RESPIRABLE DUST TRENDS IN COAL MINES WITH LONGWALL OR CONTINUOUS MINER SECTIONS

WINTHROP F. WATTS, JR.* • George E. Niewiadomski†

*Twin Cities Research Center, Bureau Of Mines, U.S. Dept. of the Interior
Minneapolis, MN 55417

†Mine Safety and Health Administration, U.S. Dept. of Labor
Arlington, VA 22203

INTRODUCTION

In 1970 a mandatory respirable dust standard of 3.0 mg/m^3 was established for underground Coal mines under the Federal Coal Mine Health and Safety Act of 1969. This standard was lowered in 1972 to 2.0 mg/m^3. Mandatory dust standards for surface work areas of underground coal mines and surface mines also became effective in 1972. These regulations were continued under the Federal Mine Safety and Health Act of 1977,[6] which amended the 1969 act and merged coal and noncoal regulations into one law. In the 1969 act, "concentration of respirable dust" was defined as a measurement made with a Mining Research Establishment (MRE, Casella 113A) instrument or such equivalent concentration measured with another device. The 1977 act changed the definition of "concentration of respirable dust" to be the "average concentration of respirable dust measured with a device approved by the Secretary and the Secretary of HEW." The device approved for measuring respirable dust uses a Dorr-Oliver 10-mm nylon cyclone to remove the nonrespirable fraction of dust sampled. Measurements made with this device are converted to equivalent MRE concentrations by multiplying by a constant factor of 1.38.[3] A more rigorous standard is used if the sample contains more than 5 pct quartz. Specific regulations detailing the collection of respirable dust samples by mine operators are found in the Code of Federal Regulations, Title 30.[5]

Since 1970 more than 6.5 million respirable dust samples have been collected by coal mine operators and Mine Safety and Health Administration (MSHA) inspectors to determine compliance with the 2.0 mg/m^3 standard, or with the more rigorous standard due to the presence of excessive levels of quartz. Each year MSHA provides the Bureau with copies of these records to update the Mine Inspection Data Analysis System (MIDAS). MIDAS is a computerized, industrial hygiene data base developed by the Bureau with the assistance of MSHA to statistically analyze environmental compliance data collected by MSHA inspectors and coal mine operators.[7-8] These analyses provide information that is used to determine trends in exposure, to prioritize problem areas requiring special emphasis, and to evaluate the impact of proposed standards. Data are stored on the Bureau's mainframe computer in Denver, Colorado, but portions of the data base may be analyzed on personal computers. MIDAS is available, on-line, via the Bureau's telecommunications network to Bureau, MSHA, and National Institute of Occupational Safety and Health personnel involved in mining research.

Each record of coal mine respirable dust exposure stored in MIDAS contains coded information which identifies the state, mine, type of mine, sample date, occupation code, tons of coal mined, dust concentration, and other information. These records are edited, sorted, stored, and statistically analyzed using software developed by the Bureau.

It was previously reported[8] that the highest mean concentrations of respirable coal dust reported by MSHA inspectors were measured in coal mine sections with longwalls. These sections also had the greatest percentage of samples exceeding the 2.0-mg/m^3 standard (35 pct). Many more samples were collected at mines using continuous rippers, with 11 pct of the samples exceeding the Federal standard. However, a single sample exceeding the 2.0-mg/m^3 standard does not place a mine section out of compliance with the Federal standard. A mine is only out of compliance if the arithmetic average of five operator respirable dust samples collected over consecutive normal production shifts exceeds the standard, or if the average of two or more MSHA inspector samples exceeds statistically determined levels.

MSHA inspectors and coal mine operators regularly sample miners or areas known to have high dust exposure, but mine operators collect many more samples. In underground mines, certain occupations are referred to as designated occupation (DO) and are sampled bimonthly by coal mine operators and annually by MSHA inspectors. Examples of DO's include the continuous miner operator and the longwall shearer operator.

The objective of this paper is to summarize the recent trends in respirable dust levels in sections using longwalls or continuous ripper miners. The analysis includes the large amount of compliance data collected by coal mine operators and MSHA inspectors. Recent data will be compared to data reported for FY 78 to determine the changes that have occurred in dust levels and coal production. Data from mines using both methods of mining will also be compared. In addition, operator data will be compared to inspector data to determine if different trends exist.

