# REPORT OF THE

# FREE SILICA AND NOISE HAZARD

# TO

# WORKERS IN SAND AND GRAVEL CRUSHERS

# AND

# HOT MIX PLANTS

SURVEYS CONDUCTED

FROM JUNE 1968 TO JUNE 1969

BY

U. S. PUBLIC HEALTH SERVICE
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BUREAU OF OCCUPATIONAL SAFETY AND HEALTH
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Worker exposures to dust and noise were surveyed at 22 gravel crushing and hot mix facilities in Idaho, New Mexico and Oregon during 1968 to 1969. The companies employed a total of 118 workers. Free silica (7631869) concentrations ranged from 0.2 to 59 percent. Personal air samples contained up to 108 milligrams per cubic meter of free silica. Noise levels were 90 to 105 decibels, and the maximum daily exposure was 1 to 8 hours. Forty three percent of the workers at the dry run crushers and 67 percent of the workers in the hot mix areas that did not have emission controls were exposed to twice the threshold limit values of silica and to excessive amounts of noise. The author recommends that hot mix and crusher facility workers wear ear muffs or plugs, and that dry crusher and hot mix facility workers wear approved free silica dust masks. Workers should be given periodic chest X-ray and audiometric examinations. Crusher operations should be water washed, and all heavy equipment and dozer operation workers should be required to wear ear protective devices.

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# FREE SILICA AND NOISE HAZARD TO WORKERS IN SAND AND GRAVEL CRUSHERS AND HOT MIX PLANTS

A study was undertaken to determine the extent of potential dust and noise hazards to workers involved with gravel crushing operations and hot mix plants. A total of 22 operations with a total estimated population of 118 employees were observed or evaluated in the states of Idaho, New Mexico, and Oregon during 1968-1969.

The study was conducted principally as a result of the death of a gravel crusher employee in New Mexico whose cause of death was diagnosed as silicosis.

## Dust Evaluation

At active work sites size selective personal samples were collected to evaluate the concentration of respirable dust that the workers were exposed to. The percentage of free silica in the respirable range was also determined by standard analytical means.

## Noise Evaluation

As could be expected, noise is a significant occupational hazard in the gravel crushing and hot mix industries due to their nature. Sound level readings were obtained at the various operations using the "A" weighting network.

## Data

The results of the noise and dust studies on individual plants are tabulated below. A summary tabulation follows the tabulation of individual surveys.

## Plant Description

Crushing operations can be grouped according to hazard by 1) the use or lack of use of wash water in the process, and 2) the proximity of the worker to the crusher units. In general those crushers which were permanent installations, and used abundant water to wash the material were noticeably clean and

free of dust except for immediately around the crusher unit. In permanent (water-washed) installations the operator was typically stationed some distance from the crusher unit while in dry-run portable crushers the operator was often on top of the crusher. Dry-run crushers were observed in various sizes and are those which process material as it naturally occurs creating considerable dust. Some crushers have water sprays which have varying degrees of effectiveness of dust control. Only one crusher in this study was observed with sprays and the control achieved was not adequate. All crushers have various arrangements of conveyor belts, vibrating or roll screens, jaw, cone, and/or roll crushers, and electric, diesel-electric, or diesel power supplies. All were very noisy except where a permanent installation utilized electric line power. Locating the operators' work station away from the crusher was helpful in attenuating noise insults to the worker.

Results

As the surveys progressed it became evident that the dry crushers processing granite, marine deposits, and rounded aluvium presented considerable free silica hazard. As the study progressed opportunity occurred to extend it to examine the free silica hazard associated with Oregon crushers processing basalt. As shown in the tabulation, the lower average free silica in respirable dusts of basalt (5.6% to 9.3%) provided for a higher TLV and fewer workers were excessively exposed on the dry crusher. Interestingly, the rounded aluvium of the Willamette River Valley consisted of a mixture of stone and had a free silica content of approximately 23% in the respirable dust which was comparable to other areas surveyed.

Conclusions

Referring to the summary table shows that for free silica exposure 43% of the workers measured in the dry run crushers were more than twice the TLV

and that 67% of the workers in the hot mix plants without emission controls were also more than twice the TLV. On the other hand the workers in water-washed crusher plants and a hot mix plant with low emission had neglectable exposures.

