U.S. Department of Labor

Mine Safety and Health Administration
Pittsburgh Safety & Health Technology Center
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Dust Division

September 20, 2005

MEMORANDUM FOR STEVEN M. RICHETTA
District Manager, Metal and Nonmetal Mine Safety and Health,
North Central District, Duluth, Minnesota

THROUGH: JOHN E. UROSEK
Acting Chief, Pittsburgh Safety and Health Technology Center

FROM: ROBERT A. HANEY
Chief, Dust Division

SUBJECT: Respirable Dust and Mineral Fiber Investigation at Northshore Mining Company (Mine I.D. No. 21 00831), Silver Bay, Lake County, Minnesota

Attached is the report of the results from the respirable dust and mineral fiber investigation conducted at the Northshore Mining Company (Mine I.D. No. 21 00831), Silver Bay, Lake County, Minnesota. The study was conducted to evaluate engineering controls used to reduce worker exposure to respirable dust and mineral fibers in the mill. The study was conducted on April 26-27, 2005 and May 24-25, 2005.

If you have any questions regarding this study, please contact this office at (412) 386-6858.

Attachment

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UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION

Environmental Dust and Fiber Investigation

PS&HTC-DD-05-532
Northshore Mining Company
Silver Bay, Lake County, Minnesota
Mine I.D. No. 21 00831
April 26 - 27, 2005
May 24 - 25, 2005

by

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Objective

To evaluate engineering controls used to reduce worker exposure to respirable dust and mineral fibers in the mill and to review the facility's respiratory protection program.

Originating Office

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INTRODUCTION

On April 26-27, 2005 and May 24-25, 2005, an environmental dust and fiber investigation was conducted at the Northshore Mining Company taconite plant (Mine I.D. No. 21-00831), Silver Bay, Lake County, Minnesota. The purpose of this investigation was to evaluate engineering controls used to reduce worker exposure to respirable dust and mineral fibers in the mill and to review the facility's respiratory protection program. The investigation was conducted at the request of the District Manager, Metal and Nonmetal Mine Safety and Health (MNMS&H), North Central District. Mine Safety and Health Administration (MSHA) personnel from the Pittsburgh Safety and Health Technology Center (PS&HTC), Dust Division conducting the investigation were Robert A. Haney, Chief; Kenneth G. Fields, Mining Engineer; and Deborah M. Tomko, Industrial Engineer. MSHA personnel from MNMS&H conducting the investigation were William H. Pomroy, Mine Safety and Health Specialist, North Central District, Duluth, Minnesota, and Christopher Findlay, Industrial Hygienist, Division of Health, Arlington, Virginia.

BACKGROUND

The Northshore Mining Company taconite plant, located in Lake County, Minnesota, is an iron ore processing facility which beneficiates low-grade magnetic iron ore to produce high-grade hardened iron ore pellets. The plant was opened in 1955 by Reserve Mining Company, and the current owner, Cliffs Minnesota Minerals Company acquired the facility, re-named Northshore in 1994. The mine operates two 12-hour shifts (6:00 a.m. to 6:00 p.m.), 7 days per week for the operators and one 10-hour shift (6:00 a.m. to 4:00 p.m.), 5 days per week (Monday through Friday) for maintenance. The Northshore facility produces approximately 5.2 million tons of iron ore pellets annually. The pellets are used as primary blast furnace feedstock for iron production.

The Mesabi Iron Range extends 110 miles northeastward from the Grand Rapids, Minnesota area up to Babbitt, Minnesota where the mine that feeds the Silver Bay processing operations is located. Mining in the 12-mile long by 1-mile wide by 400-foot deep pit employs conventional hard rock surface mining unit operations. The process begins with workers drilling deep blast holes at planned intervals into the taconite ore at the Babbitt Mine. After clearing the area, the taconite is blasted into boulder-size chunks. The shovel operator loads up to 40 tons per scoop onto the trucks. Each truck can haul more than 200 tons. The boulder-size chucks are reduced to small pieces by a primary crusher (60-inch gyratory) located in Babbitt. Diesel-powered trains transport the crushed ore approximately 47 miles to the Northshore processing facility at Silver Bay on the shores of Lake Superior.

At the Silver Bay facility, the crushed taconite, which contains approximately 25% iron, is off-loaded from the trains at the Car Dump Building. The ore is then conveyed to the Fine Crusher Building where 6 cone crushers are used to further reduce the size of the stone. From the Fine Crusher Building, the ore is conveyed to the Dry Cobber Plant where dry magnetic separation is used to separate high grade and low grade ore. The low grade ore is transported by rail to a tailing disposal area about 7 miles from the plant for use in constructing tailings impoundment dams. The high grade ore is conveyed to the Concentrator Building for further refining.

In the Concentrator Building, water is mixed with the ore to form a slurry that is fed into the rod mills. The ore slurry passes through rod mills and ball mills to further reduce the particle size in the slurry. At the time of the investigation there were 10 operational rod mills and each rod mill fed 2 ball mills. The slurry coming out of the ball mills is then sent by operators through revolving drums containing powerful magnets that separate the iron-bearing particles from the waste, which is called "tailings". The tailing slurry is pumped to settling ponds.

The iron rich concentrate (approximately 65%) from the separator is rolled into marble-size pellets in a balling drum. Bentonite, which is a bonding agent, is added to help hold the pellets together. Pellets are heat-hardened at 2,400°F to enable the pellets to withstand the rigors of loading, shipping, and entry into the blast furnace. After the pellets are cooled, they are loaded into ore boats at the shipping dock located next to the Silver Bay processing facility. More than 5 million tons of taconite pellets are transported each year across the Great Lakes from the Northshore plant to the nation's steelmakers as raw material for their blast furnaces.

Controls and work practices were observed in the 4 main buildings of the facility that were the subject of this study. The Car Dump Building is approximately 78 feet by 70 feet with a height of 98 feet and a volume of 19,800 cubic yards. The Fine Crusher Building is approximately 468 feet by 89.5 feet with a height of 109 feet and a volume of 169,000 cubic yards. The Dry Cobber Building is approximately 416 feet by 84.5 feet with a height of 119 feet and a volume of 155,000 cubic yards. The Concentrator Building is approximately 1,310 feet by 154 feet with a height of 60 feet and a volume of 448,000 cubic yards.

SAMPLING AND ANALYTICAL PROCEDURE

On April 26-27, 21 area samples were collected during this portion of the survey to analyze for respirable dust and quartz. Eleven of these samples were collected in the Concentrator Building on the first day of the study. These area samples were collected in the shed; at each Feed to the Rod Mill for 103, 106, and 109; between each of the Ball Mills for 103, 106, and 109; between each of the Primary and Secondary Magnetic Separators for 103, 106, and 109; and under Regrind Mill 106. Five samples were collected from the West Plant in the Dry Cobber Building on the second day of the study. These area samples were collected in the tunnel discharge, the lower and upper floors at the center of the building, and the lower and upper floors at the west side of the building. Five samples were collected from the Fine Crusher Building on the second day of sampling. These area samples were collected at the top level, bottom level, screening area, crusher area, and beneath the crusher.

In addition to the April respirable dust sampling, 12 of the area locations were also monitored for mineral fibers. These locations included 4 different locations in the Concentrator Building on the first day of the study, 5 different locations in the Dry Cobber Building on the second day of the study, and 3 different locations in the Fine Crusher Building on the second day of the study. Depending on the visual dustiness of the location, fiber sample cassettes were changed out at 2 to 3 hour intervals to avoid overloading the cassette with mineral dust. A total of 28 area samples were collected during the survey to analyze for mineral fibers.

Seven bulk samples were collected during the April investigation. Three of these bulk samples were collected at the mine near Babbitt, Minnesota, and the remaining four samples were collected at the processing facility in Silver Bay, Minnesota. The samples collected at the mine were obtained from the west end, mid section, and east end of pit. The fourth bulk sample was collected from the Rail Car Dump. The remaining 3 bulk samples were collected from beneath the crusher, the spray-on insulation, and old shingles all located inside the Fine Crusher Building. All bulk samples were analyzed for asbestos. Additionally, all bulk samples (except for the spray-on insulation and old shingles from the Fine Crusher Building) were analyzed for quartz.

On May 24-25, six area samples were collected during this portion of the survey to analyze for respirable dust and quartz. Three of these samples were collected in the Fine Crusher Building on the first day of the study. These area samples were collected inside the baghouse of Dust Collector 305, Screen 102 (east side), and Screen 2 (west side). Two samples were collected in the Dry Cobber Building on the second day of the study. These area samples were collected in the upper level west side center of the building and upper level center under the feed belt. One sample was collected at the Car Dump Building control room on the second day of the study.

In addition to the May respirable dust sampling, one maintenance person and the above 6 area locations were also monitored for mineral fibers. Depending on the visual dustiness of the location, fiber sample cassettes were changed out at 2 to 4 hour intervals to avoid overloading the cassettes with mineral dust. A total of 3 personal sample cassettes and 11 area sample cassettes were utilized for collecting samples during the survey to analyze for mineral fibers.

Six bulk samples were also collected during the May investigation. Two of these bulk samples were collected from inside the baghouse of Dust Collector 305 located in the Fine Crusher Building: one sample from the upper level floor and one sample from the bottom of the cage. Two bulk samples were collected from the Dry Cobber Building: one sample from the lower level (east side) and one sample from Dust Collector 318 (east side). Two bulk samples were collected from the Concentrator Building: one sample from Dust Collector 121 and one sample from the hopper between Dust Collectors 120 and 121. All bulk samples were analyzed for asbestos and quartz.

Respirable dust area samples were collected with SKC pumps calibrated and operated at 1.7 liters per minute (Lpm). The samples were collected on polyvinyl chloride filters. The filters are 37 millimeter (mm) in diameter and have a 5.0 micron pore size. All filter cassettes were preweighed and postweighed on an analytical balance to a thousandth of a milligram (mg). A control filter was used to adjust postweights for variability associated with temperature and humidity variations. All samples used a 10-millimeter nylon preseparator cyclone. All dust samples were analyzed gravimetrically for final weight determination at the MSHA Pittsburgh Laboratory. Respirable dust concentrations were determined by dividing the sample mass by the volume of air sampled. Dust concentrations were calculated in units of milligram per cubic meter (mg/m^3) from the following formula:

$$Dust\ Concentration\left(\frac{mg}{m^3}\right) = \frac{Weight\ of\ Contaminant\ (mg) \times 1{,}000\ \frac{L}{m^3}}{1.7\ Lpm \times Time\ (minute)}$$

All area sample dust concentrations were based on actual sampling time resulting in time weighted averages (TWA's).

