Dust Division

MEMORANDUM FOR MICHAEL A. DAVIS
District Manager, Metal and Nonmetal Mine Safety and Health,
Southeastern District, Birmingham, Alabama

THROUGH: EDWARD J. MILLER
Chief, Pittsburgh Safety and Health Technology Center

ROBERT A. HANEY
Chief, Dust Division

FROM: MARK J. SCHULTZ
Chief, Environmental Assessment and Contaminant
Control Branch

SUBJECT: Diesel Particulate Concentrations from Diesel Particulate
Matter Studies at the Carmeuse North America, Inc., Maysville
Mine, Mine I.D. No. 15 07101, Maysville, Kentucky

Attached is a report of the diesel particulate compliance assistance visit at Carmeuse North America, Inc., Maysville Mine (I.D. No. 15 07101), Maysville, Kentucky. The study was conducted to evaluate the effectiveness of using a yellow grease biodiesel fuel to reduce diesel particulate emissions in an underground metal and nonmetal mine. A 20-80% biodiesel mixture, B20, DPM study was evaluated on December 10, 11, and 12, 2002; and a 50-50% biodiesel mixture, B50, was evaluated on January 7, 8, and 9, 2003; and a straight diesel mixture (baseline study) was evaluated on February 4, 5, and 6, 2003.

If you have any questions regarding this study, please contact this office at (412) 386-6859.

Attachment

bcc: MNM (C. Jones)
TS (L. Zeiler)
MNM (J. Etterer)
TS (E. Miller)
TS (R. Haney)
TS (M. Schultz)
TS (D. Atchison)
NIOSH (J. Noll)
Chron. Files
Report No. DD-03-808

MSHA:TS: RHaney:cmm:05/22/03:Rm106:038:412-386-6858
T:\Dust\EACC03\maysville3.doc

UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION

Environmental Diesel Particulate Matter Investigation

PS&HTC-DD-03-808

Maysville Mine
Carmeuse North America, Inc.
Maysville, Kentucky
Mine I.D. No. 15 07101

December 10, 11, and 12, 2002
January 7, 8, and 9, 2003
February 4, 5, and 6, 2003

by

Mark Schultz
Supervisory Mining Engineer

and

David J. Atchison
Mining Engineering Technician

Objective

To evaluate the effect biodiesel fuel on diesel particulate emissions and personal exposure in an underground nonmetal mine.

Originating Office

Pittsburgh Safety and Health Technology Center
Robert A. Haney
Chief, Dust Division
Cochrans Mill Road, P. O. Box 18233
Pittsburgh, Pennsylvania 15236

INTRODUCTION

A three-part diesel particulate survey was conducted at the underground Maysville Mine (I.D. No. 15 07101), Maysville, Kentucky. The purpose of the study was to evaluate the effect of biodiesel fuel on diesel particulate emissions and personal exposure in an underground nonmetal mine. Two different biodiesel fuel mixtures were tested during normal underground mining operations along with a baseline study. The surveys were jointly conducted by Mine Safety and Health Administration (MSHA) personnel and Carmeuse North America, Inc. personnel. The surveys were conducted at the request of the District Manager, Metal and Nonmetal Mine Safety and Health, Southeastern District. MSHA personnel involved in the studies were Mark Schultz, Supervisory Mining Engineer, and David J. Atchison, Mining Engineering Technician, both of Dust Division, Pittsburgh Safety and Health Technology Center; and Judith Etterer, Industrial Hygienist, Southeastern District.

A 20-80% (B20) biodiesel mixture diesel particulate matter (DPM) study was evaluated on December 10, 11, and 12, 2002; a 50-50% (B50) biodiesel mixture was evaluated on January 7, 8, and 9, 2003; and a straight diesel mixture (baseline study) was evaluated on February 4, 5, and 6, 2003. The B20 and B50, for this test, were formulated using Recycled Vegetable Oil. This product was referred to as "Yellow Grease."

BACKGROUND

The Maysville Mine, located in Mason County, Kentucky, is an underground limestone mine owned and operated by Carmeuse North America, Inc. The Camp Nelson limestone formation is mined. The mine operates two 10-hour production shifts per day to produce approximately 3.5 million tons of limestone annually. The active mining area is approximately 1,000-feet deep. Mined entries were approximately 40 to 50 feet with the final mining height ranging from 50 to 60 feet. The limestone deposit is mined using a regular room and pillar, heading and bench mining method. The headings are approximately 20-feet high and the bench ranged from 30 to 40 feet in height. This process resulted in a mine layout consisting of an upper level, which eventually was shot down to a lower level.

