HETA 93-0797-2624
Nicks Silica Company
Jackson, Tennessee

Margaret Filios, RN, ScM

PREFACE

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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, 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 Terry Stewart.

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Health Hazard Evaluation Report 93-0797-2624

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Jackson, Tennessee
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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 at specific ground silica operations by conducting a medical evaluation of active and retired miners.

On June 28-30,1993, NIOSH conducted a medical survey at Nicks Silica Company in Jackson, Tennessee. The survey included a questionnaire, spirometry, and a single view posterior-anterior (PA) chest x-ray. The criterion for inclusion in the study population was one year or greater cumulative tenure since the opening of the mill in the grinding area, or in areas downstream of the grinding process.

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. None of the 12 current and former workers who participated in the medical survey had changes on their chest x-ray consistent with silicosis. Pulmonary function testing revealed one (8%) participant with an abnormal spirometry pattern. Three participants reported chronic respiratory symptoms. All four participants with positive findings were current cigarette smokers.

There was no radiographic evidence of silicosis among participating current and former workers at Nicks Silica Company. However, because of the long latency usually associated with chronic nodular silicosis, this finding is not sufficient to conclude that current silica dust exposure levels are without adverse effect. In addition, the low participation rates among current and former workers (69% and 38%, respectively), and the small size of the study population severely limits the ability to make any meaningful comparisons, or draw conclusions concerning the medical test results.

The medical monitoring program can be improved. Recommendations for modification of the program are presented in this report and include classification of chest x-rays by a B Reader according to the 1980 International Classification of Radiographs of Pneumoconioses.

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

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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 at specific ground silica operations by conducting a medical evaluation of active and retired miners.

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). Briefly, 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 a final report of the NIOSH medical evaluation conducted at Nicks Silica Company in Jackson, Tennessee.

On the morning of June 28, 1993, an opening meeting was held with company representatives and a representative from MSHA to discuss the evaluation. The meeting concluded with a walk-through of the plant. Medical testing of workers began that afternoon and the survey concluded on June 30, 1993. All study participants received written notification of their spirometry results in July, 1993. All chest x-rays were promptly reviewed by a pulmonary physician to identify 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 February 1994.

BACKGROUND

Nicks Silica Company began operation in 1986. Raw material is dredged from a nearby lake and transported by truck to the plant for processing. At the plant, the material is dried and processed as whole grain sand or sent to the mill for grinding. Products are then either bulk loaded into dedicated railcars, tanker trucks, or bags, or transferred by truck to a separate building for bagging and storage. At the time of the survey, the company employed approximately 24 employees (including salaried and temporary personnel). The plant operates production processes 24 hours a day, 5 days a week, with three 8-hour shifts. The departments that are part of the operation are Drying, Grinding, Bagging, Maintenance, and the Laboratory. Workers often share many of the same tasks in addition to their usual job duties (e.g., running the front-end loader or forklift, bagging, clean up, or assisting with maintenance). The job categories are Dryer Operator, Separator, Mill Operator, Bagger, Maintenance, Laboratory personnel, and Supervisory personnel (i.e., Warehouse Supervisor or Plant Superintendent).

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 at each operation 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, demographic characteristics and disease

status of participants and living non-participants who met the study criterion were compared using company records.

Study Population

The criterion for inclusion in the study population was one year or greater cumulative tenure subsequent to the opening of the mill, in the grinding area or in areas downstream of the grinding process. Company records were used to help determine employees' eligibility for inclusion in the study. Jobs within and downstream of the grinding circuit were ascertained using information from both the medical survey and company records and verified with MSHA.

Prior to the survey, letters inviting participation were mailed to current and former workers identified by the company as meeting the study criterion. During the survey, all current workers were invited to participate regardless of work area or length of employment to avoid inadvertent oversight of eligible current workers with prior experience in the areas of interest. Additionally, advertisements were placed in local newspapers to reach those workers who may have moved within the local area or otherwise did not receive a letter. No further follow-up was made to eligible workers who chose not to participate in the medical survey. 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]

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 (CWXSP). 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 (NSCWP) 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 is 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			2			3		
0/-	0/0	0/1	1/0	1/1	1/2	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
Round	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, or subsequent to the opening of a plant.

