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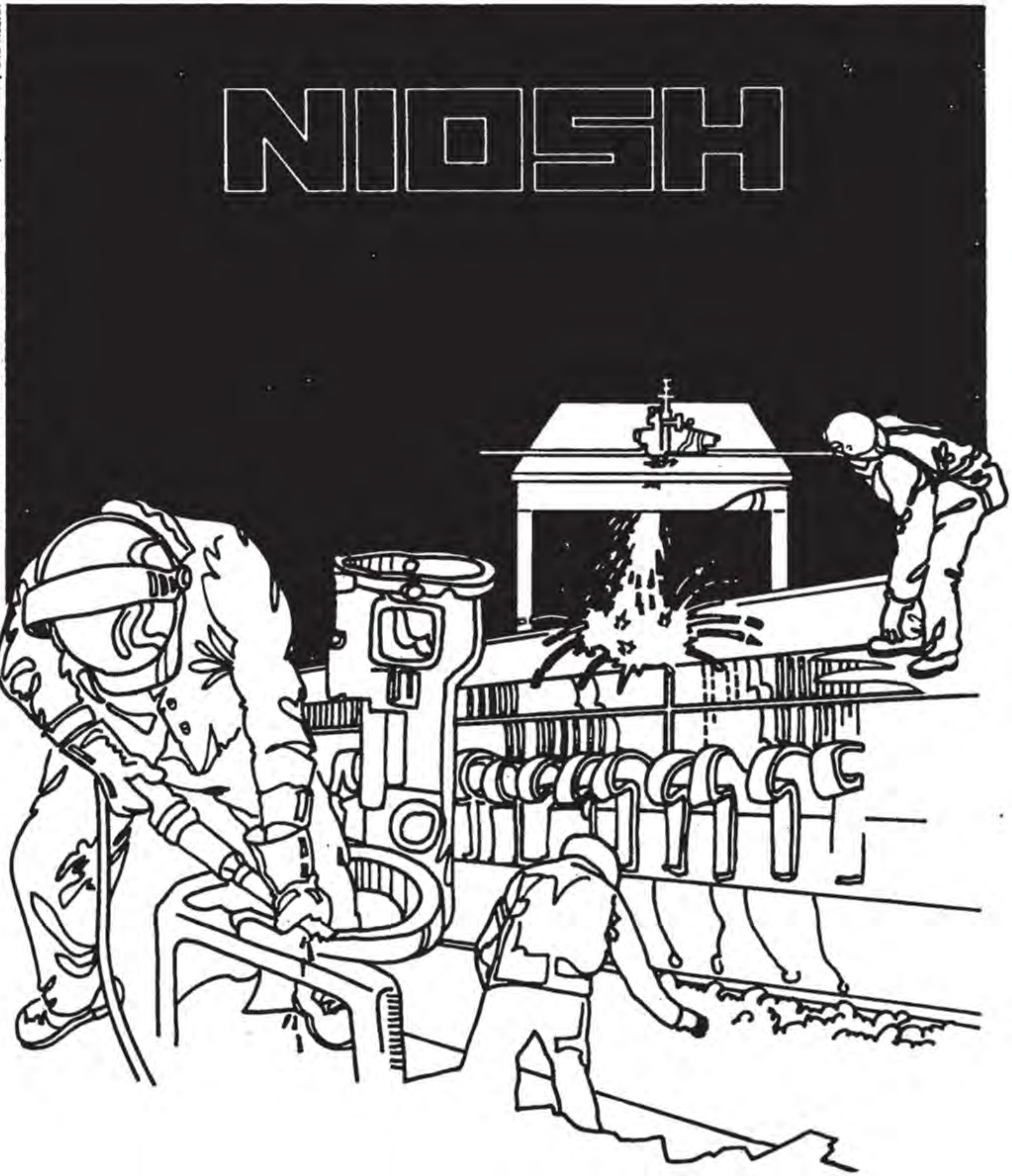

Health Hazard Evaluation Report

HETA 85-493-1786
NIAGARA MOHAWK POWER CORPORATION
LYCOMING, NEW YORK

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.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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NIAGARA MOHAWK POWER CORPORATION
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I. SUMMARY

In August 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Brotherhood of Electrical Workers (IBEW) to investigate exposures of electricians to aluminum-silicate ceramic fibers (hereafter referred to as ceramic fibers or CF) in the stress-relief operation at the Niagara Mohawk Power Corporation, Unit number II, in Lycoming, New York. The request was prompted by changes in the manufacturers' material safety data sheets (MSDS) stating that ceramic fibers presented a possible cancer hazard, based on tests in laboratory animals. Concern was also expressed over the conversion of the ceramic fibers to cristobalite, the most fibrogenic form of silica, reported in the MSDS to occur at temperatures above 865°C (1600°F).

A site-visit was conducted by NIOSH staff on September 27 and 28, 1985. The stress-relief operation involves wrapping electric heating units around the pipe weld joint, and then covering the heating units with blankets of Cerwool® or Fiberfrax®, aluminum-silicate ceramic fibers (CF). The temperature of the pipe joint is increased at a prescribed rate, held at approximately 730°C (1350°F) for about 2 hours, and then decreased at a prescribed rate. The CF blankets help maintain a uniform temperature across the weld joint. This process relieves internal stress and minimizes the potential for fracture at a later time.

Air samples were obtained for fiber characterization and quantitation and for evaluation of CF conversion to cristobalite. Eight bulk samples of insulation material were collected for qualitative fiber analysis.

No evidence of conversion of cristobalite was found in any of the air or bulk samples collected. Ceramic fiber concentrations ranged from 0.14 to 0.31 fibers/cubic centimeter of air for the six samples. No exposure criteria have been developed that are specific for airborne ceramic fiber exposures. These fiber concentrations are well below current recommendations for fibrous glass (3 fibers/cc) which apply to other man-made mineral fibers (MMMF).

Informal interviews were conducted with electricians on the stress-relief operation. They reported experiencing upper respiratory irritation and headaches after handling the ceramic fiber blankets.

A literature review, and direct communication with researchers conducting animal studies on ceramic fibers were performed. Two recent animal studies have identified tumor production after chronic inhalation exposure to ceramic fibers. No epidemiologic studies have been conducted on ceramic fiber producer or user industry populations.

Epidemiologic studies have been conducted on other forms of man-made mineral fibers: fibrous glass, rock wool, mineral wool. No consistent association has been identified between fiber exposure and the development of respiratory cancer, although lung cancer rates may be elevated after 30 years from the time of the worker's first exposure to MMMF. Extrapolating results from MMMF epidemiologic studies to ceramic fiber exposures may not be appropriate because fiber size, durability, and other factors affecting biologic activity may not be comparable.

No conversion of ceramic aluminum silicate fibers to cristobalite was detected in any air or bulk samples. Insufficient data are currently available to comment on the carcinogenicity of inhalation exposure to ceramic fibers. Since preliminary animal inhalation studies indicate that ceramic fibers may be carcinogenic, it would be prudent to minimize exposures to the extent feasible. Until further epidemiologic and animal studies on the carcinogenicity of MMMF can be completed, manufacturer's recommendations for handling ceramic fibers, which are discussed in Section VIII, should be followed.

Key Words: SIC Man Made Mineral Fibers, MMMF, ceramic fibers, CF, alumino-silicate ceramic fibers, silica, cristobalite.

II. INTRODUCTION

In August 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Brotherhood of Electrical Workers (IBEW) to investigate exposures of electricians in the stress-relief operation at the Niagara Mohawk Power Corporation, Unit II, to ceramic, aluminum-silicate fibers, a form of man-made mineral fibers (MMMF). The request was prompted by changes in the material safety data sheet (MSDS) supplied by the manufacturer which stated that ceramic fibers presented a possible cancer hazard, based on tests with laboratory animals. Concern was also expressed over the conversion of the ceramic fibers to cristobalite, the most fibrogenic form of silica, reported to occur at temperatures above 865°C (1600°F).

A letter summarizing NIOSH activities during the walk-through survey was distributed to union and company officials on October 3, 1985. On June 12, 1986, a second letter was sent which provided information on the status of the environmental tests and included a brief review of the literature on the toxicity of ceramic fibers.

III. BACKGROUND

The power plant is located on 140 acres on the south east shore of Lake Ontario, 40 miles north-northeast of Syracuse, New York. It is expected to have a capacity of 1163 Mw of power. Excavation for the project began on June 25, 1975, with a scheduled operation of October 1986. The steam pipe stress-relief operation was managed by the Stone & Webster Engineering Corporation under contract from Niagara Mohawk Power Corporation.

