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Alcatel Telecommunications Cable
Roanoke, Virginia

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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 Stan Salisbury, CIH, from the Atlanta Field Office, of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing by Pat Lovell.

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Health Hazard Evaluation Report 95-0318-2631
Alcatel Telecommunications Cable
Roanoke, Virginia
March 1997

Stan Salisbury, CIH

SUMMARY

In July 1995, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate potential exposures to silica dust, hydrofluoric and nitric acids, isopropanol, and chlorine at the Alcatel Telecommunications Cable plant in Roanoke, Virginia. This facility manufactures fiber-optic telephone cable. The chief areas of concern included the "Chemical Vapor Deposition" (CVD) area where thin layers of high quality glass are deposited inside quartz glass tubes mounted in glass-working lathes. Approximately 18 workers are assigned to CVD. Another area identified in the request was the "Chem-Clean Room" where spent or damaged quartz glass tubes are acid-cleaned and cut to shorter lengths for reuse in other parts of the fiber optic cable manufacturing process. Work in the Chem-Clean Room only required one person working about four hours per shift.

On August 27-28, 1995, a NIOSH industrial hygiene investigator visited the facility to conduct a walk-through tour of the manufacturing process, to observe work practices and potential exposure risks, and to informally interview employees. On the second day of the visit, personal breathing zone samples were collected to evaluate employee exposures to respirable airborne particulates and crystalline silica (quartz and cristobalite). Workers sampled included two CVD Operators and the Utility Glass Operator working in the Chem-Clean Room. General area samples for airborne crystalline silica were also obtained near CVD lathe equipment, and above work tables in the "Measurements Area." To characterize the composition of the airborne dusts sampled, bulk samples of settled dust were taken from the top of a lathe compartment in the CVD area, and from the glass cutting saw waste receptacle in the Chem-Clean Room. High volume "bulk air" samples were also collected to estimate the percent of crystalline (free) silica contained in airborne dust samples.

Results from sampling found only trace amounts of airborne fused silica. The airborne silica collected in the samples was identified as mostly amorphous (lacking the crystalline structure of quartz or cristobalite). However, because fused quartz glass is processed at this facility, the exposure limit for respirable amorphous fused silica (0.1 milligrams per cubic meter [mg/m^3]), as recommended by the American Conference of Governmental Hygienists (ACGIH), was selected to evaluate exposures during this survey. The highest personal exposure found during this survey, assuming all collected respirable particulate was amorphous fused silica, was 0.217 mg/m^3. This six-hour sample was collected from the Utility Glass Operator cutting glass tubes in the Chem-Clean Room.

Optical examination of material taken from the saw waste receptacle found only amorphous silica (glass) and aluminum oxide. No crystalline silica (quartz or cristobalite) was found in this material when analyzed by x-ray diffraction (XRD). A sample of glass tubing processed in the CVD Department was also ground and

microscopically analyzed by XRD. No crystalline forms of silica in the ground glass sample could be detected by XRD. Microscopic examination of the CVD tubing stock found the glass showing less than 5% crystallinity. Crystalline silica (quartz or cristobalite) was also not detectable by XRD analysis in the sample of settled dust taken from the top of a CVD compartment.

General impression from informal employee interviews found very few workers had specific health complaints, but many voiced lingering concern about the potential for exposure to silica.

Sampling results demonstrate that airborne silica exposures, either as fused, amorphous, or crystalline, are below all recommended exposure limits for workers assigned to the CVD, Clean Room, and Measurements Departments. Based on this survey and previous environmental surveys of this process, Alcatel workers are not at risk from silica exposures in the routine manufacturer of optical fiber cable. However, any non-routine work practice involving cleanup or maintenance procedures that may release fused silica (fused quartz) particles into a worker's breathing zone should be evaluated. Cleanup or maintenance workers potentially exposed to respirable particulate likely containing fused silica above 0.1 mg/m^3 should be adequately protected with effective engineering controls or required to wear appropriate respiratory protection. Local exhaust ventilation is recommended to better protect the Utility Glass Operator when sawing quartz glass tubing. Other recommendations are offered concerning transport of CVD glass bubblers containing phosphorous oxychloride, and prevention of allergic skin reactions from contact with fiber coating materials.

