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**HETA 93-0792-2654
American Tripoli, Inc.
Seneca, Missouri**

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 Terry Stewart.

Copies of this report have been sent to employee and management representatives at American Tripoli, Inc.; Oil, Chemical and Atomic Workers, Local 5-500; Oil, Chemical and Atomic Workers International; Mine Safety and Health Administration; Missouri Department of Health; Newton County Health Department; National Industrial Sand Association; Glass, Molders, Pottery, Plastics & Allied Workers International; Laborers Health and Safety Fund of North America; and General Teamsters and Allied Workers. 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 93-0792-2654
American Tripoli, Inc.**

September 1997

Margaret Filios, RN, ScM

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 American Tripoli, Inc., a silica mine and mill in Seneca, Missouri. This operation employed a total of 17 individuals at the time of the NIOSH evaluation.

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 March 24, 1994, NIOSH conducted a medical evaluation of current workers. Former workers were examined on March 26, 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.

Nine of 11 eligible current workers, and nine of 28 eligible former workers participated in the NIOSH medical evaluation, and of these 2 (11%) had a chest x-ray considered consistent with silicosis. The prevalence was 11% (1/9) among currently working participants, and there was one case of silicosis among the nine former workers who participated. Both cases, one with a median small opacity profusion category of 1/0 and the other with a median category of 1/2, were employed at American Tripoli for over 15 years, and both reported employment at other dusty jobs. Pulmonary function testing revealed that two (12.5 %) of the 16 participants who performed spirometry had abnormal patterns, both obstructive.

The prevalence of x-ray defined silicosis was 11% (1/9) among currently working participants, and there was one case of silicosis among the nine former workers who participated. Although both of the identified cases at American Tripoli reported employment in dusty jobs with other employers, in the absence of further information it is reasonable to conclude that their chest x-ray abnormalities are attributable, at least in part, to past silica dust exposure at this facility.

Additionally, one cannot conclude from these findings that current silica dust exposure levels are without adverse effect given the short tenure of the eligible current workers and the long latency usually associated with chronic nodular silicosis. Medical surveillance recommendations are presented in this report and include modification of the pre-placement examination and annual medical monitoring offered by the company.

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

TABLE OF CONTENTS

Preface	ii
Acknowledgments and Availability of Report	ii
Summary	iii
Keywords	iv
Introduction	3
Background	3
Methods	4
Study Objective	4
Study Population	4
Data Collection	4
Posterior-Anterior Chest X- Ray	4
Spirometry	5
Questionnaire	6
Medical and Personnel Records	6
Medical Monitoring	6
Evaluation Criteria	6
Chest X-Ray	6
Spirometry	7
Questionnaire	7
Medical Monitoring	7
Silicosis	7
Results	9
Participation	9
Medical Evaluation	9
Demographics	9
Chest X-Ray Results	9
Primary Job and Dustiest Job	9
Other Dusty Jobs	10
Chronic Symptoms	10
Respiratory Illnesses and Conditions	10
Spirometry	10
Company Records	10
Current Workers	10
Company Medical Monitoring	11
Discussion	12
Conclusions	14

Recommendations	14
References	15
Table 1	19
Table 2	19
Table 3	20
Table 4	21
Appendix I	22
Appendix II	33

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 American Tripoli, Inc. in Seneca, Missouri. 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 D). 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 American Tripoli, Inc.

On March 9, 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 March 23, 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 March 24, 1994, the medical evaluation of current workers was conducted. Former workers were tested on March 26, 1994. All study participants received written notification of their spirometry results in April, 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 December, 1994.

BACKGROUND

American Tripoli began operation in 1871 as Monarch Tripoli. Over the years the plant has had numerous owners and names. In 1954, American Tripoli was owned and operated by the Carborundum Company. The plant was subsequently sold to Warburg Pincus, Inc. in 1982, and was acquired by NYCO Minerals, Inc. (the current owner) in December, 1986. At the time of the NIOSH evaluation, a total of 17 employees (including full-time and part-time clerical and salaried personnel) worked at the plant, 10 of whom worked in the grinding area of the mill or in areas downstream of the grinding process.