A conventional mining system, where the limestone is drilled and blasted, was used to mine the limestone deposit. This process consisted of drilling the face or the floor and then loading the drilled holes with ammonium nitrate and fuel oil (ANFO). The blasting sequence was initiated at the end of each shift with a two-hour idle period allowed for the gasses and other contaminants to be removed by the ventilation system. The broken stone was then loaded at the faces by front-end loaders into 40-ton haulage trucks. The trucks transported the material to a crusher and a belt feeder. The conveyor system carried the stone from the crusher area and out of the mine via an

18° slope. On the surface, the stone was further crushed and screened. The product was calcined to produce Thiosorbic lime, a material used as a scrubbing agent for removing sulfur-dioxide from stack gases at coal-fired power plants. Undersized-material was sold for road-fill, backfill, or transported back into the mine. The diesel equipment used to mine limestone included: front-end loaders, haul trucks, scalers, roof bolters, face drills, a grader, a dozer, a water truck, a service truck, an explosives truck, fork lifts, and tractors. A list of all underground diesel equipment can be found in Appendix A.

Primary airflow was induced into the mine using ventilation fans located underground at the base of two vertical shafts. One intake was the main intake shaft (elevator shaft) and the other intake shaft (1 West shaft) was located off of the M-roadway in 1 West drift between panel 4 North and 4 South. Each fan installation consisted of a set of fans that worked in parallel with each other; installed side-by-side. The ventilation system induced an average mine airflow of approximately 878,000 cubic feet per minute (cfm). Air entered the mine at the elevator shaft the 1 West intake shaft. Air was then coursed to the working areas by air walls. Air wall lines were constructed of belting material approximately 10-feet long and anchored to the mine roof. Recycled fines, or waste rock, that had been brought back into the mine were then placed under the belting to complete the air wall. Freestanding auxiliary fans, which had no ductwork or tubing, induced additional ventilation to the working panels. This intake air was coursed throughout the mine to two exhaust areas, an exhaust shaft, and the belt slope. An average airflow of 629,000 cfm was measured exhausting out of the main exhaust shaft while an average of 249,000 cfm was measured exhausting out the slope. The exhaust shaft was located between the 1 North and 2 North panels while the slope was located near the main intake elevator shaft.

Ms. Melissa Howell, Executive Director for The Kentucky Clean Fuels Coalition, coordinated funding provided from two outside sources to conduct the survey. Funding was provided by The Kentucky Division of Energy and by Griffin Industries, Inc.

Biodiesel is a methyl ester product produced by combining methanol oil or feedstock, then adding a catalyst. Glycerine is spun off during the refining process with the remaining product being termed a mono-alkyl ester known as biodiesel. Biodiesel can be made from a variety of feedstocks, including soybeans, rapeseed, canola, and palm oil as well as from recycled vegetable oils. The biodiesel used for this study was the recycled vegetable oil, more commonly referred to as “yellow grease.” The biodiesel fuel was purchased from Griffin Industries, Inc.

During the studies, blends of 0/100%, 20/80%, and 50/50% biodiesel to diesel fuel were used. A partially filled fuel truck with diesel fuel was driven to Griffin Industries where the appropriate amount of biodiesel fuel was added to obtain the proper mixture. Mixing of the products occurred during transportation to the mine and during transfer to other storage tanks located within the mine. Each study lasted approximately 2 weeks. During the first week of each study, the equipment was given time to adjust to the new type of fuel. This week also gave the mine environment time to clear from the old exhaust air. DPM sampling was conducted during the second week of the study. Both MSHA personnel and mine personnel conducted DPM sampling. This report only discusses MSHA sampling results. The company was using low sulfur Number 2 diesel fuel with the biodiesel mixtures. During the standard diesel (baseline) study, Number 2 low sulfur diesel fuel was the only diesel fuel used at the mine.

Although not part of the MSHA study, several comments regarding operating characteristics and employee perception of the biodiesel blends are in order. The equipment operated well on the B20 blend, experiencing no notable mechanical problems. During the B50 test, some of the equipment experienced fuel filter plugging, requiring replacement in as little as 10 operating hours. As the biodiesel is a strong solvent, maintenance personnel speculated that engine deposits might have been mobilized. When several filters were cut open, no contaminates could be seen. However, the filter medium was saturated and the entire assembly was considerably heavier than filters changed for routine maintenance.

Employees' comments were generally favorable regarding the visual and odor aspects of the mine air with both biodiesel blends. Comments on power loss were not rare, but may have been related to fuel filter pluggage rather than combustion characteristics.

