HETA 98-0139-2769
The Society of Glass Beadmakers
Corning, New York

C. Eugene Moss
Nancy Clark Burton

PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (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.

HETAB also provides, upon request, technical and consultative assistance 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. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by C. Eugene Moss and Nancy Clark Burton of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by Peter Eller, Joseph Fernback, Ardith Grote, and Mark Millson of the Analytical Research and Development Branch, Division of Physical Sciences and Engineering, and Data Chem Laboratories. Desktop publishing was performed by Robin Smith. Review and preparation for printing was performed by Penny Arthur.

Copies of this report have been sent to employee and management representatives at The Society of Glass Beadmakers and the Occupational Safety and Health Administration (OSHA) Regional Office. 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:

NIOSH Publications Office
4676 Columbia Parkway
Cincinnati, Ohio 45226
800-356-4674

After this time, copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address.

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.

Highlights of the NIOSH Health Hazard Evaluation

Exposures During Glass Beadmaking

In 1998, NIOSH conducted a health hazard evaluation at the Society of Glass Beadmakers (SGB) annual convention in Corning, New York to look at eye exposures to various types of optical radiation and chemical exposures to substances during glass beadmaking demonstrations.

What NIOSH Did

A questionnaire was offered to all SGB members to collect information on job history, use of personal protective equipment and devices, and symptoms.

We took air samples for metals, total particulates, and volatile organic compounds (VOCs). Samples of bead release material and glass were also checked. Hand wipes were collected before and after each demonstration and analyzed for trace metals.

We checked optical radiation including brightness levels, ultraviolet (UV) radiation levels, and infrared (IR) radiation levels. Facial temperature was also measured.

What NIOSH Found

About 30 % of the conference participants returned the questionnaire. Sixty percent of the participants worked in a separate studio or at home. Most had been making glass beads for one to five years.

Most respondents reported being burned by hot glass and cut by broken glass.

No measurable amount of total particulates were found in the air. The bead release materials were clay-based.

Area samples of glass beadmakers' exposures to metals and VOCs were very low during the demonstrations. The hand wipes showed results were similar for before/after samples indicating no significant contamination from the work.

Exposure to IR radiation can occur from torches, kiln furnaces and from handling heated materials. Exposure to high IR radiation levels can occur when working close to the ovens.

UV radiation levels were below occupational exposure limits.

What Glass Beadmakers Can Do

Protective eyewear should be used when working with glass beads.

Ventilation should be used to lower exposures from torches.

Material safety data sheets (MSDSs) should be obtained when working with new products.

The work area should be designed so that the work table is at a comfortable height. Frequent breaks would reduce the strain on the hands and wrists from constantly turning the glass in the torch.

Glass beadmakers should wash their hands occasionally after working and before eating and drinking to lower their exposure to trace metals/elements.

Heat-resistant gloves should be used when working with kilns and ovens to reduce the chance of burns.

Children should be kept away from the home studio to reduce the risk of injury, especially burns and cuts.

CDC

CENTERS FOR DISEASE CONTROL AND PREVENTION

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513/841-4252 and ask for HETA Report #98-0139-2769

National Institute for Occupational Safety and Health

NIOSH

Health Hazard Evaluation Report 98-0139-2769

The Society of Glass Beadmakers
Corning, New York
December 1999

C. Eugene Moss
Nancy Clark Burton

SUMMARY

On February 28, 1998, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the president of the Society of Glass Beadmakers (SGB). The major occupational concern was optical radiation exposure during beadmaking. The requestor asked that NIOSH attend the SGB annual conference in Corning, New York, on May 7-10, 1998, and perform optical radiation measurements. NIOSH also evaluated environmental contaminants produced during the various beadmaking demonstrations at the conference. Four different demonstrations were monitored. The processes used were typical of those used at a normal worksite, but may not represent actual working conditions.

A self-administered questionnaire was distributed to conference attendees to gather information about job activities and possible health effects. Area air samples were collected for metals, total particulates, respirable particulate, and volatile organic compounds (VOCs). Bulk samples of bead release materials and glass were collected and analyzed for trace metal content. Hand-wipe samples were collected from all demonstrators before and after each glass bead event to determine trace metal contamination. Exposure levels to ultraviolet (UV), visible, and infrared (IR) radiation were documented during the production of glass beads. Air temperature was measured near the face of the demonstrators.

Most respondents reported being burned by hot glass and being cut by broken glass in the past year. All measured exposures were well below occupational exposure limits. Total particulates and respirable particulate were not detected in the air samples collected. Trace levels of some VOCs were found on samples collected near the worktable. The VOCs were probably generated by compounds used by the demonstrators (such as fuels from various torches) or from hotel cleaning products. Wipe sampling of the demonstrators' hands did not show contamination with metals. Traces of various metals were found in the bulk glass samples. The bead release materials were clay-based.

UV, visible, and IR radiation exposures measured in this investigation did not exceed the applicable standards and guidelines, although exposure to high IR levels is possible close to the ovens. Since glass bead work involves exposure to IR, distracting visible radiation (sodium flare), and particulate matter (i.e., broken glass), eye protection is recommended. Recommendations are made for minimizing hazards by using local exhaust ventilation, wearing protective eyewear, and wearing gloves to prevent burns.

