CONTROL TECHNOLOGY AND EXPOSURE ASSESSMENT FOR ELECTRONIC RECYCLING OPERATIONS UNITED STATES PENITENTIARY, LEWISBURG, PA

REPORT DATE:
January 2009

FILE NO.:
EPHB 326-17a

PRINCIPAL AUTHORS:
Dan Almaguer, MS
G. Edward Burroughs, PhD, CIH, CSP
Alan Echt, MPH, CIH
David Marlow

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Division of Applied Research and Technology
4676 Columbia Parkway, R5
Cincinnati, Ohio 45226

SITES SURVEYED:	UNICOR Recycling Operations Federal Correctional Institution Lewisburg, PA
NAICS:	562920
SURVEY DATE:	January 28 – 31, 2008
SURVEY CONDUCTED BY:	Dan Almaguer, MS Ed Burroughs, Ph.D., CIH, CSP Dave Marlow

DISCLAIMER

Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention.

The findings and conclusions in this report do not necessarily reflect the views of the National Institute for Occupational Safety and Health.

"The findings and conclusions in this report have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy."

CONTENTS

Tables, Appendices and Figures

EXECUTIVE SUMMARY

Researchers from the National Institute for Occupational Safety and Health (NIOSH) conducted a study of the recycling of electronic components at the Federal Prison Industries facilities (aka, UNICOR) in Lewisburg, PA in January 2008 to assess workers' exposures to metals and other occupational hazards, including noise, associated with these operations.

The electronics recycling operations at Lewisburg can be organized into four production processes: a) receiving and sorting, b) disassembly, c) glass breaking operations, and d) packaging and shipping. A fifth operation, cleaning and maintenance, was also addressed but is not considered a production process per se. It is known that lead (Pb), cadmium (Cd), and other metals are used in the manufacturing of electronic components and pose a risk to workers involved in recycling of electronic components if the processes are not adequately controlled or the workers are not properly trained and provided appropriate personal protective clothing and equipment.

Methods used to assess worker exposures to metals during this evaluation included: personal breathing zone sampling for airborne metals and particulate, and surface wipe sampling to assess surface contamination. Samples were analyzed for 31 metals with five selected elements (barium, beryllium, cadmium, lead and nickel) given emphasis. Noise exposures were determined using sound pressure level monitors.

The results of air sampling conducted during this visit indicated no overexposures of workers to metals above the most stringent occupational exposure limits. Exposures to airborne metals during the filter change-out maintenance operation (the task of primary concern in this evaluation) were also well below the most stringent occupational exposure limits.

Although beryllium is used in consumer electronics and computer components, such as disk drive arms (beryllium-aluminum), electrical contacts, switches, and connector plugs (copper-beryllium) and printed wiring boards [Willis and Florig 2002, Schmidt 2002], most beryllium "in consumer products is used in ways that are not likely to create beryllium exposures during use and maintenance" [Willis and Florig 2002]. This may account for the fact that beryllium in this study was not detected at levels above the detection limit of the analytical method. The removal and sorting of components seen here is typical of a maintenance activity (components are removed from the cases and sorted, rather than removed and replaced). Other e-recycling activities that include further processing, such as shredding of the components, may produce higher exposures to beryllium but shredding (except as a means to destroy memory devices) does not occur at this facility.

Samples collected during routine daily disassembly operations and glass breaking operations were less than 10% of the OSHA PELs for both Cd and Pb. Unless specified, results of samples presented are for the duration of the sample and not calculated on an 8 hour time weighted average basis.

Lead was detected on surface wipe samples in excess of recommended levels, although in 2 of 3 instances it was concluded that this was existing contamination on materials coming into the workplace. Cadmium and other heavy metals were detected in the surface wipe and bulk dust samples. There are few established standards available for wipe samples with which to compare these data although the samples collected were below recommended maximum levels which do exist. The wipe sample results generally cannot be used to determine the source of the contamination. They only estimate the surface contamination present at the time the sample was collected.

