

## **NOISE EXPOSURE IN METAL AND NONMETAL MINES AND MILLS**

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### **ABSTRACT**

The Mine Safety and Health Administration (MSHA) has federal occupational safety and health jurisdiction over metal and nonmetal mines and mills. From mid-1974 through 1997, MSHA inspectors collected nearly 274,000 personal, full-shift noise dosimeter samples to determine compliance with the 90 dBA permissible exposure limit (PEL). Most of these samples (92.6%) were collected at surface mines or mills with the remaining samples (7.4%) being collected in underground mines. The objectives of this analysis are to describe historical trends in noise exposure, and to characterize recent exposure levels using 1995-97 data by location, commodity and occupation.

The noise data were split into two groups based upon sample location - underground and surface, six year groups covering the period 1974-97 and five occupation groups. Surface mine and mill data were further broken into six commodity groups. Summary statistics were calculated to characterize these data including; the number of samples collected, the mean percentage of samples exceeding the PEL, the mean percentage of workers wearing hearing protective devices (HPD), the mean dBA (Leq), the mean percentage of samples exceeding the MSHA compliance level (UCL), and the geometric and arithmetic means and standard deviations for noise dose.

All parameters measuring noise exposure show a gradual decline over the 24 year period. There is not a correspondingly clear trend for the increased use of HPD. However, most overexposed workers were wearing HPD when sampled by MSHA inspectors. Underground mine noise exposure is greater than surface mine and mill exposure. Occupations with greater than average risk of excessive noise exposure include all types of drill and heavy equipment operators, such as those operating bulldozers, scraper-loaders, draglines and shovels.

### **INTRODUCTION**

MSHA regulates worker health and safety conditions and practices in mining under the authority of the Federal Mine Safety and Health Act of 1977.<sup>(1)</sup> Excessive noise is one of the most pervasive health hazards in mining. Regulations for noise exposure in metal and nonmetal mining are published in Title 30 of the Code of Federal Regulations.<sup>(2)</sup> This rule specifies permissible exposure limits (PEL), the primacy of feasible administrative or engineering controls, and the

interim or ultimate provision of HPD.<sup>(3)</sup>

MSHA's noise PEL is 90 dBA as an 8-hour time-weighted average (TWA), using a 5 dB exchange rate. Higher exposures for less than eight hours are permitted, to a maximum of 115 dBA. MSHA inspectors use personal noise dosimeters as the primary instrument for determining compliance.<sup>(4)</sup> A dosimeter determines, in a single number, the percentage of the permissible noise exposure (noise dose) received by a worker during the entire shift. The dosimeter is particularly useful for measuring intermittent and variable noise levels without constant attendance by an inspector with a sound level meter (SLM).

Since the dosimeter is used for enforcement, it is set at a 90 dBA criterion level with a 5 dB exchange rate and a 90 dBA threshold level. The criterion level is that sound level which, if maintained for eight hours, results in a noise dose of 100%, which is the PEL. The exchange rate is the change in sound level (5 dB) that will double or halve the dose. The threshold is the sound level at which the dosimeter begins integrating noise into the calculation of the dose. Compliance is actually based on an 8-hour TWA of 92 dBA, which is the PEL plus a 2 dB sampling factor to account for instrument and procedural errors.

The dosimeter receives the sound level through a microphone worn on the worker's shoulder. The microphone output is filtered using an A-weighted scale meeting the ANSI specifications for type 2 sound level meters. Noise levels below the 90 dBA threshold are selectively eliminated. The ratios of sound level to established limits, at every sound level above 90 dBA, are calculated and integrated with time to read-out the actual TWA exposure as a percentage of the permissible limit. A dose greater than 100% exceeds the PEL. A dose of 132% or more exceeds MSHA's compliance level.

In the discussion that follows, a noise dosimeter result  $>$  PEL is referred to as an "overexposure," and a result  $\geq$  132% is referred to as greater than or equal to the 95% upper confidence limit (UCL), or "out of compliance." This is a slight departure from MSHA's legal terminology, which refers to the latter result as an overexposure. A noise exposure  $>$  100% (PEL) but  $<$  132% (UCL) has a probability  $>$  0.5 but  $<$  0.95 of being out of compliance, and is legally in the range of uncertainty.<sup>(3)</sup>

## **NOISE DOSIMETER DATA DESCRIPTION**

Each noise dosimeter result obtained by metal and nonmetal mine inspectors is entered into a computerized database. The inspector provides the MSHA mine ID number, the date of sampling, a mine location code, the sampled miner's occupation code, the full-shift noise dose (%), whether the miner was wearing hearing protection, and any enforcement action taken. The mine ID provides a link to the mine's SIC code, primary mine type, and number of workers.

The actual duration of the sample is not reported, since the dosimeter does the time-weighting. SLM readings are also not reported, unless they exceed 115 dBA or are used to terminate a

citation. Sample duration, SLM readings, and information about the miner's activities and noise sources are recorded in the inspector's notes.

There are 85 metal and nonmetal standard industrial classification (SIC) codes, 121 occupation codes and 36 mine location codes. The SIC code describes the mined or milled commodity, such as dimension granite or crushed limestone. The occupation code describes the sampled miner's activity, such as front-end loader operator or truck driver. The location code provides additional information on the location of the activity, such as active production underground or crushing at a quarry or mill.

In 1980, the former U.S. Bureau of Mines began receiving MSHA's industrial hygiene sampling data, along with basic mine demographic data, and developed a system of statistical programs known as MIDAS<sup>(5)</sup> to analyze the data. Over time, MIDAS has evolved from a government maintained, mainframe computer database to a University maintained, PC database. The analyses presented here were performed using two Microsoft Office 97<sup>®</sup> applications - Access<sup>®</sup> and Excel<sup>®</sup>, and are patterned after previous analyses of these data<sup>(6,7)</sup>.

### **Confounding Factors and Limitations**

The noise dosimeter data used in this analysis were collected by MSHA to determine compliance with the noise PEL. Although they are not "worst case" -- metal/nonmetal inspectors are instructed to sample every occupation in every work area at every mine at least once every five years -- they are probably biased upward. Miners deemed to be at highest risk have highest priority and are sampled more often. On the other hand, overexposed miners are re-sampled after engineering noise controls have been implemented. In short, inspectors are required to take both baseline and judgment samples. Since this sampling strategy is not based upon a probability model, the classical statistical assumptions of randomness, known distribution, and homogeneous variance may not obtain. Statistical inferences must be drawn with caution.

An awkward analytical problem is created by MSHA's sampling strategy and coding system. A relatively few SIC codes (sand and gravel and crushed limestone), location codes (surface production, haulage, primary crushing; mill haulage, crushing), and occupation codes (truck driver and front-end loader operator) account for the vast preponderance of the data. This is as it should be, reflecting the nature of the metal and nonmetal mining industry, but it causes problems in grouping and analyzing these data.

Another problem from a purely scientific perspective is MSHA's 90 dBA threshold level. Although perfectly appropriate to enforce the 90 dBA PEL, it arbitrarily lowers all the data, since noise less than 90 dBA is not integrated into the dose calculation. Only when a miner is exposed to noise levels  $\geq 90$  dBA throughout the entire shift will the 90 dBA threshold not affect the dose. This factor must be considered when estimating risk or prevalence of noise-induced hearing loss, and/or when comparing MSHA data with data collected at a different threshold level.

In addition, during the past 20 years MSHA has implemented numerous legislative, policy and procedural changes. In most cases, these changes affected the noise data even though they did not directly affect mining practices or exposure levels. Seven noteworthy events were:

- The MSH Act (1978).
- The exclusion of most surface mining for 7 months (1982).
- New occupation codes (04/83).
- Revised inspection and sampling strategy (FY 1986).
- Sampling equipment shortage (1986-87).
- New engineering control guidelines (04/90).
- Revised sampling strategy (1991).

In general, these changes affected the number, and in some cases the location or occupation distribution, of samples taken. Again in general, the fewer samples taken, the higher the noise dose data, and vice versa. Tables 1 and 2 are a summary of the MSHA noise data collected each year from 1974-97 at underground and surface location. The tables show the yearly variability in noise data.

Table 1. 1974-97 Underground noise dosimeter data

| Year   | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | Dose - Geometric |               | Arithmetic mean, dBA | ≥ 1.32*PEL, pct | ≥ 1.32*PEL HPD, pct |
|--------|-------------------|------------|----------|----------------|------------------|---------------|----------------------|-----------------|---------------------|
|        |                   |            |          |                | Mean, pct        | Std.dev., pct |                      |                 |                     |
| 74     | 44                | 61.4       | 6.8      | 11.1           | 124.3            | 6.2           | 90.3                 | 59.1            | 11.5                |
| 75     | 656               | 53.2       | 32.3     | 49.3           | 111.0            | 4.4           | 90.3                 | 46.5            | 51.1                |
| 76     | 1157              | 53.9       | 59.5     | 71.6           | 99.8             | 4.8           | 88.8                 | 45.8            | 75.5                |
| 77     | 1711              | 51.3       | 57.9     | 73.0           | 85.0             | 5.4           | 87.3                 | 43.9            | 75.4                |
| 78     | 2185              | 42.5       | 66.0     | 84.5           | 64.3             | 5.0           | 84.8                 | 33.4            | 88.8                |
| 79     | 1719              | 44.9       | 65.5     | 83.9           | 71.1             | 4.5           | 85.8                 | 30.0            | 89.9                |
| 80     | 1138              | 38.0       | 61.7     | 88.5           | 60.3             | 4.2           | 84.8                 | 25.4            | 95.2                |
| 81     | 809               | 48.7       | 69.1     | 89.6           | 77.0             | 3.8           | 87.0                 | 32.3            | 93.9                |
| 82     | 1016              | 40.9       | 73.2     | 93.8           | 63.4             | 4.7           | 85.4                 | 29.0            | 98.0                |
| 83     | 668               | 41.8       | 67.8     | 83.2           | 69.3             | 3.8           | 86.2                 | 26.2            | 91.4                |
| 84     | 800               | 41.4       | 67.4     | 82.5           | 69.8             | 4.4           | 86.3                 | 26.9            | 85.6                |
| 85     | 629               | 47.5       | 69.0     | 88.3           | 79.9             | 4.1           | 87.7                 | 33.1            | 91.8                |
| 86     | 570               | 44.0       | 67.7     | 82.5           | 75.8             | 4.4           | 87.3                 | 31.6            | 89.4                |
| 87     | 652               | 44.9       | 73.6     | 88.7           | 85.7             | 4.0           | 88.6                 | 32.7            | 92.0                |
| 88     | 651               | 41.6       | 71.1     | 89.3           | 84.4             | 3.7           | 88.3                 | 30.6            | 88.9                |
| 89     | 607               | 33.4       | 65.9     | 85.7           | 74.3             | 3.5           | 87.3                 | 24.2            | 86.4                |
| 90     | 629               | 37.5       | 66.3     | 82.6           | 76.4             | 3.6           | 87.6                 | 26.2            | 90.9                |
| 91     | 630               | 41.1       | 68.4     | 85.3           | 74.5             | 4.0           | 87.1                 | 29.4            | 86.5                |
| 92     | 562               | 39.9       | 69.4     | 92.0           | 75.3             | 3.9           | 87.8                 | 29.0            | 93.9                |
| 93     | 616               | 33.3       | 49.2     | 62.9           | 57.1             | 4.0           | 84.9                 | 24.5            | 70.2                |
| 94     | 786               | 34.0       | 71.9     | 97.0           | 60.0             | 4.2           | 85.9                 | 23.9            | 97.9                |
| 95     | 688               | 32.4       | 68.5     | 91.5           | 53.6             | 4.2           | 85.1                 | 22.1            | 94.1                |
| 96     | 987               | 31.3       | 66.7     | 89.6           | 53.7             | 4.2           | 84.8                 | 19.4            | 94.8                |
| 97     | 418               | 33.7       | 67.0     | 92.2           | 58.9             | 4.4           | 85.9                 | 27.0            | 93.8                |
| Totals | 20328             | 42.4       | 64.6     | 82.4           | 71.7             | 4.4           | 86.5                 | 31.2            | 85.5                |

> PEL, pct = percentage of samples exceeding the PEL; HPD, pct = percentage of workers wearing hearing protective devices; > PEL HPD, pct = percentage of workers wearing HPD for samples > PEL; ≥1.32\*PEL, pct = percentage of samples exceeding the non-compliance level, ≥1.32\*PEL HPD, pct = percentage of workers wearing HPD where the sample exceeds the non-compliance level.

Finally, the metal/nonmetal noise dosimeter data do not include information on noise source(s),

namely, an equipment or machinery code. In some cases, this can be inferred from occupation, but more specific information would undoubtedly be useful. These data do not include information characterizing engineering controls, rather they are a mixture of "before-and-after" dosimeter readings that can only be distinguished chronologically. This is critical missing information.