Keywords: SIC 3357 (fiber optic cable) amorphous fused silica (CAS 60676-86-0), fused quartz tubing, silicon tetrachloride, phosphorous oxychloride, germanium tetrachloride

TABLE OF CONTENTS

Preface ii

Acknowledgments and Availability of Report ii

Summary iii

Introduction 2

Background 2
- Facility Description 2
- Process Description 2
  - Chem-Clean Room 3

Methods 4
- Sampling 4
- Sample analysis 4

Evaluation Criteria 5
- Amorphous Fused Silica 5

Results 6
- CVD and Sleeving 6
- Chem-Clean Room 6
- Measurements Department 7
- Bulk Sample Analyses 7

Discussion 8

Conclusions 8

Recommendations 9

References 11

Attachment - Air Monitoring Results Table 12

INTRODUCTION

On July 7, 1995, NIOSH received a confidential employee request for a health hazard evaluation at the Alcatel Telecommunications Cable plant in Roanoke, Virginia. A NIOSH industrial hygiene investigator conducted a site visit to evaluate employee concerns over potential exposures to respirable crystalline silica during the operation of the "Chemical Vapor Deposition" (CVD) process, and when cleaning and cutting quartz glass tubes in the "Chem-Clean Room." On August 27-28, 1995, the NIOSH investigator visited the facility to: conduct a walk-through tour of the manufacturing process, observe work practices and potential exposure risks, and informally interview employees working in the areas of concern. Personal breathing zone samples for two CVD Operators and the Utility Glass Operator were collected to evaluate employee exposures to respirable airborne particulates and crystalline silica (quartz and cristobalite). General area air samples were also obtained from glass working lathes in the CVD and Clean Room (sleeving) areas. High volume "bulk air" samples were collected in the Chem-Clean Room and Measurements Department to attempt identification and content of crystalline silica (quartz or cristobalite) in airborne dusts.

BACKGROUND

Facility Description

The Alcatel Telecommunications Cable facility in Roanoke, Virginia, was built in the 1960s and is owned by the ITT Corporation. The facility has 186 employees, with 35-40 salaried employees, and about 140 hourly workers. The plant operates with overlapping 10 hour shifts Monday through Thursday, and overlapping 12 hour shifts on Friday through Sunday. Approximately 35 workers per shift operate the facility. This company manufacturers 125 micron optical fiber used in the fabrication of fiber-optic telephone cable. The process used by Alcatel has been in operation at this facility since the 1970s.

Process Description

The modified chemical-vapor deposition (MCVD) process used to manufacturer optical fiber at the Alcatel Telecommunications Cable plant was invented at the AT&T Bell Laboratories. The MCVD process was the first of four processes now being used by the optical fiber industry. The MCVD process involves:

(1) vaporizing and depositing high optical quality glass on the inner surface of a quartz glass tube,
(2) collapsing the tube to form a preform rod comprised of the core/clad structure needed for light guidance, and
(3) drawing the preform into a controlled diameter light-guide fiber.

Commercial application of the MCVD process began in the early 1970s. Optical fibers produced are mainly silica (SIO_2) with additions of 1%-25% germania (GEO_2). The high purity comes from the vapor deposition of the starting materials, silicon tetrachloride and germanium tetrachloride.[1]

Alcatel's CVD Department has 22 CVD systems. Each system consists of a glass-working lathe, a large gas train compartment, and a computer control console. The gas train compartment contains the valves, fittings, flowmeters, and chemicals needed for the CVD process. Chemicals used in the gas train include silicon tetrachloride, germanium tetrachloride, phosphorous oxychloride, Zyron® (hexafluroethane), chlorine, oxygen, hydrogen, helium, and nitrogen.

To start the process, a CVD operator mounts a quartz glass tube, measuring about 2 inches in diameter and 70 centimeters (cm) in length (known as the substrate tube), in the lathe. Next a slightly smaller diameter glass tube (the exhaust tube) is inserted in the exhaust end of the substrate tube. The two tubes are joined together by heating the joint with a hand torch. Both the inlet of the substrate and the outlet of the exhaust tube are connected to the lathe via rotary unions equipped with Teflon seals. Excess gasses and fumes flowing through the tubes are exhausted through the "Tail Stock" side of the lathe into a sealed flexible exhaust duct leading to a chemical scrubber system.

To make a preform, thin layers of glass are deposited on the inside surface of the substrate tube. The deposits are mostly silicon dioxide (SIO_2) formed from a reaction of silicon tetrachloride with oxygen. The layers of glass known as the "cladding" also contain small amounts of germanium, fluorine, and phosphorous that serve to reduce the optical index of refraction. Additional glass layers called the "core" are then deposited. The core layers are mostly germanium-silicate. The core has a relatively higher index of refraction from the cladding. This difference serves to give the preform its ability to guide light. The deposition process requires heat to react the starting materials flowing from the gas train compartment. The hot zone is where the deposits of sub-micron particles of optically pure glass collect onto the inside surface of the substrate tube. The hot zone is created with a oxyhydrogen fuel torch (2000°C) that traverses back and forth along the length of the substrate tube. After deposition of the core, the traversing torch is used to collapse the tube into a solid rod. About 25% of the outside portion of the substrate tube is milled off during the collapse phase of the process. The vaporized glass milled off is captured by a small local exhaust hood mounted directly above the traversing torch. A brilliant white light is generated from the hot zone. About 9 hours are required to make what Alcatel calls their "step one preform."