Eight-hour time weighted average measurements of noise in this workplace identified several instances where exposure was greater than the REL and TLV of 85 dBA, although none which exceeded the PEL of 90 dBA.

Recommendations resulting from this study include:

- The implementation of a site-specific health and safety program at Lewisburg that includes a noise reduction program.
- The respiratory protection program for this facility should be evaluated to ensure that it complies with OSHA regulations.
- Attention should be focused on practices to prevent accidental ingestion of lead and other metals.
- Management should evaluate the feasibility of providing and laundering work clothing for all workers in the recycling facility.
- Change rooms should be equipped with separate storage facilities for work clothing and for street clothes to prevent cross-contamination.
- All UNICOR operations should be evaluated from the perspective of health, safety and the environment in the near future.

A comprehensive program is needed within the Bureau of Prisons to assure both staff and inmates a safe and healthy workplace.

I. INTRODUCTION

Researchers from the National Institute for Occupational Safety and Health (NIOSH) conducted a study of exposures to metals and other occupational hazards associated with the recycling of electronic components at the Federal Prison Industries (aka, UNICOR) in Lewisburg, PA.* The principal objectives of this study were:

1. To measure full-shift, personal breathing zone exposures to metals including barium (Ba), beryllium (Be), cadmium (Cd), lead (Pb) and nickel (Ni);
2. To evaluate contamination of surfaces in the work areas that could permit skin contact 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 metals, as well as to determine additional controls, work practices, substitute materials, or technology that can further reduce occupational exposures;
4. To evaluate the use of personal protective equipment (PPE) in operations involved in the recycling of electronic components; and,
5. To determine the size distribution of airborne particles for purposes of toxicity and control.

Other objectives such as a preliminary evaluation of noise exposures and visual observations of undocumented hazards, were secondary to those listed above but are discussed as appropriate in this document.

An initial walk-through evaluation was conducted in May 2007 to observe operations at Lewisburg in order to facilitate subsequent testing. In January 2008 an in-depth evaluation was conducted during which two full shifts of environmental monitoring were conducted for the duration of normal plant operations, and monitoring also was conducted during cleaning and maintenance as described in Section II (Process Description) and Section III (Sampling and Analytical Methods).

Computers and their components contain a number of hazardous substances. Among these are "platinum in circuit boards, copper in transformers, Ni and cobalt in disk drives, barium and cadmium coatings on computer glass, and lead solder on circuit boards and video screens" [Chepesiuk 1999]. The Environmental Protection Agency (EPA) notes that "In addition to lead, electronics can contain chromium, cadmium, mercury, beryllium, nickel, zinc, and brominated flame retardants" [EPA 2008]. Schmidt [2002] linked these and other substances to their use and location in the "typical" computer: lead used to join metals (solder) and for radiation protection, is present in the cathode ray tube (CRT) and printed wiring board (PWB). Aluminum, used in structural components and for its conductivity, is present in the housing, CRT, PWB, and connectors. Gallium is used in semiconductors; it is present in the PWB. Ni is used in structural

---

* This report documents the study conducted at Lewisburg, Pennsylvania. Other NIOSH field studies were conducted at Federal correctional facilities in Elkton, Ohio and Marianna, Florida

components and for its magneticity; it is found in steel housing, CRT and PWB. Vanadium functions as a red-phosphor emitter; it is used in the CRT. Be, used for its thermal conductivity, is found in the PWB and in connectors. Chromium, which has decorative and hardening properties, may be a component of steel used in the housing. Cd, used in Ni-Cad batteries and as a blue-green phosphor emitter, may be found in the housing, PWB and CRT. Cui and Forssberg [2003] note that Cd is present in components like SMD chip resistors, semiconductors, and infrared detectors. Mercury may be present in batteries and switches, thermostats, sensors and relays [Schmidt 2002, Cui and Forssberg 2003], found in the housing and PWB. Arsenic, which is used in doping agents in transistors, may be found in the PWB [Schmidt 2002].