Table 2. 1974-97 Surface noise dosimeter data

| Year   | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | Dose - Geometric |               | Arithmetic mean, dBA | ≥ 1.32*PEL, pct | ≥ 1.32*PEL HPD, pct |
|--------|-------------------|------------|----------|----------------|------------------|---------------|----------------------|-----------------|---------------------|
|        |                   |            |          |                | Mean, pct        | Std.dev., pct |                      |                 |                     |
| 74     | 319               | 35.1       | 14.7     | 29.5           | 54.2             | 4.0           | 85.0                 | 26.6            | 31.8                |
| 75     | 3170              | 41.4       | 18.4     | 29.7           | 64.5             | 3.9           | 86.2                 | 31.4            | 32.8                |
| 76     | 8007              | 38.7       | 31.0     | 46.4           | 58.5             | 4.3           | 84.9                 | 29.7            | 49.6                |
| 77     | 11774             | 35.4       | 38.8     | 56.1           | 52.6             | 4.3           | 84.1                 | 26.2            | 59.8                |
| 78     | 15141             | 36.2       | 48.8     | 68.0           | 55.0             | 4.1           | 84.4                 | 24.0            | 74.4                |
| 79     | 19457             | 35.3       | 51.6     | 70.5           | 56.7             | 3.6           | 84.9                 | 20.5            | 78.6                |
| 80     | 14047             | 34.0       | 52.2     | 72.2           | 58.0             | 3.3           | 85.3                 | 17.6            | 83.3                |
| 81     | 10469             | 31.1       | 52.6     | 71.6           | 53.0             | 3.4           | 84.6                 | 15.2            | 83.8                |
| 82     | 2192              | 21.0       | 59.4     | 83.3           | 34.6             | 4.0           | 80.7                 | 10.9            | 90.8                |
| 83     | 6960              | 27.4       | 56.3     | 77.1           | 49.4             | 3.4           | 84.1                 | 13.7            | 84.5                |
| 84     | 7725              | 25.6       | 55.2     | 75.3           | 44.2             | 3.6           | 82.9                 | 12.2            | 86.9                |
| 85     | 7411              | 24.2       | 53.1     | 69.2           | 44.3             | 3.5           | 83.3                 | 10.9            | 76.5                |
| 86     | 8643              | 24.9       | 51.5     | 69.2           | 46.1             | 3.4           | 83.9                 | 11.4            | 77.1                |
| 87     | 9493              | 26.6       | 48.9     | 67.4           | 50.0             | 3.3           | 84.5                 | 12.6            | 74.4                |
| 88     | 9863              | 21.8       | 52.2     | 70.1           | 47.2             | 3.2           | 84.0                 | 10.7            | 76.6                |
| 89     | 9672              | 20.7       | 46.9     | 66.7           | 45.7             | 3.1           | 83.8                 | 9.7             | 73.4                |
| 90     | 12438             | 20.0       | 47.9     | 73.0           | 43.9             | 3.2           | 83.6                 | 10.0            | 78.3                |
| 91     | 14306             | 18.8       | 49.4     | 74.4           | 38.0             | 3.5           | 82.6                 | 9.6             | 82.1                |
| 92     | 14060             | 18.4       | 49.5     | 74.7           | 38.6             | 3.3           | 82.8                 | 9.6             | 79.7                |
| 93     | 13950             | 16.7       | 33.3     | 46.0           | 36.5             | 3.4           | 82.2                 | 8.2             | 48.1                |
| 94     | 15193             | 15.5       | 52.7     | 79.3           | 33.3             | 3.5           | 81.5                 | 7.3             | 84.4                |
| 95     | 13715             | 13.6       | 52.2     | 78.5           | 29.9             | 3.5           | 80.7                 | 6.3             | 83.0                |
| 96     | 17523             | 11.4       | 48.7     | 77.6           | 27.0             | 3.7           | 79.6                 | 5.3             | 82.3                |
| 97     | 7991              | 11.7       | 50.3     | 76.8           | 26.9             | 3.6           | 79.8                 | 5.2             | 82.9                |
| Totals | 253519            | 24.2       | 48.3     | 67.9           | 43.0             | 3.6           | 83.2                 | 13.3            | 73.1                |

### NOISE DOSIMETER DATA ANALYSIS

Nearly 274,000 noise dosimeter samples were taken at metal and nonmetal mines and mills from 1974 to 1997. Nearly 75% (>205,000) of these samples were collected at surface stone and sand and gravel properties.

As mentioned previously, the noise data were partitioned into six year groups, and six industry groups -- based on SIC code. All samples collected in underground locations, regardless of SIC code were grouped together. Surface samples lacking SIC codes were not analyzed. The cement and lime data, as in the past<sup>(7)</sup>, were grouped with the crushed limestone data to avoid the creation of excess groups with small sample size. Table 3 shows the SIC codes included in each group. More detailed analyses are presented for samples collected from 1995 to 1997, including analyses for selected occupations.

Four measures of central tendency are provided: Arithmetic mean dose, geometric mean dose,

median dose and average dBA (Leq). The arithmetic mean dose is probably an inappropriately high estimate of exposure, because the noise dosimeter data are log-normally distributed.<sup>(6-8)</sup> This parameter is not shown after table 4; instead the average dBA is provided. The geometric mean is

Table 3. SIC code groups

| SIC code | Description           | SIC group  | SIC code | Description         | SIC group      |
|----------|-----------------------|--|----------|---------------------|----------------|
| 14230    | Granite - crushed     | Crushed Stone  | 13111    | Oil shale           | Nonmetal       |
| 14290    | Stone - crushed       | Crushed Stone  | 13112    | Oil sand - 1980     | Nonmetal       |
| 14291    | Marble - crushed      | Crushed Stone  | 14530    | Clay - fire         | Nonmetal       |
| 14292    | Sandstone - crushed   | Crushed Stone  | 14550    | Clay - common       | Nonmetal       |
| 14293    | Slate - crushed       | Crushed Stone  | 14590    | Clay - ceramic      | Nonmetal       |
| 14294    | Traprock - crushed    | Crushed Stone  | 14591    | Aplite              | Nonmetal       |
| 14220    | Limestone - crushed   | Crushed Limestone  | 14592    | Brucite             | Nonmetal       |
| 32410    | Cement                | Crushed Limestone  | 14593    | Feldspar            | Nonmetal       |
| 32740    | Lime                  | Crushed Limestone  | 14594    | Kyanite             | Nonmetal       |
| 14110    | Stone - dimension NEC | Dimension Stone  | 14595    | Magnesite           | Nonmetal       |
| 14111    | Granite - dimension   | Dimension Stone  | 14596    | Shale - common      | Nonmetal       |
| 14112    | Limestone - dimension | Dimension Stone  | 14720    | Barite              | Nonmetal       |
| 14113    | Marble - dimension    | Dimension Stone  | 14730    | Fluorspar           | Nonmetal       |
| 14114    | Sandstone - dimension | Dimension Stone  | 14740    | Potash,soda,borate  | Nonmetal       |
| 14115    | Slate - dimension     | Dimension Stone  | 14741    | Boron minerals      | Nonmetal       |
| 14116    | Traprock - dimension  | Dimension Stone  | 14742    | Potash              | Nonmetal       |
| 10110    | Iron ore              | Metal  | 14743    | Trona               | Nonmetal       |
| 10210    | Copper ore            | Metal  | 14744    | Sodium              | Nonmetal       |
| 10310    | Lead/zinc ore         | Metal  | 14750    | Phosphate rock      | Nonmetal       |
| 10410    | Gold lode/placer      | Metal  | 14760    | Salt - rock         | Nonmetal       |
| 10440    | Silver ore            | Metal  | 14770    | Sulfur              | Nonmetal       |
| 10510    | Aluminum ore          | Metal  | 14790    | Chem & fertilizer   | Nonmetal       |
| 10610    | Ferroalloy ore        | Metal  | 14791    | Lithium             | Nonmetal       |
| 10611    | Chromite              | Metal  | 14792    | Pigment minerals    | Nonmetal       |
| 10612    | Cobalt                | Metal  | 14793    | Pyrite              | Nonmetal       |
| 10613    | Columbium/tantalum    | Metal  | 14794    | Strontium           | Nonmetal       |
| 10614    | Manganese             | Metal  | 14920    | Gypsum              | Nonmetal       |
| 10615    | Molybdenum            | Metal  | 14960    | Talc - pyrophyllite | Nonmetal       |
| 10616    | Nickel                | Metal  | 14990    | Nonmetal minerals   | Nonmetal       |
| 10617    | Tungsten              | Metal  | 14991    | Asbestos            | Nonmetal       |
| 10920    | Mercury               | Metal  | 14992    | Gemstones           | Nonmetal       |
| 10940    | Uranium/vanadium      | Metal  | 14993    | Gilsonite           | Nonmetal       |
| 10941    | Uranium               | Metal  | 14994    | Mica                | Nonmetal       |
| 10942    | Vanadium              | Metal  | 14995    | Peat - 1979         | Nonmetal       |
| 10990    | Metal ores - nec      | Metal  | 14996    | Perlite             | Nonmetal       |
| 10991    | Antimony              | Metal  | 14997    | Pumice              | Nonmetal       |
| 10992    | Beryl                 | Metal  | 14998    | Vermiculite         | Nonmetal       |
| 10993    | Platinum group        | Metal  | 28190    | Industrial chem     | Nonmetal       |
| 10994    | Rare earths           | Metal  | 28991    | Salt - evaporite    | Nonmetal       |
| 10995    | Tin ore               | Metal  | 28992    | Salt - brine        | Nonmetal       |
| 10996    | Titanium              | Metal  | 29900    | Leonardite          | Nonmetal       |
| 10997    | Zircon                | Metal  | 00000    | Industry unknown    | Not classified |
| 28191    | Alumina - mill        | Metal  | 14410    | Sand & gravel       | Sand & Gravel  |
| All      | All                   | Underground samples regardless of SIC code are included in one group |          |                     |                |

probably an inappropriately low estimate of exposure due to the 90 dBA threshold. Medians are the 50<sup>th</sup> percentile dose and are possibly the best estimate of exposure.

Two "compliance" rates are shown: Percent of samples exceeding the PEL and percent exceeding the compliance level. In addition, the percentage of workers wearing HPD, percentage wearing HPD when the sample exceeded the PEL and the percentage wearing HPD when the sample

exceeded the compliance level are shown.

### Yearly Trends

Successful noise control should be reflected in reduced noise levels, reduced overexposures, and increased use of HPD. Table 1 shows trends in underground noise dosimeter data from 1974 to 1997. Samples exceeding the PEL declined from 61% to 34%, and the geometric mean dose from 124% to 59%. The average dBA fell by more than 4 dB. As illustrated in figure 1, the percentage of miners wearing hearing protection failed to show substantial improvement.

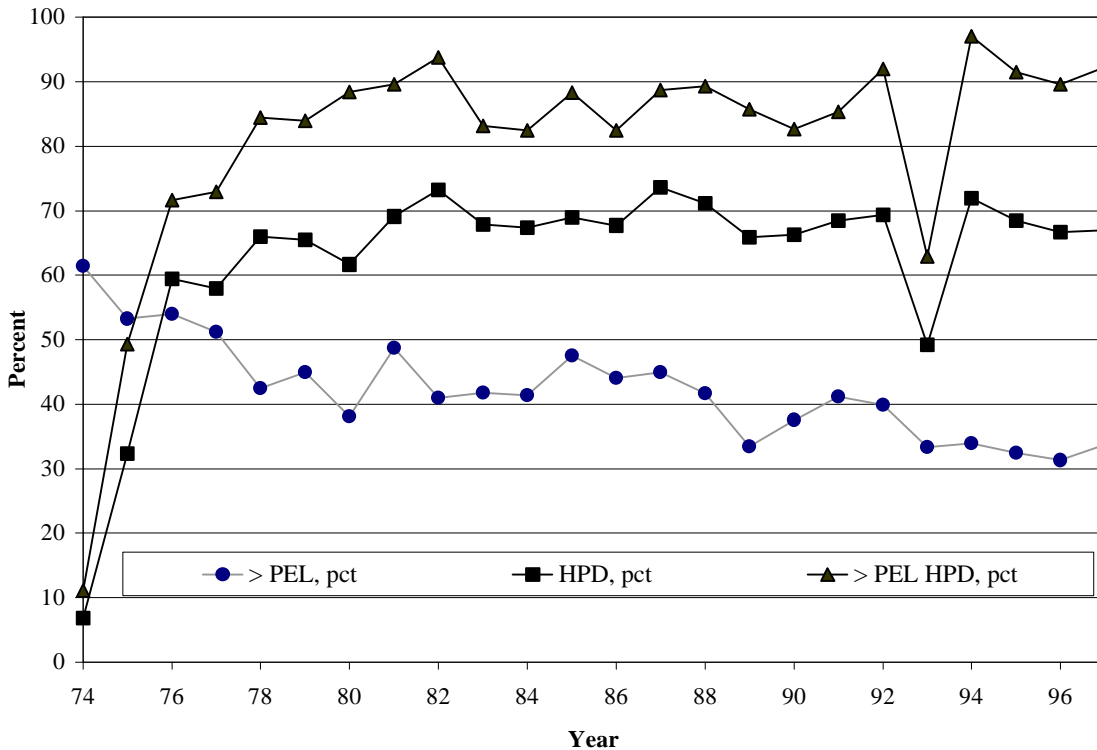


Figure 1.- Yearly trends at underground properties, 1974-97

Table 2 shows trends in surface noise dosimeter data from 1974 to 1997. Samples exceeding the PEL declined from 35% to 12%, and the geometric mean dose from 54% to 27%. The average dBA fell by more than 5 dB. As was the case with noise dosimeter samples collected underground, the percentage of miners wearing hearing protection failed to show substantial improvement as shown in figure 2.