Because of the low sample masses due to less than full-shift sampling, samples were combined for silica analysis to assure that the silica analysis was high enough for accurate reporting. Samples were combined by area of the mill sampled. The combined sample areas were:

- Fine Crusher Building, upper floors,
- Fine Crusher Building, lower floors,
- Tunnel into Dry Cobber Building,
- Dry Cobber Building,
- Concentrator Building, feeder level, and
- Concentrator Building, ball mills and separator areas.

Samples were analyzed for silica by X-Ray Diffraction at the Dust Division, Pittsburgh Laboratory. The threshold limit values (TLV's) for each of the areas sampled were calculated using the formula:

$$TLV = \frac{10}{\%\ Quartz + 2}$$

MSHA does not enforce the silica standard based on area samples; however, this calculation gives an indication of allowable dust levels in each area of the mill based on the concentration of respirable crystalline silica present in the dust samples obtained at the respective locations.

Fiber samples were collected with SKC pumps calibrated and operated at 1.7 liters per minute (Lpm). The samples were collected on black 25 mm Omega Specialty Instrument cellulose membrane cassettes with a 50 mm conductive extension cowl. The filters were 0.8 µm pore size. Control filters were used to determine any contamination of the filter from sample handling. All fiber samples were analyzed by NIOSH Method 7400, Phase Contrast Microscopy (PCM). Fiber samples were analyzed at Reservoirs Environmental Services, Inc. The samples with fibers counts greater than 0.1 fibers/cc were then mineralogically identified by NIOSH Method 7402, Transmission Electron Microscopy (TEM). These included samples collected in the Fine Crusher Building, the Dry Cobber Building, and the conveyor tunnel between the Fine Crusher and Dry Cobber Buildings. Fiber concentrations were calculated in units of fibers per cubic centimeter (fibers/cc) from the following formula:

$$Fiber\ Concentration\left(\frac{fibers}{cc}\right) = \frac{Fiber\ Count\left(\frac{fibers}{cm^2}\right) \times Area\ (cm^2)}{1.7\ Lpm \times Time\ (minute) \times 1{,}000\ \frac{cc}{L}}$$

TEM percent asbestos values were applied to the PCM concentrations to obtain asbestos concentrations. All area sample fiber concentrations were based on actual sampling times, resulting in TWA concentrations. Personal sample fiber concentrations were based on 480 minutes regardless of the time sampled resulting in shift weighted average (SWA) concentrations.

Bulk samples were analyzed for asbestos content by Polarized Light Microscopy (PLM) at Reservoirs Environmental Services, Inc. Bulk samples were analyzed for quartz by X-Ray Diffraction at the Dust Division, Pittsburgh Laboratory.

Ventilation readings and instantaneous respirable dust concentration readings were taken during the investigation. The ventilation readings were taken in the duct in the Concentrator Building, Dry Cobber Building, Fine Crusher Building, and Car Dump Building in April. A Pitot-static tube and Magnehelic gauge were used for the pressure measurements. These pressure readings were used to calculate the airflow in the dust collector systems. Instantaneous respirable dust concentration readings were taken from the Concentrator Building in April and from the Fine Crusher and Dry Cobber Buildings in May. The Thermo MIE real-time dust monitor Model PDR-1000AN was used to obtain these instantaneous dust readings. Each area was checked 3 times during the shift.

Mine officials were interviewed on the respiratory protection program. A complete review of the respiratory protection program at the mine is given in Appendix A.

RESULTS AND DISCUSSION

Table 1 shows the results of the analysis from the area respirable dust and fiber samples collected throughout the mill during the April visit. For the respirable dust samples, concentration, percent quartz, and associated TLV are given. For the fiber samples, concentration and for those samples analyzed, percent asbestos and asbestos concentration are given. The highest concentrations of both respirable dust (0.410 mg/m^3) and fibers (0.059 fibers/cc) were in the tunnel discharging into the Dry Cobber Building. The highest percent quartz was in the Fine Crusher Building. The ratio of concentration to the respirable dust TLV ranged from:

- 0.85 to 1.31 in the Fine Crusher Building,
- 0.09 to 0.60 in the Dry Cobber Building, and
- 0.07 to 0.27 in the Concentrator Building.

These ratios are based on an 8-hour shift. For a 10-hour shift, the concentrations and ratios would be multiplied by 1.25. Due to the high quartz content of the dust and the high ratio of concentration to TLV, the company should consider establishing the Fine

Crusher Building and especially baghouse maintenance work as a respirator required area/occupation.

For the 3 samples analyzed for asbestos, the total percent asbestos, as defined by NIOSH Method 7402, ranged from 85% to 100%, giving asbestos concentrations of 0.036 to 0.051 fibers/cc. The fibers were identified as cummingtonite/gunerite, tremolite asbestos and actinolite asbestos.

Table 2 shows the results of the analysis from the area respirable dust and fiber samples collected throughout the mill during the May visit. The sample results show that the main source of both silica and fiber exposure for the baghouse maintenance worker was from inside the baghouse. The respirable dust concentration inside the baghouse had a TWA of 0.380 mg/m^3 with a TLV of 0.312 mg/m^3 (30% silica). The samples from Screen 2 and Screen 102 inside the Fine Crusher Building had TWA's of 0.111 mg/m^3 and 0.059 mg/m^3 with a TLV of 0.909 mg/m^3 (9% silica). The samples from the upper level west side center of the Dry Cobber Building and the upper level center under the feed belt of the Dry Cobber Building had TWA's of 0.185 mg/m^3 and 0.225 mg/m^3 with a TLV of 0.319 mg/m^3 (29.3% silica). The gravimetric samples, collected in the Fine Crusher Building and the Dry Cobber Building, were also used to calibrate the MiniRAM and to supplement the dust to fiber concentration comparison.

The TWA fiber concentration for the area fiber sample collected inside the baghouse during cleaning was 0.165 fibers/cc. For the area samples analyzed for asbestos, the percent asbestos was 90.8%, giving an asbestos concentration of 0.150 fibers/cc. The fibers were identified as cummingtonite/gunerite, tremolite asbestos and actinolite asbestos. The TWA fiber concentration for the area fiber sample collected in the upper level center of the Dry Cobber Building was 0.093 fibers/cc. The area sample analyzed for asbestos contained 89.4% asbestos, giving an asbestos concentration of 0.083 fibers/cc. The fibers were identified as cummingtonite/gunerite, tremolite asbestos and actinolite asbestos.

Figure 1 shows a microphotograph of a dust sample with particles identified as fibers at 400x and 6,600x magnification. Fibers are counted by PCM at 400x magnification. In PCM fiber counting, a particle with an aspect ratio greater than 3 to 1 with a length greater than 5 micrometers is counted as a fiber. In the upper portion of the figure, several fibers are visible within the circular graticule. The lower portion of the figure shows the magnification of an individual fiber. Complete TEM analysis, along with microphotographs, elemental composition, and diffraction patterns for the April samples are given in Appendix B.

During the May visit, the baghouse for Dust Collector 305 was cleaned. During baghouse cleaning, the maintenance worker works inside the baghouse for most of the shift. The baghouse is approximately 9 feet by 10 feet by 8.5 feet (765 cubic feet). The entrance is a 19.5 inch by 72 inch door. This cleaning took approximately 7 hours. Cleaning included vacuuming the inside of the baghouse, checking each of the 180 bags, and replacing damaged bags. During this servicing, 6 bags needed to be replaced. There was no exhaust ventilation provided for the worker while cleaning of the baghouse. The SWA fiber concentration for the maintenance worker was 0.275 fibers/cc. This SWA was determined from three consecutive samples collected on the worker: two while cleaning the baghouse and one after the cleaning was finished. The samples contained 99%, 100%, and 97% asbestos, respectively, giving an SWA asbestos concentration of 0.271 fibers/cc. The fibers were identified as cummingtonite/gunerite, tremolite asbestos and actinolite asbestos. The exposure from the time inside the baghouse was similar to the exposure during the time outside the baghouse. This would indicate that a secondary source of exposure was involved, probably the clothing worn by the maintenance worker.

Exhaust ventilation should be provided during baghouse cleaning to control worker exposure to mineral fibers and dust containing silica. A typical air exchange rate for a cab or booth is one air change per minute. Due to the nature of the dust, the company may wish to consider a higher air change rate. An 8-inch diameter pipe would carry 1,500 cfm at a velocity over 3,600 fpm. This pipe could be attached into an adjacent dust collector or directed through the wall with airflow induced by a fan.

Table 3 shows the results of the silica and asbestos analysis for the bulk samples collected in April 2005. Three samples were collected from the west end, mid section, and east end of the Babbitt Mine with the silica content ranging from 16.4% to 18.1% quartz. The samples from the Silver Bay Car Dump Mill and beneath the Crusher Mill resulted in 31.3% and 26.7% quartz, respectively. Asbestos was not found in any of the bulk samples except the old shingles from the mill. This sample contained 30% chrysotile not cummingtonite/grunerite, tremolite asbestos or actinolite asbestos. This indicates that the shingles were not the source for the asbestos in the mineral dust.

Table 4 shows the results of the silica and asbestos analysis for the bulk samples collected in May 2005. The settled dust samples collected from the upper level floor and the bottom of the cage from inside the baghouse of the Fine Crusher Building were 27.4% and 30.3% quartz, respectively. The samples from Dust Collector 121 and the hopper between Dust Collectors 120 and 121 of the Concentrator Building were 39.9% and 10.2% quartz, respectively. The samples from the lower level east side and Dust

Collector 318 east side of the Dry Cobber Building were 25.2% and 28.8% quartz, respectively. Except for the dust hopper in the Concentrator Building, the silica content of the bulk samples ranged from 25% to 40%. These values confirm the high silica content of the dust. Asbestos was not found in any of these bulk samples.

Figure 2 is a graph of the fiber concentration (fibers/cc) versus the respirable dust concentration (mg/m^3) from the April investigation. The graph indicates some variability; however, it shows a trend for an increase in fiber concentration with an increase in dust concentration. A linear regression through the data points gives the equation:

$$\textit{Fiber Concentration} = 0.099 \times \textit{Dust Concentration} + 0.008$$
$$\textit{with } r = 0.79$$

For the April sampling, this equation indicates that for a fiber concentration of 0.10 fibers/cc (assuming fibers are 100% asbestos) the corresponding respirable dust concentration would be 0.93 mg/m^3. The quartz concentration that would result in a 0.93 mg/m^3 TLV is 8.75%. The quartz content of the respirable dust sampled at the mine in April ranged from 12% to 38%. These quartz contents would result in a TLV ranging from 0.25 to 0.71 mg/m^3. For the April sampling, this analysis indicates that if dust concentrations are maintained below the quartz TLV, fiber concentrations should be below 0.1 fibers/cc.