Keywords: SIC Code 3229 (Pressed and Blown Glass and Glassware, Not Elsewhere Classified), glass beadmaking, metals, bead release, volatile organic compounds, VOCs, silica, infrared radiation, ultraviolet radiation, UV, eye protection, personal protective equipment, ventilation.

TABLE OF CONTENTS

INTRODUCTION

On February 28, 1998, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the president of the Society of Glass Beadmakers (SGB). The major occupational concern expressed in the request was the level of optical radiation exposure during beadmaking. The requestor asked that NIOSH attend the SGB annual conference in Corning, New York, on May 7-10, 1998, to perform optical radiation measurements during several demonstrations of beadmaking techniques. Following discussions with the requestor, NIOSH investigators also evaluated exposures to environmental contaminants produced during the various beadmaking demonstrations at the conference.

BACKGROUND

Glass beadmaking is an ancient art that has been practiced for more than 3000 years. Glass beads have been used for adornment, trade, currency, and religious ritual in many cultures. Today, glass beadmaking involves lampworking, kiln forming and casting, furnace work, and cold work processes. The SGB was formed in 1993 and now has over 700 members worldwide. The society is dedicated to promoting glass beadmaking by educating its members and the general public about the process of beadmaking and the artistic value of glass beads. Among the concerns of SGB members has been exposures to optical radiation and chemical agents associated with the glass beadmaking process. SGB members typically work either in small businesses or at their homes. Approximately 250 bead makers attended the meeting. The demonstrations that were monitored included the production of urn beads, the application of color dots, metal fuming on beads, and making glass bead faces.

METHODS

Medical Questionnaire Design

A questionnaire was developed to help NIOSH investigators understand the nature of possible work-related health effects of glass bead making (Appendix A). This voluntary questionnaire was distributed at a special glass bead demonstration during the conference which was well attended. In addition, copies of the questionnaire were available from the NIOSH investigators as well as at the conference registration desk. The voluntary and confidential nature of the questionnaire was explained by a NIOSH investigator at the session. All attendees were asked to fill out the questionnaire as best they could and return it the next day. The questionnaire included items on job history, use of protective equipment and devices, and medical conditions/symptoms (particularly eye, upper/lower respiratory, and skin).

Chemical Agent Evaluation Design

Bead Release Compounds

Two bulk samples of bead release material (Sludge Plus–Mandrel Release Agent® and Bead Separator®) were collected and analyzed using IR spectroscopy, gas chromatography-mass spectroscopy for volatile organic compounds (VOCs), inductively coupled plasma–atomic emission spectrometry (ICP-AES) for metals, and polarized light microscopy for fibers. For the IR spectroscopy analysis, the samples were mixed with dry potassium bromide at a concentration of approximately two percent (weight to weight) in seven millimeter (mm) diameter pellets. The pellets were then analyzed by transmission using the Perkin-Elmer Spectrum 1000 FT-IR. To check for graphite, spectra were also obtained of acetone:cyclohexane extracts of the samples, and of a calcined portion of the Sludge Plus sample.

Metals

Area Air Samples

Two area air samples (one in the back of the room and the other on the work table) were collected for selected metals on mixed–cellulose ester filters (37 mm diameter, 0.8 micrometer [µm] pore size) using a flowrate of 2.0 liters per minute (Lpm). The samples were collected for several hours. The filters were placed in a microwave digestion vessel with a 1:1 solution of water and nitric acid. The vessels were sealed and digested in a microwave unit. The samples were transferred to flasks and diluted to volume with water. The resultant sample solutions were analyzed for metals according to NIOSH Method 7300,[1] modified for microwave digestion, using ICP-AES. The method can detect the following elements: aluminum, arsenic, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, phosphorus, platinum, selenium, silver, sodium, tellurium, thallium, titanium, vanadium, yttrium, zinc, and zirconium.[1]

Bulk Samples

Five bulk samples (four glass and one steel wool) were submitted for trace metal analysis. The glass samples were pulverized in a freezer mill under liquid nitrogen prior to analysis. Three replicate aliquots (about 0.1 grams [g]) of each were weighed and then wet-ashed with concentrated nitric, perchloric, and hydrofluoric acids. For the glass wool sample, three aliquots of 0.05 g each were ashed with nitric and perchloric acids. The samples were redissolved in 50 milliliters (mL) of dilute nitric and perchloric acids and analyzed according to NIOSH Method 7300.[1] The analytical limits of detection (LODs) and limits of quantitation (LOQs) for the metals are listed in Table 1.

Wipe Samples

Four demonstrators were asked to wipe their hands before and after the demonstration to determine metal contamination. Eight wipe samples (Wash-n-Dri®) were collected and digested and analyzed according to NIOSH Method 7300 for wipe digestion.[1] The wipes were digested on hotplates in the presence of 20 mL of concentrated nitric acid and 2 mL of 30% hydrogen peroxide and reduced to about 1 mL. After digestion, the samples were allowed to cool, transferred to 25 mL volumetric flasks, and then diluted to volume with water. The samples were analyzed using a Thermo Jarrrell Ash ICAP-61 ICP-AES controlled by a Digital DEC Station 450D2LP Personal Computer. The LOD and LOQ for each metal is provided in Table 2.