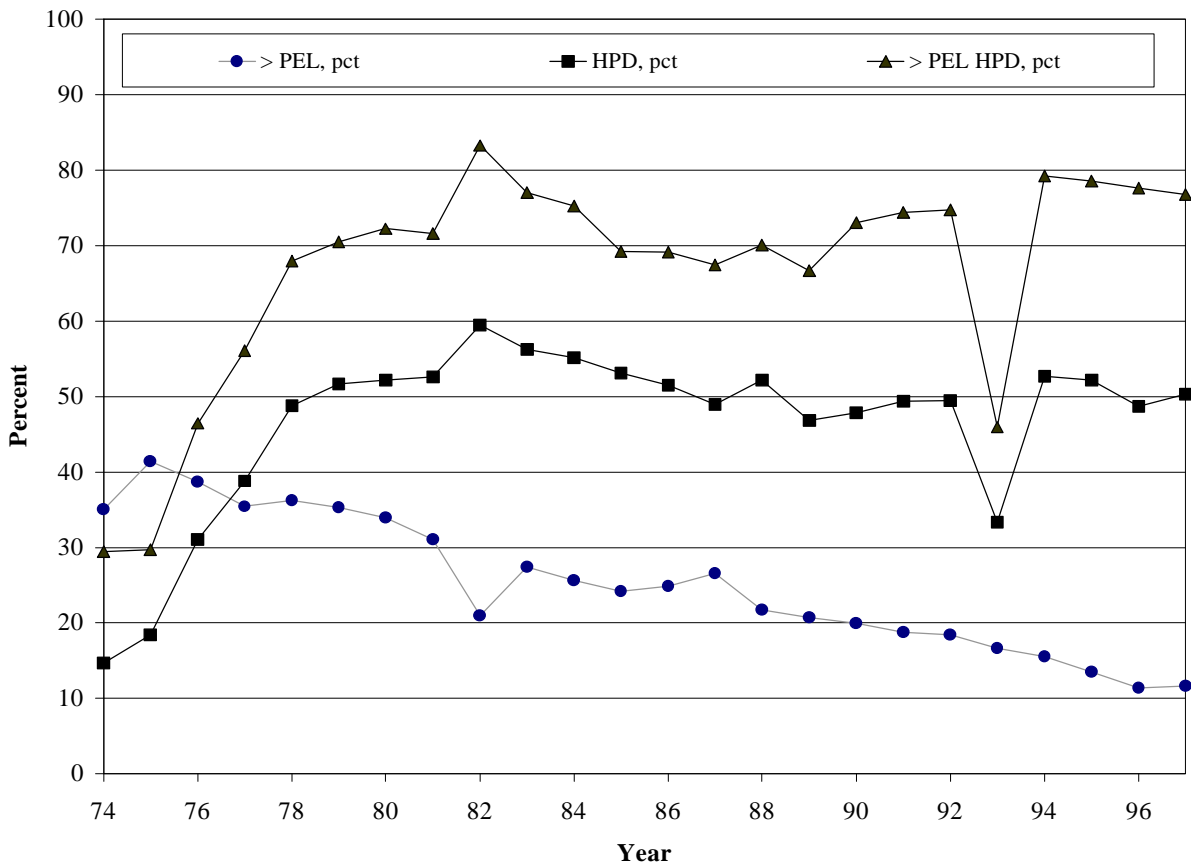


Figure 2.- Yearly trends at surface properties, 1974-97

Table 4 shows trends, over time, for the seven groups described previously for two measures; percent of samples > PEL and geometric mean dose. All groups show dramatic improvement. Table 5 shows additional statistics for the seven groups for the time period 1995-97. This table allows a comparison of the major indices of dose; arithmetic and geometric mean and the median. The geometric mean dose is less than the median dose, which is less than the arithmetic mean dose. The bulk of the samples (64%) are collected at surface sand and gravel and crushed limestone operations, but underground mine (32.3%) and surface dimension stone (23.4%) operations have the most samples exceeding the PEL. Use of HPD is greatest at surface (67.8%) and underground locations (67.2%).

Table 4. Noise dosimeter trends over time by group.

| Years                     | Number of samples | > PEL, pct | Dose - Geometric Mean, pct | Years                   | Number of samples | > PEL, pct | Dose - Geometric Mean, pct |
|---------------------------|-------------------|------------|----------------------------|-------------------------|-------------------|------------|----------------------------|
| Underground               |                   |            |                            | Surface Dimension Stone |                   |            |                            |
| 74-78                     | 5753              | 48.8       | 81.7                       | 74-78                   | 1382              | 48.4       | 81.4                       |
| 79-82                     | 4682              | 43.0       | 67.5                       | 79-82                   | 1026              | 41.5       | 73.9                       |
| 83-86                     | 2667              | 43.5       | 73.2                       | 83-86                   | 687               | 36.4       | 60.7                       |
| 87-90                     | 2539              | 39.5       | 80.2                       | 87-90                   | 902               | 34.8       | 68.0                       |
| 91-94                     | 2594              | 36.8       | 65.7                       | 91-94                   | 2076              | 31.1       | 53.4                       |
| 95-97                     | 2093              | 32.2       | 54.7                       | 95-97                   | 1397              | 23.4       | 41.9                       |
| 74-97                     | 20328             | 42.4       | 71.7                       | 74-97                   | 7470              | 35.2       | 60.1                       |
| Surface Sand and Gravel   |                   |            |                            | Surface Metal           |                   |            |                            |
| 74-78                     | 6954              | 40.4       | 62.7                       | 74-78                   | 4274              | 26.7       | 36.2                       |
| 79-82                     | 12047             | 38.2       | 64.5                       | 79-82                   | 4228              | 22.1       | 34.5                       |
| 83-86                     | 8022              | 28.6       | 50.3                       | 83-86                   | 2956              | 18.2       | 30.8                       |
| 87-90                     | 14667             | 25.1       | 50.5                       | 87-90                   | 2692              | 15.4       | 35.7                       |
| 91-94                     | 22617             | 17.6       | 36.2                       | 91-94                   | 3126              | 11.5       | 31.4                       |
| 95-97                     | 14503             | 12.3       | 26.5                       | 95-97                   | 2858              | 9.5        | 25.8                       |
| 74-97                     | 78810             | 24.3       | 43.1                       | 74-97                   | 20134             | 18.2       | 32.6                       |
| Surface Crushed Limestone |                   |            |                            | Surface Nonmetal        |                   |            |                            |
| 74-78                     | 15230             | 39.0       | 60.8                       | 74-78                   | 5874              | 27.3       | 40.1                       |
| 79-82                     | 17906             | 33.0       | 55.7                       | 79-82                   | 5387              | 28.6       | 47.4                       |
| 83-86                     | 10668             | 26.7       | 49.4                       | 83-86                   | 3912              | 19.5       | 38.3                       |
| 87-90                     | 14077             | 22.5       | 47.2                       | 87-90                   | 4232              | 15.0       | 39.9                       |
| 91-94                     | 17228             | 17.6       | 38.6                       | 91-94                   | 5092              | 14.0       | 32.0                       |
| 95-97                     | 11784             | 12.3       | 29.2                       | 95-97                   | 3520              | 9.3        | 28.2                       |
| 74-97                     | 86893             | 25.7       | 46.2                       | 74-97                   | 28017             | 19.9       | 37.7                       |
| Surface Crushed Stone     |                   |            |                            |                         |                   |            |                            |
| 74-78                     | 4589              | 43.0       | 69.3                       |                         |                   |            |                            |
| 79-82                     | 5571              | 34.9       | 57.7                       |                         |                   |            |                            |
| 83-86                     | 4492              | 25.5       | 47.6                       |                         |                   |            |                            |
| 87-90                     | 4896              | 19.5       | 42.1                       |                         |                   |            |                            |
| 91-94                     | 7314              | 16.6       | 34.3                       |                         |                   |            |                            |
| 95-97                     | 5167              | 12.4       | 27.6                       |                         |                   |            |                            |
| 74-97                     | 32029             | 24.6       | 43.3                       |                         |                   |            |                            |

Table 5. Noise dosimeter data for the period 1995-97

| Group                     | Number of samples | > PEL, pct | Dose, geometric |               | Dose median, pct | Dose, arithmetic |               | Arithmetic mean, dBA | HPD, pct |
|---------------------------|-------------------|------------|-----------------|---------------|------------------|------------------|---------------|----------------------|----------|
|                           |                   |            | mean, pct       | std.dev., pct |                  | mean, pct        | std.dev., pct |                      |          |
| Underground               | 2093              | 32.2       | 54.7            | 4.2           | 68               | 138.3            | 325.1         | 85.1                 | 67.3     |
| Surface Sand and Gravel   | 14503             | 12.3       | 26.5            | 3.7           | 32               | 51.8             | 72.4          | 79.6                 | 46.8     |
| Surface Crushed Limestone | 11784             | 12.3       | 29.2            | 3.6           | 37               | 55.2             | 80.4          | 80.3                 | 49.3     |
| Surface Crushed Stone     | 5167              | 12.4       | 27.6            | 3.6           | 33               | 53.5             | 77.6          | 79.8                 | 52.9     |
| Surface Dimension Stone   | 1397              | 23.4       | 41.9            | 3.8           | 49               | 101.8            | 261.4         | 83.1                 | 56.5     |
| Surface Metal             | 2858              | 9.5        | 25.8            | 3.5           | 32               | 46.6             | 52.1          | 79.5                 | 67.8     |
| Surface Nonmetal          | 3520              | 9.3        | 28.2            | 3.3           | 34               | 49.1             | 64.8          | 80.4                 | 47.0     |

## Analysis by Commodity and Location

Table 5 focuses on differences among the industry groups during the most recent (1995-97) time period. The underground group has a somewhat higher exposure profile (32% > PEL) than the surface dimension stone (23% > PEL), and a substantially higher exposure profile than the other surface groups. However, the underground group includes only about 5% of the samples while surface dimension stone includes about 3% of the samples. The surface sand and gravel, crushed limestone, and stone groups exhibit relatively similar exposure profiles (12% > PEL) while the surface metal and nonmetal group profiles are somewhat lower (9% > PEL).

Table 5 also shows the median dose for each group, which can be compared with, and used to "adjust," the geometric mean dose. The median ranges from 5.4 to 13.3% above the geometric mean dose, but is 14.6 to 70.3% lower than the arithmetic mean dose. This is further evidence of the log-normality of the noise dosimeter data. However, median dose may also be "suppressed" by the 90 dBA threshold level.

Previous analysis<sup>(7)</sup> showed that dimension stone, especially granite and marble, experience higher noise levels than do crushed and broken stone or sand and gravel and table 5 shows that this trend has not changed, although the individual commodity data are not shown.

In a previous analysis<sup>(7)</sup> of the stone and sand and gravel noise dosimeter data, surface mining and milling location codes were analyzed separately. It was expected that noise exposures in milling would be significantly lower. However, no difference was found in crushed limestone, other crushed stone or sand and gravel from 1987 to 1990 or 1991 to 1994 (data not shown). Further analysis<sup>(7)</sup> was conducted for 10 occupations that had substantial numbers of samples coded for both surface and mill locations during 1991 to 1993. Results were mixed, with higher mean noise levels for utility worker and sizing and washing operations at surface mining location; higher for dry screening and clean-up worker at milling locations; and the same for the other six -- crusher, truck driver, mechanic, laborer, front-end loader, and administrative, supervisory, and management personnel (data not shown). Finally, a subset of data<sup>(7)</sup> were compiled by primary mine type, and the expected difference emerged:

| <u>Mine Type</u> | <u>% &gt; PEL</u> | <u>% &gt; UCL</u> |
|------------------|-------------------|-------------------|
| Stone quarry     | 17.9              | 8.8               |
| Sand & gravel    | 17.8              | 9.1               |
| All M/N mills    | 10.1              | 4.3               |

This result sheds some light on the surface mining-milling distinction, including the cement and lime data. However, this approach was not pursued in this analysis, because only about 25% of mills have an MSHA mine ID; the other 75% are not readily identifiable within the database. It is estimated that there would be a 5-6% difference in samples > PEL if the surface/mill location data could be unambiguously isolated.

## Overexposure and Noncompliance Rates and Usage of HPD

Tables 6 and 7 show the percentage of samples exceeding the PEL, the percentage exceeding the citation level or UCL and the percentage of workers wearing HPD for various categories by year group from 1974 to 1997. The table illustrates the same improvement as discussed previously for samples exceeding the PEL, but the trend in HPD is less obvious.

Table 6. Overexposure and noncompliance rates and usage of HPD by year group

| Years       | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | $\geq 1.32$ *PEL, pct | $\geq 1.32$ PEL*HPD, pct |
|-------------|-------------------|------------|----------|----------------|-----------------------|--------------------------|
| Underground |                   |            |          |                |                       |                          |
| 74-78       | 5753              | 48.8       | 58.0     | 72.9           | 40.7                  | 75.7                     |
| 79-82       | 4682              | 43.0       | 66.9     | 88.0           | 29.1                  | 93.5                     |
| 83-86       | 2667              | 43.5       | 67.9     | 84.1           | 29.2                  | 89.5                     |
| 87-90       | 2539              | 39.5       | 69.3     | 86.8           | 28.5                  | 89.8                     |
| 91-94       | 2594              | 36.8       | 65.1     | 85.3           | 26.5                  | 87.8                     |
| 95-97       | 2093              | 32.2       | 67.3     | 90.8           | 21.8                  | 94.3                     |
| 74-97       | 20328             | 42.4       | 64.6     | 82.4           | 31.2                  | 85.5                     |
| Surface     |                   |            |          |                |                       |                          |
| 74-78       | 38411             | 36.9       | 39.2     | 55.9           | 26.5                  | 59.7                     |
| 79-82       | 46165             | 33.3       | 52.4     | 71.7           | 18.0                  | 81.4                     |
| 83-86       | 30739             | 25.5       | 53.9     | 72.7           | 12.0                  | 81.4                     |
| 87-90       | 41466             | 22.1       | 48.9     | 69.4           | 10.7                  | 75.8                     |
| 91-94       | 57509             | 17.3       | 46.4     | 69.0           | 8.7                   | 74.2                     |
| 95-97       | 39229             | 12.2       | 50.3     | 77.8           | 5.6                   | 82.7                     |
| 74-97       | 253519            | 24.2       | 48.3     | 67.9           | 13.3                  | 73.1                     |

Table 7 shows similar data for the 1995-97 noise dosimeter data broken down by commodity and location groups. Underground mines have the highest percentage of samples exceeding the PEL (32.2%) and the UCL (21.8%), but HPD was worn in most cases where the PEL was exceeded. Amongst surface groups, dimension stone workers have 23.4% of samples exceeding the PEL and 12.0% exceeding the UCL with over 80% wearing HPD. In general, the percentage of workers wearing HPD exceeds 75% when samples indicate exposure over the PEL.

