Baseline Sampling of DPM Exposures in Metal and Nonmetal Mines in the United States

Doris Ann Cash, William Baughman,
William Pomroy, and Robert Haney

MDEC 2003

U.S. Department of Labor
Mine Safety and Health Administration

1

Health is a Value.

Diesel Particulate Matter Baseline Sampling

- Metal/Nonmetal DPM Rule issued Jan 19, 2001
  - ♦ DPM measured as Total Carbon
  - ♦ Interim exposure limit 400μ/m³ July 19, 2002
  - ♦ Final exposure limit 160μ/m³ July 19, 2006
- Rule challenged in U.S. District Court
- MSHA, Industry and USWA in settlement negotiations to attempt to resolve differences
- Per partial settlement agreement July 2002, MSHA committed to conduct compliance assistance, including DPM baseline sampling

All dieselized MNM mines sampled; this paper covers 171 mines sampled prior to March 26, 2003

2

Health is a Value.

Sampling Procedures

- Followed compliance sampling strategy
- No need to worry about interferences (cigarette smoke, drill oil mist) with EC surrogate
- Personal sampling only
- Sample time - Full shift

3

Health is a Value.

DPM Sampling Train

- SKC Submicron Impactor
  (Tandem Quartz-Fiber, Filter)
- Cyclone
- Breast Plate
- Pump

4

Health is a Value.

Sample Analysis

- Total Carbon (DPM surrogate)
  - ♦ TC = EC + OC
  - ♦ TC = EC x 1.3
  - ♦ Compliance based on *lower* of [EC + OC] or [EC x 1.3]
- MSHA P-13/NIOSH 5040
- Sample - Top Filter
- Control - Tandem Filter

5

Health is a Value.

Total Carbon Concentration =

$$\frac{[EC \times 1.3] \text{ or } [OC+EC](\mu g/cm^2) \times A(cm^2) \times 1{,}000(L/m^3)}{\text{Flow Rate(Lpm)} \times 480(\text{minutes})}$$

Where:

- EC = The corrected elemental carbon concentration measured in the thermal/optical carbon analyzer
- OC = The corrected organic carbon concentration measured in the thermal/optical carbon analyzer
- A = The surface area of the deposit on the filter media used to collect the sample (8.04 cm^2)
- Flow Rate = Flow rate of the air pump used to collect the sample measured in Liters per minute (1.7 LPM)
- 480 minutes = Standardized eight-hour workshift

6

Health is a Value.

Reasons for Excluding Samples

Reason for Excluding from Analysis	Metal	Stone	Trona	Other N/M	Total
Abnormal Sample Deposit	0	1	0	0	1
Cassette/Filter Broken	0	2	0	1	3
Contaminated Backup Pad	1	0	0	0	1
Instrument Failure	1	1	0	0	2
Pump Failed	1	3	0	0	4
Total	3	7	0	1	11

7

Health is a Value.

Number of Mines and Valid Samples by Commodity Group

Commodity	Number of Mines	Number of Valid Samples	Average Number of Valid Samples by Mine
Metal	36	189	5.3
Stone	109	519	4.8
Trona	3	15	5.0
Other N/M	23	151	6.6
Total	171	874	5.1

8

Health is a Value.

Number of Valid Samples per Mine for Specific Commodities

Specific Commodity	No. of Mines	No. of Samples	Average Samples per Mine
GEMSTONES MINING	1	2	2.0
GOLD ORE MINING	17	34	2.0
DIMENSION MARBLE MINING	3	9	3.0
LIMESTONE	2	6	3.0
TALC MINING	1	3	3.0
CRUSHED & BROKEN MARBLE MINING	4	16	4.0
GYPSUM MINING	2	8	4.0
CRUSHED & BROKEN STONE MINING	5	23	4.6
CRUSHED & BROKEN LIMESTONE MINING	85	413	4.9
CLAY, CERAMIC & REFRACTORY MINERALS MINING	1	5	5.0
CONSTRUCTION SAND & GRAVEL MINING	1	5	5.0

9

Health is a Value.

