

**Pennsylvania Technical Advisory Committee
On Diesel Powered Equipment**

54 JAS
ALM
WBB
McClary
Anton
original

Paul Borchick

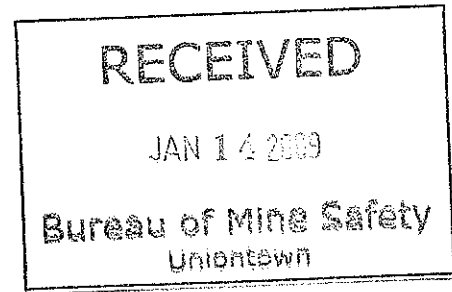
(412) 736-9105 (Cell)
(724) 485-4414 (Office)
Email: paulborchick@consolenergy.com

Ron Bowersox

(724) 726-8987 (Home)
(724) 479-8692 (Office)
Email: umwarbowersox@yahoo.com

January 9, 2009

Joseph Scaffoni, Director
Bureau of Mine Safety
Fayette County Health Center
100 New Salem Road, Room 167
Uniontown, Pa. 15401



RE: Engine and emissions control package evaluation and Alternate Test Procedure under Sections 203-A, 217-A and 218-A of the Act for a Cummins QSB4.5 110HP Engine with a M30 DST exhaust and emission control system in a Brookville Model 18M116D 18-Man Personnel Carrier

Dear Mr. Scaffoni:

Article II-A of the Pennsylvania Bituminous Coal Mine Act (the Act) provides for the use of diesel-powered equipment in underground bituminous coal mines. Section 224-A of the act created a Technical Advisory Committee ("TAC") for the purpose of advising the Department regarding implementation of Article II-A

Background

On July 10, 2008 Brookville Equipment Corporation submitted a request to the Bureau of Mine Safety (BMS) for a modification approval for the Brookville Model 18M116D Locomotive. The modification involved replacing the previously approved Cummins 4BTA3.9C engine and M30 DST exhaust and emission control system with a Cummins QSB4.5 110HP Engine with a M30 DST exhaust and emission control system. The new system has not been previously approved under Section 203-A of the Act. Brookville also requested an alternative test procedure for the 5 minute CO tests required under Sections 217-A and 218-A of the Act.

On July 16, 2008 the Director of BMS requested the TAC to evaluate the Cummins QSB4.5 110HP Engine with a M30 DST exhaust and emission control system in a Model 18M116D 18-Man Personnel Carrier and to advise the Department regarding the TAC's recommendation as to whether the referenced equipment meets requirements of Section 203-A

of the Act. The Director also requested the TAC to evaluate the need for the Alternate Test Procedure for the 5 minute CO test required under Sections 217-A and 218-A, and if so, the procedures to follow for the Alternate Test.

The diesel power package includes the following items:

- Cummins QSB4.5 110HP diesel engine (MSHA Certification No. 07-ENA040006)(Part 7)
- Emissions Control System – M30 DST exhaust and emission control system which includes:
 - Syncat Corporation - M241-260-01 oxidation catalyst
 - Paas Technologies - M30-411-01 heat exchanger
 - Fleetguard M30 particulate filter (MSHA efficiency rating 98.5 %)

More detailed information on the specifications of the diesel power package is included on the General Specification Sheet which is attached as Attachment 1.

Investigation

On December 23, 2008 the TAC and DEP traveled to Brookville Equipment Corporation in Brookville, Pa. to inspect the equipment when it became available. The TAC evaluated the engine and exhaust emissions package as well as the need for the Alternate Test procedure.

Emissions testing of the engine and after-treatment system were performed, as well as exhaust gas temperature monitoring and stall test procedure. The results of that testing are included in Attachment 2. The results of the emission tests showed the engine was performing within MSHA's approval specifications.

Monitoring of the exhaust gas temperature produced a high exhaust gas temperature reading of 175° F, which is well below the 302° F allowed by Section 203-A (b)(4) of Article II-A. It is our belief that the heat exchanger will maintain the exhaust gas temperature well below the required 302 ° F. The maximum surface temperature observed was 260° F at the end of the 5 minute CO test, and the maximum engine oil temperature recorded was 180° F.