Continuous Mining

Continuous mining is a system that allows coal to be ripped from a seam and loaded in the same operation. It was developed in the 1940's to replace the conventional mining cycle of undercutting, drilling, shooting, and loading. Continuous rippers are commonly found in room-and-pillar mines. In these mines, multiple entries are cut parallel to the main haulage lane and reached by cross tunnels, resulting in a checkerboard of alternating rooms and pillars. Pillars are left to support the mine roof; as mining is extended to greater depths, larger pillars must be left behind. This results in reduced mining efficiency.[1]

Longwall Mining

Longwall mining is the most recently introduced mechanized method of mining. Coal is cut by either a shear or a plow from a coal face that is typically 350 to 600 ft in width and 1,000 to 6,000 ft in length. Cut coal drops onto a chain conveyor that lies along the bottom of the face and is hauled to one end. Here it is transferred to the stage loader, which loads it onto a conveyor belt. The roof is supported by hydraulic roof supports which extend support over the walkway, thus creating space for mining to take place. As the coal is cut, the roof supports move forward to cover the newly exposed face, allowing the unsupported roof to fall behind and eliminating the need for permanent roof supports or pillars. Longwall sections are generally developed by continuous ripper miners,[4] and most longwalls operating in the United States are retreat operations using three or more entries on either side of the longwall panel.[2] Though fairly new to the United States, longwall mining has been used in Europe for many years, because mines there have reached greater depths, making it safer and more efficient to use longwall roof-support methods.

RESULTS OF ANALYSIS

From FY 83 through FY 87, mine operators collected 260,370 respirable coal dust samples on continuous miner operators. These samples had a mean dust concentration of 1.0 mg/m^3, with 12.2 pct of the samples exceeding the standard. This compares to 12,622 samples collected on longwall operators on the tailgate side, which had a mean concentration of 2.0 mg/m^3, with 36.8 pct of the samples exceeding the standard.

FY 87 MSHA data show that more than 65 pct of the mine sections in the United States use continuous ripper machines (about 1,750 sections). This mining method typically produces between 300 and 400 tons of coal per shift (Figure 1). Ripper sections have had a small increase in production since FY 78. Table I shows the trends in FY respirable coal dust mean concentrations for continuous ripper operators. The 0.4-mg/m^3 reduction in mean dust concentration from FY 78 to FY 87 is statistically significant and is accompanied by 11.8 pct fewer samples exceeding the 2.0-mg/m^3 standard. In FY 87, 439 ripper sections were cited for noncompliance once, and 120 were cited two or more times.

There were about 128 longwall sections operating in the United States in FY 87. This is approximately a 30-pct increase in the number of longwalls since 1978. However, only about 85 to 90 longwalls are in operational status at any given time. Most of these sections use longwall shearers, primarily of the double drum type. Since FY 78, longwall operators have experienced increases in median production from 500 tons/shift to 2,200 tons/shift, as shown in Figure 1. At the same time, respirable dust levels have also changed, as evidenced by Table II, which shows the trends in respirable coal dust mean concentration for tailgate side shearer operators. The 0.5-mg/m^3 reduction in mean dust concentration from FY 78 to FY 87 is statistically significant and is accompanied by 13.0 pct fewer samples exceeding the 2.0-mg/m^3 standard. In FY 87, 58 longwall sections were cited for noncompliance once, and 31 were cited two or more times.

Table I

Respirable Coal Dust Trends for Continuous Ripper Operators[1]

FY	N	Concentration, mg/m^3		
		Pct of N >2.0	AM	ASD
78	78,765	23.5	1.4	1.5
83	56,742	13.5	1.1	1.3
84	60,273	12.8	1.1	1.3
85	49,716	11.6	1.0	1.1
86	48,996	11.3	1.0	1.1
87	44,643	11.7	1.0	1.1

FY fiscal year. N number of samples.
AM arithmetic mean.
ASD arithmetic standard deviation.
[1]Data collected by coal mine operators

Table II

Respirable Coal Dust Trends for Longwall Operators, Tailgate Side[1]

FY	N	Concentration, mg/m^3		
		Pct of N >2.0	AM	ASD
78	2,747	51.6	2.5	1.9
83	2,392	33.7	2.0	2.0
84	2,782	37.1	2.1	2.0
85	2,234	36.5	2.0	1.6
86	2,668	38.0	2.0	1.5
87	2,546	38.6	2.0	1.5

FY fiscal year. N number of samples.
AM arithmetic mean.
ASD arithmetic standard deviation.
[1]Data collected by coal mine operators

Mines With Both Longwall and Ripper Sections

Respirable coal dust concentrations may be compared at mines having both longwall and ripper sections. The comparison was made by selecting the 10 mines with the greatest number of operator coal dust samples for the continuous miner and longwall operator on the tailgate side covering the period FY 83 through FY 87. These mines are identified as mines A through J in Table III, which summarizes the respirable coal dust concentrations. One mine is in Virginia, two mines each in Alabama, Ohio, and Pennsylvania, and the remaining three mines are in West Virginia.