Noise is also a significant hazard, 94% and 83% of the workers of the dry-run crushers and no dust control hot mix plants, respectively, were over the TLV. Of interest is that all of the dozer operators measured had a TLV of less than 3 hours, some less than 2 hours.

Recommendations

1. That all workers around hot mix plants and crusher plants wear ear protection. Many crusher workers claim they have to listen to the crusher for irregular noises which signal something wrong. It is strongly felt that once a worker was accumstomed to the use of ear muffs or ear plugs he could still hear irregular noises of the plant.

2. That all workers on dry crushers or uncontrolled hot mix plants be required to wear Bureau of Mines approved dust masks for free silica dust.

3. Workers be required to have preplacement and periodical chest X-ray examinations and audiometric examinations.

4. Hot mix plants be properly designed for low atmospheric emissions.

5. Crusher operations be water-washed if possible.

6. Heavy equipment and dozer operators across the nation be required to wear ear protective devices.

Measurements of Workers Exposure to Hazards of Free Silica in Dust and Noise
In Dry Process Sand and Gravel Crushers

| Occupation | Sample Volume (liter) | Sample Weight (mg) | Percent Free Silica | Measured Exposure ($mg/m^3$) | TLV* Exposure ($mg/m^3$) | Noise dbA | Noise *Maximum Daily Exposure (hrs) |
|---|---|---|---|---|---|---|---|
| Grizzley Operator | 378 | 0.23 | | 0.61 | 0.40 | 98 | 2½ |
| Crusher Operator | 398 | 0.70 | 53 | 1.76 | 0.40 | 92 | 6 |
| Oiler | 346 | 0.58 | 55 | 1.67 | 0.40 | 92 | 6 |
| Dozer Operator (AC-11) | 346 | 0.04 | | 0.12 | 0.40 | 97 | 3 |
| Dozer Operator (AC-21) | 350 | 0.72 | 25 | 2.06 | 0.40 | 101 | 1 3/4 |
| Truck Loader | 388 | 0.26 | 19 | 0.67 | 0.40 | 90 | 8 |
| Truck Driver | 334 | 0.14 | | 0.41 | 0.40 | 92 | 6 |
| Truck Driver | 338 | 0.00 | | Neg. | 0.40 | | |
| Settled Dust Sample | | | 23.0 Yielding a TLV of | | 0.40 | | |

The unprocessed material was a mixture of rounded rock and dirt located near Jemez Springs, New Mexico. The crusher was of medium size and very portable. Samples were taken in Jaunary 1969.

*Recommended by the American Conference of Governmental Industrial Hygienists as Threshold Limit Value (TLV). (A provisional recommendation on free silica exposure).
Survey and tabulation by Evan H. Curtis, U. S. Public Health Service, BOSH
Western Area Occupational Health Laboratory, Salt Lake City, Utah

Measurements of Workers Exposure to Hazards of Free Silica in Dust and Noise
In Dry Process Sand and Gravel Crushers

| Occupation | Sample Volume (liter) | Sample Weight (mg) | Percent Free Silica | Measured Exposure ($mg/m^3$) | TLV* Exposure ($mg/m^3$) | Noise dbA | Noise *Maximum Daily Exposure (hrs) |
|---|---|---|---|---|---|---|---|
| Grizzley Operator | 346 | 0.17 | | 0.49 | 0.30 | 94 | 4½ |
| Oiler | 348 | 0.52 | 40 | 1.50 | 0.30 | 105 | 1 |
| Driller (Jack Hammer) | 332 | 0.58 | 11 | 1.75 | 0.30 | 104 | 1½ |
| Dozer Operator (Euclid C-6) | 332 | 0.04 | | 0.12 | 0.30 | 104 | 1½ |
| Truck Driver | 362 | 0.10 | | 0.28 | 0.30 | 98-85 | 7 |
| Truck Driver | 352 | 0.73 | 23 | 2.07 | 0.30 | 98-85 | 7 |
| Truck Driver | 352 | 0.06 | | 0.17 | 0.30 | 98-85 | 7 |
| Truck Driver | 360 | 0.02 | | 0.06 | 0.30 | 98-85 | 7 |
| Settled Dust Sample | | | 30.4 | Yielding a TLV of | 0.30 | | |

This crusher operation was quarring and processing marine and lime stone deposits near Corona, New Mexico in January 1969. The crusher was of medium size and highly portable.