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 as part of 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.

The 1981 NIOSH recommendations for medical monitoring of workers exposed to ground silica (silica flour)[7], and 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

Each examined worker's test results were compared to the 95th percentile lower limit of normal (LLN) values obtained from Knudson's reference equations to identify participants with abnormal spirometry patterns of obstruction and restriction.[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 are 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] The 1977 NISA guidelines recommend a medical and occupational history, physical exam, and pulmonary function testing every two years. A chest x-ray is also recommended, although frequency is not discussed.[8]

Silicosis

Silicosis, a form of pneumoconiosis, is a chronic fibrotic pulmonary disease caused by the inhalation, deposition, and retention of dust containing crystalline silica.[9] Silicosis is usually diagnosed through chest x-ray and occupational history of exposure to silica-containing dust. Lung tissue reacts to the presence of silica dust in the lung by forming nodules, which on chest x-ray typically appear discrete, round, and more prominent in the upper lobes, although other patterns have been described.[7,10,11,12] Such radiographic abnormalities are often the first sign of silicosis. The following summarizes the clinical forms of the disease:

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.[7,9,11,13] 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.[7,14,15] Ground silica (silica flour) consists of essentially pure crystalline silicon dioxide (quartz) particles, of respirable size (<10 micrometers).[16,17] 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.[18,19]

A continuum is thought to exist between the chronic and accelerated forms of nodular silicosis. Factors determining the progression of disease are unclear.[12] Chronic silicosis (the presence of detectable, discrete, nodules <1cm 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.[9,10,20] 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. Radiographic abnormalities usually appear within 5-10 years.[20] 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.[9,10,20] 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.[7,9,21,22] On chest x-ray, the appearance is different from that of nodular silicosis, with very little of the typical nodular scarring.[7,13,15] Consequently, it may often be mis-diagnosed as pulmonary edema, pneumonia, or tuberculosis. Respiratory impairment is severe with acute silicosis, and the disease is usually fatal within a year of diagnosis.[13,15]

Both chronic and accelerated silicosis can become complicated by the development of infection and/or progressive massive fibrosis (PMF). Infections (i.e., tuberculosis and/or fungal infections) are believed to result from the inability of the overwhelmed lung scavenger cells (macrophages) to kill the organisms that cause these diseases.[23,24] 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.[9,10,11,13]

Evidence suggests that crystalline silica is a potential occupational carcinogen,[25-27] and NIOSH currently recommends that crystalline silica be treated as a potential occupational carcinogen.[28,29]

RESULTS

Participation

Of 24 current employees, 13 were eligible for entry into the study; nine (69%) participated in the medical survey. Of the estimated nine living former workers (from information provided by the company), eight were eligible for entry into the study, and three (38%) participated. The estimated total number of workers in the study population was 21: 12 were participants and nine were non-participants (Table 1). Records were not obtained for two participating former workers. In one instance, we were initially informed that the worker had been employed for less than one year and so no record was provided; later, we were given information on the worker's tenure and job and the worker was included in the study population based on this information and information obtained during the medical survey. In the second instance, the participant was included based upon information obtained during the medical survey.

Medical Survey

The following discussion of results concerns the 12 participants who met the study criterion.

DEMOGRAPHICS

All Participants

All 12 participants were men. Seven were white and five were African-American.

Current Workers

Among the nine current workers, the median age was 36 years, and ages ranged from 23 to 47 years. Current workers were employed for a median of two years. The reported number of years worked ranged between one and eight years. Seven of nine current workers were current smokers, and their median number of pack-years was 10 (one pack-year is equal to smoking an average of one pack per day for a year).

Former Workers

Of the three former workers, two were less than 30 years old and one was less than 40 years. All three were employed for less than five years, and all three were "ever" smokers (that is, either a current smoker or an ex-smoker). The number of pack-years ranged between six months and seven years. Five years or less had passed since two of the former workers had left employment at Nicks Silica Company, and less than one year had passed since the third worker reported leaving employment.

CHEST X-RAY RESULTS

None of the 12 participants had a chest x-ray considered consistent with silicosis. All of the chest x-rays were taken by NIOSH, and all 12 had a median quality score of one (the highest). Table 2 lists the chest x-ray results by Reader for all 12 participants.

