

INDUSTRIAL HYGIENE STUDY OF
THE INTERFACE CORPORATION

Willsboro, New York

Report Prepared by
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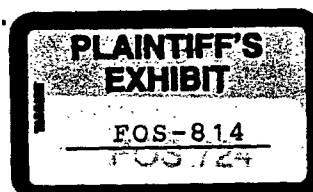
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Introduction

The National Institute for Occupational Safety and Health (NIOSH) has underway industry-wide studies to assess the chronic health hazards from occupational exposure to respirable fibers. These studies include epidemiological studies of exposed worker populations to determine health effects which may be attributed to the work environment, medical studies to assess chronic health effects, and detailed industrial hygiene studies to characterize the various agents to which these workers have been exposed.

During the week of June 14-16, 1976, Ralph Zurwalde, Mark Doeniger and Robert Wheeler (ALOSH) conducted an industrial hygiene survey of the Interpace Corporation in Hillsboro, New York. The purpose of the survey was to collect samples of airborne wollastonite, characterize its composition and evaluate worker exposures. Approximately 60 airborne samples were collected at various mining and milling operations. Of these 60 airborne samples, 45 were personal breathing zone samples with the remaining 15 samples being collected at stationary sites near processing operations. Airborne samples were collected for the determination of respirable and total dust and wollastonite fiber concentrations. All of the respirable and total dust samples were also analyzed for free silica. In addition, all stationary samples were analyzed for trace metal (Cadmium, Chromium, Cobalt, Iron, Manganese, Nickel, and Zinc) content. Settled dust samples were collected at different processing operations and were analysed in the same manner as the airborne. Some high noise levels were apparent due to mill processing operations; consequently, sound level measurements were taken at various locations within the mill.

The following paragraphs describe the sampling and analytical methods employed, sample results, conclusions and recommendations drawn for workplace improvements and worker safety. To help reduce duplication of information, a copy of the February 12, 1976 Preliminary Industrial Hygiene Survey Report of the Interpace Corporation facility is attached (Appendix I). This report documents the mining and milling processes, medical, industrial hygiene and safety practices at the facility and discusses the potential problems with the inhalation of airborne wollastonite.

Survey Procedures

The major portion of the survey was devoted to the collection of personal breathing zone samples for documenting employee exposures at various milling and mining processes. Personal air samples were collected on the employees to determine time-weighted average (TWA) concentrations for respirable and total dust, wollastonite fibers, and free silica. Samples for airborne respirable and total dust were collected at a flow rate of 1.7 liters per minute (lpm) on 37 mm diameter pre-weighed MSA type FWS (polyvinyl chloride) filters. Total dust samples were collected open faced with respirable dust samples collected for trace metal analysis using 37 mm diameter pre-weighed Millipore Type AA (cellulose ester) filters. To determine airborne wollastonite fiber concentrations both personal and stationary air samples were collected on open faced 37 mm Millipore Type AA filters (0.8 μ m pore size) at a flow rate of 1.7 lpm. All respirable, total dust and trace metal samples were collected during the majority of the work shift, whereas, wollastonite fiber samples were changed periodically during the work shift as needed to prevent particulate overloading on filters.

Free silica concentrations for air and settled dust samples were determined using X-ray diffraction as specified in the NIOSH Crystalline Silica Criteria Document.¹ Trace metal analyses for Cd, Cr, Co, Fe, Pb, Ni and Zn were determined by atomic absorption spectroscopy on stationary air samples and settled dust. To determine an index of exposure to airborne wollastonite fibers, all fiber samples were analyzed using the NIOSH asbestos counting technique.² These samples were analyzed by phase contrast microscopy at 400X magnification with fibers (3:1 length to diameter aspect ratio) counted and sized into groups of less or greater than 5 micrometers (μ m) in length. These same samples were further analyzed by transmission electron microscopy (TEM) using selected area electron diffraction and energy dispersive X-ray analysis to identify all fibrous particles. TEM was also used for determining fiber size (length and diameter) distributions using a sample preparation method developed by Ortiz³ and analyzed on a JEOL, JEM 100-B TEM at a magnification of 10,000X. A minimum of 100 fibers were analysed on each sample.

Sound level measurements were taken at various mining and milling operations for identifying potential excessive noise sources. Decibel measurements were made using a General Radio 1565A sound level meter on the A weighted scale.

