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Respirable Dust Exposures in U.S. Surface Coal Mines (1982–1986)

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ABSTRACT. Exposure of miners to respirable coal mine dust and to respirable quartz silica at surface coal mines in the United States during 1982–1986 were evaluated by job category using data collected by coal mine operators and Mine Safety and Health Administration (MSHA) inspectors. Average coal mine dust concentrations were usually well below the MSHA Permissible Exposure Limit (PEL) for all job categories, but at least 10% of the samples obtained from some coal preparation plant job areas and most drilling job areas had concentrations that exceeded the 2.0 mg/m³ limit. In contrast, a very high proportion of samples from surface mine driller areas exceeded the quartz PEL. Of all samples collected for highwall drill operators and helpers, 78% and 77%, respectively, were greater than the 0.1 mg/m³ quartz exposure limit (average concentrations were .32 and .36 mg/m³, respectively). Although MSHA compliance data may not be entirely adequate for assessing chronic exposure to quartz, these data and the results of other NIOSH studies nonetheless indicate excessive exposure to silica in a group of surface coal miners.

STUDIES DURING THE 1970s indicated that most levels of respirable dust at surface coal mines in the United States were predominately below the Mine Safety and Health Administration's (MSHA) Permissible Exposure Limit (PEL) of 2.0 mg/m³.^{1,2} This PEL was based primarily upon British research,³ which suggested that the probability of a miner developing Category 2 pneumoconiosis, or worse, during a

worklife of 35 y was nearly zero (i.e., 0.0004) if coal dust exposures were maintained at 2.0 mg/m³ or less. Parobeck and Tomb¹ reported that 91% of the samples collected in U.S. mines in 1972 were within compliance with MSHA's PEL, and Parobeck and Jankowski² indicated 95% compliance in 1977. Based upon these reports and upon exposure-response data derived from Jacobsen et al.,³ Fairman et al.⁴ suggested that the prevalence of pneumoconiosis would be expected to be low among most miners in the surface coal mine industry.

More recent studies^{5,6} of British coal miners, however, reported that the probability of developing

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Category 2 or worse pneumoconiosis during 35 y of exposure to 2.0 mg/m³ coal dust was 1–3%. Additionally, studies by the National Institute for Occupational Safety and Health (NIOSH)⁷⁻¹⁰ indicated that the prevalence of pneumoconiosis was increased among highwall drillers at some surface coal mines, which suggests that dust exposures at drilling operations may have been excessive. Because Banks et al.⁷ reported one case of silico-lipoproteinosis in a highwall driller, and Amandus et al.¹⁰ reported that quartz exposures during 1982–1983 were increased at some surface coal drilling operations, the radiographic findings in drillers were possibly evidence of silicosis rather than coal worker's pneumoconiosis (CWP). The presence of both conditions cannot be ruled out in drillers who have been employed for many years in an underground coal mine or in a coal preparation plant.

The purpose of this study was to examine exposure data collected at surface coal mines in the United States during 1982–1986. These data supplement the information previously reported by the authors for data collected during 1982–1983.¹⁰ The updated data have been summarized, and surface mine jobs with high-dust and/or high-quartz exposures are identified so that future enforcement and research activities can be focused on these high-risk areas.

Methods

The MSHA enforces a PEL of 2.0 mg/m³ respirable coal mine dust unless the quartz content of the dust exceeds 5%.¹¹ In such case, a reduced PEL is calculated by dividing the quartz percentage of the sample into 10. For example, the reduced PEL for a sample of 100% quartz would be 10/100 = .10 mg/m³; this is the maximum respirable quartz concentration allowed by MSHA.

A coal dust concentration is multiplied by a factor of 1.38 to convert the result to the British Mining Research Establishment (MRE) equivalent concentration before comparing it with the PEL. This conversion is necessary because the 2.0 mg/m³ PEL is based on a British dose-response curve derived from exposure-response data collected using the horizontal elutriator—a sampling device different from that used in the United States (i.e., the cyclone). Therefore, although the maximum quartz concentration enforced by MSHA is stated to be .10 mg/m³, this is effectively .07 mg/m³ before converting to the MRE-equivalent concentration (i.e., .07 × 1.38 = .10). The "uncorrected" value of .07 mg/m³ compares with the American Conference of Governmental Industrial Hygienists (ACGIH) respirable quartz Threshold Limit Value (TLV) of 0.1 mg/m³ and to the .05 mg/m³ Recommended Exposure Limit (REL) established by NIOSH.