Lee et al. [2004] divided the personal computer into three components, the main machine, monitor, and keyboard. They further divided the CRT of a color monitor into the "(1) panel glass (faceplate), (2) shadow mask (aperture), (3) electronic gun (mount), (4) funnel glass and (5) deflection yoke. Lee et al. [2004] note that panel glass has a high Ba concentration (up to 13%) for radiation protection and a low concentration of Pb oxide. The funnel glass has a higher amount of Pb oxide (up to 20%) and a lower Ba concentration. They analyzed a 14-in Philips color monitor by electron dispersive spectroscopy and reported that the panel contained silicon, oxygen, potassium, Ba and aluminum in concentrations greater than 5% by weight, and titanium, sodium, cerium, Pb, zinc, yttrium, and sulfur in amounts less than 5% by weight. Analysis of the funnel glass revealed greater than 5% silicon, oxygen, iron and Pb by weight, and less than 5% by weight potassium, sodium, Ba, cerium, and carbon. Finally, Lee et al. [2004] noted that the four coating layers are applied to the inside of the panel glass, including a layer of three fluorescent colors (red, blue and green phosphors) that contain various metals, and a layer of aluminum film to enhance brightness.

German investigators [BIA 2001, Berges 2008a] broke 72 cathode-ray tubes using three techniques (pinching off the pump port, pitching the anode with a sharp item, and knocking off the cathode) in three experiments performed on a test bench designed to measure emissions from the process. Neither Pb nor Cd was detected in the total dust, with one exception, where Pb was detected at a concentration of 0.05 mg/cathode ray tube during one experiment wherein the researchers released the vacuum out c. TVs by pinching off the pump port [BIA 2001, Berges 2008b]. They described this result as "sufficiently low that a violation of the German atmospheric limit value of 0.1 mg/m^3 need not generally be anticipated" [BIA 2001]. The researchers noted that "the working conditions must be organized such that skin contact with and oral intake of the dust are excluded" [BIA 2001].

However, there are few articles documenting occupational exposures among electronics recycling workers. Sjödin et al. [2001] and Pettersson-Julander et al. [2004] have reported potential exposures of electronics recycling workers to flame retardants while they dismantled electronic products, although no retardants were used in this facility. Recycling operations in the Lewisburg facility are limited to disassembly and sorting tasks, with the exception of breaking CRTs and stripping insulation from copper wiring. Disassembly and sorting probably pose less of a potential hazard from retardants as well as metals for workers than tasks that disrupt the integrity of the components, such as shredding or de-soldering PWBs.

The process of greatest concern was the glass breaking operation (described below) that releases visible emissions into the workroom atmosphere. Material safety data sheets and other information on components of CRTs broken in this operation listed several metals, including Pb, Cd, Be and Ni. In addition, FOH investigators expressed a particular interest in Ba.

II. PROCESS DESCRIPTION

The recycling of electronic components at the United States Penitentiary (USP) Lewisburg is done in one extended building that is part of the prison camp outside of the main prison. That building is composed of three sections: 1) a receiving and warehousing area which also contains offices and areas where laptop refurbishing is done; 2) a middle or center section where most of the disassembly is performed; and 3) a third area where some disassembly is done which also houses the glass breaking operation. Diagrams of these work areas are shown in Figures I and II with an enlargement of the glass breaking operation in Figure III. These figures provide a general visual description of the layout of the work process, although workers often moved throughout the various areas in the performance of their tasks.

The electronics recycling operations can be organized into four production processes: a) receiving and sorting, b) disassembly, c) (glass breaking operation), and d) packaging and shipping. A fifth operation, cleaning and maintenance will also be addressed but is not considered a production process per se.

Incoming materials to be recycled are received at the warehouse (Figure I) where they are examined and sorted. During this evaluation it appeared that the bulk of the materials received were computers, either desktop or notebooks, or related devices such as printers. Some items, notably notebook computers, could be upgraded and resold, and these items were sorted out for that task.