Total Particulates and Respirable Silica (Quartz)

Two area air samples (one in the back of the room and the other on the worktable) were collected for total particulate on pre–weighed polyvinyl chloride (PVC) filters (37 mm diameter, 5 µm pore size) using a flowrate of 2.0 Lpm. One area air sample was collected for respirable dust (aerodynamic diameter less than or equal to 10 µm) on the demonstration table at a flowrate of 1.7 Lpm using a 10 mm nylon cyclone containing a pre–weighed PVC filter (37 mm diameter, 5 µm pore size). The samples were collected for several hours during the four demonstrations to get some idea of potential exposures. The three samples were analyzed for particulate weight by gravimetric analysis according to NIOSH Methods 0500[2] and 0600[3], respectively, with LODs of 0.020 mg, which are equilivant to minimum detectable concentrations (MDCs) of 0.02 micrograms per cubic meter (mg/m^3), assuming sample volumes of 1002 liters.

Volatile Organic Compounds (VOCs)

One sample for VOCs was collected on a worktable during the four demonstrations using a thermal desorption tube which contained three beds of sorbent material. The sample was dry-purged with helium to remove water. The sample was analyzed for VOCs using a Perkin–Elmer automatic thermal desorption (TD) system interfaced directly to a gas chromatograph (GC) and a mass selective detector (MSD).

Physical Agent Evaluation Design

Measurements were taken on four different workers performing a range of beadmaking tasks. Each of the four workers performed their work on an elevated stage in the front of a large room. The work generally took about 30 minutes. Every attempt was made not to interfere with the process. Measurements were made several times during this 30-minute period to determine variation in optical radiation levels. All optical radiation measurements were made near the worker's face or hands.

The following equipment was used to measure levels of optical radiation.

• **Luminance or Brightness Levels**. These were measured with a Spectra Mini-Spot photometer having a one degree field of view. The measurements were obtained in units of foot-lamberts (fL) which were then converted to candela per square centimeter (cd/cm^2). The luminance of a source is a measure of its brightness when observed by an individual without eye protection, independent of the distance from the source. Measurements were made one meter from the worker.

• **Ultraviolet (UV) Radiation Levels**. An International Light radiometer, model 1700, with specially calibrated detectors was used to evaluate the UV radiation levels. One detector was designed to read the actinic UV radiation (200 to 315 nanometers [nm]) region in biologically effective units of microwatts per square centimeter (µW/cm^2), while the other detector measured near UV (320-400 nm) in units of milliwatts per square centimeter (mW/cm^2) with no biologic weighting factor. UV measurements were made at the worker's eye location, which was about 20 inches from the glass bead location.

• **Infrared (IR) Radiation Levels**. A Laser Probe Rm-3700 Universal radiometer, with a RkT-10 Probe and special Oriel IR transmitting filter, was used to evaluate the IR radiation levels. The RkT-10 Probe measured IR over the 0.19 to 20 µm region in units of mW/cm^2, and the IR transmitting filter located in a special filter holder in front of the probe passed IR in the 0.8 to 3 µm region. Most occupational IR measurements were made at the worker's eye level.

• **Temperature**. A Thermodyne PM-20700 digital pyrometer and detector was used to document the temperature produced at the face of the bead worker. This temperature system could document levels to within 0.1 degree Fahrenheit (^{0}F) over the range of -50 to 200 ^{0}F.

In addition to these optical radiation measurements, a complete set of welding shade and other specialized filters was used to determine the approximate shade useful in controlling optical radiation emissions. All equipment had been calibrated within six months either by NIOSH or the respective manufacturer.

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 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, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[6] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. At present, there is limited information from OSHA on exposure criteria for workers exposed to physical agents.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm.[7] Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PEL's and STEL's. An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL. Criteria for physical agents not covered by OSHA come from either ACGIH, NIOSH, or in some cases from consensus standards promulgated by the American National Standards Institute (ANSI).

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.

Chemical Agents

Several metals are used in the production of art glass and glass beads. These include arsenic (As), antimony (Sb), aluminum (Al), zinc (Zn), chromium (Cr), nickel (Ni), tin (Sn), selenium (Se), cadmium (Cd), lead (Pb), manganese (Mn), copper (Cu), cobalt (Co), and iron (Fe).[8,9,10] The majority of these metals are used for glass coloring. Hydrofluoric and sulphuric acid are used in the polishing process. Pyrex® glass is a borosilicate type of glass.

Glass dust can irritate eyes, skin, and the respiratory tract. Rubbing after skin exposure can cause abrasions or skin irritation. Epidemiological studies have indicated that industrial art glass workers have increased mortality risks for certain types of cancer (stomach, colon, lung, skin, and brain) and for cardiovascular and cerebrovascular disease.[11,12,13,14,15,16,17] The International Agency for Research on Cancer (IARC) has determined that the manufacture of art glass entails exposures that are probably carcinogenic to humans.[18] Glass blowing is one major occupation in the art glass industry which shows an increased cancer risk, possibly because the blow pipe introduces the potential for oral exposure.[19] However, glass blowing is not commonly used to make glass beads.