SAMPLING AND ANALYTICAL PROCEDURES

Generally, six area samples and five personal samples were collected during each day of the three-phase study. Area samples were collected as follows: one each at the two main intake locations, the bottom of the intake airshaft (elevator shaft) and the outlet end of the dual intake fans located at the 1 West shaft; return samples, two at the bottom of the return airshaft and two approximately 400 feet up the slope.

The study sampling was designed to determine whether concentration reductions were significant at the 95% confidence level. Prior to the test, it was assumed that the baseline exhaust concentration would be approximately 400 $\mu g/m^3$ with a standard deviation of 20% and the reduction from biodiesel fuel would be approximately 20%.

A "t-test" would be used to determine whether reductions were significant. The critical "t" values for a 95% confidence limit range from 2 to 3. Using the following "t-test" equation:

$$t = \frac{(xi - xo)}{s / (n)^{1/2}}$$

Where:

xi = Initial concentration,
xo = Final concentration,
s = Standard deviation, and
n = Sample size.

Solving for the sample size "n" gives:

$$n = \frac{t^2 \text{ x } (s)^2}{(xi - xo)^2} \quad \text{or} \quad n = \frac{2.5^2 \text{ x } (80)^2}{(400 - 320)^2} \sim \quad 6 \text{ samples}$$

To allow for variability and mine operational delays, a sample size of 6 was selected. This resulted in the collection of 2 samples per day for 3 days at each of the mine intake and exhaust air locations (shafts and slope). The critical "t" value at 95% for a two-sided test with 5 degrees of freedom (6 – 1 samples) is 2.571. This value was used in the analysis of the data to confirm significance.

In addition to the six area samples (one at each intake shaft, two at the exhaust slope, and two at the exhaust shaft), five personal samples were collected on each shift. The personal samples were collected on individuals depending on the availability of the mine personnel. Those sampled were loader operators, truck drivers, high scalers, face scalers, face drills, roof bolters, down hole drill operators, and the powdermen.

Individual area and personal samples were collected with SKC, Inc. diesel particulate sampling cassettes. This cassette includes a submicron impactor and a quartz fiber filter. All sampling units used 10-millimeter nylon preseparator cyclones. Samples were collected using SKC pumps and MSA Elf's calibrated and operated at 1.7 liters per minute (Lpm) of airflow. Smoking was permitted underground in the mine. There were not enough nonsmokers working production, so smokers and nonsmokers were selected for sampling.

The airborne carbon samples were analyzed by NIOSH at the Pittsburgh Research Laboratory, according to NIOSH Method 5040. Elemental carbon (EC), organic carbon (OC), and total carbon (TC) values were determined from the samples collected. This method uses a thermal/optical carbon analyzer to determine the organic and EC matter per square centimeter of filter surface. Separation of different types of OC is accomplished through temperature ramping over time and controlled atmospheric conditions. Carbonaceous minerals are separated at a temperature of 750°C (fourth OC peak). The carbonaceous mineral content, evolved at the 750°C peak, was subtracted from the OC portion of the analysis, using the software capability of the analytical program. This correction for the carbonaceous mineral content was made because it is associated with mineral dust and is not considered diesel particulate. OC and EC were added together to obtain the TC. A field blank correction was also applied to the carbon measurements. If the field blank correction resulted in a negative carbon measurement, the carbon measurement was defaulted to zero. Concentrations of carbon were calculated from the following formulas:

$$\text{Carbon Concentration } (\mu g/m^3) = \frac{C\ (\mu g/cm^2) * A\ (cm^2) * 1{,}000\ L/m^3}{1.7\ \text{Lpm} * \text{Time (min)}}$$

and,

$$TC = OC + EC \qquad \text{or} \qquad TC = 1.3 \times EC$$

Where:

C = The corrected OC or EC, concentration measured in the thermal/optical carbon analyzer.

A = The surface area of the filter media used. The surface area of the filters is 8.04 cm^2**.**

All area sample concentrations were based on actual sampling time resulting in time weighted averages (TWA's). For MSHA enforcement activities, normal MSHA Metal and Non-metal protocol is to base all personal samples as shift weighted averages (SWA's). SWA's calculations use 480 minutes as the sampled time regardless of the time sampled. The personal samples are reported as SWA's.

RESULTS AND DISCUSSION

Tables 1 and 2 show the average results of area and personal samples. The information compiled in Tables 1 and 2 was derived from the data in Appendices B and C. Appendices B and C are the raw data concentrations measured during each of the 3-day studies. Appendix B is the raw data for the area samples and Appendix C is the raw data for the personal samples.

