1.0 PURPOSE

This Standard Test Procedure (STP) is to be used by investigators to determine the gaseous ventilation rate of a diesel engine.

2.0 SCOPE

This procedure applies to gaseous ventilation rate tests conducted by the on diesel power packages to determine compliance with the requirements of 30 CFR 7.88: "Test to Determine the Gaseous Ventilation Rate".

3.0 REFERENCES

3.1. 30 CFR Part 7, Subpart E, "Diesel Engines Intended for Use in Underground Coal Mines"

3.2. 30 CFR Part 36, Subpart C, "Approval Requirements for Permissible Mobile Diesel-Powered Transportation Equipment – Test Requirements"

4.0 DEFINITIONS

4.1. Brake Power – The observed power measured at the crankshaft or its equivalent when the engine is equipped only with standard auxiliaries necessary for its operation on the test bed.

4.2. Category A Engines – Diesel engines intended for use in areas of underground coal mines where permissible electric equipment is required.

4.3. Category B Engines – Diesel engines intended for use in areas of underground coal mines where nonpermissible electric equipment is allowed.

4.4. Diesel Engine – Any compression ignition internal combustion engine using the basic diesel cycle where combustion results from the spraying of fuel into air heated by compression.

4.5. Exhaust Emission – Any substance emitted to the atmosphere from the exhaust port of the combustion chamber of a diesel engine.

4.6. Intermediate Speed – Maximum torque speed if it occurs between 60 percent and 75 percent of rated speed. If the maximum torque speed is less than 60 percent of rated speed, then the intermediate speed shall be 60 percent of the

rated speed. If the maximum torque speed is greater than 75 percent of the rated speed, then the intermediate speed shall be 75 percent of rated speed.

4.7. Low Idle Speed – The minimum no load speed as specified by the engine manufacturer.

4.8. Maximum Torque Speed – The speed at which an engine develops maximum torque.

4.9. Operational Range – All speed and load (including percent loads) combinations from the rated speed to the minimum permitted engine speed at full load as specified by the engine manufacturer.

4.10. Particulates – Any material collected on a specified filter medium after diluting exhaust gases with clean, filtered air at a temperature of less than or equal to 125 °F (52 °C), as measured at a point immediately upstream of the primary filter. This is primarily carbon, condensed hydrocarbons, sulfates, and associated water.

4.11. Percent Load – The fraction of the maximum available torque at an engine speed.

4.12. Rated Horsepower – The nominal brake power output of a diesel engineas specified by the engine manufacturer with a specified production tolerance. For laboratory test purposes, the fuel pump calibration for the rated horsepower must be set between the nominal and the maximum fuel tolerance specification.

4.13. Rated Speed – Speed at which the rated power is delivered, as specified by the engine manufacturer.

4.14. Steady-State Condition – Diesel engine operating condition which is at a constant speed and load and at stabilized temperatures and pressures.

4.15. Total Oxides of Nitrogen – The sum total of the measured parts per millions (ppm) of nitric oxide (NO) plus the measured ppm of nitrogen dioxide (NO2).

5.0 TEST EQUIPMENT

5.1. Dynamometer stand/test cell to provide loading on the engine.

5.2. An apparatus for measuring torque that provides an accuracy of +/-2.0 percent based on the engine's maximum value.

5.3. An apparatus for measuring revolutions per minute (rpm) that provides an accuracy of +/-2.0 percent based on the engine's maximum value.

5.4. An apparatus for measuring temperature that provides an accuracy of +/- 4 ^{o}F (2 ^{o}C) of the absolute value except for the exhaust gas temperature device that provides an accuracy of +/-27 ^{o}F (15 ^{o}C).

5.5. An apparatus for measuring intake and exhaust restriction pressures that provides an accuracy of +/-5 percent of maximum.

5.6. An apparatus for measuring atmospheric pressure that provides an accuracy of +/-0.5 percent of reading.

5.7. An apparatus for measuring fuel flow that provides an accuracy of +/-2 percent based on the engine's maximum value.

5.8. An apparatus for measuring the inlet air flow rate of the diesel engine that provides an accuracy of +/-2 percent based on the engine's maximum value.

5.9. For testing category A engines, an apparatus for metering in 1.0 +/-0.1 percent, by volume, of methane (CH_4) into the intake air system shall be provided.