PRIMARY JOB AND DUSTIEST JOB

Four of the participants reported holding their primary job (the job held for the longest period of time) as a Bagger, three as a Mill Operator, two reported Maintenance, one reported working as a Laborer, one reported working as a Welder, and one as a Dryer Operator. Both Bagger and Mill Operator were reported with equal frequency by participants as the single dustiest job at the plant.

OTHER DUSTY JOBS

Ten of the 12 participants reported previous work in occupations or industries other than a ground silica operation that might have been associated with exposure to fibrogenic dusts. Four reported working over 20 years at other dusty jobs, three reported working between 10 to 20 years, one worked between five and 10 years, and two reported working between one to five years at other dusty jobs. The two remaining participants reported never working at any other dusty job. The type of work reported included welding, construction, grinding metals, mining, and roadbuilding, among others.

CHRONIC SYMPTOMS

As defined in the "Methods" section of this report, one of the 12 participants reported symptoms of chronic cough, a second reported both chronic cough and chronic phlegm, and a third reported symptoms of chronic cough, phlegm, and dyspnea (shortness-of-breath). All three symptomatic participants were current smokers.

RESPIRATORY ILLNESSES AND CONDITIONS

Physician-diagnosed asthma and tuberculosis were each reported once. Other reported physician-diagnosed lung conditions were prior chest surgery and pneumonia. Eight participants reported no physician-diagnosed respiratory illness or condition.

SPIROMETRY

One participant, a current smoker, had spirometry results that fell below the normal range, exhibiting an obstructive lung pattern.

COMPANY RECORDS

Information on age, sex, and smoking history was obtained for 10 of the 12 participants, and information concerning tenure was obtained for 11 participants. This same information was obtained for all nine of the non-participants. Table 3 presents data by employment status for the currently working participants and all of the non-participants. Because of the small number and limited data obtained for former workers who participated (a single record), this information is not presented.

The four eligible non-participating current workers were slightly older than their participating counterparts (median 44 years versus 37 years), and were employed for a slightly longer period of time (median of five years versus three years). Among those former workers for whom data are presented, the median age was 32 years and the median tenure was two years.

Data regarding race was available from the company records for all of the non-participants and eight of the 12 participants. Of the nine non-participants, company records indicated that four were African-American and five were white; three of eight participants were African-American and five were white. Information on prior work was available for the entire study population except the two participants for whom we had no records. However, in a few instances it was not clear from the jobs listed or from the information obtained whether or not there was a potential for dust exposure. Records of five participants and two non-participants indicated work in prior jobs with a potential for dust exposure.

Company records contained only clinical radiology reports from which silicosis might be ascertained. Chest x-ray results were obtained for 10 (83%) of the 12 participants and all nine non-participants. None of the 19 employees for whom we had a report had results that met our established silicosis case definition (case definition 2). Sixteen of the 19 chest x-rays were taken in 1992 and read by two different radiologists. One chest x-ray was taken in 1990, and the two remaining chest x-rays were taken in 1989 and read by two other radiologists.

The company attempted to collect information in a standardized manner using three different forms: a detailed medical questionnaire (which contained questions concerning respiratory conditions and symptoms, smoking, and a medical and occupational history), a brief "Pulmonary History" questionnaire, and a form regarding an employee's fitness for respirator use. Not every employee for whom a record was obtained had all three forms on file. The first two forms appeared to be filled out by either a second party and/or the worker, and the third form was filled out by the examining physician. Although the records contained information as to current job assignment and length of that assignment at the time of the company evaluation, specific dates of different job assignments were not recorded on these forms. Dates of employment were provided by the company and in several instances contradicted tenure information found within the records themselves (e.g., the

date of hire or date of termination differed from the date or dates indicating when a particular form was filled out). Subsequently, the company had to be contacted several times to resolve the discrepancies and assemble a work history in these instances.