Table 7. Overexposure and noncompliance rates and usage of HPD by location and commodity group, 1995-97

| Group                     | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | $\geq 1.32$ *PEL, pct | $\geq 1.32$ PEL*HPD, pct |
|---------------------------|-------------------|------------|----------|----------------|-----------------------|--------------------------|
| Underground               | 2093              | 32.2       | 67.3     | 90.8           | 21.8                  | 94.3                     |
| Surface Sand and Gravel   | 14503             | 12.3       | 46.8     | 75.4           | 5.6                   | 80.8                     |
| Surface Crushed Limestone | 11784             | 12.3       | 49.3     | 78.0           | 5.7                   | 83.7                     |
| Surface Crushed Stone     | 5167              | 12.4       | 52.9     | 78.1           | 6.0                   | 78.4                     |
| Surface Dimension Stone   | 1397              | 23.4       | 56.5     | 81.0           | 12.0                  | 87.5                     |
| Surface Metal             | 2858              | 9.5        | 67.8     | 91.9           | 4.0                   | 94.7                     |
| Surface Nonmetal          | 3520              | 9.3        | 47.0     | 74.3           | 3.6                   | 82.5                     |

## Analysis by Occupation

Noise dosimeter results by occupation are presented in two different formats; figures showing

trends and tables showing the 1995 to 1997 data. Trends for the percentage of samples exceeding the PEL and geometric mean dose are shown in figures 3-10 for all occupations grouped into eight categories. The groups include underground (figures 3-6) and surface (figures 7-10) load-haul-dump, development and production, maintenance, and mineral processing. Only occupations classified as “miscellaneous occupations”, with a relatively small number of samples are not shown. The occupation codes included in each group are defined in the MSHA inspection manual. This is a slightly different approach than what was used previously<sup>(7)</sup> where 17 individual occupations were plotted. [Note: data from which plots for individual occupations grouped by year and location can be made are available in Excel<sup>®</sup>.]

Development and production occupations include all drilling associated activities such as jumbo percussive drill, jackleg or stoper drill, wagon drill, churn drill as well as scaling, roofbolting, continuous mining and other noisy occupations. The highest overall exposures are found in these occupations and are reflected in figures 3 and 8. Occupations with the next highest exposures are those associated with load-haul-dump such as truck driver, front-end loader operator, shovel operator, and mucking machine operator. These exposures are shown in figures 4 and 7. Maintenance and mineral processing have lower overall exposures.

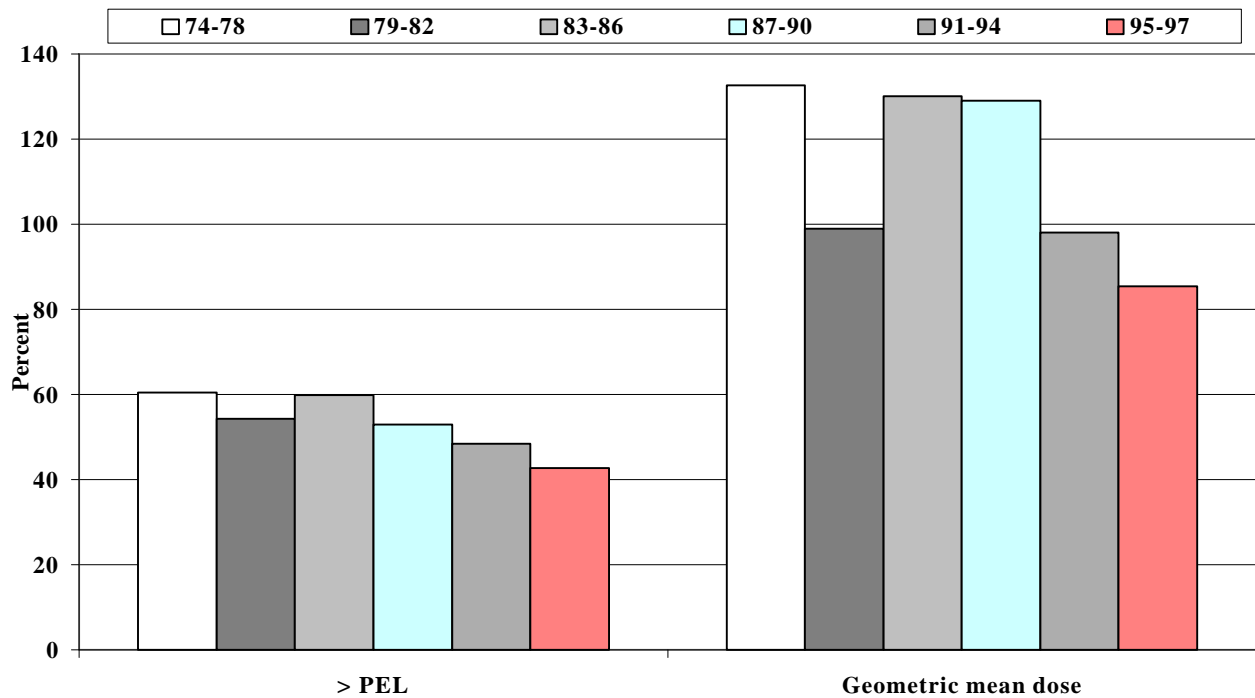


Figure 3. - Trends in underground development and production occupations, N=7,409