5.10. Gaseous emission sampling system.

5.11. Diesel fuel meeting the specifications in 30 CFR Part 7.86(a)(2) Table E-1.

6.0 TEST SAMPLES

N/A

7.0 PROCEDURES

The test shall be performed in the order listed in Table E-2. The test for determination of the particulate index described in Part 7.89 may be done simultaneously with this test.

7.1. Couple the diesel engine to the dynamometer and attach the sampling and measurement devices as specified in Part 7.86.

7.2. A minimum time of 10 minutes is required for each test mode.

7.3. CO, CO_2, NO_x, and CH_4 analyzers shall be zeroed and spanned at the analyzer range to be used prior to testing.

7.4. Run the engine.

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

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

7.5. The engine shall be at a steady-state condition before starting the test modes.

7.5.1. The output from the gas analyzers shall be measured and recorded with exhaust gas flowing through the analyzers a minimum of the last three (3) minutes of each mode.

7.5.2. To evaluate the gaseous emissions, the last 60 seconds of each mode shall be averaged.

7.5.3. A 1.0+/-0.1 percent CH_4, by volume, shall be injected into the engine's intake air for category A engines.

7.5.4. The engine speed and torque shall be measured and recorded at each test mode.

7.5.5. The data required for use in the gaseous ventilation calculations specified in paragraph (6.9) of this section shall be measured and recorded at each test mode.

7.6. Operate the engine at each rated speed and horsepower rating requested by the applicant according to Table E-2 in order to measure the raw exhaust gas concentration, dry basis, of CO, CO_2, NO, NO_2, and CH_4- exhaust (category A engines only).

7.6.1. Test speeds shall be maintained within +/-1 percent of rated speed or +/-3 RPM, which ever is greater, except for low idle which shall be within the tolerances established by the manufacturer.

7.6.2. The specified torque shall be held so that the average over the period during which the measurements are taken is within +/-2 percent of the maximum torque at the test speed.

7.7. The concentration of CH_4 in the intake air shall be measured for category A engines.

7.8. After completion of the test modes, the following shall be done:

7.8.1. Zero and span the analyzers at the ranges used during the test.

7.8.2. The gaseous emission test shall be acceptable if the difference in the zero and span results taken before the test and after the test are less than 2 percent.

7.9. The gaseous ventilation rate for each exhaust gas contaminant shall be calculated as follows:

7.9.1. The following abbreviations shall apply to both category A and category B engine calculations as appropriate:

cfm – Cubic feet per minute (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 (^oF)
PCAir – Percent Air
$PCCH_4$ – Percent CH_4 (intake air)
UCH_4 – Unburned CH_4
$PCECH_4$ – Percent Exhaust CH_4

7.9.2. Exhaust gas flow calculation for category B engines shall be

$$(m\ Exh)=(A)+(m\ fuel).$$

7.9.3. Fuel/air ratio for category B engines shall be

$$(f/a)=(m\ fuel)/(A).$$

7.9.4. Methane flow through category A engines shall be determined by the following:

$$PCAir=100 - PCCH_4$$
$$Y=(PCAir)(0.289)+(PCCH_4)(0.16)$$
$$Z=(0.16)(PCCH_4)/Y$$
$$mCH_4=(A)(Z)/(1 - Z)$$

7.9.5. Exhaust gas flow calculation for category A engines shall be

$$(m\ Exh)=(A)+(m\ fuel)+(m\ CH_4).$$

7.9.6. Unburned CH_4 (lbs/hr) calculation for category A engines shall be

$$mUCH_4=(m\ Exh)(0.0052)(PCECH_4).$$

7.9.7. Fuel/air ratio for category A engines shall be

$$(f/a)=((m\ fuel)+(m\ CH_4)-(m\ UCH_4))/(A).$$

7.9.8. 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:

$$J=(f/a)(-1.87)+(1-(0.00022)(H))$$

7.9.9. 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)

7.9.10. 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)

7.9.11. 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 section 7.84(c)).

8.0 TEST DATA

N/A

9.0 PASS/FAIL CRITERIA

The gaseous ventilation rate for each requested rated speed and horsepower shall be the highest ventilation rate calculated in paragraph 6.9.11 of the above section.

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

9.2. 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.

TABLE E-2 --- GASEOUS TEST MODES

Speed	Rated speed				Intermediate speed			Low-idle speed
% Torque	100	75	50	10	100	75	50	0