During the baseline survey, the elevator shaft intake air concentration ranged from 0 to 5 µg/m^3 of TC for an average of 2 µg/m^3. The 1 West intake air shaft concentrations ranged from 3 to 5 µg/m^3 of TC for an average of 4 µg/m^3. The low intake TC DPM concentrations indicate the intake air was relatively free of TC DPM and that the increases in TC DPM levels were due to conditions in the mine.

Table 1 contains the summary of the average area DPM sampling results for the three surveys. The exhaust weighted average concentration was obtained by multiplying the individual return concentrations by the associated airflow then dividing the sum of these two products by the total airflow. Using the TC = EC × 1.3 data, this table shows that the weighted return average DPM for the baseline samples was 352 µg/m^3. When the B20 biodiesel mixture was used, the weighted average return concentration was reduced to 235 µg/m^3. When the B50 biodiesel mixture was used, this weighted average return concentration was further reduced to 109 µg/m^3.

Because the total exhaust airflows were similar for each test, a comparison of concentrations can be used to assess the impact of the various blends of bio-diesel fuel. This comparison showed a 33% DPM reduction when using the B20 biodiesel fuel mixture and a 69% DPM reduction when using the B50 biodiesel fuel mixture. When using TC = EC + OC data, similar reductions are seen. Figure 1 is a graph showing the DPM concentrations at the slope and at the return shaft during all three of the surveys. As seen on the graph, DPM concentrations decreased as the percentage of biodiesel fuel increased. All the percent reductions were determined to be statistically significant at the 95% level.

Table 2 is a SWA summary of the averages of the personal DPM sampling for all employees sampled. Table 2 is further broken down into employees working inside of cabs and employees working outside of cabs. Since the surveys covered 9 separate days of sampling with each 3-day study separated by approximately 1 month, the results of the personal sampling data were affected by numerous variables. Different pieces of equipment were used, different locations were mined, employees sampled varied, occupations sampled varied, ventilating air quantities changed, and daily production tonnages varied. Since smoking affected the OC concentrations, the formula TC = EC x 1.3 was used to evaluate personal TC DPM concentrations.

Table 2 shows that the average TC = EC x 1.3 concentration of employees working inside of cabs during the baseline survey was 220 $\mu g/m^3$. During the B20 biodiesel survey, this average concentration was 219 $\mu g/m^3$. During the B50 biodiesel survey, this average concentration was reduced to 89 $\mu g/m^3$. These concentrations correspond to less than a 1% TC DPM reduction during the B20 biodiesel survey and a 60% TC DPM reduction during the B50 biodiesel survey. Miners working outside of cabs showed similar results. The average TC concentration of employees working outside of cabs during the baseline survey was 300 $\mu g/m^3$. During the B20 biodiesel survey, this average concentration was reduced to 208 $\mu g/m^3$ for a 31% TC DPM reduction. Only one employee fit this category for the B50 biodiesel survey. This employee, working outside of the cab, had a concentration of 216 $\mu g/m^3$ representing a 28% reduction from the baseline concentration.

Because many variables can affect personal sample results, the best indication of the impact of the biodiesel fuel is demonstrated by the area samples collected at the exhaust shafts. The personal samples are effective in determining whether the person sampled would have been in compliance with current and future DPM regulations. Currently, regulations limit total carbon DPM concentrations to 400 $\mu g/m^3$. This concentration will be reduced to 160 $\mu g/m^3$ in the future.

Table 3 is a SWA summary of the personal samples indicating how many employees would have been in compliance with the DPM standard. During the baseline survey, two personal samples exceeded the 400 $\mu g/m^3$ standard, nine employees were in the 161 $\mu g/m^3$ to 399 $\mu g/m^3$ range, and four employees were at 160 $\mu g/m^3$ or less. The roof bolter had both of the concentrations exceeding 400 $\mu g/m^3$. This occupation had SWA concentrations of 601 $\mu g/m^3$ and 440 $\mu g/m^3$ on two different sampling days. During the B20 biodiesel survey, zero employees exceeded the 400 $\mu g/m^3$ standard, thirteen employees were in the 161 $\mu g/m^3$ to 399 $\mu g/m^3$ range, and four employees were at 160 $\mu g/m^3$ or less. The highest personal sample SWA concentration measured during the B20 study was 395 $\mu g/m^3$ measured on truck driver. This truck was not sampled during the baseline survey. During the B50 biodiesel survey, zero employees exceeded the 400 $\mu g/m^3$ standard and only one employee was in the 161 $\mu g/m^3$ to 399 $\mu g/m^3$ range. This employee was the roof bolter. He had a SWA concentration of 216 $\mu g/m^3$. Thirteen employees had SWA concentrations that were at 160 $\mu g/m^3$ or less.

