CHARACTERISTICS OF CHRONICALLY DUSTY LONGWALL MINES IN THE U.S.

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INTRODUCTION

Concentration of respirable coal mine dust in underground mines in the U.S. has been analyzed as industry wide averages and in relation to specific mining technologies.[2,7,12,13] Industry wide averages do not consider important differences between mines and analyses of exposure classified by mining technologies do not consider differences and associations within mines.

The proportion of sections in or out of compliance with the 2.0 mg/m^3 dust standard is also a common method of measuring performance. This type of analysis usually does not consider performance over longer periods of time. Since most lung diseases caused by dust require chronic exposure, it would be more appropriate for the task of disease prevention to assess patterns of violation over longer time periods than is done with measures at one point in time. And since the principal focus of enforcement is a mine, we should analyse performance of mines.

Therefore, the principal analytical unit considered in this paper is individual mines whose performance is assessed over a four year period, from FY 1984–1987. The purpose of this analysis is to describe a method for identifying chronically dusty mines and to consider characteristics of these mines that may provide insight into achieving improved dust control.

Feasible engineering controls for conventional, continuous, and longwall mining methods have been developed and described.[3,6,9] The principal methods for having these controls adopted in mines include enforcement of regulations adopted by the Mine Safety and Health Administration (MSHA), and providing technical assistance by MSHA and the U.S. Bureau of Mines (BOM).

Exposure to respirable dust has been significantly reduced since 1969 when the Federal Coal Mine Health and Safety Act was enacted.[4] However, in recent years, progress in controlling dust exposure in mines, particularly those that use longwall methods, has ceased. (Table I) Therefore, it is appropriate to question what additional opportunities exist or may be created for continuing progress in controlling exposure to dust. This analysis is limited to mines that have one or more longwall sections.

The question remains which mines have the poorest records and what do these mines have in common. The Bureau of Mines has identified some engineering problems at mines with excessive dust concentration.[5] I wish to describe some characteristics that may provide additional opportunities for intervention.

MATERIALS, METHODS

Data were gathered from three sources. First, measurements of dust exposure by mine operators were obtained from MSHA. Operators in the U.S. are required to monitor exposure to respirable dust for five consecutive production shifts six times each year.[11] High exposure personal or quasi-personal samples are taken for specified workers or "designated occupations" at each mechanized mining unit (MMU) or mine section.

The purpose of this monitoring program is to assess compliance with the statutory limit of 2.0 mg/m^3. If the average of five samples exceeds the limit, the operator is issued a citation for non-compliance and is required to continue sampling and make adjustments to reduce exposure.

This sampling program generates approximately 100,000 individual dust samples each year—an exceptionally large data base that can be used to consider a wide variety of issues. This data set includes the mine identification number (including a state code), MMU number, mining method, occupation code, date the sample was taken, and dust concentration.

The dust analysis program at the United Mine Workers of America acquires and analyzes this data on a regular basis in order to identify those mines with the most persistent dust exposure problems. Annual average dust exposure is calculated for each MMU taken at each mine. Those mines that have one or more MMUs with annual averages above 2.0 mg/m^3 are considered "dusty mines." Industry-wide average dust exposure for each mining method and the proportion of mine sections with averages over 2.0 mg/m^3 are also calculated.

Certain mines appear regularly on this list. Chronically dusty mines are those that have appeared on the dusty mines list for at least three out of the past four years.

Second, we acquired additional information about mines with active longwall sections from annual census data published in industry trade publications.[10] This includes the dimensions of longwall panels (length, width, thickness), and number of entries, and the average depth for each mine.

Third, since diesel powered equipment generates respirable

Table I

Percent of Longwall Sections with Annual Average Concentration of Respirable Dust Over 2.0 mg/m^3

FY	%
1982	33.7
1983	35.5
1984	32.8
1985	37.7
1986	32.7
1987	38.4

particulates, it is possible that excess exposure to dust is associated with use of this equipment. At the present time, personal respirable dust sampling units cannot distinguish between diesel particulate and respirable coal mine dust generated by coal cutting and transport.[8] Therefore, we obtained from MSHA a census of diesel powered equipment currently used in underground mines.

