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Oglebay Norton Industrial Sands, Inc.
(Central Silica Company)
Glass Rock, Ohio

Margaret Filios, RN, ScM

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Margaret Filios, RN, ScM, of the Respiratory Disease Hazard Evaluations and Technical Assistance Program, Clinical Investigations Branch, Division of Respiratory Disease Studies (DRDS). Assistance was provided by Jean Cox-Ganser, Ph.D., and Brian Day, MA, Epidemiological Investigations Branch; and Ken Ream, Examination Processing Branch. Desktop publishing by Nichole Herbert. Review and preparation for printing was performed by Penny Arthur.

Copies of this report have been sent to employee and management representatives at Oglebay Norton Industrial Sands, Inc. (formerly Central Silica Company); Glass, Molders, Pottery, Plastics & Allied Workers, Local 191; Glass, Molders, Pottery, Plastics & Allied Workers International; Mine Safety and Health Administration; Ohio Department of Health; National Industrial Sand Association; Laborers Health and Safety Fund of North America; General Teamsters and Allied Workers; Oil, Chemical and Atomic Workers International. This report is not copyrighted and may be freely reproduced. Single copies of this report will be available for a period of three years from the date of this report. To expedite your request, include a self-addressed mailing label along with your written request to:

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Health Hazard Evaluation Report 93-0791-2701
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Glass Rock, Ohio
August 1998

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SUMMARY

In July 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the Mine Safety and Health Administration (MSHA) to estimate the prevalence of silicosis among active and retired miners at Central Silica Company, a subsidiary of the Oglebay Norton Company, in Glass Rock, Ohio. Subsequent to the MSHA request and the NIOSH medical evaluation, Central Silica Company merged with other industrial sand companies owned by the Oglebay Norton Company and was re-named Oglebay Norton Industrial Sands, Inc.

Current and former workers with one year or greater cumulative tenure since 1970 in the grinding area of the mill or in areas downstream of the grinding process represented the population of primary interest. On April 27-28, 1994, a medical evaluation of current workers was conducted. Former workers were examined on April 29, 1994. The medical evaluation included a questionnaire, spirometry, and a single view posterior-anterior (PA) chest x-ray. Chest x-rays were independently classified according to the 1980 International Labour Office (ILO) system by three NIOSH-certified B Readers who were unaware of the participant's age, occupation, occupational exposure, smoking history, or any identifying information. For the purposes of this evaluation, silicosis was defined on the basis of a chest x-ray with median small opacity profusion classification of category 1/0 or greater.

A total of 31 current workers and two former workers participated in the NIOSH medical evaluation, and of these, four (12%) had a chest x-ray consistent with silicosis; the prevalence among currently working participants was 13% (4/31). The highest median ILO profusion category was 1/1. Two of the four participants whose chest x-rays were consistent with silicosis had progressive massive fibrosis (PMF); one had "C" size large opacities and the second had large opacities without a consensus on size, as classified by at least two Readers. Pulmonary function testing revealed that eight (24%) of the participants had abnormal spirometry patterns. Abnormal spirometry patterns were identified for three of the four participants with a chest x-ray consistent with silicosis.

MSHA has documented periods of non-compliance with its respirable silica dust standard at the Glass Rock operation since 1974. As reported in the MSHA environmental study, during the period 11988 to January 1994, 63% (31/49) of personal samples collected by MSHA inspectors in the mill area or affected downstream operations were citable under the MSHA standard for respirable crystalline quartz.

Four (12%) of the 33 survey participants who met the study criterion were found to have changes on their chest x-ray consistent with silicosis. This is consistent with past silica dust exposure at this facility. Additionally, one cannot conclude that current silica dust exposure levels are without adverse effect given the long latency usually associated with chronic nodular silicosis. Medical surveillance recommendations are presented in this report and include modification of the baseline medical examination and annual medical monitoring provided by the company.

Keywords: SIC 1446 (Industrial Sand), Silica, Silicosis, Mineral processing, Ground silica, Silica flour

TABLE OF CONTENTS

INTRODUCTION

In July 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the Mine Safety and Health Administration (MSHA) to estimate the prevalence of silicosis among active and retired miners at Central Silica Company, a subsidiary of the Oglebay Norton Company, in Glass Rock, Ohio. Subsequent to the MSHA request and the NIOSH medical evaluation, Central Silica Company merged with other industrial sand companies owned by the Oglebay Norton Company and was re-named Oglebay Norton Industrial Sands, Inc. The medical evaluation was part of a joint project between MSHA and NIOSH to study silica exposures and the prevalence of silicosis in workers in a number of ground silica mills. A protocol outlined the responsibilities of each agency (see Appendix I). MSHA selected nine sites and was responsible for evaluation of silica dust exposures and dust control methods, while NIOSH was responsible for conducting medical evaluations at each site. This is the final report of the NIOSH medical evaluation conducted at Oglebay Norton Industrial Sands, Inc. (formerly Central Silica Company).

On April 14, 1994, NIOSH representatives met with company and union representatives, and several employees, along with an MSHA representative, to discuss logistical and administrative considerations of the NIOSH evaluation. On April 26, 1994, an opening meeting was held with company and union representatives and a representative from MSHA to discuss the ensuing evaluation and to address any last minute questions. The meeting concluded with a walk-through of the plant.

On April 27-28, 1994, the medical evaluation of current workers was conducted. Former workers were tested on April 29, 1994. All study participants received written notification of their spirometry results in May, 1994. All chest x-rays were promptly reviewed by a pulmonary physician for acute health problems upon return to NIOSH and prior to the classification process. All study participants received written notification of their chest x-ray results in January, 1995.

BACKGROUND

Oglebay Norton Industrial Sands, Inc. (formerly Central Silica Company) began operation in 1903. The Glass, Molders, Pottery, Plastics & Allied Workers Union local which represents employees at this plant was chartered in February, 1937. A company representative estimated that ground silica had been produced at this plant at least since the early 1950's, or earlier. Raw material is surface-mined at a nearby quarry and transported via aerial tramway to the plant, where it is crushed, classified, and stored in the plant yard prior to being dried and processed into different products. The various products are then either bagged or bulk- loaded into trucks or railroad cars. The plant operates production processes 24 hours a day, five days a week, with some maintenance occurring on the weekends. At the time of the survey, a total of 54 employees (including clerical, salaried, and a part-time janitor) worked at the Glass Rock facility, 49 of whom were hourly employees. Workers often had multiple overlapping job duties. The majority of the hourly workers and salaried personnel worked during the day shift. Bagging, loading, and maintenance occurred only during the day shift. Five employees worked the evening shift and five worked during the night shift. The departments at the Glass Rock operation are: Mining/Quarrying, Refining/Processing, Drying, Milling, Shipping (Loading), Maintenance (e.g., electricians, mechanics, welders, tramway maintenance, millwright, etc.), and Supervisory/Administrative personnel.

METHODS

Study Objective

The primary objective of the study was to estimate and report the prevalence of silicosis among participating current and former employees in the grinding area and/or downstream of the grinding area by tenure and job, if feasible.

Although not a primary objective, it was of interest to assess the direction and magnitude of possible bias in the prevalence estimate obtained from the medical evaluation as it applied to the study population as a whole. To do so, an attempt was made to compare demographic characteristics and disease status of participants and living non-participants who met the study criterion using information obtained from company records. As a corollary, company medical monitoring programs and practices were also examined and evaluated.

Study Population

The criterion for inclusion in the study population was one year or greater cumulative tenure since 1970 in the grinding area of the mill or in areas downstream of the grinding process. Company records and information, and union rosters, were used to help determine employees' eligibility for inclusion in the study. Tenure data supplied by the company were considered more accurate than information obtained by questionnaire during the medical evaluation, which can be subject to errors from recall. Jobs within and downstream of the grinding circuit were ascertained using information from the company, the medical evaluation, and MSHA.

Using rosters provided by the company, letters were mailed inviting eligible current and former workers to participate in the medical evaluation. To avoid inadvertent oversight of eligible current workers with prior experience in these areas, all current workers were invited to participate regardless of work area or length of employment. Additionally, advertisements were placed in local newspapers to reach those workers who may have moved within the local area or otherwise may have failed to receive a letter. No further follow-up was made to eligible workers who chose not to participate in the medical evaluation. Current and former workers who met the study criterion are the focus of this report.

