Dust Division

MEMORANDUM FOR MICHAEL A. DAVIS
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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 (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 soybean-based biodiesel fuel to reduce diesel particulate emissions in an underground metal and nonmetal mine. A straight diesel mixture (baseline study) was evaluated on February 4, 5, and 6, 2003, and a B50 soybean-based biodiesel mixture was evaluated on April 1, 2, and 3, 2003.

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

Attachment

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Report No. DD- 03-311

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UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION

Environmental Diesel Particulate Matter Investigation

PS&HTC-DD-03-311

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

February 4, 5, and 6, 2003
April 1, 2, and 3, 2003

by

Mark J. Schultz
Supervisory Mining Engineer

and

David J. Atchison
Mining Engineering Technician

Objective

To evaluate the effectiveness of using a soybean-based biodiesel fuel to reduce diesel particulate emissions in an underground metal and nonmetal mine.

Originating Office

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INTRODUCTION

A two-part diesel particulate survey was conducted at the underground Maysville Limestone Mine (I.D. No. 15 07101), Maysville, Kentucky. The purpose of the study was to evaluate the effectiveness of using a soybean-based biodiesel fuel to reduce diesel particulate emissions in an underground metal and nonmetal mine. The survey was conducted at the request of the District Manager, Metal and Nonmetal Mine Safety and Health, Southeastern District. The survey was jointly conducted by Mine Safety and Health Administration (MSHA) personnel and Carmeuse North America, Inc. personnel. MSHA personnel involved in the study were Mark Schultz, Supervisory Mining Engineer, and David Atchison, Mining Engineering Technician, both of Dust Division, Pittsburgh Safety and Health Technology Center.

A straight diesel mixture (baseline study) was evaluated on February 4, 5, and 6, 2003. A 50-50% (B50) soybean-based biodiesel fuel mixture was evaluated on April 1, 2, and 3, 2003. The B50, for this test, was formulated using Virgin Soy Oil.

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 wide 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 in height 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 is listed 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 panels 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. This ventilation system induced an average mine airflow of approximately 892,000 cubic feet per minute (cfm) during the baseline survey and 748,000 cfm during the B50 soybean biodiesel survey. The change in airflow was the result from a change in natural ventilating pressures (NVP) occurring between the baseline survey and the B50 soybean survey. Surface air temperature changed from 40° Fahrenheit during the baseline survey to 85° Fahrenheit range during the soybean survey. During the baseline survey, NVP assisted with the mine mechanical ventilation, but during the soybean survey, NVP worked against the mine mechanical ventilation.

Air entered the mine at the elevator shaft and the 1 West intake shaft during the baseline survey. These air quantities were proportionately reduced during the soybean survey. 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. During the baseline survey, an average airflow of 640,000 cfm was measured exhausting out of the main exhaust shaft while an average of 250,000 cfm was measured exhausting out the slope. During the soybean survey, an average airflow of 530,000 cfm was measured exhausting out of the main exhaust shaft while an average of 220,000 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.

The quantity of air ventilating the mine decreased by 16% from the baseline survey to the soybean survey. Since the quantity of air is directly proportional to the dilution capacity, a comparison of the results of the two surveys will have to consider the increased air quantity during the baseline survey.

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 produced from soybeans. The biodiesel fuel was purchased from Peter Cremer North America.

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 B50 blend, experiencing no notable mechanical problems. Employees' comments were generally neutral to unfavorable regarding the visual aspects of the mine air (white smoke rather than black smoke). Very few comments were made regarding perceived (or real) power loss.

SAMPLING AND ANALYTICAL PROCEDURES

Six area and five personal samples were collected during each day of the two-phase study. Area samples were collected at two main intake locations: one at the bottom of the elevator shaft and one at the outlet end of the dual intake fans located at the 1 West shaft. Return samples were also taken: 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" was 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,
n = Sample size.

Solving for the sample size "n" gives:

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

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. Personal samples were collected on the down hole drill operator, roof bolter, high scaler, 988 loader operator, and the 631 truck driver.

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.