The power plant has many large steam and water pipes which are welded together. Stress which develops in the metal during welding is relieved by heating the pipe weld joints above 730°C (1350°F) for two hours. Crews of three to four electricians wrap electric heating units around the pipe weld joints. Blankets of Cerwool® or Fiberfrax®, ceramic fibers, are then wrapped around the heaters to maintain the temperature of the pipe at the prescribed temperature. Wrapping the electric heaters and the ceramic blankets around the pipe can take up to one hour, unwrapping the pipe up to one-half hour, and cleaning-up the area up to one-half hour.

The walk-through survey was conducted on September 27 and 28, 1985. At this time only ten workers were assigned to the stress-relief operation. During earlier peak building periods 30 to 40 electricians were reportedly assigned to the operation. Electricians report they frequently transfer between job assignments. Only two of the stress-relief electricians reported more than 4 years exposure to CF.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Air samples and bulk insulation samples were obtained during evaluation of the following heat stress operations:

1. The weld joints of two sections of steam piping (10-inch diameter), which had previously been wrapped with heating elements and Cerwool® insulating blankets, were unwrapped. The two sections were prepared on pipe stands in an open area, specifically for this survey. Strip chart recordings documented that the surface of the Cerwool® blanket in contact with the heating element reached 1800°F and was "soaked" (maintained) at this temperature for approximately 2 hours.

2. One 12-inch diameter steam pipe, which had a welded joint heat stressed in a manner similar to that described above using Cerwool® insulating blankets, was also unwrapped. This section of pipe was recently installed in the reactor building and was in a more enclosed area than in (1) above.

3. A welded joint on one 42-inch diameter steam pipe was being wrapped with Cerwool® insulating blanket material in preparation for the heat-stress procedure. Six air samples (four personal breathing zone air samples and two area air samples) were obtained on mixed cellulose ester filters (37 mm) at a sampling rate of 2 liters per minute (Lpm) using pre-calibrated, battery-operated pumps. Each of these filter samples were submitted for fiber characterization and fiber count by Transmission Electron Microscopy (TEM). A section was cut from each filter with a number 6 cork bore and prepared for TEM analysis(1). One-hundred fields having a total area of .706 mm^2 were examined on each preparation. Fiber sizing was performed at 10,000X magnification.

Eight additional air samples were collected on pre-weighed FWSB filters (37 mm). Each was housed in a 10 mm cyclone sampling apparatus which was operated at a sampling rate of 1.7 Lpm. X ray diffraction (XRD) and X ray fluorescence (XRF) techniques were used to evaluate the samples for the presence of respirable silica (manufacturer's information indicates that, at temperatures above 1600°F, Cerwool® may convert to cristobalite, a form of crystalline silica).

Eight bulk samples of insulation material (all blanket type) were submitted for XRD and XRF analysis. A portion of each bulk sample was "back-packed" on XRF sample holders, and analyzed qualitatively by XRD by stepscanning 4, through 80 degrees at a rate of 1 sec/0.02x using a computer-controlled powder diffractometer. One bulk sample (known to be used multiple times) and the heaviest filter sample were then analyzed from 20-40x at a very slow scan rate of .5 sec/0.02x to obtain a higher level of sensitivity. These two samples were also analyzed by XRF to obtain the elemental composition of the fibers. A computer-controlled fluorescence spectrometer was used to analyze 74 selective atomic elements above fluorine.

B. Medical

Stone & Webster Engineering Corporation conducted baseline chest X rays on all workers at Niagara Mohawk potentially exposed to ceramic fibers. The screening program was suggested to the company by Aetna Life Insurance Company representatives. Electricians on the stress-relief operation were included in the 200 workers who had X rays taken.

Informal interviews were conducted with eight electricians on the stress-relief operation and two other workers who worked near these activities. Concern was expressed because of recent changes in the material safety data sheets (MSDS) warning that ceramic fibers are carcinogenic in animals. Workers reported upper respiratory irritation after handling the ceramic fiber blankets. Two workers were concerned that their recent respiratory illnesses were caused by or exacerbated by fiber, or cristobalite exposure. Their medical records were obtained and reviewed.

To evaluate the potential carcinogenicity of ceramic fibers, contact was made with the Thermal Insulation Manufacturers Association (TIMA) which suggested the change in the MSDS, and a literature review was conducted. To evaluate the potential for conversion of aluminum-silicate fibers to cristobalite, a review of the literature was conducted and bulk samples of used CF were analyzed.

V. EVALUATION CRITERIA

Ceramic Fibers

Man-made mineral fibers (MMMF)(also referred to as man-made vitreous fibers, MMVF) generally refer to amorphous glassy fibers made from molten slag, rock or glass. Four general classifications of MMMF exist; slag wools, rock wools, glass, and ceramic wools and filaments. Unlike asbestos, MMMF are amorphous, generally have a larger diameter and fracture in a transverse plane. (Asbestos fibers fracture longitudinally producing a large number of fine fibrils.) Advances in production have allowed manipulation of fiber length, diameter, physical form, and chemical composition to meet specialized needs and applications. The fibers referred to in this report are the alumino-silicate ceramic fibers, produced by melting Kaolin clay, or alumina and silica, to form alumino-silicate glasses which are "blown" or "spun" to form the fibers. They are generally used for high temperature applications and are produced in blanket, modular block, paper and textile forms.[2]

Inhalation and deposition properties of fibers

The airways are made of a series of branching tubes which decrease in size and diameter until they dead-end at the alveoli. Alveoli are small thin-walled air sacs designed to allow quick transport of inhaled gases into the blood stream. Along with gases, different sized particles can also be inhaled. Most particles are deposited in the nose, pharynx, or trachea. Particles deposited in the upper portions of the airway are cleared by special ciliated cells which line the air passages (mucociliary clearance). Smaller sized particles can deposit in the deeper portions of the airways, and are cleared by another form of the body's defense mechanism (alveolar clearance). Small particles are engulfed by macrophages, scavanger cells, which attempt to clear the particles from the lung by secreting powerful enzymes or by moving the particles to the lymphatic system or back up the airways. Particles which deposit in the upper airways are more likely to be removed by the lung's clearance mechanisms while smaller particles, which reach the deeper portions of the airway, are less efficiently cleared.[4]

Fibers, by definition, have a length to diameter ratio (aspect ratio) greater than 3:1. Although fiber shape might seem to preclude deposition in the deeper portions of the airway, inhaled fibers can align parallel to the airway and act aerodynamically as if they were spheres.[3] As the ratio of fiber length to diameter increases, fiber length begins to affect the properties of fiber inhalation and deposition.[4] (Nominal fiber diameter and fiber length determine fiber aerodynamic equivalent diameter. As the fiber aspect ratio increases, the ratio of fiber aerodynamic equivalent diameter to nominal fiber diameter approaches a constant which varies from 2.5 to 3.5. For example, a fiber of 1 micrometer (uM) nominal diameter and 20 uM long can have aerodynamic properties of a 3 uM spherical particle.[3]) Particles with diameters less than 3.5 uM are capable of reaching the deeper portions of the human airway.[4] In rats, fibers with a mass median aerodynamic diameter between 3 and 6 uM were capable of alveolar deposition, although at much reduced levels (1-2%).[5]

Animal studies [6,7] indicate that fibers longer than 10-15 uM may be less efficiently cleared from the lungs by macrophage mediated processes. In one study ceramic fiber clearance reached a maximum at 11-15 uM and then decreased with increasing fiber length.[8]

Animal Studies

Concern for the carcinogenic potential of MMMF increased in the 1970's, after a number of intra-pleural (placement of glass fibers inside the pleural cavity) and intra-peritoneal injection studies compared the biological response of animals to asbestos, a naturally occurring fiberous mineral, and man-made glass fibers. Although glass fibers were much less carcinogenic than asbestos fibers, certain sized glass fibers were also capable of inducing mesothelioma. The authors hypothesized that fibrous shape and not chemical composition may determine carcinogenic potential;(9,10) fibers less than or equal to 1.5 um in diameter and greater than 8 um in length had the highest probability of inducing the development of mesothelioma.(9) Other studies have indicated that fiber durability may also affect carcinogenic potential. After inhalation and deposition in the lungs, fibers which maintain their integrity for longer periods may exert greater carcinogenic effects on lung tissue.(7,8) Asbestos fibers are stable in physiologic solutions that completely dissolve glass fibers.(11) Other solubility studies have shown that ceramic fibers are more durable than mineral wool fibers, which are more durable than glass fibers.(12)