Figure 3 is a graph of the fiber concentration (fibers/cc) versus the respirable dust concentration (mg/m^3) from the May investigation. A linear regression through the data points gives the equation:

$$\textit{Fiber Concentration} = 0.396 \times \textit{Dust Concentration} - 0.003$$
$$\textit{with } r = 0.91$$

For the May sampling, this equation indicates that for a fiber concentration of 0.10 fibers/cc (assuming fibers are 100% asbestos) the corresponding respirable dust concentration would be 0.26 mg/m^3. The quartz concentration that would result in a 0.26 mg/m^3 TLV is 36.46%. The quartz content of the respirable dust sampled at the mine in May was approximately 30%. This quartz contents would result in a TLV of 0.31 mg/m^3. For the limited data from the May sampling, the analysis indicates that if dust concentrations need to be controlled below the quartz TLV, to assure fiber concentrations below 0.1 fibers/cc.

These regressions indicate that the specific relationship between respirable dust and fiber concentration varies depending on the material being supplied to the plant. However, regardless of the material, the fiber concentration increased as the dust concentration increased.

The results of the average real-time instantaneous dust measurements taken in the Concentrator, Fine Crusher, and Dry Cobber Buildings are shown in Tables 5, 6, and 7. Each concentration represents the average of 3 measurements taken during the shift for each location. For the readings in each building, a factor was developed to convert the instantaneous measurements to gravimetric measurements. This factor was developed by dividing the associated gravimetric measurement by the average real-time measurements at the location. The average factors for the Concentrator, Fine Crusher, and Dry Cobber Buildings were 1.119, 0.623, and 1.293, respectively and are shown in Appendix C. The average factor for each building was used to create the average corrected real-time instantaneous dust measurements, which are shown in Tables 5a, 6a, and 7a.

Tables 5 and 5a show the results of the average and corrected average real-time dust measurements taken throughout the Concentrator Building from 29 different locations. The locations consisted of 4 levels (Feed to Rod Mill, between Ball Mills, between the Primary and Secondary Magnetic Separator, and under Regrind Mill) and 7 production lines (103 through 109). Also, a measurement was obtained from the shed on the Feed to Rod Mill level. The corrected average concentrations ranged from 0.063 mg/m^3 (between the Primary and Secondary Magnetic Separators for 107 and 108) to 0.151 mg/m^3 (Feed to Rod Mill 104). The corrected average concentrations from production lines 103 through 109 ranged from 0.072 mg/m^3 (production line 109) to 0.116 mg/m^3 (production line 106). Production line 106 had been down for maintenance the entire sampling day. The corrected average concentration from the shed on the Feed to Rod Mill level was 0.119 mg/m^3. The corrected average concentrations from the 4 different levels ranged from 0.076 mg/m^3 (between the Primary and Secondary Magnetic Separator) to 0.109 mg/m^3 (Feed to Rod Mill). The corrected average concentration from all 3 measurements at the 29 locations was 0.096 mg/m^3. The sample results showed that there were no "hot spots" in the building. All measurements were fairly consistent, with the highest area being around the Feed to Rod Mill 106.

Tables 6 and 6a show the results of the average and corrected average real-time dust measurements taken throughout the Fine Crusher Building from 35 different locations. The locations consisted of 5 levels (top, screen, crusher, below crusher, and bottom floors) and 7 areas starting from the west to east side of the building (West 3, 2, 1;

elevator; and East 101, 102, 103). The corrected average concentrations ranged from 0.031 mg/m^3 (elevator, bottom floor) to 0.115 mg/m^3 (West 2, crusher floor). The corrected average concentrations from the 5 levels ranged from 0.044 mg/m^3 (bottom floor) to 0.084 mg/m^3 (screen floor). The corrected average concentrations from the 7 areas from across the building ranged from 0.061 mg/m^3 (East 103) to 0.083 mg/m^3 (West 2). The corrected average concentration from all 3 measurements at the 35 locations was 0.071 mg/m^3. All measurements were consistent throughout the building.

Tables 7 and 7a shows the results of the average and corrected average real-time dust measurements taken throughout the Dry Cobber Building from 15 different locations. The locations consisted of 3 levels (dust collector, upper, and bottom floors) and 5 areas starting from the west to east side of the building (West 1, 2; Center 3; and East 4, 5). The corrected average concentrations ranged from 0.076 mg/m^3 (East 4, bottom floor) to 0.518 mg/m^3 (East 4, dust collector floor). The corrected average concentrations from the 3 levels ranged from 0.175 mg/m^3 (bottom floor) to 0.350 mg/m^3 (dust collector floor). The corrected average concentrations from the 5 areas from across the building ranged from 0.192 mg/m^3 (Center 3) to 0.307 mg/m^3 (West 2). The corrected average concentration from all 3 measurements at the 15 locations was 0.239 mg/m^3. Measurements in the Dry Cobber Building were higher than measurements from the Concentrator and Fine Crusher Buildings with the highest area measurement found around East 4 on the dust collector floor.

Table 8 shows a summary of the results of the airflow measurements taken on the dust collection systems in the various mill buildings. The table shows the total airflow for each of the dust collector systems measured, the number of similar dust collector systems in the building, the approximate total airflows for all those systems, and the total approximate airflow for each of the 4 buildings.

The dust collection systems appeared to be effective in capturing and transporting respirable dust to the dust collectors. Hoods and pickups were properly installed around dust generation points. The dust collectors were located on the top floors of each building. As a result, many of the main ducts into the dust collectors were vertical. Because the ducts were vertical, clogging was not observed, even with transport velocities around 2,500 fpm, which is about 1,000 fpm below that recommended by the ACGIH. Most transport velocities were around 2,500 fpm.

Table 9 shows the hourly airflow exchange rate for each of the 4 mill buildings. The airflow exchange rate was calculated by dividing the hourly airflow by the building volume:

$$Airflow\ Exchange\ Rate\left(\frac{changes}{hour}\right) = \frac{Airflow\ (cfm) \times 60\ \frac{minutes}{hour}}{Building\ Volume\ (cf)}$$

NIOSH recommends that in a mill the air exchange rate should be approximately 10 air changes per hour. This value may need to be increased when the dust has a high silica content or can be decreased when an effective exhaust ventilation system is in place. The air exchange rates were 0.6 for the Concentrator Building, 3.2 for the Dry Cobber Building, 1.9 for the Fine Crusher Building, and 7.7 for the Car Dump Building. While all of the dust collection systems appeared to be effective, due to the high silica content of the dust in the Fine Crusher Building, consideration should be given to increase the airflow exchange rate in this building. During the April visit, none of the roof fans were in operation. During the May visit, roof fans in the Fine Crusher Building were operating and roof fans in the Dry Cobber Building were not operating. Operation of the roof fans increases the general mill ventilation and dilutes the dust generation.

Accumulations of settled fugitive dust were observed on all flat surfaces within the various processing buildings. Due to the amount of accumulated dust, it is difficult to isolate any one source. Overall cleanup of the building is recommended. Any method of cleanup that re-entrains dust into the air, such as brooms and shovels/dust pans, should be avoided. Dust collection systems are located near all of the primary dust generating areas of this facility and there are numerous commercially available vacuum systems, which can be interfaced with these dust collectors. These vacuum systems could make routine cleanup of settled dust relatively easy, quick, and efficient.

CONCLUSIONS AND RECOMMENDATIONS

1. Results of the survey indicate that if dust concentrations are maintained below the quartz TLV, fiber concentrations should be below 0.1 fibers/cc.

2. A local exhaust or dilution ventilation system should be utilized to control dust and fibers inside the baghouse during cleaning operations.

3. The coveralls of maintenance workers who clean baghouses should be laundered daily and changed after the cleaning operation is completed to avoid a secondary source of dust and fiber exposure.

4. The total airflow exhausted from the Fine Crusher Building should be increased to provide 10 air changes per hour.

5. Due to the high silica content of the dust, consideration should be given to establishing the Fine Crusher Building and baghouses as respiratory required areas.

6. The practice of housekeeping using brooms and shovel/dust pans should be stopped. Vacuum systems, similar to that used to clean the inside of the baghouse, should be installed throughout the mill. Vacuum systems avoid the re-entrainment of dust during cleanup operations.

7. Recommendations relative to deficiencies and inconsistencies in the company's Respiratory Protection Plan are discussed in Appendix B.

Table 1. Results of Respirable Dust Analysis, Average Percent Silica, and Fiber Sample Analysis, April 26-27, 2005.

Location	Dust Conc. TWA (mg/m³)	Percent Silica (%)	TLV (mg/m³)	Fiber Conc. (fibers/cc)	Percent Asbestos (%)	Asbestos Fiber Conc. (fibers/cc)
Fine Crusher Building						
Upper Level	0.307	37.63	0.252	---		
Screen Level	0.331	37.63	0.252	0.036	100.0	.036
Crusher Level	0.215	37.63	0.252	---		
Below Crusher	0.243	37.63	0.252	0.030		
Bottom Floor	0.237	37.63	0.252	0.021		
West Plant Dry Cobber Building						
Tunnel Discharge	0.410	12.13	0.708	0.059	87.0	0.051
Upper Level Center	0.331	16.19	0.550	0.039	97.9	0.038
Upper Level West	0.145	16.19	0.550	0.032		
Lower Level West	0.166	16.19	0.550	0.039		
Lower Level Center	0.052	16.19	0.550	0.010		
Concentrator Building						
Feed at 103	0.088	12.21	0.704	0.012		
Shed at 106	0.130	12.21	0.704	---		
Feed at 106	0.190	12.21	0.704	0.009		
Feed at 109	0.101	12.21	0.704	---		
Ball Mills 109	0.079	12.21	0.704	---		
Ball Mills 106	0.062	12.21	0.704	---		
Ball Mills 103	0.092	12.21	0.704	---		
Separators 103	0.053	12.21	0.704	---		
Separators 106	0.052	12.21	0.704	0.018		
Separators 109	0.071	12.21	0.704	---		
Regrind at 106	0.073	12.21	0.704	0.017		

Note: For a 10-hour shift the above concentrations would be multiplied by approximately 1.25.

Table 2. Results of Respirable Dust Analysis, Average Percent Silica, and Fiber Sample Analysis, May 24-25, 2005.