Table 1 contains the summary of average area DPM sampling results for the two surveys. Using TC = EC + OC, the elevator shaft intake air concentration ranged from 0 to 5 µg/m^3 of TC for an average of 2 µg/m^3 during the baseline survey. The dual fan intake concentrations ranged from 3 to 5 µg/m^3 of TC for an average of 4 µg/m^3 for the same study. 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. During the soybean survey, the elevator shaft air concentration ranged from 5 to 13 µg/m^3 of TC for an average of 9 µg/m^3. The 1 West shaft intake concentrations ranged from 17 to 23 µg/m^3 of TC for an average of 19 µg/m^3. The weighted average intake concentration was 3 µg/m^3 of TC for the baseline survey and 14 µg/m^3 of TC for the soybean survey. When using TC = EC x 1.3, the weighted average intake concentration was 2 µg/m^3 for the baseline survey and

8 µg/m³ for the soybean survey. The weighted average DPM concentrations were obtained by multiplying each location's air quantity by its respective DPM concentration, and then dividing the sum of these two products by the combined total airflow.

Table 1 also shows the return concentrations measured during the surveys. Using TC = EC + OC, the return shaft had an average concentration of 398 µg/m³ and the slope had an average concentration of 123 µg/m³ during the baseline survey. During the B50 soybean survey, these concentrations were 232 µg/m³ and 200 µg/m³ respectively. The weighted return concentration was 321 µg/m³ during the baseline survey and 223 µg/m³ during the B50 soybean survey.

The results are very similar when the formula TC = EC x 1.3. Using this formula, the return shaft had an average concentration of 446 µg/m³ while the slope had an average concentration of 111 µg/m³ during the baseline survey. During the B50 soybean survey, these concentrations were 236 µg/m³ and 185 µg/m³ respectively. The weighted return concentration was 352 µg/m³ during the baseline survey and 221 µg/m³ during the B50 soybean survey.

These two surveys were conducted under different weather conditions. The baseline survey was conducted during the winter. Outside temperatures were cold. The soybean survey was conducted during the spring with warm weather outside. The weather conditions significantly affected the amount of air ventilating the mine. Total return air quantities measured during the baseline survey averaged 892,000 cfm. This average air quantity was reduced to 748,000 cfm during the B50 soybean survey. Both of these conditions directly affect the DPM concentrations in the mine.

Because the airflows are different in the two surveys, the comparison of effectiveness must be made using the total mass of particulate emitted. This value is obtained by multiplying the concentration by the airflow. The bottom row of Tables 1 gives the results adjust for changes in airflow and intake concentration. For the B50 soybean biodiesel fuel survey, there was a 45% reduction in TC when using the formula TC = EC + OC and a 49% reduction when using TC = EC x 1.3.

Figure 1 is a graph showing the DPM concentrations at the slope and the return shaft during both of the surveys. As seen on the graph, DPM concentrations decreased from the baseline survey to soybean biodiesel survey except for the slope. 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 working inside and outside of cabs. Since the surveys covered six separate days of sampling with the surveys separated by two months, the results of the personal sampling data were affected by numerous variables. Different locations were mined, employees sampled varied, ventilating air quantities changed, and daily production tonnages varied. Additionally, smoking elevated OC concentrations for smokers and second hand smoke affected OC concentrations of nonsmokers. 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 µg/m^3. During the B50 biodiesel survey, this average concentration was reduced to 212 µg/m^3 for a 3% TC DPM reduction. Miners working outside of cabs showed similar results. The average TC concentration of employees working outside of cabs during the baseline survey was 300µg/m^3. During the B50 biodiesel survey, this average concentration increased to 313 µg/m^3 for a 4% TC DPM increase. This increase is attributed to the reduction in airflow, not the use of biodiesel fuel. Standard deviations in this table are all high indicating that the personal samples are not as effective in evaluating the effectiveness of biodiesel fuel.

Personal samples had many variables affecting their exposure to DPM concentrations; therefore, they are not as useful in determining the effectiveness of the biodiesel fuels as are the area samples. However, 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 µg/m^3. This concentration will be reduced to 160 µg/m^3 in the future. These concentration limits are based on full shift exposure, representing a shift weighted average (SWA) exposure limit.