Injection studies in animals are commonly used to assess toxicological properties of chemicals and other products. These studies can identify carcinogenic potential, however, they by-pass many defense mechanisms and do not correlate well with human routes of exposure. Results from these studies can be of questionable validity when extrapolated to human populations. To overcome these limitations, researchers studying fiber carcinogenicity have exposed animals to aerosolized particles of MMMF. Most of these inhalation studies have not shown an association between exposure to inhaled fibrous glass and tumor production.(13,14,15) One researcher concludes that fibrous glass dust may act like an inert dust because it is rapidly removed from the lung by the lung's clearance mechanism.(14) However, in one study, malignant tumors were identified in 2 % of rats exposed to aerosolized samples of glass microfibre, rock wool, and glass wool (n=48 for all three studies).(16)

Most animal studies on MMMF have investigated the effects of exposure to fibrous glass and mineral wool. Ceramic fibers have only recently been included in animal toxicity studies as use has increased. A recent study compared pulmonary lesions in rats and hamsters after intra-peritoneal and intra-tracheal injection of fibrous glass, mineral wool, crocidolite asbestos, and refractory ceramic fibers. After intra-tracheal exposure, only those exposed to asbestos developed primary alveolar tumors. After intra-peritoneal injection, abdominal mesotheliomas developed in 80% of the rats implanted with ceramic fibers or asbestos, but only in 32% of those implanted with fibrous glass.(17) In another CF intra-peritoneal injection study on rats, 3 of 32 rats developed peritoneal tumors, 1 mesothelioma, and 2 fibrosarcomas.(18)

These studies also exposed animals to aerosolized ceramic fiber particles. In the first study, one of 70 Syrian hamsters developed a mesothelioma after 10 months of CF inhalation exposure, none of the Osborne-Mendel (OM) rats developed tumors.(17) By comparison, none of the asbestos inhalation-exposed hamsters developed tumors, although, 3 of the 57 asbestos exposed OM rats developed primary tumors (1 mesothelioma, 2 bronchoalveolar tumors). None of the animals exposed to fibrous glass developed tumors. Fibrosis developed in 22% (12) of the CF exposed rats, but only in one of the CF exposed hamsters. By comparison, only 2%-7% of rats (n ranged from 52 to 70) exposed to four types of fibrous glass developed fibrosis. In the second study, 8 of 48 Wistar Rats developed pulmonary neoplasms after inhalation exposure to CF. The tumors were identified as malignant histiocytomas and carcinomas with squamous histological patterns.(18) Generation of fiber aerosols resulted in unusually shaped fibers and a large quantity of non-fibrous particulates. Concern has been expressed by industry representatives that the dust cloud may have been contaminated by metal particulate matter abraded from the blades used in the dust generator and may have contributed to the development of lesions.(19)

Epidemiologic studies

Many epidemiological studies have been conducted on workers exposed to man-made mineral fibers, although none of them have studied ceramic fiber exposures. The studies on MMMF have not identified a consistent dose or duration of exposure association between fibrous glass exposure and cancer. In particular, two large historical cohort studies have been conducted. Saracci(20) looked at 25,000 workers in 13 European glass-wool and rock-wool plants, while Enterline(21) looked at 16,000 workers in 17 American glass, rock, slag-wool, and continuous filament plants. In both studies, lung cancer rates were elevated after 30 years from the time of first employment (SMR=192 and 138 respectively), however, no consistent association was detected between duration of employment or type of fiber exposure and cancer mortality. Since the increases in lung cancer rates are more prominent for certain segments of the MMMF industry (mineral wool), Saracci hypothesizes that 30 years ago environmental exposures and conditions in these segments of the MMMF industry may have been very different than today.(22) Neither study addressed smoking habits or the presence of other environmental substances likely to affect worker health. Results of other epidemiologic investigations in the MMMF industry have recently been reviewed.(22)

Despite all the studies conducted on fibrous glass and mineral wool production workers, no epidemiological studies have been conducted on ceramic fiber producer or user industry populations. Extrapolating from the health effects observed in the studies performed on fiberous glass and mineral wool to CF exposures, may not be appropriate because parameters affecting fiber carcinogenic potential--fiber dimension and rate of dissolution, may not be comparable. Under experimental conditions, the rate of ceramic fiber clearance from the lung was much slower than the rate for mineral wool clearance. Unlike mineral wool and fibrous glass, ceramic fibers are more durable and do not undergo dissolution in the lung.[8]

Conversion of Ceramic Fibers to cristobalite (free silica)

Silica is the most common mineral found in the earth and commonly appears in crystalline form as quartz. Besides quartz, other crystalline and amorphous forms of silica are found. After heating, naturally occurring free silica can undergo conversion to crystalline tridymite and then to crystalline cristobalite[25].

Inhalation of respirable particles of crystalline free silica can produce silicosis, a disabling form of pulmonary fibrosis characterized by the presence of nodulation in the lungs.[23] Three forms of silicosis have been identified; chronic silicosis developing after 30 to 40 years of low dose occupational exposure; accelerated silicosis developing after 4 to 8 years of high exposure and generally seen in sand blasters; and acute silicosis, a rare form of the disease occurring after 1 to 3 years of heavy exposure in confined spaces.[24] Smoking status and respiratory infections can accelerate the development of symptoms.[25]

Conversion of amorphous ceramic fibers to crystalline silica, cristobalite, has been reported to occur at 1000°C (1742°F)[26], and 1150°C(2012°F)[27]. In the latter study, conversion to mullite (an aluminum-silicate) occurred rapidly while subsequent conversion to cristobalite required 2 weeks at sustained temperatures. A recent study of two types of alumino-silicate CF, Kaowool® and Fiberfrax®, confirmed that fiber conversion to cristobalite may require sustained temperatures over a period of days to weeks. Both brands of CF converted to mullite within a few hours, although only Fiberfrax, with higher levels of titanium, sodium and potassium oxides, subsequently converted to cristobalite. The authors suggest that oxide impurities may aid the conversion of mullite into cristobalite.[28]

Removal of ceramic fiber insulation from high heat furnaces may present the greatest potential for exposure to fibers which have converted to cristobalite. Furnace insulation can be in service for many hours at temperatures over 1000°C. In a recent study of CF used in furnaces, cristobalite formation was estimated to occur at 920°C (1700°F). Air and bulk samples collected during insulation removal identified cristobalite at levels up to 15% to 20% of the sample. The insulation was exposed to temperatures which ranged from 270°C to 1350°C (500°F - 2550°F), with exposure times ranging from 100 hours to 470 hours.(29)

VI. RESULTS

A. Medical

Medical records of two workers with a history of respiratory problems were reviewed. One worked on the stress-relief operation for 4 years and the other worked near the blanket storage area. The first worker was diagnosed with a pulmonary abscess in June 1985, the other with an acute flare-up of asthma in July 1985. Neither of these illness can definitively be correlated with known effects of fiber or cristobalite exposure. However, exposure to a dusty environment would be expected to exacerbate symptomatology.

Of the 200 X rays taken during the screening evaluation of workers exposed to ceramic fibers, three were read by the radiologist as "abnormal, not clinically significant," and one was read as requiring further follow-up. Two of these workers reported asbestos exposure, one had a lung removed, and one had a lesion in the mid-right lung which correlated with the abscess diagnosed in July 1985.

Environmental

Airborne fiber concentrations ranged from 0.07 to 0.31 f/cc. All three personal breathing zone samples obtained during the time when the blanket insulation was being removed (unwrapped) were very similar (ranged from 0.27 to 0.31 f/cc). The one personal breathing zone sample obtained during a wrapping procedure was less than one-half (0.14 f/cc) the exposure measured during the unwrapping stage. The two area air samples (one positioned nearby during the wrapping and one during the unwrapping) were about 1/3 the concentrations measured using the personal breathing zone sampling technique.

The dimensional characteristics (length and diameter) of the fibers counted on each air sample are presented in Figures 1 through 6. All of the fibers counted were 4 um or less in diameter and fell predominantly (>70%) in the 0.5 -2.0 um range. Fiber lengths varied from 1 to >30 um; and nearly 60% exceeded 20 um. In general, the thicker (largest diameters) fibers were also the longest. The majority of the fibers would be considered to be of respirable size.

No cristobalite was found in any of the air samples which were analyzed using TEM, XRD and XRF techniques. Also, analysis of the bulk samples using the same analytical techniques did not produce any evidence of a conversion from the ceramic fiber to cristobalite. The limit of detection for cristobalite was 0.2%-0.5% for the samples run by XRD (slow scan) and 1% for those run by XRD (normal scan).