Location	Dust Conc. TWA (mg/m³)	Percent Silica (%)	TLV (mg/m³)	Fiber Conc. (fibers/cc)	Percent Asbestos (%)	Asbestos Fiber Conc. (fibers/cc)
Fine Crusher Building						
Screen 102	0.059	9.0	0.909	0.016		
Screen 2	0.111	9.0	0.909	0.021		
Inside Dust Collector 305 Baghouse	0.380	30.0	0.312	0.165	90	0.15
Maintenance Worker Full Shift Personal **	--	--	--	0.275	98	0.27
West Plant Dry Cobber Building						
Upper Level West Side Center	0.185	29.3	0.319	0.093	89	0.08
Upper Level Center Under Belt Feed	0.225	29.3	0.319	0.048		
Car Dump Facility						
Inside Control Room	0.000	---	---	0.018		

Note: For a 10-hour shift the above concentrations would be multiplied by approximately 1.25.

** Shift Weighted Average (SWA)

Table 3. Results of Bulk Sample Silica and Fiber Analysis, April 26-27, 2005.

Sample Number	Location	Silica Content % Quartz	Fiber Content % Asbestos
1	West End Mine	18.1	ND
2	Mid Section Mine	17.7	ND
3	East End Mine	16.4	ND
4	Car Dump Mill	31.3	ND
5	Beneath the Crusher Mill	26.7	ND
6	Spray-on Insulation Mill	---	ND
7	Old Shingles Mill	---	30*

ND - not detected above detection limit.
* 30% chrysotile

Table 4. Results of Bulk Sample Silica and Fiber Analysis, May 24-25, 2005.

Sample Number	Location	Silica Content % Quartz	Fiber Content % Asbestos
1	Inside Baghouse (Fine Crusher Building)	27.4	ND
2	Bottom of Cage from Inside Baghouse (Fine Crusher Building)	30.3	ND
3	Dust Collector 121 (Concentrator Building)	39.9	ND
4	Hopper Between Dust Collectors 120 and 121 (Concentrator Building)	10.2	ND
5	Lower Level East Side (Dry Cobber Building)	25.2	ND
6	Dust Collector 318 East Side (Dry Cobber Building)	28.8	ND

ND - not detected above detection limit.

Table 5. Average Real-Time Sample Results in Concentrator Building on 4/26/05.

Location	Concentration (mg/m³)				
	Feed to Rod Mill	**Between Ball Mills**	**Between Primary & Secondary Magnetic Separator**	**Under Regrind Mill**	**Average**
Shed	0.106	---	---	---	0.106
103	0.085	0.085	0.052	0.102	0.081
104	0.135	0.099	0.062	0.099	0.099
105	0.104	0.094	0.096	0.077	0.093
106	0.131	0.088	0.079	0.116	0.104
107	0.089	0.102	0.056	0.092	0.085
108	0.066	0.075	0.056	0.076	0.068
109	0.061	0.062	0.077	0.057	0.064
Average	0.097	0.086	0.068	0.088	0.085

Table 5a. Corrected Average Real-Time Sample Results in Concentrator Building on 4/26/05, MiniRam Factor - 1.119.

Location	Concentration (mg/m³)				
	Feed to Rod Mill	**Between Ball Mills**	**Between Primary & Secondary Magnetic Separator**	**Under Regrind Mill**	**Average**
Shed	0.119	---	---	---	0.119
103	0.095	0.095	0.058	0.114	0.091
104	0.151	0.111	0.069	0.111	0.111
105	0.116	0.105	0.107	0.086	0.104
106	0.147	0.098	0.088	0.130	0.116
107	0.100	0.114	0.063	0.103	0.095
108	0.074	0.084	0.063	0.085	0.077
109	0.068	0.069	0.086	0.064	0.072
Average	0.109	0.097	0.076	0.099	0.096

Table 6. Average Real-Time Sample Results in Fine Crusher Building on 5/24/05.

Location	Concentration (mg/m³) West Side			Center		East Side		Average
	3	2	1	Elevator	101	102	103	
Top Floor	0.107	0.150	0.180	0.153	0.092	0.115	0.101	0.128
Screen Floor	0.127	0.145	0.138	0.162	0.140	0.123	0.112	0.135
Crusher Floor	0.136	0.184	0.130	0.116	0.115	0.088	0.094	0.123
Below Crusher Floor	0.108	0.122	0.105	0.111	0.091	0.114	0.115	0.109
Bottom Floor	0.095	0.067	0.061	0.049	0.081	0.070	0.066	0.070
Average	0.115	0.134	0.123	0.118	0.104	0.102	0.098	0.113

Table 6a. Corrected Average Real-Time Sample Results in Fine Crusher Building on 5/24/05, MiniRam Factor - 0.623.

Location	Concentration (mg/m³) West Side			Center		East Side		Average
	3	2	1	Elevator	101	102	103	
Top Floor	0.067	0.093	0.112	0.095	0.057	0.072	0.063	0.080
Screen Floor	0.079	0.090	0.086	0.101	0.087	0.077	0.070	0.084
Crusher Floor	0.085	0.115	0.081	0.072	0.072	0.055	0.059	0.077
Below Crusher Floor	0.067	0.076	0.065	0.069	0.057	0.071	0.072	0.068
Bottom Floor	0.059	0.042	0.038	0.031	0.050	0.044	0.041	0.044
Average	0.071	0.083	0.076	0.074	0.065	0.064	0.061	0.071

Table 7. Average Real-Time Sample Results in Dry Cobber Building on 5/25/05.

Location	Concentration (mg/m³)					
	West Side		Center	East Side		Average
	1	2	3	4	5	
Dust Collector Floor	0.201	0.261	0.213	0.401	0.277	0.271
Upper Floor	0.140	0.210	0.132	0.149	0.111	0.148
Bottom Floor	0.208	0.242	0.100	0.059	0.068	0.135
Average	0.183	0.238	0.148	0.203	0.152	0.185

Table 7a. Corrected Average Real-Time Sample Results in Dry Cobber Building on 5/25/05, MiniRam Factor - 1.293.

Location	Concentration (mg/m³)					
	West Side		Center	East Side		Average
	1	2	3	4	5	
Dust Collector Floor	0.260	0.337	0.275	0.518	0.358	0.350
Upper Floor	0.181	0.272	0.171	0.193	0.144	0.192
Bottom Floor	0.269	0.313	0.129	0.076	0.088	0.175
Average	0.237	0.307	0.192	0.262	0.197	0.239

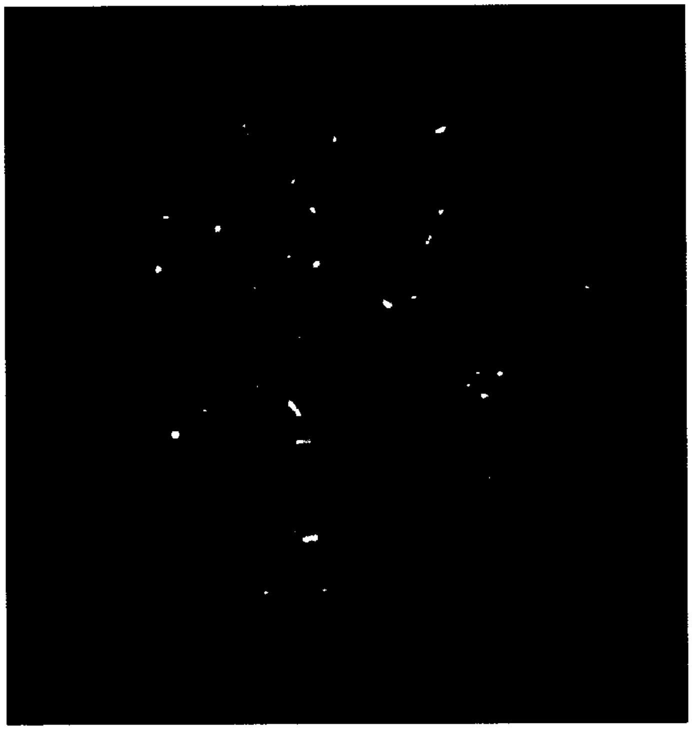
Table 8. Dust Collector Airflow Measurement Results.

Location	Airflow (cfm)	Number of Similar Dust Collectors	Total Airflow (cfm)
Car Dump Building			
East and West	34,500	2	69,000
Building Total			69,000
Fine Crusher Building			
305-307, 310-312	15,000	6	90,000
308 & 309	28,000	2	56,000
Building Total			146,000
Dry Cobber Building			
West Plant DC 1	59,900	2	119,800
West Plant DC 2	36,800	2	73,600
Center Belt DC	31,600	1	31,600
Building Total			225,000
Concentrator Building			
New Feed Belt DC	17,800	1	17,800
Old Feed Belt DC	12,000	9	108,000
Building Total			125,800

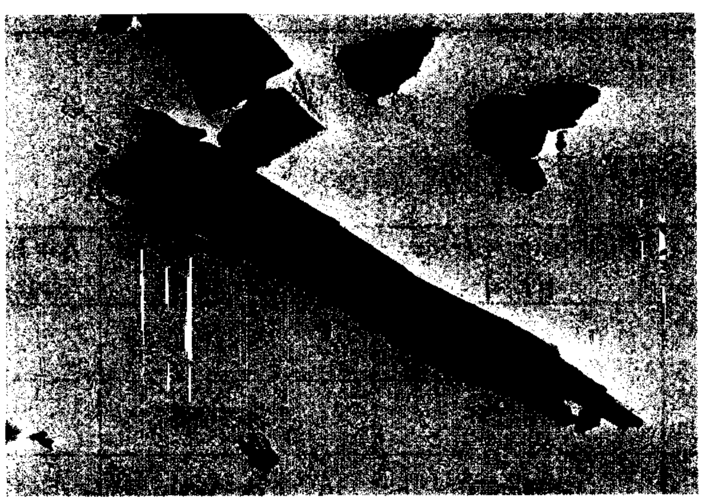
Table 9. Building Air Exchange Rate.

Location	Building Airflow (cfm)	Building Volume (cubic feet)	Air Exchange Rate (air changes/hr)
Car Dump Building	69,000	535,000	7.7
Fine Crusher Building	146,000	4,563,000	1.9
Dry Cobber Building	225,000	4,185,000	3.2
Concentrator Building	125,800	12,096,000	0.6

Figure 1. Microphotographs of Dust Samples.



400x magnification



6,600x magnification

Figure 2. Graph of Fiber Concentration versus Dust Concentration with Regression Analysis for April 26-27, 2005.