Data Collection

Posterior-Anterior Chest X- Ray

Chest x-rays were taken on a full size (14 x 17 inch) film. All chest x-rays were read independently by three B Readers who, without knowledge of the participant's age, occupation, occupational exposure, smoking history, or any identifying information, classified the films according to the 1980 ILO International Classification of Radiographs of Pneumoconioses.[1] A B Reader is a physician who has demonstrated the ability to classify chest x-rays for the pneumoconioses (dust diseases of the lung) by passing a certification examination administered by NIOSH using the ILO Classification System.

The NIOSH-certified pneumoconiosis B Readers used in this project had each classified at least 500 chest x-rays for the 4th round of the NIOSH Coal Workers X-Ray Surveillance Program. They had also participated in a pilot study which entailed a reading trial of over 400 films of anthracite miners in preparation for a current exposure-response study using National Study for Coal Workers Pneumoconiosis films. After

determining that NIOSH B Reader certification was not due to expire any time between June 1993 and December 1994, the Readers were contacted and interest and availability to read chest x-rays for the present study were ascertained. The same three B Readers were used throughout the entire project.

The ILO classification method is used for epidemiological research, for the surveillance of workers in dusty occupations, and for clinical purposes. The method recognizes two major categories of opacity size; small and large.[2]

The profusion (i.e., number) of small opacities are recorded using a graduated 12-point scale within four major categories (0,1,2,3). A major profusion category of 0 indicates no apparent abnormality, while 3 indicates substantial abnormality. Film classification is achieved by comparing the subject film with the appearance of "standard films" which define small opacity profusion. In classifying small opacity profusion, the final determination of major category is listed first. If a higher or lower major category has also been seriously considered, this category is also listed after a slash mark. If there is no question as to major category, the two listed numbers are identical.[1,2]

Thus, the small opacity profusion scale is as follows:

0			1		
0/-	0/0	0/1	1/0	1/1	1/2

2			3		
2/1	2/2	2/3	3/2	3/3	3/+

Size and shape of the small opacities are also classified, both being differentiated using the letters of the alphabet. Two letters are used to record size [in millimeters (mm)] and shape, the first listed letter indicating the predominant type.[1,2]

Classification of Small Opacity Type

Shape	Size		
	Up to 1.5 mm	1.5 - 3 mm	3-10 mm
Rounded	p	q	r
Irregular	s	t	u

To record the distribution of the small opacities, the lungs are divided into six zones--three on the left and three on the right, for the upper, middle, and lower portions of the lungs.[1,2]

Three categories are used to define large opacities according to size [measured in centimeters (cm)]: A, B, and C.[1] Category A is specified as an opacity >1 cm but <5 cm, or several opacities >1 cm whose combined diameters are <5 cm; Category B is one or more opacities >5 cm whose combined area is less than the equivalent area of the right upper lung zone; Category C is one or more opacities whose combined area is greater than the equivalent area of the right upper lung zone.[1,2]

The technical quality of the chest x-ray (or film quality) is graded and recorded using four scores, 1,2,3, or 4. A "1" represents the highest score, or quality, while a "4" represents a chest x-ray considered by a Reader as "unacceptable" or "unreadable" for classification purposes.[1,2]

Spirometry

Spirometry was performed using a dry rolling-seal spirometer interfaced to a dedicated computer. At least five maximal expiratory maneuvers were recorded for each person. All values were corrected to BTPS (body temperature, ambient pressure, saturated with water vapor). The largest forced vital capacity (FVC) and forced expiratory

volume in one second (FEV_1) were the parameters selected for analysis, regardless of the curves on which they occurred. Testing procedures conformed to the American Thoracic Society's recommendations for spirometry.[3] Predicted values were calculated using the Knudson reference equations.[4] Predicted values for African-Americans were determined by multiplying the value predicted by the Knudson equation by 0.85.[5]

Questionnaire

A modified version of the Medical Research Council (MRC) questionnaire[6] on respiratory symptoms, supplemented with questions concerning demographic information, work history, cigarette smoking habits, physician-diagnosed respiratory illness, frequency and content of company medical evaluations, and participant's knowledge of prior test results, was administered by trained NIOSH personnel.

Medical and Personnel Records

Each company was asked to provide medical and personnel records of current and former employees who had worked at least one year since 1970. Three types of company-held documents were identified from which the presence or absence of silicosis was ascertained -- ILO classifications, clinical radiology reports (a chest x-ray report by a radiologist), and miscellaneous documents (e.g., CT scan results, letters from physicians, etc.). The following case definitions for silicosis were established for each type of document:

1. An ILO small opacity profusion classification of 1/0 or greater on the most recent chest x-ray.

OR

2. A clinical radiology report which contained explicit words or phrases (e.g., "silicosis" or "pneumoconiosis"), or other descriptions considered consistent with silicosis (see "Results" section).

OR

3. A physician diagnosis of silicosis, or a diagnosis of pneumoconiosis if silicosis was considered in the differential diagnosis.

The case definition used in the analysis depended on the type of records obtained from the company. ILO classifications were considered ideal and the preferred document type for definition, followed by clinical radiology reports, and finally miscellaneous documents. Therefore, if all three types of documents were available for an individual, ILO classifications were used to identify silicosis (case definition 1). If company records contained both clinical radiology reports and miscellaneous documents, case definition 2 was used. Case definition 3 was used when only miscellaneous documents were available.

Medical Monitoring

The 1981 NIOSH recommendations for medical monitoring of workers exposed to ground silica (silica flour)[7], and the recently revised recommendations published by the National Industrial Sand Association (NISA) for workers exposed to crystalline silica[8] were used as the basis to evaluate company medical monitoring practices.

EVALUATION CRITERIA

Chest X- Ray

A chest x-ray was defined as consistent with silicosis if the median, or middle, classification of small opacity profusion was 1/0 or greater. For cases where only one Reader considered a film of unacceptable quality, an additional classification was sought if the participant met the criterion for inclusion in the study population. If the film was considered unacceptable a second time, it was then classified as unreadable (UR). However, if the film was able to be classified, this classification was used to determine the median, and the results were subsequently used in the data analysis. This procedure was followed so as not to give undue weight to the judgement of a single Reader. Progressive Massive Fibrosis (PMF) was defined as the presence of large opacities of ILO category A, B, or C classified by at least two Readers.

The overall shape of the small opacities was based on the predominant shape (i.e., the first listed letter) classified by two or more Readers. If only two Readers classified shape and the predominant type differed, the shape was considered "mixed."

Spirometry

To identify participants with abnormal spirometry patterns of obstruction and restriction, each examined worker's test results were compared to the 95th percentile lower limit of normal (LLN) values obtained from Knudson's reference equations.[4] Five percent of a normal population will have predicted values that fall below the normal range, or LLN, while 95% will have predicted values above the lower limit.

Using this comparison, obstructive and restrictive patterns were defined as:

Obstruction: Observed ratio of FEV_1 /FVC% below the LLN.
Restriction: Observed FVC below the LLN.

Questionnaire

The following definitions were established for the purpose of questionnaire analysis:

Chronic Cough: a cough on most days for as much as 3 months during the year.

Chronic Phlegm: the production of phlegm on most days for as much as 3 months during the year.

Chronic Dyspnea: shortness-of-breath walking with individuals of similar age on level ground.

Chronic Bronchitis: cough and phlegm on most days for as much as 3 months for 2 or more years.

Medical Monitoring

The 1981 NIOSH recommendations for medical examinations of ground silica workers include a medical and occupational history, chest x-ray, and pulmonary function testing (spirometry) for all workers prior to job placement and annually thereafter.[7] NISA guidelines recommend a medical and occupational history, physical exam, and pulmonary function testing prior to job placement and at least every two years; a pre-placement skin test for tuberculosis (TB) is an optional component of the medical monitoring program recommended by NISA. A chest x-ray is also recommended, with frequency determined by worker age, time since first exposure to silica dust, or as determined by a physician if a worker has any signs or symptoms of silicosis.[8] For a worker who is 35 years of age or less, with 8 years or less since first exposure, NISA guidelines recommend a chest x-ray every 4 years. The frequency increases to every 2 years for workers over 35 years of age with more than 8 years since first exposure.[8] NISA's earlier guidelines[9] did not discuss chest x-ray frequency.