The fibers identified consisted of amorphous material(s). XRF analysis indicated that the air samples and bulk samples were similar in composition and contained primarily aluminum, silicon, and titanium. Other elements in smaller amounts were in decreasing order: iron, calcium, potassium, copper, zirconium, strontium, molybdenum, nickel, and zinc. The fibers identified using TEM were of the alumino-silicate species. The fibers longer than 50 microns were curly, and those shorter than 50 microns were straight.

VII. DISCUSSION

Determination of the toxicity of MMMF has primarily relied on data from animal experiments and epidemiologic studies. Animal experiments have attempted to determine the toxicity of fibers by controlling exposure variables such as type and dose of fiber exposure. The validity of extrapolating results of animal studies to human populations is an important limitation to these studies. Epidemiologic studies have attempted to quantitate the risk of developing illness based on occupational exposure to the fibers. The limitations of both approaches are discussed in more detail in another publication.[30]

No epidemiologic studies have investigated the health effects of worker exposure to ceramic fibers. Exposure studies in ceramic fiber production plants have identified a wide-range of average airborne fiber concentrations, 0.01 - 3.4 fibers/cm^3.[31] The levels of airborne ceramic fibers detected in this study (0.07 to 0.31 f/cc) are below standards currently in effect for fibrous glass--3 fibers per cubic centimeter of air having a diameter equal to or less than 3.5 micrometers (um) and a length equal to or greater than 10 micrometers, determined as a time-weighted average (TWA) concentration for up to a 10-hour work shift in a 40-hour workweek.[1] No other criteria currently apply to ceramic fiber exposures. All fibers had diameters less than 4 micrometers (uM) and 85% (124/146) were less than 2 uM in diameter. Of the fibers less than 2 uM in diameter, 82% (102/124) were longer than 10 uM in length. Therefore, although fiber concentrations were low, a large proportion of the fibers are long thin respirable fibers. We conclude that routine handling of ceramic fiber blankets during the stress-relief operation results in exposure to a low concentration of predominately respirable fibers.

The stress-relief operation at Niagara Mohawk requires heating pipe weld joints to temperatures above 730°C (1350°F) for 2 hours. Although temperatures on the electric heaters may reach 920°C (1700°F), these temperatures are not sustained for more than 2 hours. Currently, ceramic fiber blankets are used once and then discarded. (Workers report that prior to the change in the MSDS, blankets were reused until the blanket began to fall apart.) No conversion to cristobalite was detected in air samples while single-use blankets were being wrapped or unwrapped. Bulk samples of single-use and old multiple-use blankets (temperature or duration of exposure estimates were not available) did not show evidence of conversion to cristobalite. It is likely that conversion to cristobalite did not occur because the temperature was not high enough for a long enough period. We conclude that single-use of ceramic fiber blankets in the stress-relief operation does not meet the temperature and time criteria for conversion to cristobalite.

Two animal studies have identified tumor production after long-term inhalation exposure to aluminum silicate fibers. Differences in experimental methodology, constituents of the dust clouds, animal species, and tumors which developed, make comparisons between the studies difficult. The results of one study(18) have been questioned because of the nature of the dust cloud generated.(19) Tumor development after inhalation exposure to glass and rock wool fibers has also been reported. Current evidence suggests that fibre size and durability, rather than chemical composition, may determine carcinogenic potential.

Increased durability of ceramic fibers relative to the other forms of MMMF may play a role in their toxic potential. Ceramic fibers do not undergo dissolution as readily as glass fibers under laboratory conditions,(12) and are not as readily cleared from the lungs.(8) The need for further evaluation of the fibrogenic and carcinogenic potential of aluminum silicate ceramic fibers and glass fibers is clear.

Epidemiologic studies have not been conducted on ceramic fiber producer or user industry populations. Ceramic fiber production is growing but remains a small proportion (1%) of the total MMMF industry. It is estimated that only 600 workers are currently involved in CF production in the U.S.(19) Many more workers are exposed to CF in user industry occupations. However, user industry workers may not be an appropriate cohort to study because their duration and type of fiber exposure are difficult to define, and they are potentially exposed to other hazardous agents. Cancer generally does not develop until 20 to 30 years after exposure to a carcinogen. Therefore, epidemiological studies of workers recently exposed to a suspect carcinogen are not likely to identify any cancer. For these reasons, Niagara Mohawk CF exposed electricians are not a suitable exposure group for epidemiologic studies; workers were only recently exposed to the fibers, none reported more than 4 years of exposure, transfer between job sites and functions was reported to be common, and the total number of workers who routinely work with the ceramic fibers is relatively small.

Animal studies sponsored by the Thermal Insulation and Manufacturers Association are being conducted to examine the intra-pleural, intra-tracheal, and inhalation toxic potential of four types of CF in the hamster and the rat. The results from this chronic toxicity study are not expected until 1989. While further animal studies are being performed, the search for a cohort of workers with a longer exposure to ceramic fibers (15 to 20 years) should continue.

In summary, no cristobalite was detected after single-use of ceramic fiber blankets in the stress-relief operation at Niagara Mohawk. Current evidence on fiber glass suggests that fiber size and durability in the lung may determine carcinogenic potential. Ceramic fibers are reported to be more durable than fibrous glass fibers. Since preliminary animal inhalation studies indicate that ceramic fibers may be carcinogenic, it would be prudent to minimize exposures to the extent feasible. Handling ceramic fiber insulation material without taking the proper precautions should be considered a health hazard.

VIII. RECOMMENDATIONS

1. During this survey, those electricians handling the Cerwool® insulating blankets used personal protective equipment in the form of tyvek coveralls, gloves, boot covers (tyvek), and respirators (disposable dust, fume and mist type). This equipment was, reportedly, seldom used prior to 1985. Until more information is available, measures to reduce exposures using engineering controls, personal protective equipment, and proper handling procedures are warranted. It is recommended that half-mask respirators with high efficiency filters (HEPA) be used as a minimum.

2. Medical surveillance of all workers occupationally exposed to ceramic fibers is recommended. Pre-placement physical examinations with emphasis on the respiratory system should be used to identify workers with pre-existing respiratory conditions. Routine X-ray surveillance for evaluation of the development of lung cancer is not recommended because the latency between carcinogen exposure and tumor development is long, and because the carcinogenicity of CF exposures remain uncertain.

3. No program for evaluation of pneumoconioses is recommended for workers at Niagara Mohawk because no conversion of ceramic fibers to cristobalite was detected. If processes are developed which expose fiber blankets to higher heat levels for longer periods of time, the potential conversion of ceramic fibers to cristobalite should be evaluated. If cristobalite is detected, medical surveillance as suggested for pneumoconioses, including periodic chest X-rays which are evaluated by a certified "B" reader, would be recommended.[32]

   Records from the base-line X-ray screening program conducted by Niagara Mohawk in January 1986, should be saved for at least 30 years after the workers termination of employment. Future X-ray evaluations should be interpreted by a "B" reader, a radiologist trained in recognizing early stages of pneumoconioses. A list of certified "B" readers is available from NIOSH.

IX. REFERENCES

1. NIOSH U.S. DHEW: Criteria for a recommended standard. Occupational exposure to fibrous glass (NIOSH) 77-152. Washington, D.C.,: U.S. Govt. Print. Office, 1977.

2. National Research Council, Assessing non-occupational exposure to asbestiform fibers, in, Asbestiform fibers, non-occupational health risks (National Academy Press, Washington, D.C., 1984) p.74.

3. Gross P. Consideration of the aerodynamic equivalent diameter of respirable mineral fibers. American Ind. Hyg. Assoc. J. 42:449-452;1981.

4. Timbrell V. The inhalation of fiberous dusts. In: Whipple HE., ed. Biological effects of asbestos. Ann. N.Y. Acad. Sci. 132:255-273; 1965.

5. Morgan A, Talbot R.J., and Holmes A, Pritchard JN; Deposition of sized glass fibers in the respiratory tract of the rat. Ann. Occup. Hyg. 23:353-366, 1980.

6. Morgan A, Talbot R.J., and Holmes A, Significance of fibre length in the clearance of asbestos fibers from lungs. Br. J. Ind. Med 35: 146-153. 1978.

7. Morgan A; Holmes A. The deposition of MMMF in the respiratory tract of the rat, their subsequent clearance, solubility in vivo and protein coating. In: Guthe T, ed. Biological effects of man-made mineral fibers: Proceedings of a WHO/IARC conference in association with JEMRB and TIMA Copenhagen, April 20-22, 1982. World Health Organization, Regional Office for Europe, Copenhagen, 1984, pp. 1-17.