From the CVD department the step one preform is sent to the Clean Room. Here it is inspected for optical and physical characteristics and sent to the "Sleeving" area where four other glass working lathes are located. In Sleeving, the step one preform is inserted inside a second quartz glass tube and the two tubes are fused together with a traversing oxyhydrogen torch. Sleeving increases the preform diameter to increase the amount of fiber that can be obtained from each preform. The rod, now called a "step two preform," is further inspected and then sent to the "Draw Room" where the rod is vertically mounted in a "draw tower" and heated to melt the bottom of the preform. The Draw Operator captures the "gob" of molten glass falling from the preform and manually threads this now relatively large diameter glass fiber stream down from the furnace to a capstan drive. The capstan drive temporarily feeds the fiber stream into a vacuum hose until the fiber diameter is reduced small enough to feed the fiber through the fiber coaters and curing fixtures. The UV cured acrylic coating gives the fiber extra strength and flexibility. After the fiber is at the specified diameter, the fiber is threaded onto a "draw spool." The lengths of fiber wound onto the draw spools vary according to customer specifications. The draw speed is computer regulated to pull the molten glass from the melting preform at a rate that will maintain a fiber diameter of 125 microns. Alcatel currently has eight draw towers at this facility.

From the Draw Room, the draw spools are sent to the "Measurements Department" for various tests. After testing the draw spool is sent to the "Rewind Room" where the spools of fiber are rewound under zero tension onto "zero tension spools" so the fiber can again undergo additional testing in the Measurements Department. After final testing, the fiber is unwound from the zero tension spools onto the spools used for shipping the finished product.

Chem-Clean Room

Although most quartz-glass tubes are acid washed with hydrofluoric and nitric acid inside an enclosed (Polyflow) cabinet located in the "Clean Room" adjacent to the CVD Department, some out-of-tolerance or used quartz tubes are cleaned by hand in the "Chem-Clean Room" by the "Utility Glass" operator. Working under a back-drafted local exhaust hood, the Utility Glass operator places several tubes into a trough filled with a solution of 48% hydrofluoric (HF) acid (3 gallons of HF to 6 gallons of water). After soaking for several minutes, the tubes are rinsed by lifting the tubes over to an adjacent trough (directly in front of the acid trough) containing deionized water. This dualtrough sink is about four feet long, with each trough being about 10 inches wide and about 6 inches deep.

After acid cleaning and rinsing, the tubes are placed onto a cart and moved next to a radial-arm glass saw where they are cut to specified lengths. A water spray on the saw blade is used to control airborne dust, but no local exhaust system is available for the saw. The Utility Glass operator normally works in the Chem-Clean Room about four hours each shift. Personal protective equipment worn includes an acid resistant apron, safety glasses, face shield, protective sleeves, and gloves. During the NIOSH site visit, a 3M® 8710 disposable dust/mist respirator was worn when operating the glass saw. The face shield was used only when acid washing tubes.

METHODS

Sampling

Before conducting the environmental evaluation, background information was requested by the NIOSH investigator concerning previous environmental surveys conducted at the facility. The most recent monitoring data provided was for silica sampling done in 1985. The survey report found crystalline silica was below detectable limits for air samples and less than 0.5% in bulk samples analyzed by x-ray diffraction.

Because of lingering employee concerns about potential exposures to airborne free silica (quartz and cristobalite) in the CVD Department and Chem-Clean Room, two CVD Operators and the Utility Glass Operator were asked to wear personal sampling devices. General area air samples for respirable airborne particulates were also obtained from CVD lathe equipment, and from above a lathe machine in the Sleeving area. To further identify the composition of airborne dusts being sampled, bulk samples of settled dust were taken from the top of a lathe compartment in the CVD area, and from the glass cutting saw waste receptacle in the Chem-Clean Room. High volume "bulk air" samples were collected to estimate the percent of crystalline (free) silica contained in airborne dust samples. To evaluate the crystallinity or amorphous nature of the fused quartz glass tubing processed by Alcatel, a sample of glass tubing was analyzed using a polarizing light microscope with follow-up XRD analysis.

