CONTROL TECHNOLOGY AND EXPOSURE ASSESSMENT FOR OCCUPATIONAL EXPOSURE TO BERYLLIUM: BERYLLIUM FACILITY #2 - COPPER/BERYLLIUM MACHINE SHOP

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SITES SURVEYED:	Beryllium Facility #2 Copper/Beryllium Machine Shop Mid-Western USA
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SURVEY CONDUCTED BY:	Dan Almaguer, M.S. Ed Burroughs, Ph.D, CIH Dave Marlow LiMing Lo, Ph.D

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I. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), working under an interagency agreement with the Office of Regulatory Analysis of the Occupational Safety and Health Administration (OSHA), conducted a study of occupational exposures in secondary beryllium processing facilities to document engineering controls and work practices affecting those exposures. The performance of a thorough industrial hygiene survey for a variety of individual employers provides valuable and useful information to the public and employers in the industries included in the work. The principal objectives of this study were:

1. To measure full-shift, personal breathing zone exposures to metals including beryllium, copper and other toxic metals.

2. To evaluate contamination of surfaces in the work areas that could create dermal exposures or allow re-suspension of metals into the air.

3. To identify and describe the control technology and work practices in use in operations associated with occupational exposures to beryllium, as well as to determine additional controls, work practices, substitute materials, or technology that can further reduce occupational beryllium exposures.

4. To evaluate the use of personal protective equipment in these facilities.

5. To determine the size distribution of airborne particles.

An initial walk-through evaluation was conducted by NIOSH researchers from the Engineering and Physical Hazards Branch, Division of Applied Research and Technology, Cincinnati, Ohio in May 2007, to observe processes and conditions in order to prepare for subsequent testing. An in-depth evaluation was conducted June 18-21, 2007. During this evaluation, two full shifts of environmental monitoring were conducted for the duration of normal plant operations.

II. PROCESS DESCRIPTION

On June 18 - 21, 2007, NIOSH conducted an in-depth industrial hygiene survey at a copper/beryllium machine shop with a total workforce of 17 employees working two shifts. The first shift has a total of 13 employees; seven machinists, four quality control inspectors, one tool maker and one full-time maintenance employee. Four machinists were employed on the second shift. This was the second of three facilities selected to investigate worker exposures to beryllium where secondary processing of beryllium products takes place. The purpose of the study was to measure airborne beryllium and heavy metal concentrations in the machining operations and to identify and describe the control technology and work practices being used in this facility.

Process Description and Work Practices

Machine Shop

Processes utilized in the machine shop include: machining, grinding, polishing, and buffing (see Plant Diagram). Each of these processes has the potential to create airborne particles of increasingly smaller size. The company has 35 Swiss screw machine automatic lathes that are used in the production of connectors and test pins for the electronics industry (see Photo 1 and 2). The lathe operators manually insert 12 metal rods, 10-12 feet in length into the lathes prior to running the automatic lathes. The operators remain in the machining area to observe and ensure proper operation of the lathes and randomly collect and inspect products. The lathe automatically feeds the metal rods which are machined to diameters of less than 1/8 of an inch and cut to lengths ranging from 4/100 to 2 inches. Approximately 50% of the company's total production utilizes a copper/beryllium alloy containing 2% beryllium. On the days of our evaluation four of the 35 lathes were running the copper/beryllium alloy which was reported to be a typical production day. Metal cutting fluids are used during machining to aid in the cutting process, to extend the life of the cutting tools and to control and contain the release of dust. One full-time maintenance employee was assigned cleaning duties and used a HEPA vacuum and wet mop to clean floors and surfaces throughout the workday.

Cutting tools used in machining generally remove metal in relatively large chips or turnings, and tend to produce little respirable particulate. The use of coolants and enclosure of machining operations further reduces this potential. The potential for dermal exposure, however, is significant in machining with beryllium and the coolant both being of concern.

Grinding, polishing and buffing all involve the removal of metals from the surface of the metal rods, but in increasingly smaller amounts. The decrease in mass, however, may be offset by a corresponding decrease in particle size that may carry with it an increase in toxicity. For this reason, particle size information was collected in the machine shop area.

Control Technology

Machining operations are enclosed and coolants are used when operating to control the release of airborne metals. Grinding and buffing of some products are conducted in an Air King M-35P downdraft booth equipped with a HEPA filter (see Photo 3) which is exhausted to the outdoors.

Personal Protective Equipment

Personal protective equipment utilized throughout this facility included safety glasses, safety shoes, ear plugs, and neoprene gloves. At the time of the NIOSH survey the company provided disposable filtering face masks (R1085 disposable dust mask 50200) for voluntary use. These disposable masks did not have a NIOSH certification number. NIOSH researchers recommended that NIOSH certified respirators be used. As a result of that recommendation, the company immediately ordered NIOSH certified respirators, Moldex 2730 N100 disposable respirators.

III. SAMPLING AND ANALYTICAL METHODS

This field study was conducted in accordance with regulations governing NIOSH investigations of places of employment.[1] Methods used to assess worker exposures in this workplace evaluation included: personal breathing zone and area sampling for metals; particle size sampling; and surface wipe sampling to assess surface contamination. The methods used in this evaluation are described in more detail in the following section and the resulting data is presented in Section V. RESULTS AND DISCUSSION.

A. Workplace Observations

Information pertinent to process operation and control effectiveness (e.g. control methods, ventilation rates, work practices, use of personal protective equipment, etc.) was collected. Observations regarding work practices and use of personal protective equipment were recorded. Information was obtained from conversations with the workers and management to determine if the sampling day was a typical workday and to help place the sampling results in proper perspective. In addition, engineering control information including ventilation flow rates and distance measurements were collected.

B. Particulate Sampling and Analysis

Personal breathing zone and general area airborne particulate samples were collected and analyzed using inductively coupled plasma spectroscopy (ICP) according to NIOSH Method 7300[2] (with modifications) for 31 metals/elements. Samples were collected for as much of the work shift as possible, at a flow rate of 3 liters/minute using a calibrated battery-powered sampling pump (model 224, SKC Inc., Eighty Four, PA) connected via flexible tubing to a 37-mm diameter filter (0.8 μm pore-size mixed cellulose ester filter) in a 3-piece, clear plastic cassette sealed with a cellulose shrink band.

C. Particulate Size Sampling - Measurement of Size/Mass Distribution of Airborne Particles

One of the objectives of this study was to determine the particle size and mass concentration of airborne beryllium particles generated during the manufacturing process. There is substantial evidence that the presence of an ultrafine component increases the toxicity for chronic beryllium disease and possibly other toxic effects.[3, 4, 5] The potential hazard for chemical substances present in inhaled air, as suspensions of solid particles or droplets, depends on particle size and the mass concentration because of 1) the effects of particle size on the deposition site within the respiratory tract, and 2) the tendency for many occupational diseases to be associated with material deposited in particular regions of the respiratory tract.[6] For example, the ACGIH recommends particle size-selective TLVs for crystalline silica because of the well established association between silica and respirable mass concentrations.[6] Because of this association, size-selective sampling was conducted to collect information on the aerosol size distribution to assist in evaluation of the health hazard. Additionally, the measurement and characterization of airborne particle size and mass distribution in workplace environments can provide useful information about the emission and exposure routes of air contaminants generated; and the data collected can be used to identify appropriate control methods to reduce or eliminate contaminate sources to protect workers.

The measurement of particle size and distribution was accomplished using three different instruments and methods. Personal breathing zone and general area air samples were collected using Sioutas cascade impactors to determine particle size distribution. Additionally, a Micro-Orifice Uniform Deposit Impactor (MOUDI) and an Aerodynamic Particle Sizer (APS) spectrometer were used to measure the particle size and respirable mass concentrations in the general workplace air.

1. Sioutas Cascade Impactor Samples

Personal breathing zone and general area aerosol size distributions were determined using four-stage Sioutas Cascade Impactors (SKC, Inc., Eighty Four, PA), having nominal 50% cut points of 0.25 μm, 0.5 μm, 1 μm, and 2.5 μm aerodynamic diameter. The sampling flow rate for these impactors was 9 liters/minute, provided by a calibrated Leland Legacy™ sampling pump (SKC, Inc., Eighty Four, PA). A 25-mm diameter, 0.8 μm pore size PVC filter was used on each stage of the impactor to collect particles. A 37-mm diameter, 5 μm pore size PVC filter was used as a backup to collect all particles that were not impacted on the previous four stages. The impactor filters were analyzed for 31 metals/elements by ICP in accordance with NIOSH Method 7300 modified for microwave digestion.[2]

2. Micro-Orifice Uniform Deposit Impactor (MOUDI) Samples

The MOUDIs (Model 110, MSP Corp., Minneapolis, MN) were used to determine aerosol size distributions in the general area of several production processes at this facility. The MOUDIs were connected via tubing to a high volume pump operating at a flow rate of 30 liters per minute. The MOUDI consists of a pre-filter to collect particles larger than 18 μm, ten filter stages in series with nominal cut points of 10 μm, 5.6 μm, 3.2 μm, 1.8 μm, 1.0 μm, 0.56 μm, 0.32 μm, 0.18 μm, 0.10 μm, and 0.056μm and a post-filter to collect all remaining particles smaller than 0.056μm. At each filter stage particles larger than the cut size are collected by a 47-mm diameter substrate on the impaction plate due to inertial impaction while particles smaller than the cut size follow the airflow streamlines and proceed to the next stage until the final stage filter (37-mm diameter, PTFE, SKC Inc.).

Three different substrates were used in the MOUDIs to collect airborne particulate: Aluminum foil filters, PTFE membrane filters with a 0.5-μm-pore-size manufactured by SKC Inc., and PTFE membrane filters with a 2.0-μm-pore-size manufactured by Pall Corp. The two different PTFE membrane filters with different pore sizes and manufactures were used to eliminate sampling bias from collecting materials; and the Aluminum foil filters were used because the accuracy of gravimetric analysis of membrane filters can be affected by environmental humidity and sample transit.[7] To prevent particle bounce during sampling, a thin layer of silicon spray was applied to the Aluminum foil filters, and the filters were baked for a minimum of 2 hours at 100°C. All the sample filters remained in the balance room for 24 hours before pre-weighing on an electric balance (Model AT20, Mettler-Toledo, Switzerland) to 2 μg resolution, stored and transported in Petri dishes before and after sampling.

Three MOUDIs were used in this study to measure the mass distribution of airborne particles at the locations near furnaces and cutting equipment where high particle concentrations were expected. Usually 8-hour sampling is necessary to obtain adequate mass for the following gravimetric analysis. Similar to the preparation steps mentioned above, the filter samples were kept in the Petri dishes after MOUDI sampling, and the post-weighing was conducted in the NIOSH laboratory after 24-hour conditioning in the balance room. After post-weighing, the PTFE filters were sent to a contract laboratory for the metal analysis.

3. Aerodynamic Particle Sizer (APS) Samples

An APS spectrometer (Model 3321, TSI, Shoreview, MN) was used to collect real time particle number measurements at various locations throughout this machine shop including the locations where the MOUDI samples were collected. All the APS sampling data were collected by Aerosol Instrument Manager Software for APS Sensors. This instrument is capable of measuring particles ranging from 0.5 µm to 20 µm at 5.0 liters per minute (lpm) total sampling flow rate including 1.0 lpm aerosol flow and 4.0 lpm sheath flow. A minimum of 10 samples were collected at each sample location with the APS set to run in a one-minute sampling mode.

D. Surface Sampling Procedures and Analysis

Surface sampling is not as useful as airborne contaminant measurements for evaluating exposed dose since there are few criteria for reference, but some comparisons and professional judgments can be made based on the data collected, as discussed below. Surface sampling is useful for evaluating process control and cleanliness and for determining suitability for release of equipment.

Surface wipe samples were collected using Ghost™ Wipes (Environmental Express, Mt. Pleasant, SC) and Palintest® Dust Wipes (Gateshead, United Kingdom) to evaluate surface contamination. These wipe samples were collected in accordance with ASTM Method D 6966-03,[8] except the cardboard template, with a 10-cm by 10-cm square hole was held in place by hand to prevent movement during sampling. Wipes were placed in sealable test tube containers for storage until analysis.

Ghost Wipes™ were sent to the laboratory to be analyzed for metals according to NIOSH Method 7303.[9] Palintest wipes were analyzed for beryllium using the Quantech Fluorometer (Model FM109515, Barnstead International, Dubuque, Iowa) for spectrofluorometric analysis.[10]

E. Other Measurements

Ventilation airflow measurements were collected at the Air King down draft booth using a TSI VelociCalc Plus Air Velocity Meter Model 8360. An Air King M-35P downdraft booth equipped with a HEPA filtered exhaust was the lone operation equipped with local exhaust ventilation. This small downdraft booth is used on an intermittent as needed basis to chamfer smaller diameter rods on a bench grinder/buffer contained within the booth. The booth is approximately 6 feet high by 3 feet wide and 2 feet deep. The operator stands at the face of the booth to grind and buff the small diameter rods. Ventilation measurements were collected at the face of the downdraft hood opening which measured 24 inches by 24 inches. Additionally, smoke tube tracers were used to visualize air flow patterns at the face of the hood.

IV. OCCUPATIONAL EXPOSURE LIMITS AND HEALTH EFFECTS

In evaluating the hazards posed by workplace exposures, NIOSH investigators use mandatory and recommended occupational exposure limits (OELs) for specific chemical, physical, and biological agents. Generally, OELs 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 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 exposure limit. Combined effects are often not considered in the OEL. Also, some substances can be absorbed by direct contact with the skin and mucous membranes in addition to being inhaled, thus contributing to the overall exposure. Finally, OELs may change over the years as new information on the toxic effects of an agent become available.

Most OELs are expressed as a time-weighted average (TWA) exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday.‡ Some chemical substances and physical agents have recommended short-term exposure limits (STEL) or ceiling values where there are health effects from higher exposures over the short-term. Unless otherwise noted, the STEL is a 15-minute TWA exposure that should not be exceeded at any time during a workday, and the ceiling limit is an exposure that should not be exceeded at any time, even instantaneously.