Specific Commodity	No. of Mines	No. of Samples	Average Samples per Mine
COPPER ORE MINING	1	5	5.0
CRUSHED & BROKEN SANDSTONE MINING	1	5	5.0
HYDRAULIC CEMENT	1	5	5.0
LIME	4	20	5.0
TRONA MINING	3	15	5.0
DIMENSION LIMESTONE MINING	4	22	5.5
LEAD-ZINC ORE MINING	10	70	7.0
SALT MINING	14	98	7.0
MISCELLANEOUS METAL ORE MINING	1	9	9.0
MOLYBDENUM ORE MINING	2	19	9.5
PLATINUM GROUP ORE MINING	2	20	10.0
POTASH MINING	3	30	10.0
SILVER ORE MINING	3	32	10.7
AVERAGE OF ALL SAMPLES	171	874	5.1

10

Health is a Value.

Valid Samples, by Occupation and Commodity Group

Occupation	Metal	Stone	Trona	Other N/M	Total
Truck Driver	55	121	0	7	183
Front-end Loader Operator	23	115	4	13	155
Blaster, Powder Gang	9	72	0	19	100
Scaling (mechanical)	1	53	0	9	63
Drill Operator, Rotary	0	53	0	5	58
Mechanic	6	10	0	10	26
Drill Operator, Jumbo Perc.	4	9	0	8	21
Mucking Mach. Operator	15	0	0	3	18
Utility Man	5	3	8	2	18
Scaling (hand)	3	12	0	2	17
Complete Load-Haul-Dump	1	0	0	16	17
Roof Bolter, Rock	3	6	0	5	14
Drill Operator, Rotary Air	1	12	0	1	14
Crusher Oper/Worker	0	12	0	2	14
All Others Combined	63	41	3	49	156
Totals	189	519	15	151	874

11

Health is a Value.

Comparison of Results with 400_{TC} µg/m³, Calculating TC by OC+EC or ECx1.3

All Valid Samples		EC x 1.3		Total
		> 400 µg/m³	< 400 µg/m³	
EC + OC	> 400 µg/m³	126 (14.4%)	44 (5.0%)	170 (19.4%)
	< 400 µg/m³	11 (1.3%)	693 (79.3%)	704 (80.6%)
Total		137 (15.7%)	737 (84.3%)	874 (100%)

12

Health is a Value.

Occupations With at Least One Sample ≥ 400_{TC} µg/m³

Occupation	Total Samples	Minimum	Median	Maximum
Engineer	1	438	438	438
Roof Bolter, Mounted	8	98	335	588
Miner, Stope	11	165	330	622
Clean Up Person	2	66	283	499
Mucking Machine Operator	18	15	278	872
Shuttle Car, Diesel	2	95	257	419
Drill Operator, Rotary Air	14	56	231	1145
Belt Crew	8	26	225	502
Blaster, Powder Gang	101	6	216	960
Drill Operator, Jumbo	21	41	194	708

13

Health is a Value.

Occupation	Total Samples	Minimum	Median	Maximum
Complete Load-Haul-Dump	17	42	188	824
Miner, Drift	14	16	185	1459
Scaling (Hand)	17	18	166	2014
Roof Bolter, Rock	14	63	157	829
Truck Driver	184	0	155	1074
Front End Loader	155	0	136	1743
Drill Operator, Rotary	58	3	133	1109
Scaling (Mechanical)	63	0	131	750
Utility Person	18	29	93	638
Supervisor	10	1	87	856
Crusher Operator	14	1	47	427

14

Health is a Value.