After electronic memory devices (e.g., hard drives, discs, etc.) were removed and degaussed or destroyed, computer central processing units (CPUs), servers and similar devices were sent for disassembly; monitors and other devices (e.g., televisions) that contain CRTs were separated and sent for disassembly and removal of the CRT. Printers, copy machines and any device that could potentially contain toner, ink, or other expendables were segregated and inks and toners were removed in the warehouse prior to being sent to the disassembly area.

In the disassembly process (see Figures II and III), external cabinets, usually plastic, were removed from all devices and segregated. Valuable materials such as copper wiring and aluminum framing were removed and sorted by grade for further treatment if necessary. Components such as circuit boards or chips that may have value or may contain precious metals such as gold or silver were removed and sorted. With few exceptions each of the approximately 85 workers in the main factory will perform all tasks associated with the disassembly of a piece of equipment into the mentioned components with the use of powered and non-powered hand tools (primarily screwdrivers and wrenches), with a few workers collecting the various parts and placing them into the proper collection bin. Work tasks included removing screws and other fasteners from cabinets, unplugging or clipping electrical cables, removing circuit boards, and using whatever other methods necessary to break these devices into their component parts.

Essentially all of these component parts are sorted and separated, then repackaged and sold for some type of recycling.

Personal protective equipment in these first two operations consisted of safety glasses and gloves where needed. Control of dust and surface contamination was accomplished primarily by good housekeeping procedures which included brushing dust from work tables and sweeping floors up to twice a day. Protective clothing and housekeeping were more stringent in the third operation and are described below.

The third production process to be evaluated was the glass breaking operation where CRTs from computer monitors and TVs were sent for processing. This was an area of primary interest in this evaluation due to concern from staff, review of process operations and materials involved, and observations during an initial walk-through. This was the only process where local exhaust ventilation was utilized or where respiratory protection was in universal use. Workers in other locations would wear eye protection and occasionally would voluntarily wear a disposable respirator. Additional PPE in the glass breaking operation included Tyvek™ coveralls, hand and arm protection for broken glass, and powered air-purifying respirators (PAPRs). Glass breaking was done in an enclosed booth (see Figure III), approximately 25 ft by 14 feet, located as shown in Figure II. The local exhaust ventilation system, contained in that booth, consisted of 2 reverse flow horizontal filter modules (model HFM24-ST/RD/SP, Atmos-Tech Industries, Ocean, NJ), for funnel glass and for panel glass. These units were 16 ga. galvanized steel with filter faces approximately 26 inches high and 51 inches wide. The units were 36 inches deep. Filtration was achieved with three 16 inch x 24 inch x 1 inch pleated pre-filters preceding a single 24" x 48" x 6" high efficiency particulate air (HEPA) filter. Air was exhausted through the HEPA filter back into the glass breaking booth. Exhaust fans and air filters were placed on top of the glass breaking booth to produce air movement between the booth and the general work area.

Workers in the glass breaking operation wore PAPRs, (MB14-72 PAPR w/ Super Top Hood, Woodsboro, MD, Global Secure Safety), work boots, gloves and coveralls. Of the UNICOR recycling facilities evaluated to date, Lewisburg has the most adequate arrangement for donning and doffing personal protective clothing and equipment. A typical work area that requires the use of protective clothing includes: a) an outer change area where workers can remove and store their street clothing and don their work clothing and personal protective equipment before entering the work area; b) upon completion of their work, workers exit the work area through a "decon" area (e.g., where they vacuum the outer surface of their clothes); c) they then enter a separate, "dirty" locker area, where their soiled work clothes are removed and placed in receptacles for cleaning or disposal. The workers then pass through a shower area, and then enter the outer change area, where they change into their street clothes again. In some cases (e.g., asbestos removal), respirators are worn into the shower and not removed until the exterior surfaces are rinsed.