The after-treatment system is fitted with a DST M-30 disposable filter. The filter is rated by MSHA at a 98.5 % efficiency rating, which meets the requirements of Section 203-A (b) (1) of Article II-A. The engine and filter extrapolations show that the diesel power package will result in an average ambient concentration of .0311 mg/m³ of diesel particulate matter when diluted by 100% of the MSHA approval plate ventilation rate for this engine, which is well below the .12 mg/m³ requirement of Section 203-A (a)(1) Article II-A. (see Attachment 1)

In addition to the testing that was conducted, our investigation and our observations confirmed that the diesel power package is capable of meeting all the requirements of Section 203-A of Article II-A of the act without reducing or compromising the level of health or safety afforded by the act.

The need for the Alternate Test procedure was also evaluated. Both 5 minute and 90 second tests were observed and the results recorded (Attachment 2).

The 5 minute CO test was conducted first without the use of an external water cooler for the transmission oil. The maximum transmission oil temperature observed was 220° F at the end of the 5 minute CO test. This was close to the transmission oil shut down temperature, and the manufacturer recommended that premature oil breakdown and ultimately transmission damage could occur under such stall conditions. This recommendation and observation showed the need for the Alternate 90 second CO Test Procedure so that damage to the transmission would not occur.

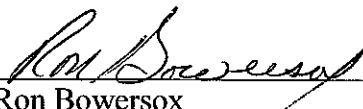
The 90 second Alternate CO Test was conducted and the results recorded. Test results of both the required test and the alternate test confirm comparable results. (Attachment 2)

Recommendation

Our recommendation is based upon the data supplied by Brookville, the results of the tests conducted on December 23, 2008, as well as the data acquired and observations made during our investigation. The TAC has determined that the Cummins QSB4.5 110HP Engine with a M30 DST exhaust and emission control system meets all requirements of Section 203-A of Article II-A of the Pennsylvania Bituminous Coal Mine Act. As such, we are recommending approval of the above described diesel power package. This recommendation is provided with the understanding that the General Specification Sheet (Attachment 1) be strictly adhered to.

Although the diesel powered package can withstand the emissions tests as described in Sections 217-A and 218-A of Article II-A, we recommend approval of the attached Alternative Test Procedure (Attachment 3). Test results of both the required test and the alternate test confirm comparable results and as such we recommend the use of the alternate test.


Paul Borchick


Ron Bowersox

**BROOKVILLE EQUIPMENT CORP.
MODEL 18M116D
Diesel 18-Man Personnel Carrier**

General Specifications of the Diesel-Powered Equipment Package

| | | | | |
|--|--------------------|------------------------------|---------------|-----------------------|
| Engine Manufacturer | | CUMMINS | | |
| Engine Model | | QSB4.5 | | |
| Horsepower | | 110 HP | | |
| Rated Speed | | 2500 RPM | | |
| Manufacturer's Recommended Exhaust Back-pressure (InH2O) | | 40.826 Inches Water Gauge | | |
| Maximum Exhaust Out Temperature | | 777 deg F | | |
| MSHA Engine Approval | | MSHA Part 7 | | |
| MSHA Certification No. | | 07-ENA040006 | | |
| Rated Speed | | 2500 RPM | | |
| Rated Horsepower | | 110 HP | | |
| Exhaust GAS Flow (SCFM) | | 701 CFM @ 414 deg C | | |
| ISO 8178-1 Average DPM (gr/hr) | | 11.1 gr/hr | | |
| Average Ambient DPM Level (mg/m3) | | 0.0311 mg/m3 | | |
| MSHA Ventilation Rate (CFM) | | 4,500 CFM (Part 7) | CFM (Part 32) | |
| Pa. State Ventilation Rate (CFM) | | | | |
| Emissions Control System | | DST Management System | | |
| Fuel Injection Pump | Make | Cummins | | |
| | P/N | LP 90312 | | |
| Oxidation Catalyst | Make | Syncat Corp. | | |
| | P/N | M241-260-01 | | |
| Heat Exchanger | Make | Paas Tech. | | |
| | P/N | M30-411-01 | | |
| DPM Filter | Make | Fleet Guard | Model | M 30 |
| | P/N | M 30 | Filter Size | 16 x 12 in Diameter |
| | Air Rating (CFM) | 345 CFM | Filter Length | 20 in |
| | Surface Area (in3) | 42,231 in3 | | |
| | Efficiency | | | |
| Recommended Exhaust Back-Pressure | | | | 25 Inches Water Gauge |

ATTACHMENT 1

CALCULATION: AMBIENT DPM EMISSION LEVEL FOR CUMMINS QSB4.5 ENGINE

BASED ON SOUTHWEST RESEARCH INSTITUTE TEST DATA

RE: To meet the requirements of the Pennsylvania ACT 182 Diesel Powered Equipment Law, Section 203-A, a) 1), entitled Exhaust Emission Control

To comply with section 203-A-a-1, the tailpipe emissions for the equipment cannot exceed $0.12\text{mg}/\text{m}^3$, when diluted by 100% of the MSHA approval plate ventilation rate for that diesel engine.