The mine average respirable coal dust concentrations for the continuous miner and longwall operator samples in Table III are 1.2 and 2.1 mg/m^3, respectively. These means approximate the overall means for the two occupations over the same time period, which were 1.0 and 2.0 mg/m^3, respectively. Mines C, D, E, and J had the highest mean respirable coal dust concentrations for both the continuous miner operator and the longwall operator on the tailgate side. Mine H had the highest median longwall production (2,230 tons/shift) and the second lowest mean longwall operator dust concentration (1.4 mg/m^3).

Comparison of Mine Operator and MSHA Inspector Data

Figures 2 through 4 compare data collected by mine operators to data collected by MSHA inspectors on continuous miner operators and longwall operators on the tailgate side. The arithmetic mean (Figure 2), the percent of samples <0.2 mg/m^3 (Figure 3), and the percent of samples >2.0 mg/m^3 (Figure 4) are used because these measures cover a wide range of exposure. The only measure of the three to show a remarkable trend is the percent of samples <0.2 mg/m^3 (Figure 3), which clearly shows that operators are more likely to submit a sample with a low dust concentration. Approximately 27.4 pct of the operator samples collected on continuous miner operators had concentrations <0.2 mg/m^3, compared to approximately 16.1 pct of the MSHA samples. The trend is also apparent for samples collected on the tailgate side longwall operator, where 6.6 pct of the operator samples and only 1.5 pct of the inspector samples are <0.2 mg/m^3. Possible explanations for this difference are that operators collect five samples over consecutive work shifts during which operating conditions may change and affect dust levels, and since operators sample far more frequently, there is a