The MSHA requires that respirable dust samples be collected by surface mine operators to determine compliance with PELs for coal mine dust and silica.¹¹ At a minimum, surface coal mine operators are in-

structed to collect samples bi-monthly at "designated work positions," as determined by MSHA field personnel. These work positions include areas where average dust levels exceed 1.0 mg/m³ (or the equivalent reduced standard when excessive quartz is present). This selective sampling strategy is based on the assumption that, if consistently "high-risk" occupations are in compliance with the dust standard, then all other occupations are probably in compliance also.

The MSHA also conducts periodic mine inspections during which samples for respirable dust and quartz analyses are collected. Both operator- and inspector-collected samples are obtained using 10-mm cyclones operated at 2.0 lpm. If either MSHA- or operator-collected samples indicate noncompliance, immediate corrective action to lower dust levels is required, followed by additional sampling until levels are regularly shown to be within compliance.

The three types of surface mine samples collected during 1982–1986 that were used for our data analyses included (1) "inspector quartz samples," of which 3 743 samples were collected by MSHA inspectors and were analyzed for quartz content; (2) "inspector dust samples," of which 40 296 samples were collected for respirable coal mine dust during MSHA inspections (samples analyzed for quartz were a subset of these samples); and (3) "operator dust samples," of which 58 924 samples were collected for respirable coal mine dust by mine operators and were submitted to MSHA for gravimetric analysis.

Results

Sampling frequency. The data were initially examined to detect any trends in the number of samples collected annually. Table 1 presents the number of coal mine dust and respirable quartz samples collected by MSHA inspectors and mine operators during each year from 1982–1986. Also listed are the number of producing mines during the same period.

These data represent a 27% decrease in the number of producing mines, a 57% decline in the number of operator samples, a 19% drop in inspector dust samples, and a 74% increase for the number of inspector samples for quartz. (No meaningful trend in the sampling frequency for quartz can be ascertained because results are available for only a portion of 1982.)

Also shown in Table 1 are the consecutively lower annual numbers of coal mine dust samples per mine collected by operators between 1982 and 1986, whereas the average number of samples per mine collected by inspectors increased slightly. The average number of quartz samples collected per mine remained less than one during the 5-y period.

Respirable dust and quartz concentrations. The yearly average coal mine dust (MRE-converted) and respirable quartz concentrations (not converted) are shown in Tables 2 and 3, respectively. Average dust

Table 1.—Number of Surface Coal Mines and Samples Collected by Year (1982–1986)*

Year	Total no. mines in operation	Coal Mine Dust						Respirable quartz		
		Operator samples			Inspector samples			Inspector samples		
		No. of mines samples	No. samples	No. samples per mine	No. mines sampled	No. samples	No. samples per mine	No. mines sampled	No. samples	no. samples per mine
1982	2 250	1 144	17 232	7.7	1 898	8 879	3.9	†	†	†
1983	2 010	947	13 059	6.5	1 663	8 053	4.0	392	857	.4
1984	2 090	915	12 086	5.8	1 749	8 174	3.9	450	915	.4
1985	1 912	818	9 165	4.8	1 683	7 968	4.2	356	641	.3
1986	1 640	701	7 382	4.5	1 559	7 222	4.4	363	845	.5

* Per phone conversation with George Niewiadomski (MSHA) on 1/14/88.
 † Data available only for partial year.

Table 2.—Average Surface Coal Mine Dust Concentrations by Year

Year	Operator samples				Inspector samples			
	n	AVG	SD	%>2.0*	n	AVG	SD	%>2.0*
1982	17 232	0.6	0.9	5	8 879	0.6	1.8	4
1983	13 059	0.7	1.1	6	8 053	0.7	1.8	5
1984	12 086	0.7	1.3	6	8 174	0.6	1.4	5
1985	9 165	0.7	0.9	5	7 968	0.6	1.5	4
1986	7 382	0.8	1.1	7	7 222	0.6	1.6	4
1982–86	58 924	0.7	1.1	6	40 296	0.6	1.7	4

Notes: n = number of samples; AVG = average; SD = standard deviation.
 *Percentage of samples that exceeded the Mine Safety and Health Administration's Permissible Exposure Limit for respirable coal mine dust (MRE-equivalent) concentrations (mg/m³) for samples collected during 1982–1986 by operators and inspectors.