Personal air sampling for respirable dust was accomplished using Gilian HFS 513 pre-calibrated air sampling pumps. A flow rate of 1.7 liters per minute (Lpm) was used to draw sample air through an MSA cyclone fitted with a tared, 37 millimeter, 5 micron pore size, polyvinyl chloride filter mounted in a 3-piece plastic cassette. The cyclone removes the non-respirable particulates so the filter collects only that portion of the dust (<10 micrometers) that penetrates to the deeper areas of the lung.

Bulk air samples were also collected using a high-volume electric powered vacuum pump configured to pull air at 9 Lpm through a pair of filter cassettes placed side by side. Each filter in the pair was connected via plastic tubing to a "T" connector attached to a plastic tube connected to the vacuum pump. Precise air flow was obtained through each filter by pulling air from the filter through a critical orifice mounted inside the plastic tubing downstream from the filter cassette and upstream from the "T" connector. One of the filters was configured with a stainless steel cyclone to collect only respirable dust. The other filter had no cyclone and therefore collected total airborne dust. Bulk air sampling is frequently done when evaluating exposures to airborne free (crystalline) silica. Pulling a larger volume of air collects a greater quantity of respirable dust on the filter, thereby increasing the chance that the quantity of dust collected will contain sufficient free silica to exceed the detection limit for x-ray diffraction (XRD) analysis. Bulk air samples were obtained con-currently with personal samples collected from the "Utility Glass" operator. Due to concerns voiced by employees working in the Measurements Depart-ment, high volume air samples for total and respirable particulates were also collected in that location.

Sample analysis

Airborne particulate concentrations were determined by gravimetric analysis according to NIOSH Method 0500.[2] The total weight of each sample was determined by weighing the sample plus the filter on an electrobalance and subtracting the previously determined tare weight of the filter. Sample values less than the limit of detection were reported as not detected (ND).

Filter samples were analyzed for quartz and cristobalite by x-ray diffraction (XRD) using NIOSH Method 7500[3] with modifications that called for dissolving filters in tetrahydrofuran rather than being ashed in a furnace, running standards and samples concurrently, and using an external calibration curve from the integrated intensities rather than using the suggested normalization procedure.

The bulk samples of material taken from the glass saw and from the top of a CVD cabinet were also analyzed for quartz and cristobalite using the XRD method noted previously. A two-milligram portion of each bulk was weighed onto an FWSB filter prior to analysis. Both samples were also optically examined and described. To further evaluate the crystallinity or amorphous nature of the fused quartz glass tubing processed by Alcatel, a sample of glass tubing was microscopicly examined with a polarizing light microscope, and then further subjected to XRD analysis to attempt identification of crystalline silica.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[4], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs™)[5] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs).[6] In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Amorphous Fused Silica

Selection of the appropriate criteria for evaluating exposures to silica in the CVD and Chem-Clean areas was based on the assumption that the form of silica most likely encountered by Alcatel employees is amorphous fused silica. Fused silica is a colorless, odorless solid that is a form of quartz. This material is also know as quartz glass, identified by the Chemical Abstract Service as (CAS) 60676-86-0. This CAS number appears on the Material Safety Data Sheet (MSDS) for the quartz tubing supplied to Alcatel by the General Electric (GE) Company. The GE MSDS contains a statement that "when quartz tubing is heated to working temperatures, the silica vapors given off condense as amorphous silica." The GE MSDS also indicates the OSHA eight-hour TWA PEL for amorphous silica is 6 mg/m^3 and the ACGIH TLV is 10 mg/m^3. Although fused silica is structurally non-crystalline (amorphous), there is considerable confusion in the toxicological literature concerning fused silica.[7] The exposure limits cited in the GE MSDS, dated 1991, were for amorphous silica, diatomaceous earth (CAS 61790-53-2), and are not appropriate for evaluating exposures to amorphous silica, fused.

The toxicology of fused silica, in spite of its amorphous non-crystalline structure, has been found to produce fibrosis and pulmonary lesions (although less severe than crystalline silica) in laboratory animals.[7] Several studies have reported exposures to silica fume can produce a unique form of acute and chronic respiratory symptoms that subside after exposures ceases. Although condensed silica fume may be amorphous,[8] brief high exposures to silica fume have been associated with symptoms of metal fume fever persisting up to three months.[9]

Currently the ACGIH believes that fused quartz (amorphous fused silica) could be nearly as fibrogenic as crystalline quartz.[7] Therefore the ACGIH has adopted the TLV for quartz (0.1 mg/m^3 - respirable particulates) as their TLV for amorphous fused silica. The NIOSH REL[4] specified for amorphous fused silica is 0.05 mg/m^3. However, determination of exposures based on the NIOSH REL requires the application of a more complex analytical method[10] (NIOSH Method 7501) that calls for XRD analysis before and after heat treating the sample to 1500° C. This method has not been fully validated for samples containing amorphous fused silica.