Nitrogen dioxide (NO_2) diffusion tubes were also collected with all of the samples taken. The highest concentrations of NO_2 recorded were 1.5 parts per million (ppm) on the high scaler and on a loader operator. These numbers did not significantly change from survey-to-survey. There was no indication that NO_2 concentrations increased during either the B20 biodiesel fuel mixture or the B50 biodiesel mixture. Mine Safety Appliance Company Passports® were also placed in the return shaft and the slope air currents to monitor these air currents for NO_2, carbon monoxide (CO), and for nitrogen oxides (NO_x). Data loggers on these instruments recorded the average concentration of each gas every minute and also recorded the highest peak every minute. There were no indications of increased levels of the gases monitored. CO and CO_2 diffusion tubes were taken with the slope and return samples. These results ranged from 0 to 5 ppm CO and 800 to 1,200 ppm CO_2 .

FINDINGS AND CONCLUSIONS

1. The highest SWA personal exposure to DPM for the baseline test was a concentration of 601 $\mu g/m^3$ measured on the roof bolter.

2. The highest SWA personal exposure to DPM for the B20 biodiesel test was a concentration of 395 $\mu g/m^3$ measured on a truck driver.

3. The highest SWA personal exposure to DPM for the B50 biodiesel test was a concentration of 216 $\mu g/m^3$ measured on the roof bolter.

4. Based on TC = 1.3 x EC, the weighted exhaust TWA DPM concentration during the baseline, B20 and B50 surveys were 352 $\mu g/m^3$, 235 $\mu g/m^3$, and 109 $\mu g/m^3$, respectively. These concentrations indicate a 33% and 69% DPM reduction when using the B20 and B50 biodiesel fuels.

5. Based on TC = EC + OC, the weighted exhaust TWA DPM concentration during the baseline, B20 and B50 surveys were 321 $\mu g/m^3$, 225 $\mu g/m^3$, and 121 $\mu g/m^3$, respectively. These concentrations indicate a 30% and 62% DPM reduction when using the B20 and B50 biodiesel fuels.

6. Two employees exceeded the 400 $\mu g/m^3$ standard during the baseline survey, while no employees exceeded this standard during the B20 or B50 biodiesel tests.

7. The use of biodiesel fuel reduced did not have a significant effect on ambient gaseous emissions or exposures.

Table 1. Average Area Sample Diesel Particulate Matter Concentrations (TWA), B20 December 10-12, 2002; B50 January 8-10, 2003; and Baseline February 4-6, 2003

	Baseline				B20 Recycled Vegetable Oil Biodiesel				B50 Recycled Vegetable Oil Biodiesel			
Location	Airflow (cfm)	TC EC x 1.3 (μg/m^3	TC EC + OC (μg/m^3)	Ratio EC/TC	Airflow (cfm)	TC EC x 1.3 (μg/m^3)	TC EC + OC (μg/m^3)	Ratio EC/TC	Airflow (cfm)	TC EC x 1.3 (μg/m^3)	TC EC + OC (μg/m^3)	Ratio EC/TC
Intake Elevator Shaft		2	2	0.69		2	3	0.37		1	5	0.23
Intake 1 West Shaft		2	4	0.29		9	12	0.61		4	4	0.75
Shaft Return	643,000	446	398	0.86	624,000	274	258	0.81	619,000	124	135	0.70
Slope	249,000	111	123	0.69	259,000	143	146	0.75	239,000	72	86	0.64
Exhaust Weighted Average	892,000	352	321		883,000	235	225		858,000	109	121	
Percent Reduction From Baseline						**33%**	**30%**			**69%**	**62%**	

Table 2. SWA Summary of Personal Diesel Particulate Matter Concentrations, B20 December 10-12, 2002;
B50 January 8-10, 2003; and Baseline February 4-6, 2003

	Baseline	B20 Biodiesel	B50 Biodiesel
Occupation	TC EC x 1.3 (µg/m^3)	TC EC x 1.3 (µg/m^3)	TC EC x 1.3 (µg/m^3)
Average – Workers Inside Cabs	220	219	89
Standard Deviation	91	102	21
Percent Reduction From Baseline	-----	0	60
Average – Workers Outside Cabs	300	208	216
Standard Deviation	193	111	One person sampled
Percent Reduction From Baseline	-----	31	28