Table 3.—Average Respirable Quartz Concentrations by Year

Year	n	AVG	SD	%>.072* PEL	%>.050* REL
1982	485	0.15	0.41	38	43
1983	857	0.13	0.33	35	41
1984	915	0.12	0.28	35	41
1985	641	0.10	0.21	32	38
1986	845	0.08	0.16	25	32
1982–1986	3 743	0.11	0.28	33	39

Notes: n = number of samples; AVG = average; SD = standard deviation.
 *Percentage of samples that exceeded the permissible exposure limit (PEL) and NIOSH-recommended exposure limit (REL) for respirable quartz concentrations (mg/m³) for samples collected by Mine Safety and Health Administration during 1982–1986.

levels determined from samples obtained by inspectors remained essentially constant at 0.6 mg/m³ between 1982 and 1986, whereas a slight increase (0.6 to 0.8 mg/m³) was observed for samples obtained by operators during 1982–1986.

Average quartz concentrations have declined by almost 50% (i.e., from .15 mg/m³ in 1982 to .08 mg/m³ in 1986, Table 3). The percentage of samples that exceeded exposure limits also decreased during 1982–1986 (percentage > .07 quartz PEL decreased from 38% to 25%, and the percentage > .05 NIOSH REL decreased from 43% to 32%).

Coal mine dust and respirable quartz concentrations are shown by job category for inspector and operator data in Table 4. As shown, surface mine jobs are categorized as follows: strip mine—where actual mining activities occur; prep facility (or coal preparation plant)—where coal is crushed, cleaned, dried, loaded for shipment; shop/maintenance—where general support personnel are assigned; and miscellaneous. Excluding sweepers and dispatchers, for whom very few samples were taken, the average coal mine dust concentration for any job was less than 1.3 mg/m³ (inspector data) or 1.7 mg/m³ (operator data). The average quartz concentration was less than .06 mg/m³ for any job not at the strip mine (with most of these jobs at .01 to .02 mg/m³). However, the quartz concentration for the five drilling jobs in the strip mine ranged from .04–.36 mg/m³; the highwall drill operator and helper had the two highest quartz