Fused silica is not specifically regulated by OSHA under the "mineral dust exposure formula" as shown in Table Z3 of OSHA's General Industry Standard.[6] Because X-ray diffraction cannot be used for direct quantitative analysis of amorphous fused silica, a simple gravimetric analysis of a respirable dust sample is recommended by the ACGIH.[7] Using this method, exposures to respirable dusts containing amorphous fused silica should be controlled to maintain levels below 0.1 mg/m^3.

RESULTS

CVD and Sleeving

All air sampling results are shown in the attached table. As discussed in the Evaluation Criteria section of this report, the exposure assessment method chosen for this survey was designed to monitor airborne respirable particulate concentrations. All particulates collected were assumed to consist entirely of amorphous fused silica. Analysis of air samples collected found CVD operators (samples 2007 and 2010) not exposed to respirable amorphous fused silica above concentrations detectable by gravimetric analysis (less than 0.02 mg/m^3). This detection limit shows that potential exposures for CVD operators to respirable amorphous fused silica are well below the ACGIH TLV of 0.1 mg/m^3 and also below the NIOSH REL for respirable free silica (0.05 mg/m^3). Area air samples collected directly above the traversing torch of two glass-working lathes, one in CVD (sample 1993), and one in the Sleeving Area (sample 1998), also failed to collect respirable particulates above the 0.02 mg/m^3 detection limit. Each filter cassette was clipped to the outside edge of the torch exhaust hood to capture any silica fumes escaping beyond the capture of the exhaust. These locations were selected to monitor what was believed to be a worse-case environment for quartz fume emissions.

Chem-Clean Room

Samples collected in the Chem-Clean Room did detect measurable airborne respirable particulates. Using a conservative approach for evaluating fused quartz exposure for the Utility Glass Operator assumes all respirable particles collected were amorphous fused silica. Based on gravimetric analysis of the personal six-hour sample taken from the operator (sample 2008) the average airborne concentration detected during the sampling period was 0.217 mg/m^3. If no silica exposure is assumed for the non-sampled portion of the 8-hour shift, this result is equivalent to 0.16 mg/m^3 as an eight-hour TWA. This concentration was above the ACGIH TLV of 0.1 mg/m^3 for an eight-hour TWA. A high-volume "bulk air" sample collected in an area above and in front of the glass saw detected an airborne respirable particulate concentration of 0.135 mg/m^3. An XRD analysis was performed on this sample and the amount of free crystalline silica detected in the samples was estimated at 4.8%. Based on this estimate, an exposure to 0.2 mg/m^3 of respirable particulate would be equivalent to less than 0.01 mg/m^3 of respirable free (crystalline) silica. This concentration is well below the NIOSH REL of 0.05 mg/m^3. The actual amounts of amorphous fused silica in the samples were not determined.

Acid gases were not monitored during acid washing activities, but the face velocity of the local exhaust hood was checked with a calibrated air-flow meter. The average velocity, as determined from readings taken at 15 points across the face of exhaust hood, was about 150 feet per minute. This flow was effectively capturing HF vapors released from the washing tank. No odor, eye, or respiratory irritation was noted when standing next to the tank during this activity.

Measurements Department

The "bulk air" sample collected in the Measurements Department did not detect respirable particulates at a concentration that would indicate an exposure risk for silica. The sample (number 1243) detected only 0.025 mg/m^3 respirable particulates. Other airborne particles are also likely within this sample, but assuming all particles were fuzed quartz, the concentration was still well below the 0.1 mg/m^3 TLV. No free crystalline silica was detected in the bulk air samples when analyzed by XRD.

Bulk Sample Analyses

The bulk sample of light gray fibrous material taken from the top surface of a CVD cabinet (sample 6313) and wet gray mass of material (sample 6314) taken from inside the water spray collection receptacle of the glass saw used by the Utility Glass Operator were optically examined by the NIOSH contract laboratory with the following observations: Sample 6313 was mostly a gray fibrous mass with some loose particles trapped within the fibrous material. The particles were described as unidentified black opaques of possible amorphous silica and other particles believed to be aluminum oxide. The wet sample (6314) was dried, and when examined appeared to be very fine cream colored particles and small to medium shards of clear glass. No fibers were present in this sample. The cream-colored particles appeared to be aluminum oxide. No crystalline quartz or cristobalite were observed in either sample using X-ray diffraction (XRD) analysis. The glass shards were reported by the laboratory to be "amorphous in nature," with the finer particles also thought to be to be amorphous silica.