None of these data sources is perfect. Operator samples of respirable dust may systematically underestimate concentration.[1] The industry census was incomplete, is dependent on voluntary contributions, and could not be independently confirmed. MSHA's census of diesel equipment also could not be independently confirmed and was a measure only at one point in time.

We compared characteristics of chronically dusty longwall mines with other longwall mines and with the remainder of the industry. Variables examined include geographic distribution, dust exposure at non-longwall sections (Without exception, these are all continuous mining sections) at these mines, number of entries, use of diesel powered equipment, and dimensions of the longwall panels.

RESULTS

Included among all longwall mines are 19 that are chronically dusty. While they occur in most mining regions, they are concentrated in the west. Out of 16 longwall mines in the west (Utah, Colorado, New Mexico, and Wyoming), 9 are chronically dusty. (Table II) Both the proportion and the number of chronically dusty longwall mines is greater than that in the mid-west, northern Appalachia or southern Appalachia.

Chronically dusty mines are somewhat more likely to use diesel powered equipment than not, though the difference is not significant (Table III). They are four to five times more likely to employ two entries for their longwall panel as other mines. This association is highly significant statistically ($p=0.002$) (Table IV).

Use of diesel powered equipment and two-entry mining are also concentrated in the west. (Tables V, VI) These three characteristics—geographic distribution, use of two entries, and use of diesels—are almost completely confounded, making it difficult to separate independent associations.

The length, width and cutting height of chronically dusty longwall panels are slightly but not significantly larger than that of other longwall panels. (Table VII) Moreover, they are also, on average, under deeper cover, especially for mines in the west. (Table VIII) Taken together, these factors may contribute to dust problems. Wider panels and larger cutting height may be associated with dust generation by increasing cutting time per shift and increased contact between cutting bits and the coal seam. Greater depth of cover puts greater pressure on the coal seam which could result in less stability and increased friability.

It is not only longwall sections at these mines that have greater dust exposure; there is greater dust exposure on continuous mining sections at these same mines. Average dust exposure (for FY 1987) and proportion of MMUs with annual averages over 2.0 mg/m^3 at continuous mining sections at chronically dusty mines are both significantly greater than those at other longwall mines and greater than the remainder of continuous mining sections throughout the industry. (Tables IX, X) This is consistent with findings we have reported before.[14]

DISCUSSION

Annual average dust concentrations based on operator samples taken in order to assess compliance is a conservative measure of exposure. Because of institutional incentives, operator samples may underestimate exposure to dust. Furthermore, an annual average based on measurements taken for the purpose of assessing compliance may also underestimate exposure. After a determination of noncompliance, the operator must take additional samples until the average is reduced. In the analysis presented here, we included all measurements, including those taken for the purpose of demonstrating compliance.

By limiting attention to those mines with longwall sections that generate averages over 2.0 mg/m^3 for at least three of the past four years, we miss considering those mines that

Table II

Geographic Distribution of Chronically Dusty Mines

	Number of LW Mines	Chronically Dusty Mines	(%)
West (CO, UT, NM, WY)	16	9	(56)
Mid-West (IL)	5	0	(0)
No. Appalachia (MD, OH, PA)	12	3	(25)
So. Appalachia (AL, KY, VA, WV)	44	7	(16)
Total	77	19	(25)

Table III

Chronically Dusty Mines Classified by Use of Diesel Powered Equipment (percent) 1987

	Number of LW Mines	Chronically Dusty Mines	
Using Diesel Powered Equipment	31	10	(32)
Not Using Diesel Powered Equipment	46	9	(20)
Total	77	19	

Chi Square = 1.61, 1 d.f., NS

Table IV

Chronically Dusty Mines Classified by the Number of Support Entries (percent)