Sample Results

Attached as Appendix II in a brief description of each job within the mill and also the mine, a description of sampling and analytical methods utilized,

results of all individual samples, and appropriate summary statistics. All job categories have been identified by a 4 digit job code. The first 2 digits represent the general work area while the last 2 digits correspond to specific jobs within these areas. Tabular summaries of time-weighted average concentrations by job category for free silica and respirable and total mass dust samples (wollastonite) are given in Table 1. Presented in Table 2 is a summary of the trace metal analyses of settled dust samples collected at various locations within the mill.

TWA free silica concentrations calculated for each job category appear to be within acceptable limits as recommended by NIOSH.¹ Some individual respirable sampler did indicate free silica concentrations in excess of the NIOSH recommended TWA standard of 0.050 mg/m^3 . However, there is some questions as to the interpretation of these concentrations since the analysis for free silica on most of the samples was reported near the lower detection limit of the analytical method ($0.05 \text{ mg per filter}$). Trace metal (Cd, Cr, Co, Fe, Mn, Ni, Zn) analyses performed on collected airborne samples indicated levels near the lower detection limit of the analytical method, hence, air sample concentrations (ug/m^3) for trace metals reported in Appendix II reflect these low levels. The trace metal analysis of the settled dust samples, as indicated in Table 2, substantiates the low levels found in the air samples. Iron was the only trace metal found in any appreciable quantity (0.5 - 5.5%).

As reported in Table 1 all TWA concentrations for respirable dust were below 5 mg/m^3 , however, some TWA concentrations for total dust exceeded 10 mg/m^3 . Since there is currently no specific occupational health standard for wollastonite the standards for inert or nuisance dusts are applicable. At present the Mine Enforcement and Safety Administration (MESA) dust standard is 5 mg/m^3 respirable and 10 mg/m^3 total, whereas, the Occupational Safety and Health Administration (OSHA) dust standard is 5 mg/m^3 respirable and 15 mg/m^3 total.

Listed in Table 3 are airborne concentrations for wollastonite fibers at various operations within the mine and mill. These concentrations along with fiber sizing were performed by both optical phase contrast and electron microscopy. It is apparent from the data that fiber concentrations, both total and $> 5 \text{ }\mu\text{m}$, within the mine are much lower than those found in the mill. Also, sample concentrations in the mine for $> 5 \text{ }\mu\text{m}$ fibers were similar for both the optical and electron microscopy analysis. However, those samples collected in the mill indicated higher $> 5 \text{ }\mu\text{m}$ fiber concentrations when determined by optical microscopy. This difference could be attributed to the high fiber density per counting field which contributed to the difficulty in accurately sizing and counting fibers. All reported fiber concentrations for both mine and mill substantiate those sample results previously reported in the February 12, 1976 Preliminary Industrial Hygiene Survey Report (Appendix I).

Samples evaluated by transmission electron microscopy were also characterized for other fibrous minerals by utilizing selected area electron diffraction and energy dispersive X-ray analysis at a magnification of $17,000\times$.⁴ A few chrysotile asbestos fibers were identified from the 15 analyzed airborne samples.

However, these few asbestos fibers could have resulted through contamination in handling and sample preparation methods. Illustrated in Figure 1 is a typical photomicrograph, selected area electron diffraction pattern, and X-ray spectrum of airborne wollastonite fibers found in the mill.

In addition to determining fiber concentrations on airborne samples, size distributions were also performed on observed fibers using both phase contrast and TEM. Samples analysed by phase contrast microscopy, as illustrated in Table 4, indicated that 92-97% of the airborne fibers observed had diameters less than 3.5 μm , of which, 98% had lengths less than 50 μm . Those same samples were analysed by TEM at 10,000X magnification. Approximately 1300 fibers were sized from both mine and mill airborne samples for the determination of length and diameter medians. As reported in Table 5 the count median was calculated to be 0.22 μm for diameters and 2.5 μm for lengths. This data closely compares with the fiber size data reported in the Preliminary Industrial Hygiene Survey Report. As the TEM fiber size data indicates there are a considerable number of airborne fibers with small diameters and short lengths which were not resolved by phase contrast microscopy.

Sound level measurements taken in the mine ranged from 104-112 dBA near the drilling operations to 78 dBA on the loading dock of the mill. All sound level measurements are reported in Appendix II.