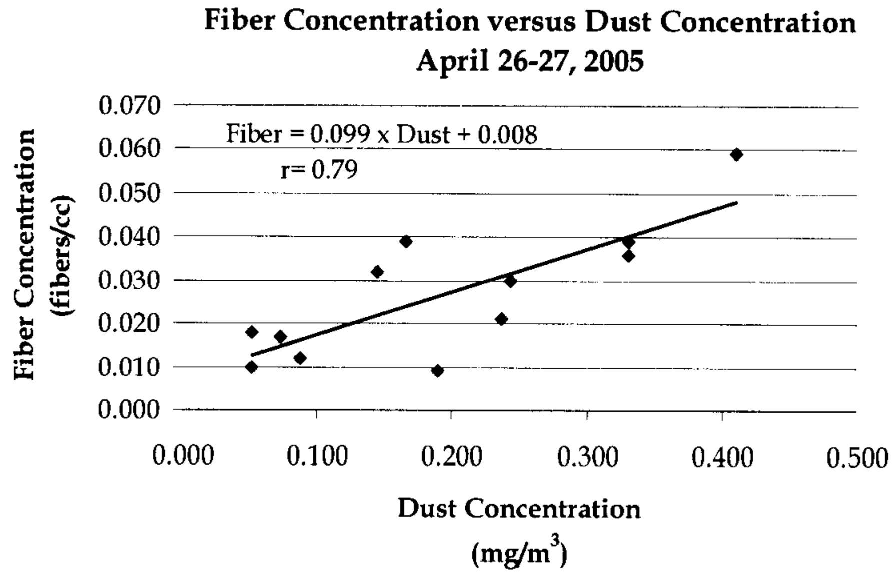
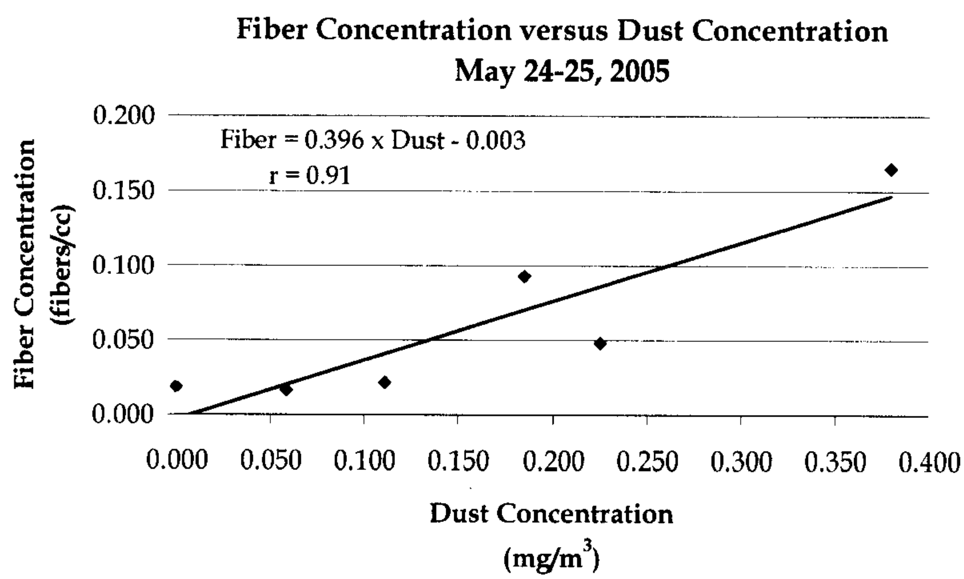


Figure 3. Graph of Fiber Concentration versus Dust Concentration with Regression Analysis for May 24-25, 2005.



Appendix A. Review of Respiratory Protection Program at Northshore Mining Company's Silver Bay Operations.

Northshore Mining Company Respiratory Protection Policy:

The Northshore Mining Company taconite processing plant at Silver Bay, MN (Mine I.D. No. 21 00831) has a written "Respiratory Protection Policy" dated May 11, 2004. This policy assigns responsibilities and establishes general guidelines for the selection and use of respirators at this facility. The policy does not address fit testing, inspection, cleaning, maintenance, or storage of respirators, training of respirator users, surveillance of the work area where respirators are being worn, or oversight or periodic evaluation of the respiratory protection program. These requirements are listed in ANSI Z88.2-1969 Practices for Respiratory Protection, which is referenced in 30CFR57.5005, and which MSHA follows for determining acceptability of a respiratory protection program when such a program is required.

Respirator training is covered in Part 48 training at Northshore for new miners and newly hired experienced miners, and during annual refresher training and task training. Thus, employees do receive appropriate training on respiratory protection even though the written respiratory protection policy does not address training. ANSI Z88.2-1969 specifies that responsibility for administering the respiratory protection program shall be vested in one individual, however, at Northshore Mining Company, program administration responsibilities are shared between the safety and human resources departments.

The Northshore written policy does not address medical evaluation of employees who wear respirators, lung function testing (spirometry), and medical clearance for respirator use, although the company does regular medical screening of employees (every 3 years).

Northshore Mining Company has not established any mandatory respirator use areas or jobs at the Silver Bay facility. Employees may wear their company-issued respirator if they wish, on a purely voluntary basis. The subject respiratory protection policy includes an Appendix that identifies 16 areas at the Silver Bay facility where respirator usage is recommended. However, respirator usage in these areas is not mandatory, and these areas are not posted as respirator required areas.

MSHA Observations Regarding Policy and Usage of Respiratory Protection:

The MSA Advantage 200 respirator, along with the 3M Model 8110 respirator, are the only respirators specified in the Northshore Mining Company Respiratory Protection

Policy that are approved by the company. Reference to the 3M Model 8110 respirator is problematic because there is no current NIOSH approval for a 3M Model 8110 respirator, and the 3M internet website does not contain any reference to a 3M Model 8110 respirator in current production. NIOSH approvals and product references were located for 3M Model 8210 and 3M Model 8110S respirators which are both N-95 disposable particulate respirators, and boxes of 3M 8210 respirators were observed at various locations throughout the plant. The 3M Model 8110S respirator is almost identical to the 3M Model 8210 respirator, but intended for smaller faces. Thus, it is suspected that the reference to the 3M Model 8110 respirator in the subject policy is erroneous, and that the policy should have referenced 3M Model 8210 and 3M Model 8110S respirators.

The Northshore respiratory protection policy includes the statement, "The 8710 3M-dust mask is an optional protection against certain 'nuisance dust.'" However, the 3M Model 8710 respirator (also a disposable particulate respirator) has been off the market since 1998. It is suspected that reference to the 3M Model 8710 respirator is also erroneous, and that this reference should also have been to the 3M Model 8210 (or Model 8110S) respirator.

Although not identified in the subject policy as a company approved respirator, Moldex 2200 and 3M Model 8511 formed face-piece disposable particulate respirators were also observed at Northshore Mining Company. The 3M Model 8210 and 8511 respirators, and the Moldex 2200 respirator observed at the Northshore facility are NIOSH approved N-95 disposable particulate respirators that do not provide protection against asbestos fiber exposure.

Northshore Mining Company adopted the MSA Advantage 200 cartridge-type half-mask respirator as the company standard issue respirator in 1998. All existing employees were fit tested on the MSA Advantage 200 respirator at that time, and all new employees are fit tested on this respirator at the time they are hired. The MSA Advantage 200 respirator, when fitted with a P100 cartridge, is approved by NIOSH for protection against all dusts and fumes, including asbestos fibers. The NIOSH assigned protection factor (APF) for half-mask respirators is 10, meaning that a properly fitted and trained user should be protected if exposed to dust or fume concentrations exceeding the applicable TLV by a factor of 10 times.

The fit-test protocol practiced by Northshore involves the subject donning the respirator and performing various exercises while being exposed to bitrex® mist. This fit test protocol is followed for MSA Advantage 200 respirators, but not for the 3M 8210 respirators.

As noted above, the Northshore written policy does not address medical evaluation of employees who wear respirators, lung function testing, or medical clearance for respirator use. The issue of medical limitations for persons assigned to tasks requiring use of respirators is addressed in ANSI Z88.2-1969 in the form of recommendations. Therefore, coverage of medical limitations for respirator users is recommended, but not required by MSHA to be included in a minimally acceptable respiratory protection program.

For all areas where respiratory protection is recommended, the recommended respirator is specified as either the MSA Advantage 200 or the 3M Model 8110. The company policy gives employees the option of using either respirator. As noted above, reference to the 3M Model 8110 is probably erroneous, and the actual reference should be to the 3M Model 8210 or 3M Model 8110S.

These recommendations seem to contradict the statement in the policy that, "The 8710 3M-dust mask is an optional protection against certain 'nuisance dust.'" Although this statement is ambiguous, it suggests that use of N-95 disposable particulate filter respirators should be limited to areas where the airborne contaminant is "nuisance dust." The airborne contaminants that are associated with the 16 areas listed in Appendix A include silica, mineral fibers, respirable dust, acid gases, and metal fumes, but not "nuisance dust." Thus, in one section, the policy appears to recommend that N-95 disposable respirator use be limited to protection against "nuisance dust," but in another section, the policy appears to allow use of N-95 disposable respirators for protection against silica, mineral fibers, respirable dust, acid gases, and metal fumes. At the very least, the policy must exclude N-95 disposable particulate respirators for protection against mineral fibers, acid gases, or metal fumes.

Operations were observed in the Concentrator, Dry Cobber, Fine Crusher, and Car Dump Buildings, which were all listed in Appendix A of the Northshore Mining Company Respiratory Protection Policy as being respirator recommended areas. Despite obviously dusty conditions, especially in the Dry Cobber Building, no workers were wearing respirators during the two days that operations were observed (except the baghouse attendant who wore a respirator when she pulled two bags - - see below). As noted earlier, boxes of 3M Model 8210 disposable respirators were observed stashed throughout the facility, and used respirators were seen in garbage cans. But no workers were actually observed wearing them (with the exception of the baghouse attendant referenced above). A few workers were randomly polled regarding their respiratory training and knowledge of proper respirator usage. Everyone recalled their respiratory protection training, had a basic understanding of respiratory hazards, and knew how to don and use their respirator. They said they wore their respirators when it got real dusty.

As noted above, a baghouse attendant demonstrated the procedure for checking the condition of dust collector bags in the Fine Crusher. She worked inside the baghouse (clean side) without wearing a respirator until she actually changed a bag. She donned her respirator while pulling the bag and placing it in a garbage bag for disposal. Once the dust collector bag was placed in the garbage bag, she removed her respirator. She said this was her normal procedure when working inside a baghouse.

MSHA Recommendations:

1. Update and expand respiratory protection policy to include fit testing protocol, periodic respirator inspections, and cleaning, maintenance, and storage of respirators. Also, address training of respirator users, even if simply referring to Part 48 training plan. Also, include surveillance of the work area where respirators are being worn, and oversight or periodic evaluation of the respiratory protection program. A single person or position also needs to be identified as the program administrator, and there should be a reference to the company's medical evaluation program as it relates to lung function testing and an employee's suitability to wear a non-powered, tight-fitting, half-mask, air purifying negative pressure respirator.

2. The respiratory protection needs to be corrected for apparent errors in current policy with respect to the 3M respirator models approved by the Company. As noted above, the current references to 3M Model 8110 and 8710 respirators are probably erroneous.