Table 3. SWA Summary of Personal DPM Samples that Meet or Exceed the Current and Future EC x 1.3 Concentration Limits of 400 and 160 µg/m³, B20 December 10-12, 2002; B50 January 8-10, 2003; and Baseline February 4-6, 2003

Baseline				B20 Biodiesel				B50 Biodiesel			
Date	Above 400 µg/m³	161 to 399 µg/m³	Below 160 µg/m³	Date	Above 400 µg/m³	161 to 399 µg/m³	Below 160 µg/m³	Date	Above 400 µg/m³	161 to 399 µg/m³	Below 160 µg/m³
2/4/03	1	3	1	12/10/02	0	3	2	1/7/03	0	0	4
2/5/03	1	2	2	12/11/02	0	6	0	1/8/03	0	0	5
2/6/03	0	4	1	12/12/02	0	4	2	1/9/03	0	1	4
Totals	2	9	4		0	13	4		0	1	13

Appendix A. Underground Diesel Equipment List,
Maysville Mine, Carmeuse North America, Inc., Maysville, Kentucky

Description	Engine Manufacturer	Date of Manufacture	Engine Model	Engine Serial Number	Engine HP
MY-00002-Getman maintenance/boom vehicle	Caterpillar	3/30/97	3304pc	04B27202	88
MY-00014-electric mlg welder				84WS06786	
MY-00052-Miller diesel welder				165067	
MY-00054-Miller diesel welder				KH342988	
MY-02006-Atlas-Copco face drill	Deutz		FGL921W	6502754	88
MY-02007-Atlas-Copco face drill	Deutz	5/29/85	FGL92W	9047051	88
MY-02009-Atlas-Copco face drill	Deutz	1/10/97	BF4M1013C	135906	142
MY-03005-Gardner Denver bench drill	Caterpillar	3/21/94	#3306B (DITA)	64Z15222	285
MY-03006-Gardner Denver bench drill	Caterpillar	7/8/96	#3306B (DITA)	1GO2R33	285
MY-04006-Getman powder rig	Caterpillar	1/1/97	#3304 (PCT)	04B27206	125
MY-04007-Getman powder rig	Caterpillar	8/1/02	BF4M 1013C	11275	112
MY-06001-CAT 631D w/Kress bed	Caterpillar	11/1/82	3408 (DITA)	48W13227	450
MY-06004-CAT 631D w/Kress bed	Caterpillar	5/27/85	3408 (DITA)	48W19072	450
MY-06005-CAT 631D w/Kress bed	Caterpillar	2/3/86	3408 (DITA)	48W17755	450
MY-06008-CAT 637D w/Kress bed (cert.)	Caterpillar	3/5/01	3408 (DITA)	48W41556	450
MY-06009-CAT 631G w/Kress bed (new)	Caterpillar	12/1/01	3408 (DITA)	5XD00477	450
MY-06010-CAT 631G w/Kress bed (new)	Caterpillar	12/1/01	3408 (DITA)	5XD00478	450
MY-09003-CAT 988B loader (recertified)	Caterpillar	1/28/86	3408 (DITA)	48W20475	375
MY-09006-CAT 988B loader (recertified)	Caterpillar	3/11/98	3408 (DITA)	48W41083	375
MY-09007-CAT 988B loader (recertified)	Caterpillar	10/3/01	3408 (DITA)	50W75773	375
MY-09008-CAT 988G loader (new)	Caterpillar	Apr-02	3456	BNT00471	475
MY-10012-Fletcher mechanical bolter	Caterpillar	9/1/91	3304	2B17895	165

Appendix A (continued)