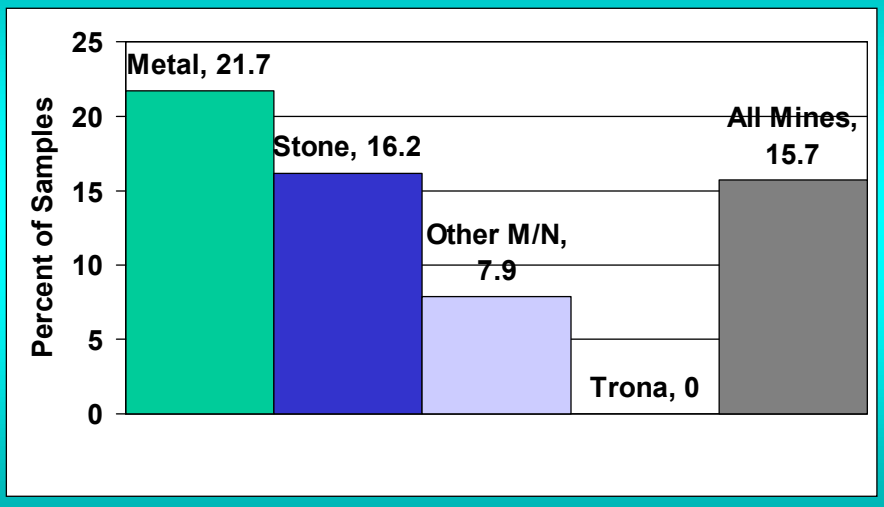
Baseline Samples by Commodity (TC=EC x 1.3)

Commodity Group	Number less than 400_{TC} µg/m³	Number greater than 400_{TC} µg/m³	Total	Percent greater than 400_{TC} µg/m³
Metal	148	41	189	21.7%
Stone	435	84	519	16.2%
Other N/M	139	12	151	7.9%
Trona	15	0	15	0.0%
All Mines	737	137	874	15.7%

15

Health is a Value.

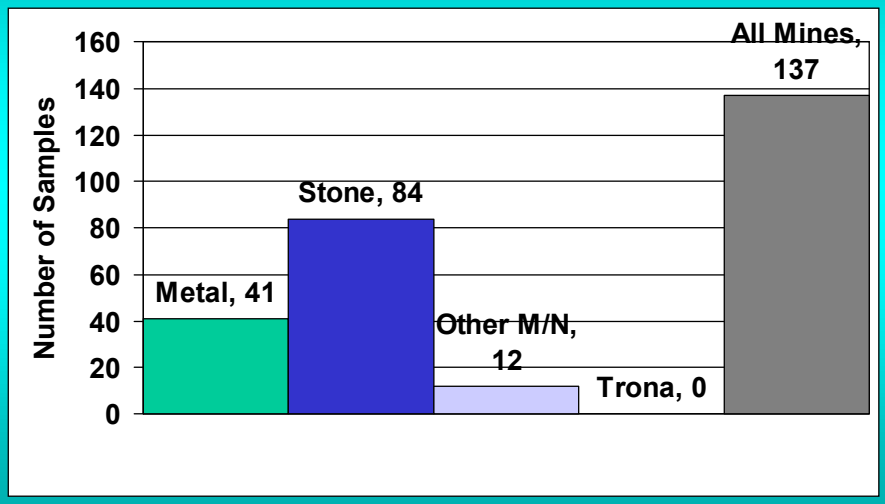
Percent of Overexposures by Commodity Group (400_{TC} µg/m³, TC=EC x 1.3)



17

Health is a Value.

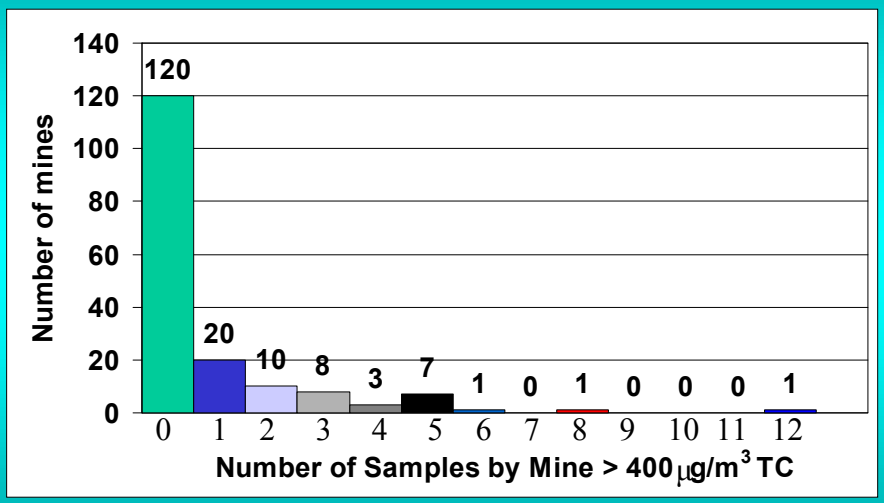
Frequency of Overexposures by Commodity (400_{TC} µg/m³, TC=EC x 1.3)



18

Health is a Value.

