) *Determination of maximum test speed.* Calculate the maximum test speed from the speedfactor analysis described in this paragraph (d).

(1) For a given combination of engine power and speed (i.e., a given power/speed point), the speedfactor is the distance to the normalized power/speed point from the zero power, zero speed point. The value of the speedfactor is defined as:

$$\text{Speedfactor} = \sqrt{(\text{power})^2 + (\text{speed})^2}$$

(2) Calculate speedfactors for the power/speed data points on the lug curve, and determine the maximum value.

(3) Maximum test speed is the speed at which the maximum value for the speedfactor occurs.

(e) For constant-speed engines, rated speed is the maximum test speed.

(f) For Category 3 engines, manufacturers may choose to set the maximum test speed at the maximum in-use engine speed instead of the speed specified in § 94.107(d).

[64 FR 73331, Dec. 29, 1999, as amended at 68 FR 9784, Feb. 28, 2003]