8. Hammad YY. Deposition and Elimination of MMMF. In: Guthe T., ed. Biological effects of man-made mineral fibers: Proceedings of a WHO/IARC conference in association with JEMRB and TIMA Copenhagen, April 20-22, 1982. Volume 2. World Health Organization, Regional Office for Europe, Copenhagen, 1984, pp. 126-141.

9. Pott F; Huth F; Friedrichs KH. Results of animal carcinogenic studies after application of fibrous glass and their implications regarding human exposure. In: US Department of Health Education and Welfare. Occupational exposure to fibrous glass: Proceedings of a symposium, College Park, Maryland, June 26-27, 1974. Washington, D.C., 1976, pp 183-193. (DHEW Publication no (NIOSH) 76-151).

10. Stanton MF; Wrench C. Mechanisms of Mesothelioma induction with asbestos and fibrous glass. J Nat Cancer Inst 48:797-821;1972

11. Forester H. The behavior of mineral fibers in physiologic solutions. In: Guthe T., ed. Biological effects of man-made mineral fibers: Proceedings of a WHO/IARC conference in association with JEMRB and TIMA Copenhagen, April 20-22, 1982. Volume 2. World Health Organization, Regional Office for Europe, Copenhagen, 1984, pp. 27-59.

12. Leineweber, J.P., Solubility of fibers in vitro and in vivo, In: Guthe T., ed. Biological effects of man-made mineral fibers: Proceedings of a WHO/IARC conference in association with JEMRB and TIMA Copenhagen, April 20-22, 1982. Volume 2. World Health Organization, Regional Office for Europe, Copenhagen, 1984, pp. 87-101.

13. Schepers GWH. The comparative pathogenicity of of inhaled fibrous glass dust. In: US Department of Health Education and Welfare. Occupational exposure to fibrous glass: Proceedings of a symposium, College Park, Maryland, June 26-27, 1974. Washington, D.C., 1976, pp. 265-341. (DHEW Publication no (NIOSH) 76-151).

14. Gross P. The effects of fibrous glass dust on the lungs of animals. In: US Department of Health Education and Welfare. Occupational exposure to fibrous glass: Proceedings of a symposium, College Park, Maryland, June 26-27, 1974. Washington, D.C., 1976, pp. 169-178. (DHEW Publication no (NIOSH) 76-151).

15. Lee KP; Barras CE; Griffith F; Waritz R. Pulmonary response to glass fibers by inhalation exposure. Lab Invest, 40:123-133;1979

16. Wagner JC, Berry GB, Hill RJ, Munday DE, Skidmore JW; Animal experiments with MM(V)F fibers - effects of inhalation and intra-pleural inoculation in rats, In: Guthe T., ed. Biological effects of man-made mineral fibers: Proceedings of a WHO/IARC conference in association with JEMRB and TIMA Copenhagen, April 20-22, 1982. Volume 2. World Health Organization, Regional Office for Europe, Copenhagen, 1984, pp. 209-233.

17. Smith DW; Oritz LW; Archuleta RF; Johnson NF. Long-term health effects in hamsters and rats exposed chronically to man-made vitreous fibers. Presented at the International Symposium, Man-made mineral fibers in the working environment, Copenhagen, October 28-29, 1986, World Health Organization, Regional Office for Europe, Copenhagen.

18. Davis JMG; Addison J; Bolton RE; Donaldson K; Jones AD; Wright A. The pathogenic effects of fibrous ceramic aluminum silicate glass administered to rats by inhalation or peritoneal injection. In: Guthe T, ed., Biological effects of man-made mineral fibers: Proceedings of a WHO/IARC conference in association with JEMRB and TIMA Copenhagen, April 20-22, 1982. Volume 2. World Health Organization, Regional Office for Europe, Copenhagen 1984, pp. 303-322.

19. Breitsman WB. Consultant to Carborundum Corp., Former VP Carborundum Corp. Personal Communication, 1987.

20. Saracci R, et al. Mortality and incidence of cancer of workers in the man-made vitreous fibers producing industry: an international investigation of 13 European plants. Br J Ind Med 41:425-436;1984.

21. Enterline PE; Marsh GM. The health of workers in the MMMF industry. In: Guthe T, ed. Biological effects of man-made mineral fibers: Proceedings of a WHO/IARC conference in association with JEMRB and TIMA Copenhagen, April 20-22, 1982. Volume 1. World Health Organization, Regional Office for Europe, Copenhagen, 1984, pp. 311-339.

22. Saracci R. Ten years of epidemiologic investigations on man-made mineral fibers and health. Scand J Work Environ Health, 12, Suppl 1:5-11;1986.

23. Seaton A. "Silicosis" Occupational Lung Diseases, eds. Morgan, Keith W.; Seaton, Anthony (Philadelphia: W.B. Saunders Co., 1984), pp. 250-294.

24. Ziskind M; Jones H; Weill H. Silicosis, State of the Art. American Review of Respiratory Diseases, 113:643-655;1976.

25. Jones, Robert N. "Silicosis," Environmental and Occupational Medicine, ed., Rom, William N. (Boston: Little, Brown, and Company, 1983), pp. 197-206.

26. Strubel G; Fraij B; Rodelsperger K. et al., Letter to the Editor American Journal of Industrial Medicine, 10:101-102;1986.

27. Vine G; Young J; Nowell IW. Letter to the Editor, Health hazard associated with alumino-silicate fibre products. The Annals of Occupational Hygiene, 28:356-359;1984.

28 Khorami J, et al. Induced conversion of aluminum silicate fibers into mulite and cristobalite by elevated temperatures: A comparative study of two commercial products. Proceedings of the 15th North American Thermal Analysis Society Conference, Cincinnati, Ohio, September 21-24, 1986, pp. 343-350.

29. Gannier B. Respiratory hazard from removal of ceramic fiber insulation from high temperature industrial furnaces. Amer Indust Hygiene Assoc J. 47:530-534;1986.

30. National Research Council, Effects of asbestiform fibers on human health, in, Asbestiform fibers, non-occupational health risks (National Academy Press, Washington, D.C., 1984) p.97-100.

31. Esman NA; Hammad YY. Recent studies of the environment in ceramic fibre production. In: Guthe T., ed. Biological effects of man-made mineral fibers: Proceedings of a WHO/IARC conference in association with JEMRB and TIMA Copenhagen, April 20-22, 1982. Volume 1. World Health Organization, Regional Office for Europe, Copenhagen, 1984, pp. 222-231.

32. NIOSH U.S. DHEW: Criteria for a recommended standard. Occupational exposure to crystalline silica (NIOSH) 75-120. Washington, D.C.,: U.S. Govt. Print. Office, 1974.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Niagara Mohawk Power Station, Unit Number 2
2. International Brotherhood of Electrical Workers (IBEW)
3. NIOSH, Boston Region
4. OSHA, Region I