For Brookville Mining Equipment Corporation's request for BOTE modification approval for our Model 18M116D personnel carrier/locomotive, the Cummins Diesel Engine will be used at 110 hp @ 2500 rpm.

MSHA specifications for the Cummins QSB4.5:
Approval No: 07-ENA040006
Ventilation Req't: 4,500 cfm

The MSHA approved ventilation rate for the Cummins QSB4.5 is as follows:

Ventilation Rate: 4,500 cfm under MSHA approval 07-ENA040006

Using the equation:

$$\text{Ambient DPM Level} = \text{DPM}_{\text{AVG}} = \text{PT}/V_{\text{vent}}$$

Where:

V_{VENT} = Quantity of ventilation air req'd per MSHA 24/D88

$$= \frac{4,500 \text{ ft}^3}{\text{min}} \times \frac{1 \text{ m}^3}{35.31 \text{ ft}^3}$$

$$= 127.44 \text{ m}^3/\text{min}$$

DPM volume extracted from Cummins /MSHA Research Test Data:

| Mode Number | DPM Corrected (g/hr) | Weighting Factor | DPM X Weighting Factor |
|-------------|----------------------|------------------|------------------------|
| 1 | 20.10 | .15 | 3.01 |
| 2 | 19.56 | .15 | 2.93 |
| 3 | 13.73 | .15 | 2.06 |
| 4 | 8.86 | .10 | 0.89 |
| 5 | 6.50 | .10 | 0.65 |
| 6 | 6.49 | .10 | 0.65 |
| 7 | 6.74 | .10 | 0.67 |
| 8 | 1.57 | .15 | 0.24 |

Average DPM level over 8178-1 8 mode Test = 11.103 g/hr

Based on Southwest Research Institute testing filter efficiency was found to be 96.9%. Therefore the DPM would be $11.103 \times .031 = 0.344$ g/hr

PT = Average DPM level

$$= \frac{0.344 \text{ gr}}{1 \text{ hour}} \times \frac{1000 \text{ mg}}{1 \text{ gr}} \times \frac{1 \text{ hour}}{60 \text{ min}}$$

$$= 5.733 \text{ mg/min}$$

SOLVE FOR AMBIENT DPM LEVEL:

$$\text{DPM}_{\text{AMB}} = \frac{(5.733 \text{ mg/min})}{184.08 \text{ m}^3/\text{min}}$$

$$= 0.0311 \text{ mg.m}^3$$

CONCLUSION: To comply with section 203-A-a-1, the tailpipe emissions for the equipment cannot exceed 0.12 mg/m^3 , when diluted by 100% of the MSHA approval plate ventilation rate for that diesel engine. $0.0311 \text{ mg/m}^3 < 0.12 \text{ mg/m}^3$, therefore, this engine package meets the requirement.

BROOKVILLE DIESEL 18M116D 9 TON PERSONNEL CARRIER ENGINE: CUMMINS MODEL QSB4.6 110 HP AT 2500 RPM

| 5 MINUTE TEST DATE | RAW TEST | TEST | | | | |
|--------------------|------------|--------|--------|---------|---------|-------|
| | 12/23/2008 | | | | | |
| TIME | O2 % | CO ppm | NO ppm | NO2 ppm | NOX ppm | CO2 % |
| 0:00:00 | 14 | 533 | 117 | 64 | 181 | 5.1 |
| 0:00:30 | | | | | | |
| 0:01:00 | 13.9 | 166 | 140 | 52 | 192 | 5.2 |
| 0:01:30 | | | | | | |
| 0:02:00 | 13.8 | 155 | 145 | 48 | 193 | 5.3 |
| 0:02:30 | | | | | | |
| 0:03:00 | 13.8 | 145 | 153 | 43 | 196 | 5.3 |
| 0:03:30 | | | | | | |
| 0:04:00 | 13.9 | 144 | 156 | 42 | 198 | 5.2 |
| 0:04:30 | | | | | | |
| 0:05:00 | 13.9 | 142 | 159 | 42 | 201 | 5.2 |
| 0:05:30 | | | | | | |
| 0:06:00 | | | | | | |