Number of Support Entries	Number of LW Mines	Chronically Dusty Mines
2	6	5 (83)
3	27	7 (26)
4 +	39	6 (15)
Unknown	5	1

*P=0.002 Fisher's Exact Test for 2 entries v. others

Table V

Geographic Distribution of Longwall Mines that Use Diesel Powered Equipment (percent)

	Number of LW Mines	Number Using Diesels	
West (CO , UT, WY)	16	16	(100)
Mid-West (IL)	5	0	(0)
No. Appalachia (MD, OH, PA)	12	1	(8)
So. Appalachia (AL, KY, VA, WV)	44	14	(32)
Total	77	31	(40)

Table VI

Geographic Distribution of Longwall Mines by Number of Support Entries

	Number of Mines by Number of Support Entries			
	2	3	4+	Unknown
West (CO, UT, WY)	6	5	1	1
Mid-West (IL)	0	4	0	0
No. Appalachia (MD, OH, PA)	0	6	8	2
So. Appalachia (AL, KY, VA, WV)	0	12	30	2
Total	6	27	39	5

Table VII

Average (SD) Panel Dimensions and Depth of Longwall Sections

	Chronically Dusty Mines N=19	Others N-58
Cutting Height (inches)	85 (27)	74 (21)
Panel Width (feet)	632 (113)	622 (95)
Panel Length (feet)	5028 (1247)	4949 (1311)
Depth (feet)	1131 (697)	965 (533)

(None of the differences are statistically significant , $p > .05$, t test.)

Table VIII

Average Depth of Longwall Mines Classified by Geographic Location

	Average Depth (feet)	(SD)	N of mines
West (CO, NM, UT)	1492	(704)	16
Mid-West (IL)	620	(60)	5
No. Appalachia (MD, OH, PA)	598	(179)	12
So. Appalachia (AL, KY, VA, WV)	1084	(535)	44

$p < .01$ one-way ANOVA

have only recently developed longwall sections or that have temporarily stopped production. Dust exposure at these mines (the number is unknown and assumed small) may be similar to that of the mines shown bere.

It is likely that several factors could contribute, independently or in combination, to the concentration of chronically dusty mines in the west. These include development of two entries, increased depth, and panel dimensions. Assessing the contribution of these factors would require more detailed examination. It is also possible that mine management or regulatory agency practices unique to this area may be contributing factors.

The relatively poor performance in continuous mining sections (in addition to longwall sections) at chronically dusty mines suggests that dust control problems at these mines may be mine-wide rather than confined to any one section or mining method. Excess dust exposure in continuous mining sections shows no geographic association and therefore, no association with any of its correlates—use of diesel powered equipment or two support entries.

We have described and demonstrated a method for identifying mines that exhibit a pattern of excess concentration respirable dust. This method could be employed more efficiently to use resources throughout the industry for the pur-

Table IX

Continuous Mining Sections With Annual Averages Over 2 mg/m^3

	Total Number of Continuous Mining Sections	Number with Annual Averages > 2.0 mg/m3	(%)
Longwall Mines:			
Chronically Dusty	74	8	(11)
Other	281	8	(3)
Non-Longwall Mines	1,659	60	(4)
Total	2,014		

p < .01, Chi Square, 1 d.f., Chronically Dusty Longwall Mines v. all others.

Table X

Average Dust Exposure on Continuous Mining Sections

	Average (SD) (mg/m3)	N of samples
Chronically Dusty Mines	1.38 (1.25)	1,685
Industry-Wide Average	0.98 (1.11)	44,773

pose of achieving better dust control and thereby, to reduce the risk of chronic occupational lung disease.

We have shown that mines in the west have the poorest performance, that chronically excessive dust concentration is associated with use of two entries, and that excessive dust concentration is not limited to longwall sections. Chronic excessive dust concentration is weakly associated with increased panel dimensions and depth of cover.

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