Noise and Silica Exposures
A Survey of Washington State Quarry Operations

The Mine Safety and Health Administration (MSHA) issued a new standard for hearing protection effective in September 2000. The new rule requires that mine operators enroll miners in a hearing protection program if they are exposed to an average sound level of 85 decibels (dBA) or more during an eight-hour period. In order to determine average sound level, workplace noise monitoring is required.

The Field Research and Consultation Group (FRCG) at the University of Washington received requests from ten open surface mines in Washington State to conduct noise monitoring to meet these new requirements. In addition, mine operators also requested monitoring for silica to determine silica quartz exposures.

The companies evaluated were all small employers, with one to seven quarry operations employees working in three types of open surface mines. The three types of mines included two basalt excavation mines, three portable crusher operations, and five sand and gravel operations. The primary difference in the three operations is the source, size, and type of rock handled. In basalt excavation, blasting and drilling is employed to break rock free of an open face; sand and gravel quarries dredge material from an open pit or pond; and portable crusher plants obtain material from near a road or pond to process for roadbed construction. In all three types of operations dump trucks, excavators, and front-end loaders are used to transport material. The rock is delivered to a processing area where the material is transported via conveyors through a series of crushers and screens for breaking and sorting. There are two types of crushers: cone and jaw. Jaw crushers break large rock into smaller sizes, while cone crushers are used to break aggregate into smaller aggregate. The crusher is run by a crusher operator who usually stays inside the operator's booth. In small operations, the operator would sometimes go outside to clear jams or for other equipment maintenance purposes. At larger operations there was also often a crusher mechanic and groundsman. The crusher mechanic worked outside near the crusher doing maintenance/repair tasks and frequently worked during breaks when there were no other noise sources nearby. The groundsman was a laborer who cleared jams on conveyors, directed traffic and handled other labor requirements near the crusher.

In some cases, workers operated several pieces of equipment over the course of a shift.

Figure 1: Portable screening and crusher operation

Quarry operators reported that they control dust with water spray during dry weather conditions using water trucks or loaders to wet roadways. Some, but not all quarries had water spray systems to control dust during conveyor transport, at conveyor transitions, and during screening. Many of the samples gathered were collected during wet weather conditions and may not reflect dust/silica exposures during dry weather.

Figure 2: Loader feeding shaker

Figure 3: Truck loading from hopper

Figure 4: Crusher operator's booth at basalt excavation mine

Methods

Samples were collected between April 2000 and March 2001 across all seasons. Quarry employees were monitored if they had potential for exposure to noise or silica dust. At three operations monitoring occurred on two separate days, while monitoring was done for one day at the other quarries.

Noise – Noise samples were collected using Quest 300 or Metrosonics 308 noise dosimeters. Dosimeters were set for slow response with two sets of measurement parameters: 1) a criterion level of 90 dBA, a threshold limit of 90 dBA, and an exchange

rate of 5 dBA to measure MSHA PEL compliance, and 2) a criterion level of 90 dBA, a threshold limit of 80 dBA, and an exchange rate of 5 dBA for MSHA hearing protection program requirements. The microphone was clipped at the dominant hand shoulder. Measurement results using the first parameter set are compared to the MSHA PEL of 90dBA and results using the second parameter set are compared to 85 dBA, the hearing protection program level. The maximum sound level is compared to 115 dBA. When measures exceed 115 dBA, engineering controls must be implemented to reduce exposure.

Silica - Full shift TWA samples were collected from each worker using a Dorr-Oliver nylon cyclone at a flow rate of 1.7 lpm. Samplers were placed at the worker's lapel on the dominant hand side. Samples were collected on a pre-weighed PVC filter in a 2 stage cassette. Samples were analyzed gravimetrically by the FRCG lab for respirable dust then sent to the University of Washington Environmental Health Lab for percent quartz analysis. Field blanks were submitted with each sample set. The MSHA PEL is 10 mg/m^3/(% quartz + 2). The calculated quartz PEL is compared to the respirable dust concentration.

Results

The findings for noise and silica exposure are summarized in Table 1 by job type. For measurements using the PEL criterion, only groundsmen exceeded the PEL of 90 dBA, although crusher mechanics approached this limit with a mean of 89.1 dBA. When exposures exceed the PEL, exposures must be reduced below 90 dBA, and until exposures are reduced below that level hearing protectors are mandatory.

For all eight job types monitored, the mean 8-hour noise exposure was over the 85dBA hearing protection program level. When that level is exceeded, hearing protection program requirements must be implemented including training, voluntary hearing testing, and provision of hearing protectors for voluntary use.

The allowable maximum sound level of 115 dBA was exceeded for two jobs: crusher operator and crusher mechanic. When this occurs, the job must be analyzed to determine if engineering controls are feasible for reducing the sound level.

For silica exposure, only groundsmen had a mean exposure at the silica PEL, with 3 samples at a mean of 100% of the MSHA PEL. In westernWashington, where these companies are located, damp weather conditions can limit dust levels for much of the year. Many of these samples were collected under damp weather conditions. It is probable that higher exposures do occur during dry weather conditions frequently seen in summer months.