At this facility, tripoli (an ore containing microcrystalline quartz) is surface mined from four different sites and brought to the plant for processing where it is crushed, dried, milled, and bagged. The product is then loaded onto pallets and hauled to storage areas prior to shipment in railroad cars or trucks. The plant operates production processes 10 hours a day, 4 days a week, with some maintenance activities occurring on the fifth day. Three departments are part of the American Tripoli operation: Mining (or Quarry), Milling, and Maintenance. Job categories are Quarryman, Truck Driver/Loader Operator, Crusher Operator, Packer (operates a bagging machine and runs the forklift in the warehouse), Packer/Pallet Builder, Maintenance Man, and supervisory personnel (i.e., Plant Foreman and Quarry Foreman). Except for the Maintenance Man and the Crusher Operator, workers share the same tasks throughout the plant. MSHA has documented periods of non-compliance with the MSHA respirable silica dust standard at this facility in the past (see Appendix 1, Attachment 1 and 2).

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 the 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. Information obtained from the company (job and tenure) was 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 is subject to errors from recall. Jobs within and downstream of the grinding circuit were ascertained using information from both the medical evaluation and the company, and verified with MSHA.

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.

Using a roster provided by the company, letters were mailed inviting current and former workers to participate in the medical evaluation. 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⁾

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 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			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
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 (FEV₁) 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 FEV₁ /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⁾ NIOSH 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 NIOSH. 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, NIOSH 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⁾ NIOSH’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 in the lung 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 <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.^(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). 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.^(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 17 current employees, 11 were eligible for the medical evaluation; nine (82%) of the 11 participated. Of the estimated 28 former workers who were assumed to be living, 26 were eligible and nine (35%) of the 26 participated (Table 1). Thus, of 37 eligible workers, 18 participated and 19 were non-participants. The company reported that a fire in 1976 destroyed many records. Additionally, little formal documentation was kept of employee job assignments, other than transfers of personnel from hourly to salaried positions. The available information on job(s) and tenure was obtained for all current workers. Of the nine participating former workers, job and tenure was available only for four. Information on job was obtained for another two participants whom the company indicated worked at least one year since 1970, although exact tenure was unknown since their records were destroyed in the fire. Job and tenure information was not obtained for three participating former workers. These three participants were included in the study population based upon information gathered during the medical evaluation.

Medical Evaluation

The following discussion of results concerns the 18 participants who met the study criterion.

DEMOGRAPHICS

All of the participants were men, and the majority (94%) were white. Selected characteristics of the participants are presented in Table 2. Current and former workers differed primarily with regards to cigarette smoking status, pack-years (one pack-year is equal to smoking an average of one pack of cigarettes per day for a year), and tenure. Fewer current workers were “ever” smokers (that is,

either a current smoker or an ex-smoker) than former workers, but their median number of pack-years was more than two times that of the former workers. Former workers were employed for a shorter length of time (four years) than current workers (10 years). An average (mean) of 13 years had passed since former workers had left employment. The median number of years since leaving employment was 14, and former workers had left American Tripoli between four and 20 years prior to the time the NIOSH evaluation was conducted.

CHEST X-RAY RESULTS

Overall, 11% (2/18) of the participants had a chest x-ray considered consistent with silicosis; the prevalence among currently working participants was 11% (1/9). One former worker had a positive chest x-ray. The highest median ILO profusion category among the participants was 1/2. All of the chest x-rays were taken by NIOSH. Twelve had a median film quality score of 1 (the highest) and six had a median score of 2. Table 3 lists the chest x-ray results by Reader for all 18 participants. Both participants with x-ray evidence of silicosis were over 50 years of age, and both were employed in production at American Tripoli for over 15 years. Privacy concerns preclude reporting the specific primary job (the job held for the longest period of time) of either of the participants with a positive chest x-ray. One of the participants was an ex-smoker, and the other had never smoked cigarettes. The predominant shape of small opacities on both chest x-rays was rounded, and the upper zones were more affected in both cases.