To further evaluate the crystallinity or amorphous nature of the fused quartz glass tubing processed by Alcatel, a sample of glass tubing was also analyzed. Portions of the tube were ground with a mortar and pestle to obtain particles small enough to fit under a microscope cover slip mounted on a glass slide. The particles were examined in 1.55 refractive index liquid with a Leitz Dialux 20 polarizing light microscope at 160X magnification. With the polars crossed, less than 5% of the particles showed indistinct little patches of low birefringence (whitish areas on a black particle background). These little patches are where the silica has some crystallinity, whereas, the black parts are amorphous without definite crystalline lattice. A portion of the ground tubing was further ground to pass through a 38 µm screen and analyzed by XRD to determine if crystalline silica minerals could be detected. The XRD scan (Figure 1) of the fused silica is overlayed with index lines (noted with a Q or a C) to show the positions for quartz and cristobalite peaks. The scan shows two broad peaks in the lower two-theta regions which are indicative of amorphous silica. The primary cristobalite peak is hidden in the large amorphous silica peak. There was no way to prove by XRD if cristobalite is present. The primary quartz peak is on the right shoulder of the amorphous silica peak and is also hidden. In this sample, quartz must be reported as not detected.

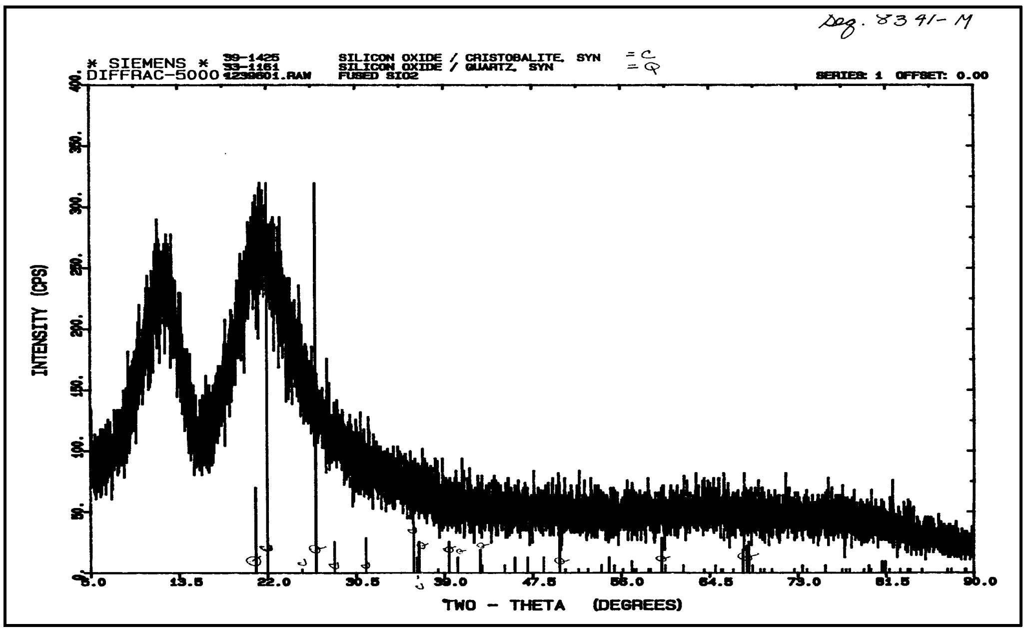

Figure 1 XRD Scan of fused quartz glass tubing

DISCUSSION

Sampling results from this survey indicate that inhalation exposures to respirable amorphous, crystalline, or fused silica are not likely for workers assigned to the CVD, Clean Room, and Measurements Departments. The most conservative approach for evaluating this exposure risk was used. This survey method assumed that all collected respirable particulates were amorphous fused silica (fused quarts). Although laboratory analyses of bulk samples indicates the silica from the glass tubing is technically non-crystalline (amorphous), toxicity data for fused quartz suggests that use of the exposure limit specified for amorphous silica is not applicable. Therefore, monitoring results were not compared to the NIOSH REL[4] for amorphous silica (6 mg/m^3). The laboratory analysis of bulk samples collected in this survey also indicates that subjecting samples to XRD analysis to identify the sample's crystalline silica (e.g. quartz or cristobalite) content is more than likely an exercise in futility.

Based on this survey and previous environmental surveys of this process, Alcatel workers are not at risk from silica exposures in the routine manufacturer of optical fiber cable. That is not to say that precautions are not needed. Any non-routine work practice, cleanup, or maintenance procedures that might release fused quartz particles into a worker's breathing zone should be evaluated. Maintenance or cleanup workers potentially exposed to airborne respirable particulates above 0.1 mg/m^{3}should be adequately protected with effective engineering controls or required to wear appropriate respiratory protection. For example, a procedure where excess exposures could occur might include maintenance activity on containment or pollution control systems that receive excess chemical residue (soot) from CVD tail stock exhausts.