Discussion

In determining any possible chronic respiratory health effects resulting from wollastonite fibers, it is necessary to determine what portion of the

airborne fibers actually reach the lung alveolar regions. The respirability of fibers is not clearly understood at the present time. As was discussed in the Preliminary Industrial Hygiene Survey Report, research performed by some investigators have suggested that the physical parameters of the airborne fibers (e.g. size and morphology) dictate its respirability and potential for producing tumorigenic effects.^{5,6} In a study to determine the airborne behavior of fibrous particles, Timbrell⁷ reviewed the mechanisms by which particles deposit in the respiratory system, and addressed specifically the problem of fiber deposition. His study identified settling, inertial impaction, and brownian diffusion as deposition mechanisms which operate for both compact particles and fibers. In addition, he identified a fourth mechanism, direct interception, which is of little significance for compact particles but which may be of importance for fibers. Using an aerosol spectrometer he found that the terminal settling velocity of fibers is mainly a function of fiber diameter, with length being of secondary importance and that fibers with diameters less than 3.5 μm could escape upper respiratory deposition by settling and inertial deposition and penetrate deeply into the pulmonary spaces. Timbrell's work was substantiated in a later mathematical model study performed by Harris et al.⁸ in which an estimation of lung deposition of fibers was derived based on the aerodynamic behavior of thin straight rods.

These aforementioned studies, in addition to postmortem studies of the lungs of animals and asbestos workers^{9,10,11}, suggest that the majority of fibers which can penetrate into the alveolar regions are within a size range of less than 3.5 μm in diameter and less than 50 μm in length. The fiber size data which has been presented in this report demonstrates that most (92%-97%) of the airborne wollastonite fibers found in the mine and mill are potentially respirable. In

view of this, it would appear prudent that exposures be kept at an absolute minimum by the use of good engineering controls and work practices. In addition, persons working with wollastonite also should receive very close medical surveillance and be advised of the associated potential health hazards.

It is difficult to interpret the free silica results of the airborne samples since the analysis for free silica was determined at the secondary X-ray diffraction quartz peak. It appears that wollastonite has a significant interference at the primary quartz peak and a less intense interference reflection at the secondary peak, making is somewhat subjective in quantifying the amount of quartz. However, the sample data shows that some areas within the mill had total dust concentrations that exceeded 10 mg/m^3 . And, with a moderate free silica content (1% to 3%) associated with these high dust levels, the potential for inducing respiratory health problems is enhanced.

It was noted during the survey that improvements had been made with the exhaust ventilation around the bagging operations. These improvements, since our preliminary industrial hygiene survey, have help to reduce total dust exposure throughout the mill. Additional measures to reduce spills, improve clean-up procedures, and maximize existing exhaust ventilation systems still appears warranted.

Drilling operations in the mine and areas around the ore crushing operations in the mill often had sound level measurements exceeding 90 dBA. It was observed, however, that most employees working in these areas wore hearing protection. Other areas throughout the mill often had sound level measurements between 70 and 82 dBA. It has been documented in the NIOSH Noise Criteria Document¹²

that 8 to 10 hour time-weighted average exposures to sound levels between 85 and 90 dBA can induce hearing impairments. Therefore, it is recommended that employees exposed to these levels be requested to wear hearing protection. It is also suggested that employees be made aware of areas which have excessive noise levels. Because of the range of sound levels found throughout the mine and mill it would be advisable to initiate a hearing conservation program with periodic hearing examinations.

Table 1. Interpace Corporation Concentrations
Summary of Time-Weighted Average (TWA)
Airborne Concentrations by Job Title

Samples by Job Title	Respirable Mass Free Silica (SiO ₂) mg/m ³	Total Mass Free Silica (SiO ₂) mg/m ³	Dust Concentrations (Wollastonite)	
			Respirable Mass mg/m ³	Total Mass mg/m ³
0101 Driller	<0.016	<0.018*	0.469*	0.332*
0102 Loader	<0.066*	<0.017*	--	2.714*
0202 Trucker Crusherman	<0.131*	--	1.346*	--
0203 Beneficiator	<0.065*	--	1.355*	--
0204 Beneficiator Mill-Helper	<0.069*	--	1.488*	--
0205 Miller	--	<0.079*	--	7.250*
0206 F-1 Miller	<0.013*	<0.067*	0.618*	2.597*
0207 Packer	<0.068*	<0.068	1.545*	9.818*
0209 Laborer	<0.013*	<0.066*	2.120*	4.637
0221 Maintenance	<0.065*	<0.162*	1.822	16.072*
0213 Stationary General Area Samples (Milling Operations)	<0.079	<0.353	4.956	16.386

Interference at primary peak for SiO₂ required the use of secondary peaks. Therefore, reported TWA concentrations for respirable and total mass SiO₂ are values determined at the lower limit of detection of the secondary peaks (0.05 mg per filter).

NOTE: (*) Represents one sample
(--) No sample collected