PRIMARY JOB AND DUSTIEST JOB

Fourteen (78%) of the participants reported holding their primary job (the job held for the longest period of time) as a Packer or Packer/Pallet Builder, two reported Maintenance as their primary job, one worked as a Truck

Driver/Quarryman, and one reported working in a supervisory position. Working as a Packer, specifically bagging and tying 2000 pound bags or changing the bags in the dust collector, was reported by participants as the single dustiest job at the plant.

OTHER DUSTY JOBS

Twelve (67%) of the 18 participants reported previous work in occupations or industries other than a ground silica operation that might have been associated with exposure to fibrogenic dusts. Two participants reported working over 20 years at other dusty jobs, three reported working between 10 to 20 years, three worked between 5 and 10 years, and four reported working less than five years at another dusty job. The type of work reported included construction, mining, farming, welding, and tire making. The six remaining participants reported never working at any other dusty job. Both of the participants with a positive chest x-ray reported working between 5 and 10 years at such jobs. A review of their job histories indicated that, for at least one of these individuals, the dust exposure from his previous job was unlikely to have been very high.

CHRONIC SYMPTOMS

One of the 18 participants reported symptoms of chronic phlegm, two reported chronic dyspnea (shortness-of-breath), and two reported symptoms of chronic bronchitis. All of the participants reporting chronic symptoms were former workers, and all but one were "ever" smokers.

RESPIRATORY ILLNESSES AND CONDITIONS

Physician-diagnosed chronic bronchitis and emphysema were each reported once, and there were two reports of asthma. One participant reported a prior lung infection requiring antibiotic therapy. The remaining 13 participants reported no physician-diagnosed respiratory illness.

SPIROMETRY

Eighty-nine percent (16/18) of the participants performed spirometry and 12.5% (2/16) of those had results below the normal range, in both cases an obstructive pattern. One participant with an abnormal pattern was a current worker and one was a former worker. One had never smoked cigarettes and one was an ex-smoker. Neither of these participants had a positive chest x-ray.

Company Records

Information on sex, race, age, and tenure, was provided for all 11 eligible current workers, and information concerning smoking status and prior dust exposure was available for 45% (5/11) of the current workers, all five of whom were participants. As stated earlier in this report, a fire in 1976 reportedly destroyed many records, and little formal documentation was kept of employee job assignments. Thus the only information able to be provided for 46% (12) of the 26 eligible former workers was tenure. Table 4 presents the available tenure data by participation and employment status.

Current Workers

Of the 11 eligible current workers, all nine participants and both non-participants were men. All of the participants except one were white; both non-participants were white. The two non-participants differed in age from the nine participants, with a median of 45 years versus 38 years. Information concerning cigarette smoking status indicated that one of the nine participants was an ex-smoker, four participants had never smoked, and the status of the four remaining participants was unknown. Cigarette smoking status was unknown for both of the non-participants. None of the five participants for whom information on prior work history was available had a job with the potential for dust exposure. Information concerning prior dusty

jobs was unavailable for the four remaining participants and both non-participants.

Chest x-ray results from medical records were available for 82% (9/11) of the eligible current workers. Results were available for seven of the nine participants, and both non-participants. Although the chest x-rays were known to be classified by a B Reader, ILO classification sheets were not available. Chest x-ray information was provided in summary form (e.g., the record indicated the results were “normal”). None of the nine current workers for whom there was chest x-ray information had results that met our established silicosis case definition (case definition 1), nor case definitions 2 or 3 when these definitions were applied. All of the chest x-rays were taken in 1991 and five were classified by the same B Reader. It was assumed that the remaining chest x-rays were also classified by this B Reader.

Company Medical Monitoring

Medical monitoring of workers was reported to have begun in 1968 and initially consisted of an annual chest x-ray by a local physician, who is deceased. It was not known if these chest x-rays were reviewed by a radiologist. Pulmonary function testing of workers was conducted for three years (1987, 1988, and 1989) at a nearby hospital. In 1990, and again in 1991, the company utilized the services of a mobile health testing company. Participation was voluntary, and screening included a medical and occupational history, chest x-ray, and pulmonary function testing. The chest x-rays from these two medical evaluations were classified by a NIOSH-certified B Reader.