In the U.S., OELs have been established by Federal agencies, professional organizations, state and local governments, and other entities. Some OELs are mandatory, legal limits; others are recommendations. The U.S. Department of Labor Occupational Safety and Health Administration (OHSA) Permissible Exposure Limits (PELs) [29 CFR 1910 (general industry); 29 CFR 1926 (construction industry); and 29 CFR 1915, 1917 and 1918 (maritime industry)] are legal limits that are enforceable in workplaces covered under the Occupational Safety and Health Act[11] and in Federal workplaces under Executive Order 12196.[12] NIOSH recommended

† On March 20, 1991, the Supreme Court decided the case of International Union, United Automobile, Aerospace & Agricultural Implement Workers of America, UAW v. Johnson Controls, Inc., 111 S. Ct. 1196, 55 EPD 40,605. It held that Title VII forbids sex-specific fetal protection policies. Both men and women must be protected equally by the employer.

‡ OSHA PELs, unless otherwise noted, are TWA concentrations that must not be exceeded during any 8-hour workshift of a 40-hour work-week [NIOSH 1997]. NIOSH RELs, unless otherwise noted, are TWA concentrations for up to a 10-hour workday during a 40-hour workweek [NIOSH 1997]. ACGIH® TLVs®, unless otherwise noted, are TWA concentrations for a conventional 8-hour workday and 40-hour workweek [ACGIH 2008]

exposure limits (RELs) are recommendations that are made based on a critical review of the scientific and technical information available on the prevalence of hazards, health effects data, and the adequacy of methods to identify and control the hazards. Recommendations made through 1992 are available in a single compendium;[13] more recent recommendations are available on the NIOSH Web site (http://www.cdc.gov/niosh). NIOSH also recommends preventive measures (e.g., engineering controls, safe work practices, personal protective equipment, and environmental and medical monitoring) for reducing or eliminating the adverse health effects of these hazards. The NIOSH Recommendations have been developed using a weight of evidence approach and formal peer review process. Other OELs that are commonly used and cited in the U.S. include the threshold limit values (TLVs)® recommended by the American Conference of Governmental Industrial Hygienists (ACGIH)®, a professional organization.[6] ACGIH-TLVs are considered voluntary guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards." Workplace environmental exposure levels (WEELs) are recommended OELs developed by AIHA, another professional organization. WEELs have been established for some chemicals "when no other legal or authoritative limits exist."[14]

Employers should understand that not all hazardous chemicals have specific OSHA-PELs and for many agents, the legal and recommended limits mentioned above may not reflect the most current health-based information. However, an employer is still required by OSHA to protect their employees from hazards even in the absence of a specific OSHA-PEL. In particular, 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 [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, NIOSH investigators encourage employers to make use of other OELs when making risk assessment and risk management decisions to best protect the health of their employees. NIOSH investigators also encourage the use of the traditional hierarchy of controls approach to eliminating or minimizing identified workplace hazards. This includes, in preferential order, the use of: (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation) (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) personal protective equipment (e.g., respiratory protection, gloves, eye protection, hearing protection).

Both the OSHA PELs and ACGIH® TLVs® address the issue of combined effects of airborne exposures to multiple substances.[6,11] ACGIH® states:

> When two or more hazardous substances have a similar toxicological effect on the same target organ or system, their combined effect, rather than that of either individually, should be given primary consideration. In the absence of information to the contrary, different substances should be considered as additive where the health effect and target organ or system is the same. That is, if the sum of
>
> $$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots \frac{C_n}{T_n} \qquad \text{Eqn. 1}$$

exceeds unity, the threshold limit of the mixture should be considered as being exceeded (where C_1 indicates the observed atmospheric concentration and T_1 is the corresponding threshold limit...).

A. Inhalation Exposures

Metals found in the workplace under investigation range from slightly toxic to extremely toxic by inhalation. While a subset of five primary contaminants have been selected for consideration through the body of this report because of their high toxicity or other special interest, the occupational exposure limits of all 31 metals/elements quantified in this work are listed in Table 1.

Occupational Exposure Criteria for Beryllium

The current OSHA PELs for beryllium are 2 micrograms per cubic meter ($\mu g/m^3$) as an 8-hour TWA, 5 $\mu g/m^3$ as a ceiling not to be exceeded for more than 30 minutes at a time, and 25 $\mu g/m^3$ as a peak exposure never to be exceeded.[11] The current NIOSH Recommended Exposure Limit (REL) for beryllium is 0.5 $\mu g/m^3$ for up to a 10-hour work day, during a 40-hour workweek.[15] The current American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Value (TLV®)[6] is an 8-hr TWA of 2 $\mu g/m^3$, and a Short Term Exposure Limit (STEL) of 10 $\mu g/m^3$.

Beryllium has been designated a Group1, known human carcinogen, by the International Agency for Research on Cancer (IARC 1993). In 2006 the ACGIH published a Notice of Intended Change (NIC) to reduce the TLV® for beryllium from 0.002 milligrams per cubic meter (mg/m^3) to 0.00005 mg/m^3 or 0.05 $\mu g/m^3$ based upon studies investigating both chronic beryllium disease (CBD) and beryllium sensitization (BeS).[3]

Occupational Exposure Criteria for Copper

In this facility copper metal is present in two physical states, copper fume and copper dust, and each has a separate environmental criteria. The NIOSH-REL[15] and OSHA-PEL[11] for copper fume are 0.1 mg/m^3 (100 $\mu g/m^3$), while the ACGIH-TLV is 0.2 mg/m^3 (200 $\mu g/m^3$) as an eight-hour TWA.[6] Inhalation of copper fume has resulted in irritation of the upper respiratory tract, metallic taste in the mouth, and nausea. Exposure has been also associated with the development of metal fume fever.[13,16]

The NIOSH-REL for copper dust is 1 mg/m^3 (1000 $\mu g/m^3$) measured as an 8-10 hour TWA.[15] The ACGIH-TLV and OSHA-PEL are also 1 mg/m^3 (1000 $\mu g/m^3$) measured as an 8-hour TWA.[6,11]

B. Surface Contamination Criteria

Occupational exposure criteria have been discussed above for airborne concentrations of several metals. Surface wipe samples can provide useful information in two circumstances; first, when settled dust on a surface can contaminate the hands and then be ingested when transferred from hand to mouth; and second, if the surface contaminant can be absorbed through the skin and the skin is in frequent contact with the surface.[17] Although some OSHA standards (e.g. asbestos, lead, cadmium, shipyards, longshoring, grain handling facilities, etc.) contain housekeeping provisions which address the issue of surface contamination by mandating that surfaces be maintained as free as practicable of accumulations of the regulated substances, there are currently no quantitative surface contamination criteria included in OSHA standards.[18] For example, under the Lead standard (29 CFR 1910.1025); employers need to establish a housekeeping program sufficient to maintain all surfaces as free as practicable of accumulations of lead dust. Vacuuming is the preferred method of meeting this requirement, and the use of compressed air to clean floors and other surfaces is absolutely prohibited. Dry or wet sweeping, shoveling, or brushing may not be used except where vacuuming or other equally effective methods have been tried and do not work. Vacuums must be used and emptied in a manner which minimizes the reentry of lead into the workplace. The health hazard from these regulated substances results principally from their inhalation and to a smaller extent from their ingestion; those substances are by and large "negligibly" absorbed through the skin.[17] NIOSH RELs do not address surface contamination either, nor do ACGIH TLVs or AIHA WEELs. Caplan stated, "There is no general quantitative relationship between surface contamination and air concentrations..." and that "Wipe samples can serve a purpose in determining if surfaces are as 'clean as practicable'. Ordinary cleanliness would represent totally insignificant inhalation dose; criteria should be based on surface contamination remaining after ordinarily thorough cleaning appropriate for the contaminant and the surface."[17] With those caveats in mind, the following paragraphs present guidelines that help to place the results of the surface sampling conducted at this facility in perspective.

Surface Contamination Criteria for Beryllium

A useful guideline to address the issues of beryllium surface contamination is provided by the U.S. Department of Energy (DOE), where DOE and its contractors are required to conduct routine surface sampling to determine housekeeping conditions wherever beryllium is present in operational areas of DOE/NNSA facilities.[3] Those facilities must maintain removable surface contamination levels that do not exceed 3μg/100 cm^2 during non-operational periods. The DOE also has release criteria that must be met before beryllium-contaminated equipment or other items can be released to the general public or released for use in a non-beryllium area of a DOE facility. These criteria state that the removable contamination level of equipment or item surfaces does not exceed the higher of 0.2 μg/100 cm^2, or the level of beryllium in the soil in the area of release. Removable contamination is defined as "beryllium contamination that can be removed from surfaces by nondestructive means, such as casual contact, wiping, brushing, or washing."

Surface Contamination Criteria for Copper

NIOSH, OSHA, AIHA and ACGIH® have not established occupational exposure limits for copper on surfaces.

V. RESULTS AND DISCUSSION

On June 18 - 21, 2007, air, surface wipe, and particle size samples were collected throughout this copper/beryllium products machine shop. These samples were analyzed for thirty-one metals/elements (aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lanthanum, lead, lithium, magnesium, manganese, molybdenum, nickel, phosphorus, potassium, selenium, silver, strontium, tellurium, thallium, tin, titanium, vanadium, yttrium, zinc, and zirconium) in accordance with NIOSH Method 7303 with modifications.[9] Because this machine shop manufactured copper/beryllium metal products the focus of this evaluation was beryllium and copper with a primary emphasis on beryllium. The entire set of sample data for the air, surface wipe, and cascade impactor particle size samples for all thirty-one elements are listed in Appendices A, B, and C, respectively.

A. Air Sample Results

Personal breathing zone and area air sampling results for beryllium and copper are contained in Table 2; while the entire sample data set of 31 elements/metals analyses is presented in Appendix A. At the time of the NIOSH survey, four of the 35 lathes were using a copper/beryllium alloy containing 2% beryllium. A total of 15 full-shift samples were collected on two consecutive days (8 personal breathing zone samples and 7 general area air samples) for elements/metals. The sample time (in minutes) is listed along with the calculated airborne beryllium and copper concentrations in Table 2. Exposure concentrations were calculated from the analytical results after correcting for the results of field blanks.

Beryllium was detected in one personal breathing zone air sample; none of the general area air samples collected had measurable quantities of beryllium. The lone sample with a measurable quantity of airborne beryllium indicated a concentration of 0.047 $\mu g/m^3$, which is approximately 1/10 of the NIOSH REL of 0.50 $\mu g/m^3$. The machinists remain in the area to monitor the lathes to ensure that they are operating properly and inspect the products. Metal cutting fluids are used during machining to aid in the cutting process, to extend the life of the cutting tools and to control and contain the release of dust.

Because this facility is a machine shop, the airborne copper generated in the operation would be expected to be in the form of dust. Therefore, the measured concentrations are compared to the copper dust evaluation criteria. Copper was detected in two of 15 samples collected. The two samples with measurable copper concentrations were both personal breathing zone samples, none of the general area air samples had measurable copper concentrations. Both samples with measurable copper dust concentrations were less than 1% of the occupational exposure criteria (1000 $\mu g/m^3$). The highest concentration measured was 2.84$\mu g/m^3$.

Other elements/metals detected were aluminum, cobalt, selenium, and titanium; all at concentrations less than 1% of the most stringent OEL.

B. Surface Wipe Sample Results

The results of surface wipe sampling for beryllium, cadmium, copper, lead, and nickel are presented in Table 3. These five metals are presented in Table 3 because of their potential toxicity, or in the case of copper because it is one of the primary metals expected to be present in this workplace environment. The entire surface wipe sample data set for 31 elements/metals is presented in Appendix B. A total of 20 surface wipe samples were collected on June 19, 2007; 10 using Ghost Wipes™ which were analyzed for the 31 metals/elements; and 10 using Palintest® Dust Wipes which were analyzed for beryllium only.

Ghost Wipes™ indicated measurable quantities of beryllium on 9 of 10 samples collected (see Table 3). Detectable surface concentrations ranged from 0.033 μg/100 cm^2 to 3.6 μg/100 cm^2. The highest beryllium surface concentration detected (3.6 μg/100 cm^2) was on a sample collected on the tool/workbench along the west wall of the machine shop. This one sample exceeds the DOE Guideline to maintain removable surface contamination levels that do not exceed 3μg/100 cm^2 during non-operational periods[3], and six of the ten samples are above DOE release guidelines (0.2 μg/100 cm^2, or the level of beryllium in the soil in the area of release). The next highest beryllium surface concentration detected was 1.1 μg/100 cm^2 and was detected on a sample collected on top of the electrical box in the center of the machine shop.

Of the other metals detected on these wipes, lead was detected on one wipe sample at a concentration of concern. The sample collected on top of the electrical box indicated a lead concentration of 120 μg/100 cm^2 or about 1100 μg/ft^2. However, all other wipe samples indicated that surface concentrations of lead were less than 160 μg/ft^2.

Palintest® Dust Wipes were analyzed for beryllium only and measurable quantities of beryllium were detected on 9 of 10 samples collected (see Table 3). The highest beryllium surface concentration detected on the Palintest® Dust Wipes was 0.3 μg/100 cm^2 which was detected on a sample collected on top of the electrical box in the center of the machine shop.

C. Particulate Size/Mass Distribution Results

One of the objectives of this study was to determine the particle size and mass concentration of airborne beryllium particles generated during the manufacturing process because there is substantial evidence that the presence of an ultrafine component increases the toxicity for chronic beryllium disease and possibly other toxic effects.