Silicosis

Silicosis, a form of pneumoconiosis, is a chronic fibrotic pulmonary disease caused by the inhalation, deposition, and retention of dust containing crystalline silica.[10] Silicosis is usually diagnosed through chest x-ray and occupational history of exposure to silica-containing dust. In nodular silicosis, lung tissue reacts to the presence of silica dust by forming nodules, which on chest x-ray typically appear discrete, round, and more prominent in the upper zones, although other patterns have been described.[7,11,12,13] Such radiographic abnormalities are often the first sign of silicosis.

In acute silicosis, the lung is overwhelmed by crystalline silica particles, and a proteinaceous fluid accumulates in the lungs as a reaction to the silica dust.[7,10,14,15] On chest x-ray, the appearance is different from that of nodular silicosis, with very little of the typical nodular scarring.[7,16,17] Consequently, it may often be mis-diagnosed as pulmonary edema, pneumonia, or tuberculosis.

The following table summarizes the clinical forms of silicosis:

Form	Time to Onset	Intensity of Exposure
NODULAR		
-Chronic	10+ years	Low
-Accelerated	5-10 years	High
ACUTE	weeks-4 or 5 years	Extremely High

Each form is differentiated by time to onset of clinically apparent disease after initial exposure (induction period), intensity of exposure, and the rate at which the disease progresses.[7,10,12,16] The percentage of crystalline silica in the dust, size of the dust particle, form of crystalline silica, and length of exposure also affect disease onset and progression.[7,17,18] Ground silica (silica flour) consists of essentially pure crystalline silicon dioxide (quartz) particles of respirable size (< 10 micrometers).[19,20] Particles of this size may be invisible to the naked eye and are small enough to be deposited in the alveoli. Freshly ground, or fractured, crystalline silica -- which is a typical form of silica in ground silica facilities -- may be more toxic or fibrogenic (i.e., produce more scarring of the lungs), than aged silica.[21, 22]

A continuum is thought to exist between the chronic and accelerated forms of nodular silicosis. Factors determining the progression of disease are unclear.[13] *Chronic silicosis* (the presence of detectable, discrete, nodules <1 cm in diameter on chest x-ray) is the most common form of silicosis and usually becomes evident after 10 years or more of exposure to dust containing crystalline silica.[10,11,23] There may be few, if any, clinical symptoms; the most common symptoms are cough, with or without sputum production, and shortness of breath. There may be little or no decrement in pulmonary function. *Accelerated silicosis* is associated with higher exposures to crystalline silica and has a shorter induction period than chronic silicosis. Chest x-ray abnormalities usually appear within 5-10 years.[23] This form of silicosis often progresses after exposure has been discontinued. *Acute silicosis* may develop in a few weeks to 4 or 5 years after initial exposure and is associated with exposures to extremely high concentrations of crystalline silica.[10,11,23] Respiratory impairment is severe with acute silicosis, and the disease is usually fatal within a year of diagnosis.[16,17]

Both chronic and accelerated silicosis can become complicated by the development of infection and/or progressive massive fibrosis (PMF). Increased susceptibility to infectious diseases (i.e., tuberculosis and/or fungal infections) is believed to

result from the inability of the overwhelmed lung scavenger cells (macrophages) to kill the organisms that cause these diseases.[24,25] Progressive massive fibrosis (PMF) has at times been called "complicated" silicosis, and is the result of silicotic nodules fusing into large masses. PMF profoundly affects both the structure and function of the lungs.[10,11,12,16]

Recently, a committee of the International Agency for Research on Cancer (IARC) reclassified crystalline silica (quartz or cristobalite) from occupational sources as a substance "carcinogenic to humans," and evidence suggests that individuals with silicosis are at increased risk for lung cancer.[26] NIOSH currently recommends that crystalline silica be considered a potential occupational carcinogen.[27,28]

RESULTS

Participation

Of 54 current employees, 37 were eligible for inclusion in the study population; 31(84%) of the 37 participated in the medical survey. Of the estimated 51 former workers who worked on or after January 1, 1970, and who were assumed to be living, 12 were eligible and 2 (17%) of the 12 participated (Table 1). Thus, of 49 eligible workers, 33 participated. Except for those maintenance employees who worked ***only*** in the quarry or maintained the tramway (that is, they held no other jobs at the facility other than those related to the quarry or tramway), employees who worked as electricians, mechanics, or welders, etc. were included in the study population because of reported intermittent exposure.

Job assignment and/or tenure at the facility was available from company records for all 49 eligible workers. For workers with multiple job assignments for a single time period, the first job listed was used as the job assignment for that particular time period based on discussions with a company representative. Although a particular job assignment was usually indicative of a work area (e.g., the assigned job was known to be in the quarry or in shipping), the work area was not always apparent. For six non-participants, the recorded job assignment (e.g., "working foreman") did not allow the determination of a specific work area at the plant. For these six non-participants, eligibility and inclusion in the study population of interest was based primarily on tenure.

Medical Evaluation

The following discussion of results concerns the 33 participants who met the study criterion. Given the small number of former workers who chose to participate, their demographic results will be presented separately from the results obtained from participating current workers.

Demographics

Current Workers

All 31 participating current workers were white males. Their median age was 43 years, and ages ranged from 29 to 63 years. Current workers were employed for a median of 17 years. Six (19%) were employed for 10 years or less, six (19%) were employed between 11 and 15 years, and the majority, 19 (61%), were employed for over 15 years. The reported number of years worked ranged between 4 and 30 years. One current worker reported prior employment (> 1 year) at the company's Millwood operation, a facility that also produces ground silica. The

previously cited median tenure reflects only his tenure at the company's Glass Rock mill.

Nineteen (61%) of the 31 participating current workers were "ever" smokers (that is, current and ex-smokers combined). Of these 19 "ever" smokers, 11 were current smokers and eight were ex-smokers. Overall, "ever" smokers had a median of 28 pack-years (a pack-year is equal to smoking an average of one pack per day for a year) of cigarette smoking; current smokers had a median of 33 pack-years versus a median of 17 pack-years for ex-smokers. Twelve (39%) of the participating current workers had never smoked cigarettes.

Former Workers

Both of the participating former workers were white males. Their median age was 41 years and median tenure was eight years, less than half the tenure of the participating current workers. Neither of the two participating former workers reported ever smoking. An average (mean) of seven years had passed since the former workers left employment at the time of the NIOSH evaluation.

Chest X-Ray Results

Overall, 12% (4/33) of the participants had a chest x-ray considered consistent with silicosis; the prevalence among currently working participants was 13% (4/31). Neither former worker had a positive chest x-ray. The highest ILO profusion category among the participants was 1/1. Two of the four with x-ray evidence of silicosis had chest x-rays consistent with PMF, one with "C" size large opacities and one with differing categories as classified by at least two Readers. Table 2 lists the chest x-ray results by Reader for all 33 participants. None of the 14 participants employed 15 years or less had a positive chest x-ray. Of the 19 participants employed over 15 years, four (21%) had x-ray evidence of silicosis; two of the four were employed for 20 years or more. Three of the four participants with a positive chest x-ray were between 40 and 50 years of age, and one was over 50 years. Of these four participants, two reported holding a primary job (the job held for the longest period of time) in the Quarry and two worked in Loading.

All of the chest x-rays were taken by NIOSH. Eighty-eight percent (29/33) of the chest x-rays had a median film quality score of 1 (the highest), three had a score of 2, and one had a film quality score of 3. This last chest x-ray required an additional classification (the first Reader marked the film"UR," or "unreadable") and the results were used to determine the median classification.

The predominant shape of the small opacities was examined in relation to cigarette smoking status for the four participants with x-ray evidence of silicosis. All four participants were "ever" smokers (i.e., either a current smoker or an ex-smoker). Two chest x-rays showed small opacities that were predominantly rounded, one film had predominantly irregular opacities, and one was "mixed."