CRTs that had been removed from their cases were trucked to this process area in large boxes and were fed into the glass-breaking booth through an opening on the side and placed on a metal grid for breaking (see Figure IV). As the CRT moved from right to left in the booth the electron gun was removed by tapping with a hammer to break it free from the tube, then a series of hammer blows was used to break the funnel glass and allow it to fall through the metal grid into large Gaylord boxes (cardboard boxes approximately 3 feet tall designed to fit on a standard pallet) positioned below the grid. This was done at the first (right) station in Figure IV. The CRT was moved to the second (left) station where any internal metal framing or lattice was removed before the panel glass was broken with a hammer and also allowed to fall into a Gaylord box. During the two days of sampling 551 CRTs were broken (293 on day 1 and 258 on day 2). No count was made by the survey team regarding the number of color vs monochrome monitors broken.

The final production process, packing and shipping, moved the various materials segregated during the disassembly and glass breaking processes to the loading dock to be sent to contracted purchasers of those individual materials. To facilitate shipment some bulky components such as plastic cabinets or metal frames were placed in a hydraulic bailer to be compacted for easier shipping. Other materials were boxed and removed for subsequent sale to a recycling operation.

In addition to monitoring routine daily activities in the four production processes described above, environmental monitoring was conducted to evaluate exposures during the replacement of filters in the local exhaust ventilation system used for the glass breaking operation. This is a maintenance operation that occurs at approximately monthly intervals during which the two sets of filters in this ventilation system are removed and replaced. This operation was of particular interest because of concern expressed by management and workers, and also because of elevated exposures documented in similar operations. Two workers in Tyvek™ coveralls, gloves and PAPRs remove both sets of filters, clean the system, and replace the filters. They are assisted by two additional workers who wear Tyvek™ coveralls and gloves while working outside the glass breaking enclosure. The filter change is a maintenance operation that occurs at approximately monthly intervals during which the ventilation system is shut down and all filters are removed and replaced. Initially the exhaust system components, including the accessible surfaces of the filters, are vacuumed with a HEPA vacuum. Then the filters are removed and bagged for disposal, and the area inside the filter housing is vacuumed. New filters are inserted to replace the old ones, the LEV system is reassembled, and any residual dust is removed with a HEPA vacuum.

III. SAMPLING AND ANALYTICAL METHODS

Air sampling techniques

Methods used to assess worker exposures in this workplace evaluation included: personal breathing zone and area sampling for airborne metals and particulate (total and respirable fractions); and surface wipe sampling to assess surface contamination. Material safety data sheets and background information on CRTs and other processes in this operation listed several metals, including Pb, Cd, Be and Ni. Additionally, FOH personnel expressed specific interest in Ba. Therefore emphasis is placed on those five analytes in this report.

Personal breathing zone and general area samples were collected and analyzed for total airborne particulate and metals. Samples were collected for as much of the work shift as possible with durations (ranging from 20% to 90% of an 8-hour work shift) indicated below in respective tables of results. Samples were collected at a flow rate of 3 liters/minute (L/min) 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) in a 3-piece, clear plastic cassette sealed with a cellulose shrink band. It is possible to determine both airborne particulate as well as metals on the same sample by using a pre-weighed filter and then post-weighing that filter to determine weight gain according to NIOSH Method 0500 [NIOSH 1994] before subsequent analysis for metals using inductively coupled plasma spectroscopy (ICP) according to NIOSH Method 7303 [NIOSH 1994] with modifications. This combination of analytical techniques produces a measure for dust and a measure of 31 elements, including the five of particular interest mentioned above. Because Method 7303 is an elemental analysis, the laboratory report describes the amount of the element present in each sample (µg/sample) as the element, regardless of the compound in which the element was present in the sample.