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1

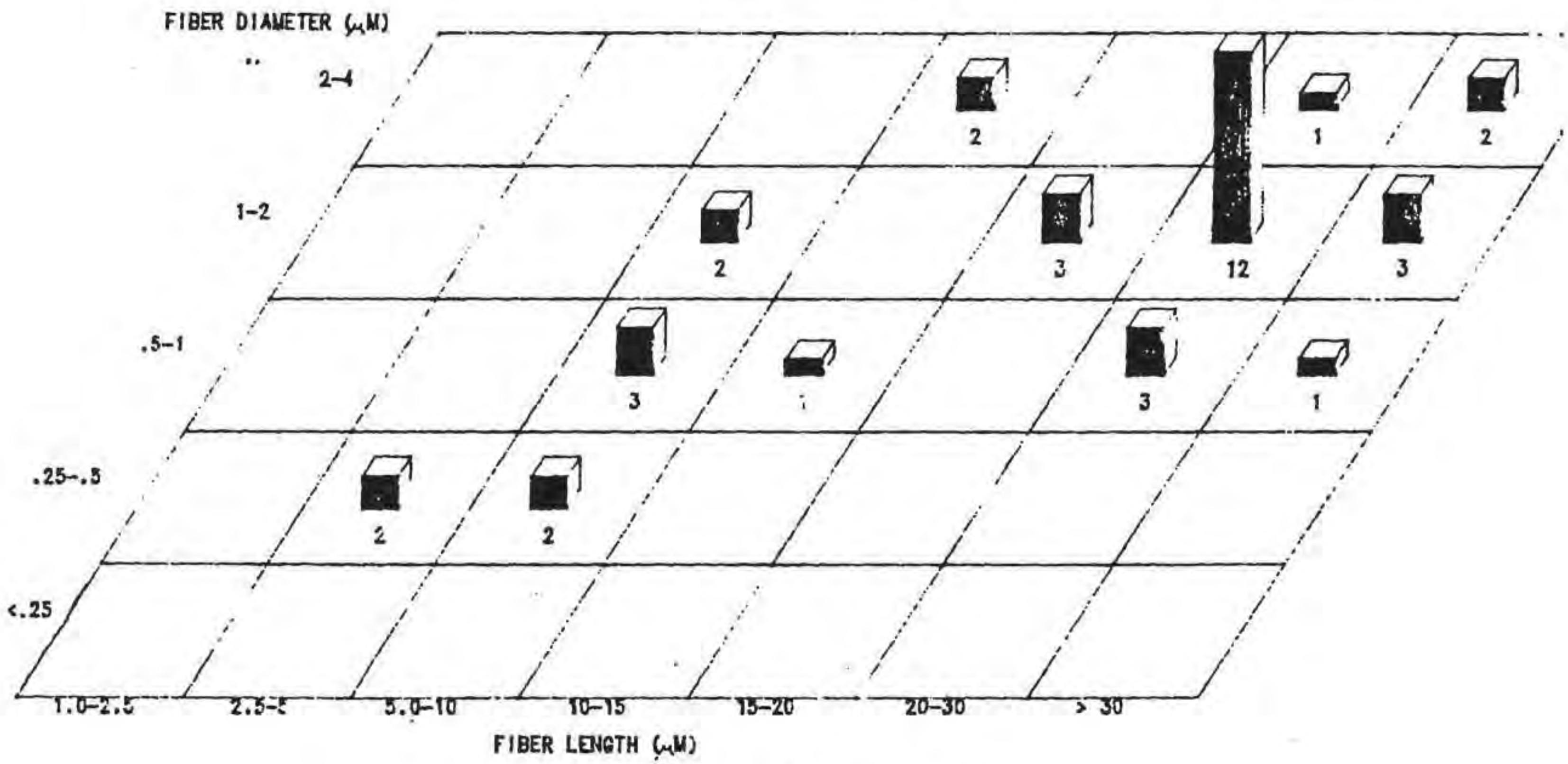
Airborne Fiber[1]
Niagara Mohawk Power Corporation
9 Mile Point, Unit 2

HETA 85-493
September 27, 1985

Job/Location	Sample Type[2]	Sample Time	Fiber Concentrations f/cc[3]	Comments
Heat stress electrician	PBZ	0920-1030	0.31	unwrapping,[4] 10" pipe
Heat stress electrician	PBZ	0920-1030	0.30	unwrapping, 10" pipe
Heat stress electrician	PBZ	1045-1130	0.27	unwrapping, 12" pipe
Floor level, 5 feet North	A	0920-1030	0.09	unwrapping, 10" pipe
5 feet from joint, South	A	1045-1130	0.07	wrapping, 42" pipe
Heat stress electrician	PBZ	1045-1130	0.14	wrapping, 42" pipe

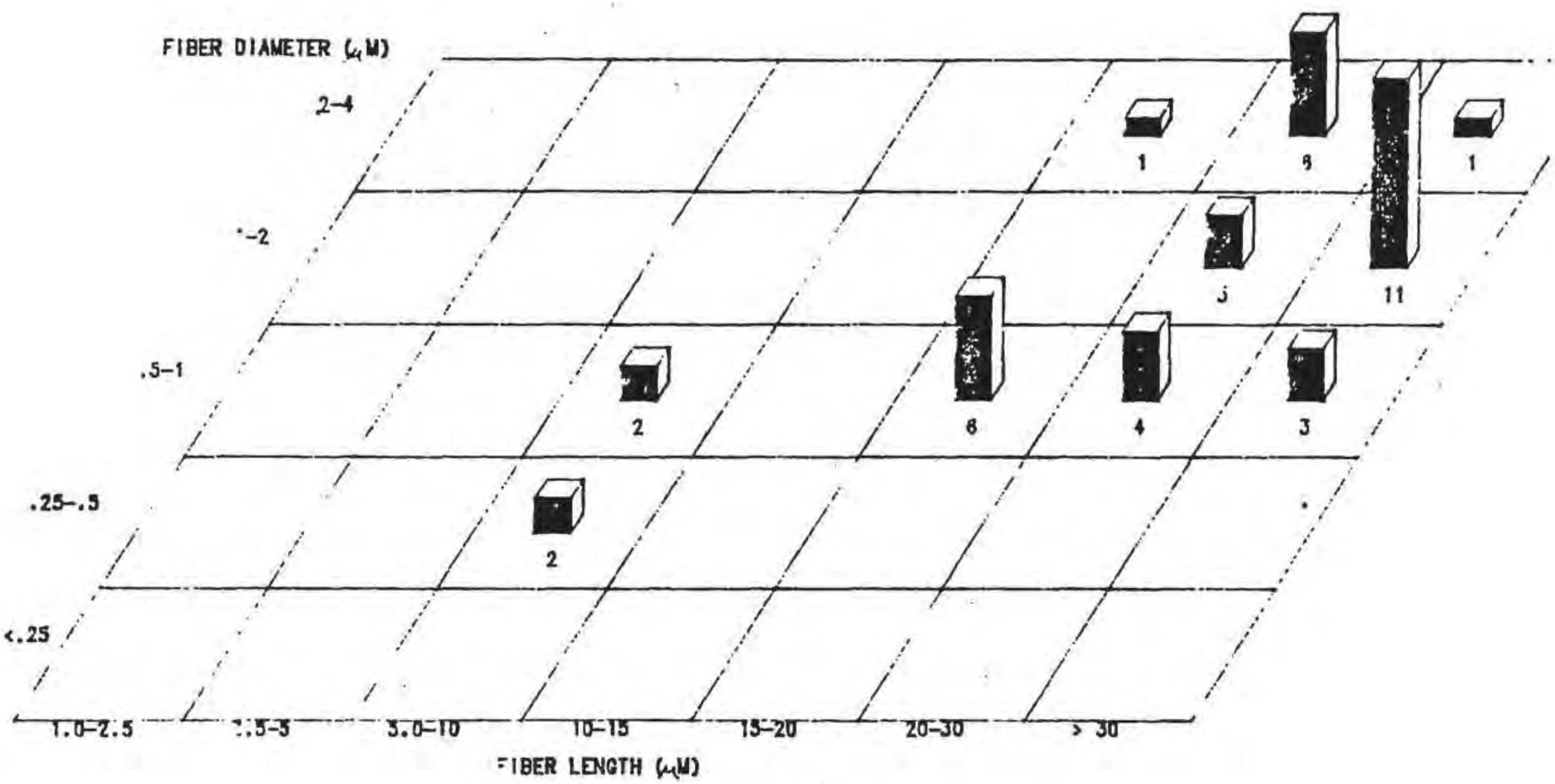
Notes:
(1) Samples collected during a demonstration of unwrapping and during an actual wrapping and unwrapping.
(2) PBZ = Personal Breathing Zone; A = Area
(3) f/cc = fibers per cubic centimeter of air
(4) The insulating blanket material used during the procedures evaluated was Cerwool®.