A copy of the medical test results from the 1990 and 1991 medical screening were the only medical records reported to be maintained at the plant. When asked, a company representative indicated that the whereabouts of earlier company medical monitoring results and records were unknown. At the time of the NIOSH medical

evaluation, the identified medical records kept at the plant were isolated from other records in a separate locked file with access limited to the General Manager.

Twelve (67%) of the 18 participants reported taking part in at least one of the company medical evaluations (chest x-ray, or pulmonary function testing, or mobile health screening). A total of nine participants reported having had a chest x-ray as part of a past company evaluation. Seven participants, six of whom were current workers, were able to recall their chest x-ray results. One participant (a former worker) either never knew or didn't remember his results. A second participant recalled results of a chest x-ray, but (based on his questionnaire response) we were unable to determine if the results were related to a company evaluation. A company representative reported that each individual employee who chose to participate in the 1990 and 1991 screening received a letter with his/her individual test results.

Currently, pre-placement examinations are conducted by a local physician; this examination does not include a chest x-ray or pulmonary function testing. A company representative indicated that these tests may be included as part of the pre-placement examination in the future. Subsequent to the NIOSH evaluation, routine medical monitoring, which includes these screening tests, has been conducted annually since 1994 by the mobile health testing service the company utilized previously. The chest x-rays are classified by a B Reader. Employee participation in the medical monitoring has remained voluntary. Discussion of the medical monitoring test results with a health care professional is left to the individual employee; those employees who chose to participate and have abnormal test results receive a letter from the company encouraging discussion of the results with their personal physician.

DISCUSSION

Two (11%) of the 18 current and former workers who participated in the medical evaluation were found to have changes on their chest x-ray consistent with silicosis; one was a current worker and the second was a former worker. Both of these participants were over 50 years of age, had been employed at American Tripoli for over 15 years, and both reported employment at other dusty jobs.

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. The information needed for non-participants from company records (i.e., age and disease status) to assess whether our prevalence estimate of 11% represents an over-estimate or an under-estimate (as applied to the study population as a whole) was missing, and tenure was available for less than half of the non-participants. Despite this, a perspective can be gained by examining the possible range of the prevalence.

The study population prevalence of x-ray defined silicosis among the 37 participants and non-participants could range from 5-57%, depending upon the number of cases among the non-participants. An explanation of how these upper and lower boundaries on the estimate were obtained follows. Neither of the two non-participating current workers had x-ray evidence of silicosis, based on company records. Assuming all 17 non-participating former workers had no radiographically-defined evidence of silicosis yields the lower estimate, 5% (2/37). Conversely, assuming all 17 non-participating former workers had x-ray evidence of silicosis, yields a higher estimate, 51% (19/37). It is also possible that both of the non-participating current workers could have developed clinically apparent disease since the time of the last company chest x-ray, yielding the highest estimate, 57% (21/37). The

“true” study population prevalence lies somewhere within this range.

Generally, testing of active workers or recently active workers can result in an under-estimation of a 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. Cases of silicosis that may have occurred among deceased former workers were not included in this evaluation. Additionally, 64% (7/11) of the eligible current workers were employed 10 years or less at American Tripoli. One would not expect to see chronic nodular silicosis develop in less than 10 years from the time of first exposure. This factor, coupled with the low participation rate among eligible former workers (35%), the degree to which company records were absent, lost, or missing, and the study design itself, may have reduced the likelihood of identifying more cases of silicosis.

Pulmonary function testing revealed that two (12.5%) of the 16 participants who performed spirometry had abnormal patterns. None of the current workers reported a chronic symptom, while dyspnea (shortness-of-breath) and bronchitis were reported with equal frequency by former workers and appeared related to cigarette smoking. One of the two participants with abnormal spirometry was an ex-smoker and one had never smoked. Occupational exposures to mineral dust have been associated with airflow limitation and chronic obstructive pulmonary disease.^(26,29,30) Among dust-exposed workers who also smoke, pulmonary impairment is associated with both cigarette smoking and cumulative dust exposure, with or without the presence of radiographically detectable disease.^(26,30,31, 32)