Description	Engine Manufacturer	Date of Manufacture	Engine Model	Engine Serial Number	Engine HP
MY-10014-Canon manual bolter	Caterpillar	5/13/98	3304	2B18145	165
MY-10015-Fletcher manual Bolter	Caterpillar	5/1/01	BF4M1013C	516131	142
MY-11022-CAT M318 excavator/scaler	Caterpillar	8/21/96	3116 (DIT)	4TF28477	110
MY-11025-CAT M318 excavator/scaler	Caterpillar	11/30/00	3116 (DIT)	4TF66110	110
MY-11026-CAT 320C excavator/scaler	Caterpillar	6/17/02	3116 (DIT)	7JK54942	110
MY-11027-CAT 320M excavator/scaler	Caterpillar	8/26/02	3116 (DIT)	4TF79342	110
MY-12012-J.C./Amador Skyreach 90 F	Deutz	4/15/85	F6L912W		88
MY-12016-J.C./Amador Skyreach	Deutz	6/21/89	F6L912W		88
MY-12021-Amador Skyreach high scaler	Deutz	8/23/95	F6L912W		88
MY-16002-Joy/Longyear diamond drill	Caterpillar	8/16/82	3304 (PCTA)	40763	165
MY-20003-CAT 12G grader	Caterpillar	8/1/87	3306 dina	8Z24631	135
MY-20006-John Deere 455G track loader	John Deere	8/10/92	404 dt004	TO4045D3809	170
MY-20007-CAT 814F wheel dozer	Caterpillar	Jan-02	3306 (DITA)	6NC31541	220
MY-26018-Ford tractor	Ford	4/13/87		C769973	
MY-26022-Kubota tractor	Kubota	4/7/89	S2602-D1-A	S2609-D1-A 15538	48
MY-26023 -Kubota tractor (grease)	Kubota	4/7/89	S2602-D1-A	S2602-D1-A 71387	48
MY-26024 -Kubota tractor (grease)	Kubota	4/7/89	S2602-D1-A	S2062-D1-A 71387	48
MY-26026 -Kubota 5030 tractor	Kubota	6/13/90	S2602-D1-A	S2609-D1A_40760	53
MY -26027-Kubota tractor (electrician)	Kubota	6/13/90	S2602-D1-A	S2808-D1A-32848	48
MY-26028-Kubota tractor (belt crew)	Kubota	6/13/90	S2602-D1-A	S2802- D1-A 71328	53
MY-26029-Kubota tractor (drill crew)	Kubota	3/30/93	S2602-D1-A	S2808-D1-A 71389	53
MY-26030-Kubota tractor (mine maintenance)	Kubota	8/23/95	S2602-D1-A	S2809-D1-A 94909	53
MY-26031-Kubota tractor (mine maintenance)	Kubota	8/23/95	S2602-D1-A	F2808-142389	53

Appendix A (continued)

Description	Engine Manufacturer	Date of Manufacture	Engine Model	Engine Serial Number	Engine HP
MY-26032-Kubota tractor (GU supervisor)	Kubota	8/23/95	S2602-D1-A	8809-147892	53
MY-26033-Kubota tractor (muck supervisor)	Kubota	5/27/98	S2602-D1-A	S2808-139880	53
MY-26034-Kubota tractor (drill supervisor)	Kubota	2/28/99	S2602-D1-A	3-WA154786	53
MY-26035-Kubota tractor (production supervisor)	Kubota	9/7/01	M4900	F2803-YY0966	49
MY-26036-Kubota tractor (maintenance superintendent)	Kubota	9/7/01	M4900	F2808-YZ0456	49
MY-26037-Kubota tractor (mine manager)	Kubota	Jan-02	M4900	3-2G6524	49
MY-26038-Kubota tractor (maintenance 4x4)	Kubota	Jan-02	MX5000 4WD	Y2403-2A0818	36
MY-36004-Fiat-Allis 605 forklift	Kubota	6/15/77	2900 MK11	sD89010	120
MY-36014-Jarvis-Clark service truck	Caterpillar	2/5/87	3306 (PCTA)	66D50162	175
MY-36019-Ingersol-Rand Compressor	John Deere	Jan-98	3029 John Deere	297748UBJ221	80
MY-36024-Getman utility/lift vehicle	Deutz	8/22/91	F6L912W	7853966	88
MY-36025-CAT RC-50 forklift	Caterpillar	9/1/87	LT 437 PERK	LDV160680	70.5
MY-36026-CAT 950 (loader) forklift	Caterpillar	8/3/94	3306 (PCTA)	81J13611	175
MY-36028-Getman utility/lift vehicle	Deutz	12/2/97	FGL912W	8501606	88
MY-36034-CAT 613C w/holt tank	Caterpillar	June-97	3116	8LJ01604	175
MY-36037-CAT D25D service truck	Caterpillar	Dec-95	3306	13Z33746	260
MY-36038-CAT D250E ll w/holt tank	Caterpillar	Jan-00	3360	13Z48482	260
MY-36046-Clark mobile crane	Cummings		Cummings	20176492	210

Appendix B. Results of Area Sample Results, Maysville Mine, B20 December 10-12, 2002; B50 January 8-10, 2003; and Baseline February 4-6, 2003