Physical Agents

Infrared Radiation [5,20,21,22]

All objects having temperatures above absolute zero emit IR as a function of temperature. In biological systems, IR exposure causes a rise in the temperature of the absorbing tissue. Physical factors which influence this temperature rise are the wavelength, heat conduction parameters, exposure time, and total amount of energy delivered to the exposed tissue. Since IR photons are low in energy, they would not be expected to enter into photochemical reactions with biological systems. Molecular interactions with radiation in the IR regions are characterized by various vibrational-rotational transitions resulting in an increase in thermal energy of the molecule.

Since the primary effect of IR on biological tissues is thermal, the skin provides its own warning mechanism by having a pain threshold below that of the burn threshold. However, there is no such adequate warning mechanism in the eye. Traditionally, safety personnel consider IR to be a cataractogenic agent, but recent information has raised questions about whether IR cataracts can be produced in the workplace from non-coherent optical sources, such as glass furnace operations.

IR radiation above 1400 nm can produce corneal and eyelid burns, as well as dry eyes and skin. The primary biological effect of IR on the retina and choroid is thermal in nature, with the amount of damage being proportional to the length and intensity of exposure. If the radiation intensity is low enough, normal retinal blood flow may be sufficient to dissipate any heat generated. Small amounts of IR, however, can produce a relatively intense point energy distribution on the retina, resulting in a burn.

Visible Radiation [5,23,24,25]

Visible radiation, from either the sun or artificial sources, is an important occupational health consideration because of its major role in our daily life. High light levels at certain wavelength regions are retinal hazards. These types of direct retinal effects from excessive light levels have been well known and documented for many years (i.e., staring at welding arcs or the sun). The ACGIH TLVs for visible radiation are intended to offer protection from retinal thermal injury and from photochemical injury that can occur from exposure to wavelengths in the region from 400-500 nm. While protective eyewear is essential under some conditions to protect the eye from ocular damage, often the luminous transmittance of the protective eyewear is so low that workers may not be able to see sufficiently well to perform a given task or job.

Ultraviolet Radiation [5,26,27,28]

UV radiation is an invisible radiant energy produced naturally by the sun and artificially by arcs operating at high temperatures. Examples of the latter include germicidal and blacklight lamps, carbon arcs, welding and cutting torches, electric arc furnaces, and various laboratory equipment.

Since the eyes and skin readily absorb UV radiation, they are particularly vulnerable to injury. The severity of radiation injury depends on exposure time, intensity of the radiation source, distance from the source, wavelength, sensitivity of the individual, and presence of sensitizing agents. Sunburn is a common example of the effect of UV radiation on the skin. Repeated UV exposure of lightly pigmented individuals may result in actinic skin: a dry, brown, inelastic, wrinkled skin. Actinic skin is not normally debilitating but is a warning that conditions such as actinic keratosis, squamous cell epithelioma, and basal cell epithelioma may develop. Since UV is not visible, the worker may not be aware of an exposure at the time it is occurring.

Absorption of UV radiation by the eye and eyelids can cause conjunctivitis. Lesions may also be formed on the cornea as a result of high exposure levels (photo keratitis). Such injuries usually manifest themselves 6 to 12 hours after exposure. The injuries may be very painful and incapacitating, but impairment is usually temporary. Workers also need to be aware that some photosensitizing agents, including drugs such as hydrochlorothiazide, can produce exaggerated sunburn when exposed to certain UV radiation wavelengths.

RESULTS

Medical Questionnaire

Characteristics of the Respondents

Of the 250 individuals attending the conference, 74 (30%) returned completed questionnaires. Almost 90% of the respondents were female, with a median age range of 36 to 45 years. Ninety-three percent of the respondents were 55 years of age or younger. There were no respondents younger than 25.

Almost 2/3 of the respondents had worked with glass beads for 1 to 5 years; only 15% had worked for more than 10 years in the field. Most worked either in their home or at a separate studio. Eighty-three percent of the respondents indicated they worked less than 30 hours per week at bead making and 64% stated that they worked at another job. When the respondents were asked which injuries had they suffered from in the last year, 81% reported being burned by hot glass, 63% were cut by broken glass, and only 1 reported any injury to the eye. Due to the very low response rate and the fact that most respondents do this work part-time and have other jobs, the reported medical conditions and symptoms on the questionnaires are not reported due to potential participation bias.

Vision Issues

Seventy-seven percent of the respondents reported wearing either eyeglasses or contact lenses to improve vision. Only 3 respondents did not report wearing any type of safety eyewear while bead making. Of the respondents that did report wearing eyewear, 29 wore rose-colored glasses, 23 used AUR-92™ lenses, and 19 wore didymium glasses. (The AUR-92™ lense is a commercially available product that is widely used by glass beadmakers.)

Environmental Monitoring

Bead Release Compounds

Bead Separator® is kaolin with a trace of added titanium compound. Kaolin is a clay mineral compound consisting of aluminum oxide, silicon dioxide, water, and titanium dioxide with small amounts of calcium oxide, magnesium oxide, and iron oxide. Sludge Plus–Mandrel Release Agent® is made of a compound similar to kaolin, with magnesium and aluminum compounds and a high molecular weight acetate such as polyvinylacetate or cellulose acetate and traces of tetrachlorophthalonitrile. The bead release compounds did not contain graphite or fibers.