3. The respiratory protection needs to address the apparent usage of respirators that are not approved by the Company - namely, the Moldex 2200 and 3M Model 8511 respirators. If continued usage of these respirators is desired, they need to be included in the respiratory protection policy and program, along with corresponding training requirements, fit testing, etc.

4. It is clear that the policy of voluntary use of respirators in the 16 respirator recommended areas has not resulted in widespread respirator use among workers in these areas. If the company desires to protect workers from potential overexposures, respirator use should be mandatory where the potential for overexposures exists. The respiratory protection policy should therefore include specific guidance on when and where respirator usage is required. As a rule of thumb, personal protective equipment (PPE) is usually recommended when exposures reach or exceed ½ of the applicable threshold limit value (TLV). To identify areas where contaminant concentration could reach or exceed ½ of the TLV, the company should conduct systematic area sampling over multiple work shifts in all parts of the facility subject to such exposure hazards. Areas should then be posted for mandatory respirator usage wherever this sampling indicates the potential for contaminant concentration to reach ½ of the applicable TLV. Respirator use can continue to be recommended in other areas where the potential for overexposure is less. However, in high risk areas, respirator usage should be mandatory. Employees need to be instructed where respirator usage is mandatory, and the company needs to enforce this policy.

5. Regarding the question of asbestos fiber exposures, the prudent and conservative approach that errs on the side of employee safety would be to protect against the potential hazard of asbestos fiber exposure until conclusive evidence is presented establishing that no hazard exists. At present, Northshore Mining Company is disputing whether the fibrous particles at the Northshore plant are a regulated form of asbestos. However, company officials concede that the particles in question satisfy MSHA's definition of asbestos fibers in terms of mineralogy, particle size, and particle shape, and the company can offer no evidence to suggest that these fibrous particles are nontoxic. Therefore, they should be considered as hazardous, and recognized as such in the respiratory protection program. At the present time, MSHA's asbestos exposure standard of 2 fibers/cc has not been exceeded at Northshore. Thus, respiratory protection for potentially affected workers cannot be mandated by MSHA. However, in light of numerous full shift personal sample results that indicate asbestos fiber exposures exceeding the OSHA personal exposure limit (TLV) of 0.1 fibers/cc, good industrial hygiene practice dictates that respiratory protection for affected workers be required by the company until engineering controls can be implemented to consistently reduce exposures.

6. Need to address apparent contradiction regarding N-95 disposable respirator usage. One section of the current policy appears to limit such usage to "nuisance dust" exposures, while the Appendix suggests that they are allowed for protection against silica, mineral fibers, respirable dust, acid gases, and metal fumes in the 16 recommended respirator usage areas. At the very least, N-95 disposable particulate respirators cannot be approved for protection against exposure to mineral fibers, acid gases, or metal fumes because they are not "nuisance dusts".

7. In the current policy, the reader is advised that the "appropriate cartridge" is required for protection against specified airborne hazards. Since the reader's knowledge regarding respirator cartridge selection is unknown and could be quite limited, it would be helpful to list the appropriate cartridge for a variety of common airborne hazards, such as silica (quartz) dust, mineral fibers, acid gases, metal fumes, etc.

8. In the Appendix, not sure what is meant by "respirable mine dust." Normally, MSHA samples for crystalline silica bearing respirable dust. If crystalline silica bearing respirable dust is not believed to be present, MSHA samples for undifferentiated "total dust," which is sometimes also referred to as "nuisance dust" or "particulates not otherwise classified (PNOC)." When sampling for "total dust," MSHA does not include a cyclone in the sampling train to remove non-respirable sized dust particles. Should item 2 in the Appendix refer to "total dust," "nuisance dust," or a similar term?

Appendix B

TEM Analysis Northshore Mining

Micrographs, Elemental Composition, and Diffraction Patterns

Report from

Reservoirs Environmental, Inc.

Reservoirs Environmental, Inc.

2059 Bryant St. Denver, CO 80211
(303) 964-1986 Fax (303) 477-4275 Toll Free (866) RESI-ENV

September 14. 2005

Mr. Mark Weslowski
US Dept of Labor. MSHA
626 Cochrans Mill Road. Building 166
Pittsburgh PA 15236

RE: RES 115494R Micrographs

Dear Mr. Weslowski,

This report has been revised to correct and clarify fiber identifications in the micrograph captions. The fiber numbers are correlated to the hand written laboratory bench sheets.

Reservoirs Environmental, Inc. has collected the following micrographs to document the debris and fibers detected during transmission electron microscopy of the samples in RES Job Number 115494. Many energy dispersive spectra are also included to indicate the composition of the fibers. Fibers were counted based on a 3:1 aspect ratio and identified based on the morphology, random axis diffraction pattern and elemental composition of the fiber. No attempt was made to differentiate fibers from cleavage fragments.

Many of the fibers in these samples were more "fractured" in appearance but fulfilled the 3:1 aspect ratio. This is illustrated in the micrographs. The amphibole fibers in these samples were from the cummingtonite/grunerite and the tremolite/actinolite solid solution series. High iron content, the presence of manganese as well as variable calcium content was observed in some of the fibers. Discussions with Greg Meeker of the USGS indicated chemical variations observed could be from crystal intergrowths within the amphibole fiber or contribution from particles adhering to the fiber surfaces. Fibers were not excluded based on peak heights alone. Comprehensive identification of each individual amphibole fiber by zone axis diffraction and quantitative EDS was not part of this investigation.

If you have any questions about the attached micrographs or spectra, please call me at 303-964-1986.

Sincerely,

Jeanne S. Orr
President

Attachments

Heavy debris were on Sample 2005039315-16 – EM 962215

962215 50523

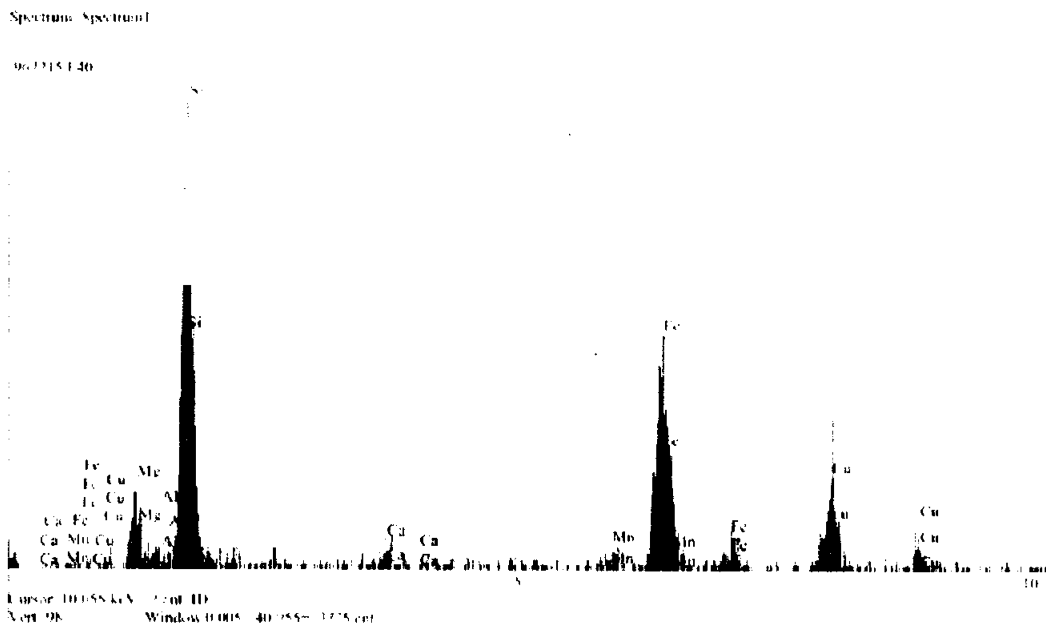
Debris 1600X Magnification

962215 50724

Debris and Fibers 2600X Magnification
Approximate Dimensions:
F40 10.1um x 1.3um
F41 15.7um x 2.2um
F42 9.5um x 2.2um

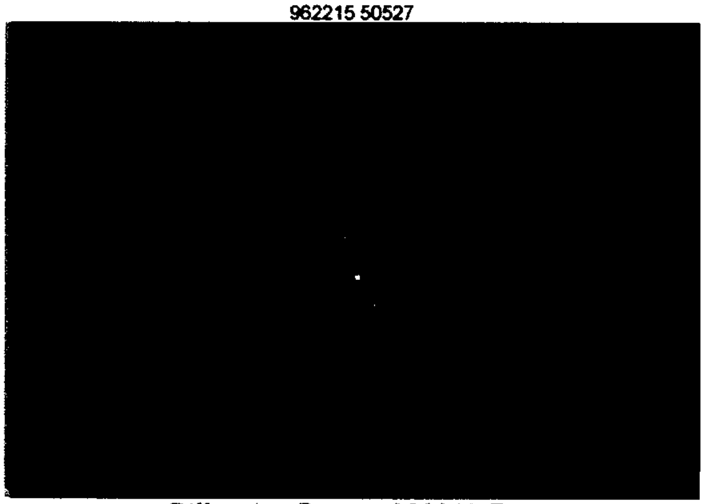
Individual Fibers were identified by morphology (previous micrograph), diffraction pattern and elemental composition. Fibers 962215 – F40, F41, and F42 are documented below.