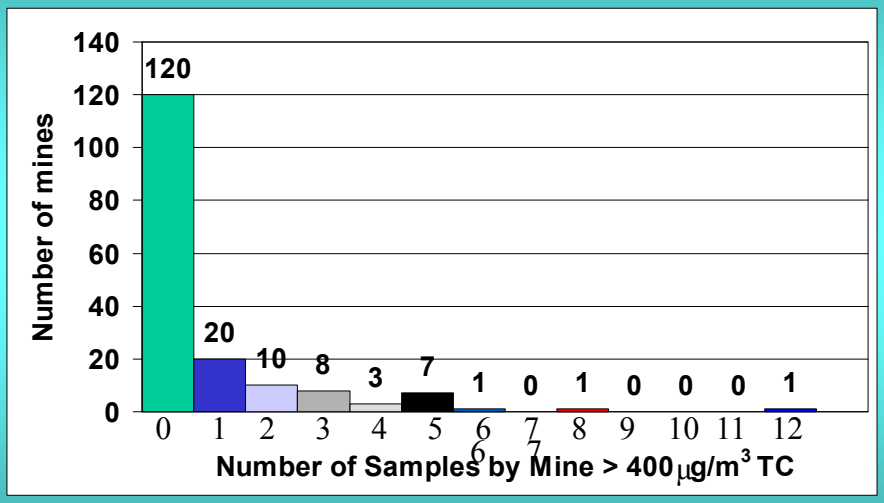
Number of Mines by the Amount of Overexposures Samples for that Mine (TC=EC x1.3)



19

Health is a Value.

Number of Mines by the Amount of Overexposures Samples for that Mine (TC=EC x1.3)

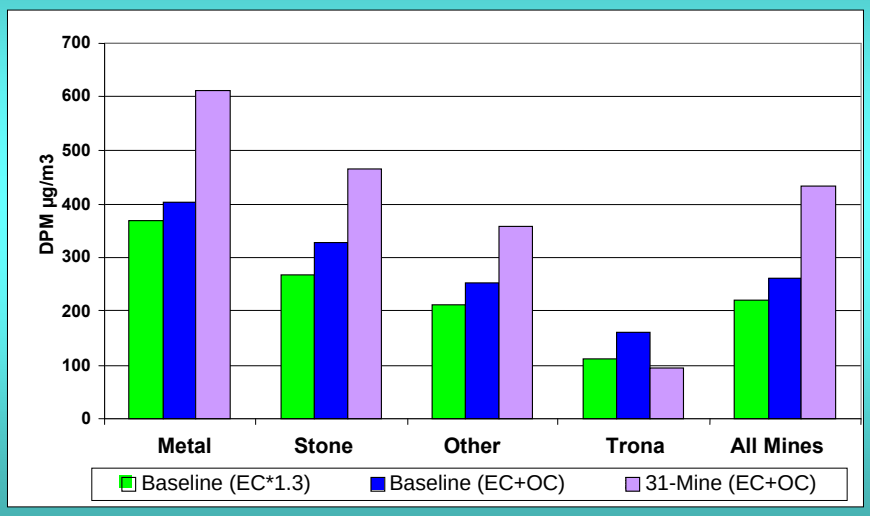


µ

19

Health is a Value.

Comparison of Mean DPM Levels from Baseline Sampling and the 31-Mine Study



20

Health is a Value.

Conclusions

- DPM levels (mean values) from baseline sampling appear to be consistently lower than in 31-Mine Study
- Possible reasons:
  - 31-Mine Study not representative of industry as a whole
  - Continual upgrading to low-emission engines/equipment
  - 31-Mine Study did not sample inside enclosed cabs if equipment operator was a smoker
  - Ventilation upgrades since 31-Mine Study
  - Bio-diesel fuel blends used at some mines

21

Health is a Value.

22

Health is a Value.