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 1 January 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 both of the positive chest x-rays was rounded. One of the two participants with a positive chest x-ray had never smoked cigarettes and the second participant was an ex-smoker. Cigarette smoking alone would not explain the second participants' observed chest x-ray abnormalities. There is little evidence that smoking without occupational dust exposure results in pneumoconiosis-like opacities, and the opacities that have been observed have been predominantly irregular, not rounded.⁽³⁹⁾

In the present evaluation, one of the participants with a positive chest x-ray began working at American Tripoli before MSHA's current silica dust standard came into effect (July 1974) and one began working after 1974. Both participants began working at American Tripoli when the plant was owned and operated by the Carborundum Company. Both participants reported over 15 years of tenure at American Tripoli. Although each of these participants reported employment at another dusty job, 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.^(26,40) The degree to which these participants' prior or subsequent dust exposure contributed to the abnormalities seen on their respective chest x-rays is not known. For at least one of these individuals, the dust exposure was unlikely to have been very high, based on the reported job. Additionally, MSHA has documented periods of non-compliance

with the MSHA respirable silica dust standard at this operation since 1974.

Annual medical monitoring has been available to employees since 1994; it includes the screening tests (spirometry and posterior-anterior chest x-ray) recommended by both NIOSH and NIOSA. Chest x-rays are classified by a NIOSH-certified B Reader. These screening tests were not reported to be part of the pre-placement examination however, and because of the voluntary nature of the annual monitoring, the possibility exists that some workers would not receive any monitoring. Pre-placement and annual medical examinations which include a 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⁾ NIOSA guidelines recommend both a baseline and periodic evaluation of employees exposed to crystalline silica.⁽⁸⁾

CONCLUSIONS

The prevalence of x-ray defined silicosis among currently working 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) was 11% (1/9). In addition, there was one case of silicosis among the 9 former workers who participated in the NIOSH evaluation.

It is reasonable to conclude that the abnormalities seen on these chest x-rays are attributable, at least in part, to past silica dust exposure at this facility. This conclusion is supported by MSHA documentation of prior periods of non-compliance with the MSHA respirable silica dust standard at this operation. Additionally, one cannot conclude from these findings that current silica dust exposure levels are without adverse effect given the short tenure of the eligible current workers, 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.

RECOMMENDATIONS

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

1. The pre-placement examination should be modified to include, at a minimum:^(7, 8)

A. A medical and occupational history to collect data on worker exposure to crystalline silica dust and signs and symptoms of respiratory disease. This information should be collected from an employee by the health care professional conducting the pre-placement examination (e.g., the physician or nurse).

B. A chest radiograph (posterior-anterior 14" x 17"), classified by a B reader according to the 1980 ILO International Classification of Radiographs of Pneumoconioses (or revision thereof, whichever is current at the time of the examination).

C. Pulmonary function tests, including forced vital capacity (FVC) and forced expiratory volume at one second (FEV₁), using equipment and methods consistent with ATS recommendations.⁽³⁾

D. Skin testing for tuberculosis (TB).^(41, 42) Assistance may be requested from the Newton County Health Department in Neosho for follow-up and treatment, as indicated. The association of tuberculosis with silicosis and silica exposure is well known.^(26, 43)

2. The annual medical monitoring should be modified to include skin testing of employees for tuberculosis (TB).^(41, 42) Those employees who choose not to participate in the annual medical monitoring offered by the company should be encouraged to have a TB skin test performed elsewhere (for example, by their personal physician or the county health department).

3. Both the company and union should work together to encourage worker participation in the annual medical monitoring offered by the company. Those employees who choose not to participate in the annual medical monitoring should inform their personal physician of their potential exposure to crystalline silica dust at work. Alternately, the company may wish to provide each employee with an information sheet for employees to give to their personal physician. Workers employed at facilities that grind silica are considered to be at high risk for silicosis and other adverse effects related to crystalline silica exposure, namely chronic respiratory symptoms, pulmonary impairment, and possibly lung cancer.⁽²⁶⁾

4. Each employee should receive a copy of his or her company medical examination results in full detail, whether or not the results are abnormal. Arrangements should be made for employees to review the results with a health care professional at the time the employee receives his or her individual results. This could be accomplished by arranging for the annual medical monitoring results to be sent to the local physician who conducts the pre-placement examinations.