Primary Job and Dustiest Job

Privacy concerns preclude listing the specific primary job (the job held for the longest period of time) held by a participant for each department or work area. Therefore, information concerning primary job is, for the most part, presented by department.

Eleven (33%) of the participants reported holding their primary job as a Loader in the Shipping department, 10 (30%) reported working at various Maintenance positions, and seven (21%) reported a primary job in the Quarry. Three participants reported working in the Refining/Processing area

of the plant, and two worked in Milling (i.e., the pulverizer or ball mill). Working as a Loader, a job that includes both bagging and bulk loading ground silica, was reported with the greatest frequency by participants as the single dustiest job at the plant. Maintenance activities such as repairing the ball mills and working on the dust collectors followed in frequency.

Other Dusty Jobs

A total of 19 (58%) of the 33 participants reported previous employment in occupations or industries other than a ground silica operation that might have been associated with exposure to fibrogenic dusts. For four (21%) of these 19 participants, that employment was one year or less. Six (32%) participants reported working at such jobs between two to five years, two (11%) participants worked five to 10 years, four (21%) worked 15-20 years, and three (16%) worked at other dusty jobs for 20 years or more. The type of work reported included construction, roadbuilding, glass production, grinding metals, brick manufacturing, welding, mining, farming, and cement manufacturing, among others.

Three of the four participants with a positive chest x-ray reported working at another dusty job, none of whom reported working over ten years. One worked for two years, and a second worked for over 5 years. Of the two participants with PMF, one reported working at a previous dusty job for less than one year and the second reported never working at any other dusty job.

Chronic Symptoms

A total of five participants reported a chronic symptom or health effect, as defined in the "Methods" section of this report. Chronic bronchitis and chronic dyspnea (shortness-of-breath) were reported by two participants each, and one participant reported both cough and dyspnea. All of the participants who reported a chronic symptom were "ever" smokers. None of the participants with a positive chest x-ray reported a chronic symptom.

Respiratory Illnesses and Conditions

Physician-diagnosed chronic bronchitis and asthma were each reported twice. Other physician-diagnosed lung conditions that were reported were pneumonitis and silicosis, among others. Twenty-four participants reported no physician-diagnosed respiratory illness or condition.

Spirometry

All 33 participants performed spirometry, and 24% (8/33) of those had results that fell below the normal range. Six of these participants exhibited an obstructive lung pattern, one exhibited a combined obstructive and restrictive pattern, and one exhibited a restrictive lung pattern. Of the eight participants with abnormal patterns, two had never smoked cigarettes, three were ex-smokers, and three were current smokers. Three of the four participants with a positive chest x-ray, including both with PMF, had abnormal pulmonary function test results. Both participants with PMF exhibited an obstructive lung pattern.

Company Records

Information on age was available from company records for all of the participants and 81% (13/16) of the non-participants, and tenure was available for the entire study population of interest. This information was examined by employment status for both participants and non-participants (Table 3). The six eligible, non-participating, current workers were of similar median age (45 years) as their participating counterparts (43 years) and had a slightly longer median length of employment,

21 years versus 17 years. In contrast, the median age of non-participating former workers was 74 years, and for participants, median was 40 years. Median tenure for non-participating former workers was 23 years, almost three times that of participants' eight years.

Information on sex was available for all but one study subject; all were male. Information concerning race was available for 32 (97%) of the 33 participants and 15 (94%) of the 16 non-participants; all were white.

Information concerning cigarette smoking status was missing for 27% (13/49) of the study population overall. Among participants, 12% (4/33) of this information was missing, and 56% (9/16) of the information on cigarette smoking was missing for non-participants. The available information for participants indicated 18 were current smokers, three were ex-smokers, and eight had never smoked. Among non-participants, six were current smokers, one was an ex-smoker, and the cigarette smoking status of the nine remaining non-participants was unknown. Information concerning prior work history was not contained in any of the records obtained from the company.

Chest x-ray results from company medical records were available for 98% (48/49) of the study population as a whole. All 37 eligible current workers had an ILO small opacity profusion classification; three met our case definition for silicosis. Two participated in the NIOSH evaluation and one was a non-participant. One worker had a small opacity profusion of 1/1 with "A' size large opacities, the small opacity profusion of the second worker was 2/2 with "B" size large opacities, and the third worker had a small opacity profusion of 1/2. The 34 remaining chest x-rays were classified 0/0. All of these chest x-rays were classified in 1993 by the same B Reader.

Of the 11 out of 12 eligible former workers for whom there were chest x-ray results, only one had an ILO classification (a median small opacity profusion of 1/0 based on 3 B Reader classifications in 1990). The rest of the records contained 1977 ILO reading sheets and clinical radiology reports. Because the radiologists who filled out the classification sheets were not B Readers, all of the records were considered clinical radiology reports. None of the 10 remaining workers had results that met our established silicosis case definition (case definition 2). Of the 10 chest x-rays, one was taken in 1959 and one in 1973, and each was read by a different radiologist. Five chest x-rays were taken in 1980 and read by three other radiologists. Two chest x-rays were taken in 1987, and one was taken in 1990.

Summary work history and medical information were recorded using the forms found in NISA's early (1977) occupational health program guidelines. The work history forms were incomplete, particularly for former workers, due to a lack of information. Recorded information included job assignment(s) when known, and tenure; work area was not recorded on most of the records, although a particular job assignment was usually indicative of a work area.

Company Medical Monitoring

Routine medical monitoring has been conducted at this facility since 1980 and initially consisted of a chest x-ray taken every 2 to 3 years. Prior to 1980, chest x-rays were taken as part of the company's pre-employment examination and were reviewed by various local radiologists. In 1980, the chest x-rays were sent to a local group practice of radiologists and classified using the ILO system, although none of the classifications were completed by a NIOSH-certified B Reader. In 1986, pulmonary function testing (spirometry) was added to the pre-employment examination and medical monitoring offered by the company.

Starting in 1990, chest x-rays with radiographic evidence of pneumoconiosis were sent for B Reader classification.

At the time of our evaluation in 1994, a company representative reported that beginning in 1992, all chest x-rays were classified by a NIOSH-certified B Reader. The medical monitoring program was reported to be offered every two years and was voluntary, although the company representative indicated that all employees participated. If any questionable results were noted, the employee was referred to his personal physician for follow-up, and a chest x-ray was then taken every year. Company medical records were kept at a company office located off-site from the mine, with access limited to the Vice President and his secretary, or a designated employee. The company representative reported that employees were given a copy of a narrative report of their chest x-ray results and were required to sign a document indicating that they had received the results. The plant manager was responsible for handling this documentation procedure, then forwarding the signed document to the off-site company office.

All 33 participants reported taking part in company medical monitoring at one time or another. Twenty-two (67%) participants were able to recall their chest x-ray results as it related to the company monitoring. Five participants either didn't know or didn't recall their company chest x-ray results. The six remaining participants reported also having had a chest x-ray, but for other reasons than the company medical monitoring program. Participants reported that the company medical monitoring was offered every three years to "very irregularly." We received no anecdotal reports of how the notification process was conducted or whether the narrative reports workers received contained any detailed information.

Subsequent to the NIOSH evaluation, routine medical monitoring, which includes a chest x-ray and respirator fit test, has been conducted every two years. A medical questionnaire and skin testing for tuberculosis (TB) are not part of the medical monitoring, and spirometry is no longer offered. A company representative reported that employee participation in the medical monitoring is now mandatory. Chest x-rays continue to be classified by a NIOSH certified B Reader. Currently, pre-placement examinations are conducted at a local hospital and include a medical questionnaire, spirometry, chest x-ray, skin testing for TB, and an x-ray of the back, among other tests. Medical records are still maintained at the off-site company office in locked files with access limited to the office manager and the Manager of Environmental Health and Safety. Each employee is personally provided with his or her individual written chest x-ray results by the Environmental Safety and Health Manager.

