(9) The gaseous ventilation rate for each exhaust gas contaminant shall be calculated as follows—

(i) The following abbreviations shall apply to both category A and category B engine calculations as appropriate:

cfm—Cubic feet per min (ft^3/min)
Exh—Exhaust
A—Air (lbs/hr)
H—Grains of water per lb. of dry intake air
J—Conversion factor
m—Mass flow rate (mass/hr)
TI—Intake air temperature (°F)
PCAir—Percent Air
PCCH$_4$—Percent CH$_4$ (intake air)
UCH$_4$—Unburned CH$_4$
PCECH$_4$—Percent Exhaust CH$_4$

(ii) Exhaust gas flow calculation for category B engines shall be (m Exh)=(A)+(m fuel).

(iii) Fuel/air ratio for category B engines shall be (f/a)=(m fuel) / (A).

(iv) Methane flow through category A engines shall be determined by the following:

PCAir=100−PCCH$_4$
Y=(PCAir)(0.289)+(PCCH$_4$)(0.16)
Z=(0.16)(PCCH$_4$)÷Y
mCH$_4$=(A)(Z)÷(1−Z)

(v) Exhaust gas flow calculation for category A engines shall be (m Exh)=(A)+(m fuel)+(m CH$_4$)

(vi) Unburned CH$_4$ (lbs/hr) calculation for category A engines shall be mUCH$_4$=(m Exh)(0.0052)(PCECH$_4$)

(vii) Fuel/air ratio for category A engines shall be (f/a)=((m fuel)+(m CH$_4$)−(m UCH$_4$))÷(A)

(viii) Conversion from dry to wet basis for both category A and category B engines shall be:

(NO wet basis)=(NO dry basis)(J)
(NO$_2$ wet basis)=(NO$_2$ dry basis)(J)
(CO$_2$ wet basis)=(CO$_2$ dry basis)(J)
(CO wet basis)=(CO dry basis)(10^{-4})(J)

Where:
J=(f/a)(−1.87)+(1−(0.00022)(H))

(ix) NO and NO$_2$ correction for humidity and temperature for category A and category B engines shall be:

(NO corr)=(NO wet basis)÷(E)
(NO$_2$ corr)=(NO$_2$ wet basis)÷(E)

Where:
E=1.0+(R)(H−75)+(G)(TI−77)
R=(f/a)(0.044)−(0.0038)
G=(f/a)(−0.116)+(0.0053)

(x) The calculations to determine the m of each exhaust gas contaminant in grams per hour at each test point shall be as follows for category A and category B engines:

(m NO)=(NO corr)(0.000470)(m Exh)
(m NO$_2$)=(NO$_2$ corr)(0.000720)(m Exh)
(m CO$_2$)=(CO$_2$ wet basis)(6.89)(m Exh)
(m CO)=(CO wet basis)(4.38)(m Exh)

(xi) The calculations to determine the ventilation rate for each exhaust gas contaminant at each test point shall be as follows for category A and category B engines:

(cfm NO)=(m NO)(K)
(cfm NO$_2$)=(m NO$_2$)(K)
(cfm CO$_2$)=(m CO$_2$)(K)
(cfm CO)=(m CO)(K)

Where:
K=13,913.4/ (pollutant grams/mole) (pollutant dilution value specified in §7.84(c)).

(b) The gaseous ventilation rate for each requested rated speed and horsepower shall be the highest ventilation rate calculated in paragraph (a)(9)(xi) of this section.

(1) Ventilation rates less than 20,000 cfm shall be rounded up to the next 500 cfm.

Example: 10,432 cfm shall be listed 10,500 cfm.

(2) Ventilation rates greater than 20,000 cfm shall be rounded up to the next 1,000 cfm.

Example: 26,382 cfm shall be listed 27,000 cfm.

[61 FR 55504, Oct. 25, 1996; 62 FR 34640, June 27, 1997]

§ 7.89 Test to determine the particulate index.

The test shall be performed in the order listed in Table E–3.

(a) *Test procedure.* (1) Couple the diesel engine to the dynamometer and connect the sampling and measurement devices specified in §7.86.