Because there is evidence that the presence of an ultrafine component increases the toxicity for chronic beryllium disease and possibly other toxic effects, information on the aerosol size distribution was collected to assist in evaluation of the potential exposure [McCawley et al. 2001]. A subset of samples was collected using BGI cyclones (BGI Incorporated, Waltham, MA) at a flow rate of 4.2 lpm and analysis according to NIOSH Methods 0600 and 7303 [NIOSH 1994] to determine the particulate and metal concentrations, respectively, in the respirable size range.

Bulk sampling and analysis
Unlike the other evaluations conducted in UNICOR facilities, no bulk samples were collected by NIOSH researchers at Lewisburg, but rather wipe samples were used to determine metallic composition of settled dust.

Surface contamination technique
Surface wipe samples were collected using Ghost™ Wipes for metals (Environmental Express, Mt. Pleasant, SC) and Palintest® Dust Wipes for Be (Gateshead, United Kingdom) to evaluate surface contamination. These wipe samples were collected in accordance with ASTM Method D 6966-03 [ASTM 2002], with a disposable paper template with a10-cm by 10-cm square opening. The templates were held in place by hand or taped in place, 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 9102 [NIOSH 1994]. Palintest wipes were analyzed for Be using the Quantech Fluorometer (Model FM109515, Barnstead International, Dubuque, Iowa) for spectrofluorometric analysis by NIOSH Method 9110 [NIOSH 1994].

<u>*Local Exhaust Ventilation Characterization Methods*</u>
Methods used to evaluate the local exhaust ventilation system included measuring air velocity at the face of each of the reverse flow horizontal filter modules (HFMs) inside the glass-breaking area, and observing air flows at the plastic curtains enclosing the glass-breaking operation. A Velocicalc Plus Model 8388 thermal anemometer (TSI Incorporated, St. Paul, MN) was used to measure air speeds at the face of each HFM. A Wizard Stick smoke device (Zero Toys, Inc., Concord, MA) was used to visualize air flow.

The face velocity tests were performed by dividing the face of the HFM into 12 rectangles of equal area and measuring the velocity at the center of each square. Face velocities were taken at each center point averaged over a period of 30 seconds, using a 5-second time averaging setting on the instrument. The metal grid in front of the pre-filters was used to support the edge of the probe, and the researcher stood to one side to avoid obstructing air flow. To measure the velocities achieved by the control at each center point, the anemometer probe was held perpendicular to the air flow direction at those points. The same measurements were repeated at the front edge of the plastic strip curtains enclosing the area immediately in front of each HFM to determine the capture velocity at that point.

Smoke was released as the strips of plastic curtain enclosing the glass breaking booth were parted to qualitatively evaluate the air flow patterns and determine areas of concern. By releasing smoke at these points the path of the smoke, and thus any airborne material potentially released at that point, could be qualitatively determined.

Sound pressure measurements
An initial assessment of noise levels during various tasks in all operations was made during the initial walk-through study using a hand held sound level meter. This brief sound-level survey was used to determine where to target noise dosimetry during the follow-up study. During the follow-up study time weighted average noise exposures were determined using personal dosimeters (Quest Technologies model Q300, Oconomowoc, WI) capable of simultaneously logging sound pressure levels under three sets of parameters. For this evaluation data are reported using both the Occupational Safety and Health Administration (OSHA) and NIOSH parameters as follows:

	OSHA	NIOSH
Criteria (dB)	90	85
Exchange rate	5	3
Threshold	80	0
Weight	A	A
Time constant	Slow	Slow

All dosimeters and sound level meters were calibrated on-site prior to use with a 110 dB source and data were downloaded to a laptop computer.

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 to help place the sampling results in proper perspective.

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[1]. 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

[1] 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.

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[2]. 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 (OSHA) 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 and in Federal workplaces under Executive Order 12196 [NARA 2008]. NIOSH Recommended 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 [NIOSH 1992]; 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 [ACGIH 2008]. 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 the American Industrial Hygiene Association (AIHA), another professional organization. WEELs have been established for some chemicals "when no other legal or authoritative limits exist" [AIHA 2007].