Volatile Organic Compounds (VOCs)

Trace amounts of methanol, ethanol, trichloroethylene, perchloroethylene, toluene, limonene, siloxanes, and various C_9–C_{12} aliphatic hydrocarbons were found on the sample collected at the demonstration table. These could have been generated by the compounds the demonstrators were using, the fuels from the various torches, or the cleaning products used at the hotel.

Metals

Very low levels of iron, molybdenum, lead, lithium, magnesium, sodium, and vanadium (range: non–detectable to 2 micrograms per cubic meter [$\mu g/m^3$]) were measured in the area air samples. All concentrations detected at the conference were below current occupational exposure limits for those metals that have such limits. None of the other metals (elements) were detected.

The bulk steel wool sample contained 78.2% iron, 0.3% manganese, 0.2% sodium, 0.06% nickel, 0.05% chromium, 0.04% copper, 0.03% calcium, and 0.03% cobalt. It also contained very low levels of aluminum, barium, cadmium, molybdenum, sodium, phosphorus, lead, potassium, tin, strontium, titanium, vanadium, yttrium, and zinc.

The results for the four bulk glass samples are shown in Table 1. In addition to silica, the main components of the glass pieces are aluminum, calcium, cobalt, iron, potassium, silver, sodium, tin, and zinc. Beryllium, platinum, and tellurium were not found in any of the samples.

The results for the wipe samples are presented in Table 2. Aluminum, calcium, copper, iron, magnesium, sodium, and zinc were the major elements/metals detected in the wipe samples. Trace to low levels of arsenic, barium, cadmium, cobalt, chromium, lead, lithium, manganese, molybdenum, nickel, phosphorus, silver, tellurium, titanium, vanadium, yttrium, and zirconium were found. Beryllium, platinum, selenium, and thallium were not detected in any of the wipe samples. There was not any noticeable difference in the metals or amount of metal detected between wipes collected before and after the demonstrations.

Total Particulates and Respirable Silica (Quartz)

The three samples collected for total particulate and respirable silica had no detectable particulate at a MDC of 0.02 mg/m^3 so no further silica analysis was completed.

Physical Agents

Luminance

The luminance levels measured on the days of evaluation ranged from 0.03 to 1.33 candela per square centimeter (cd/cm^2). All luminance measurements were made with the photometer aimed approximately 15 inches from the particular glass bead source. The highest reading occurred while working with 24 karat gold.

Several other measurements were made of luminance levels at other locations during the conference. These measurements were quite sporadic since often they were performed during demonstrations of torches or other products. For all of these other non-exhibition activities, luminance levels were in the range given above.

Ultraviolet Radiation

Levels of both near (315 to 400 nm) and actinic (200 to 315 nm) UV radiation were measured on all of the exhibition processes. In every case, no actinic radiation was detected. The maximum level of near UV radiation was 0.1 µW/cm^2 as measured at the operator's face. These levels of near and actinic UV radiation are below the TLV and are not considered to be an optical or skin hazard to the unprotected worker. No operator wore any type of protective glove. Additional non-exhibition measurements made at selected times and locations at the conference also indicated similar low levels of UV radiation.

Infrared Radiation

Exposure to IR radiation could occur from three major sources: torches, kiln furnaces, and heated material used in the beadmaking processes. Measured IR levels at the worker's face ranged from 16 to 400 mW/cm^2. The 400 mW/cm^2 value was measured when the worker was loading material into the furnace approximately 6 to 9 inches away. Operators would not normally work for long periods of times with the furnace open. However, to protect against cornea and lens damage the operator should either move the furnace further away from the work area, shield the furnace, or wear eye protection. The facial IR exposure from the heated work piece could increase as much as 4 to 5 times when the worker bends closer to the heated material or when the heated material is brought closer to the eye to view progress.

The IR TLV for unprotected workers is based on avoiding thermal injury of the cornea and lenticular cataracts.[5] The IR exposure is limited to 10 mW/cm^2 for time periods greater than or equal to 1000 seconds (about 16.5 minutes). For time periods (t) less than 1000 seconds, the limit is given by the equation: $1.8t^{-0.75}$ W/cm^2. In this evaluation, operators were exposed to facial IR levels ranging from 16 to 400 mW/cm^2. NIOSH investigators estimated that the exposure time for the operators in the evaluation was 15 to 20 minutes. Therefore, appropriate eye and skin protection would be necessary. The operators wore either AUR-92™ lenses or didymium glasses which were appropriate. If the exposure time was considerably lower (i.e., 10 to 500 seconds), then exposure levels could go as high as 320 mW/cm^2, before eye and skin protection was needed.

Temperature

The facial temperature for each operator was measured several times during each of the beadmaking processes. The steady state levels ranged from 23 to 25°Centigrade (C) (73 to 77°F) for all operators. Measurements made at the wrist and finger areas were approximately 4°C (7°F) higher. These are acceptable ranges for comfort.

DISCUSSION AND CONCLUSIONS

This evaluation addressed materials used in glass beadmaking and is indicative of exposures associated with other glass applications. The processes used during the demonstrations were typical of those used at a normal worksite, but the duration of the process may be different. In general, beadmaking processes use smaller torches with reduced flame temperature, less material volume, and easier to melt material (such as Moretti glass) than other glass operations (such as those using borosilicate glass). NIOSH investigators have previously noted that the emitted optical radiation levels are proportional to the quantity of material being heated.[22] Small quantities of material will produce less IR than larger quantities, all other things being equal. In beadmaking, smaller quantities of materials are used than in commercial and/or scientific glass blowing.