The results of particle size measurements collected using the Sioutas cascade impactors are summarized below and presented in Table 4. The MOUDI and APS data are summarized below and presented in Tables 4 and 5, and Figure 1; the entire Sioutas cascade impactor data set is contained in Appendix C. The term particle size refers to the aerodynamic size which is defined as the diameter of a unit density (1g/cm^3) sphere which has the same settling velocity as the particle in question.[19]

a. Sioutas Cascade Size-Selective Impactor Results

The results of size-selective sampling for beryllium and copper using the Sioutas Cascade Impactors are presented in Table 4, while the entire data set for the 31 metals/elements included in the laboratory analyses is presented in Appendix C. A mass analysis of the beryllium data collected with the Sioutas Cascade Impators is not appropriate because a large percentage (approximately 90%) of the data was non-detectable, however, a summary of the data follows. A total of 15 size-selective impactor samples were collected during the two days of air sampling; 8 were personal breathing zone air samples and 7 were area samples. The results presented in Table 4 show the beryllium and copper concentrations measured on each of the five impactor stages and the sum total of all five stages for each sample collected. Beryllium was detected on 4 of 8 personal samples and on one of 7 area samples collected, three of these samples indicate measurable quantities of beryllium particles smaller than 2.5 µm (stages B to E). This tends to suggest that airborne beryllium is present in concentrations that may potentially reach the lower portions of the respiratory tract. Copper was detected on 8 of 8 and on 4 of 7 area samples collected in the machine shop and the quality control room.

b. *MOUDI Size-Selective Impactor and APS Results*

The MOUDIs size-selective impactor sample results for the total particulate are presented in Table 5. Due to the low particle concentrations detected at this site, the MOUDI samples were not analyzed for 31 elements/metals typically included in the sample protocol for this study. The MOUDI samples results indicate measurable mass concentrations of airborne particles in the respirable range. These samples failed to provide conclusive information about the particle mass distributions due to either (1) the low airborne particle concentrations at the sample locations selected or (2) the potential loss of material from these fragile samplers during unloading at the end of the sample period and/or transit back to the laboratory for the gravimetric analysis. The airborne particulate mass concentration was low for all samples, making interpretation of this data problematic. Therefore, this data is provided for reference only.

The APS was used to check the number concentrations of airborne particles at the sampling locations where the MOUDI samples were collected on June 19 and 20, 2007. The APS data are presented graphically in Figure 1 and are summarized numerically in Table 6. Based on summarized APS data (Table 6) indicate that the particle counts measured in the sanding/grinding area were not much different from other working areas as may be expected. This was most likely due to the use of a local exhaust ventilation booth that was employed to control the particle emission. Overall the APS data suggest that the count median diameter (CMD) is close to the lower detection limit (0.5 µm) of APS instrument. However, based on the MMD from MOUDI which has a higher size resolution, one might expect that the CMD is likely smaller than 0.5 µm.

D. Ventilation Measurement Observations/Results

An Air King M-35P downdraft booth equipped with a HEPA filtered exhaust was the lone operation equipped with local exhaust ventilation. This downdraft booth is used on an intermittent as needed basis to chamfer smaller diameter rods on a bench grinder/buffer contained within the booth. The operator stands at the face of the booth to grind and buff the small diameter rods. On the days of sampling the grinding booth was not being used, however, the LEV was turned on to collect a few ventilation measurements. The LEV and the grinder are interlocked to ensure that the grinder is not operable unless the particle capture system is on and functioning. Ventilation measurements at the face of the downdraft hood measured velocities of 320 to 360 feet per minute (fpm); the downdraft opening measured 24 inches by 24 inches. Visual observations using smoke tube tracers confirmed that smoke is captured by downdraft booth.

VI. CONCLUSIONS AND RECOMMENDATIONS

The results of sampling during the June 2007, NIOSH in-depth survey indicate that none of the measured airborne beryllium concentrations exceeded the NIOSH REL of 0.5 $\mu g/m^3$ (currently the most restrictive OEL). Only one of eight personal breathing zone samples collected indicated a detectable quantity of beryllium; the concentration detected (0.047 $\mu g/m^3$) is less than 10% of the current NIOSH REL and less than 3% of the OSHA PEL of 2.0 $\mu g/m^3$. Beryllium was not detected on any of the seven area samples collected.

However, surface wipe sampling results indicate that special attention should be given to cleaning any equipment before moving the equipment to non-beryllium areas of the facility, and before transferring or moving the equipment off-site. This will ensure that surface contamination levels are below the DOE guideline.[3]

A written respiratory protection program specific to the facility should be developed and should comply with OSHA regulation 1910.134. Additionally, a hazard communication program compliant with OSHA regulation 1910.1200 should be developed in both English and Spanish.

Controlling worker exposures to beryllium dust and fume can be accomplished through the use of engineering controls, work practices, administrative actions, and personal protective equipment (PPE). Engineering controls include such things as isolating the source and using ventilation systems to control dust and is the preferred method for controlling worker exposures. Administrative actions include limiting the worker's exposure time and providing showers. PPE includes wearing the proper respiratory protection and personal protective clothing.

Recommendations to further reduce airborne beryllium concentrations and controlling worker exposures to beryllium-containing dust and fume include:

- Only employees who have been cleared to work in beryllium designated areas should be allowed access to areas where beryllium-containing materials are processed.
- Employees should receive regular training on the proper handling of beryllium, as well as the hazards of beryllium exposure. Additionally, those employees whose first language is Spanish should be provided training in Spanish to ensure comprehension.
- The use of dry sweeping techniques should not be used in beryllium designated work areas. The use of HEPA-filtered vacuums to remove dust from floors and work surfaces is recommended.
- The use of respirators requires the implementation of a site specific written respiratory protection program. Therefore, a written respiratory protection program should be implemented and should include: the training of employees; the selection, maintenance, and use of respirators; and monitoring of the program to ensure its ongoing effectiveness and compliance with OSHA regulation 1910.134. Only NIOSH certified respirators should be used. Disposable respirators provided at the time of the NIOSH survey were not NIOSH certified respirators, but have been replaced with NIOSH certified disposable facemask. – Moldex 2730 N100.
- The installation of a change room designed with a clean side and dirty side is recommended. This room should be equipped with lockers and showers for exposed workers to shower and change from contaminated, company-provided work clothes to

street clothes prior to leaving the facility reduces the potential for post-work exposure and the possibility of carrying contamination home. The OSHA lead standard, 29 CFR 1910.1025(i)(2)(i) provides additional detail regarding the design of change rooms. At the time of the NIOSH evaluation the change room was not properly designed; the room did not have separate entrances to segregate the clean side from the dirty side and did not have showers for employees. Following proper design will help control the spread of beryllium contamination and prevent take home contamination. Employees should be required to shower and change from contaminated work clothing to clean street clothes prior to leaving the worksite. Work clothing should be left at work and clean work clothes provided.

Other guidelines for housekeeping in workplaces that use beryllium are available from several sources. In 1999, OSHA issued a Hazard Information Bulletin, Preventing Adverse Health Effects from Exposure to Beryllium on the Job (OSHA 1999). The web link to that document is provided below:

http://www.osha.gov/dts/hib/hib_data/hib19990902.html

There are several sources of information on engineering controls including the ACGIH Industrial Ventilation Manual.[20] The NIOSH website is also an excellent source of information on beryllium.

http://www.cdc.gov/niosh/topics/beryllium/

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Table 1
Occupational Exposure Criteria for Metal/Elements

TABLE 2. EXPOSURE LIMITS, CAS #, RTECS

Element (Symbol)	CAS #	RTECS	Exposure Limits, mg/m³ (Ca = carcinogen) OSHA	NIOSH	ACGIH
Silver (Ag)	7440-22-4	VW3500000	0.01 (dust, fume, metal)	0.01 (metal, soluble)	0.1 (metal) 0.01 (soluble)
Aluminum (Al)	7429-90-5	BD0330000	15 (total dust) 5 (respirable)	10 (total dust) 5 (respirable fume) 2 (salts, alkyls)	10 (dust) 5 (powders, fume) 2 (salts, alkyls)
Arsenic (As)	7440-38-2	CG0525000	varies	C 0.002, Ca	0.01, Ca
Barium (Ba)	7440-39-3	CQ8370000	0.5	0.5	0.5
Beryllium (Be)	7440-41-7	DS1750000	0.002, C 0.005	0.0005, Ca	0.002, Ca
Calcium (Ca)	7440-70-2	–	varies	varies	varies
Cadmium (Cd)	7440-43-9	EU9800000	0.005	lowest feasible, Ca	0.01 (total), Ca 0.002 (respir.), Ca
Cobalt (Co)	7440-48-4	GF8750000	0.1	0.05 (dust, fume)	0.02 (dust, fume)
Chromium (Cr)	7440-47-3	GB4200000	0.5	0.5	0.5
Copper (Cu)	7440-50-8	GL5325000	1 (dust, mists) 0.1 (fume)	1 (dust) 0.1 (fume)	1 (dust, mists) 0.2 (fume)
Iron (Fe)	7439-89-6	NO4565500	10 (dust, fume)	5 (dust, fume)	5 (fume)
Potassium (K)	7440-09-7	TS6460000	–	–	–
Lanthanum	7439-91-0	–	–	–	–
Lithium (Li)	7439-93-2	–	–	--	–
Magnesium (Mg)	7439-95-4	OM2100000	15 (dust) as oxide 5 (respirable)	10 (fume) as oxide	10 (fume) as oxide
Manganese (Mn)	7439-96-5	OO9275000	C 5	1; STEL 3	5 (dust) 1; STEL 3 (fume)
Molybdenum (Mo)	7439-98-7	QA4680000	5 (soluble) 15 (total insoluble)	5 (soluble) 10 (insoluble)	5 (soluble) 10 (insoluble)
Nickel (Ni)	7440-02-0	QR5950000	1	0.015, Ca	0.1 (soluble) 1 (insoluble, metal)
Phosphorus (P)	7723-14-0	TH3500000	0.1	0.1	0.1
Lead (Pb)	7439-92-1	OF7525000	0.05	0.05	0.05
Antimony (Sb)	7440-36-0	CC4025000	0.5	0.5	0.5
Selenium (Se)	7782-49-2	VS7700000	0.2	0.2	0.2
Tin (Sn)	7440-31-5	XP7320000	2	2	2
Strontium (Sr)	7440-24-6	–	–	–	–
Tellurium (Te)	13494-80-9	WY2625000	0.1	0.1	0.1
Titanium (Ti)	7440-32-6	XR1700000	–	–	–
Thallium (Tl)	7440-28-0	XG3425000	0.1 (skin) (soluble)	0.1 (skin) (soluble)	0.1 (skin)
Vanadium (V)	7440-62-2	YW240000	–	C 0.05	–
Tungsten	7440-33-7	–	5	5 10 (STEL)	5 10 (STEL)
Yttrium (Y)	7440-65-5	ZG2980000	1	N/A	1
Zinc (Zn)	7440-66-6	ZG8600000	–	–	–
Zirconium (Zr)	7440-67-7	ZH7070000	5	5, STEL 10	5, STEL 10

Beryllium Facility #2 – Plant Diagram
Copper/Beryllium Machine Shop – June 2007

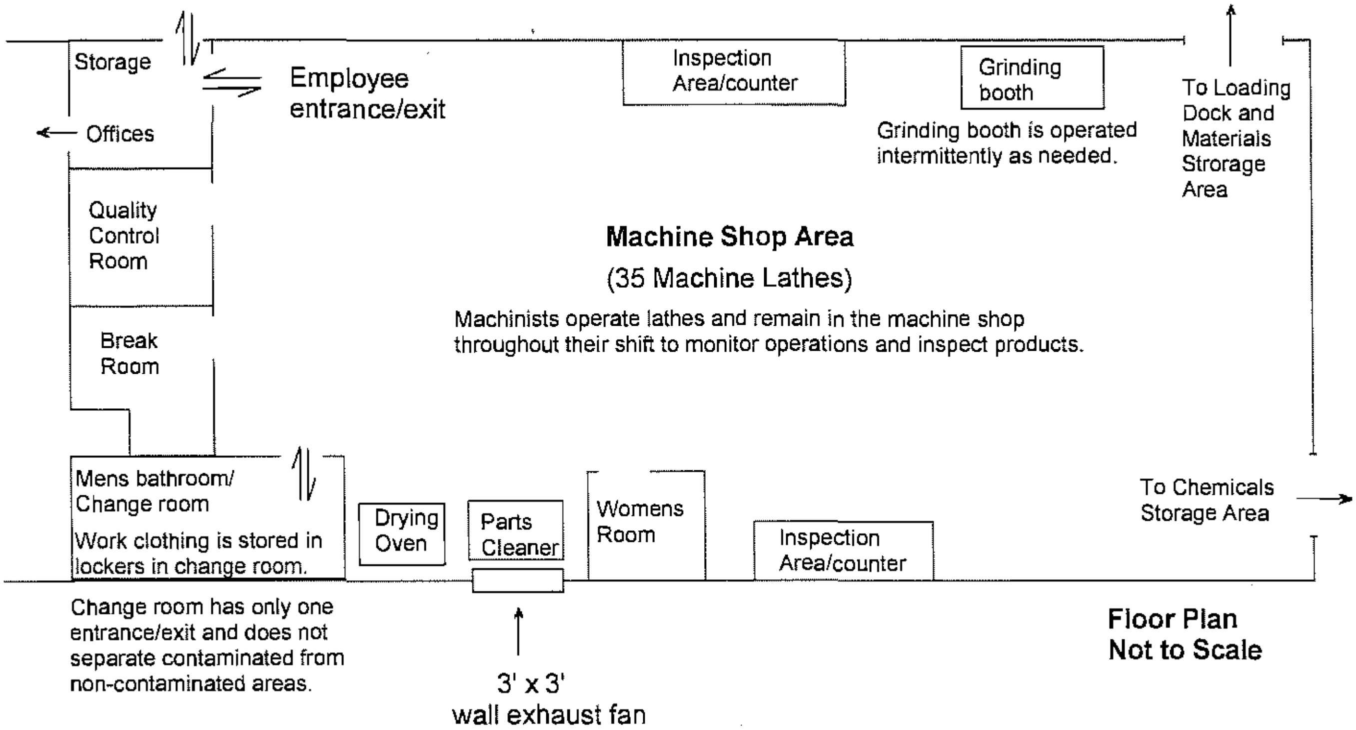

Photo #1 – shows a view of the machine shop, lathes and a lathe operator. The lathe operator manually inserts 10-12 foot metal rods (containing 1% to 2% beryllium) into the long tubes seen in the photograph. In this photo the cutting shield which is used to control cutting fluid splashes is in the up position with the operator preparing for a run. During operation the shield is down and the lathe automatically feeds metal rods to the cutting end of the lathe.