FIGURE 1
CERWOOL® BLANKET: UNWRAP
NIAGARA MOHAWK POWER CORPORATION
SEPTEMBER, 1985



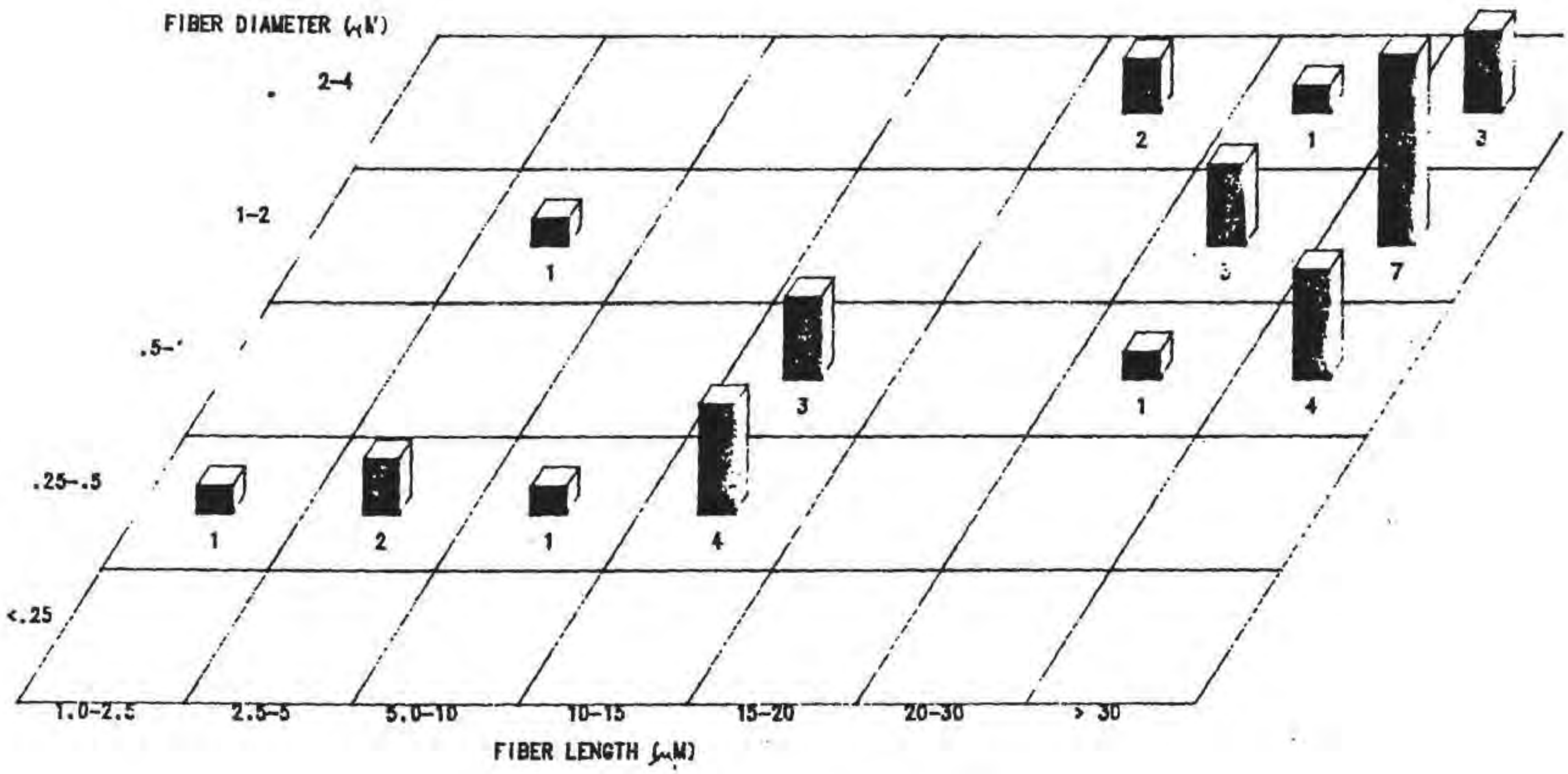
TOTAL FIBERS COUNTED: 37
AIRBORNE FIBER CONCENTRATION: 0.31 F/CC

FIGURE 2
CERWOOL® BLANKET: UNWRAP
NIAGARA MOHAWK POWER CORPORATION
SEPTEMBER, 1985



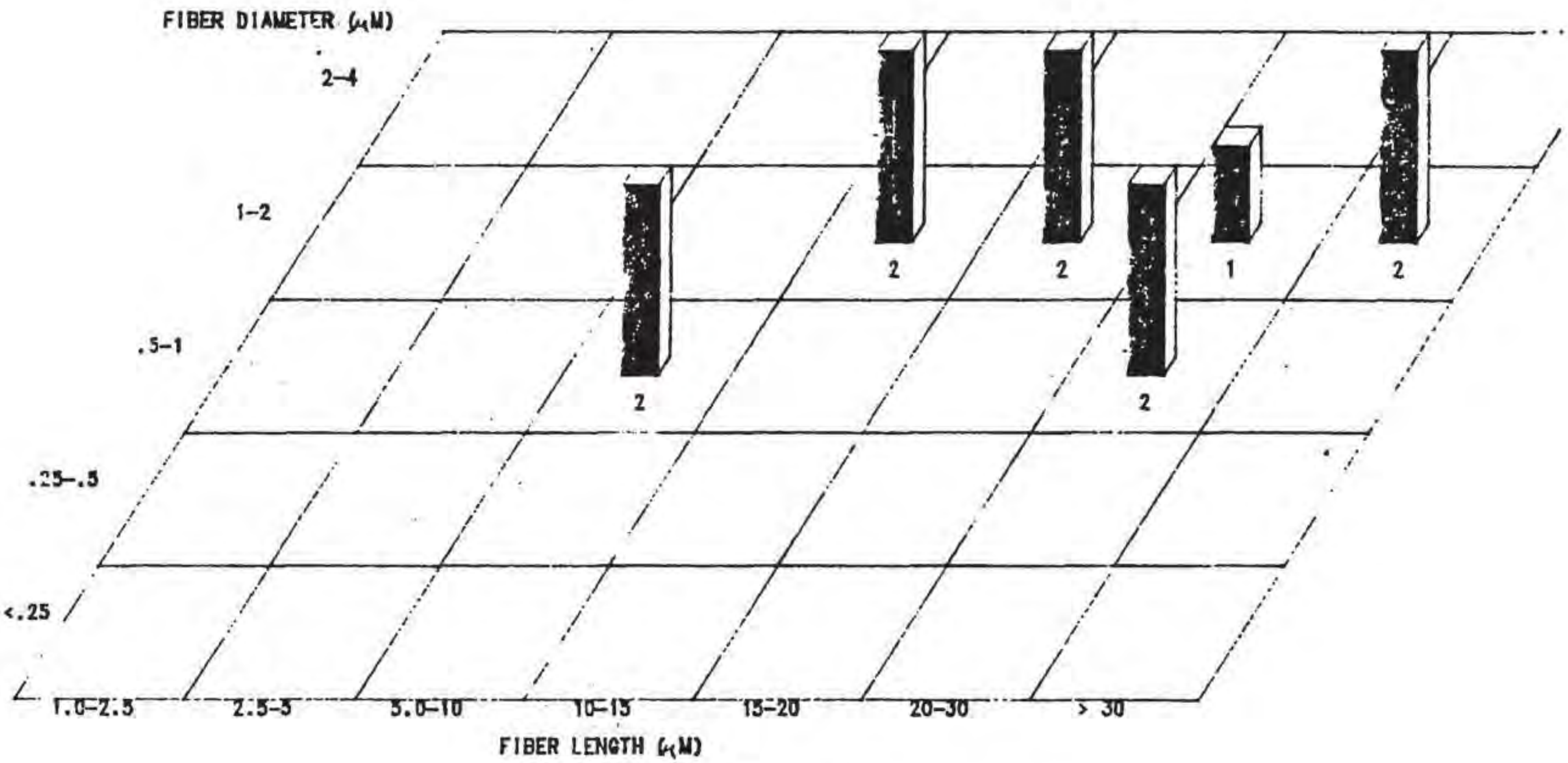
TOTAL FIBERS COUNTED: 39
AIRBORNE FIBER CONCENTRATION: 0.30 F/CC

FIGURE 3
CERWOOL® BLANKET: UNWRAP
NIAGARA MOHAWK POWER CORPORATION
SEPTEMBER, 1985



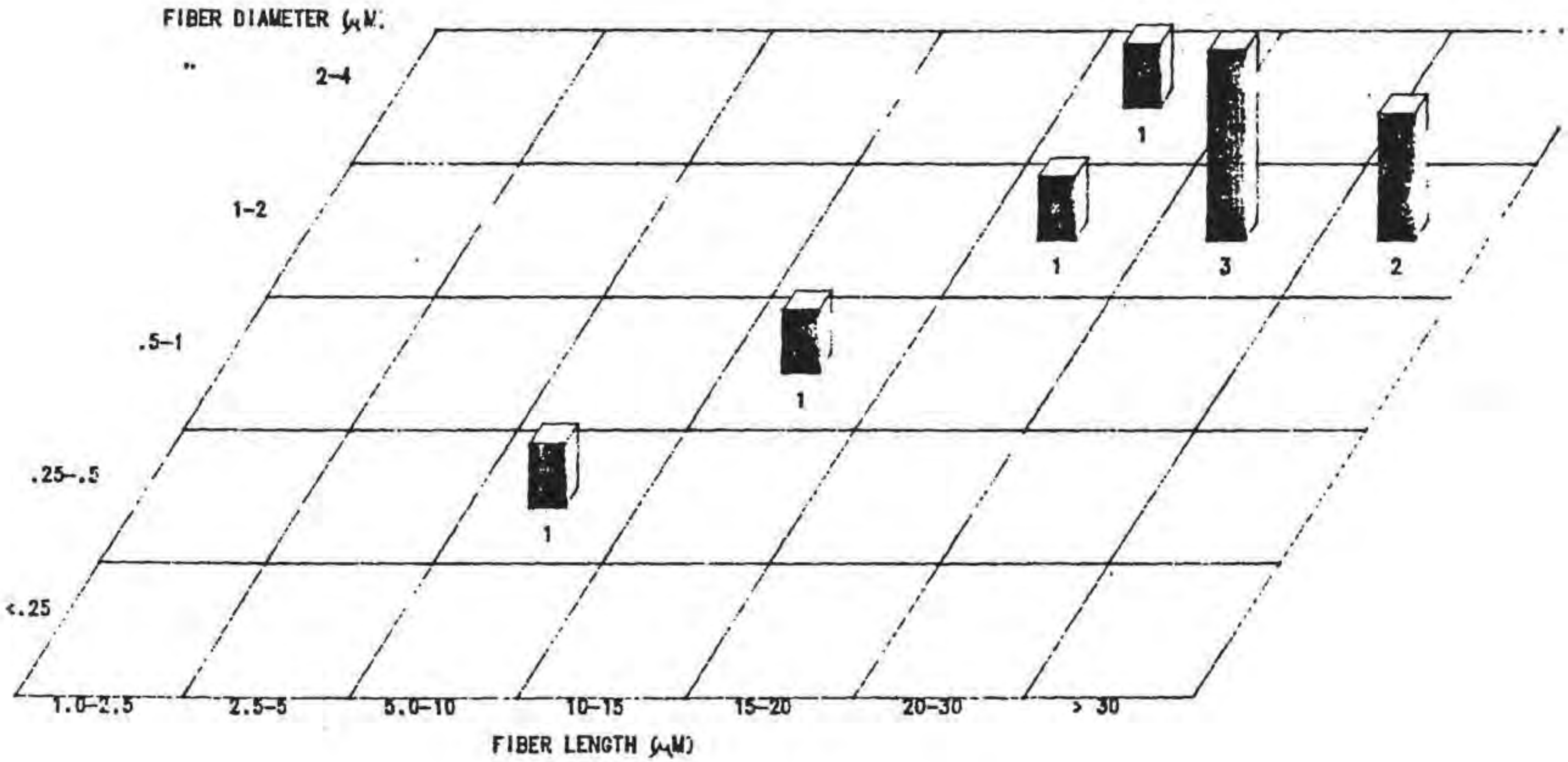
TOTAL FIBERS COUNTED: 33
AIRBORNE FIBER CONCENTRATION: 0.27 F/CC

FIGURE 4
CERWOOL® BLANKET: UNWRAP
NIAGARA MOHAWK POWER CORPORATION
SEPTEMBER, 1985



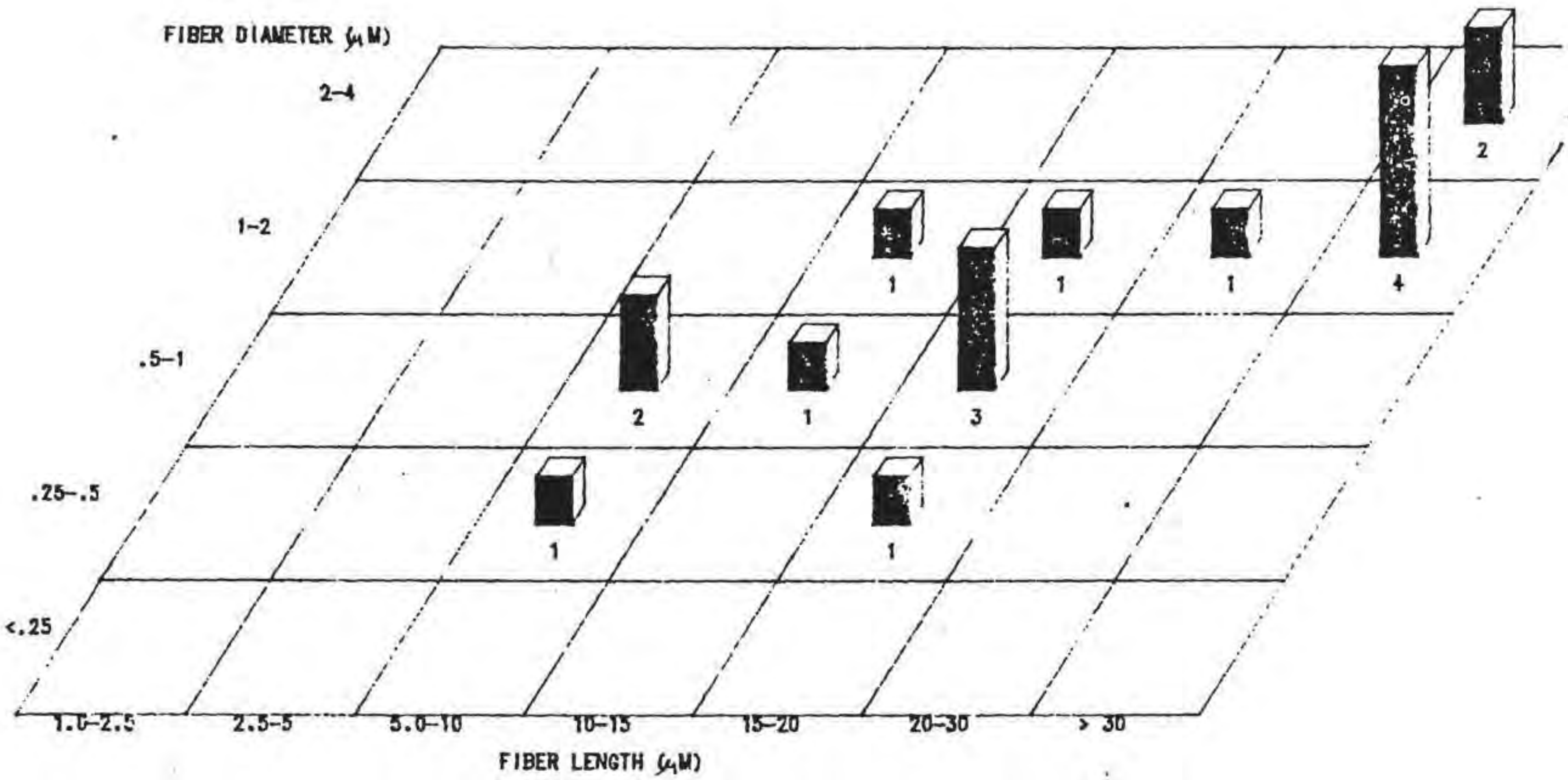
TOTAL FIBERS COUNTED: 11
AIRBORNE FIBER CONCENTRATION: 0.09 F/CC

FIGURE 5
CERWOOL® BLANKET: WRAP
NIAGARA MOHAWK POWER CORPORATION
SEPTEMBER, 1985



TOTAL FIBERS COUNTED: 9
AIRBORNE FIBER CONCENTRATION: 0.14 F/CC

FIGURE 6
CERWOOL® BLANKET: WRAP
NIAGARA MOHAWK POWER CORPORATION
SEPTEMBER, 1985



TOTAL FIBERS COUNTED: 17
AIRBORNE FIBER CONCENTRATION: 0.07 F/CC

Warning