Detected concentrations of metals and VOCs were very low during the demonstrations. Total particulates were not detected in the area air samples. The hand wipes showed similar results before and after various work processes. The bead release materials were clay-based. The bulk steel wool sample contained mainly iron. The metals in the bulk glass samples were mainly aluminum, calcium, cobalt, iron, potassium, silver, sodium, tin, and zinc.

Beadmakers need to be aware that the OSHA Hazard Communication Standard (29 CFR 1910.1200) requires manufactures to list the components of their products and supply material safety data sheets (MSDSs).[29] Interviews with conference attendees indicate that many individuals were unaware that MSDSs exist and others were unable to obtain them on products they used. The MSDS will help to explain the product ingredients and their health and safety hazards.

Many beadmakers work at home. This raises concerns about exposing household members, particularly young children, to physical and/or chemical agents involved in making beads. This may become a problem if ventilation of combustion products is not sufficient. Several attendees mentioned the use of propane-oxygen torches in their homes. Combustion products, such as carbon monoxide and nitrogen oxide, can be generated from the use of such devices. These substances can cause asphyxiation or respiratory irritation if present in high concentrations. In addition, the presence of broken glass or ceramic material and of hot torches poses a risk for cuts and burns.

When soda lime glass was heated with a flame, a bright yellowish color was produced for a short time. This was a sodium flare, which generates wavelengths around 590 nm. The presence of this light can be visually distracting, but the intensity is low and the wavelengths do not appear to produce deleterious ocular effects. One technique used by beadmakers to minimize this sodium flare is to wear eyewear with specific filters for this wavelength.

The major issue in the selection of protective eyewear is the degree of optical attenuation needed to protect the worker, while providing sufficient luminance transmittance levels. Based on the measurements made during this evaluation, it appears that beadmakers are exposed to minimal UV and blue light wavelengths, while the sodium flare and IR wavelengths are present at varying intensity levels. For an IR irradiance of about 80 mW/cm^2, a #3 filter shade would afford reasonable IR ocular protection. While higher filter shades can be used, the corresponding darker tint may make it harder to see the work piece. Several types of protective eyewear are commercially available, and NIOSH has discussed the spectral distribution characteristics of such products in a previous report.[30] Since the levels of optical radiation produced in these glass bead operations are generally below occupational exposure levels, many beadmakers may believe they do not need to wear any type of eye protection. NIOSH investigators believe that appropriate eyewear needs to be worn for the following reasons:

a) to minimize sodium flare and IR levels.
b) to protect the eyes from broken glass
c) to prevent burns of the eyelids.

NIOSH investigators observed several potential ergonomic hazards, including rotating or twisting beads in the torch flame, finger and wrist deviations, unsupported arms and elbows, sitting in non-adjustable chairs, and awkward work postures. This issue was not raised in the HHE request, however, and the NIOSH investigators were not prepared to conduct an ergonomic assessment.

RECOMMENDATIONS

The setting of this evaluation and the results obtained may not represent actual working conditions under which glass beadmakers work. Based on this evaluation, the following general recommendations are offered for home/work studios:

(1) Appropriate eyewear should be purchased and used at all times. However, regardless of the flame temperature, quantity of material, or type of glass used, glass beadmakers should wear appropriate eye protection to control exposures from optical radiation, as well as from hot and broken glass. Additional information on this topic can be found in "More Than You Ever Wanted To Know About Glass Beadmaking".[31]

(2) Local exhaust ventilation should be used to reduce exposures to torch combustion products.

(3) MSDSs should be obtained and reviewed when working with new products.

(4) Heat-resistant gloves should be used when working with kilns and ovens to reduce the incidence of burns.

(5) The work area should be designed so that the work table is of an appropriate height to reduce back and shoulder strain. Frequent breaks would reduce the strain on the hands and wrists from constantly turning the glass in the torch. Additional information on ergonomic hazards can be found on the NIOSH website "http://www.cdc.gov/niosh/homepage.html" including "Elements of Ergonomics Programs: A Primer Based on Workplace Evaluations of Musculoskeletal Disorders".

(6) Glass beadmakers should wash their hands at the end of the work day and before eating, drinking, or smoking to reduce exposure to trace metals/elements.

(7) Children should be kept away from the home studio to reduce the risk of injury, especially burns and cuts.

REFERENCES

1. NIOSH [1994]. Elements by ICP: method no. 7300, issue 2. In: Eller PM and Cassinelli ME, eds. NIOSH manual of analytical methods (NMAM). 4th. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94–113.

2. NIOSH [1994]. Particulates not otherwise regulated, total: method no. 0500. In: Eller PM and Cassinelli ME, eds. NIOSH manual of analytical methods (NMAM). 4th. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94–113.

3. NIOSH [1994]. Particulates not otherwise regulated, respirable: method no. 0600, issue 2. In: Eller PM and Cassinelli ME, eds. NIOSH manual of analytical methods (NMAM). 4th. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94–113.