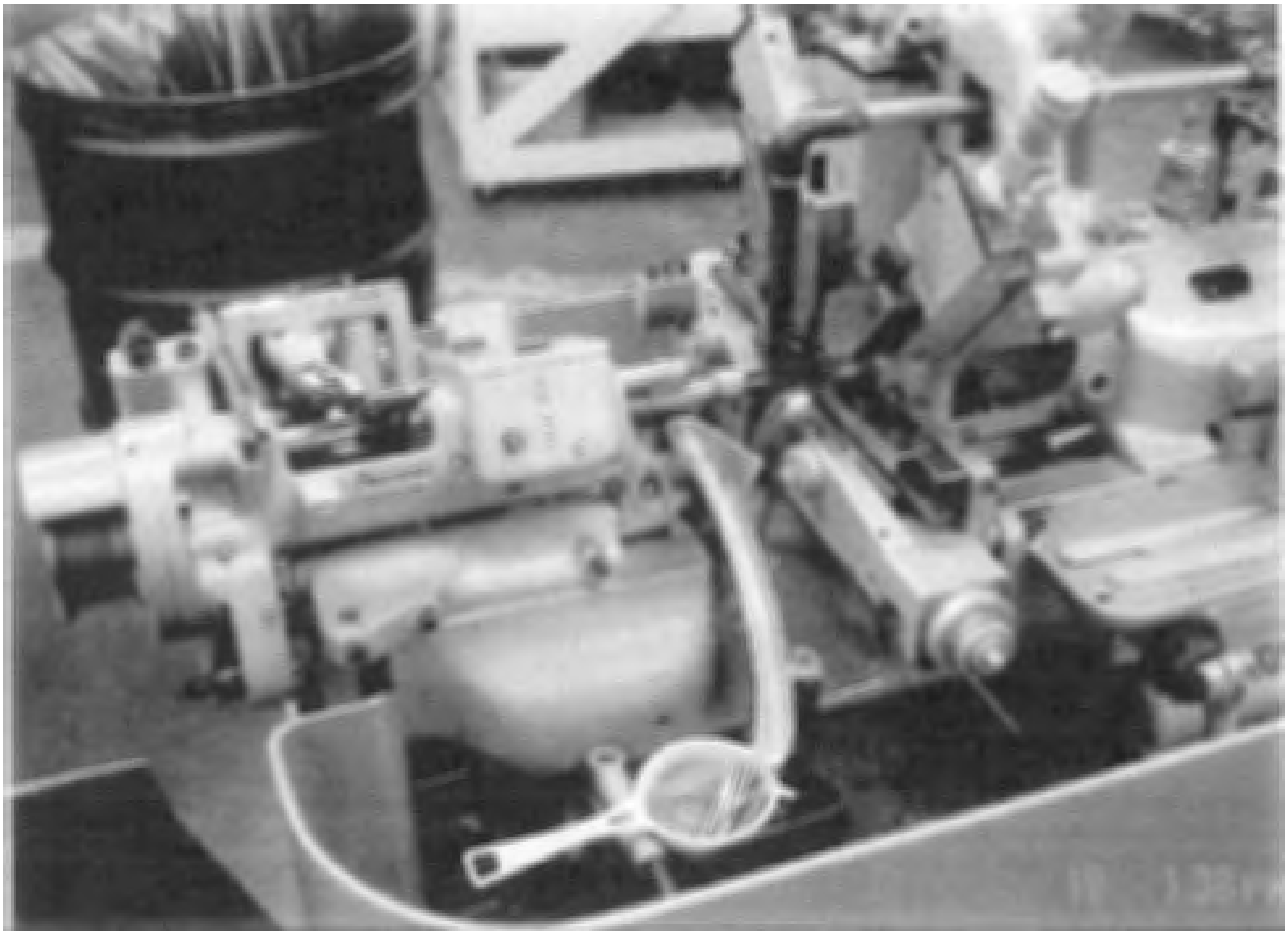

Photo #2 – metal rods are automatically fed to the cutting end of the lathe where the final product and cutting fluid flow into a trough where the pins are collected. The machinist stands at the cutting end, but moves around throughout the machine shop to monitor the operation of the lathes and collect random samples for inspection to ensure proper operation of the lathes. Cutting fluid is used to aid the cutting process, to extend the life of the cutting tools and to control and contain the release of dusts.

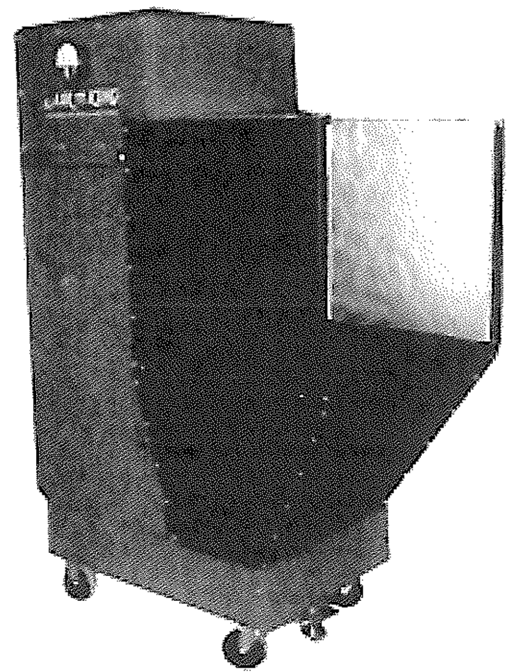

Photo #3 - An Air King M-35P downdraft booth was the lone operation equipped with local exhaust ventilation. The booth is approximately 6 feet high by 3 feet wide and 2 feet deep, and is equipped with a HEPA filter and is exhausted to the outdoors. The operator stands at the face of the booth to grind and buff small diameter rods. The booth is used on an intermittent as needed basis to chamfer smaller diameter rods on a bench grinder/buffer contained within the booth.

Table 2
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone (P) and Area (A) Air Sample Results for Beryllium (Be) and Copper (Cu)

Sample Number	Job Description/ Work Location	Sample Date	Sample Time (min.)	Sample Type	Be Concentration (µg/m^3)*	Cu Concentration (µg/m^3)*
NC-A-T-F01	Quality Control	6/19/2007	410	P	<0.017	<0.17
NC-A-T-F02	Quality Control	6/19/2007	327	P	<0.021	<0.21
NC-A-T-F03	Machine Shop	6/19/2007	412	P	<0.017	<0.17
NC-A-T-F04	Machine Shop	6/19/2007	416	P	<0.017	<0.17
NC-A-T-F05	Area north end of shop	6/19/2007	397	A	<0.018	<0.18
NC-A-T-F06	Area central near machine #8	6/19/2007	395	A	<0.017	<0.17
NC-A-T-F07	Area south end of shop	6/19/2007	389	A	<0.017	<0.17
NC-A-T-F08	Area multi spindles (steel)	6/19/2007	385	A	<0.018	<0.18
NC-A-W-F21	Machine Shop	6/20/2007	424	P	<0.016	0.23
NC-A-W-F22	Machine Shop	6/20/2007	436	P	<0.016	<0.16
NC-A-W-F23	Machine Shop	6/20/2007	418	P	0.047	2.84
NC-A-W-F24	Quality Control	6/20/2007	431	P	<0.015	<0.15
NC-A-W-F25	Area north end of shop	6/20/2007	425	A	<0.016	<0.16
NC-A-W-F26	Area central near machine #5	6/20/2007	421	A	<0.017	<0.17
NC-A-W-F27	Area south end near machine #2	6/20/2007	416	A	<0.016	<0.16
	EVALUATION CRITERIA		**NIOSH REL**		**0.5**	**1000**
			OSHA PEL		**2.0**	**1000**

* micrograms per cubic meter of air

Table 3
Facility #2 – Copper/Beryllium Machine Shop
Surface Wipe Sample Results for Beryllium (Be), Cadmium (Cd), Copper (Cu), Lead (Pb), and Nickel (Ni)

Sample Number	Sample Location	Sample Date	Be Conc. (µg/100cm²)	Cd Conc. (µg/100cm²)	Cu Conc. (µg/100cm²)	Pb Conc. (µg/100cm²)	Ni Conc. (µg/100cm²)
NC-A-T-**G11**	Break room counter	6/19/2007	0.033	0.15	2.7	<0.6	<0.7
NC-A-T-**P11**	Break room counter	6/19/2007	0.033	na	na	na	na
NC-A-T-**G12**	Parts cleaning table (next to men's room)	6/19/2007	0.38	0.092	27	3.7	<0.7
NC-A-T-**P12**	Parts cleaning table (next to men's room)	6/19/2007	0.008	na	na	na	na
NC-A-T-**G13**	Tool/work bench (along west wall)	6/19/2007	3.6	0.16	210	6.9	<0.7
NC-A-T-**P13**	Tool/work bench (along west wall)	6/19/2007	<0.006	na	na	na	na
NC-A-T-**G14**	Top of non-conforming materials cabinet (along west wall)	6/19/2007	0.31	0.72	65	17	7.9
NC-A-T-**P14**	Top of non-conforming materials cabinet (along west wall)	6/19/2007	0.058	na	na	na	na
NC-A-T-**G15**	Picnic table top in the steel area	6/19/2007	<0.03	0.15	3.3	0.88	<0.7
NC-A-T-**P15**	Picnic table top in the steel area	6/19/2007	0.016	na	na	na	na
NC-A-T-**G16**	Electrical box top,machine shop center, 10 feet above floor	6/19/2007	1.1	1.3	120	120	11
NC-A-T-**P16**	Electrical box top,machine shop center, 10 feet above floor	6/19/2007	0.300	na	na	na	na
NC-A-T-**G17**	Shelf in the men's room	6/19/2007	0.12	0.10	9.1	1.8	<0.7
NC-A-T-**P17**	Shelf in the men's room	6/19/2007	0.024	na	na	na	na
NC-A-T-**G18**	Shelf in the ladies room	6/19/2007	0.2	0.12	33	12	1.8
NC-A-T-**P18**	Shelf in the ladies room	6/19/2007	0.108	na	na	na	na
NC-A-T-**G19**	Tray in the quality control room	6/19/2007	0.74	0.11	110	5.2	1.6
NC-A-T-**P19**	Tray in the quality control room	6/19/2007	0.124	na	na	na	na
NC-A-T-**G20**	Bench top in storage area next to the office	6/19/2007	0.12	0.25	10	16	<0.7
NC-A-T-**P20**	Bench top in storage area next to the office	6/19/2007	0.016	na	na	na	na

µg/100cm² = micrograms per 100 square centimeters of wiped surface
G = Ghost wipes
P= Palintest wipes analyzed for beryllium only; na = sample **not analyzed** for cd, cu, pb or ni

Table 4
Facility #2 – Copper/Beryllium Machine Shop
Sioutas Size-Selective Impactor Air Sample Results for Beryllium (Be) and Copper (Cu)

Sample Number	Job Description/ Work Location	Sample Date	Particle Size (µm)	Sample Type	Be Conc. (µg/m^3)	Cu Conc. (µg/m^3)
NC-A-T-I01A	Quality Control	6/19/2007	2.5	P	0.019	0.81
NC-A-T-I01B	Quality Control	6/19/2007	1.0	P	<0.006	<0.06
NC-A-T-I01C	Quality Control	6/19/2007	0.50	P	<0.006	0.09
NC-A-T-I01D	Quality Control	6/19/2007	0.25	P	0.006	0.12
NC-A-T-I01E	Quality Control	6/19/2007	<0.25	P	<0.006	<0.06
NC-A-T-I01	Quality Control	6/19/2007		P	0.025	1.02
NC-A-T-I02A	Machine Shop	6/19/2007	2.5	P	<0.005	<0.05
NC-A-T-I02B	Machine Shop	6/19/2007	1.0	P	<0.005	<0.05
NC-A-T-I02C	Machine Shop	6/19/2007	0.50	P	0.010	0.21
NC-A-T-I02D	Machine Shop	6/19/2007	0.25	P	<0.005	<0.05
NC-A-T-I02E	Machine Shop	6/19/2007	<0.25	P	<0.005	<0.05
NC-A-T-I02	Machine Shop	6/19/2007		P	0.010	0.21
NC-A-T-I03A	Machine Shop	6/19/2007	2.5	P	<0.006	<0.06
NC-A-T-I03B	Machine Shop	6/19/2007	1.0	P	<0.006	0.60
NC-A-T-I03C	Machine Shop	6/19/2007	0.50	P	<0.006	<0.06
NC-A-T-I03D	Machine Shop	6/19/2007	0.25	P	<0.006	<0.06
NC-A-T-I03E	Machine Shop	6/19/2007	<0.25	P	<0.006	<0.06
NC-A-T-I03	Machine Shop	6/19/2007		P	<0.006	0.60
NC-A-T-I04A	Machine Shop	6/19/2007	2.5	P	<0.006	0.10
NC-A-T-I04B	Machine Shop	6/19/2007	1.0	P	<0.006	<0.06
NC-A-T-I04C	Machine Shop	6/19/2007	0.50	P	<0.006	<0.06
NC-A-T-I04D	Machine Shop	6/19/2007	0.25	P	<0.006	<0.06
NC-A-T-I04E	Machine Shop	6/19/2007	<0.25	P	<0.006	<0.06
NC-A-T-I04	Machine Shop	6/19/2007		P	<0.006	0.10

Table 4 - *continued*
Facility #2 – Copper/Beryllium Machine Shop
Sioutas Size-Selective Impactor Air Sample Results for Beryllium (Be) and Copper (Cu)