DISCUSSION

Four (12%) of the 33 current and former workers who participated in the medical evaluation were found to have changes on their chest x-ray consistent with silicosis; two of these four had PMF. The prevalence among currently working participants was 13% (4/31). All four participants with a positive chest x-ray were current or ex-smokers, and three of the four were between 40 and 50 years of age. Two of these participants had been employed at Oglebay Norton Industrial Sands (Central Silica Company) for over 15 years, and two were employed for 20 years or more.

The availability of recent (1993) ILO classification sheets for all 37 eligible current workers from company records permits a comparison of the estimated prevalence of chest x-ray-defined silicosis from two different sources of information. Two (6%) of the 31 participating current workers had x-ray evidence of silicosis (defined as small

opacity profusion 1/0 or greater) based on company records. The prevalence of silicosis among the same current workers who chose to participate in the NIOSH evaluation was 13% (4/31). The difference may be a function of (a) the difference in methodology (i.e., use of the median classification from 3 B Readings versus classification by a single B Reader), or (b) progression of disease since the time of the company chest x-ray in 1993.

A population prevalence estimate based on the results from a sample of volunteer participants may result in an over-estimate if those who choose to participate are less healthy than those who do not participate. Available data on age and tenure of this workforce, however, suggest that 12% may be an under-estimate, since non-participants had a higher median age and tenure. The study population prevalence of x-ray defined silicosis among the 49 eligible current and former workers could range from 8% - 31% depending upon the source of information (company records or the NIOSH evaluation) and number of cases counted from each source. An explanation of how these upper and lower boundaries on the estimate were obtained follows.

Two currently working participants, one of the six non-participating current workers, and one of the 10 non-participating former workers had x-ray evidence of silicosis based on company records. Assuming the remaining nine non-participating former workers (one who had no records available and eight who did not have an ILO classification) had no radiographically-defined evidence of silicosis, yields the lower boundary of the prevalence estimate, 8%(4/49).

To determine the upper boundary of the prevalence estimate, both sources of information were used to count the number of cases. Assuming the one non-participating former worker with missing records had x-ray evidence of silicosis, and the eight other non-participating former workers developed clinically apparent disease since the time of their last company chest x-ray, and including the four cases found during the NIOSH evaluation and the two cases from company records, yields the highest estimate, 31% (15/49).

Excluding maintenance workers (8 participants and 6 non-participants), who were included in the study population based on reported intermittent exposure, would have the effect of lowering to 35 the number of employees in the study population as a whole, and raising the estimated prevalence to 17% (6/35) when cases are counted using information from both company records and the NIOSH evaluation. Using the same process and assumptions described previously for determining the upper and lower boundaries on the prevalence, the estimated population prevalence could range from 11% (4/35) to 43% (15/35). The "true" prevalence for the study population lies somewhere within the ranges presented.

Generally, testing of active workers or recently active workers can result in an under-estimation of prevalence due to a "healthy worker survivor effect." This effect, or bias, is a pattern typically found in working populations where healthy people are employed and remain employed, while individuals who are less healthy tend not to be employed in the first place, and those who become ill tend to leave employment over time. The median tenure of both participants and non-participants is indicative of a low turn-over rate. Additionally, cases of silicosis that may have occurred among deceased former workers were not included in this evaluation. These factors, coupled with the low participation rate among eligible former workers (17%), and the study design itself, may have reduced the likelihood of identifying more cases of silicosis.

Occupational exposures to mineral dust have been associated with airflow limitation and chronic obstructive pulmonary disease.[26,29,30] Published

studies suggest that pulmonary impairment, which may be greater among dust-exposed workers who also smoke, is associated with both cigarette smoking and cumulative dust exposure, irrespective of the presence or absence of abnormalities detected on a chest x-ray.[26,30,31,32] Pulmonary function testing revealed that eight (24%) of the 33 participants had abnormal spirometry patterns. Abnormal pulmonary function test results were identified among three of the four participants with a positive chest x-ray, including both who had progressive massive fibrosis. The most frequently reported chronic symptom was dyspnea (shortness-of-breath), and chronic symptoms appeared related to cigarette smoking. None of the participants with a positive chest x-ray reported a chronic symptom. Among the eight participants with abnormal spirometry patterns, only two reported a chronic symptom.

Cases of silicosis are not rare events among workers currently or formerly employed at facilities that produce ground silica; workers at these facilities are, and have been historically, considered to be at high risk for silicosis. A NIOSH evaluation at a silica mining and milling operation in 1979 found that 7 (27%) of 26 participating current and former workers with one or more years exposure had chest x-ray changes consistent with silicosis.[33] Three cases were identified among 15 current workers and four cases were identified among 11 former workers. The participation rate among all current workers (i.e., including those with less than 1 year of exposure) was 83% (25/30), and among former workers with one year or more exposure was 35% (11/31).

A similar evaluation at the same time at another silica mining and milling operation found that 17 (44%) of 39 participating current and former workers with one or more years exposure had chest x-ray changes consistent with silicosis; three cases were identified among 15 current workers and 14 cases were identified among 24 former workers.[34] The participation rate among all current workers was 73% (30/41), and among former workers with one year or more exposure was 47% (24/51).

In 1980, a NIOSH evaluation at a plant in New Jersey found six (13%) radiographically-defined cases of silicosis among 47 participating current and former workers.[35] Five out of the six cases identified during this evaluation were current workers. The participation rate for all current workers was 87% (26/30), and among former workers with one year or more employment since January 1, 1972 was 70% (21/30).

These previous investigations utilized similar procedures and the standard pneumoconiosis classification of the time, the 1971 ILO-U/C.[36] More recently, Johnson and Busnardo[37] described a case of silicosis in a maintenance mechanic employed from 1976 - 1981 at a plant that manufactures ground silica. By way of comparison, a 1985 study involving the classification (ILO-U/C 1971) of chest x-rays of 1422 blue-collar workers not exposed to dust or other respiratory hazards found only 3 (0.21%) chest x-rays with a median small opacity profusion of 1/0 or greater.[38] This study also found only one chest x-ray with irregular small opacity profusion of 1/0, and no chest x-rays with rounded small opacity profusion of 1/0 or greater among over 700 males.

In the present evaluation, the predominant shape of small opacities on two of the four positive chest x-rays was rounded, a third was "mixed," and the fourth showed predominantly irregular small opacities. Although all of the participants with a positive chest x-ray were "ever" smokers, cigarette smoking alone would not explain all of the observed chest x-ray abnormalities. There is little evidence that smoking without occupational dust exposure results in pneumoconiosis-like opacities, and the smoking-related opacities that

have been observed have been predominantly irregular, not rounded.[39]

MSHA's current silica dust standard came into effect July 1974. Since that time MSHA has documented periods of non-compliance with its respirable silica dust standard at the Glass Rock operation (see Appendix I, Attachment 2). In addition, as reported in the MSHA environmental study, during the period 1988 to January 1994, 63% (31/49) of personal samples collected by MSHA inspectors in the mill area or affected downstream operations were citable under the MSHA standard for respirable crystalline silica.[40] Two participants with a positive chest x-ray began working at Glass Rock one year or less before July 1974 and two began working after July 1974. All four of these participants reported over 15 years of tenure. Three of the four participants with a positive chest x-ray reported previous work at other dusty jobs. One of these participants had prior employment of a length (> 5 years) that may have made a major contribution to radiographic signs of silicosis; although the degree to which this participant's prior dust exposure contributed to the abnormalities seen on his chest x-ray is not known. The development of chest x-ray abnormalities is known to be related to both duration of exposure and to intensity of exposure, together known as cumulative exposure. A relationship between exposure to increasing levels of silica dust and the prevalence of chest x-ray evidence of silicosis is accepted, although the precise relationship is unknown.[26,41]

Routine medical monitoring has been available to employees of the Glass Rock operation since 1980, is offered approximately every two years, and is currently known to include only one of the screening tests (a chest x-ray) recommended by both NIOSH and NISA. Spirometry, screening for TB, and a medical and occupational history were not reported to be part of this routine medical monitoring. Pre-placement baseline medical examinations include a medical questionnaire, spirometry, and TB skin testing. Pre-placement and annual medical examinations which include medical and occupational history, chest x-ray, and spirometry are recommended by NIOSH for all workers who manufacture, use, or handle ground silica or materials containing ground silica.[7] NISA guidelines recommend a physical examination, medical and occupational history, and pulmonary function testing prior to job placement and periodically.[8]

CONCLUSIONS

Four (12%) of the 33 survey participants who met the study criterion (one year or greater cumulative tenure since 1970 in the grinding area of the mill or in areas downstream of the grinding process) were found to have changes on their chest x-ray consistent with silicosis. The prevalence among current workers was 13% (4/31). Two of these four participants had PMF and little to no exposure to fibrogenic dust at other jobs. Available data on age and tenure from company records suggest that 12% may be an under-estimate as applied to the study population as a whole.