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

---

[2] 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]

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 [29 CFR 1910.1000(d)(1)(i), ACGIH 2008]. ACGIH® [2008] 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

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots \frac{C_n}{T_n} \qquad \textit{Eqn. 1}$$

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. Exposure Criteria for Occupational Exposure to Airborne Chemical Substances

The OELs for the five primary contaminants of interest, in micrograms per cubic meter (µg/m³), are summarized and additional information related to those exposure limits is presented below.

Occupational Exposure Limits for Five Metals of Primary Interest (µg/m³)

	Ba	Be	Cd	Pb	Ni
PEL	500 TWA	2 TWA 5 (30 minute ceiling) 25 (peak exposure never to be exceeded)	5 TWA	50 TWA	1000 TWA
REL	500 TWA	0.5 TWA	Lowest Feasible Concentration	50 TWA	15 TWA

TLV	500 TWA	2 TWA 10 (STEL)	10 (total) TWA 2 (respirable) TWA	50 TWA	1500 TWA (elemental) 100 TWA (soluble inorganic compounds) 200 TWA (insoluble inorganic compounds

This subset of five metals has been selected for consideration through the body of this report because their presence was noted on MSDSs or other information pertaining to CRTs and other processes at this facility (Be, Cd, Pb and Ni) or due to the interest expressed in Ba exposures by FOH personnel.

The occupational exposure limits of all 31 metals quantified in this work are listed in Appendix A. Note that these limits refer to the contaminant as the element (e.g., the TLV®s, Be and compounds, as Be; Cd and compounds, as Cd [ACGIH 2008]). Additionally, the OEL for dust is presented here to place those air sampling results in perspective.

Occupational Exposure Criteria for Ba

The current OSHA PEL, NIOSH REL, and ACGIH® TLV® is 0.5 mg/m^3 as a TWA for airborne Ba exposures (Ba and soluble compounds, except Ba sulfate, as Ba) [29 CFR 1910.1000, NIOSH 2005, ACGIH 2008]. There is no AIHA WEEL for Ba [AIHA 2007]. Skin contact with Ba, and many of its compounds, may cause local irritation to the eyes, nose, throat and skin, and may cause dryness and cracking of the skin and skin burns after prolonged contact [Nordberg 1998].

Occupational Exposure Criteria for Be

The OSHA general industry standard sets a Be PEL of 2 μg/m^3 for an 8-hour TWA, a ceiling concentration of 5 μg/m^3, not to exceed 30 minutes and a maximum peak concentration of 25 μg/m^3, not to be exceeded for any period of time [29 CFR 1910.1000]. The NIOSH REL for Be is 0.5 μg/m^3 for up to a 10-hour work day, during a 40-hour workweek [NIOSH 2005]. The current TLV® is an 8-hr TWA of 2 μg/m^3, and a STEL of 10 μg/m^3 [ACGIH 2008]. The ACGIH® published a notice of intended changes for the Be TLV® to 0.05 μg/m^3 TWA and 0.2 μg/m^3 STEL based upon studies investigating both chronic beryllium disease and beryllium sensitization [ACGIH 2008]. There is no AIHA WEEL for Be [AIHA 2007]. Be has been designated a known human carcinogen by the International Agency for Research on Cancer [IARC 1993].