5. Employment history at American Tripoli should be collected and/or recorded in a standardized manner for all employees. Particular attention should be paid to the accuracy and completeness of the data recorded, and the record should be up-dated on a regular basis.

6. Medical records should continue to be maintained separately and in a confidential manner, and access should be limited to health

care personnel. These records should be kept for at least 30 years following an employee's termination of employment.

7. All cases of silicosis should be reported to MSHA by the company, and to the Missouri Department of Health by the examining physician, health care provider, contractor, and/or radiologist, as required. 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. Silicosis is a reportable condition in the state of Missouri.^(44, 45) 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⁾

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TABLE 1
 Study Population and Participation Rate By Employment Status
 American Tripoli, Inc.
 HETA 93-0792-2654

Employment Status	N	Workers Eligible For Study			
		Total # Eligible	Number of Participants	Number of Non-Participants	Participation Rate (%)
Current Worker	17	11	9	2	82
Former Worker	28	26	9	17	35
TOTAL	45	37	18	19	49

TABLE 2
 Characteristics of 18 Participants by Employment Status
 American Tripoli, Inc.
 HETA 93-792-2654

CHARACTERISTIC	EMPLOYMENT STATUS		
	9 Current Workers	9 Former Workers	TOTAL N=18
Age (yrs) [median]	38	39	39
Range (yrs)	28-62	28-75	28-75
Tenure (yrs) [median]	10	4	8
Range (yrs)	1-27	1-24	1-27
Cigarette Smoking Status	Number	Number	Number
Never	6	3	9
Ever	3	6	9
Pack-Years (median)	44	20	

TABLE 3
 Chest X-Ray Results by Reader for 18 Participants
 American Tripoli , Inc.
 HETA 93-0792-2654

READER A			READER B			READER C			MEDIAN	
Profusion	Size/Shape	Zone(s)**	Profusion	Size/Shape	Zone(s)	Profusion	Size/Shape	Zone(s)	Profusion	Film quality
0/0			0/0			0/0			0/0	1
0/0			1/1	sp	1,2,3,4,5,6	0/0			0/0	1
0/0			0/0			0/0			0/0	1
0/0			1/0	st	2,3,5,6	0/0			0/0	1
1/0	qr	1,2,4,5	1/0	st	1,2,3,4,5,6	1/0	qt	1,4	1/0	2
0/0			0/0			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	2
0/0			0/0			0/0			0/0	1
0/0			1/0	sp	1,2,3,4,5,6	0/0			0/0	1
0/1	qs	1,4	1/1	st	2,3,5,6	0/0			0/1	2
1/1	rq	1,2,4,5	2/2	pq	1,2,3,4,5,6	1/2	qr	1,2,3,4,5	1/2	1
0/0			0/0			0/0			0/0	1
0/0			0/0			0/0			0/0	2
0/0			0/0			0/0			0/0	2
0/0			0/0			0/0			0/0	2
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.

TABLE 4
 Tenure by Participation and Employment Status from Company Records
 American Tripoli, Inc.
 HETA 93-0792-2654

	PARTICIPANTS		NON-PARTICIPANTS	
	Current Worker N = 9	Former Worker N = 9	Current Worker N = 2	Former Worker N = 17
No. of Workers With Tenure	9	4	2	8
TENURE (yrs) [median]	10	8*	11	8*
Range (yrs)	1-21	2-23	---@	1-28

* Tenure missing for 5 participating and 9 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.

APPENDIX I (con't)

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 $> 1/0$ 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.

APPENDIX I (con't)

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.

APPENDIX I (con't)

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

APPENDIX I (con't)

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 using 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

APPENDIX I (con't)

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.

APPENDIX I (con't)

ATTACHMENT 1

GROUND SILICA MILLS - 1991

			Employees
	Northeastern District		
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

			Employees
	Northeastern District		
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 > 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 of 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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