It is reasonable to conclude that the abnormalities seen on these chest x-rays are attributable to past silica dust exposure at this facility. This conclusion is supported by MSHA documentation of prior periods of non-compliance with its respirable silica dust standard at the Glass Rock operation. Additionally, one cannot conclude that current silica dust exposure levels are without adverse effect given the long latency usually associated with chronic nodular silicosis and the historically high risk of developing chest x-ray abnormalities consistent with silicosis among workers employed at facilities that produce ground silica. Employees without detectable disease at the time of the 1994 NIOSH survey may be at risk of developing silicosis in the future, considering the MSHA-documented exposures from 1988 to January 1994.

RECOMMENDATIONS

The following recommendations are based on findings of the medical evaluation conducted by NIOSH at Oglebay Norton Industrial Sands, Inc., MSHA regulations, and NIOSH policy. Recommendations regarding primary prevention through environmental controls will be provided by MSHA in a separate report.

1. A medical examination and screening tests should be available to all workers prior to job placement and annually thereafter.[7,23,42] However, medical monitoring should not be used as a substitute for environmental controls to reduce worker exposure to crystalline silica. Both pre-placement and annual medical examinations should include at a minimum:[7,23,42]

A. A medical and occupational history to collect data on worker exposure to crystalline silica dust, signs and symptoms of respiratory disease, and information on cigarette smoking. This information should be collected from an employee by the health care professional conducting the examination.

B. A chest x-ray (posterior-anterior 14" x 17"), preferably obtained using a high kilo-voltage technique, and classified by a B Reader according to the 1980 International Labour Organization (ILO) International Classification of Radiographs of Pneumoconioses. Film quality and technique should conform to specifications outlined by Wagner et al.[43]

C. Pulmonary function tests, including forced vital capacity (FVC) and forced expiratory volume at one second (FEV_1), using equipment and methods consistent with ATS recommendations.[44]

D. Skin testing for tuberculosis (TB)[45,46], with appropriate follow-up for definitive diagnosis and medical treatment, as indicated. The association of TB with silicosis and silica exposure is well-known.[26,47] Skin testing procedures should be in accordance with CDC guidelines.[48,49]

2. Continue to refer any employee with chest x-ray abnormalities, and also refer those employees who have abnormal spirometry and/or symptoms of respiratory distress (e.g., shortness-of -breath), for a more thorough medical evaluation. The evaluation should be conducted by a physician qualified to advise the employee and company whether work-related exposure to silica dust at the Glass Rock operation would be associated with increased risk of impairment of respiratory health.

3. Each employee should receive a written copy of his medical examination results in full detail, whether or not the results are abnormal. Results should be provided directly to the employee by the medical facility or contractor responsible for the examination, and employees should have the opportunity to review the results with a health care professional at the time the employee receives them.

4. Medical records should be maintained separately from personnel records and in a confidential manner, and access should be limited to health care personnel.

5. Continue to record work history information in a standard manner. Particular attention should be paid to the accuracy and completeness of the data collected, and the record should be up-dated on a regular basis.

6. All cases of silicosis should be reported to MSHA by the company, and to the Ohio Department of Health by the examining physician, health care provider, contractor, and/or radiologist,

as required. MSHA requires operators to report any miner with small opacity profusion of 1/0 or greater on chest x-ray, or a diagnosis of silicosis, or an award of compensation. Silicosis is a reportable condition in the state of Ohio.[50,51] To enhance the uniformity of reporting, NIOSH has developed reporting guidelines and a surveillance case definition for silicosis (Appendix II). This definition and guidelines are recommended for surveillance of work-related silicosis by State health departments and regulatory agencies receiving reports of cases from physicians and other health care providers.[12]

7. Changes in lung function may be accelerated by occupational exposure to respirable mineral dust in combination with cigarette smoking.[26, 31] For this reason, and to protect non-smokers from exposure to environmental tobacco smoke, a plant-wide no-smoking policy and smoking cessation program should be implemented if one is not already in place.[52]

8. X-rays of the back should be eliminated from the pre-employment physical. Such x-rays are of little value in controlling or predicting back injury and expose employees to unnecessary radiation.[53]

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Table 1
Study Population and Participation Rate By Employment Status
Oglebay Norton Industrial Sands, Inc.
HETA 93-0791

Workers Eligible For Study					
Employment Status	N	Total # Eligible	Number of Participants	Number of Non-Participants	Participation Rate (%)
Current Worker	54	37	31	6	84
Former Worker	51	12	2	10	17
Total	105	49	33	16	67

Table 2
Chest X-ray Results by Reader for 33 Participants
Oglebay Norton Industrial Sands, Inc.
HETA 93-0791

READER A			READER B			READER C			MEDIAN	
Profusion Zone(s)*	Size/Shape		Profusion	Size/Shape	Zone(s)	Profusion Zone(s)	Size/Shape		Profusion	Film Quality
0/0			1/2	st	All	0/0			0/0	1
0/0			1/1	pp	All	0/0			0/0	1
0/0			0/0			0/0			0/0	1
0/0			0/0			0/0			0/0	1
1/1	rq	1,2,4,5	1/1, A	pq	All	1/1, B	rq	1,2,4,5,6	1/1 @	1
0/0			0/0			0/0			0/0	1
1/0	st	2,3,5,6	1/2	st	2,3,5,6	0/0			1/0	1
0/0			1/1	st	2,3,5,6	0/0			0/0	1
0/0			1/1	st	2,3,5,6	1/0	rr	1,4	1/0	1
0/0			1/1	st	All	0/0			0/0	1
0/0			1/0	st	2,3,5,6	0/0			0/0	1
0/0			0/0			0/0			0/0	1
0/0			1/0	ss	2,3,5,6	0/0			0/0	2
0/0			0/0			0/0			0/0	1
0/0			0/0			0/0			0/0	1
0/0			0/0			0/0			0/0	1
0/0			0/0			0/0			0/0	1
0/0			1/1	st	2,3,5,6	0/0			0/0	1
0/0			1/0	ps	All	0/0			0/0	1
0/0			1/1	pp	All	0/0			0/0	2
0/0			0/0			0/0			0/0	1
0/0			0/0			0/0			0/0	1
0/0			0/0			0/0			0/0	1
0/0			1/1	st	2,3,5,6	0/0			0/0	1
UR			1/1	st	2,3,5,6	0/0			0/0	3**

Table 2 (continued)
Chest X-ray Results by Reader for 33 Participants
Oglebay Norton Industrial Sands, Inc.
HETA 93-0791

READER A			READER B			READER C			MEDIAN	
Profusion	Size/Shape	Zone(s)*	Profusion	Size/Shape	Zone(s)	Profusion	Size/Shape	Zone(s)	Proofusion	Film Quality
1/1 ,B	rt	1,2,4,5	1/1, C	pq	1,2,4,5	1/0, C	rr	1,4	1/1, C @	1
0/0			1/1	ps	All	0/0			0/0	1
0/0			1/0	ss	2,3,5,6	0/0			0/0	2
0/0			1/1	st	2,3,5,6	0/0			0/0	1
0/0			1/1	st	All	0/0			0/0	1
0/0			0/0			0/0			0/0	1
0/0			0/0			0/0			0/0	1
0/0			0/0			0/0			0/0	1

* 1, 2, and 3 correspond to the right upper, middle, and lower zones, respectively; while 4, 5, and 6 correspond to the left upper, middle, and lower zones.

** The additional small opacity profusion classification was 0/0 with a film quality score =3. The median column incorporates this additional reading.

@ Progressive Massive Fibrosis without a consensus on size.