COMPANY MEDICAL MONITORING

Routine medical monitoring began in 1989. Company medical monitoring includes an initial employment examination (conducted approximately one month after the date of hire), and mandatory annual screening. At the time of the NIOSH survey, both the initial examination, or "silica physical," and the annual screening consisted of pulmonary function testing, a chest x-ray, and other biological testing (i.e., blood and urine). The pulmonary history questionnaire, and respirator fitness form were filled out at the time of the initial employment examination and on an annual basis. The detailed medical questionnaire was completed only at the time of the initial employment examination. Chest x-rays were reviewed by a radiologist, but were not classified for pneumoconiosis by a B Reader. Results of the initial employment and annual examinations were kept by the local clinic where the examinations were performed, and a copy was sent to an off-site company office where both medical and personnel records were separately maintained. The Vice President, Plant Superintendent, and an employee who appeared to function as both a lab technician and administrative assistant, had access to these records.

Currently, Nicks Silica Company is participating in NISA's voluntary Silicosis Prevention Program which was established in 1993 and consists of six elements that participating companies agree to implement.[30] One element involves the classification of chest x-rays by certified B Readers. At the time this report was written the company was working to implement this element of the NISA Program. A company representative stated that there have been some changes in the forms used to collect data, but could not recall what changes had been made. The company continues to receive a copy of medical examinations results, and access was reported to be limited to a single person (the Vice President). The company representative was unable to recall whether the medical records have continued to be maintained separately from personnel records, since employee records are now maintained on-site at the plant.

Eleven of the 12 participants reported taking part in the company medical monitoring. At the time of the medical survey, a company representative stated that employees were not notified of their individual test results. Only one participant was aware of his chest x-ray results.

DISCUSSION

None of the 12 current and former workers who participated in the medical survey had changes on their chest x-ray consistent with silicosis. Pulmonary function testing revealed one of the 12 participants had an abnormal spirometry pattern. Three participants reported chronic respiratory symptoms. All four of these participants were current cigarette smokers.

The chest x-ray results were not unexpected given the short period of time the company had been in operation. One would not expect to see chronic nodular silicosis develop in less than 10 years from the time of first exposure. The low participation rates among current and former workers (69% and 38%, respectively), and the small size of the study population severely limits the ability to make any meaningful comparisons, or draw conclusions

concerning these results.

Routine medical monitoring has been in place since 1989 and includes the medical tests (pulmonary function testing and posterior-anterior chest x-ray) recommended by NIOSH. The examinations are conducted within one month of hire and annually thereafter. Chest x-rays are not yet classified by a B Reader, and the "Pulmonary History" form that is filled out annually contains limited information.

CONCLUSIONS

There was no radiographic evidence of silicosis among participating current and former workers at Nicks Silica Company. However, because of the long latency usually associated with chronic nodular silicosis, this finding is not sufficient to conclude that current silica dust exposure levels are without adverse effect.

RECOMMENDATIONS

1. The medical monitoring program can be improved with the implementation of the six NISA Silicosis Prevention Program elements and concurrent conformation with the NIOSH medical surveillance recommendations for ground silica workers. It is recommended that the medical monitoring program be modified as follows:

   a) Conduct the first medical examination before an employee begins working, rather than one month after hire, and annually thereafter.

   b) Implement that element of the NISA Silicosis Prevention Program which calls for the classification of chest x-rays by a B Reader. Chest x-rays should be classified according to the 1980 International Classification of Radiographs of Pneumoconioses (or revision thereof, whichever is current at the time of the examination).

   c) A comprehensive medical and occupational history, similar to that collected on the current initial medical questionnaire, should be collected at the time of the annual examination. The questionnaire should be administered by a trained third party (preferably a health professional), rather than completed by the individual employee, each time it is completed.

   d) Provide for skin testing for tuberculosis (TB) of all employees,[31] with appropriate follow-up for definitive diagnosis and medical treatment, as indicated. The association of tuberculosis with silicosis and silica exposure is well known.

2. Collect work history information utilizing the forms found in the NISA Occupational Health Program (OHP) guidelines (either the current guidelines or the revised guidelines, once available). 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.

3. Each employee should receive a copy of the company medical examinations results in full detail, with the results reviewed with a health care professional at the time the employee receives their individual results.

4. Personnel and medical records should be maintained separately and in a confidential manner, with access to medical records limited to health care personnel. These records should be kept for at least 30 years following an employee's termination of employment.