Table 4.—Surface Coal Mine Dust Concentrations by Job Category

Job category	Inspector (quartz samples)					Inspector (coal mine dust samples)				Operator (coal mine dust samples)			
	n	% > .072*	% > .050	AVG	SD	n	% > 2.0	AVG	SD	n	% > 2.0	AVG	SD
<i>Strip mine</i>													
Shotfirer	17	65	77	.11	.09	216	4	.6	.9	445	5	.6	1.10
Pan scraper opr.	71	46	59	.10	.10	1 116	2	.4	.8	806	1	.4	.5
Coal drill hlpr.	1	0	0	.04	—	20	0	.4	.3	59	5	.6	.8
Coal drill opr.	18	44	44	.20	.43	107	2	.6	1.2	672	6	.6	.9
Rock drill opr.	21	81	86	.29	.22	119	13	1.1	1.9	524	9	.8	1.2
Coal shovel opr.	11	10	27	.06	.11	388	0	.3	.9	187	1	.4	.5
Bulldozer opr.	608	54	63	.17	.25	7 992	2	.5	1.0	9 870	3	.5	.8
Road grader opr.	6	50	50	.08	.07	421	0	.4	2.3	270	0	.3	.3
Coal truck drv.	33	40	42	.06	.08	859	1	.5	2.1	1 597	2	.4	.6
Drag line opr.	12	8	17	.03	.06	1 024	0	.3	1.5	276	0	.3	.4
High lift opr.	304	21	32	.05	.07	7 193	1	.4	1.6	3 019	1	.4	.5
Highwall drill hlp.	53	77	85	.36	.94	378	10	1.1	2.9	1 419	6	.7	.9
Highwall drill opr.	683	78	84	.32	.47	3 618	15	1.3	2.5	10 021	10	.9	1.8
Refuse truck driver	329	38	48	.07	.07	3 044	3	.6	1.4	3 464	2	.5	.9
Rotary bucket opr.	0	—	—	—	—	35	3	.3	.5	32	9	.6	1.3
Coal strip opr.	0	—	—	—	—	24	0	.3	.2	63	3	.5	.6
Strip shovel opr.	8	63	63	.12	.14	227	0	.2	.2	101	1	.3	.4
Water truck opr.	2	0	0	.00	.00	85	0	.2	.2	85	0	.3	.3
Groundman	2	0	0	.00	.00	65	2	.7	2.6	118	1	.3	.4
Rotary dump opr.	0	—	—	—	—	11	0	.3	.3	0	—	—	—
Scoop opr.	0	—	—	—	—	3	0	.4	.0	0	—	—	—
Sweeper opr.	3	0	33	.02	.03	17	18	3.5	10.2	2	0	.1	.1
Auger opr.	9	11	22	.03	.04	240	0	.3	.3	36	0	.4	.4
Auger hlpr.	16	6	6	.02	.03	199	0	.4	.4	66	0	.4	.4
Clam opr.	0	—	—	—	—	16	0	.2	.1	0	0	—	—
Boom opr.	4	0	0	.00	.01	64	2	.4	.5	29	17	1.1	1.2
<i>Prep facility</i>													
Coal sampler	44	9	11	.04	.09	300	8	.9	2.7	681	8	.8	.9
Crusher attendant	34	9	21	.06	.18	215	3	.9	1.1	200	9	.9	1.2
Dispatcher	0	—	—	—	—	4	25	12.1	23.8	0	—	—	—
Motorman	0	—	—	—	—	15	0	.3	.4	7	0	.4	.3
Carl dropper	15	0	0	.01	.01	474	1	.3	.4	822	4	.5	.8
Cleaning plant opr.	158	1	1	.01	.03	920	5	.9	2.8	1 860	4	.8	.8
Dryer opr.	44	2	2	.01	.03	184	8	.9	1.0	488	7	.8	.7
Fine coal plt opr.	164	2	3	.01	.04	744	14	1.2	1.2	2 203	13	1.1	.9
Scalper/screen opr.	109	6	13	.02	.03	496	11	1.1	1.5	1 291	7	.8	.8
Silo opr.	6	0	33	.02	.03	30	13	1.0	1.0	62	18	1.5	1.2
Triple opr.	193	1	3	.01	.02	877	5	.6	2.3	3 260	6	.7	.8
Weighman	2	0	0	.00	.00	189	1	.3	.4	23	0	.2	.1
Yard engineer	0	—	—	—	—	16	0	1.1	.1	0	—	—	—
Brakeman	0	—	—	—	—	7	0	.2	.1	0	—	—	—
Steel worker	0	—	—	—	—	10	0	.3	.3	0	—	—	—
Washer opr.	19	0	0	.01	.01	151	8	.8	.7	157	12	1.0	.9
Barge attendant	1	0	0	.01	—	87	0	.3	.3	40	0	.3	.3
Car trimmer/loader	2	0	0	.01	.00	159	0	.3	.2	42	0	.4	.4
Car shake-out	1	0	0	.00	—	28	11	.7	.9	3	0	.5	.1
Froth cell opr.	14	0	7	.00	.02	70	21	1.3	.9	80	6	1.0	.9
Diester table opr.	2	0	0	.01	.02	11	9	.9	.7	5	0	.8	.4
<i>Shop/maintenance</i>													
Electrician	24	0	0	.00	.00	405	0	.4	.4	922	4	.6	.7
Electrician helper	0	—	—	—	—	15	0	.2	.2	51	0	.2	.2
Mechanic	145	3	3	.01	.06	1 529	3	.5	1.2	3 591	5	.7	.8
Mechanic hlpr.	0	—	—	—	—	59	0	.4	1.2	132	4	.4	.8
Supplyman	1	0	0	.00	—	20	5	.3	.5	27	0	.3	.3
Laborer	303	5	8	.02	.07	2 201	6	.7	1.1	5 576	7	.8	.9
Greaser/oiler	55	0	6	.01	.02	806	1	.4	.5	1 148	2	.5	.5
Welder	31	3	3	.01	.02	520	13	1.1	2.7	289	6	.7	1.4
Welder-nonshop	18	0	0	.00	.00	99	10	.9	1.2	300	5	.8	.8
Shopman	2	0	0	.01	.01	23	0	.2	.3	66	0	.2	.2
Carpenter	0	—	—	—	—	14	7	.6	1.1	11	0	.3	.3
Mason	1	0	0	.00	—	8	0	.3	.6	0	0	—	—
Bit sharpener	0	—	—	—	—	10	0	.3	.2	41	10	.8	1.5
Machinist	1	0	0	.00	—	78	0	.3	.2	8	0	.6	.4