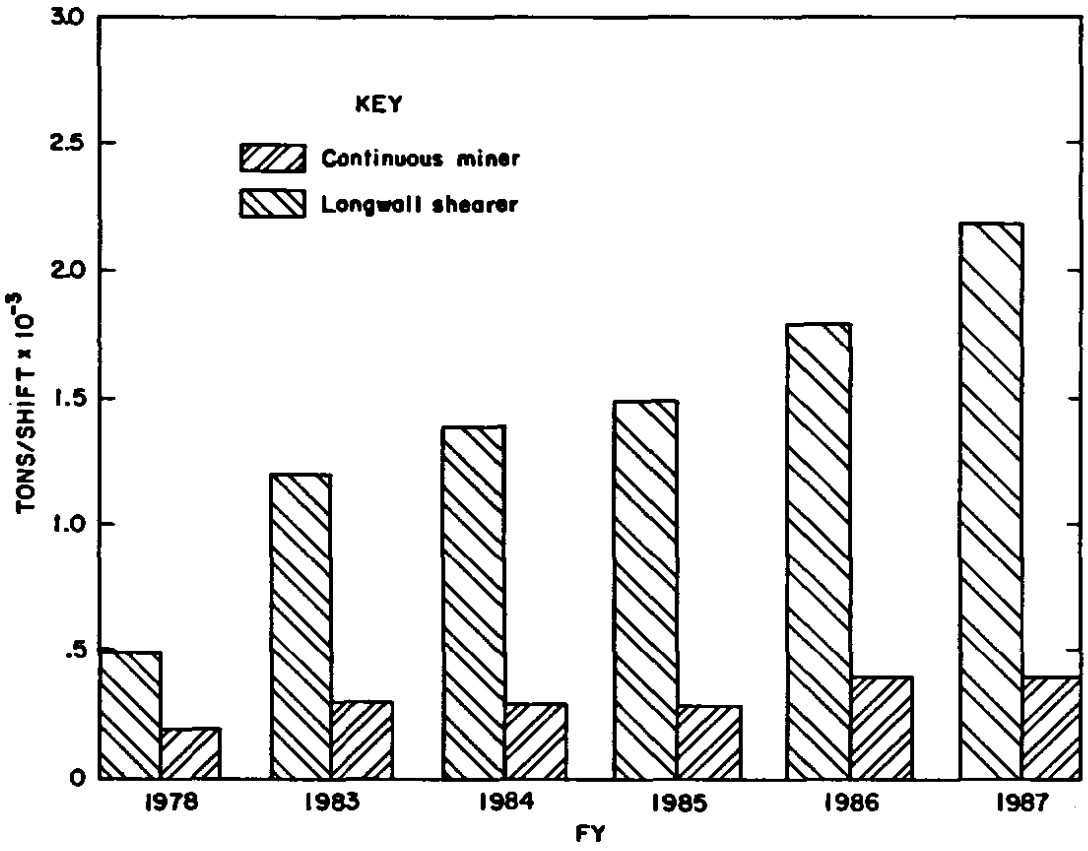

Figure 1. Underground median production as reported by mine operators for longwall shearers and continuous miners.

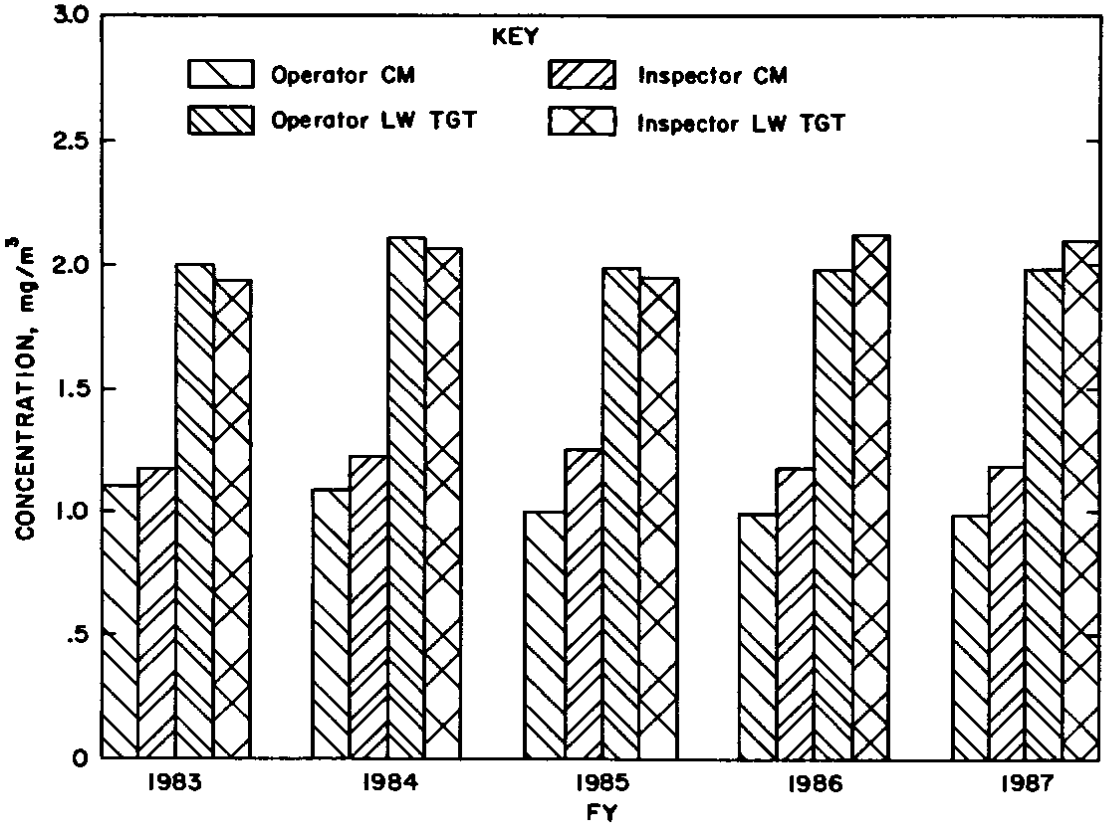

Figure 2. Arithmetic mean concentration for operator and inspector samples collected on continuous miner and tailgate side longwall operators.