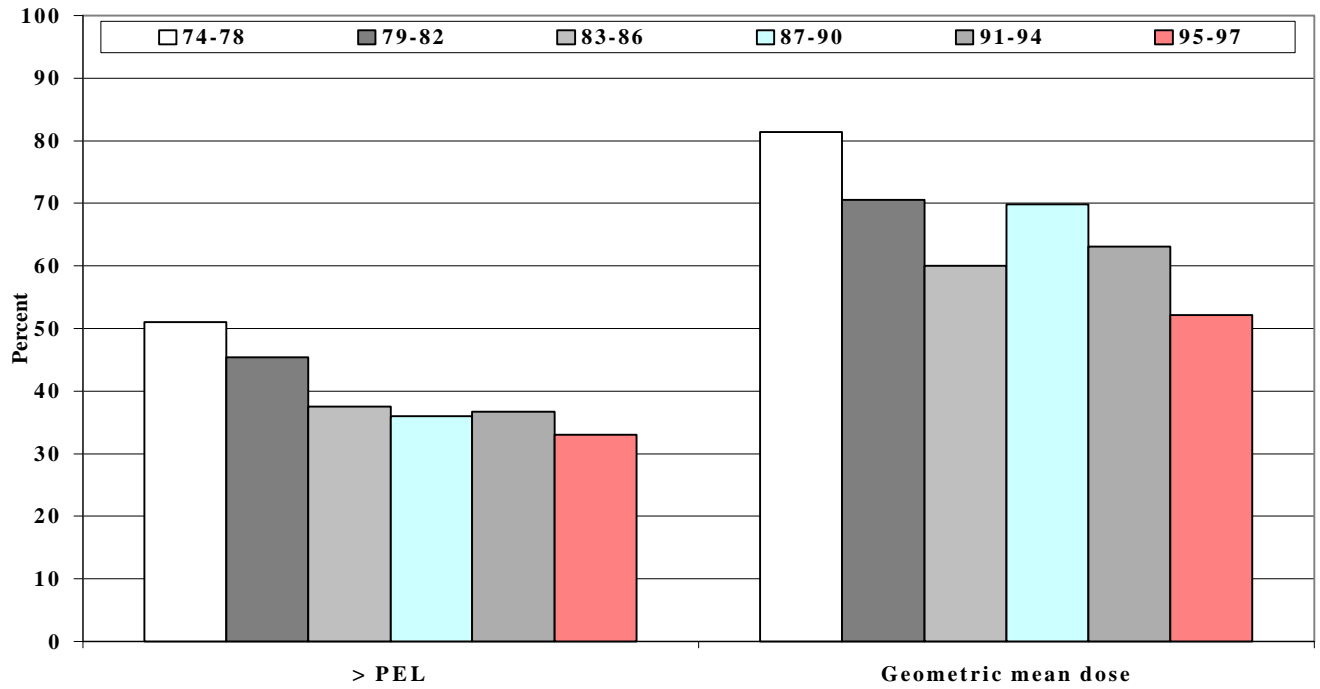


Figure 4. - Trends in underground load-haul-dump occupations, N=9,014

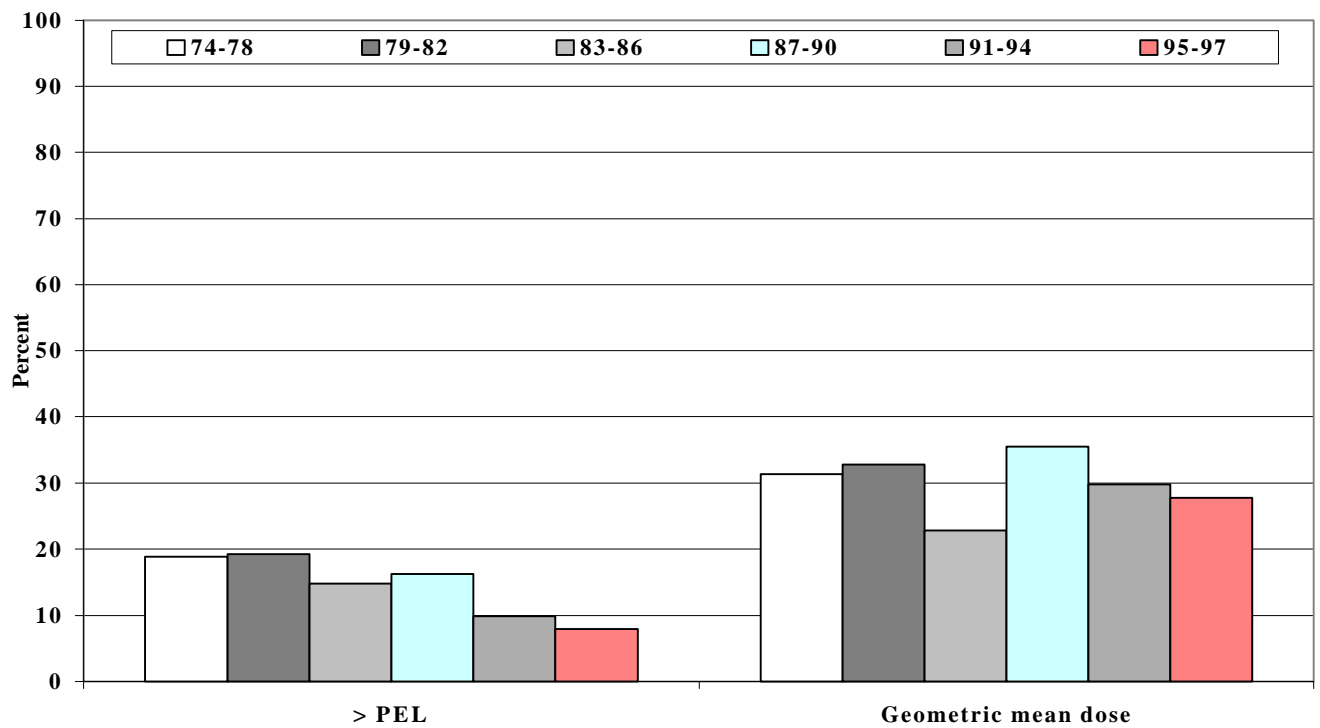


Figure 5. - Trends in underground maintenance occupations, N=2,147

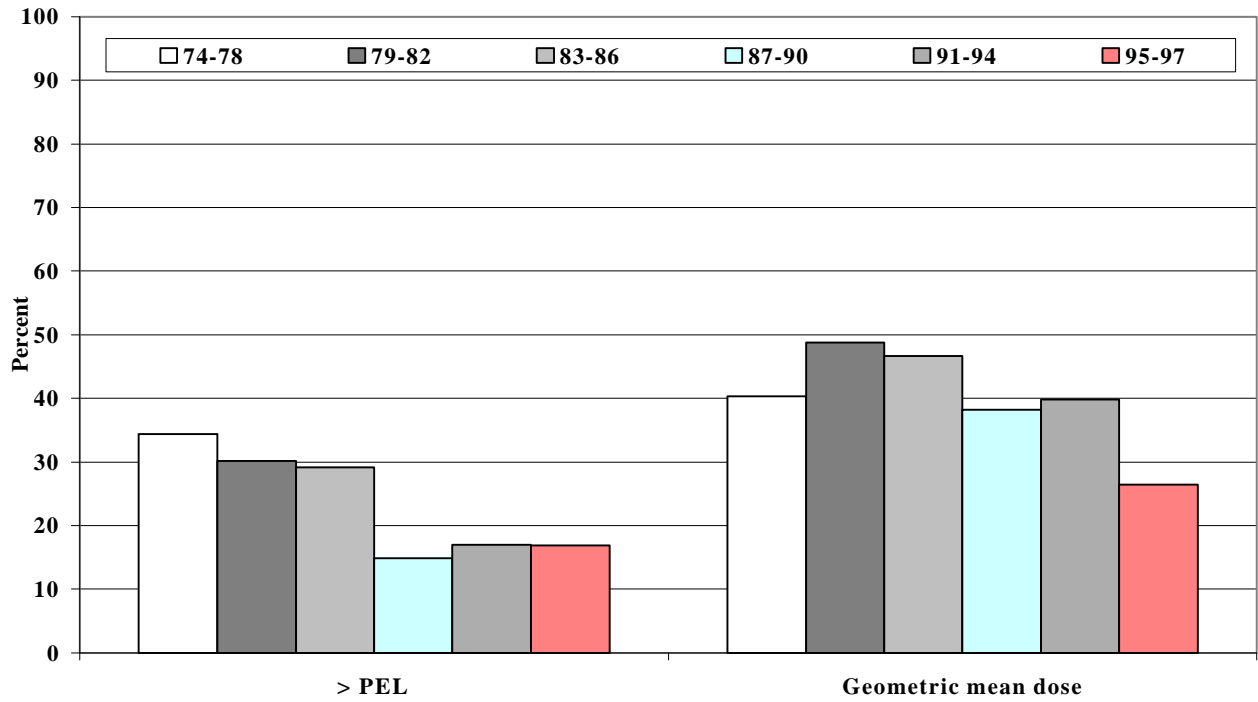


Figure 6. - Trends in underground mineral processing occupations, N = 1,210

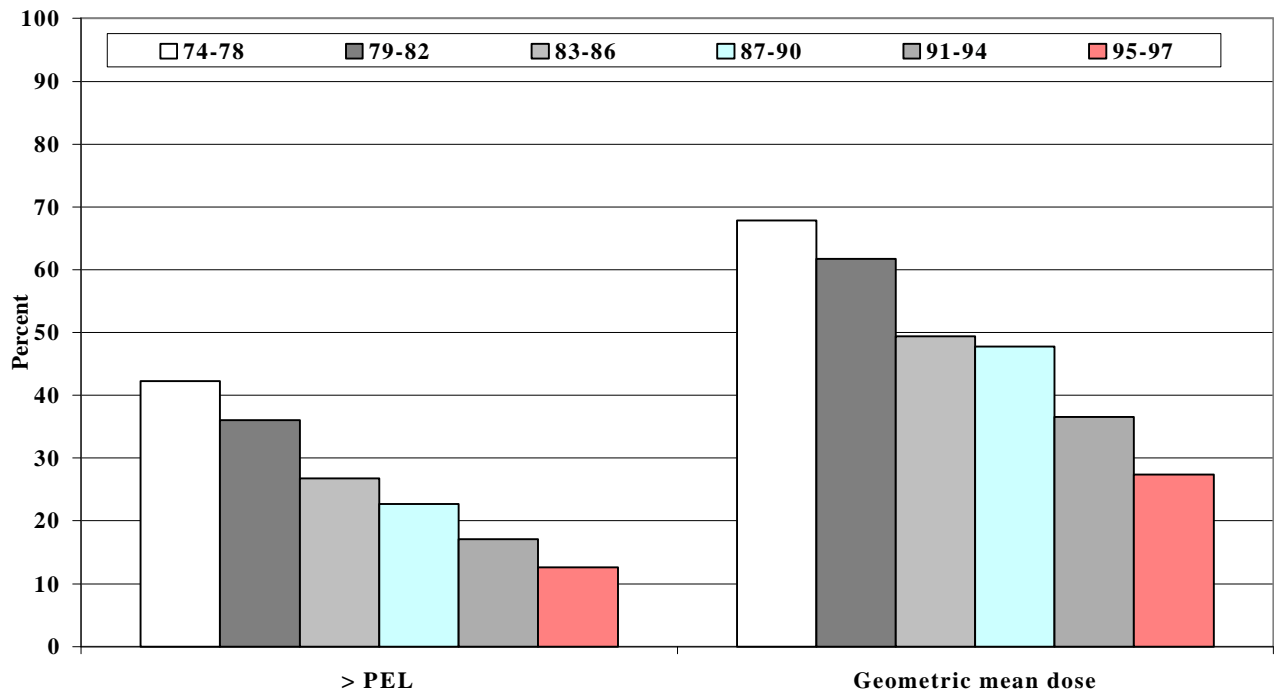


Figure 7. - Trends in surface load-haul-dump occupations, N = 140,564

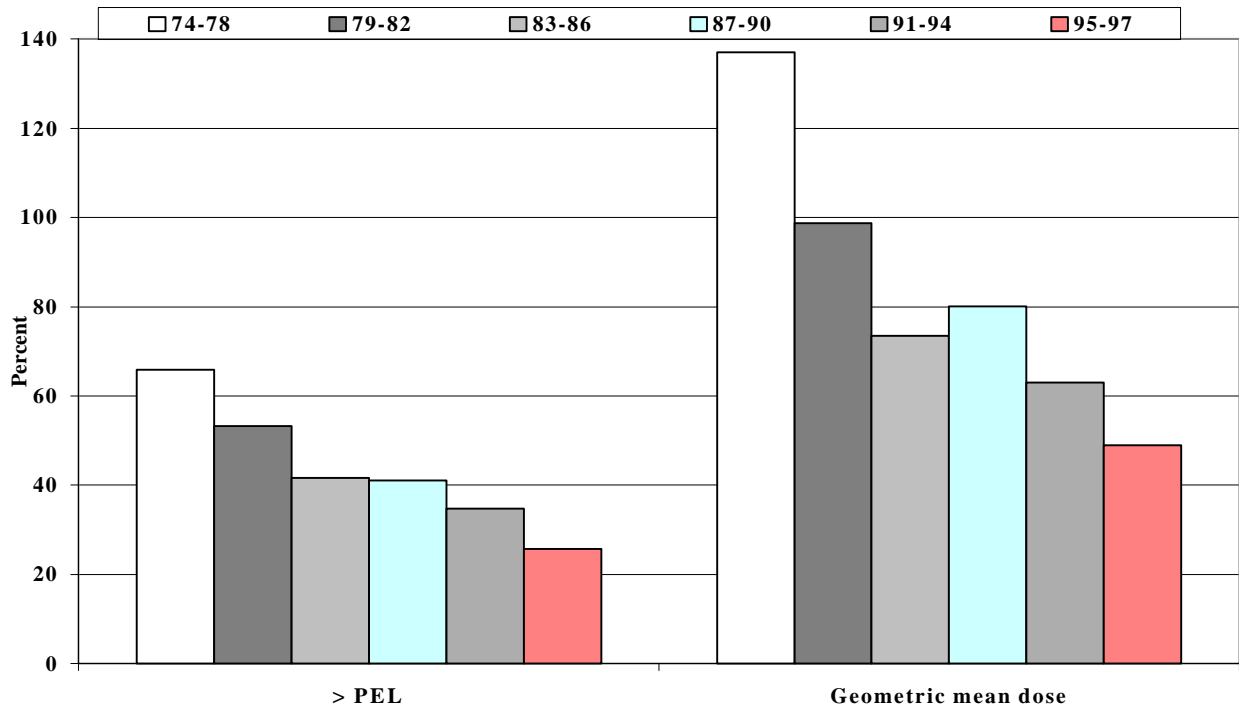


Figure 8. - Trends in surface development and production occupations, N = 12,920

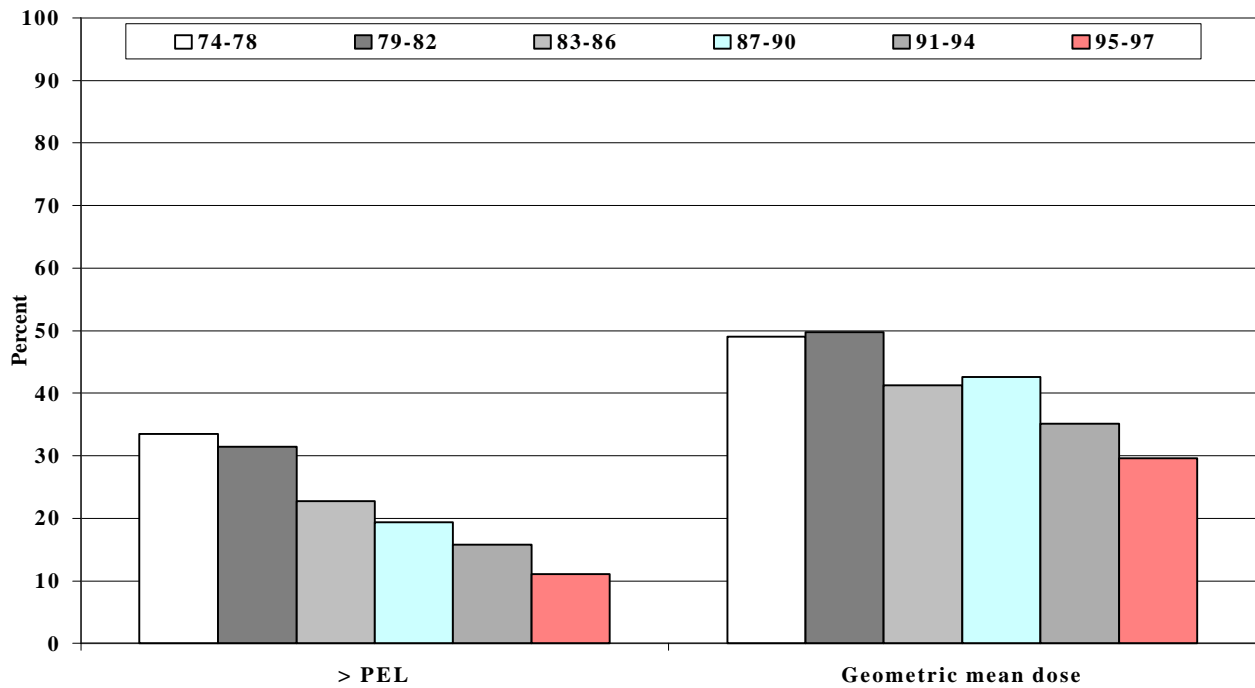


Figure 9. - Trends in surface mineral processing occupations, N = 67,967

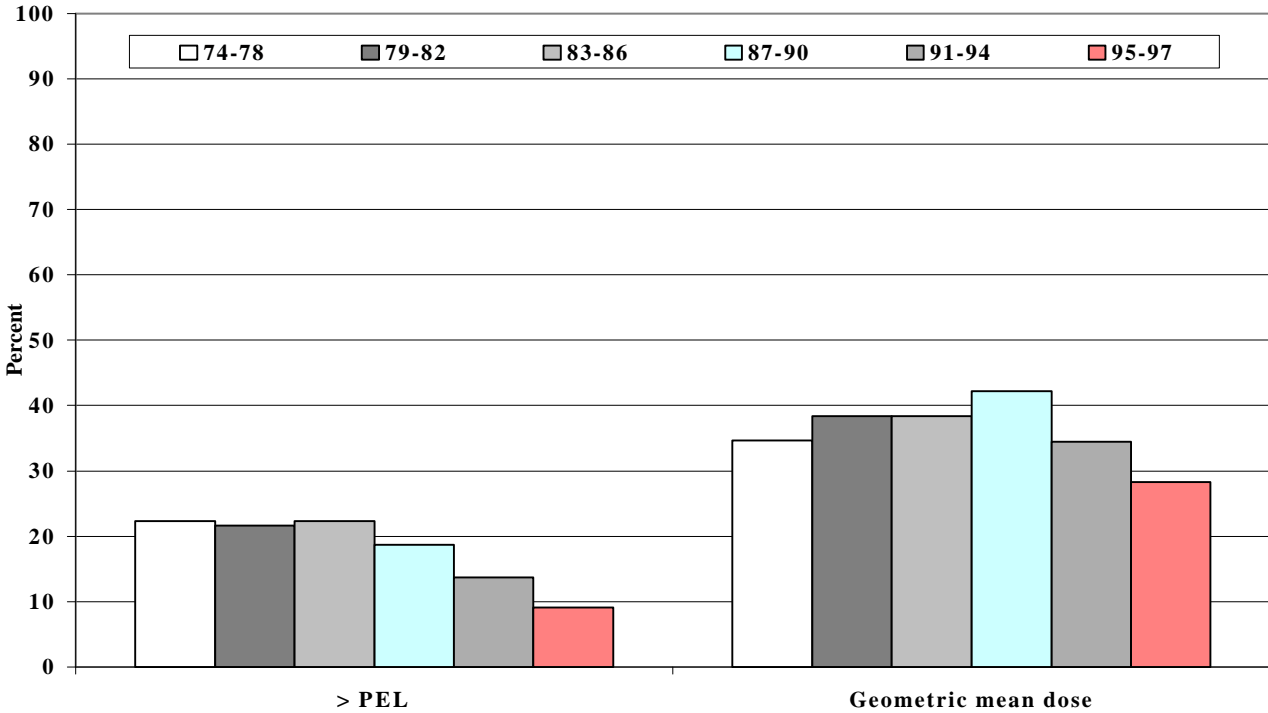


Figure 10. - Trends in surface maintenance occupations, N = 25,585

Tables 8 - 14 show summary statistics for 1995-97 for individual occupations within the seven location and commodity groups. The occupations are ordered by the percentage of samples exceeding the PEL from highest to lowest and within each group a minimum sample size for inclusion is specified. Overall, the occupations listed in the tables account for 95.3% of the samples collected by MSHA during this time period.

Noise dosimeter samples are not equally distributed by occupation code. Front-end loader operators and truck drivers are the most heavily sampled occupations, accounting for 40% of all noise dosimeter samples collected by MSHA inspectors from 1995-97. These two occupations are probably sampled most frequently because they are very common within the industry. Clearly, noise exposure for these two occupations is not that high when compared to other occupations.

Tables 8 - 14 show the geometric mean dose. As discussed previously, the geometric mean dose probably underestimates exposure because of the 90 dBA threshold. This dose can be adjusted upward by adding the difference between the median and the geometric mean. The average differences by commodity and location group can be calculated from data shown in table 5. The average differences are as follows: underground 13.3%, surface sand and gravel 5.5%, surface crushed limestone 7.8%, surface crushed stone 5.4%, surface dimension stone 7.1%, surface metal 6.1%, and surface nonmetal 5.8%. For occupations with large sample sizes a more accurate adjustment could be made by calculating the median for specific occupations.