962215 50723

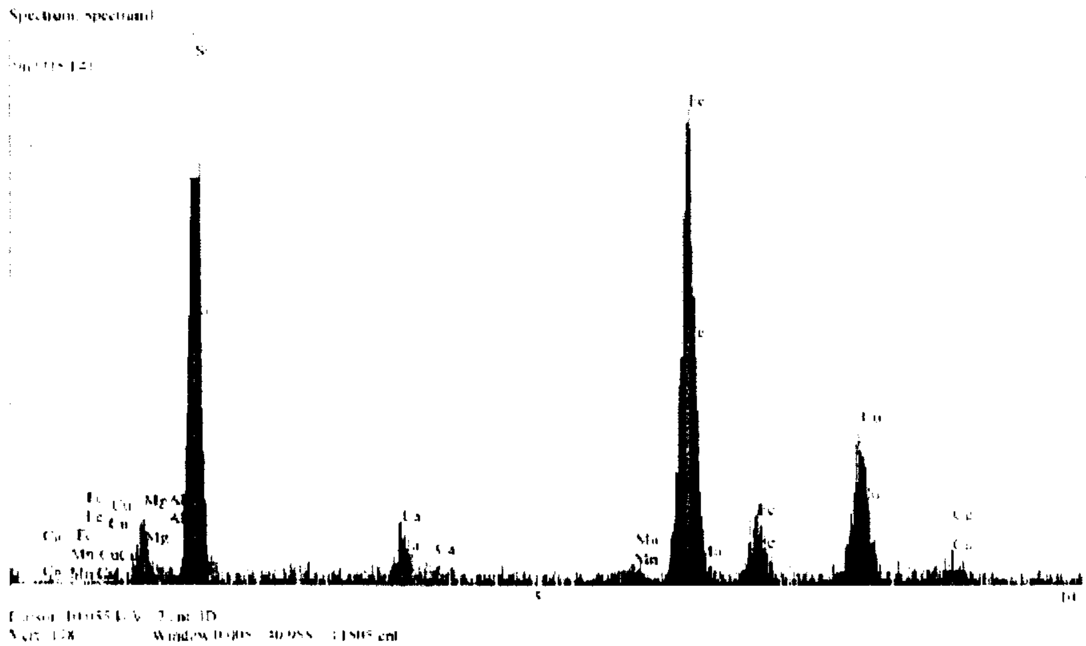


Elemental Spectra for 962215 F40

962215 50527

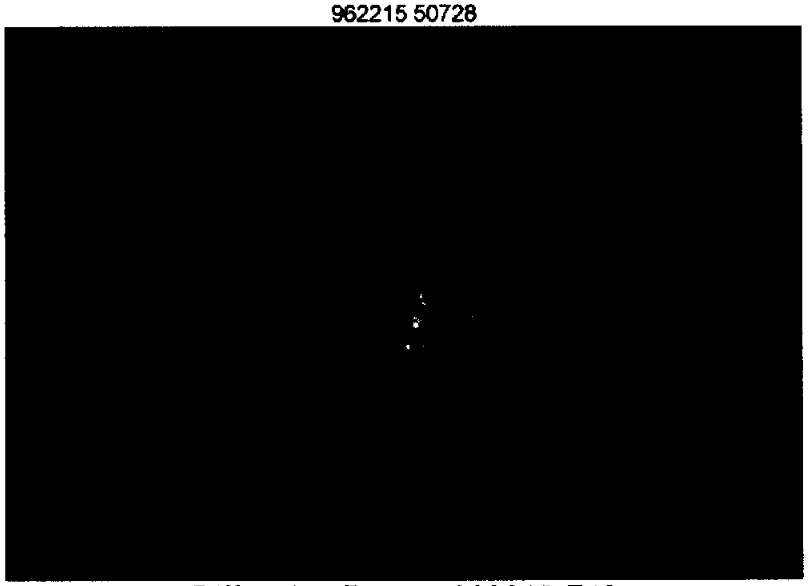


Diffraction Pattern 962215 F41

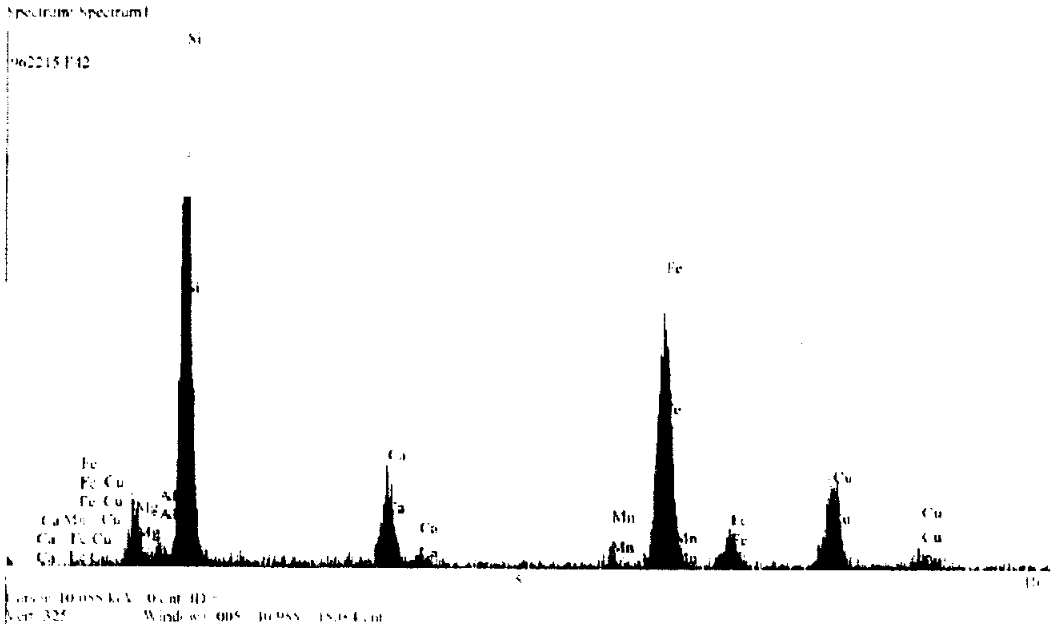


Elemental Spectra 962215 F41

962215 50728



Diffraction Pattern 962215 F42

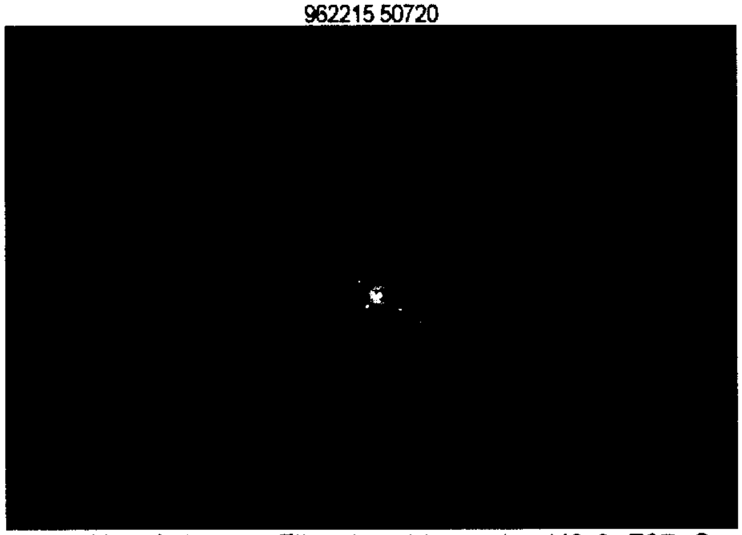


Elemental Spectra 962215 F42

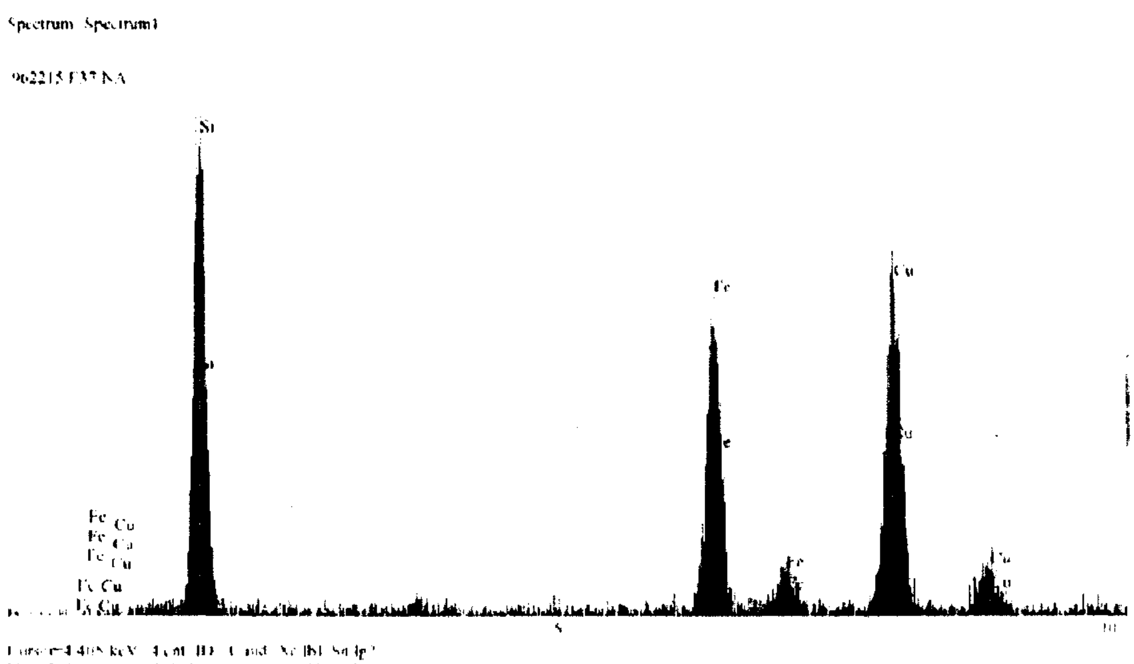
962215 50719

Non Asbestos Fiber in grid opening H2-6, F37 Magnification 10,000X
Approximate Dimensions
6.7um x1.1um

962215 50720



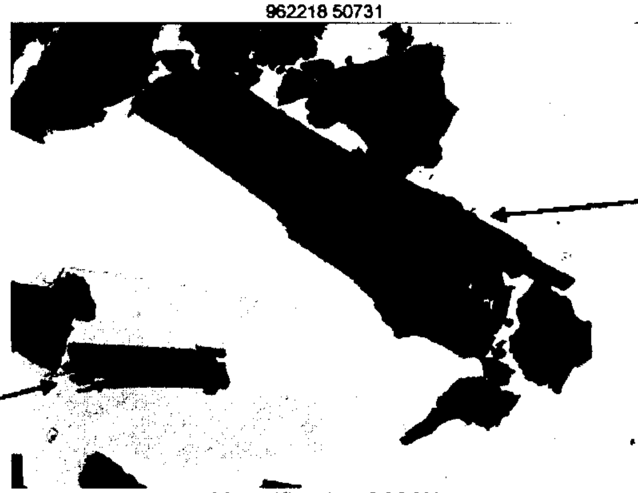
Diffraction Pattern Non Asbestos Fiber in grid opening H2-6, F37, Sample 962215



Spectra from Non-Asbestos fiber in grid opening H2-6, F37, Sample 962215

2005039319-17 (962218) and 2005039335-52 (962230) Fibers had similar morphology and composition to the previous sample.