Table 3 is a SWA summary of the personal samples indicating how many personal samples would have been in compliance with the new DPM regulations. During the baseline survey, two personal samples exceeded the 400 µg/m^3 standard, nine employees were in the 161 µg/m^3 to 399 µg/m^3 range, and four employees were at 160 µg/m^3 or less. The roof bolter had both of the concentrations exceeding 400 µg/m^3. This occupation had SWA concentrations of 601 µg/m^3 and 440 µg/m^3 on two different sampling days. During the B50 soybean mixture survey, two personal samples exceeded the 400 µg/m^3 standard, twelve personal samples were in the 161 µg/m^3 to 399 µg/m^3 range, and one personal sample was at 160 µg/m^3 or less. The roof bolter had both of the concentrations exceeding 400 µg/m^3. This occupation had SWA concentrations of 413 µg/m^3 and 621 µg/m^3 on two different sampling days.

Nitrogen Dioxide (NO_2) diffusion tubes were also collected with all of the samples taken. The highest concentrations of NO_2 recorded were one part per million (ppm) on the roof bolter, the down hole drill operator, and a loader operator. These numbers did not significantly change from survey to survey. There was no indication that NO_2 concentrations increased during the B50 soybean based study from the baseline study.

FINDINGS AND CONCLUSIONS

1. The two surveys were conducted two months apart, during different outside weather conditions. The different weather conditions resulted in a 16% decrease in mine ventilation during the soybean survey and it resulted in slightly higher intake DPM concentrations during the soybean survey.

2. The highest SWA personal exposure to DPM for the baseline survey was a concentration of 601 µg/m^3 measured on the roof bolter.

3. The highest SWA personal exposure to DPM for the B50 soybean biodiesel survey was a concentration of 621 µg/m^3 also measured on the roof bolter.

4. When adjustments are made for intake concentrations and the 16% decrease in mine ventilation during the soybean survey, the average weighted return concentrations represent a 45% (TC = EC +OC) and 49% (TC = EC X 1.3) decrease in DPM during the B50 soybean biodiesel survey.

5. The use of the B50 soybean biodiesel fuel did not have any significant effect on NO_2 concentrations.

Table 1. Average Area Sample Diesel Particulate Matter Concentrations (TWA), Return DPM Concentrations Adjusted for Intake Concentrations, February 4-6, 2003; and April 1-3, 2003

	Baseline				B50 Soy Fuel			
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
Intake Elevator Shaft		2	2	0.7		3	9	0.2
Intake 1 West Shaft		2	4	0.5		13	19	0.5
Weighted Intake		2	3			8	14	
Return Shaft	643,000	446	398	0.9	530,000	236	232	0.8
Slope	249,000	111	123	0.7	218,000	185	200	0.7
Weighted Return	892,000	352	321		748,000	221	223	
Concentrations Adjusted for Intake								
Return Shaft	643,000	444	395		530,000	228	218	
Slope	249,000	109	120		218,000	177	186	
Weighted Return	892,000	350	318		748,000	213	209	
Percent Reduction *		-----	-----			**49%**	**45%**	

* Adjusted for Change in Airflow

Table 2. SWA Summary of Average Personal DPM Concentrations Average Values, Inside and Outside Cab, Baseline February 4-6, 2003; and B50 April 1-3, 2003

	Baseline	B50 Soy Fuel
Occupation	TC EC x 1.3 (µg/m^3)	TC EC x 1.3 (µg/m^3)
Average – Workers Inside Cabs	220	212
Standard Deviation	91	45
Percent Reduction From Baseline	-----	4
Average – Workers Outside Cabs	300	313
Standard Deviation	193	173
Percent Reduction From Baseline	-----	(4)

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/m^3, Baseline February 4-6, 2003; and B50 April 1-3, 2003