5. The health care provider should be made aware of the NIOSH reporting guidelines and surveillance case definition for silicosis (Appendix II), as well as the company's requirement to report cases of silicosis to MSHA. The NIOSH 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.[11] MSHA requires operators to report any miner with a history of exposure to pneumoconiosis-producing dust with small opacity profusion of 1/0 or greater on chest x-ray, or a diagnosis of silicosis, or an award of compensation.

6. In accordance with the NISA Silicosis Prevention Program, a smoking cessation program should be implemented if one is not already in place.

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TABLE 1
Study Population and Participation Rate By Employment Status
Nicks Silica Company
HETA 93-0797

Employment Status	N	Total # Eligible	Number of Participants	Number of Non-Participants	Participation Rate (%)
Current Worker	24	13	9	4	69
Former Worker	9	8	3	5	38
TOTAL	33	21	12	9	57

TABLE 2
Chest X-Ray Results* by Reader for 12 Participants
Nicks Silica Company
HETA 93-0797

READER A			READER B			READER C			MEDIAN
Profusion	Size/Shape	Zone(s)**	Profusion	Size/Shape	Zone(s)	Profusion	Size/Shape	Zone(s)	Profusion
0/0			1/0	st	2356	0/0			0/0
0/0			1/0	st	2356	0/0			0/0
0/0			1/0	st	2356	0/0			0/0
0/0			0/0			0/0			0/0
0/0			1/0	st	2356	0/0			0/0
0/0			0/0			0/0			0/0
0/0			0/0			0/0			0/0
0/0			1/1	st	12356	0/0			0/0
0/0			0/0			0/0			0/0
0/0			0/0			0/0			0/0
0/0			0/0			0/0			0/0
0/0			0/0			0/0			0/0

* All 12 chest x-rays had a median film quality score of 1.
**1,2, and 3 correspond to the right upper, middle, and lower zones (refering to portions of the lungs), respectively; while 4, 5, and 6 correspond to the left upper, middle, and lower zones.

TABLE 3
Estimated Age, Length of Employment, and Cigarette Smoking Status
from Company Records by Participation and Employment Status
Nicks Silica Company
HETA 93-0797

	PARTICIPANTS		NON-PARTICIPANTS	
	Current Worker N = 9	Former Worker* N = 3	Current Worker N = 4	Former Worker N = 5
AGE (yrs) [median]	37	*	44	32
Range (yrs)	24 - 47	*	31 - 58	23 - 34
TENURE (yrs) [median]	3	*	5	2
Range (yrs)	1 - 7	*	3 - 7	1 - 4
CIGARETTE SMOKING	Number	Number	Number	Number
Ever Smoker	6	*	4	3
Never Smoker	3	*	0	2

* Company records obtained for 1 former worker. See text page 12.

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.

APPENDIX I (con't)

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.

APPENDIX I (con't)

(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 radiographs 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.

APPENDIX I (con't)

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.

APPENDIX I (con't)

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 $\geq$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.

APPENDIX I (con't)

III . REFERENCES

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APPENDIX I (con't)

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

APPENDIX I (con't)

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

APPENDIX I (con't)

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.

APPENDIX I (con't)

(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.

APPENDIX I (con't)

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 [11]

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

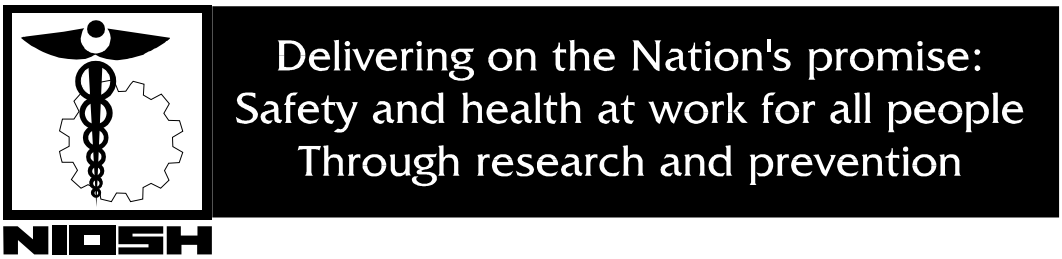
A. 1. History of occupational exposure to airborne silica dust

AND

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

OR

B. Pathologic findings characteristic of silicosis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