(Table 4 continued on page 206)

Table 4.—Surface Coal Mine Dust Concentrations by Job Category

<i>Miscellaneous</i>													
Conveyor opr.	12	8	8	.02	.02	177	5	.6	.8	226	5	.7	.7
Belt vulcanizer	0	—	—	—	—	2	0	.4	.4	2	0	.5	.6
Clean-up	109	3	4	.01	.02	609	9	.9	1.1	2 103	7	.8	.9
Transitman	0	—	—	—	—	4	2	.4	.5	9	0	.3	.3
Beltman	0	—	—	—	—	73	14	.9	1.2	44	43	1.7	1.3
Waterboy	0	—	—	—	—	8	0	.3	.2	0	—	—	—
Hoist hlpr.	0	—	—	—	—	4	0	.5	.2	0	—	—	—
Lampman	0	—	—	—	—	5	0	.2	.1	6	0	.2	.2
Rodman/surveyor	0	—	—	—	—	3	0	.6	.5	9	0	.4	.4
Cage attendant	0	—	—	—	—	4	0	.2	.1	0	—	—	—
Watchman	0	—	—	—	—	1	0	.1	—	0	—	—	—
Fan attendant	0	—	—	—	—	1	0	1.0	—	0	—	—	—
Hoist opr.	1	0	0	.01	—	7	0	.2	.2	0	—	—	—
All samplest	3 743	33	39	.11	.28	40 296	4	.6	1.7	58 924	6	.7	1.1

Notes: *n* = number of samples, AVG = average, and SD = standard deviation of respirable coal mine dust (British Mining Research Establishment-equivalent) and quartz concentration (mg/m³) for samples collected in 1982–1986 by operators and Mine Safety and Health Administration inspectors.

*Percentage of samples with a quartz concentration > .072 mg/m³ [.072 mg/m³ × 1.38 = .10 mg/m³ quartz Permissible Exposure Limit (PEL)].

†Includes other job categories not listed.

exposures and the two highest coal mine dust concentrations. Significant are the very high percentages of samples from strip mines that exceed the quartz PEL and the moderate percentages of coal preparation plant samples that exceed the coal mine dust PEL.

The 10 jobs that entail exposure to the highest average concentration of coal mine dust are listed in Table 5. Although prep facility jobs predominate in this listing, drilling jobs at strip mines also had high-dust exposures. Average job exposures were usually well below the 2.0 mg/m³ PEL; the highest was 1.3 mg/m³ (fine coal plant operator). However, at least 10% of the samples from various job areas had concentrations of coal mine dust that exceeded the PEL.

Table 6 shows that 8 of the 10 jobs with the highest quartz exposure were for jobs at strip mines; in fact,

87% of the total number of samples in violation of the quartz PEL were from strip mine job categories. The average quartz concentrations for the 2 highest exposure jobs (i.e., highwall drill helpers and operators) were 0.36 and 0.32 mg/m³, respectively; both were 400% greater than the .07 mg/m³ quartz PEL.

Sampling trends. Sampling trends are presented for the job category most frequently in violation of the respective MSHA coal mine dust and quartz PELs (Table 7). Although quartz concentrations have decreased since 1982 for highwall drill operators, 71% of the samples still exceeded the quartz PEL in 1986 (vs. 87% in 1982). The average coal dust concentration and the percentage of coal mine dust PEL violations remained essentially the same between 1982 and 1986 for coal plant operators and highwall drill operators.

Table 5.—Ten Dustiest (Coal Mine Dust) Surface Coal Mine Jobs (1982–1986)