4. NIOSH [1992]. Recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

5. ACGIH [1999]. 1999 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental industrial Hygienists.

6. Code of Federal Regulations [1997]. 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

7. Public Law 91 – 596 Occupational safety and Health Act of 1970, Sec. 5.(a)(1).

8. Apostoli P, Giusti S, Bartoli D, Perico A, BaVazzano P, Alessiro L [1998]. Multiple exposure to arsenic, antimony, and other elements in art glass manufacturing. Am J of Ind Med. 34(12):65-72.

9. Lüdersdorf R, Fuchs A, Mayer P, Skulsuksai G, Schäcke G [1987]. Biological assessment of exposure to antimony and lead in the glass-producing industry. Int Arch Occup Environ Health 59:469-474.

10. Ide CW, Bullough GR [1988]. Arsenic and old glass. J. Soc. Occup. Med. 38:85-88.

11. Wingren G, Axelson O [1985]. Mortality pattern in a glass producing area in SE Sweden. Br J Ind Med. 42:411-414.

12. Wingren G, Axelson O [1987]. Mortality in the Swedish glassworks industry. Scand J Work Environ Health. 13:412-416.

13. Wingren G, Englander V [1990]. Mortality and cancer morbidity in a cohort of Swedish glassworkers. Int Arch Occup Environ Health. 62:253-257.

14. Sankila R, Karjalainen S, Pukkala E, Oksanene H, Hakulinen T, Teppo L, Hakama M [1990]. Cancer risk among glass factory workers: an excess of lung cancer? Br J Ind Med. 47:815-818.

15. Mallin K, Rubin M, Joo E [1989]. Occupational cancer mortality in Illinois white and black males, 1979-1984, for seven cancer sites. Am J Ind Med 15:699-717.

16. Tagesson C, Källberg, Wingren G [1996]. Urinary malondialdehyde and 8-hydroxydepxyguanosine as potential markers of oxidative stress in industrial art glass workers. Int Arch Occup Environ Health. 69(1):5-13.

17. Wingren G, Axelson O [1993]. Epidemiologic studies of occupational cancer as related to complex mixtures of trace elements in the art glass industry. Scand J Work Environ Health. 19 supple 1:95-100.

18. IARC [1997]. Beryllium, cadmium, mercury, and exposures in the glass manufacturing industry. Lyon, France: International Agency for Research on Cancer. IARC Monographs Evaluations Volume 58.

19. Andersson L, Wingren G, Axelson O [1990]. Some hygienic observations from the glass industry. Int Arch Occup Environ Health. 62:249-252.

20. NIOSH [1977]. Occupational diseases: a guide to their recognition. U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 77-181, Revised June 1977.

21. WHO [1980]. Infrared radiation. In manual on Health Aspects of Exposure to Nonionizing Radiation by Moss, C. E. 9et. Al). World Health Organization Regional Office for Europe. Copenhagen, Denmark.

22. NIOSH [1982]. Biological effects of infrared radiation. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 82-109.

23. AIHA [1997]. The Occupational Environment-Its Evaluation and Control, edited by DiNardi, S. R., Fairfax, VA:American Industrial Hygiene Association Press.

24. Lehman, R. S. [1999]. Eye Hazards in Glass working. Reviewed manuscript available on web at http://www.fandm.edu/departments/psychology/eyeprotection/papers.html.

25. IES [1981]. Lighting Handbook, Reference Volume, edited by Kaufman, J. E. New York, NY:Illuminating Engineering Society of North America.

26. Sliney, DH and Wolbarsht, M [1980]. Safety with lasers and other optical sources. New York, NY: Plenum Press.

27. NIOSH [1973]. Criteria for a recommended standard: occupational exposure to ultraviolet radiation. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health. DHEW (NIOSH) Publication No. 73-11009.

28. Sliney, DH, Moss, CE, et. al [1981]. Semitransparent curtains for control of optical radiation hazards. Applied Optics 20(14): 2352-2361, 1981.

29. Code of Federal Regulations [1996]. 61 FR 5507 - CFR 1910.1200. Washington, DC: U.S. Government Printing Office, Federal Register.

30. NIOSH [1996]. NIOSH Health Hazard Evaluation - Glass Schell Fused Glass Masks, Houston, TX. Cincinnati, OH: U.S. Department

of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health. HETA 95-0119-2554.

31. Kervin, J [1999]. More than You Ever Wanted to Know about Glass Beadmaking. Glasswear Studio, Lawrence, CA.

Table 1
Metal Analysis of Bulk Glass Samples
The Society of Glass Beadmakers
Corning, New York
HETA 98-0139-2769