Table 1: Quarry Exposure Assessment for Noise and Silica

Job	Noise Samples (n)	Hearing Protection TWA (dBA)	PEL TWA (dBA)	Max Level (dBA)	Silica Samples (n)	% of Silica PEL
Loader	12	86.7	83.4	112.2	15	36%
Truck driver	4	89.4	84.0	112.4	5	22%
Excavator	5	86.1	81.3	113.2	4	15%
Crusher operator	4	86.8	82.7	117.7	3	17%
Crusher mechanic	2	91.0	89.1	118.4	1	43%
Groundsman	3	92.6	95.3	114.1	3	100%
Dredger	2	86.4	74.8	109.5	0	-
Multiple machines	6	86.9	87.1	113.8	5	57%
Other *	3	83.0	77.2	114.0	1	6%
Total	**41**	**86.7**	**83.6**	**114.2**	**37**	**38%**

Highlighted exposures are over related MSHA standard

*weigh station operator, scraper operator, and rock wash operator

Noise and silica exposures are presented by quarry type in Table 2. For basalt excavation and portable crusher plants, mean noise exposures exceeded the hearing protection program level, indicating a need for a plant-wide hearing protection program. For sand and gravel operations, full shift exposures measured with the PEL and hearing protection criterion where below their associated limits, although the maximum sound level of 115 dBA was exceeded for five of the seven jobs monitored.

Table 2: Noise and Silica Exposures by Quarry Type

Quarry Type	Loader	Truck Driver	Excavator	Crusher Operator	Crusher Mechanic	Grounds-man	Dredger	Multiple Machines	Other	TOTAL
Basalt Excavation – 2 operations										
Noise N	3	1	3	1				3	1	**12**
HP twa (dBA)	87.1	NM	89.4	93.2				90.1	75.1	**87.6**
PEL twa (dBA)	81.4	79.2	82.7	92.6				85.1	65.0	**82.0**
MAX (dBA)	107.4	99.9	110.8	128.4				111.9	110.8	**110.8**
Silica N	4	2	3	1				2	0	**12**
% of Silica PEL	26%	6%	20%	19%				24%	-	**20%**
Portable Crusher Plant – 3 operations										
Noise N	5	2		1	1	3	1	2	1	**16**
HP twa (dBA)	93.3	NM		83.6	89.4	92.6	92.1	NM	88.5	**90.4**
PEL twa (dBA)	90.9	84.8		74.3	86.4	95.3	89.7	96.4	84.0	**89.9**
MAX (dBA)	115.2	114.9		106.8	117.6	114.1	112.8	116.1	110.5	**114.3**
Silica N	6	1		0	0	3	0	2	1	**13**
% of Silica PEL	67%	77%		-	-	100%	-	116%	6%	**78%**
Sand and Gravel – 5 operations										
Noise N	4	1	2	2	1		1	1	1	**13**
HP twa (dBA)	83.1	89.4	82.8	85.2	92.6		80.7	80.7	85.6	**84.4**
PEL twa (dBA)	75.6	87.1	79.3	81.9	91.7		59.8	74.7	82.6	**78.5**
MAX (dBA)	111.9	117.8	116.8	117.8	119.2		106.2	115.1	120.8	**115.2**
Silica N	5	2	1	2	1			1	0	**12**
% of Silica PEL	5%	12%	2%	16%	43%			4%	-	**11%**

BE- basalt excavation; PP- portable crusher plant; SG- sand and gravel; NM- not measured

Highlighted exposures are over related MSHA standard

Discussion and Recommendations

Noise - The revised MSHA noise standard was developed to protect miners' hearing, based on research indicating that hearing loss occurs with average sound levels below 90 dBA. The operations monitored in this study had average sound levels less than 90 dBA but over 85 dBA, the new level for required hearing protection programs. MSHA has developed resources to assist mine operations with compliance with the revised noise standards. These resources can be accessed at:http://www.msha.gov/1999noise/noise.htm.

When average sound levels exceed 90 dBA or when maximum sound levels exceed 115 dBA, feasible engineering controls must be implemented to reduce noise levels. Hearing protectors are not an acceptable alternative if feasible engineering controls are available.

Some examples of controls for open surface mining operations include:

Heavy Equipment

- Fit heavy equipment with enclosed cabs and air conditioning. Ensure that doors and windows are kept closed.
- Ensure all equipment has exhaust mufflers and that exhaust pipes are directed away from the operator's cab.

Generator and Generator Trailer

- Fit generator with supply and exhaust air mufflers.
- Keep generator doors tightly closed.
- The generator hood can be lined with sound dampening material.
- If possible, keep the trailer closed. If that is not possible because of heat build up, position the doors away from where quarry personnel are located.
- Locate the trailer as far away as possible from personnel. Noise levels fall as the distance increases from the generator. For example, if a sound level at the generator is 120 dB, it will be 85 dB 50 feet away.
- Double hearing protection (plugs and muffs) should be worn if the trailer must be entered when the generator is operating. An alternative is to prohibit entry into the trailer when the generator is operating.

Conveyors

- Upgrade or install conveyor belt brushes to clear soil from belts to reduce the need for belt cleaning by the groundsman.

Crushers

- Sound proof and air condition the crusher operator's booth. Holes and cracks open to the outside are the greatest source for noise transmission from outside. The booth can be lined with sound proofing or thick plywood to further reduce sound levels inside the booth.
- The operator should spend as much time as possible inside the booth with doors and windows closed.

Shakers

- For rod decks, experiment with increasing the slot width during the wet season to reduce the frequency of jams and need for manual cleaning. Covering this apparatus would keep the unit drier and may reduce binding.

Other

- Install silencers on compressed air wands.
- Prohibit use of compressed air to clean clothes.
- Shift the groundsman work schedule to reduce time near operating equipment (e.g. remove accumulated soil beneath conveyors pre- or post-shift) or use a mini-cat with enclosed cab to remove accumulated soil.

Silica – During our survey, dust and silica exposures were usually below the PEL, although overexposures did occur at two of the portable crusher operations. Since the majority of sampling occurred during wet weather, further sampling is recommended to assess exposure during dry weather.