| | ENGINE TEMP | ENGINE OIL TEMP | TRANSMISSION OIL TEMP | EXHAUST GAS TEMP |
|-------|-------------|-----------------|-----------------------|------------------|
| START | 180 | 160 | 130 | 160 |
| END | 190 | 160 | 220 | 170 |

| 5 MINUTE TEST DATE | TREATED TEST | TEST | | | | |
|--------------------|--------------|--------|--------|---------|---------|-------|
| | 12/23/2008 | | | | | |
| TIME | O2 % | CO ppm | NO ppm | NO2 ppm | NOX ppm | CO2 % |
| 0:00:00 | 15.6 | 677 | 253 | 36 | 289 | 4 |
| 0:00:10 | 14.8 | 591 | 202 | 29 | 231 | 4.5 |
| 0:00:20 | 14.4 | 337 | 201 | 24 | 225 | 4.8 |
| 0:00:30 | 14.4 | 180 | 209 | 19 | 228 | 4.8 |
| 0:00:40 | 14.4 | 101 | 215 | 17 | 232 | 4.8 |
| 0:00:50 | 14.4 | 60 | 219 | 16 | 235 | 4.8 |
| 0:01:00 | 14.4 | 43 | 221 | 15 | 236 | 4.8 |
| 0:01:10 | 14.3 | 32 | 220 | 15 | 235 | 4.9 |
| 0:01:20 | 14.3 | 27 | 221 | 15 | 236 | 4.9 |
| 0:01:30 | 14.3 | 24 | 222 | 15 | 237 | 4.9 |
| 0:01:40 | 14.3 | 22 | 224 | 15 | 239 | 4.9 |
| 0:01:50 | 14.3 | 21 | 225 | 15 | 240 | 4.9 |
| 0:02:00 | 14.3 | 19 | 226 | 15 | 241 | 4.9 |
| 0:02:10 | 14.3 | 18 | 227 | 14 | 241 | 4.9 |
| 0:02:20 | 14.3 | 17 | 228 | 14 | 242 | 4.9 |
| 0:02:30 | 14.3 | 17 | 229 | 14 | 243 | 4.9 |
| 0:02:40 | 14.3 | 16 | 230 | 14 | 244 | 4.9 |
| 0:02:50 | 14.3 | 16 | 231 | 14 | 245 | 4.9 |
| 0:03:00 | 14.3 | 15 | 232 | 14 | 246 | 4.9 |
| 0:03:10 | 14.3 | 15 | 232 | 14 | 246 | 4.9 |
| 0:03:20 | 14.3 | 15 | 232 | 14 | 246 | 4.9 |
| 0:03:30 | 14.4 | 15 | 230 | 14 | 244 | 4.8 |
| 0:03:40 | 14.4 | 15 | 229 | 14 | 243 | 4.8 |
| 0:03:50 | 14.4 | 15 | 229 | 15 | 244 | 4.8 |
| 0:04:00 | 14.4 | 15 | 229 | 15 | 244 | 4.8 |
| 0:04:10 | 14.4 | 14 | 228 | 15 | 243 | 4.8 |
| 0:04:20 | 14.4 | 15 | 227 | 15 | 242 | 4.8 |
| 0:04:30 | 14.4 | 15 | 229 | 15 | 244 | 4.8 |
| 0:04:40 | 14.4 | 14 | 230 | 14 | 244 | 4.8 |
| 0:04:50 | 14.4 | 14 | 231 | 14 | 245 | 4.8 |
| 0:05:00 | 14.4 | 14 | 231 | 14 | 245 | 4.8 |
| 0:05:10 | | | | | | |
| 0:05:20 | | | | | | |
| 0:05:30 | | | | | | |

| | ENGINE TEMP | ENGINE OIL TEMP | TRANSMISSION OIL TEMP | EXHAUST GAS TEMP |
|-------|-------------|-----------------|-----------------------|------------------|
| START | 180 | 160 | 130 | 160 |
| END | 190 | 180 | 220 | 170 |