Table 3
Age and Length of Employment from Company Records
by Participation and Employment Status
Oglebay Norton Industrial Sands, Inc.
HETA 93-0791

CHARACTERISTIC	PARTICIPANTS		NON-PARTICIPANTS	
	Current Worker N = 31	Former Worker N = 2	Current Worker N = 6	Former Worker N = 10
Age (yrs) [median]	43	40	45	74*
Range (yrs)	29 - 62	__@	33 - 55	61 - 79
Tenure (yrs) [median]	17	8	21	23
Range (yrs)	4 - 30	__@	6 - 30	4 - 46

* Age missing for 3 non-participating former workers
@ Cell size too small (N=2)

APPENDIX I

PROTOCOL
MSHA/NIOSH GROUND SILICA MILL STUDY

This protocol describes a joint Mine Safety and Health Administration (MSHA) and National Institute for Occupational Safety and Health (NIOSH) project to study silica exposure and the prevalence of silicosis in workers in ground silica mills. MSHA selected the mill portions of nine ground silica operations, based on one or more of the following criteria: (1) one or more outstanding violations of MSHA's respirable silica standard and a history of overexposure to respirable silica; (2) size of the mills, both large and small, based on number of employees; (3) use of advanced control technology; and (4) a representative number of ground silica mills from each Metal and Nonmetal Mine Safety and Health District. Nine mills were chosen for the study rather than all sixteen because of the two year time frame (fiscal years 1993 - 1995) planned to complete the study. A list of the sixteen mills is provided in Attachment 1 and a list of the nine selected mills is given in Attachment 2. Noncompliance with MSHA's respirable silica standard is indicated on the attachments.

In late 1991, when the selection was made, six of the sixteen mills were selected using criteria number one. U.S. Silica Company's Berkeley Mill and Columbia Mill, and the Nicks Silica Company Mill had no outstanding respirable silica violations. The Berkeley Mill uses many advanced controls and is the largest mill. The Columbia Mill, a large mill and Nicks Silica Company, a small mill in MSHA's Southeastern District, were selected using criteria number two and four. There are ground silica mills in four of the six Metal and Nonmetal Mine Safety and Health Districts and each of these four Districts are represented in the study. Three mills were selected from the South Central District and North Central District, two mills were selected from the Southeastern District, and one mill was selected from the Northeastern District.

MSHA will evaluate silica dust exposures in the 9 selected ground silica mills. NIOSH will estimate the prevalence of silicosis in active and former workers in the same 9 mills. At the completion of the study, MSHA will issue a report on findings of each mill and a summary of all mills.

I. BACKGROUND

Ground silica particles are hazardous due to their respirable size and high concentration of crystalline silica, a known cause of nonmalignant respiratory disease (silicosis) and possible cause of lung cancer. A NIOSH feasibility study of the adequacy of company records for a proposed NIOSH study of silicosis was released in 1990. Examination of four industrial sand facilities' B Reader reports found 27% of workers with > 20 years work experience had small opacities on x-ray.[1] The feasibility study was of industrial sand mills of which ground silica was a subset.

II. PROTOCOL OBJECTIVES & METHODS

The following protocol describes the joint MSHA/NIOSH study and identifies responsibilities for each part of the project.

1. NIOSH and MSHA will inform management and employee representatives about the project prior to initiation.

(a) Entrance and close-out meetings will be held with local management and employees or employee representatives at each site.

(b) All current and former employees will receive invitations from NIOSH to participate in the medical portion of the study.

2. NIOSH will radiographically examine current and former employees at the 9 selected ground silica mills for evidence of silicosis.

(a) Posterior-anterior radiographs will be taken, randomly mixed, and independently classified for pneumoconiosis according to the 1980 ILO system by two NIOSH certified B Readers. If the two readings do not agree on small opacity profusion, a third reading will be obtained and the median reading will be used to define an abnormality. A chest x-ray showing opacities of profusion category $\geq$ 1/0 in a ground silica mill worker will be categorized as consistent with silicosis. The B Readers will not be informed of any exposure history and the films will be masked of identifying information. The same three B Readers will be used throughout the entire project.

(b) Participants with a recent chest x-ray (within 1 year of the current NIOSH survey) may provide the chest x-ray to NIOSH to be read, rather than have a new chest x-ray taken during this evaluation.

(c) All participants will receive written notification of their chest x-ray results. Persons found to have abnormal chest x-rays will be encouraged to consult their personal physician.

3. NIOSH will administer a questionnaire which elicits occupational history, demographic information, respiratory symptoms, and smoking history.

4. NIOSH will obtain pertinent records held by the companies.

(a) NIOSH will copy pertinent medical and personnel records

(b) Review company medical records for diagnoses suggestive of silicosis.

(c) Collect personnel records showing detailed work histories for current and former workers.

5. NIOSH will evaluate the pulmonary function status of the participants through spirometry testing.

(a) Spirometry will conform to the American Thoracic Society's criteria for screening spirometry.

(b) All participants will receive written notification of their spirometry results. Persons found to have abnormal results will be encouraged to consult their personal physician.

6. MSHA will determine exposure levels of employees at the 9 ground silica mills.

   (a) Obtain and compare records of past respirable silica dust sampling performed by MSHA and the ground silica mill operators.

   (b) Sample all job classifications in the mill portion of the nine selected ground silica mills.

   (c) Cite, under MSHA regulations, any overexposure to respirable silica dust determined from MSHA samples.

7. MSHA Technical Support will evaluate the effectiveness of dust controls in the selected mills.

   (a) Observe and measure the performance of dust controls. Evaluate maintenance, housekeeping and work practices and how they effect dust control.

8. MSHA will evaluate respiratory protection programs at the 9 ground silica mills.

   (a) Evaluate respiratory programs to determine if they meet the minimum requirements of ANSI Z88.2-1969, Practices For Respiratory Protection, as mandated by Title 30 CFR, Part 56.5005, when respirators are required. The minimum requirements are listed in Attachment 3.

9. NIOSH and MSHA will report results of their surveys as follows:

   (a) NIOSH reports will summarize findings of medical surveys, including the prevalence of silicosis among participants overall, by mill, job, and tenure if feasible.

   (b) MSHA will issue reports combining findings of NIOSH and MSHA for each of the 9 mills selected as well as a summary report.

   (c) Each agency will review and comment on all reports prior to release.

   (d) Individual mill reports and summary report will be provided to the industry associations, national unions representing workers in the ground silica industry, participating mill management and employee representatives, and other interested parties.

III. STUDY POPULATION

All current (estimated 332) and former workers (estimated number unknown) of the 9 mills to be studied will be invited to participate. No further follow up will be made to eligible individuals who do not participate.

ADDENDUM: FURTHER STUDIES OF TWO SOUTHERN ILLINOIS GROUND SILICA MILLS PREVIOUSLY STUDIED BY NIOSH IN 1979 (11-01982 AND 11-02051)

I. BACKGROUND

In 1979, NIOSH was requested to provide Technical Assistance to MSHA at two ground silica mills.[2,3] Through medical and environmental surveys, NIOSH determined that a significant health hazard existed at these mills due to overexposure to respirable quartz. Forty-four percent of workers with greater than a year experience in one mill were found to have x-ray evidence of silicosis. Twenty-seven percent of the workers with similar work histories in the other mills were also found to have x-ray evidence of silicosis. Of 65 current and former workers with ≥1 year exposure studied in the two mills, 7 cases of progressive massive fibrosis were discovered by NIOSH.

In response to these findings, NIOSH in 1981 issued Current Intelligence Bulletin 36, "Silica Flour: Silicosis (Crystalline Silica)", describing a significant respiratory hazard in silica flour mills from respirable quartz.[4]

II. OBJECTIVES AND METHODS

1. NIOSH will estimate the incidence of new cases of silicosis among workers at the two mills.

    (a) The x-rays of current and former employees of the two mills will be compared with those previously taken in 1979 to identify any new cases of silicosis developing since 1979.

2. NIOSH will compare the prevalence estimates of silicosis found in the 1979 Technical Assistance surveys of two southern Illinois ground silica mills to the current estimates of prevalence for those two mills.

    (a) Methods 2 (a) and (b) discussed in the study protocol.