Table 8. Noise dosimeter data for selected underground occupations<sup>1</sup>

| Occupation             | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | Dose - Geometric |               | Arithmetic mean, dBA | >= 1.32*PEL, pct | >= 1.32*PEL HPD, pct |
|------------------------|-------------------|------------|----------|----------------|------------------|---------------|----------------------|------------------|----------------------|
|                        |                   |            |          |                | Mean, pct        | Std.dev., pct |                      |                  |                      |
| Continuous miner       | 18                | 94.4       | 88.9     | 88.2           | 193.2            | 1.8           | 94.7                 | 66.7             | 91.7                 |
| Load-haul-dump cycle   | 56                | 85.7       | 83.9     | 91.7           | 192.2            | 2.2           | 94.7                 | 69.6             | 94.9                 |
| Jack stoper drill      | 39                | 84.6       | 87.2     | 84.8           | 371.8            | 4.9           | 98.0                 | 66.7             | 88.5                 |
| Stope miner            | 34                | 76.5       | 100.0    | 100.0          | 184.2            | 6.1           | 91.1                 | 64.7             | 100.0                |
| Scoop                  | 51                | 70.6       | 82.4     | 80.6           | 166.7            | 2.5           | 93.7                 | 60.8             | 80.6                 |
| Drift miner            | 77                | 64.9       | 77.9     | 82.0           | 133.6            | 4.0           | 92.1                 | 37.7             | 96.6                 |
| Diamond drill          | 13                | 61.5       | 76.9     | 87.5           | 120.8            | 1.9           | 91.4                 | 30.8             | 100.0                |
| Pneumatic drill        | 35                | 60.0       | 80.0     | 95.2           | 141.6            | 4.1           | 92.5                 | 45.7             | 100.0                |
| Jumbo percussive drill | 88                | 54.5       | 77.3     | 97.9           | 133.1            | 3.7           | 91.4                 | 46.6             | 100.0                |
| Mucking machine        | 10                | 50.0       | 80.0     | 100.0          | 120.5            | 2.2           | 91.3                 | 40.0             | 100.0                |
| Rock & roof bolter     | 36                | 47.2       | 88.9     | 94.1           | 93.4             | 4.4           | 89.5                 | 25.0             | 100.0                |
| Roof bolt mounted      | 29                | 41.4       | 79.3     | 91.7           | 102.9            | 1.8           | 90.2                 | 20.7             | 100.0                |
| Cutting machine        | 15                | 40.0       | 73.3     | 100.0          | 106.3            | 1.6           | 90.4                 | 13.3             | 100.0                |
| Motor                  | 39                | 38.5       | 84.6     | 86.7           | 81.5             | 2.1           | 88.5                 | 20.5             | 87.5                 |
| Utility                | 48                | 35.4       | 62.5     | 94.1           | 64.3             | 2.3           | 86.8                 | 16.7             | 87.5                 |
| Skip tender            | 16                | 31.3       | 75.0     | 80.0           | 43.4             | 4.7           | 80.4                 | 18.8             | 100.0                |
| Truck driver           | 315               | 30.8       | 63.2     | 90.7           | 55.4             | 3.9           | 85.5                 | 24.4             | 96.1                 |
| Supply nipper          | 10                | 30.0       | 100.0    | 100.0          | 65.8             | 2.5           | 87.0                 | 20.0             | 100.0                |
| Mechanical scaling     | 95                | 29.5       | 74.7     | 96.4           | 56.4             | 3.1           | 85.9                 | 20.0             | 94.7                 |
| Rotary drill           | 116               | 28.4       | 74.1     | 97.0           | 53.8             | 3.4           | 85.5                 | 17.2             | 100.0                |
| Front-end loader       | 210               | 22.9       | 59.0     | 95.8           | 34.9             | 3.9           | 81.9                 | 14.3             | 96.7                 |
| Stone & rock sawer     | 18                | 22.2       | 100.0    | 100.0          | 65.7             | 2.1           | 87.0                 | 5.6              | 100.0                |
| Crusher                | 64                | 15.6       | 54.7     | 60.0           | 24.7             | 4.3           | 79.0                 | 6.3              | 75.0                 |
| Hand scaling           | 27                | 14.8       | 66.7     | 100.0          | 28.9             | 3.8           | 76.8                 | 0.0              | 0.0                  |
| Laborer & bullgang     | 14                | 14.3       | 78.6     | 100.0          | 34.6             | 2.8           | 82.3                 | 7.1              | 100.0                |
| Powder gang            | 77                | 13.0       | 70.1     | 100.0          | 44.6             | 2.4           | 84.2                 | 6.5              | 100.0                |
| Administratation       | 79                | 10.1       | 57.0     | 87.5           | 24.4             | 3.8           | 79.1                 | 3.8              | 100.0                |
| Cager                  | 10                | 10.0       | 50.0     | 0.0            | 28.1             | 3.0           | 80.8                 | 10.0             | 0.0                  |
| Electric shuttle       | 15                | 6.7        | 93.3     | 100.0          | 54.9             | 2.2           | 85.7                 | 0.0              | 0.0                  |
| Mechanic               | 125               | 4.8        | 41.6     | 83.3           | 26.8             | 2.6           | 80.0                 | 0.8              | 100.0                |
| Hoist                  | 37                | 2.7        | 35.1     | 100.0          | 5.1              | 3.6           | 67.0                 | 0.0              | 0.0                  |
| Warehouse              | 17                | 0.0        | 47.1     | 0.0            | 10.9             | 3.6           | 74.0                 | 0.0              | 0.0                  |
| Electrician            | 16                | 0.0        | 43.8     | 0.0            | 22.4             | 3.5           | 79.2                 | 0.0              | 0.0                  |

<sup>1</sup>Minimum of 10 samples

Table 8 shows the underground mine sample results for occupations with at least 10 samples. The table includes 88% of the samples collected by MSHA at underground mines. Five occupations have more than 60% of the samples at or above the MSHA UCL or citation level (132% of the PEL); continuous miner operator, load-haul-dump cycle, jack stoper drill operator, stope miner, and scoop operator. A very high percentage (>80%) of these workers were wearing HPD. These exposures are among the highest in the metal and nonmetal noise dosimeter data set. As shown in table 5, underground miners sampled by MSHA generally wear HPD (67.3%). Usage of HPD is exceptionally high among miners exposed to noise levels exceeding the PEL as shown in table 8. Interestingly, mechanics are frequently sampled but are rarely overexposed.

Table 9 shows the noise dosimeter statistics for surface dimension stone occupations with at least 10 samples. The table includes 92% of the samples collected by MSHA inspectors at these operations. Four occupations have more than 45% of the samples at or above the MSHA UCL; churn drill operator (90%), jet-piercing channeler (71.4%), jumbo percussive drill operator (58.3%) and rotary drill operator (48.6%). All of these workers were wearing HPD. As shown in table 5, surface dimension stone workers typically are using HPD (67.8%) when sampled by

MSHA inspectors. The most frequently sampled occupations are stone and rock saw (21.2 % > PEL), front-end loader operator (15.5% > PEL), pneumatic drill operator (48.5% > PEL) and truck driver (10.6 % > PEL).

Table 9. Noise dosimeter data for selected occupations<sup>1</sup> at surface dimension stone mines and mills, 1995-97

| Occupation             | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | Dose - Geometric |               | Arithmetic mean, dBA | ≥ 1.32*PEL, pct | ≥ 1.32*PEL HPD, pct |
|------------------------|-------------------|------------|----------|----------------|------------------|---------------|----------------------|-----------------|---------------------|
|                        |                   |            |          |                | Mean, pct        | Std.dev., pct |                      |                 |                     |
| Churn drill            | 10                | 100.0      | 90.0     | 90.0           | 295.5            | 1.7           | 97.8                 | 90.0            | 100.0               |
| Jet-piercing chaneler  | 21                | 85.7       | 90.5     | 94.4           | 410.0            | 4.9           | 100.2                | 71.4            | 100.0               |
| Jumbo percussive drill | 12                | 66.7       | 91.7     | 100.0          | 140.4            | 3.6           | 92.4                 | 58.3            | 100.0               |
| Rotary drill           | 35                | 65.7       | 88.6     | 91.3           | 140.4            | 3.3           | 92.4                 | 48.6            | 100.0               |
| Jackhammer             | 24                | 58.3       | 79.2     | 92.9           | 96.1             | 3.1           | 89.7                 | 29.2            | 85.7                |
| Sizing & washing       | 15                | 53.3       | 93.3     | 100.0          | 72.8             | 3.5           | 87.7                 | 33.3            | 100.0               |
| Bulldozer              | 16                | 50.0       | 56.3     | 50.0           | 88.7             | 2.6           | 89.1                 | 31.3            | 40.0                |
| Pneumatic drill        | 130               | 48.5       | 83.1     | 88.9           | 94.0             | 4.3           | 89.1                 | 28.5            | 89.2                |
| Cutting machine        | 11                | 36.4       | 63.6     | 75.0           | 57.7             | 2.4           | 86.0                 | 27.3            | 66.7                |
| Stone & rock sawer     | 331               | 21.1       | 50.2     | 70.0           | 44.4             | 2.9           | 84.0                 | 5.7             | 84.2                |
| Front-end loader       | 206               | 15.5       | 52.4     | 78.1           | 33.9             | 3.3           | 81.1                 | 5.8             | 75.0                |
| Crusher                | 42                | 14.3       | 57.1     | 66.7           | 30.1             | 3.6           | 81.3                 | 11.9            | 80.0                |
| Truck driver           | 94                | 10.6       | 42.6     | 90.0           | 29.9             | 3.1           | 80.7                 | 2.1             | 100.0               |
| Laborer & bullgang     | 57                | 10.5       | 31.6     | 83.3           | 23.5             | 3.7           | 79.5                 | 5.3             | 100.0               |
| Backhoe                | 39                | 10.3       | 35.9     | 100.0          | 18.0             | 3.1           | 77.6                 | 5.1             | 100.0               |
| Tipple                 | 10                | 10.0       | 60.0     | 100.0          | 18.4             | 2.5           | 77.8                 | 0.0             | 0.0                 |
| Mobile crane           | 42                | 9.5        | 73.8     | 100.0          | 33.0             | 2.5           | 82.0                 | 0.0             | 0.0                 |
| Utility                | 53                | 9.4        | 67.9     | 60.0           | 37.0             | 3.6           | 82.8                 | 3.8             | 100.0               |
| Administration         | 56                | 8.9        | 51.8     | 60.0           | 19.0             | 4.4           | 73.0                 | 0.0             | 0.0                 |
| Forklift               | 42                | 4.8        | 45.2     | 100.0          | 25.4             | 2.7           | 78.7                 | 2.4             | 100.0               |
| Mechanic               | 23                | 0.0        | 30.4     | 0.0            | 16.6             | 2.8           | 77.0                 | 0.0             | 0.0                 |
| Bag & pack             | 10                | 0.0        | 10.0     | 0.0            | 25.6             | 2.8           | 80.2                 | 0.0             | 0.0                 |

<sup>1</sup>Minimum of 10 samples

Table 10 shows the noise dosimeter statistics for surface crushed limestone occupations including cement and lime with at least 50 samples. The table includes 94% of the samples collected by MSHA inspectors at these operations. Three occupations have more than 20% of the samples at or above the MSHA UCL; bulldozer operator (32.9%), and pneumatic (27.5%) and rotary drill operators (21.9%). The great majority of these workers were wearing HPD. As shown in table 5, surface crushed limestone workers have a lower rate of HPD usage (49.3%) when sampled by MSHA inspectors. The most frequently sampled occupations are front-end loader operator (8.7% > PEL) and truck driver (11.3 % > PEL).

Table 11 shows the noise dosimeter statistics for surface crushed stone occupations with at least 30 samples. The table includes 94% of the samples collected by MSHA inspectors at these operations. Three occupations have more than 30% of the samples at or above the MSHA UCL; pneumatic drill operator (36.0%), bulldozer operator (31.4%) and mobile crane operator (31.4%). Most of these workers were wearing HPD. As shown in table 5, surface crushed stone workers have a lower rate of HPD usage (52.9%) when sampled by MSHA inspectors. As was the case for surface crushed limestone, the most frequently sampled occupations are front-end loader operator (7.9% > PEL) and truck driver (8.9 % > PEL).

Table 10. Noise dosimeter data for selected occupations<sup>1</sup> at surface crushed limestone mines and mills, 1995-97