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(A provisional recommendation on free silica exposure).
Survey and tabulation by Evan H. Curtis, U. S. Public Health Service, BOSH
Western Area Occupational Health Laboratory, Salt Lake City, Utah

Measurements of Workers Exposure to Hazards of Free Silica in Dust and Noise
In Dry Process Sand and Gravel Crushers

| Occupation | Sample Volume (liter) | Sample Weight (mg) | Percent Free Silica | Measured Exposure ($mg/m^3$) | TLV* Exposure ($mg/m^3$) | Noise dbA | Noise *Maximum Daily Exposure (hrs) |
|---|---|---|---|---|---|---|---|
| Cleanup Man | 290 | 0.58 | 44 | 2.00 | 0.20 | 95 | 4 |
| Plant Operator | 288 | 0.27 | 44 | 0.94 | 0.20 | 95 | 4 |
| Dozer Operator Moving Stock Piles | 280 | 0.61 | 48 | 2.18 | 0.20 | 98 | 2½ |
| Small, highly portable crusher located near Albuquerque, New Mexico crushing rounded aluvial stone from a hillside. Sampled in July 1968. | | | | | | | |
| Cleanup Man | 646 | 0.26 | 59 | 0.40 | 0.17 | 95-102 | 2½ |
| Plant Operator | 648 | 0.33 | 59 | 0.51 | 0.17 | 96 | 3½ |
| Small, highly portable crusher located near Albuquerque, New Mexico crushing rounded aluvial stone from a hillside. Sampled in July 1968. | | | | | | | |
| Crusher operator | 334 | 1.97 | 20 | 5.9 | 0.5 | 101-104 | 1½ |
| Cleanup Man | 196 | .58 | 20 | 2.7 | 0.5 | 104-105 | 1 |
| Dust from a Machine Air Filter | | | 20.3 | Yielding a TLV of 0.5 | | | |

The above crusher is located in a subterranean excavation crushing freshly quarried granite for the construction of Dwarshak Dam near Orofino, Idaho. Samples taken June 1968 and project completion scheduled for 1972. Crusher scheduled to run twenty-four hours a day.

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(A provisional recommendation on free silica exposure)
Survey and tabulation by Evan H. Curtis, U.S. Public Health Service, BOSH
Western Area Occupational Health Laboratory, Salt Lake City, Utah

Measurements of Workers Exposure to Hazards of Free Silica in Dust and Noise
In Dry Process Sand and Gravel Crushers

| Occupation | Sample Volume (liter) | Sample Weight (mg) | Percent Free Silica | Measured Exposure ($mg/m^3$) | TLV* Exposure ($mg/m^3$) | Noise dbA | Noise *Maximum Daily Exposure (hrs) |
|---|---|---|---|---|---|---|---|
| Crusher Operator | 314 | 0.37 | 8 | 1.18 | 0.9 | 94-104 | 3 |
| Grizzley Feeder | 342 | 0.01 | | 0.03 | 0.9 | 98-102 | 2 |
| Plant Operator | 211 | 0.21 | 16 | 0.99 | 0.9 | 94-104 | 3 |
| Oiler | 174 | 0.04 | | 0.23 | 0.9 | 94 | 4 |
| (Large Respirable dust sample obtained near roll crusher). | | 5.04 | 9.3 | Yielding TLV | 0.9 | | |
| This crusher was using a damp river side pit of rounded river aluvial stone (located near Grants Pass, Oregon). | | | | | | | |
| Foreman: Loader Operator | 354 | 0.12 | | 0.34 | 0.95 | 90-102 | 5 |
| Cleanup Laborer | 339 | 0.83 | 8.8 | 2.44 | 0.95 | 90-98 | 5 |
| Grizzley Operator | 351 | 0.11 | | 0.31 | 0.95 | 91-94 | 6 |
| The above crusher was near Klamath Falls, Oregon and was processing basalt debris from a fault. | | | | | | | |
| Plantman | 313 | 0.59 | 5.6 | 1.88 | 1.3 | 87 | 8 |
| Loader Operator | 297 | 0.00 | | 0.00 | 1.3 | | |
| Foreman | 268 | 0.11 | | 0.41 | 1.3 | 93-96 | 4½ |
| Grizzley Operator | 231 | 0.06 | | 0.26 | 1.3 | 98-102 | 2 |
| This crusher was running basalt blasted from a hillside near Condon, Oregon. A wind was blowing during sampling away from those lightly exposed and toward the man heavily exposed. | | | | | | | |