Table III

Respirable Coal Dust Concentration, mg/m³ at Mines Using Continuous Rippers and Longwalls[1]

Mine	Continuous miner operator			Longwall operator tailgate side		
	N	AM	ASD	N	AM	ASD
A	970	1.0	1.0	464	2.1	1.8
B	1,222	1.0	0.7	371	2.0	1.5
C	1,437	1.8	1.8	566	2.7	2.1
D	1,172	1.7	1.7	573	2.5	1.8
E	870	1.3	1.1	201	2.6	1.7
F	1,369	0.5	0.7	165	1.8	1.3
G	517	1.0	0.7	139	1.4	1.3
H	681	1.1	1.1	289	1.4	1.2
I	966	0.9	0.9	338	1.3	1.0
J	902	1.4	1.7	173	3.1	2.9

N number of samples. AM arithmetic mean.
ASD arithmetic standard deviation.
[1]Data collected by coal mine operators.

greater chance of collecting samples with low dust concentrations. In addition, MSHA results could be higher because no prior announcement of arrival is given to the mine operator; thus, these samples may be indicative of truer day-to-day conditions.

SUMMARY

Over the past 5 years, operators of longwall shearer sections reported increases in median production from 1,200 to 2,200 tons/shift. This increase in production was accompanied by a continuing problem with respirable dust despite the significant decrease in mean dust levels that has occurred since FY 78. A number of longwall sections still experience difficulty in maintaining continuous compliance with the Federal standard. Longwall sections have arithmetic mean respirable dust concentrations that are more than double the concentrations reported by continuous ripper sections (2.0 mg/m³ vs. 1.0 mg/m³). In FY 87, 45 pct (58) of the longwall sections were found to be in noncompliance once, and an additional 24 pct (31) were cited two or more times. Thus, 69 pct of the longwall sections in operation during FY 87 experienced compliance problems. It is evident from these data that dust problems continue to plague longwall mining operations as longwall production continues to rise. If more high-producing longwalls are to be brought on-line to realize the full potential of this mining method, additional effective dust

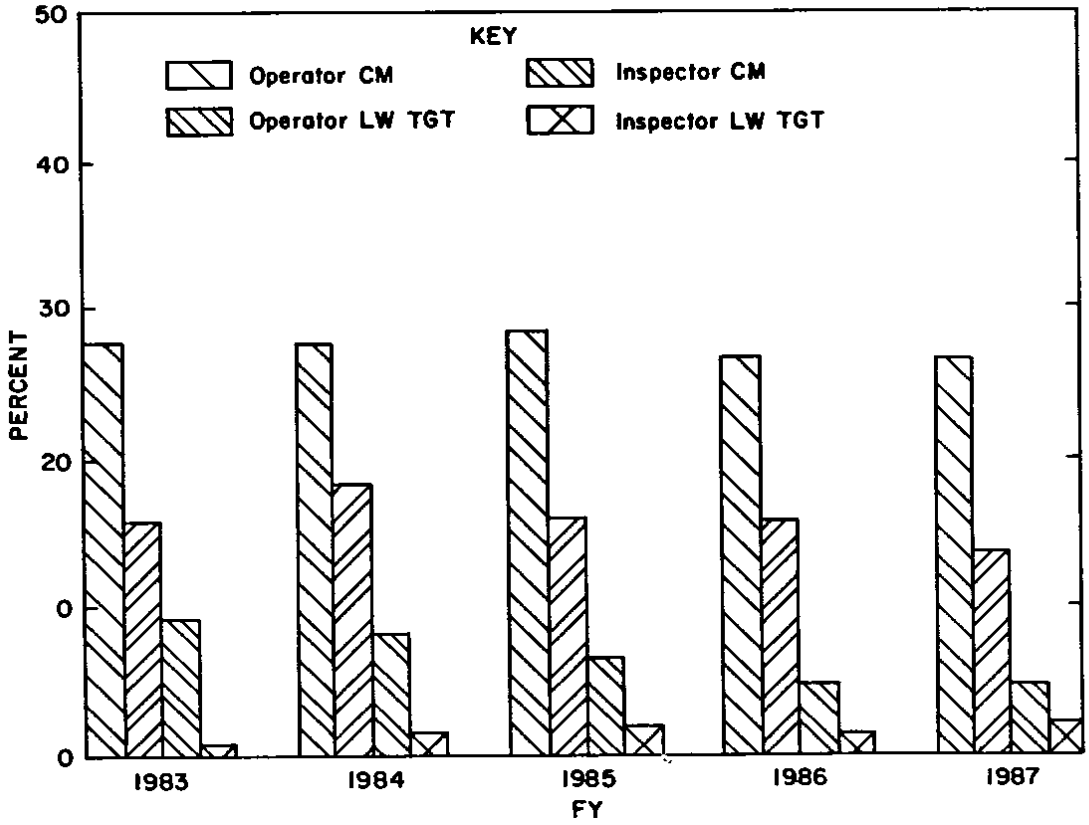

Figure 3. Percent of samples <0.2 mg/m^3 for operator and inspector samples collected on the continuous miner and tailgate operator.