Sample Number	Job Description/ Work Location	Sample Date	Particle Size (μm)	Sample Type	Be Conc. (μg/m^3)	Cu Conc. (μg/m^3)
NC-A-T-I05A	Area north end of shop	6/19/2007	2.5	A	<0.006	0.17
NC-A-T-I05B	Area north end of shop	6/19/2007	1.0	A	<0.006	0.28
NC-A-T-I05C	Area north end of shop	6/19/2007	0.50	A	0.006	0.19
NC-A-T-I05D	Area north end of shop	6/19/2007	0.25	A	<0.006	0.35
NC-A-T-I05E	Area north end of shop	6/19/2007	<0.25	A	<0.006	<0.06
NC-A-T-I05	Area north end of shop	6/19/2007		A	0.006	0.99
NC-A-T-I06A	Area central near machine #8	6/19/2007	2.5	A	<0.006	<0.06
NC-A-T-I06B	Area central near machine #8	6/19/2007	1.0	A	<0.006	<0.06
NC-A-T-I06C	Area central near machine #8	6/19/2007	0.50	A	<0.006	<0.06
NC-A-T-I06D	Area central near machine #8	6/19/2007	0.25	A	<0.006	<0.06
NC-A-T-I06E	Area central near machine #8	6/19/2007	<0.25	A	<0.006	<0.06
NC-A-T-I06	Area central near machine #8	6/19/2007		A	<0.006	<0.06
NC-A-T-I07A	Area south end of shop	6/19/2007	2.5	A	<0.006	0.09
NC-A-T-I07B	Area south end of shop	6/19/2007	1.0	A	<0.006	<0.06
NC-A-T-I07C	Area south end of shop	6/19/2007	0.50	A	<0.006	0.08
NC-A-T-I07D	Area south end of shop	6/19/2007	0.25	A	<0.006	<0.06
NC-A-T-I07E	Area south end of shop	6/19/2007	<0.25	A	<0.006	<0.06
NC-A-T-I07	Area south end of shop	6/19/2007		A	<0.006	0.17
NC-A-T-I08A	Area multi spindles (steel)	6/19/2007	2.5	A	<0.006	<0.06
NC-A-T-I08B	Area multi spindles (steel)	6/19/2007	1.0	A	<0.006	<0.06
NC-A-T-I08C	Area multi spindles (steel)	6/19/2007	0.50	A	<0.006	<0.06
NC-A-T-I08D	Area multi spindles (steel)	6/19/2007	0.25	A	<0.006	<0.06
NC-A-T-I08E	Area multi spindles (steel)	6/19/2007	<0.25	A	<0.006	<0.06
NC-A-T-I08	Area multi spindles (steel)	6/19/2007		A	<0.006	<0.06

Table 4 - *continued*
Facility #2 – Copper/Beryllium Machine Shop
Sioutas Size-Selective Impactor Air Sample Results for Beryllium (Be) and Copper (Cu)

NC-A-W-I21A	Machine Shop	6/20/2007	2.5	P	0.009	0.96
NC-A-W-I21B	Machine Shop	6/20/2007	1.0	P	0.029	1.60
NC-A-W-I21C	Machine Shop	6/20/2007	0.50	P	<0.005	0.06
NC-A-W-I21D	Machine Shop	6/20/2007	0.25	P	0.018	1.12
NC-A-W-I21E	Machine Shop	6/20/2007	<0.25	P	<0.005	0.06
NC-A-W-I21	Machine Shop	6/20/2007		P	0.056	3.80
NC-A-W-I22A	Machine Shop	6/20/2007	2.5	P	<0.006	0.47
NC-A-W-I22B	Machine Shop	6/20/2007	1.0	P	<0.006	0.08
NC-A-W-I22C	Machine Shop	6/20/2007	0.50	P	<0.006	0.14
NC-A-W-I22D	Machine Shop	6/20/2007	0.25	P	<0.006	<0.06
NC-A-W-I22E	Machine Shop	6/20/2007	<0.25	P	<0.006	<0.06
NC-A-W-I22	Machine Shop	6/20/2007		P	<0.006	0.69
NC-A-W-I23A	Quality Control	6/20/2007	2.5	P	0.012	1.47
NC-A-W-I23B	Quality Control	6/20/2007	1.0	P	<0.006	0.08
NC-A-W-I23C	Quality Control	6/20/2007	0.50	P	<0.006	<0.06
NC-A-W-I23D	Quality Control	6/20/2007	0.25	P	<0.006	<0.06
NC-A-W-I23E	Quality Control	6/20/2007	<0.25	P	<0.006	<0.06
NC-A-W-I23	Quality Control	6/20/2007		P	0.012	1.55
NC-A-W-I24A	Quality Control	6/20/2007	2.5	P	<0.006	0.56
NC-A-W-I24B	Quality Control	6/20/2007	1.0	P	<0.006	<0.06
NC-A-W-I24C	Quality Control	6/20/2007	0.50	P	<0.006	<0.06
NC-A-W-I24D	Quality Control	6/20/2007	0.25	P	<0.006	<0.06
NC-A-W-I24E	Quality Control	6/20/2007	<0.25	P	<0.006	<0.06
NC-A-W-I24	Quality Control	6/20/2007		P	<0.006	0.56

Table 4 - *continued*
Facility #2 – Copper/Beryllium Machine Shop
Sioutas Size-Selective Impactor Air Sample Results for Beryllium (Be) and Copper (Cu)

NC-A-W-I25A	Area north end of shop	6/20/2007	2.5	A	<0.005	<0.05
NC-A-W-I25B	Area north end of shop	6/20/2007	1.0	A	<0.005	0.07
NC-A-W-I25C	Area north end of shop	6/20/2007	0.50	A	<0.005	<0.05
NC-A-W-I25D	Area north end of shop	6/20/2007	0.25	A	<0.005	0.07
NC-A-W-I25E	Area north end of shop	6/20/2007	<0.25	A	<0.005	<0.05
NC-A-W-I25	Area north end of shop	6/20/2007		A	<0.005	0.14
NC-A-W-I26A	Area central near machine #5	6/20/2007	2.5	A	<0.006	<0.06
NC-A-W-I26B	Area central near machine #5	6/20/2007	1.0	A	<0.006	<0.06
NC-A-W-I26C	Area central near machine #5	6/20/2007	0.50	A	<0.006	<0.06
NC-A-W-I26D	Area central near machine #5	6/20/2007	0.25	A	<0.006	<0.06
NC-A-W-I26E	Area central near machine #5	6/20/2007	<0.25	A	<0.006	<0.06
NC-A-W-I26	Area central near machine #5	6/20/2007		A	<0.006	<0.06
NC-A-W-I27A	Area south end near machine #2	6/20/2007	2.5	A	<0.006	0.14
NC-A-W-I27B	Area south end near machine #2	6/20/2007	1.0	A	<0.006	<0.06
NC-A-W-I27C	Area south end near machine #2	6/20/2007	0.50	A	<0.006	<0.06
NC-A-W-I27D	Area south end near machine #2	6/20/2007	0.25	A	<0.006	<0.06
NC-A-W-I27E	Area south end near machine #2	6/20/2007	<0.25	A	<0.006	<0.06
NC-A-W-I27	Area south end near machine #2	6/20/2007		A	<0.006	0.14

Table 5
Facility #2 – Copper/Beryllium Machine Shop
MOUDI Size-Selective Impactor Air Sample Results for Total Particulate

Sample Number	Sample Location	Sample Date	Sample Volume (m^3)	Particle Size (μm)	Particulate Conc. (mg/m^3)
A1-0	Beside Machine #9	6/19/2007	12.18	>18	0.028
A1-1	Beside Machine #9	6/19/2007	12.18	10	0.009
A1-2	Beside Machine #9	6/19/2007	12.18	5.6	0.009
A1-3	Beside Machine #9	6/19/2007	12.18	3.2	0.017
A1-4	Beside Machine #9	6/19/2007	12.18	1.8	0.020
A1-5	Beside Machine #9	6/19/2007	12.18	1.0	0.032
A1-6	Beside Machine #9	6/19/2007	12.18	0.56	0.039
A1-7	Beside Machine #9	6/19/2007	12.18	0.32	0.030
A1-8	Beside Machine #9	6/19/2007	12.18	0.18	0.018
A1-9	Beside Machine #9	6/19/2007	12.18	0.1	0.014
A1-10	Beside Machine #9	6/19/2007	12.18	0.056	0.017
A1-F	Beside Machine #9	6/19/2007	12.18	<0.056	0.007
A1-total	Beside Machine #9	6/19/2007	12.18	Total	0.244
B1-0	Between Machines #29 and #30	6/19/2007	12.27	>18	0.027
B1-1	Between Machines #29 and #30	6/19/2007	12.27	10	-0.031
B1-2	Between Machines #29 and #30	6/19/2007	12.27	5.6	0.009
B1-3	Between Machines #29 and #30	6/19/2007	12.27	3.2	0.020
B1-4	Between Machines #29 and #30	6/19/2007	12.27	1.8	0.014
B1-5	Between Machines #29 and #30	6/19/2007	12.27	1.0	0.026
B1-6	Between Machines #29 and #30	6/19/2007	12.27	0.56	0.010
B1-7	Between Machines #29 and #30	6/19/2007	12.27	0.32	0.011
B1-8	Between Machines #29 and #30	6/19/2007	12.27	0.18	0.005
B1-9	Between Machines #29 and #30	6/19/2007	12.27	0.1	0.010
B1-10	Between Machines #29 and #30	6/19/2007	12.27	0.056	0.014
B1-F	Between Machines #29 and #30	6/19/2007	12.27	<0.056	0.007
B1-total	Between Machines #29 and #30	6/19/2007	12.27	Total	0.123

Table 5 - *continued*
Facility #2 – Copper/Beryllium Machine Shop
MOUDI Size-Selective Impactor Air Sample Results for Total Particulate

Sample Number	Sample Location	Sample Date	Sample Volume (m^3)	Particle Size (µm)	Particulate Conc. (mg/m^3)
C1-0	Between Machines #29 and #30	6/19/2007	12.12	>18	0.066
C1-1	Between Machines #29 and #30	6/19/2007	12.12	10	0.000
C1-2	Between Machines #29 and #30	6/19/2007	12.12	5.6	0.351
C1-3	Between Machines #29 and #30	6/19/2007	12.12	3.2	0.004
C1-4	Between Machines #29 and #30	6/19/2007	12.12	1.8	0.033
C1-5	Between Machines #29 and #30	6/19/2007	12.12	1.0	0.000
C1-6	Between Machines #29 and #30	6/19/2007	12.12	0.56	0.000
C1-7	Between Machines #29 and #30	6/19/2007	12.12	0.32	0.000
C1-8	Between Machines #29 and #30	6/19/2007	12.12	0.18	0.000
C1-9	Between Machines #29 and #30	6/19/2007	12.12	0.1	0.000
C1-10	Between Machines #29 and #30	6/19/2007	12.12	0.056	0.000
C1-F	Between Machines #29 and #30	6/19/2007	12.12	<0.056	0.006
C1-total	Between Machines #29 and #30	6/19/2007	12.12	Total	0.144
A2-0	Beside Machine #27	6/20/2007	12.57	>18	0.003
A2-1	Beside Machine #27	6/20/2007	12.57	10	0.001
A2-2	Beside Machine #27	6/20/2007	12.57	5.6	0.003
A2-3	Beside Machine #27	6/20/2007	12.57	3.2	0.005
A2-4	Beside Machine #27	6/20/2007	12.57	1.8	0.006
A2-5	Beside Machine #27	6/20/2007	12.57	1.0	0.042
A2-6	Beside Machine #27	6/20/2007	12.57	0.56	0.003
A2-7	Beside Machine #27	6/20/2007	12.57	0.32	0.003
A2-8	Beside Machine #27	6/20/2007	12.57	0.18	0.007
A2-9	Beside Machine #27	6/20/2007	12.57	0.1	0.002
A2-10	Beside Machine #27	6/20/2007	12.57	0.056	0.001
A2-F	Beside Machine #27	6/20/2007	12.57	<0.056	0.004
A2-total	Beside Machine #27	6/20/2007	12.57	Total	0.078

Table 5 - *continued*
Facility #2 – Copper/Beryllium Machine Shop
MOUDI Size-Selective Impactor Air Sample Results for Total Particulate

Sample Number	Sample Location	Sample Date	Sample Volume (m^3)	Particle Size (µm)	Particulate Conc. (mg/m^3)
B2-0	Between Machines #29 and #30	6/20/2007	12.6	>18	0.012
B2-1	Between Machines #29 and #30	6/20/2007	12.6	10	-0.007
B2-2	Between Machines #29 and #30	6/20/2007	12.6	5.6	0.011
B2-3	Between Machines #29 and #30	6/20/2007	12.6	3.2	0.010
B2-4	Between Machines #29 and #30	6/20/2007	12.6	1.8	0.012
B2-5	Between Machines #29 and #30	6/20/2007	12.6	1.0	0.014
B2-6	Between Machines #29 and #30	6/20/2007	12.6	0.56	0.004
B2-7	Between Machines #29 and #30	6/20/2007	12.6	0.32	-0.008
B2-8	Between Machines #29 and #30	6/20/2007	12.6	0.18	0.001
B2-9	Between Machines #29 and #30	6/20/2007	12.6	0.1	0.000
B2-10	Between Machines #29 and #30	6/20/2007	12.6	0.056	0.000
B2-F	Between Machines #29 and #30	6/20/2007	12.6	<0.056	0.003
B2-total	Between Machines #29 and #30	6/20/2007	12.6	Total	0.052
C2-0	Between Machines #29 and #30	6/20/2007	12.6	>18	0.038
C2-1	Between Machines #29 and #30	6/20/2007	12.6	10	0.013
C2-2	Between Machines #29 and #30	6/20/2007	12.6	5.6	0.013
C2-3	Between Machines #29 and #30	6/20/2007	12.6	3.2	0.016
C2-4	Between Machines #29 and #30	6/20/2007	12.6	1.8	0.000
C2-5	Between Machines #29 and #30	6/20/2007	12.6	1.0	0.000
C2-6	Between Machines #29 and #30	6/20/2007	12.6	0.56	0.000
C2-7	Between Machines #29 and #30	6/20/2007	12.6	0.32	0.000
C2-8	Between Machines #29 and #30	6/20/2007	12.6	0.18	0.029
C2-9	Between Machines #29 and #30	6/20/2007	12.6	0.1	0.043
C2-10	Between Machines #29 and #30	6/20/2007	12.6	0.056	0.000
C2-F	Between Machines #29 and #30	6/20/2007	12.6	<0.056	0.003
C2-total	Between Machines #29 and #30	6/20/2007	12.6	Total	0.155