- POSSIBLE CANCER HAZARD BASED ON TESTS WITH LABORATORY ANIMALS.
- MAY BE IRRITATING TO SKIN, EYES AND RESPIRATORY TRACT.
- MAY BE HARMFUL IF INHALED.
- CRISTOBALITE (CRYSTALLINE SILICA) FORMED AT HIGH TEMPERATURES (ABOVE 1600 F°) CAN CAUSE SEVERE RESPIRATORY DISEASE.

Before using this product, read the MSDS which contains more detailed precautionary measures and handling instructions.

RECOMMENDED WORK PRACTICES WHEN POTENTIAL FOR AIRBORNE EXPOSURE EXCEEDS 2 FIBERS/CC.:

- ☐ Provide engineering controls, where feasible, to keep airborne fiber exposure at the lowest level attainable.
- ☐ Use a NIOSH or MSHA approved air purifying respirator (3M 8710 or equivalent) during installation and removal of products used at high temperatures. For airborne concentrations > 5 fibers/cc. consult the product MSDS for additional information.
- ☐ Wear long-sleeve clothing, gloves, hat and eye protection to prevent skin and eye contact. Wash thoroughly after handling.
- ☐ Avoid taking unwashed work clothes home or provide disposable work clothing. Wash work clothes separately from other clothing. Rinse washing machine thoroughly after use.