962218 50731



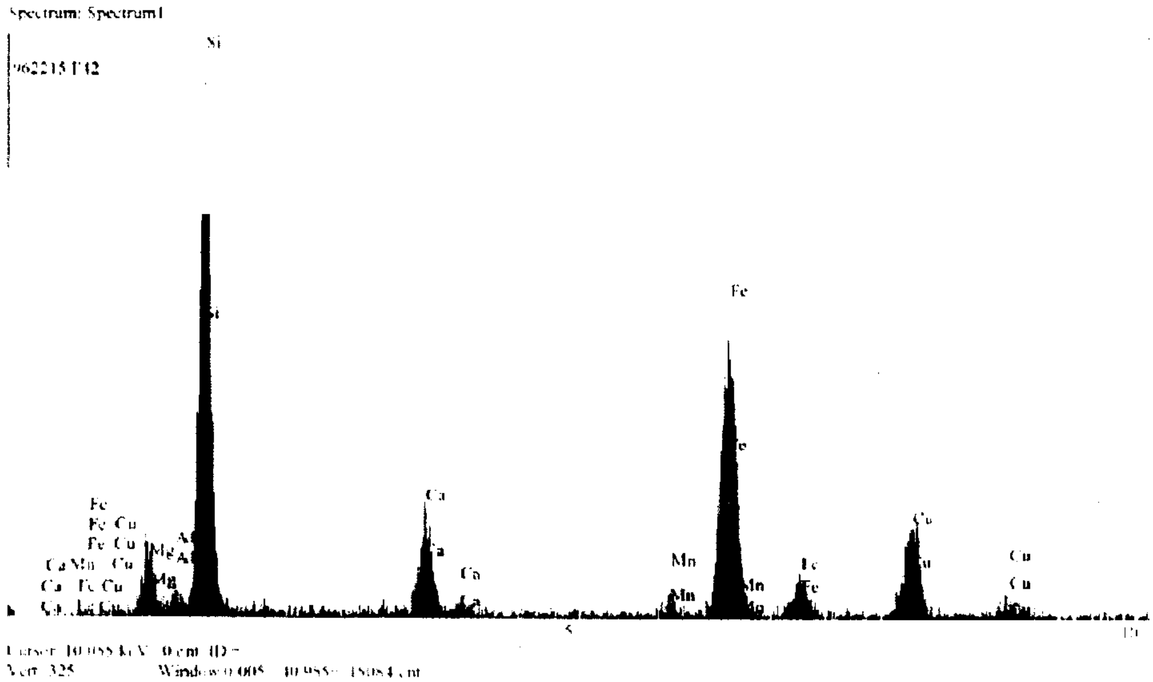
962218 F43

962218 F42

Magnification 5000X
Approximate Dimensions:
F42 – 5.0um x 1.1um
F43 – 15.1 x 3.4

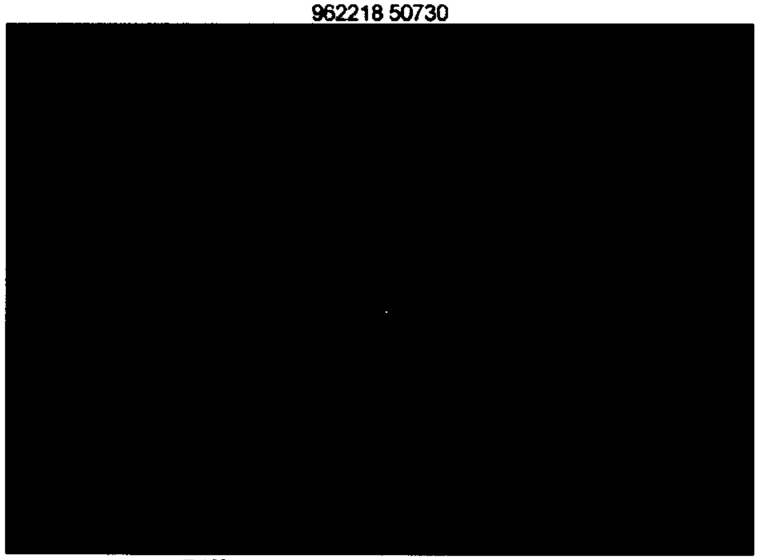
962218 50729

Diffraction Pattern 962218 F42

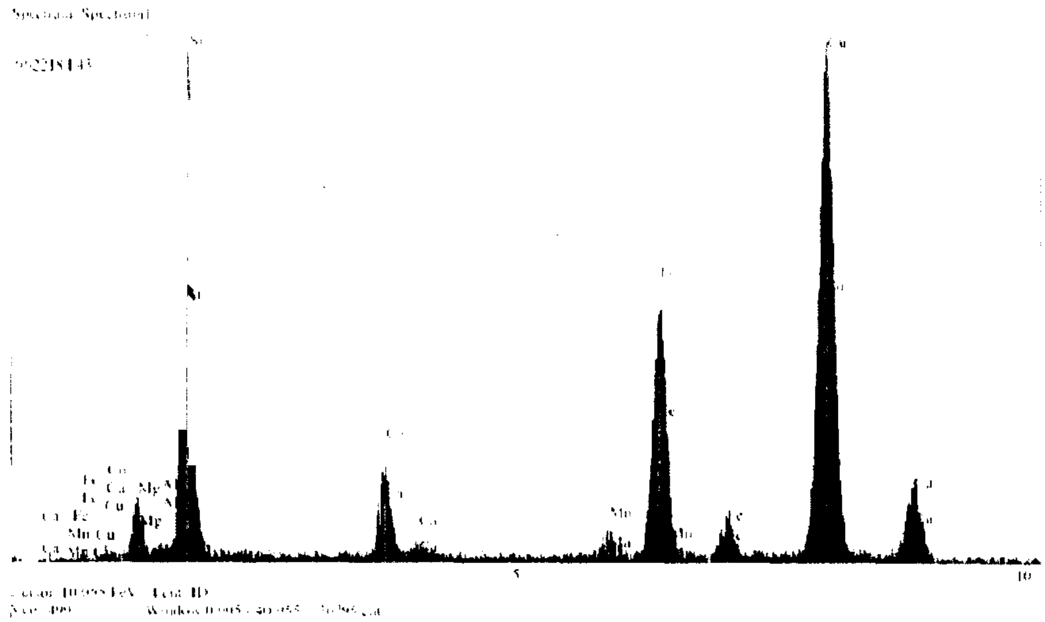


Spectra for 962218 F42

962218 50730

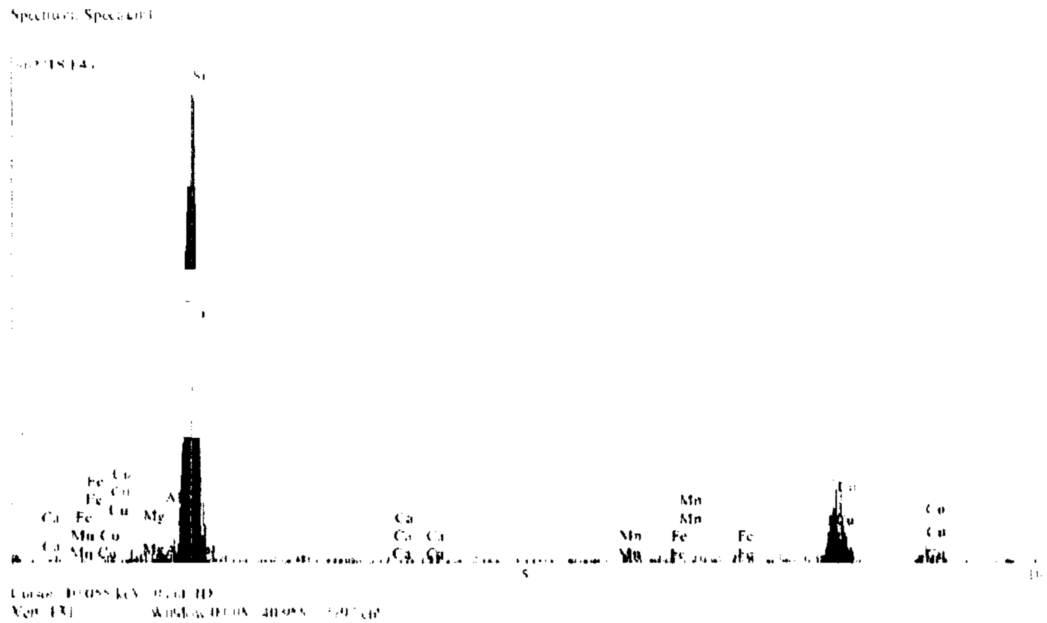


Diffraction pattern 962218 F43



Spectra for 962218 F43

Non-asbestos fiber 962218 Grid Opening G4-3 Magnification 3300X
Approximate Dimensions
11.8um x 3.9um



Spectra for non-asbestos 962218, Grid Opening G4-3

Examples of a few more fibers.

962218 F19 Magnification 6600X
Approximate Dimensions:
10.6um x 1.1um

962230 50606

962230 F4 Magnification 10,000X
Approximate Dimensions:
6.7um x 0.6um

962215 50526

962215 F18 Magnification 10,000X
Approximate Dimensions:
9.5um x 1.9um

Appendix C. Comparison of Actual Respirable Results to Average Real-Time Results from Concentrator, Fine Crusher, and Dry Cobber Buildings

Concentrator Building, 4/26/05.

Location	Type of Reading	Concentration (mg/m^3)				
		Feed to Rod Mill	Between Ball Mills	Between Primary & Secondary Magnetic Separator	Under Regrind Mill	Average
Shed	Actual	0.130	---	---	---	0.130
	Real-Time	0.106	---	---	---	0.106
	Ratio	**1.226**	**---**	**---**	**---**	**1.226**
103	Actual	0.088	0.092	0.053	---	0.078
	Real-Time	0.085	0.085	0.052	---	0.074
	Ratio	**1.035**	**1.082**	**1.019**	**---**	**1.054**
106	Actual	0.190	0.062	0.052	---	0.101
	Real-Time	0.131	0.088	0.079	---	0.099
	Ratio	**1.450**	**0.705**	**0.658**	**---**	**1.020**
109	Actual	0.101	0.079	0.071	0.073	0.081
	Real-Time	0.061	0.062	0.077	0.057	0.064
	Ratio	**1.656**	**1.274**	**0.922**	**1.281**	**1.266**
Average	Actual	0.127	0.078	0.059	0.073	Average Factor **1.119**
	Real-Time	0.096	0.078	0.069	0.057	
	Ratio	**1.323**	**1.000**	**0.855**	**1.281**	

Fine Crusher Building, 5/24/05.

Type of Reading	Concentration (mg/m^3)		
	Screen 2 West	Screen 102 East	Average Factor
Actual	0.111	0.059	**0.623**
Real-Time	0.145	0.123	
Ratio	**0.766**	**0.480**	

Dry Cobber Building, 5/25/05.

Type of Reading	Concentration (mg/m^3)		
	Upper Level Center	Upper Level Under Feeder Belt	Average Factor
Actual	0.185	0.225	**1.293**
Real-Time	0.210	0.132	
Ratio	**0.881**	**1.705**	