CONCLUSIONS

Based on the assumption that all airborne respirable particulates sampled were fused quartz, the only Alcatel employee found with potential exposures above the evaluation criteria of 0.1 mg/m^3 was the Utility Glass Operator working in the Chem-Clean Room. This person should continue to use respiratory protection designed and approved to protect against exposure to fused silica. NIOSH recommends[11] the use of an air-purifying respirator with a high-efficiency particulate filter in work-settings where maximum concentration would not exceed 0.5 mg/m^3.

RECOMMENDATIONS

1. The MSDS supplied by the General Electric Company needs updating to reflect the exposure limits applicable for fused quartz. This 1991 MSDS states the TLV for amorphous silica is 10 mg/m^3. This TLV is applicable to inhalable particles of diatomaceous earth (CAS 61790-53-2). As discussed in the criteria section of this report, the current TLV recommended by the ACGIH for amorphous fused silica (fuzed quartz) is 0.1 mg/m^3.

2. Local exhaust ventilation is recommended for the Chem-clean glass saw. The exhaust hood should be designed to enclose the saw wheel and slide-table as much as possible without interfering with visibility or handling of the longer pieces being cut. The saw should be operated so that the flow of the abrasive fragments and glass dust coming off the cutting wheel is directed to the back of the enclosure hood. An example of this type of hood is shown in Figure 2.

3. The Utility Glass operator cutting quartz tubes was wearing 3M 8710 (TC-21C-132) particulate dust/mist (DM) respirator. These respirators were certified under old regulations (30 CFR 11) that have since been revised and replaced with new respirator certification regulations (42 CFR 84). However, until they are phased out, respirators certified under the old regulations will still be available on the market until July 1998.

Research has shown that particles sized 2 micrometers (2 µmd) or less can penetrate some DM filters certified under 30 CFR 11, and these filters should only be used if the particle size of the aerosol present in the workplace has been characterized, and the mass median aerodynamic diameter (MMAD) is known to be greater than 2 µmd.[12] Under the new regulations, particulate filters are tested under much more demanding conditions, using the most penetrating aerosols. As such, these filters are effective against any size aerosol.

Because the particle size of fused quartz glass dust generated from the saw is not known, until effective ventilation controls are implemented, the glass saw operator should use a DM respirator certified under the new NIOSH respirator certification regulations. The minimum protective filter that should be used is N95. These respirators will have a certification label with the NIOSH and Department of Health and Human Services (DHHS) emblem, with a numbering sequence of TC-84A-xxxx.

4. Draw Operators who work with uncured acrylic coating materials (Desolite®) should be aware of the

potential for allergic skin reactions from direct skin contact with these coatings. Chemical ingredients for both the primary (product code 3471U1-135) and secondary (product code 3471-2-102) UV cured coating materials are classified as "multifunctional acrylates." The specific chemical ingredients for these compounds are designated as "Trade Secrets" by the coating's supplier, DSM Desotech Inc., Elgin, IL. When contacted by NIOSH, DSM confirmed that unreacted acrylics in these products are known skin sensitizers. Although NIOSH was not given the specific ingredients, based on a review of the literature, and information provided by DSM, NIOSH offers the following comments:

- According to DSM Desotech, no solvents are used in the products. The MSDS for each coating material indicates the products contain less that 1% volatiles. There is a low potential for exposure through inhalation.
- DSM recommends using acetone or butyl alcohol as clean-up solvents.
- According to DSM Desotech, no skin sensitization or irritation is expected from the coatings after curing. However, it appears that once a worker becomes sensitized it is possible that allergic skin reaction can occur, even to finished fibers.[13] Workers who handle these coating materials and who experience skin rash