Job	Operator samples				Job	Inspector samples			
	<i>n</i>	AVG	SD	% > 2.0		<i>n</i>	AVG	SD	% > 2.0
Fine coal plant opr.	2 203	1.1	0.9	13	<i>Highwall driller opr.</i>	3 618	1.3	1.8	15
Washer Opr.	157	1.0	0.9	12	Fine coal plant Opr.	744	1.2	1.2	15
<i>Highwall drill opr.</i>	10 021	0.9	1.8	10	Welder	520	1.1	2.7	13
Crusher Attendant	200	0.9	1.2	9	<i>Rockdriller</i>	119	1.1	1.9	13
<i>Rock driller</i>	524	0.8	1.2	9	Scalper-screen opr.	496	1.1	1.5	11
Coal Sampler	681	0.8	0.9	8	<i>Highwall driller hlp.</i>	378	1.1	2.9	10
Cleanup man	2 103	0.8	0.9	7	Cleanup man	609	0.9	1.1	9
Laborer	5 516	0.8	0.9	7	Dryer opr.	184	0.9	1.0	8
Welder-nonshop	300	0.8	0.8	5	Coal sampler	300	0.9	2.7	8
Cleaning Plant Opr.	1 860	0.8	0.8	4	Cleaning plant opr.	920	0.9	2.8	5

Notes: Job titles that appear in italics refer to jobs that are exclusively mining operations. *n* = number of samples collected; AVG = average; SD = standard deviation; and % = percentage of samples in which concentrations of respirable coal mine dust (British Mining Research Establishment equivalent [mg/m³]) collected by operators were greater than 2.0 mg/m³ (Mine Safety and Health Administration's Permissible Exposure Limit). Only includes jobs for which more than 100 samples were collected.

Job	<i>n</i>	AVG	SD	% > .072 PEL*	% > .050 REL†
<i>Highwall drill hlpr.</i>	53	0.36	0.94	77	84
<i>Highwall drill opr.</i>	683	0.32	0.47	78	85
<i>Rockdriller</i>	21	0.29	0.22	81	86
<i>Bulldozer opr.</i>	608	0.17	0.25	54	63
<i>Pan scraper opr.</i>	71	0.11	0.14	46	59
<i>Refuse truck driver</i>	329	0.07	0.07	38	48
<i>Coal truck driver</i>	33	0.06	0.06	39	42
<i>Crusher attendant</i>	34	0.06	0.18	9	21
<i>Highlift opr.</i>	304	0.05	0.07	21	32
<i>Coal sampler</i>	44	0.04	0.04	9	11

Notes: Jobs printed in italics refer to mining jobs only. *n* = number of samples collected; AVG = average; and SD standard deviation. Only includes jobs for which more than 20 samples were collected.
 *Percentage of samples with concentrations of quartz greater than the .072 mg/m³ Permissible Exposure Limit (PEL) issued by the Mine Safety and Health Administration.
 †Percentage of samples with concentrations of respirable quartz greater than the .050 mg/m³ Recommended Exposure Limit (REL) established by the National Institute for Occupational Safety and Health.

Year	Coal mine dust* (Fine coal plant opr.)			Coal mine dust† (Highwall drill opr.)			Respirable quartz‡ (Highwall drill opr.)			
	<i>n</i>	AVG	% > 2.0‡	<i>n</i>	AVG	% > 2.0‡	<i>n</i>	AVG	% > .072§	> .050#
1982	475	1.1	12	651	1.4	14	99	.44	87	91
1983	422	1.1	13	775	1.6	20	160	.35	88	93
1984	503	1.1	14	817	1.3	17	188	.33	73	81
1985	434	1.1	13	741	1.1	11	126	.22	70	76
1986	369	1.1	12	634	1.0	13	110	.24	71	80

Notes: *n* = number of samples collected and AVG = average.
 *Samples collected by surface coal mine operators.
 †Samples collected by MSHA inspectors.
 ‡Mine Safety and Health Administration's Permissible Exposure Limit (PEL, 2.0 mg/m³) for coal mine dust (British Mining Research Establishment equivalent).
 §Respirable quartz PEL = .072 mg/m³.
 #National Institute for Occupational Safety and Health's Recommended Exposure Limit for respirable quartz (.050 mg/m³).

Discussion

NIOSH has concluded, primarily on the basis of earlier studies of Vermont granite shed workers, that the risk of silicosis is negligible only for quartz exposures less than .05 mg/m³.¹² The average quartz concentrations during 1982–1986 for highwall drill operators and helpers at surface coal mines in the United States were .36 and .32 mg/m³, respectively. Eleven other jobs at strip mines had average concentrations at or above .05 mg/m³. Thirty-nine percent of all surface mine samples analyzed for quartz exceeded the NIOSH REL, and 33% exceeded the higher MSHA PEL (.07 mg/m³). These results are consistent with an earlier report by Tomb et al.,¹³ which

indicated that more than 40% of samples collected in 1983 for highwall drillers exceeded 0.1 mg/m³.