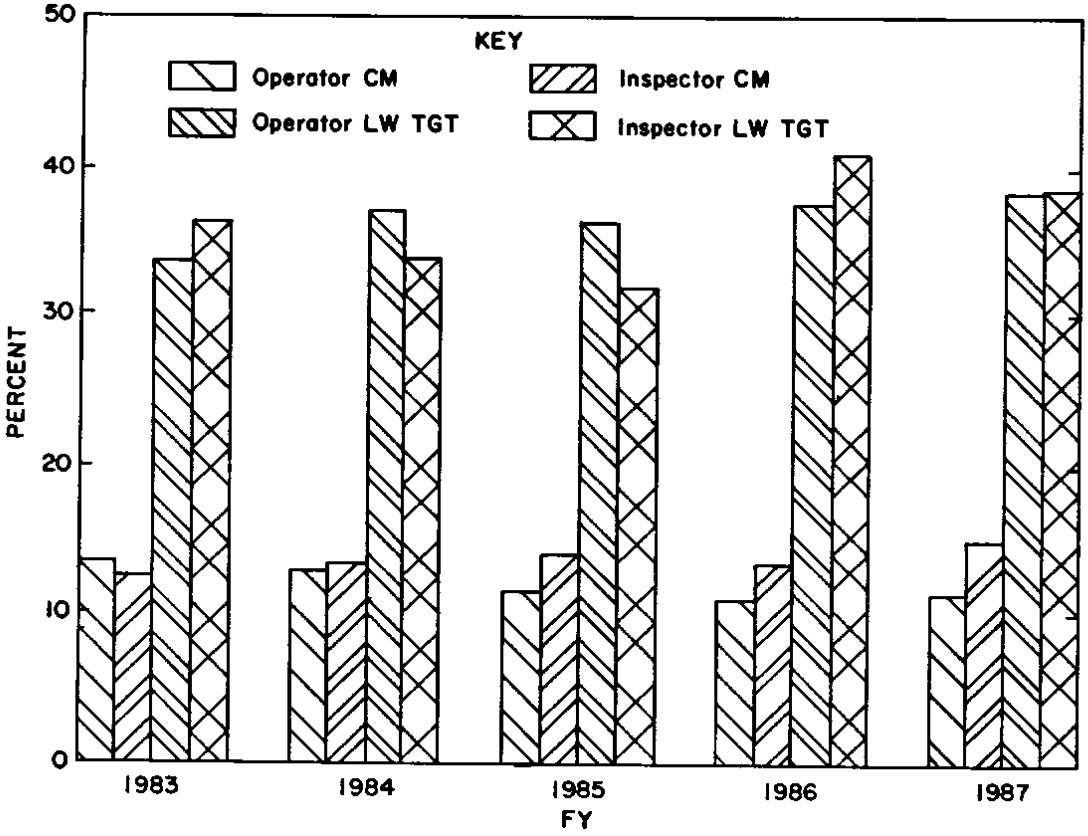

Figure 4. Percent of samples >2.0 mg/m^3 for operator and inspector samples collected on the continuous miner and tailgate side longwall operator.

control measures must be put into place and maintained to more consistently control dust levels on a continuous basis.

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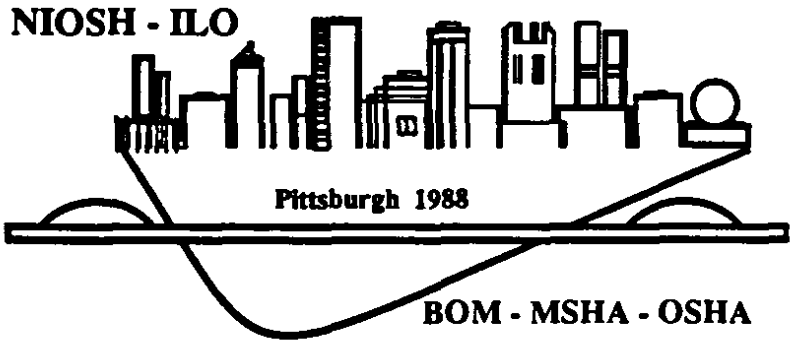

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