    (b) Reclassify the x-rays taken by NIOSH in 1979 at these two mills according to the 1980 ILO classification system. (The films taken in 1979 were classified used the 1971 ILO classification system). The B Readers will not be made aware when more than one film on an individual is to be classified. The films will be randomly mixed and classified independently. The same three B Readers will be used throughout the entire project.

3. NIOSH will evaluate the change in spirometry results among the workers previously examined in 1979.

    (a) Compare an individual worker's 1979 spirometry results to those obtained in this study.

4. NIOSH will review the implementation of recommendations made in the 1979 NIOSH Technical Assistance survey reports (HETA Nos. 79-103-108 and 79-104-107). The following recommendations were made: engineering and work practice improvements to reduce free silica exposures below the NIOSH REL; periodic environmental monitoring of silica exposures by the operator; respiratory protection while the effectiveness of the engineering controls are evaluated; all workers exposed to silica dust not examined in the NIOSH study should undergo comprehensive medical examinations; workers with radiographic evidence of silicosis should be given the opportunity to transfer to jobs without silica exposure; current workers with pulmonary function impairment be evaluated by a qualified physician and advised whether to continue in a dusty trade; medical examinations should be performed at first exposure to silica dust and at yearly intervals; bagged silica flour should be correctly labeled and contain appropriate health warnings.

    (a) Review company industrial hygiene records.
    (b) Review company respiratory protection program.

(c) Review employee medical and personnel records.
(d) Review product bag labels.

III . REFERENCES

1. Amandus H [1990]. A feasibility study of the adequacy of company records for a proposed NIOSH study of silicosis in industrial sand workers. Final report to Director, NIOSH. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Division of Respiratory Disease Studies, DHHS (NIOSH).

2. NIOSH [1979]. Hazard evaluation and technical assistance report: Tammsco, Incorporated: Tamms, Illinois. Morgantown, WV: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 79-104-107.

3. NIOSH [1979]. Hazard evaluation and technical assistance report: Illinois Minerals Company: Elco, Illinois. Morgantown, WV: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 79-103108.

4. NIOSH [1981]. Current Intelligence Bulletin 36: silica flour; silicosis (crystalline silica). Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 81-137.

ATTACHMENT 1

GROUND SILICA MILLS - 1991

	Northeastern District		Employees
46-02805	U.S. Silica Co.	Berkeley Plant	102
	Southeastern District		
38-00027	Spartan Minerals Co.	Pacolet Mill	21
38-00138	U.S. Silica Co.	Columbia Plant	50
38-00299	Unimin Corp. Unimin-Lugoff	19	
40-02937	Nicks Silica Co.	Nicks Silica Co.	13
	North Central District		
11-01013	U.S. Silica Co.	Ottawa Plant	94
11-01580	Unimin Corp. Troy Grove Plant	18	
11-01981	Unimin Specialty Min.	Plant (NC)	30
11-02051	Unimin Specialty Min.	Plant/Mill (NC)	22
33-01354	Central Silica Co.	Glass Rock Quarry (NC)	34
33-01355	Central Silica Co.	Millwood Sand Div.	25
	South Central District		
03-00299	Malvern Minerals	Malvern Minerals Sandstone (NC)	19
23-00504	American Tripoli, Inc.	American Tripoli, Inc. (NC)	12
23-00544	U.S. Silica Co.	Pacific Plant	30
34-00377	U.S. Silica Co.	Mill Creek Plant (NC)	50
41-01059	Unimin (Texas) Corp.	Unimin (Texas)	20

NC - Noncompliance

ATTACHMENT 2

GROUND SILICA MILLS - 1991

	Northeastern District		Employees
46-02805	U.S. Silica Co.	Berkeley Plant	102
	Southeastern District		
38-00138	U.S. Silica Co.	Columbia Plant	50
40-02937	Nicks Silica Co.	Nicks Silica Co.	13
	North Central District		
11-01981	Unimin Specialty Min.	Plant (NC)	30
11-02051	Unimin Specialty Min.	Plant/Mill (NC)	22
33-01354	Central Silica Co.	Glass Rock Quarry (NC)	34
	South Central District		
03-00299	Malvern Minerals	Malvern Minerals Sandstone (NC)	19
23-00504	American Tripoli, Inc.	American Tripoli, Inc. (NC)	12
34-00377	U.S. Silica Co.	Mill Creek Plant (NC)	50

NC - Noncompliance

ATTACHMENT 3

Minimum Requirements of ANSI Z88.2-1969

(1) The operator must establish a written standard operating procedure governing the selection and use of the respirator.

(2) The operator must select the respirators on the basis of the hazards to which the worker is exposed. The respirator must be MSHA/NIOSH approved for the specific hazards.

(3) The respirator user shall be instructed and trained in the proper use of respirators and their limitations. The minimum training shall include the following (as quoted from ANSI Z88.2-1969):

a. Instruction in the nature of the hazard, whether acute, chronic, or both, and a complete appraisal of what may happen if the respirator is not used.

b. Explanation of why more positive control is not immediately feasible. This shall include recognition that every reasonable effort is being made to reduce or eliminate the need for respirators.

c. A discussion of why this is the proper type of respirator for the particular purpose.

d. A discussion of the respirator's capabilities and limitations.

e. Instruction and training in actual use of the respirator (especially a respirator for emergency use) and close and frequent supervision to ensure that it continues to be properly used.

f. Classroom and field training to recognize and cope with emergency situations.

g. Other special training as needed for special use.

Training shall provide the employees an opportunity to handle the respirator, have it fitted properly, test its facepiece-to-face seal, wear it in normal air for a long familiarity period, and, finally, to wear it in a test atmosphere.

(4) Fit testing

All respirator wearers must be fit tested before using negative pressure respirators. ANSI Z88.2-1969 does not require fit testing of positive pressure respirators. Use a validated protocol for fit testing.

(5) The operator must keep records to show that the proper respirator was issued to the respirator wearer. This is usually accomplished by recording the fit test results for each wearer, along with the date that the wearer received the respirator.

(6) Respirators shall be cleaned and disinfected. Respirators used routinely shall be inspected during cleaning. Worn or deteriorated parts shall be replaced to maintain MSHA/NIOSH approval. ANSI states that cleaning and maintenance shall be done "as frequently as necessary to ensure proper protection is provided to the wearer."

(7) Emergency-use respirators must be thoroughly inspected at least once per month and after each use. Keep a record of the inspection dates and findings.

(8) Respirators shall be stored in a convenient, clean and sanitary location. The respirators must be stored in a manner that protects them against contamination, temperature extremes, and other potentially damaging conditions.

(9) A single individual must administer the respiratory protection program. This individual shall regularly evaluate the effectiveness of the program. Monitoring will be conducted regularly to ensure that the selected respirators continue to provide appropriate protection to the wearer.

ATTACHMENT 4

PART II 2 (a) OBJECTIVES AND METHODS

Posterior-anterior radiographs will be taken, randomly mixed, and independently classified for pneumoconiosis according to the 1980 ILO system by three NIOSH certified B Readers. The median reading will be used to report an abnormality. A chest x-ray showing opacities of profusion category $\geq$ 1/0 in a ground silica mill worker will be categorized as consistent with silicosis. The B Readers will not be informed of any exposure history. The films will be masked of identifying information. The same B Readers will be used throughout the entire project.

APPENDIX II [12]

SURVEILLANCE GUIDELINES: SILICOSIS

Reporting Guidelines

State health departments and regulatory agencies should encourage physicians (including radiologists, pathologists, and other health care providers) to report all diagnosed or suspected cases of silicosis. These reports should include persons with

-- a physician's provisional or working diagnosis or silicosis, OR

-- a chest radiograph interpreted as consistent with silicosis, OR

-- pathologic findings consistent with silicosis

To set priorities for workplace investigations, State health departments and regulatory agencies should collect appropriate clinical, epidemiologic, and workplace information about persons reported to have silicosis.

Surveillance Case Definition

A. 1. History of occupational exposure to airborne silica dust

AND

2. Chest radiograph or other imaging technique interpreted as consistent with silicosis

OR

B. Pathologic findings characteristic of silicosis