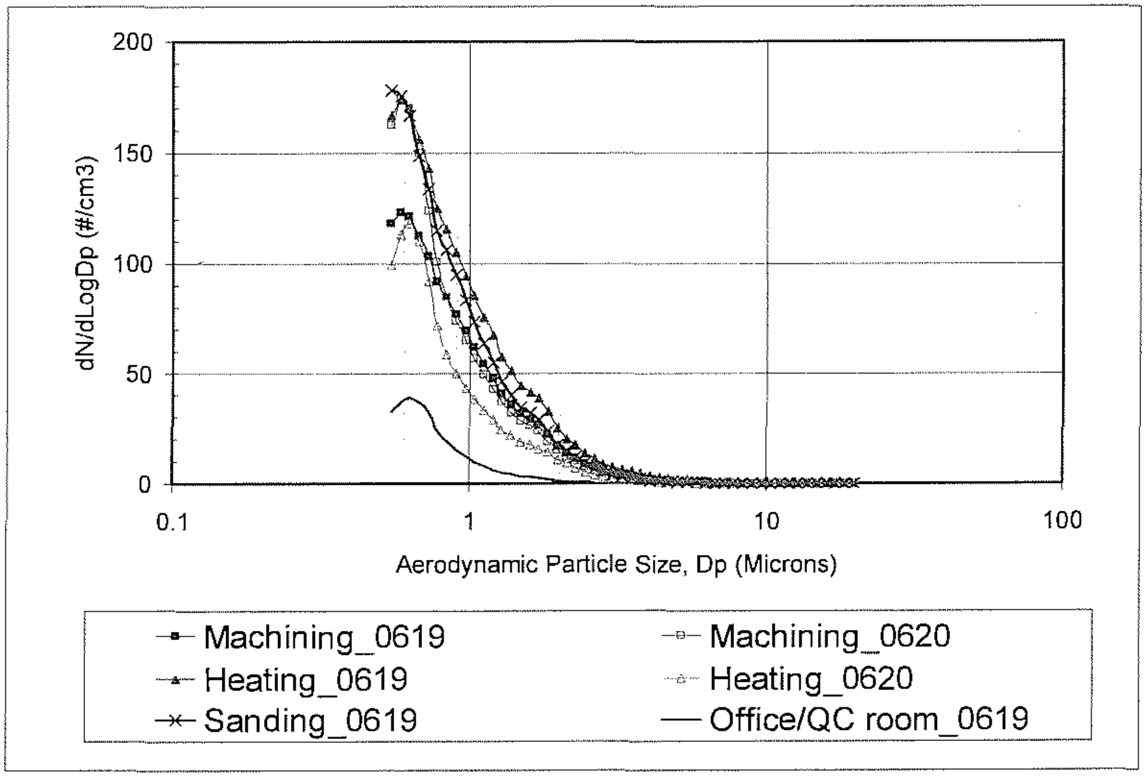

Figure 1. APS data from Facility #2 – Copper/Beryllium Machine Shop.

Table 6.
Facility #2 – Copper/Beryllium Machine Shop
Summary of APS data from Site 2.

Sampling location_date	Geometric mean (µm)	Mode (µm)	Particle number Concentration at mode size (#/cm^3)
Machining_0619	0.893	0.583	123.1
Heating_0619	0.909	0583	173.9
Sanding_0619	0.855	0.542	177.9
Machining_0620	0.833	0.583	174.7
Heating_0620	0.836	0.626	118.2
Office/QC room_0619	0.763	0.626	38.9

Appendix A
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Air Sample Results for Thirty-one Elements

Sample Number	Al (μg/m³)	Sb (μg/m³)	As (μg/m³)	Ba (μg/m³)	Be (μg/m³)	Cd (μg/m³)	Ca (μg/m³)	Cr (μg/m³)	Co (μg/m³)	Cu (μg/m³)	Fe (μg/m³)
NC-A-T-F01	<0.33	<0.25	<0.83	<0.02	<0.02	<0.02	<0.58	<0.17	<0.02	<0.2	<1.7
NC-A-T-F02	<0.42	<0.31	<1.05	<0.02	<0.02	<0.02	<0.73	<0.21	<0.03	<0.2	<2.1
NC-A-T-F03	<0.34	<0.25	<0.85	<0.02	<0.02	<0.02	<0.59	<0.17	<0.03	<0.2	<1.7
NC-A-T-F04	<0.34	<0.24	<0.85	<0.02	<0.02	<0.02	<0.59	<0.17	<0.03	<0.2	<1.7
NC-A-T-F05	<0.36	<0.27	<0.90	<0.02	<0.02	<0.02	<0.63	<0.18	<0.03	<0.2	<1.8
NC-A-T-F06	<0.34	<0.26	<0.86	<0.02	<0.02	<0.02	<0.60	<0.17	<0.03	<0.2	<1.7
NC-A-T-F07	<0.34	<0.26	<0.86	<0.02	<0.02	<0.02	<0.60	<0.17	<0.03	<0.2	<1.7
NC-A-T-F08	<0.35	<0.27	<0.89	<0.02	<0.02	<0.02	<0.62	<0.18	<0.03	<0.2	<1.8
NC-A-W-F21	<0.31	<0.23	<0.78	<0.02	<0.02	<0.02	<0.54	<0.16	<0.02	0.23	<1.6
NC-A-W-F22	<0.31	<0.23	<0.78	<0.02	<0.02	<0.02	<0.55	<0.16	<0.02	<0.2	<1.6
NC-A-W-F23	0.65	<0.26	<0.86	<0.02	0.05	<0.02	<0.60	<0.17	<0.03	2.84	<1.7
NC-A-W-F24	<0.31	<0.23	<0.77	<0.02	<0.02	<0.02	<0.54	<0.15	0.03	<0.2	<1.5
NC-A-W-F25	<0.33	<0.25	<0.82	<0.02	<0.02	<0.02	<0.57	<0.16	<0.02	<0.2	<1.6
NC-A-W-F26	<0.34	<0.26	<0.86	<0.02	<0.02	<0.02	<0.60	<0.17	<0.03	<0.17	<1.7
NC-A-W-F27	<0.32	<0.24	<0.81	<0.02	<0.02	<0.02	<0.57	<0.16	<0.02	<0.16	<1.6

Appendix A - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Air Sample Results for Thirty-one Elements

Sample Number	La (µg/m³)	Pb (µg/m³)	Li (µg/m³)	Mg (µg/m³)	Mn (µg/m³)	Mo (µg/m³)	Ni (µg/m³)	P (µg/m³)	K (µg/m³)	Se (µg/m³)
NC-A-T-F01	<0.01	<0.2	<0.8	<0.8	<0.06	<0.2	<0.02	<1.7	<0.4	<0.58
NC-A-T-F02	<0.01	<0.3	<1.0	<1.0	<0.07	<0.2	<0.03	<2.1	<0.5	<0.73
NC-A-T-F03	<0.01	<0.3	<0.8	<0.8	<0.06	<0.2	<0.03	<1.7	<0.4	<0.59
NC-A-T-F04	<0.01	<0.3	<0.8	<0.8	<0.06	<0.2	<0.03	<1.7	0.8	0.30
NC-A-T-F05	<0.01	<0.3	<0.9	<0.9	<0.06	<0.2	<0.03	<1.8	<0.4	<0.63
NC-A-T-F06	<0.01	<0.3	<0.9	<0.9	<0.06	<0.2	<0.03	<1.7	<0.4	<0.60
NC-A-T-F07	<0.01	<0.3	<0.9	<0.9	<0.06	<0.2	<0.03	<1.7	<0.4	0.30
NC-A-T-F08	<0.01	<0.3	<0.9	<0.9	<0.06	<0.2	<0.03	<1.8	<0.4	0.49
NC-A-W-F21	<0.01	<0.2	<0.8	<0.8	<0.05	<0.2	<0.02	<1.6	<0.4	<0.54
NC-A-W-F22	<0.01	<0.2	<0.8	<0.8	<0.05	<0.2	<0.02	<1.6	<0.4	0.82
NC-A-W-F23	<0.01	<0.3	<0.9	<0.9	<0.06	<0.2	<0.03	<1.7	<0.4	0.73
NC-A-W-F24	<0.01	<0.2	<0.8	<0.8	<0.05	<0.2	<0.02	<1.5	<0.4	0.04
NC-A-W-F25	<0.01	<0.2	<0.8	<0.8	<0.06	<0.2	<0.02	<1.6	<0.4	<0.57
NC-A-W-F26	<0.01	<0.3	<0.9	<0.9	<0.06	<0.2	<0.03	<1.7	<0.4	0.30
NC-A-W-F27	<0.01	<0.2	<0.8	<0.8	<0.06	<0.2	<0.02	<1.6	<0.4	0.85

Appendix A - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Air Sample Results for Thirty-one Elements

Sample Number	Ag (µg/m³)	Sr (µg/m³)	Te (µg/m³)	Tl (µg/m³)	Sn (µg/m³)	Ti (µg/m³)	V (µg/m³)	Y (µg/m³)	Zn (µg/m³)	Zr (µg/m³)
NC-A-T-F01	<0.02	<0.01	<0.4	<0.6	<0.8	0.012	<0.02	<0.005	<0.2	<0.3
NC-A-T-F02	<0.02	<0.01	<0.5	<0.7	<1.0	<0.003	<0.03	<0.006	<0.2	<0.4
NC-A-T-F03	<0.02	<0.01	<0.4	<0.6	<0.8	<0.003	<0.03	<0.005	<0.2	<0.3
NC-A-T-F04	<0.02	<0.01	<0.4	<0.6	<0.8	<0.003	<0.03	<0.005	<0.2	<0.3
NC-A-T-F05	<0.02	<0.01	<0.4	<0.6	<0.9	<0.003	<0.03	<0.005	<0.2	<0.2
NC-A-T-F06	<0.02	<0.01	<0.4	<0.6	<0.9	<0.003	<0.3	<0.005	<0.2	<0.3
NC-A-T-F07	<0.02	<0.01	<0.4	<0.6	<0.9	<0.003	<0.03	<0.005	<0.2	<0.3
NC-A-T-F08	<0.02	<0.01	<0.4	<0.6	<0.9	0.003	<0.03	<0.005	<0.2	<0.4
NC-A-W-F21	<0.02	<0.01	<0.4	<0.6	<0.8	<0.002	<0.02	<0.005	<0.2	<0.3
NC-A-W-F22	<0.02	<0.01	<0.4	<0.5	<0.8	<0.002	<0.02	<0.005	<0.2	<0.3
NC-A-W-F23	<0.02	<0.01	<0.4	<0.6	<0.9	0.033	<0.03	<0.005	<0.2	<0.3
NC-A-W-F24	<0.02	<0.01	<0.4	<0.5	<0.8	<0.002	<0.02	<0.005	<0.2	<0.3
NC-A-W-F25	<0.02	<0.01	<0.4	<0.6	<0.8	<0.002	<0.02	<0.005	<0.2	<0.3
NC-A-W-F26	<0.02	<0.01	<0.4	<0.6	<0.9	<0.003	<0.03	<0.005	<0.2	<0.3
NC-A-W-F27	<0.02	<0.01	<0.4	<0.6	<0.8	<0.002	<0.02	<0.005	<0.2	<0.3

Appendix B
Facility #2 – Copper/Beryllium Machine Shop
Surface Wipe Sample Results for Thirty-one Elements

Sample Number	Al (µg/100cm^2)	Sb (µg/100cm^2)	As (µg/100cm^2)	Ba (µg/100cm^2)	Be (µg/100cm^2)	Cd (µg/100cm^2)	Ca (µg/100cm^2)	Cr (µg/100cm^2)
NC-A-T-G11	4	<2	<3	0.48	0.033	0.15	270	<0.3
NC-A-T-G12	4	<2	<3	0.4	0.38	0.092	430	4.1
NC-A-T-G13	4	<2	<3	4.7	3.6	0.16	300	0.99
NC-A-T-G14	43	<2	<3	2.6	0.31	0.72	440	19
NC-A-T-G15	3.6	<2	<3	0.9	<0.03	0.15	320	0.76
NC-A-T-G16	290	<2	<3	12	1.1	1.3	2700	24
NC-A-T-G17	3.6	<2	<3	0.97	0.12	0.10	300	0.48
NC-A-T-G18	19	<2	<3	1.5	0.2	0.12	430	4.4
NC-A-T-G19	45	<2	<3	0.43	0.74	0.11	380	3.2
NC-A-T-G20	34	<2	<3	1.2	0.12	0.25	560	1.2

Sample Number	Co (µg/100cm^2)	Cu (µg/100cm^2)	Fe (µg/100cm^2)	La (µg/100cm^2)	Pb (µg/100cm^2)	Li (µg/100cm^2)	Mg (µg/100cm^2)	Mn (µg/100cm^2)
NC-A-T-G11	<0.1	2.7	<20	<0.3	<0.6	0.053	130	0.24
NC-A-T-G12	<0.1	27	34	<0.3	3.7	0.063	140	0.74
NC-A-T-G13	0.5	210	340	<0.3	6.9	0.050	110	6.8
NC-A-T-G14	28	65	3000	0.41	17	0.420	190	32
NC-A-T-G15	<0.1	3.3	22	<0.3	0.88	0.024	130	0.42
NC-A-T-G16	14	120	1200	0.35	120	1.0	980	30
NC-A-T-G17	<0.1	9.1	<20	<0.3	1.8	0.024	130	0.39
NC-A-T-G18	1.1	33	71	<0.3	12	0.046	140	2
NC-A-T-G19	<0.1	110	27	<0.3	5.2	0.048	120	0.48
NC-A-T-G20	1.4	10	250	<0.3	16	0.076	210	4.0

Appendix B - *Continued*

Facility #2 – Copper/Beryllium Machine Shop

Surface Wipe Sample Results for Thirty-one Elements

Sample Number	Mo (µg/100cm^2)	Ni (µg/100cm^2)	P (µg/100cm^2)	K (µg/100cm^2)	Se (µg/100cm^2)	Ag (µg/100cm^2)	Sr (µg/100cm^2)	Te (µg/100cm^2)
NC-A-T-G11	<0.2	<0.7	19	110	<2	<0.06	0.68	0.19
NC-A-T-G12	<0.2	<0.7	12	100	<2	<0.06	0.79	0.23
NC-A-T-G13	<0.2	<0.7	7	88	2.8	0.14	0.78	0.26
NC-A-T-G14	3.1	7.9	26	120	<2	2.8	1.1	<0.1
NC-A-T-G15	<0.2	<0.7	26	130	<2	<0.06	0.73	0.3
NC-A-T-G16	4.7	11	100	300	<2	0.46	3.5	0.26
NC-A-T-G17	<0.2	<0.7	21	120	<2	<0.06	0.70	<0.1
NC-A-T-G18	0.21	1.8	24	110	3.6	<0.06	0.95	0.13
NC-A-T-G19	<0.2	1.6	7	91	<2	<0.06	2.3	<0.1
NC-A-T-G20	<0.2	<0.7	23	100	<2	<0.06	0.94	0.28