(2) A minimum time of 10 minutes is required for each measuring point.

(3) Prior to testing, condition and weigh the particulate filters as follows:

(i) At least 1 hour before the test, each filter (pair) shall be placed in a closed, but unsealed, petri dish and placed in a weighing chamber (room) for stabilization.

(ii) At the end of the stabilization period, each filter (pair) shall be weighed. The reading is the tare weight.

(iii) The filter (pair) shall then be stored in a closed petri dish or a filter holder, both of which shall remain in the weighing chamber (room) until needed for testing.

(iv) The filter (pair) must be reweighed if not used within 8 hours of its removal from the weighing chamber (room).

(4) Run the engine.

(i) The parameter for f_a shall be calculated in accordance with §7.87(a)(3).

(ii) The air inlet and exhaust backpressure restrictions on the engine shall be set as specified in §§7.87(a)(3) (iii) and (iv).

(iii) The dilution air shall be set to obtain a maximum filter face temperature of 125 °F (52 °C) or less at each test mode.

(iv) The total dilution ratio shall not be less than 4.

(5) The engine shall be at a steady state condition before starting the test modes.

(i) The engine speed and torque shall be measured and recorded at each test mode.

(ii) The data required for use in the particulate index calculation specified in paragraph (a)(9) of this section shall be measured and recorded at each test mode.

(6) A 1.0 ±0.1 percent CH_4, by volume shall be injected into the engine's intake air for category A engines.

(7) Operate the engine at each rated speed and horsepower rating requested by the applicant according to Table E–3 to collect particulate on the primary filter.

(i) One pair of single filters shall be collected or eight multiple filter pairs shall be collected.

(ii) Particulate sampling shall be started after the engine has reached a steady-state condition.

(iii) The sampling time required per mode shall be either a minimum of 20 seconds for the single filter method or a minimum of 60 seconds for the multiple filter method.

(iv) The minimum particulate loading specified in §§7.86(c)(18) (iii) or (iv) shall be done.

TABLE E–3—PARTICULATE TEST MODES

Speed	Rated speed				Intermediate speed			Low-idle speed
% Torque	100	75	50	10	100	75	50	0
Weighting factor	0.15	0.15	0.15	0.1	0.1	0.1	0.1	0.15

(v) Test speeds shall be maintained within ± percent of rated speed or ±3 RPM, which ever is greater, except for low idle which shall be within the tolerances set by the manufacturer.

(vi) The specified torque shall be held so that the average over the period during which the measurements are being taken is within ±2 percent of the maximum torque at the test speed.

(vii) The modal weighting factors (WF) given in Table E–3 shall be applied to the multiple filter method during the calculations as shown in paragraph (a)(9)(iii)(B) of this section.

(viii) For the single filter method, the modal WF shall be taken into account during sampling by taking a sample proportional to the exhaust mass flow for each mode of the cycle.

(8) After completion of the test, condition and weigh the particulate filters in the weighing chamber (room) as follows:

(i) Condition the filters for at least 1 hour, but not more than 80 hours.

(ii) At the end of the stabilization period, weigh each filter. The reading is the gross weight.

(iii) The particulate mass of each filter is its gross weight minus its tare weight.

(iv) The particulate mass (P_F for the single filter method; $P_{F,i}$ for the multiple filter method) is the sum of the particulate masses collected on the primary and back-up filters.

(v) The test is void and must be rerun if the sample on the filter contacts the petri dish or any other surface.

(9) The particulate index for the mass particulate shall be calculated from the equations listed below—

(i) The following abbreviations shall be:

cfm—Cubic feet per min (ft^3 min)
PT—Particulate (gr/hr)
m mix—Diluted exhaust gas mass flow rate on wet basis (kg/hr)
m sample—Mass of the diluted exhaust sample passed through the particulate sampling filters (kg)
P_f—Particulate sample mass collected on a filter (mg) at each test mode as determined in Table E–3.
K_p—Humidity correction factor for particulate
WF—Weighting factor
i-Subscript denoting an individual mode, i=1,...n
PI—Particulate Index (cfm)

(ii) When calculating ambient humidity correction for the particulate concentration (P_f part), the equation shall be:

$P_{fcorr}=(P_f)(K_p)$
$K_p=1/(1+0.0133*(H-10.71))$

Where:

H_a=humidity of the intake air, g water per kg dry air
$H_a=(6.220*R_a*p_a)/(p_B-p_a-R_a*10^{-2})$
R_a=relative humidity of the intake air, %
p_a=saturation vapor pressure of the intake air, kPa
p_B=total barometric pressure, kPa

(iii) When the multiple filter method is used, the following equations shall be used.