In addition, respirable coal mine dust exposures for drilling jobs and some prep facility jobs are excessive when compared with the 2.0 mg/m³ PEL established to reduce the risk of CWP. Therefore, to the extent that MSHA samples provide an estimate of long-term exposure to respirable quartz, the data strongly suggest that many jobs at coal strip mines—particularly drilling jobs—involve an above-average risk of excessive exposure to respirable quartz. Any conclusions based upon MSHA sampling about the level of pneumoconiosis (including silicosis) risk in the surface coal mining industry should be made cautiously. Risk depends on the average level of ex-

posure and on duration. For example, the risk in miners exposed for long periods of time to very low concentrations may be quite different from that in miners exposed for short periods to high-dust levels. Therefore, risk must be based, in part, upon accurate exposure and work histories on an individual basis.

The MSHA sampling strategy is designed to ensure compliance with dust and quartz standards by focusing primarily on jobs and job areas that are dusty regularly. This strategy often involves nonrandom, repetitive sampling in "worse-case" areas until compliance is achieved; this sampling strategy inherently results in clusters of samples (by mine, occupation, and/or time). Corn et al.¹⁴ have stated that the MSHA coal mine dust sampling program "reflects a dust control strategy, not a strategy aimed at estimation of long-term miner exposure to respirable coal mine dust for the epidemiological purpose of deriving a dose-response curve for a chronic disease agent." The MSHA sampling strategy may be different from that optimally chosen for a research study.

Also, the frequency of sampling for quartz must be considered when using the MSHA data to estimate miner exposures. As was shown in Table 1, less than one quartz sample per mine has been taken each year since at least 1982. Although the average number of samples per mine has increased since 1982 (i.e., from 0.2 to 0.5), this extremely low sampling rate contributes uncertainty to the representativeness of the quartz data.

Nevertheless, the high silica exposures for drilling jobs at surface coal mines indicate the possibility of an increased silicosis risk among these occupations. This is of concern to surface coal mine operators and miners, MSHA, and NIOSH.

Two specific medical findings are suggestive of a silicosis risk among surface coal drillers. In 1983, NIOSH reported that a driller employed at a West Virginia coal strip mine had developed acute silicosis and died within 5 y of employment.⁷ The MSHA data indicated that coal mine dust levels were within compliance; however, no samples had been analyzed for silica. Similarly, in a more recent study,⁹ NIOSH found that a 25-y-old driller had developed Category II pneumoconiosis within 3 y of initial employment at a Pennsylvania anthracite strip mine; there were no quartz samples taken at the time from 1980 to 1985.

Control options. A significant portion of excessive dust exposures at surface coal mines in the United States results from drilling operations. A number of specific dust control options are available to focus on these high-risk areas. Drill operators, in particular, can be educated about the health hazards associated with excessive exposures and instructed to minimize emissions. Proper training, work practices, and dust suppression techniques should be emphasized. For example, dry drilling techniques that use compressed air to clear drill holes of cut-

tings and to cool the bits are commonly used by the surface mining industry. This practice generates clouds of dust largely composed of overburden materials (including sandstone), thereby exposing both the drill operator and helper to substantial amounts of quartz.

Various techniques may be used to reduce or contain dust emissions while drilling. Rubber "skirts" can be placed around the drill site to provide a containment barrier between the dust and worker. The use of dust suppressants, particularly water, can be effective in reducing dust emissions; unfortunately, wet drilling is not often used because of increased operating costs.

Local exhaust ventilation systems are available that capture dust at the drill hole and discharge it at a site remote from workers. Equipment cabs with positive pressure air conditioning systems also provide a dust-free environment for the operator.

Conclusions

The MSHA data collected between 1982 and 1986 suggest that excessive exposures to quartz occur in the stripping operations at surface coal mines in the United States. Particularly significant are the very high percentages of samples that were greater than the quartz PEL collected for highwall drill operators (78%) and helpers (77%).

Although there may be some question concerning the representativeness of MSHA compliance data for assessing long-term average exposures to quartz, these data should nonetheless be of concern to both the government and to the mining industry. The MSHA data indicate highwall drill operators and helpers are consistently exposed to excessive concentrations of dust and respirable quartz. Immediate actions that are available to improve this hazardous situation include increased environmental sampling and medical surveillance, implementation of effective dust control options, and improved training and education programs.

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