Sample Number	Tl (µg/100cm^2)	Sn (µg/100cm^2)	Ti (µg/100cm^2)	V (µg/100cm^2)	Y (µg/100cm^2)	Zn (µg/100cm^2)	Zr (µg/100cm^2)	
NC-A-T-G11	<7	<2	<2	<0.04	<0.02	42	<40	
NC-A-T-G12	<7	<2	<2	<0.04	<0.02	79	<40	
NC-A-T-G13	<7	<2	<2	<0.04	<0.02	77	<40	
NC-A-T-G14	<7	<2	<2	1.0	0.022	110	<40	
NC-A-T-G15	<7	<2	<2	<0.04	<0.02	65	<40	
NC-A-T-G16	<7	<2	11	1.9	0.26	190	<40	
NC-A-T-G17	<7	2.2	<2	<0.04	<0.02	55	<40	
NC-A-T-G18	<7	<2	<2	0.075	<0.02	67	<40	
NC-A-T-G19	<7	<2	<2	<0.04	<0.02	86	<40	
NC-A-T-G20	<7	13	2.0	0.1	<0.02	150	<40	

Appendix C
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (µm)	Al (µg/m³)	Sb (µg/m³)	As (µg/m³)	Ba (µg/m³)	Be (µg/m³)	Cd (µg/m³)	Ca (µg/m³)	Cr (µg/m³)	Co (µg/m³)	Cu (µg/m³)	Fe (µg/m³)
NC-A-T-I01A	2.5	1.73	<0.09	<0.29	<0.005	0.019	<0.005	0.52	<0.06	<0.01	0.81	<0.6
NC-A-T-I01B	1.0	<0.12	<0.09	<0.29	<0.005	<0.005	<0.005	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-T-I01C	0.50	<0.12	<0.09	<0.29	<0.005	<0.005	<0.005	<0.20	<0.06	<0.01	0.09	<0.6
NC-A-T-I01D	0.25	<0.12	<0.09	<0.29	<0.005	0.006	<0.005	<0.20	<0.06	<0.01	0.12	<0.6
NC-A-T-I01E	filter	<0.12	<0.09	<0.29	<0.005	<0.005	<0.005	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-T-I01	total	1.73	<0.09	<0.29	<0.005	0.025	<0.005	0.52	<0.06	<0.01	1.02	<0.6
NC-A-T-I02A	2.5	0.72	<0.08	<0.27	<0.005	<0.005	<0.005	0.25	<0.05	<0.01	<0.05	<0.5
NC-A-T-I02B	1.0	0.38	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.05	<0.01	<0.05	<0.5
NC-A-T-I02C	0.50	0.20	<0.08	<0.27	<0.005	0.010	<0.005	<0.19	<0.05	<0.01	0.21	<0.5
NC-A-T-I02D	0.25	0.46	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.05	<0.01	<0.05	<0.5
NC-A-T-I02E	filter	<0.11	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.05	<0.01	<0.05	<0.5
NC-A-T-I02	total	1.75	<0.08	<0.27	<0.005	0.010	<0.005	0.25	<0.05	<0.01	0.21	<0.5
NC-A-T-I03A	2.5	5.68	<0.09	<0.28	<0.006	<0.006	<0.006	0.37	<0.06	<0.01	<0.06	<0.6
NC-A-T-I03B	1.0	56.85	<0.09	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	0.60	<0.6
NC-A-T-I03C	0.50	3.98	<0.09	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-T-I03D	0.25	2.22	<0.09	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-T-I03E	filter	<0.11	<0.09	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-T-I03	total	68.73	<0.09	<0.28	<0.006	<0.006	<0.006	0.37	<0.06	<0.01	0.60	<0.6
NC-A-T-I04A	2.5	3.08	<0.09	<0.28	<0.006	<0.006	<0.006	<0.20	0.08	<0.01	0.10	<0.6
NC-A-T-I04B	1.0	2.24	<0.09	<0.28	<0.006	<0.006	0.009	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-T-I04C	0.50	1.09	<0.09	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-T-I04D	0.25	5.89	<0.09	<0.28	<0.006	<0.006	<0.006	0.28	<0.06	<0.01	<0.06	<0.6
NC-A-T-I04E	filter	<0.11	<0.09	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-T-I04	total	12.31	<0.09	<0.28	<0.006	<0.006	0.009	0.28	0.08	<0.01	0.10	<0.6

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (μm)	Al (μg/m^3)	Sb (μg/m^3)	As (μg/m^3)	Ba (μg/m^3)	Be (μg/m^3)	Cd (μg/m^3)	Ca (μg/m^3)	Cr (μg/m^3)	Co (μg/m^3)	Cu (μg/m^3)	Fe (μg/m^3)
NC-A-T-I05A	2.5	22.61	<0.09	<0.29	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	0.17	<0.6
NC-A-T-I05B	1.0	49.92	<0.09	<0.29	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	0.28	<0.6
NC-A-T-I05C	0.50	1.32	<0.09	<0.29	<0.006	0.006	<0.006	<0.21	<0.06	0.01	0.19	<0.6
NC-A-T-I05D	0.25	29.37	<0.09	<0.29	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	0.35	<0.6
NC-A-T-I05E	filter	<0.12	<0.09	<0.29	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I05	total	103.22	<0.09	<0.29	<0.006	0.006	<0.006	<0.21	<0.06	0.01	0.99	<0.6
NC-A-T-I06A	2.5	0.53	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I06B	1.0	0.23	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I06C	0.50	0.25	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I06D	0.25	0.25	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I06E	filter	<0.12	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I06	total	1.26	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I07A	2.5	0.26	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	0.09	<0.6
NC-A-T-I07B	1.0	0.86	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I07C	0.50	0.65	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	0.08	<0.6
NC-A-T-I07D	0.25	0.18	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I07E	filter	<0.12	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I07	total	1.95	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	0.17	<0.6
NC-A-T-I08A	2.5	0.23	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	0.12	<0.01	<0.06	<0.6
NC-A-T-I08B	1.0	<0.12	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I08C	0.50	<0.12	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I08D	0.25	0.12	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I08E	filter	<0.12	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	<0.06	<0.01	<0.06	<0.6
NC-A-T-I08	total	0.35	<0.09	<0.30	<0.006	<0.006	<0.006	<0.21	0.12	<0.01	<0.06	<0.6

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (μm)	Al (μg/m³)	Sb (μg/m³)	As (μg/m³)	Ba (μg/m³)	Be (μg/m³)	Cd (μg/m³)	Ca (μg/m³)	Cr (μg/m³)	Co (μg/m³)	Cu (μg/m³)	Fe (μg/m³)
NC-A-W-I21A	2.5	0.80	<0.08	<0.27	<0.005	0.009	<0.005	1.04	<0.05	<0.01	0.96	<0.6
NC-A-W-I21B	1.0	0.51	<0.08	<0.27	<0.005	0.029	<0.005	<0.19	<0.05	<0.01	1.60	<0.6
NC-A-W-I21C	0.50	1.55	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.05	<0.01	0.06	<0.6
NC-A-W-I21D	0.25	0.32	<0.08	<0.27	<0.005	0.018	<0.005	<0.19	<0.05	<0.01	1.12	<0.6
NC-A-W-I21E	filter	<0.11	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.05	<0.01	0.06	<0.6
NC-A-W-I21	total	3.17	<0.08	<0.27	<0.005	0.056	<0.005	1.04	<0.05	<0.01	3.80	<0.6
NC-A-W-I22A	2.5	0.18	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.06	0.02	0.47	<0.6
NC-A-W-I22B	1.0	0.89	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.06	<0.01	0.08	<0.6
NC-A-W-I22C	0.50	0.75	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.06	<0.01	0.14	<0.6
NC-A-W-I22D	0.25	0.58	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	0.27	<0.01	<0.06	0.9
NC-A-W-I22E	filter	<0.11	<0.08	<0.27	<0.005	<0.005	<0.005	0.28	<0.06	0.01	<0.06	<0.6
NC-A-W-I22	total	2.40	<0.08	<0.27	<0.005	<0.005	<0.005	0.28	0.27	0.03	0.69	0.9
NC-A-W-I23A	2.5	0.31	<0.08	<0.27	<0.005	0.012	<0.006	<0.19	<0.06	<0.01	1.47	<0.6
NC-A-W-I23B	1.0	<0.11	<0.08	<0.27	<0.005	<0.005	<0.006	<0.19	<0.06	<0.01	0.08	<0.6
NC-A-W-I23C	0.50	0.12	<0.08	<0.27	<0.005	<0.005	<0.006	<0.19	<0.06	<0.01	<0.06	<0.6
NC-A-W-I23D	0.25	0.22	<0.08	<0.27	<0.005	<0.005	<0.006	<0.19	<0.06	<0.01	<0.06	<0.6
NC-A-W-I23E	filter	0.23	<0.08	<0.27	<0.005	<0.005	<0.006	<0.19	<0.06	<0.01	<0.06	<0.6
NC-A-W-I23	total	0.89	<0.08	<0.27	<0.005	0.012	<0.006	<0.19	<0.06	<0.01	1.55	<0.6
NC-A-W-I24A	2.5	0.31	<0.08	<0.28	<0.006	<0.006	<0.006	0.23	<0.06	<0.01	0.56	<0.6
NC-A-W-I24B	1.0	0.19	<0.08	<0.28	<0.006	<0.006	<0.006	<0.20	0.08	<0.01	<0.06	<0.6
NC-A-W-I24C	0.50	<0.11	<0.08	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-W-I24D	0.25	0.85	<0.08	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-W-I24E	filter	<0.11	<0.08	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-W-I24	total	1.34	<0.08	<0.28	<0.006	<0.006	<0.006	0.23	0.08	<0.01	0.56	<0.6

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (μm)	Al (μg/m³)	Sb (μg/m³)	As (μg/m³)	Ba (μg/m³)	Be (μg/m³)	Cd (μg/m³)	Ca (μg/m³)	Cr (μg/m³)	Co (μg/m³)	Cu (μg/m³)	Fe (μg/m³)
NC-A-W-I25A	2.5	0.63	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.05	<0.01	<0.05	<0.5
NC-A-W-I25B	1.0	0.71	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.05	<0.01	0.07	<0.5
NC-A-W-I25C	0.50	0.93	<0.08	<0.27	0.170	<0.005	<0.005	<0.19	<0.05	<0.01	<0.05	<0.5
NC-A-W-I25D	0.25	1.02	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.05	<0.01	0.07	<0.5
NC-A-W-I25E	filter	<0.11	<0.08	<0.27	<0.005	<0.005	<0.005	<0.19	<0.05	<0.01	<0.05	<0.5
NC-A-W-I25	total	3.30	<0.08	<0.27	0.170	<0.005	<0.005	<0.19	<0.05	<0.01	0.14	<0.5
NC-A-W-I26A	2.5	0.80	<0.08	<0.28	<0.006	<0.006	<0.006	0.30	<0.06	<0.01	<0.06	<0.6
NC-A-W-I26B	1.0	1.02	<0.08	<0.28	<0.006	<0.006	<0.006	0.21	<0.06	<0.01	<0.06	<0.6
NC-A-W-I26C	0.50	1.27	<0.08	<0.28	<0.006	<0.006	<0.006	<0.19	<0.06	<0.01	<0.06	<0.6
NC-A-W-I26D	0.25	1.02	<0.08	<0.28	<0.006	<0.006	<0.006	<0.19	<0.06	<0.01	<0.06	<0.6
NC-A-W-I26E	filter	<0.11	<0.08	<0.28	<0.006	<0.006	<0.006	<0.19	<0.06	<0.01	<0.06	<0.6
NC-A-W-I26	total	4.11	<0.08	<0.28	<0.006	<0.006	<0.006	0.51	<0.06	<0.01	<0.06	<0.6
NC-A-W-I27A	2.5	2.39	<0.08	<0.28	<0.006	<0.006	<0.006	0.20	<0.06	<0.01	0.14	<0.6
NC-A-W-I27B	1.0	1.15	<0.08	<0.28	<0.006	<0.006	<0.006	0.45	<0.06	<0.01	<0.06	<0.6
NC-A-W-I27C	0.50	0.48	<0.08	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-W-I27D	0.25	1.38	<0.08	<0.28	<0.006	<0.006	<0.006	0.23	<0.06	<0.01	<0.06	<0.6
NC-A-W-I27E	filter	<0.11	<0.08	<0.28	<0.006	<0.006	<0.006	<0.20	<0.06	<0.01	<0.06	<0.6
NC-A-W-I27	total	5.39	<0.08	<0.28	<0.006	<0.006	<0.006	0.88	<0.06	<0.01	0.14	<0.6

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (µm)	La (µg/m³)	Pb (µg/m³)	Li (µg/m³)	Mg (µg/m³)	Mn (µg/m³)	Mo (µg/m³)	Ni (µg/m³)	P (µg/m³)	K (µg/m³)	Se (µg/m³)
NC-A-T-I01A	2.5	<0.003	3.5	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-T-I01B	1.0	<0.003	1.8	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-T-I01C	0.50	<0.003	1.7	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-T-I01D	0.25	<0.003	1.5	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-T-I01E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	0.28
NC-A-T-I01	total	<0.003	8.5	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	0.28
NC-A-T-I02A	2.5	<0.003	1.7	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.13	0.26
NC-A-T-I02B	1.0	<0.003	0.6	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.13	0.29
NC-A-T-I02C	0.50	<0.003	1.9	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.13	<0.19
NC-A-T-I02D	0.25	<0.003	2.0	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.13	<0.19
NC-A-T-I02E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.13	<0.19
NC-A-T-I02	total	<0.003	6.2	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.13	0.56
NC-A-T-I03A	2.5	<0.003	5.4	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-T-I03B	1.0	<0.003	4.3	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	0.26
NC-A-T-I03C	0.50	<0.003	3.4	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	0.28
NC-A-T-I03D	0.25	<0.003	2.7	<0.3	<0.3	<0.02	<0.06	0.07	<0.6	<0.14	<0.20
NC-A-T-I03E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-T-I03	total	<0.003	15.8	<0.3	<0.3	<0.02	<0.06	0.07	<0.6	<0.14	0.53
NC-A-T-I04A	2.5	<0.003	5.0	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	0.17	<0.20
NC-A-T-I04B	1.0	<0.003	1.3	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-T-I04C	0.50	<0.003	4.5	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-T-I04D	0.25	<0.003	2.8	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-T-I04E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	0.22
NC-A-T-I04	total	<0.003	13.7	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	0.17	0.22