Baseline				B50 Soy Bean Based Mixture			
Date	Above 400 µg/m^3 standard	161 to 399 µg/m^3 standard	Below 160 µg/m^3 standard	Date	Above 400 µg/m^3 standard	161 to 399 µg/m^3 standard	Below 160 µg/m^3 standard
2/4/03	1	3	1	4/1/03	0	4	1
2/5/03	1	2	2	4/2/03	1	4	0
2/6/03	0	4	1	4/3/03	1	4	0
Totals	2	9	4		2	12	1

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. Area Sample DPM Concentrations (TWA), Baseline February 4-6; and B50 April 1-3, 2003

	Baseline				B50 Soy Fuel			
Location	Airflow (cfm)	TC EC x 1.3 (µg/m³)	TC EC + OC (µg/m³)	Ratio EC/TC	Airflow (cfm)	TC EC x 1.3 (µg/m³)	TC EC + OC (µg/m³)	Ratio EC/TC
Intake Elevator Shaft	442,300	3	2	1	360,000	7	13	0.4
Intake Elevator Shaft	459,000	1	0	2	397,400	0	5	0.0
Intake Elevator Shaft	433,600	3	5	0.6	391,100	1	8	0.1
Intake 1 West Shaft	416,500	5	5	0.7	400,700	12	23	0.4
Intake 1 West Shaft	428,900	1	5	0	382,900	13	18	0.5
Intake 1 West Shaft	438,300	0	3	0	391,200	15	17	0.7
Return Shaft	626,900	632	554	0.9	519,800	266	289	0.7
Return Shaft	626,900				519,800	250	249	0.8
Return Shaft	670,300	411	371	0.9	515,600	169	163	0.8
Return Shaft	670,300	425	382	0.9	515,600	153	156	0.8
Return Shaft	631,200	392	351	0.9	554,500	290	267	0.8
Return Shaft	631,200	368	331	0.9	554,500	285	267	0.8
Slope	245,300	150	159	0.7	196,300	160	205	0.6
Slope	245,300	93	103	0.7	196,300	169	180	0.7
Slope	251,400	110	121	0.7	226,400	159	172	0.7
Slope	251,400	124	118	0.8	226,400	149	161	0.7
Slope	249,200	92	113	0.6	231,400	237	241	0.8
Slope	249,200	96	125	0.6	231,400	237	241	0.8

Appendix C. Personal Sample DPM Concentrations (SWA),
Baseline February 4-6; and B50 April 1-3, 2003

	Baseline			B50 Soy Fuel	
Occupation	Cab or No Cab	TC EC x 1.3 ($\mu g/m^3$)	TC EC + OC ($\mu g/m^3$)	TC EC x 1.3 ($\mu g/m^3$)	TC EC + OC ($\mu g/m^3$)
Loader 908	Cab	144 $_n$	175	154 $_n$	144
Loader 908	Cab	195 $_n$	171	194 $_n$	180
Loader 908	Cab	191 $_n$	176	193 $_n$	184
Roof bolter	No Cab	440 $_s$	424	234 $_s$	314
Roof bolter	No Cab	601 $_s$	573	413 $_s$	475
Roof bolter	No Cab	308 $_s$	314	621 $_s$	680
High scaler	No Cab	186 $_s$	268	191 $_n$	190
High scaler	No Cab	76 $_s$	118	188 $_n$	191
High scaler	No Cab	191 $_n$	253	228 $_n$	221
Truck 608	Cab	390 $_s$	385	235 $_n$	238
Truck 608	Cab	143 $_n$	135	275 $_n$	258
Truck 608	Cab	245 $_n$	243	286 $_n$	265
Down hill drill	Cab	186 $_s$	284	219 $_n$	214
Down hill drill	Cab	Not sampled		179 $_n$	174
Down hill drill	Cab	Not sampled		175 $_n$	209
Loader 907	Cab	346 $_s$	419	Not sampled	
Cleanup Loader	Cab	140 $_n$	146	Not sampled	

$_n$ denotes nonsmoker
$_s$ denotes smoker

Figure 1. Graph of DPM Average Concentrations for the Return Shaft, the Slope, And the Weighted Exhaust, Baseline February 4-6; and B50 April 1-3, 2003