| Occupation            | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | Dose - Geometric |               | Arithmetic mean, dBA | ≥ 1.32*PEL, pct | ≥ 1.32*PEL HPD, pct |
|-----------------------|-------------------|------------|----------|----------------|------------------|---------------|----------------------|-----------------|---------------------|
|                       |                   |            |          |                | Mean, pct        | Std.dev., pct |                      |                 |                     |
| Bulldozer             | 343               | 50.1       | 69.7     | 84.9           | 92.3             | 2.9           | 89.4                 | 32.9            | 87.6                |
| Pneumatic drill       | 142               | 40.8       | 85.2     | 98.3           | 72.2             | 3.7           | 87.6                 | 27.5            | 97.4                |
| Rotary drill          | 192               | 30.2       | 73.4     | 81.0           | 58.5             | 3.5           | 86.1                 | 21.9            | 78.6                |
| Cleanup               | 297               | 19.2       | 54.2     | 86.0           | 51.9             | 2.3           | 85.3                 | 8.4             | 92.0                |
| Dragline              | 68                | 19.1       | 30.9     | 84.6           | 38.5             | 3.3           | 82.3                 | 11.8            | 87.5                |
| Ball & rod mill       | 85                | 17.6       | 69.4     | 100.0          | 47.9             | 2.9           | 84.7                 | 12.9            | 100.0               |
| Utility               | 269               | 16.7       | 65.4     | 86.7           | 44.7             | 3.0           | 83.6                 | 7.1             | 94.7                |
| Laborer & bullgang    | 315               | 14.3       | 65.7     | 91.1           | 39.8             | 2.6           | 83.2                 | 6.0             | 89.5                |
| Shovel                | 99                | 14.1       | 51.5     | 71.4           | 27.4             | 4.2           | 80.1                 | 8.1             | 62.5                |
| Dry screen plant      | 301               | 12.6       | 52.8     | 84.2           | 31.1             | 3.5           | 81.0                 | 7.0             | 90.5                |
| Truck driver          | 2556              | 11.3       | 47.6     | 68.4           | 35.6             | 2.9           | 82.4                 | 4.0             | 78.2                |
| Crusher               | 1590              | 11.1       | 52.8     | 80.7           | 26.0             | 3.5           | 79.6                 | 5.9             | 81.9                |
| Backhoe               | 140               | 10.0       | 39.3     | 64.3           | 23.2             | 3.8           | 78.7                 | 3.6             | 60.0                |
| Bag & pack            | 332               | 9.3        | 51.2     | 54.8           | 34.2             | 2.5           | 82.1                 | 2.1             | 71.4                |
| Front-end loader      | 2827              | 8.7        | 41.7     | 68.3           | 23.8             | 3.5           | 79.3                 | 2.8             | 70.9                |
| Sizing & washing      | 153               | 8.5        | 62.1     | 92.3           | 23.4             | 3.4           | 79.1                 | 2.6             | 100.0               |
| Forklift              | 80                | 7.5        | 35.0     | 50.0           | 32.1             | 2.5           | 81.8                 | 2.5             | 0.0                 |
| Puller & truck loader | 128               | 7.0        | 46.9     | 88.9           | 24.8             | 3.1           | 79.9                 | 2.3             | 100.0               |
| Greaser & oiler       | 64                | 4.7        | 54.7     | 66.7           | 33.9             | 2.3           | 82.2                 | 0.0             | 0.0                 |
| Welder                | 57                | 3.5        | 35.1     | 100.0          | 19.5             | 2.8           | 76.2                 | 1.8             | 100.0               |
| Mechanic              | 291               | 3.4        | 38.5     | 60.0           | 21.9             | 2.8           | 78.8                 | 0.7             | 100.0               |
| Administration        | 325               | 3.1        | 39.4     | 80.0           | 12.2             | 4.2           | 69.9                 | 0.9             | 100.0               |
| Dryer & kiln          | 141               | 2.8        | 51.1     | 100.0          | 24.9             | 3.1           | 79.6                 | 0.7             | 100.0               |
| Weigh & scale         | 193               | 0.0        | 18.1     | 0.0            | 2.3              | 3.3           | 43.6                 | 0.0             | 0.0                 |
| Lab technician        | 62                | 0.0        | 37.1     | 0.0            | 12.5             | 3.0           | 73.2                 | 0.0             | 0.0                 |
| Electrician           | 56                | 0.0        | 51.8     | 0.0            | 14.8             | 2.8           | 76.2                 | 0.0             | 0.0                 |

<sup>1</sup>Minimum of 50 samples

Table 11. Noise dosimeter data for selected occupations<sup>1</sup> at surface crushed stone mines and mills, 1995-97

| Occupation            | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | Dose - Geometric |               | Arithmetic mean, dBA | ≥ 1.32*PEL, pct | ≥ 1.32*PEL HPD, pct |
|-----------------------|-------------------|------------|----------|----------------|------------------|---------------|----------------------|-----------------|---------------------|
|                       |                   |            |          |                | Mean, pct        | Std.dev., pct |                      |                 |                     |
| Pneumatic drill       | 50                | 50.0       | 78.0     | 92.0           | 121.9            | 2.8           | 91.4                 | 36.0            | 94.4                |
| Bulldozer             | 140               | 47.9       | 63.6     | 71.6           | 74.9             | 3.9           | 87.9                 | 31.4            | 75.0                |
| Mobile crane          | 35                | 45.7       | 77.1     | 93.8           | 82.4             | 2.1           | 88.6                 | 31.4            | 90.9                |
| Rotary drill          | 69                | 29.0       | 73.9     | 100.0          | 49.3             | 3.4           | 84.1                 | 15.9            | 100.0               |
| Cleanup               | 142               | 20.4       | 64.1     | 89.7           | 40.0             | 3.1           | 83.0                 | 7.7             | 81.8                |
| Crusher               | 888               | 15.9       | 59.3     | 82.3           | 28.5             | 3.8           | 79.9                 | 8.1             | 79.2                |
| Utility               | 143               | 14.7       | 62.2     | 90.5           | 41.6             | 2.6           | 83.7                 | 4.2             | 100.0               |
| Laborer & bullgang    | 123               | 14.6       | 74.0     | 83.3           | 44.6             | 2.5           | 84.2                 | 5.7             | 85.7                |
| Shovel                | 78                | 14.1       | 57.7     | 81.8           | 29.4             | 3.6           | 81.2                 | 7.7             | 66.7                |
| Puller & truck loader | 52                | 9.6        | 48.1     | 100.0          | 14.5             | 4.2           | 72.8                 | 0.0             | 0.0                 |
| Truck driver          | 917               | 8.9        | 49.7     | 70.7           | 30.6             | 2.9           | 81.4                 | 2.6             | 75.0                |
| Dryer & kiln          | 46                | 8.7        | 45.7     | 100.0          | 27.3             | 2.8           | 80.6                 | 0.0             | 0.0                 |
| Welder                | 48                | 8.3        | 39.6     | 75.0           | 21.5             | 3.3           | 78.9                 | 0.0             | 0.0                 |
| Front-end load        | 1279              | 7.9        | 47.1     | 61.4           | 24.3             | 3.3           | 79.5                 | 3.6             | 60.9                |
| Bag & pack            | 118               | 7.6        | 61.0     | 77.8           | 27.2             | 2.6           | 80.6                 | 3.4             | 100.0               |
| Sizing & wash         | 80                | 7.5        | 52.5     | 100.0          | 17.5             | 4.1           | 74.6                 | 2.5             | 100.0               |
| Forklift              | 30                | 6.7        | 43.3     | 50.0           | 19.7             | 2.9           | 78.3                 | 3.3             | 100.0               |
| Administration        | 190               | 6.3        | 49.5     | 100.0          | 16.1             | 3.8           | 73.5                 | 1.6             | 100.0               |
| Backhoe               | 90                | 5.6        | 52.2     | 80.0           | 26.4             | 2.9           | 80.4                 | 3.3             | 66.7                |
| Dry screen plant      | 107               | 4.7        | 49.5     | 60.0           | 24.5             | 3.4           | 78.8                 | 3.7             | 75.0                |
| Mechanic              | 125               | 3.2        | 30.4     | 50.0           | 18.2             | 2.9           | 77.2                 | 0.8             | 100.0               |
| Weigh & scale         | 80                | 0.0        | 16.3     | 0.0            | 2.1              | 3.0           | 40.3                 | 0.0             | 0.0                 |
| Lab technician        | 44                | 0.0        | 34.1     | 0.0            | 11.8             | 3.5           | 70.7                 | 0.0             | 0.0                 |

<sup>1</sup>Minimum of 30 samples

Table 12 shows the noise dosimeter statistics for sand and gravel occupations with at least 20 samples. The table includes 98% of the samples collected by MSHA inspectors at these operations. Two occupations have more than 20% of the samples at or above the MSHA UCL; bulldozer operator (33.4%) and dragline operator (22.5%). Most of these workers were wearing HPD. As shown in table 5, sand and gravel workers have the lowest overall rate of HPD usage (46.8%) when sampled by MSHA inspectors. The most frequently sampled occupations are front-end loader operator (8.9% > PEL), crusher worker (15.4% > PEL) and truck driver (10.8% > PEL).

Table 12. Noise dosimeter data for selected occupations<sup>1</sup> at sand and gravel operations, 1995-97

| Occupation            | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | Dose - Geometric |               | Arithmetic mean, dBA | >= 1.32*PEL, pct | >= 1.32*PEL HPD, pct |
|-----------------------|-------------------|------------|----------|----------------|------------------|---------------|----------------------|------------------|----------------------|
|                       |                   |            |          |                | Mean, pct        | Std.dev., pct |                      |                  |                      |
| Bulldozer             | 515               | 52.6       | 68.0     | 80.8           | 88.8             | 3.2           | 88.9                 | 33.4             | 82.0                 |
| Dragline              | 373               | 36.2       | 62.2     | 83.0           | 60.5             | 3.2           | 85.9                 | 22.5             | 88.1                 |
| Scraper-loader        | 95                | 27.4       | 70.5     | 96.2           | 54.2             | 3.5           | 85.6                 | 16.8             | 93.8                 |
| Shovel                | 73                | 23.3       | 37.0     | 58.8           | 35.1             | 3.9           | 82.4                 | 9.6              | 28.6                 |
| Barge & dredge        | 776               | 22.9       | 46.0     | 70.8           | 37.5             | 3.6           | 82.3                 | 8.6              | 73.1                 |
| Belt clean & pick     | 51                | 17.6       | 54.9     | 100.0          | 28.1             | 4.1           | 79.7                 | 13.7             | 100.0                |
| Crusher               | 1582              | 15.4       | 69.3     | 85.2           | 36.8             | 3.3           | 82.2                 | 7.5              | 87.4                 |
| Cleanup               | 326               | 15.0       | 66.3     | 79.6           | 42.1             | 2.8           | 83.8                 | 6.1              | 75.0                 |
| Greaser & oiler       | 55                | 12.7       | 70.9     | 85.7           | 40.0             | 2.6           | 83.4                 | 5.5              | 100.0                |
| Laborer & bullgang    | 388               | 11.3       | 61.3     | 88.6           | 31.5             | 3.3           | 81.5                 | 4.9              | 84.2                 |
| Truck driver          | 1137              | 10.8       | 42.2     | 65.9           | 30.1             | 3.3           | 80.7                 | 4.1              | 70.2                 |
| Scalper-screen        | 28                | 10.7       | 50.0     | 100.0          | 28.3             | 3.3           | 80.9                 | 3.6              | 100.0                |
| Dry screen plant      | 218               | 9.2        | 50.0     | 95.0           | 27.9             | 3.0           | 80.8                 | 3.2              | 100.0                |
| Front-end loader      | 5591              | 8.9        | 41.4     | 66.3           | 23.5             | 3.4           | 79.2                 | 3.2              | 76.5                 |
| Ball & rod mill       | 27                | 7.4        | 59.3     | 100.0          | 35.5             | 2.4           | 82.5                 | 3.7              | 100.0                |
| Sizing & washing      | 774               | 6.7        | 44.4     | 69.2           | 25.5             | 3.1           | 79.5                 | 2.8              | 81.8                 |
| Load-haul-dump cycle  | 46                | 6.5        | 54.3     | 100.0          | 34.5             | 2.6           | 82.3                 | 2.2              | 100.0                |
| Utility               | 255               | 5.1        | 41.2     | 76.9           | 24.8             | 3.1           | 79.9                 | 1.6              | 75.0                 |
| Bag & pack            | 160               | 5.0        | 38.1     | 62.5           | 25.9             | 3.0           | 80.2                 | 1.3              | 50.0                 |
| Administration        | 564               | 4.3        | 35.6     | 83.3           | 12.8             | 4.1           | 72.7                 | 2.1              | 75.0                 |
| Slurry & mix          | 25                | 4.0        | 32.0     | 0.0            | 15.1             | 2.8           | 76.4                 | 0.0              | 0.0                  |
| Welder                | 58                | 3.4        | 44.8     | 100.0          | 20.9             | 2.3           | 78.7                 | 1.7              | 100.0                |
| Dryer & kiln          | 126               | 3.2        | 29.4     | 75.0           | 19.4             | 3.0           | 77.3                 | 0.8              | 100.0                |
| Flotation             | 36                | 2.8        | 58.3     | 100.0          | 22.9             | 2.5           | 79.3                 | 0.0              | 0.0                  |
| Mechanic              | 280               | 2.5        | 34.6     | 57.1           | 17.7             | 2.9           | 76.9                 | 0.7              | 50.0                 |
| Backhoe               | 323               | 2.5        | 26.3     | 50.0           | 16.8             | 3.5           | 76.4                 | 0.6              | 100.0                |
| Weigh & scale         | 274               | 0.0        | 9.9      | 0.0            | 2.2              | 3.0           | 44.3                 | 0.0              | 0.0                  |
| Lab technician        | 49                | 0.0        | 44.9     | 0.0            | 6.8              | 4.1           | 67.1                 | 0.0              | 0.0                  |
| Puller & truck loader | 38                | 0.0        | 44.7     | 0.0            | 15.8             | 2.7           | 76.7                 | 0.0              | 0.0                  |
| Forklift              | 36                | 0.0        | 19.4     | 0.0            | 18.4             | 3.1           | 77.8                 | 0.0              | 0.0                  |

<sup>1</sup>Minimum of 20 samples

Table 13 shows the noise dosimeter statistics for surface metal mine/mill occupations with at least 20 samples. The table includes 91% of the samples collected by MSHA inspectors at these operations. Two occupations have more than 10% of the samples at or above the MSHA UCL; bulldozer operator (10.6%) and pneumatic drill operator (14.3%). Most of these workers were wearing HPD. As shown in table 5, surface metal mine and mill workers have the highest overall rate of HPD usage (67.8%) when sampled by MSHA inspectors. The most frequently sampled occupations are crusher worker (9.6% > PEL), truck driver (9.5% > PEL) and front-end loader operator (5.0% > PEL).