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (μm)	La (μg/m^3)	Pb (μg/m^3)	Li (μg/m^3)	Mg (μg/m^3)	Mn (μg/m^3)	Mo (μg/m^3)	Ni (μg/m^3)	P (μg/m^3)	K (μg/m^3)	Se (μg/m^3)
NC-A-T-I05A	2.5	<0.003	0.2	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I05B	1.0	<0.003	2.9	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I05C	0.50	<0.003	1.3	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	0.44
NC-A-T-I05D	0.25	<0.003	0.5	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I05E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I05	total	<0.003	4.9	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	0.44
NC-A-T-I06A	2.5	<0.003	1.9	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I06B	1.0	<0.003	1.5	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I06C	0.50	<0.003	2.0	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I06D	0.25	<0.003	1.7	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I06E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I06	total	<0.003	7.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I07A	2.5	<0.003	3.3	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I07B	1.0	<0.003	0.3	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	0.21
NC-A-T-I07C	0.50	<0.003	2.5	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I07D	0.25	<0.003	2.7	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I07E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I07	total	<0.003	8.6	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	0.21
NC-A-T-I08A	2.5	<0.003	2.0	<0.3	<0.3	<0.02	<0.06	0.04	<0.6	<0.15	<0.21
NC-A-T-I08B	1.0	<0.003	2.7	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I08C	0.50	<0.003	1.2	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I08D	0.25	<0.003	2.2	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I08E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-T-I08	total	<0.003	8.1	<0.3	<0.3	<0.02	<0.06	0.04	<0.6	<0.15	<0.21

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (µm)	La (µg/m³)	Pb (µg/m³)	Li (µg/m³)	Mg (µg/m³)	Mn (µg/m³)	Mo (µg/m³)	Ni (µg/m³)	P (µg/m³)	K (µg/m³)	Se (µg/m³)
NC-A-W-I21A	2.5	<0.003	0.5	<0.3	0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-W-I21B	1.0	<0.003	2.9	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-W-I21C	0.50	<0.003	0.9	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-W-I21D	0.25	<0.003	4.5	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-W-I21E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-W-I21	total	<0.003	8.8	<0.3	0.3	<0.02	<0.06	<0.01	<0.6	<0.15	<0.21
NC-A-W-I22A	2.5	<0.003	0.6	<0.3	0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I22B	1.0	<0.003	0.7	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I22C	0.50	<0.003	5.6	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I22D	0.25	<0.003	4.5	<0.3	<0.3	<0.02	<0.06	0.12	<0.6	<0.14	<0.20
NC-A-W-I22E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	0.47	<0.20
NC-A-W-I22	total	<0.003	11.3	<0.3	0.3	<0.02	<0.06	0.12	<0.6	0.47	<0.20
NC-A-W-I23A	2.5	<0.003	1.3	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.19
NC-A-W-I23B	1.0	<0.003	1.6	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.19
NC-A-W-I23C	0.50	<0.003	1.9	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.19
NC-A-W-I23D	0.25	<0.003	1.4	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.19
NC-A-W-I23E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.19
NC-A-W-I23	total	<0.003	6.2	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.19
NC-A-W-I24A	2.5	<0.003	1.8	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I24B	1.0	<0.003	1.8	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I24C	0.50	<0.003	0.9	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I24D	0.25	<0.003	1.4	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I24E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I24	total	<0.003	5.9	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (µm)	La (µg/m³)	Pb (µg/m³)	Li (µg/m³)	Mg (µg/m³)	Mn (µg/m³)	Mo (µg/m³)	Ni (µg/m³)	P (µg/m³)	K (µg/m³)	Se (µg/m³)
NC-A-W-I25A	2.5	<0.003	4.4	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.14	0.19
NC-A-W-I25B	1.0	<0.003	4.1	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.14	<0.19
NC-A-W-I25C	0.50	<0.003	4.4	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.14	<0.19
NC-A-W-I25D	0.25	<0.003	4.4	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.14	<0.19
NC-A-W-I25E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.14	<0.19
NC-A-W-I25	total	<0.003	17.3	<0.3	<0.3	<0.02	<0.05	<0.01	<0.5	<0.14	0.19
NC-A-W-I26A	2.5	<0.003	0.7	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.19
NC-A-W-I26B	1.0	<0.003	4.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.19
NC-A-W-I26C	0.50	<0.003	7.5	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.19
NC-A-W-I26D	0.25	<0.003	2.3	<0.3	<0.3	<0.02	<0.06	0.03	<0.6	<0.14	<0.19
NC-A-W-I26E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.19
NC-A-W-I26	total	<0.003	14.6	<0.3	<0.3	<0.02	<0.06	0.03	<0.6	<0.14	<0.19
NC-A-W-I27A	2.5	<0.003	2.4	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I27B	1.0	<0.003	1.0	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I27C	0.50	<0.003	0.5	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I27D	0.25	<0.003	0.9	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I27E	filter	<0.003	<0.1	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20
NC-A-W-I27	total	<0.003	4.9	<0.3	<0.3	<0.02	<0.06	<0.01	<0.6	<0.14	<0.20

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (µm)	Ag (µg/m³)	Sr (µg/m³)	Te (µg/m³)	Tl (µg/m³)	Sn (µg/m³)	Ti (µg/m³)	V (µg/m³)	Y (µg/m³)	Zn (µg/m³)	Zr (µg/m³)
NC-A-T-I01A	2.5	<0.006	<0.003	<0.14	<0.20	<0.29	0.004	<0.009	<0.002	<0.06	<0.12
NC-A-T-I01B	1.0	<0.006	<0.003	<0.14	<0.20	<0.29	0.003	<0.009	<0.002	<0.06	<0.12
NC-A-T-I01C	0.50	<0.006	<0.003	<0.14	<0.20	<0.29	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I01D	0.25	<0.006	<0.003	<0.14	<0.20	<0.29	0.007	<0.009	<0.002	<0.06	<0.12
NC-A-T-I01E	filter	<0.006	<0.003	<0.14	<0.20	<0.29	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I01	total	<0.006	<0.003	<0.14	<0.20	<0.29	0.014	<0.009	<0.002	<0.06	<0.12
NC-A-T-I02A	2.5	<0.005	0.003	<0.13	<0.19	<0.27	0.002	<0.008	<0.002	<0.05	<0.11
NC-A-T-I02B	1.0	<0.005	<0.003	<0.13	<0.19	<0.27	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-T-I02C	0.50	<0.005	<0.003	<0.13	<0.19	<0.27	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-T-I02D	0.25	<0.005	<0.003	<0.13	<0.19	<0.27	0.002	<0.008	<0.002	<0.05	<0.11
NC-A-T-I02E	filter	<0.005	<0.003	<0.13	<0.19	<0.27	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-T-I02	total	<0.005	0.003	<0.13	<0.19	<0.27	0.003	<0.008	<0.002	<0.05	<0.11
NC-A-T-I03A	2.5	<0.006	<0.003	<0.14	<0.20	<0.28	0.003	<0.008	<0.002	<0.05	<0.11
NC-A-T-I03B	1.0	<0.006	<0.003	<0.14	<0.20	<0.28	0.006	<0.008	<0.002	<0.05	<0.11
NC-A-T-I03C	0.50	<0.006	0.006	<0.14	<0.20	<0.28	0.002	<0.008	<0.002	<0.05	<0.11
NC-A-T-I03D	0.25	<0.006	<0.003	<0.14	<0.20	<0.28	0.001	<0.008	<0.002	<0.05	<0.11
NC-A-T-I03E	filter	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-T-I03	total	<0.006	0.006	<0.14	<0.20	<0.28	0.012	<0.008	<0.002	<0.05	<0.11
NC-A-T-I04A	2.5	<0.006	<0.003	<0.14	<0.20	<0.28	0.003	<0.008	<0.002	<0.05	<0.11
NC-A-T-I04B	1.0	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-T-I04C	0.50	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-T-I04D	0.25	<0.006	<0.003	<0.14	<0.20	<0.28	0.002	<0.008	<0.002	<0.05	<0.11
NC-A-T-I04E	filter	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-T-I04	total	<0.006	<0.003	<0.14	<0.20	<0.28	0.005	<0.008	<0.002	<0.05	<0.11

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (µm)	Ag (µg/m^3)	Sr (µg/m^3)	Te (µg/m^3)	Tl (µg/m^3)	Sn (µg/m^3)	Ti (µg/m^3)	V (µg/m^3)	Y (µg/m^3)	Zn (µg/m^3)	Zr (µg/m^3)
NC-A-T-I05A	2.5	<0.006	<0.003	<0.15	<0.21	<0.29	0.004	<0.008	<0.002	<0.06	<0.12
NC-A-T-I05B	1.0	<0.006	<0.003	<0.15	<0.21	<0.29	0.005	<0.008	<0.002	<0.06	<0.12
NC-A-T-I05C	0.50	<0.006	<0.003	<0.15	<0.21	<0.29	0.002	<0.008	<0.002	<0.06	<0.12
NC-A-T-I05D	0.25	<0.006	<0.003	<0.15	<0.21	<0.29	0.003	<0.008	<0.002	<0.06	<0.12
NC-A-T-I05E	filter	<0.006	<0.003	<0.15	<0.21	<0.29	<0.001	<0.008	<0.002	<0.06	<0.12
NC-A-T-I05	total	<0.006	<0.003	<0.15	<0.21	<0.29	0.013	<0.008	<0.002	<0.06	<0.12
NC-A-T-I06A	2.5	<0.006	<0.003	<0.15	<0.21	<0.30	0.002	<0.009	<0.002	<0.06	<0.12
NC-A-T-I06B	1.0	<0.006	0.005	<0.15	<0.21	<0.30	0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I06C	0.50	<0.006	0.003	<0.15	<0.21	<0.30	0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I06D	0.25	<0.006	0.004	<0.15	<0.21	<0.30	0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I06E	filter	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I06	total	<0.006	0.012	<0.15	<0.21	<0.30	0.006	<0.009	<0.002	<0.06	<0.12
NC-A-T-I07A	2.5	<0.006	<0.003	<0.15	<0.21	<0.30	0.002	<0.009	<0.002	<0.06	<0.12
NC-A-T-I07B	1.0	<0.006	0.009	<0.15	<0.21	<0.30	0.003	<0.009	<0.002	<0.06	<0.12
NC-A-T-I07C	0.50	<0.006	<0.003	<0.15	<0.21	<0.30	0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I07D	0.25	<0.006	<0.003	<0.15	<0.21	<0.30	0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I07E	filter	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I07	total	<0.006	0.009	<0.15	<0.21	<0.30	0.007	<0.009	<0.002	<0.06	<0.12
NC-A-T-I08A	2.5	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I08B	1.0	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I08C	0.50	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I08D	0.25	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I08E	filter	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-T-I08	total	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (µm)	Ag (µg/m³)	Sr (µg/m³)	Te (µg/m³)	Tl (µg/m³)	Sn (µg/m³)	Ti (µg/m³)	V (µg/m³)	Y (µg/m³)	Zn (µg/m³)	Zr (µg/m³)
NC-A-W-I21A	2.5	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I21B	1.0	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I21C	0.50	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I21D	0.25	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I21E	filter	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I21	total	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I22A	2.5	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I22B	1.0	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I22C	0.50	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I22D	0.25	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I22E	filter	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I22	total	<0.006	<0.003	<0.15	<0.21	<0.30	<0.001	<0.009	<0.002	<0.06	<0.12
NC-A-W-I23A	2.5	<0.006	<0.003	<0.14	<0.19	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I23B	1.0	<0.006	<0.003	<0.14	<0.19	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I23C	0.50	<0.006	<0.003	<0.14	<0.19	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I23D	0.25	<0.006	<0.003	<0.14	<0.19	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I23E	filter	<0.006	<0.003	<0.14	<0.19	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I23	total	<0.006	<0.003	<0.14	<0.19	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I24A	2.5	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	0.011	<0.06	<0.11
NC-A-W-I24B	1.0	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	0.011	<0.06	<0.11
NC-A-W-I24C	0.50	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	0.002	<0.06	<0.11
NC-A-W-I24D	0.25	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	0.002	<0.06	<0.11
NC-A-W-I24E	filter	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	0.004	<0.06	<0.11
NC-A-W-I24	total	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	0.030	<0.06	<0.11

Appendix C - *Continued*
Facility #2 – Copper/Beryllium Machine Shop
Personal Breathing Zone and Area Sioutas Size-Selective Impactor Air Sample Results for Thirty-one Elements

Sample Number	Particle Size (µm)	Ag (µg/m³)	Sr (µg/m³)	Te (µg/m³)	Tl (µg/m³)	Sn (µg/m³)	Ti (µg/m³)	V (µg/m³)	Y (µg/m³)	Zn (µg/m³)	Zr (µg/m³)
NC-A-W-I25A	2.5	<0.006	<0.003	<0.14	<0.19	<0.27	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-W-I25B	1.0	<0.006	<0.003	<0.14	<0.19	<0.27	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-W-I25C	0.50	<0.006	<0.003	<0.14	<0.19	<0.27	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-W-I25D	0.25	<0.006	<0.003	<0.14	<0.19	<0.27	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-W-I25E	filter	<0.006	<0.003	<0.14	<0.19	<0.27	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-W-I25	total	<0.006	<0.003	<0.14	<0.19	<0.27	<0.001	<0.008	<0.002	<0.05	<0.11
NC-A-W-I26A	2.5	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I26B	1.0	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I26C	0.50	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I26D	0.25	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I26E	filter	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I26	total	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I27A	2.5	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I27B	1.0	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I27C	0.50	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I27D	0.25	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I27E	filter	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11
NC-A-W-I27	total	<0.006	<0.003	<0.14	<0.20	<0.28	<0.001	<0.008	<0.002	<0.06	<0.11