*Recommended by the American Conference of Governmental Industrial Hygienists as Threshold Limit Value (TLV). (A provisional recommendation on free silica exposure)

Survey and tabulation by Evan H. Curtis, U. S. Public Health Service, BOSH'
Western Area Occupational Health Laboratory, Salt Lake City, Utah

Evaluation of Workers Exposure to Hazards of Free Silica in Dust and Noise
In Water Washed Sand and Gravel Crushers

| Occupation | Sample Volume (liter) | Sample Weight (mg) | Percent Free Silica | Measured Exposure ($mg/m^3$) | TLV* Exposure ($mg/m^3$) | Noise dbA | Noise *Maximum Daily Exposure (hrs) |
|---|---|---|---|---|---|---|---|
| Crusher Operator | 374 | neg. | | neg. | 1.1 | 91 | 7 |
| Crusher & Loader Operator | 370 | 0.09 | | 0.24 | 1.1 | 87 | 8 |
| Settled Dust Sample | | | 7.3 Yielding a TLV of | | 1.1 | | |
| Rounded aluvial stone was washed as it was removed from a water filled pit and stock piled by a dragline. The crusher operator stations for this permanent installation were over fifty feet from the crusher yielding a small exposure. Samples obtained in Portland, Oregon during November 1968. | | | | | | | |
| Crusher Operator | 360 | .06 | | 0.20 | 15 | 98 | 2½ |
| Oiler | 280 | .05 | | 0.20 | 15 | 90 | 8 |
| Settled Dust Sample | | | 0.2 | | 15 (TLV for nuisance dusts) | | |
| This Portland, Oregon crusher was running freshly quarried basalt. The sampling was done in November 1968, and the rock was very damp and muddy. | | | | | | | |

*Recommended by the American Conference of Governmental Industrial Hygienists as Threshold Limit Value (TLV)
(A provisional recommendation for free silica).
Survey and tabulation by Evan H. Curtis, U. S. Public Health Service, BOSH
Western Area Occupational Health Laboratory, Salt Lake City, Utah

Evaluation of Potential Exposures to Free Silica in Dust and Noise
in Water Washed Sand and Gravel Crushers

| Crusher Description | Number of Employees | Source of Material | Type of Crusher | % $SiO_2$ Settled Dust | % $SiO_2$ Respirable Dust | Noise Evaluation |
|---|---|---|---|---|---|---|
| Large, stationary water-washed, integrated with ready mix and hot mix plants. | 7-8 | Pit | Jaw, cone, and roll. | 9 | | Crusher down. |
| Large, stationary, using 4,000 gal/min. of wash water. | 6-7 | Pit | Cone<br>Roll | 11<br>10 | | Noisy. |
| Large, stationary, water-washed. | One man operates crusher loader and truck. | Riverside pit | Cone<br>Cone<br>Roll<br>Roll | 13<br><br>13<br> | 36<br>23<br>20<br>25 | Noisy. |
| Medium size, stationary, water-washed. | 1 | River level pit. | Cone<br>Roll | 15<br>16 | | Crusher down. |
| Medium size, stationary, timber constructed, water-washed, roll sieves. | 1 | Pit | Cone | 8 | | Noisy. |

In the Willamette River Valley, Oregon, where these crushers were surveyed during May 1969, the raw material is a rounded stone aluvium of various parent rocks which appears to be comparable from one location to another. The working area of these crusher plants had no appreciable dust except for immediately around the crusher units. The wet, water-washing process apparently keeps the dust at minimal levels.