Table 13. Noise dosimeter data for selected occupations<sup>1</sup> at surface metal mines and mills, 1995-97

| Occupation           | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | Dose - Geometric |               | Arithmetic mean, dBA | >= 1.32*PEL, pct | >= 1.32*PEL HPD, pct |
|----------------------|-------------------|------------|----------|----------------|------------------|---------------|----------------------|------------------|----------------------|
|                      |                   |            |          |                | Mean, pct        | Std.dev., pct |                      |                  |                      |
| Bulldozer            | 170               | 25.9       | 74.1     | 93.2           | 53.5             | 2.9           | 84.5                 | 10.6             | 94.4                 |
| Pneumatic drill      | 28                | 25.0       | 92.9     | 100.0          | 51.4             | 3.5           | 85.2                 | 14.3             | 100.0                |
| Ball & rod mill      | 124               | 21.8       | 72.6     | 81.5           | 47.0             | 3.1           | 83.2                 | 8.9              | 81.8                 |
| Dry screen plant     | 23                | 17.4       | 78.3     | 100.0          | 34.6             | 2.8           | 82.3                 | 4.3              | 100.0                |
| Pelletizing          | 42                | 14.3       | 83.3     | 100.0          | 34.1             | 2.4           | 82.2                 | 2.4              | 100.0                |
| Cleanup              | 77                | 13.0       | 83.1     | 100.0          | 30.2             | 3.1           | 81.4                 | 3.9              | 100.0                |
| Dryer & kiln         | 64                | 10.9       | 60.9     | 100.0          | 23.4             | 3.4           | 79.5                 | 3.1              | 100.0                |
| Welder               | 66                | 10.6       | 77.3     | 100.0          | 30.1             | 2.5           | 81.3                 | 3.0              | 100.0                |
| Load-haul-dump cycle | 20                | 10.0       | 80.0     | 50.0           | 57.6             | 1.9           | 86.0                 | 0.0              | 0.0                  |
| Crusher              | 239               | 9.6        | 72.8     | 95.7           | 26.9             | 3.8           | 80.3                 | 5.0              | 100.0                |
| Rotary drill         | 94                | 9.6        | 79.8     | 88.9           | 31.6             | 3.0           | 79.9                 | 4.3              | 100.0                |
| Building repair      | 21                | 9.5        | 47.6     | 50.0           | 27.2             | 3.4           | 80.6                 | 4.8              | 100.0                |
| Truck driver         | 284               | 9.5        | 66.9     | 96.3           | 26.3             | 3.5           | 79.6                 | 3.9              | 90.9                 |
| Forklift             | 22                | 9.1        | 72.7     | 100.0          | 37.0             | 2.5           | 82.8                 | 4.5              | 100.0                |
| Conveyor belt crew   | 24                | 8.3        | 41.7     | 50.0           | 31.6             | 2.2           | 81.7                 | 4.2              | 100.0                |
| Flotation            | 157               | 8.3        | 73.9     | 92.3           | 28.9             | 2.9           | 81.0                 | 3.2              | 80.0                 |
| Laborer & bullgang   | 89                | 7.9        | 69.7     | 71.4           | 29.6             | 2.8           | 81.2                 | 3.4              | 100.0                |
| Shovel               | 64                | 7.8        | 65.6     | 80.0           | 20.2             | 3.5           | 78.4                 | 1.6              | 100.0                |
| Sampler              | 28                | 7.1        | 67.9     | 100.0          | 36.1             | 3.1           | 82.7                 | 3.6              | 100.0                |
| Utility              | 46                | 6.5        | 54.3     | 100.0          | 22.5             | 2.7           | 79.2                 | 2.2              | 100.0                |
| Plumber              | 34                | 5.9        | 73.5     | 100.0          | 24.6             | 3.3           | 78.2                 | 2.9              | 100.0                |
| Leaching work        | 88                | 5.7        | 58.0     | 100.0          | 16.6             | 3.4           | 75.1                 | 3.4              | 100.0                |
| Slurry & mix         | 36                | 5.6        | 61.1     | 100.0          | 15.1             | 3.4           | 76.3                 | 2.8              | 100.0                |
| Front-end loader     | 180               | 5.0        | 64.4     | 100.0          | 24.6             | 3.5           | 79.3                 | 2.8              | 100.0                |
| Lab technician       | 121               | 5.0        | 63.6     | 83.3           | 17.3             | 4.2           | 76.4                 | 2.5              | 100.0                |
| Road grader          | 46                | 4.3        | 71.7     | 100.0          | 26.0             | 3.2           | 79.0                 | 0.0              | 0.0                  |
| Bag & pack           | 49                | 4.1        | 61.2     | 100.0          | 29.2             | 2.1           | 81.1                 | 0.0              | 0.0                  |
| Mechanic             | 215               | 2.3        | 63.7     | 80.0           | 21.2             | 2.8           | 78.5                 | 0.5              | 100.0                |
| Administration       | 77                | 0.0        | 42.9     | 0.0            | 9.7              | 3.8           | 68.0                 | 0.0              | 0.0                  |
| Electrician          | 61                | 0.0        | 63.9     | 0.0            | 13.0             | 2.8           | 75.3                 | 0.0              | 0.0                  |
| Greaser & oiler      | 21                | 0.0        | 66.7     | 0.0            | 16.3             | 3.0           | 76.9                 | 0.0              | 0.0                  |

<sup>1</sup>Minimum of 20 samples

Table 14 shows the noise dosimeter statistics for surface nonmetal mine/mill occupations with at least 10 samples. The table includes 96% of the samples collected by MSHA inspectors at these operations. Three occupations have more than 10% of the samples at or above the MSHA UCL; pneumatic drill operator (50.0%), bulldozer operator (17.0%) and scraper-loader operator (17.0%). Most of these workers were wearing HPD. As shown in table 5, surface nonmetal mine and mill workers have a lower overall rate of HPD usage (47.0%) when sampled by MSHA inspectors. The most frequently sampled occupations are bagger and packer ( 11.2% > PEL), truck driver (6.8% > PEL) and front-end loader operator (3.5% > PEL).

Table 14. Noise dosimeter data for selected occupations<sup>1</sup> at surface nonmetal mines and mills, 1995-97

| Occupation            | Number of samples | > PEL, pct | HPD, pct | > PEL HPD, pct | Dose - Geometric |               | Arithmetic mean, dBA | ≥ 1.32*PEL, pct | ≥ 1.32*PEL HPD, pct |
|-----------------------|-------------------|------------|----------|----------------|------------------|---------------|----------------------|-----------------|---------------------|
|                       |                   |            |          |                | Mean, pct        | Std.dev., pct |                      |                 |                     |
| Pneumatic drill       | 12                | 58.3       | 75.0     | 85.7           | 121.0            | 3.9           | 91.4                 | 50.0            | 83.3                |
| Shovel                | 36                | 30.6       | 61.1     | 90.9           | 39.0             | 3.6           | 83.2                 | 8.3             | 100.0               |
| Bulldozer             | 230               | 29.6       | 60.0     | 80.9           | 61.3             | 3.1           | 86.5                 | 17.0            | 89.7                |
| Scraper-loader        | 94                | 22.3       | 59.6     | 100.0          | 43.5             | 4.0           | 84.0                 | 17.0            | 100.0               |
| Building repair       | 19                | 15.8       | 57.9     | 100.0          | 39.6             | 2.6           | 83.3                 | 5.3             | 100.0               |
| Dragline              | 13                | 15.4       | 69.2     | 100.0          | 37.3             | 2.7           | 82.9                 | 7.7             | 100.0               |
| Hammer mill           | 20                | 15.0       | 65.0     | 33.3           | 51.0             | 1.9           | 85.1                 | 0.0             | 0.0                 |
| Ball & rod mill       | 83                | 13.3       | 50.6     | 72.7           | 45.1             | 2.4           | 84.3                 | 7.2             | 83.3                |
| Cleanup               | 39                | 12.8       | 53.8     | 80.0           | 29.8             | 3.0           | 81.3                 | 2.6             | 100.0               |
| Utility               | 81                | 12.3       | 46.9     | 70.0           | 32.8             | 3.6           | 80.5                 | 6.2             | 100.0               |
| Bag & pack            | 659               | 11.2       | 46.0     | 59.5           | 38.4             | 2.6           | 83.1                 | 2.4             | 50.0                |
| Crusher               | 173               | 9.8        | 59.0     | 88.2           | 26.9             | 3.4           | 79.5                 | 2.9             | 80.0                |
| Dryer & kiln          | 151               | 9.3        | 44.4     | 78.6           | 35.4             | 2.4           | 82.5                 | 2.0             | 100.0               |
| Sizing & washing      | 47                | 8.5        | 48.9     | 100.0          | 34.4             | 2.7           | 82.3                 | 4.3             | 100.0               |
| Laborer & bullgang    | 64                | 7.8        | 56.3     | 60.0           | 33.1             | 2.8           | 81.1                 | 4.7             | 66.7                |
| Dry screen plant      | 94                | 7.4        | 50.0     | 57.1           | 26.6             | 2.9           | 79.8                 | 1.1             | 0.0                 |
| Greaser & oiler       | 14                | 7.1        | 50.0     | 100.0          | 27.0             | 2.8           | 80.6                 | 0.0             | 0.0                 |
| Truck driver          | 307               | 6.8        | 51.8     | 76.2           | 24.7             | 3.2           | 79.7                 | 1.3             | 75.0                |
| Weigh & scale         | 15                | 6.7        | 20.0     | 0.0            | 8.8              | 4.8           | 64.9                 | 6.7             | 0.0                 |
| Rotary drill          | 19                | 5.3        | 89.5     | 100.0          | 21.0             | 3.9           | 75.8                 | 5.3             | 100.0               |
| Mechanic              | 150               | 4.7        | 43.3     | 57.1           | 20.9             | 3.1           | 78.0                 | 0.7             | 100.0               |
| Forklift              | 111               | 3.6        | 50.5     | 50.0           | 25.9             | 2.6           | 79.7                 | 0.0             | 0.0                 |
| Front-end loader      | 486               | 3.5        | 42.2     | 76.5           | 21.3             | 3.3           | 78.6                 | 1.6             | 75.0                |
| Slurry & mix          | 40                | 2.5        | 32.5     | 100.0          | 20.3             | 3.2           | 78.5                 | 0.0             | 0.0                 |
| Flotation             | 41                | 2.4        | 41.5     | 100.0          | 38.3             | 2.4           | 83.1                 | 0.0             | 0.0                 |
| Administration        | 147               | 2.0        | 32.7     | 66.7           | 12.1             | 3.8           | 72.1                 | 0.0             | 0.0                 |
| Backhoe               | 62                | 1.6        | 25.8     | 0.0            | 14.0             | 3.3           | 75.8                 | 0.0             | 0.0                 |
| Lab technician        | 37                | 0.0        | 16.2     | 0.0            | 8.5              | 3.5           | 67.6                 | 0.0             | 0.0                 |
| Puller & truck loader | 33                | 0.0        | 36.4     | 0.0            | 23.1             | 2.3           | 79.4                 | 0.0             | 0.0                 |
| Electrician           | 24                | 0.0        | 33.3     | 0.0            | 17.7             | 2.7           | 77.5                 | 0.0             | 0.0                 |
| Pelletizing           | 19                | 0.0        | 26.3     | 0.0            | 30.8             | 3.2           | 78.5                 | 0.0             | 0.0                 |
| Road grader           | 18                | 0.0        | 50.0     | 0.0            | 21.3             | 3.0           | 78.8                 | 0.0             | 0.0                 |
| Welder                | 15                | 0.0        | 33.3     | 0.0            | 14.1             | 1.8           | 75.8                 | 0.0             | 0.0                 |
| Tractor               | 15                | 0.0        | 33.3     | 0.0            | 32.3             | 1.5           | 81.8                 | 0.0             | 0.0                 |
| Warehouse             | 11                | 0.0        | 27.3     | 0.0            | 12.5             | 3.7           | 75.0                 | 0.0             | 0.0                 |
| Mobile crane          | 11                | 0.0        | 36.4     | 0.0            | 23.0             | 3.5           | 79.4                 | 0.0             | 0.0                 |

<sup>1</sup>Minimum of 10 samples

## SUMMARY

Since 1974, MSHA has collected more than 273,000 noise dosimeter samples at metal, nonmetal and stone mines and mills. The samples were collected to determine compliance with MSHA's noise PEL. Approximately 26% of these samples exceeded the PEL and 16.9% exceeded the UCL.

Trends in noise exposure from 1974-97 were examined. Dramatic improvements were made in reducing noise exposure by all industry and location groups, but a similar improvement in the use of HPD was not as obvious. For all data combined, the 1995-97 averages were 13.2% > PEL, 6.4% > UCL, and an average dBA (Leq) of 80. The highest overall rate of overexposure was found in underground mines (32.3% > PEL). Surface dimension stone operations continue to have higher rates of overexposure (23.4% > PEL) compared to other stone and sand and gravel

operations.

Occupations experiencing the greatest noise exposure are for underground mines; continuous miner operator, load-haul-dump cycle, drill operators, stope miner and scoop operators, and for surface mines and mills; drill operators, and heavy equipment operators of all types.

MSHA's noise dose data is based on an enforcement sampling strategy and is undoubtedly biased. Nevertheless, these data are useful in determining trends in exposure, identifying areas at greatest risk of overexposure, estimating exposure among different industry sectors and occupations, and evaluating the impact of changes in MSHA's procedures, policies, or regulations.

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### **REFERENCES**

1. Federal Mine Safety and Health Act, 30 U.S.C. 811, Nov., 1977.
2. 30 Code of Federal Regulations, 56/57.5, July, 1994.
3. MSHA, Program Policy Manual, Vol. IV and Appx. A, Apr., 1990.
4. MSHA, Metal/Nonmetal Health Inspection Procedures Handbook, PH90-IV-4, Nov., 1990.
5. Watts, W. F. and D. R. Parker. 1995. Mine Inspection Data Analysis System. *Appl. Occup. and Envir. Hyg.*, 10(4):323-330.
6. Watts, W.F. , *et al.* 1986. Noise Exposure in Metal and Nonmetal Mines. *Ann. Am. Conf. Gov. Ind. Hyg.*, Vol. 14, pp. 375-384.
7. Watts, W. F. and D. R. Parker. 1995. Noise Exposure in U. S. Stone and Sand and Gravel Mining. Proceedings of the National Stone Association's Environment, Safety and Health Forum, October 22-24, 1995, Nashville, TN.
8. Seiler, J.P., *et al.* 1994. Noise Exposure in U.S. Coal Mines, MSHA IR No. 1214.
9. MSHA, Noise, Advance Notice of Proposed Rulemaking, Federal Register, Vol. 54, No. 231, Dec., 1989.