Analyte	LOD (µg per sample)	LOQ (µg per sample)	Sample Concentrations (percent)			
			White Glass	Black Glass	Aqua Glass	Aqua/Green Twist Glass
Aluminum	4	13.3	1.2	1.1	0.77	0.85
Antimony	6.85	22.8	ND	ND	Trace	Trace
Arsenic	1.35	4.50	Trace	Trace	0.2	0.17
Barium	0.05	0.17	0.001	0.001	0.001	0.001
Beryllium	0.05	0.17	ND	ND	ND	ND
Cadmium	0.25	0.83	Trace	0.0001	0.0002	0.0001
Calcium	2.50	8.33	0.015	0.024	1.67	1.54
Cobalt	0.15	0.50	0.001	1.16	0.0002	0.0001
Chromium	0.20	0.67	0.019	0.017	0.083	0.065
Copper	1.10	3.66	0.0006	0.0004	0.57	0.23
Iron	10.8	36.0	0.14	1.34	0.51	0.179
Lanthanum	0.60	2.00	Trace	Trace	Trace	Trace
Lithium	0.05	0.17	0.0006	0.0004	0.0008	0.0014
Magnesium	2.15	7.16	0.004	0.004	0.026	0.025
Manganese	0.05	0.17	0.001	0.005	0.003	0.002
Molybdenum	0.45	1.50	0.0004	0.0007	0.0025	0.0004
Sodium	250	8.33	3.15	2.96	16.04	16.28
Nickel	0.20	0.67	0.0008	0.0034	0.0023	0.0005
Phosphorus	1.75	5.83	0.0014	0.0018	0.0028	0.0019
Lead	1.2	4.00	0.0008	0.0007	0.056	0.0167
Platinum	13.6	45.3	ND	ND	ND	ND
Potassium	2.95	9.82	0.042	0.042	3.27	3.41
Selenium	3.35	11.2	ND	ND	ND	ND
Silver	1.00	3.33	ND	1.2	Trace	Trace
Strontium	0.05	0.17	0.0006	0.0004	0.0012	0.0016
Tellurium	3.25	10.8	ND	ND	ND	ND
Thallium	5.60	18.6	ND	0.005	ND	ND
Tin	0.80	2.66	1.306	0.001	0.0003	0.0003
Titanium	0.25	0.83	0.0097	0.005	0.013	0.013
Tungsten	0.80	2.66	ND	ND	0.0148	0.0172
Vanadium	0.45	1.50	0.0007	0.0004	0.0004	0.0002
Zinc	0.95	3.16	0.0007	0.0012	1.35	1.53
Zirconium	0.35	1.17	0.027	0.025	0.0019	0.0021

Comments:
µg = microgram
LOQ = Limit of Quantitation
LOD = Limit of Detection
ND = not detected at LOD

Table 2
Hand Wipe Samples
The Society of Glass Beadmakers
Corning, New York
HETA 98-0139-2769

Analyte	LOD (µg per wipe)	LOQ (µg per wipe)	Sample Concentrations (micrograms per sample)							
			W1 (pre)	W2 (post)	W3 (pre)	W4 (post)	W5 (pre)	W6 (post)	W7 (pre)	W8 (post)
Aluminum	1	4	140	120	120	130	140	120	350	320
Arsenic	3	8	Trace	ND	ND	ND	ND	ND	Trace	ND
Barium	0.05	0.2	2.1	2	4.3	5.0	2.8	1.8	6.0	5.8
Beryllium	0.01	0.04	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	3	8	730	760	820	830	1160	1040	1040	1040
Cadmium	0.08	0.3	0.45	1.1	0.3	0.38	Trace	Trace	0.97	0.51
Cobalt	0.2	0.4	ND	ND	ND	Trace	ND	ND	ND	ND
Chromium	0.5	2	4.3	4.2	Trace	3.2	Trace	2.0	6.2	5.8
Copper	0.08	0.3	21	14	13	12	110	39	42	42
Iron	0.8	3	130	68	47	62	60	58	150	260
Lithium	0.03	0.08	0.092	Trace	0.1	0.095	0.12	0.099	0.31	0.26
Magnesium	0.5	2	145	145	145	145	165	155	165	155
Manganese	0.01	0.04	2.2	2.3	1.9	2.6	2.7	2.5	4.3	4.7
Molybdenum	0.3	0.9	ND	0.99	Trace	Trace	ND	ND	Trace	0.97
Nickel	0.5	1	3.4	3.5	2	3.8	10	4.7	9.5	8.3
Lead	0.5	2	Trace	Trace	Trace	Trace	2.6	Trace	6.7	6.1
Phosphorus	2	4	20	12	13	16	42	20	27	25
Platinum	3	8	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	2	4	ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.08	0.3	1.8	0.76	0.7	0.62	3.8	1.8	7.3	4.0
Sodium	2	7	2000	2500	2100	2800	2600	1900	3300	4400
Tellurium	0.8	3	Trace	ND	ND	ND	ND	ND	ND	ND
Thallium	3	8	ND	ND	ND	ND	ND	ND	ND	ND
Titanium	0.2	0.4	4.8	1.3	0.86	0.98	1.2	0.88	3.7	3.6
Vanadium	0.08	0.3	ND	ND	ND	Trace	ND	Trace	Trace	Trace
Yttrium	0.02	0.04	ND	ND	ND	Trace	0.041	ND	0.043	0.041
Zinc	0.5	2	26	37	110	57	62	43	120	76
irconium	0.08	0.3	3.2	0.7	1.3	3.6	0.8	Trace	2.5	2.1

Comments:
µg = microgram
LOD = Limit of Detection
LOQ = Limit of Quantitation
ND = not detected at LOD
Trace = amount detected is between LOD and LOQ
W1/W2 = task -urns
W5/W6 = task-metal fuming on beads W3/W4 = task-apply color dots

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
or visit the NIOSH Website at:
www.cdc.gov/niosh