| 90 SECOND TEST DATE | TREATED TEST | TEST | | | | |
|---------------------|--------------|--------|--------|---------|---------|-------|
| | 12/23/2008 | | | | | |
| TIME | O2 % | CO ppm | NO ppm | NO2 ppm | NOX ppm | CO2 % |
| 0:00:00 | 15.3 | 90 | 211 | 12 | 223 | 4.2 |
| 0:00:10 | 14.6 | 115 | 216 | 13 | 229 | 4.7 |
| 0:00:20 | 14.5 | 90 | 218 | 12 | 230 | 4.8 |
| 0:00:30 | 14.5 | 55 | 218 | 12 | 230 | 4.8 |
| 0:00:40 | 14.6 | 36 | 218 | 12 | 230 | 4.7 |
| 0:00:50 | 14.6 | 26 | 221 | 13 | 234 | 4.7 |
| 0:01:00 | 14.6 | 22 | 222 | 13 | 235 | 4.7 |
| 0:01:10 | 14.6 | 19 | 223 | 13 | 236 | 4.7 |
| 0:01:20 | 14.6 | 18 | 224 | 14 | 238 | 4.7 |
| 0:01:30 | 14.6 | 17 | 225 | 14 | 239 | 4.7 |

| | ENGINE TEMP | ENGINE OIL TEMP | TRANSMISSION OIL TEMP | EXHAUST GAS TEMP |
|-------|-------------|-----------------|-----------------------|------------------|
| START | 185 | 180 | 170 | 170 |
| END | 190 | 180 | 205 | 175 |

| 90 SECOND TEST DATE | RAW TEST | TEST | | | | |
|---------------------|------------|--------|--------|---------|---------|-------|
| | 12/23/2008 | | | | | |
| TIME | O2 % | CO ppm | NO ppm | NO2 ppm | NOX ppm | CO2 % |
| 0:00:00 | 14.7 | 91 | 149 | 53 | 202 | 4.6 |
| 0:00:30 | 14.1 | 160 | 144 | 51 | 195 | 5.1 |
| 0:01:00 | 14.1 | 158 | 144 | 51 | 195 | 5.1 |
| 0:01:30 | 14.1 | 158 | 144 | 51 | 195 | 5.1 |

| | ENGINE TEMP | ENGINE OIL TEMP | TRANSMISSION OIL TEMP | EXHAUST GAS TEMP |
|-------|-------------|-----------------|-----------------------|------------------|
| START | 185 | 180 | 170 | 170 |
| END | 190 | 180 | 205 | 175 |

ATTACHMENT 2

**ALTERNATIVE STALL TEST PROCEDURE FOR PA STATE ACT 182, ARTICLE II-A
DIESEL-POWERED EQUIPMENT**

ALTERNATE PROCEDURE, Section 217-A: (an alternative to items 8 through 14)

1. Place the equipment into an intake entry. Make sure no personnel are in front of or behind the equipment during test.
2. Set the brakes and chock the wheels.
3. Start the diesel engine and allow it to warm up to operating temperature.
4. Install the carbon monoxide CO sampling devices into the untreated exhaust gas port provided.
5. Allow CO sampling device to stabilize.
6. Put the transmission in high gear.
7. With brake still applied, put the engine at full throttle to induce converter stall for 90 seconds. Stop test immediately if any controls or indicators are not in their operating range, or if equipment moves while at stall.
8. Record three CO readings at 60, 75, and 90-second intervals during converter stall.
9. Return engine to low idle and put transmission in neutral. Allow the torque converter temperature to stabilize.
10. Take an average of the three readings.
11. Comply with record-keeping requirements pursuant to Section 214-A.

ALTERNATIVE PROCEDURE, Section 218-A: (an alternative to items 10-14)

1. Place the equipment into an intake entry. Make sure no personnel are in front of or behind the equipment during test.
2. Set the brakes and chock the wheels.
3. Start the diesel engine and allow it to warm up to operating temperature.
4. Install the carbon monoxide CO sampling device into the untreated exhaust gas port provided.
5. Allow CO sampling device to stabilize.
6. Put the transmission in high gear.
7. With brakes still applied, put the engine at full throttle to induce converter stall for 90 seconds. Stop test immediately if any controls or indicators are not in their operating range, or if equipment moves while at stall.
8. Record three CO readings at 60, 75, and 90-second intervals during converter stall.
9. Return engine to low idle and put transmission in neutral. Allow the torque converter temperature to stabilize.
10. Take an average of the three CO readings.
11. Install the carbon monoxide CO sampling device into the treated exhaust gas port provided.
12. Repeat steps (5) thru (10).
13. If CO reading for untreated exhaust gas is greater than twice the baseline established under 217-A(b), or if the CO reading for treated exhaust is greater than 100 ppm, the equipment has failed and must be serviced and retested before it is returned to regular service; and
14. Comply with record-keeping requirements pursuant to Section 214-A.