Survey and tabulation by Evan H. Curtis, Department of Health, Education, and Welfare, Consumer Protection and Environmental Health Service, Environmental Control Administration, Bureau of Occupational Safety and Health, Salt Lake City, Utah.

Measurements of Workers Exposure to Hazards of Free Silica in Dust and Noise in Hot Mix Plants

| Occupation | Sample Volume (liter) | Sample Weight (mg) | Percent Free Silica | Measured Exposure ($mg/m^3$) | TLV* Exposure ($mg/m^3$) | Noise dbA | Noise *Maximum Daily Exposure (hrs) |
|---|---|---|---|---|---|---|---|
| Foreman | 314 | 0.08 | 27 | 0.26 | 0.34 | 91-93** | 6 |
| Plant Operator | 312 | 0.88 | 27 | 2.82 | 0.34 | 91** | 7 |
| Cleanup Man | 312 | 0.31 | 59 | 0.99 | 0.17 | 91-105** | 2½ |
| This plant was a permanent installation. Samples were obtained in July 1968 near Albuquerque, New Mexico. | | | | | | | |
| Oiler | 198 | 21.73 | 6 | 108.00 | 1.25 | 95** | 4 |
| Plant Operator | 280 | 4.37 | 17 | 15.60 | 0.53 | 95** | 4 |
| Loader Operator Moving Stock Piled Material | 264 | 0.15 | 44 | 0.57 | 0.20 | | |
| Although permanently set-up, this plant is of a portable type. Sampled in July 1968 near Albuquerque, New Mexico | | | | | | | |
| Plant Operator | 346 | 0.06 | | 0.18 | 1.1 | 90 | 8 |
| Fireman (Oiler) | 350 | Neg. | | Neg. | 1.1 | 88-95 | 7 |
| Settled Dust Sample | | | 7.3 Yielding a TLV of | | 1.1 | | |
| This plant is located in the city limits of Portland, Oregon and was recently constructed to have plant emissions comply with Los Angeles standards (a strict control). Obviously the emissions control is largely responsible for the low dust levels in the working environment. Samples were obtained in November 1968. | | | | | | | |

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**Probably less than an eight hour per day exposure.
Survey and tabulation by Evan H. Curtis, U. S. Public Health Service, BOSH Western Area Occupational Health Laboratory, Salt Lake City, Utah

SUMMARY OF EXPOSURES TO HAZARDS OF FREE SILICA AND NOISE

| Type of Plant and Hazard | Number of Plants | Workers Measured | Exposures Over TLV* | Exposures Over ½ x TLV & Under 2 x TLV | Exposures Over 2 x TLV |
|---|---|---|---|---|---|
| Dry Run Crushers | | | | | |
| Free Silica | 9 | 35 | 22 (63%) | 9 (26%) | 15 (43%) |
| Noise | 9 | 32 | 30 (94%) | 10 (31%) | 21 (66%) |
| Wet Process Crushers | | | | | |
| Free Silica | 2 | 4 | 0 (0%) | 0 (0%) | 0 (0%) |
| Noise | 2 | 4 | 2 (50%) | 3 (75%) | 1 (25%) |

A number of water washed crushers were surveyed in which samples were not taken because by observation it was determined that the levels of dust were too low to be obtainable with the equipment utilized, and hence, they would have been insignificant exposures. These same crushers had noisy environments.

| | | | | | |
|---|---|---|---|---|---|
| Hot Mix Plant with No Dust Control | | | | | |
| Free Silica | 2 | 6 | 4 (67%) | 1 (17%) | 4 (67%) |
| Noise | 2 | 6 | 5 (83%) | 2 (33%) | 3 (50%) |
| Hot Mix Plant with Emission Control Designed to Meet Los Angeles Standards | | | | | |
| Free Silica | 1 | 2 | 0 (0%) | 0 (0%) | 0 (0%) |
| Noise | 1 | 2 | 1 (50%) | 2 (100%) | 0 (0%) |

*TLV = Threshold Limit Values as Recommended by the American Conference of Governmental Industrial Hygienists. A Provisional Recommendation.