(A) Mass of particulate emitted is calculated as follows:

$$PT\ gr\ /\ hr_i = \frac{\left(P_{fcorr}\ mg_i\right)\left(m\ mix\ kg\ /hr_i\right)}{\left(m\ sample\ kg_i\right)\left(1000\ mg\ /gr\right)}$$

(B) Determination of weighted particulate average is calculated as follows:

$$PT\ gr\ /hr = \sum_{i=1}^{i=n}\left(PT\ gr\ /hr_i\right)\left(WF_i\right)$$

(C) Determination of particulate index for the mass particulate from the average of the test modes shall be calculated as follows:

$$PI = \frac{\left(PT\ gr\ /hr\right)\left(1000\ mg\ /gr\right)\left(1\ hr\ /60\ min\right)\left(35.31\ ft^3\ /m^3\right)}{\left(1/1\ mg\ /m^3\right)}$$

(iv) When the single filter method is used, the following equations shall be used.

(A) Mass of particulate emitted:

$$PT\ gr/hr = \frac{\left(P_{fcorr}\ mg\right)\left(m\ mix\ kg/hr\right)avg.}{\left(m\ sample\ kg\right)\left(1000\ mg/gr\right)}$$

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Where:

$$\left(\text{m mix kg / hr}\right)\text{avg.} = \sum_{i=1}^{i=n}\left(\text{m mix kg / hr}_i\right)\left(\text{WF}_i\right)$$

$$\left(\text{m sample kg}\right) = \sum_{i=1}^{i=n}\left(\text{m sample kg}_i\right)$$

(B) Determination of particulate index for the mass particulate from the average of the test modes shall be as follows:

$$\text{PI} = \frac{\left(\text{PT gr /hr}\right)\left(1000 \text{ mg /gr}\right)\left(1 \text{ hr /60 min}\right)\left(35.31 \text{ ft}^3 \text{/m}^3\right)}{\left(1 / 1 \text{ mg /m}^3\right)}$$

(v) When the effective weighting factor, $\text{WF}_{E,i}$, for each mode is calculated for the single filter method, the following shall apply.

$$(A) \quad \text{WF}_{E,i} = \frac{\left(\text{m sample kg}_i\right)\left(\text{m mix kg /hr avg}\right)}{\left(\text{m sample kg}\right)\left(\text{m mix kg /hr}_i\right)}$$

(B) The value of the effective weighting factors shall be within ±0.005 (absolute value) of the weighting factors listed in Table E–3.

(b) A particulate index for each requested rated speed and horsepower shall be the value determined in paragraph (a)(9)(iii)(C) of this section for the multiple filter method or paragraph (a)(9)(iv)(B) of this section for the single filter method.

(1) Particulate indices less than 20,000 cfm shall be rounded up to the next 500 cfm. Example: 10,432 cfm shall be listed 10,500 cfm.

(2) Particulate indices greater than 20,000 cfm shall be rounded up to the nearest thousand 1,000 cfm. Example: 26,382 cfm shall be listed 27,000 cfm.

[61 FR 55504, Oct. 25, 1996; 62 FR 34640, June 27, 1997]

§ 7.90 Approval marking.

Each approved diesel engine shall be identified by a legible and permanent approval marking inscribed with the assigned MSHA approval number and securely attached to the diesel engine. The marking shall also contain the following information:

(a) Ventilation rate.

(b) Rated power.

(c) Rated speed.

(d) High idle.

(e) Maximum altitude before deration.

(f) Engine model number.

§ 7.91 Post-approval product audit.

Upon request by MSHA, but no more than once a year except for cause, the approval holder shall make a diesel engine available for audit at no cost to MSHA.