Location	Baseline				B20 Biodiesel				B50 Biodiesel			
	Airflow (cfm)	TC EC x 1.3 (μg/m^3)	TC EC + OC (μg/m^3)	Ratio EC/TC	Airflow (cfm)	TC EC x 1.3 (μg/m^3)	TC EC + OC (μg/m^3)	Ratio EC/TC	Airflow (cfm)	TC EC x 1.3 (μg/m^3)	TC EC + OC (μg/m^3)	Ratio EC/TC
Intake Elevator Shaft	442300	3	2	0.9	362400	0	1	0.1	405800	1	12	0.1
Intake Elevator Shaft	459000	1	0	1.0	346100	0	0	0.0	416500	2	2	0.8
Intake Elevator Shaft	433600	3	5	0.6	378500	7	5	1.0	440300	1	1	0.8
Intake 1 West Shaft	416500	5	5	0.7	406900	7	12	0.4	407600	5	4	1.0
Intake 1 West Shaft	428900	1	5	0.1	418200	13	13	0.7	403600	6	7	0.7
Intake 1 West Shaft	438200	0	3	0.0	424600	9	11	0.6	395800	1	2	0.5
Return Shaft	626900	632	554	0.9	600500	338	305	0.9	642600	150	159	0.7
Return Shaft	626900				600500				642600	149	161	0.7
Return Shaft	670300	411	371	0.9	645200	209	210	0.8	586400	90	122	0.6
Return Shaft	670300	425	382	0.9	645200	221	233	0.7	586400	120	130	0.7
Return Shaft	631200	392	351	0.9	627400	336	295	0.9	627800	115	115	0.8
Return Shaft	631200	368	331	0.9	627400	264	245	0.8	627800	119	125	0.7
Return Slope	245200	150	159	0.7	259100	121	142	0.7	247000			
Return Slope	245200	93	103	0.7	259100	128	150	0.7	247000	39	56	0.5
Return Slope	251400	110	121	0.7	259100	81	80	0.8	234100	77	105	0.6
Return Slope	251400	124	118	0.8	259100	159	152	0.8	234100	92	85	0.8
Return Slope	249200	92	112	0.6	259100	174	166	0.8	237300	98	116	0.6
Return Slope	249200	96	125	0.6	259100	193	184	0.8	237300	53	65	0.6

Appendix C. Personal Sample Results, Baseline February 4-6, 2003, B20 Biodiesel; December 10-12, 2002; and B50% Biodiesel January 8-10, 2003.

			Baseline		B20 Biodiesel		B50 Biodiesel	
Occupation	Smoker or Non-smoker	Working in Cab Yes or No	TC EC x 1.3 (µg/m^3)	TC EC + OC (µg/m^3)	TC EC x 1.3 (µg/m^3)	TC EC + OC (µg/m^3)	TC EC x 1.3 (µg/m^3)	TC EC + OC (µg/m^3)
Truck 601	n	Yes			395	369		
Truck 601	n	Yes			343	294		
Truck 604	n	Yes			233	208		
Truck 608	s	Yes	390	384			90	214
Truck 608	n	Yes	143	135				
Truck 608	n	Yes	245	243				
Truck 608	s	Yes					84	144
Truck 608	s	Yes					124	183
Loader 908	n	Yes	144	175				
Loader 908	n	Yes	195	171				
Loader 908	n	Yes	191	176				
Loader 908	s	Yes			171	515		
Loader 907	s	Yes	346	419	161	759	88	105
Loader 907	s	Yes			339	361	66	69
Loader 907	s	Yes			140	589	63	69
High Scaler	s	No	186	268				
High Scaler	s	No	76	118				
High Scaler	n	No	191	253				
Clean-Up Loader	n	Yes	140	146	208	194		
Down Hole Drill	s	Yes	186	284				
Down Hole Drill	n	Yes			168	198	116	143
Down Hole Drill	n	Yes			189	208	84	123
Down Hole Drill	n	Yes					89	129
Roof Bolter	s	No	440	424	99	100	216	240
Roof Bolter	s	No	601	573	321	328		
Roof Bolter	s	No	308	314				
Face Scaler	s	Yes			48	406	80	189
Face Scaler	s	Yes			205	326	78	205
Face Scaler	s	Yes			91	140	65	176
Face Scaler	s	Yes			374	446		
Face Drill	n	Yes					124	134
Powderman	n	No			203	211		

Figure 1. Graph of DPM Average Concentrations for the Return Shaft, the Slope, and the Weighted Exhaust, December 10-12, 2002; January 8-10, 2003; and February 4-6, 2003