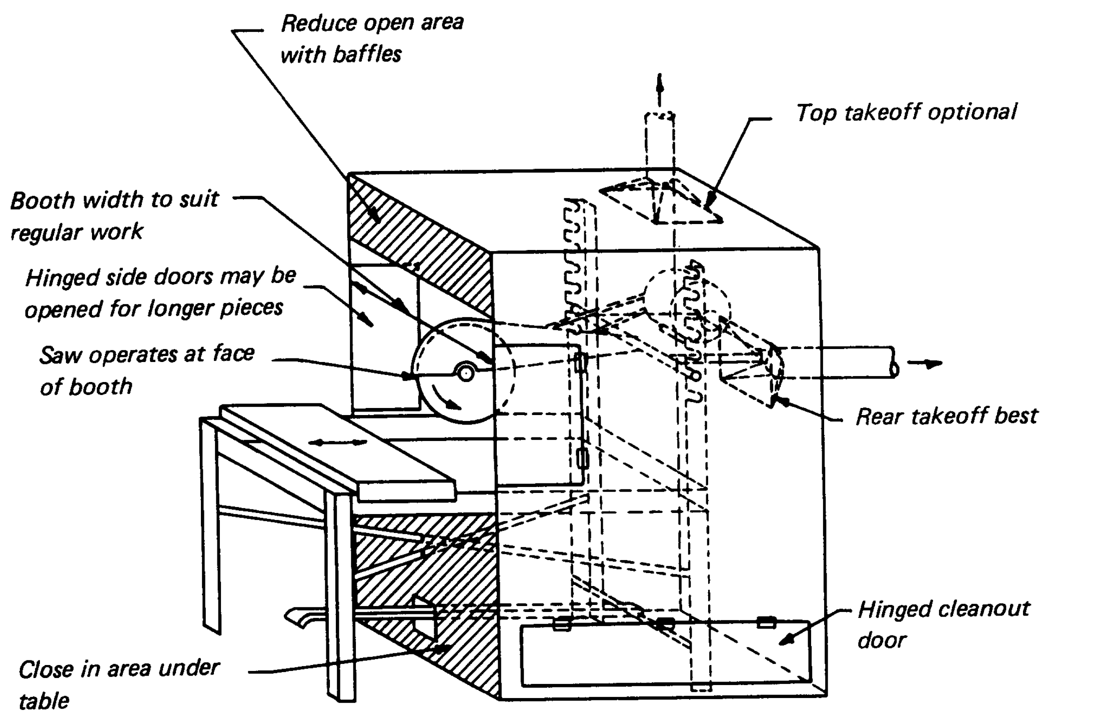

Figure 2 Glass saw exhaust hood recommendation

should immediately be referred to a dermatologist. Diagnosed sensitivity to the coatings may require reassignment of sensitized workers. Workers who work with these materials on a daily basis must avoid all direct skin contact and immediately wash the skin with soap and water if contact does occur.

- The recommended protective glove material for these products is nitrile rubber.
- A copy of the safe handling guide (available from DSM Desotech) should be obtained and made available to all Draw Operators and other Alcatel employees who must work with these coatings.

5. The CVD operating procedures for filling phosphorous oxychloride bubblers should be reviewed. The current practice of filling the bubbler at CVD system 35, and hand-carrying the glass bubbler container to the CVD gas train compartment where it is to be used, is a dangerous practice. If a worker transporting this bubbler were to accidentally drop and break a full container onto the floor of the CVD department, an extremely hazardous atmosphere could be created for workers near the spill. Any bubbler in transit should be carried in a protective outer container that would prevent breakage of the bubbler if dropped to the floor. Special bottle carriers are commercially available.

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Attachment - Air Monitoring Results Table

Table 1

Respirable Airborne Particulates / Amorphous Fused Silica

HETA 95−318
ALCATEL TELECOMMUNICATIONS CABLE
ROANOKE, VIRGINIA
August 29, 1995

Sample Number	Sample Description	Type Sample	Flow Rate	Start Time	Stop Time	Time hr:min	Volume liters	resp dust mg	TWA mg/m³
2190	field blank	blank	n/a					nd	na
2132	field blank	blank	n/a					nd	na
2007	CVD Operator	personal	1.72	08:47	18:01	09:14	952.9	nd	<0.02
2010	CVD Operator	personal	1.73	08:51	14:10	05:19	551.9	nd	<0.02
1993	CVD−above torch	area	1.71	09:50	17:58	08:08	834.5	nd	<0.02
1998	Sleeving−above torch	area	1.69	09:38	17:54	08:16	838.2	nd	<0.02
2008	Glass Utility Opr.	personal	1.7	08:34	14:26	05:52	598.4	0.13	0.217
1996	Chem−clean Room	resp blk air	9	08:35	14:30	05:55	3195.0	0.43	0.135
1243	Measurements Room	resp blk air	9	14:40	18:20	03:40	1980.0	0.05	0.025

Evaluation Criteria (8−hr TWA):

NIOSH Recommended Exposure Limit (REL), as respirable free (crystalline) silica		0.05
ACGIH Threshold Limit Value (TLV), as respirable particulates		0.1
OSHA Permissible Exposure Limit (PEL) [based on % quartz]		10/(%q+2)
Limit of Detection (mg / sample)	0.02	
	NIOSH Method 0600	

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