Occupational Exposure Criteria for Cd

The OSHA PEL for Cd is 5 μg/m^3 as a TWA [29 CFR 1910.1027]. Exposure at or above half that value, the Action Level of 2.5 μg/m^3 TWA, requires several actions by the employer. These include providing respiratory protection if requested [29 CFR 1910.1027(g)(1)(v)], medical surveillance if currently exposed more than 30 days per year [1910.1027(l)(1)(i)(A)], and medical surveillance if previously exposed unless potential aggregated Cd exposure did not exceed 60 months [1910.1027(l)(1)(i)(b)]. Initial examinations include a medical questionnaire and biological monitoring of Cd in blood (CdB), Cd in urine (CdU), and Beta-2-microglobulin in urine (β2-M) [29 CFR 1910.1027 Appendix A]. An employee whose biological testing results during both the initial and follow-up medical examination are elevated above the following trigger levels must be medically removed from exposure to Cd at or above the action level: (1) CdU level: above 7 μg/g creatinine, or (2) CdB level: above 10 μg/liter of whole blood, or (3) β2-M level: above 750 μg/g creatinine and (a) CdU exceeds 3 μg/g creatinine or (b) CdB exceeds 5 μg/liter of whole blood [OSHA 2004].

The ACGIH® TLV® for Cd and compounds as Cd is 10 $\mu g/m^3$ as a TWA, and 2 $\mu g/m^3$ TWA for the respirable fraction of airborne Cd and compounds, as Cd [ACGIH 2008]. The ACGIH® also published a Biological Exposure Index® that recommends that Cd blood level be controlled at or below 5 μg/L and urine level to be below 5 μg/g creatinine [ACGIH 2008]. There is no AIHA WEEL for Cd [AIHA 2007].

In 1976, NIOSH recommended that exposures to Cd in any form should not exceed a concentration greater than 40 $\mu g/m^3$ as a 10-hour TWA or a concentration greater than 200 $\mu g/m^3$ for any 15-minute period, in order to protect workers against kidney damage and lung disease. In 1984, NIOSH issued a Current Intelligence Bulletin, which recommended that Cd and its compounds be regarded as potential occupational carcinogens based upon evidence of lung cancer among a cohort of workers exposed in a smelter [NIOSH 1984]. NIOSH recommends that exposures be reduced to the lowest feasible concentration [NIOSH 2005]. This NIOSH REL was developed using a previous NIOSH policy for carcinogens (29 CFR 1990.103). The current NIOSH policy for carcinogens was adopted in September 1995. Under the previous policy, NIOSH usually recommended that exposures to carcinogens be limited to the "lowest feasible concentration," which was a non-quantitative value. Under the previous policy, most quantitative RELs for carcinogens were set at the limit of detection (LOD) achievable when the REL was originally established. From a practical standpoint, NIOSH testimony provided in 1990 on OSHA's proposed rule on occupational exposure to Cd noted that, "NIOSH research suggests that the use of innovative engineering and work practice controls in new facilities or operations can effectively contain Cd to a level of 1 $\mu g/m^3$. Also, most existing facilities or operations can be retrofitted to contain cadmium to a level of 5 $\mu g/m^3$ through engineering and work practice controls" [NIOSH 1990].

Early symptoms of Cd exposure may include mild irritation of the upper respiratory tract, a sensation of constriction of the throat, a metallic taste and/or cough. Short-term exposure effects of Cd inhalation include cough, chest pain, sweating, chills, shortness of breath, and weakness. Short-term exposure effects of ingestion may include nausea, vomiting, diarrhea, and abdominal cramps [NIOSH 1989]. Long-term exposure effects of Cd may include loss of the sense of smell, ulceration of the nose, emphysema, kidney damage, mild anemia, an increased risk of cancer of the lung, and possibly of the prostate [NIOSH 1989, Thun et al. 1991, Goyer 1991].

Occupational Exposure Criteria for Pb

The OSHA PEL for Pb is 50 $\mu g/m^3$ (8-hour TWA), which is intended to maintain worker blood Pb level (BLL) below 40 μg/deciliter (dL). Medical removal is required when an employee's BLL reaches 50 μg/dL [29 CFR 1910.1025]. The NIOSH REL for Pb (8-hour TWA) is 0.050 mg/m^3; air concentrations should be maintained so that worker blood Pb remains less than 0.060

mg Pb/100 g of whole blood [NIOSH 2005]. At BLLs below 40 µg/dL, many of the health effects would not necessarily be evident by routine physical examinations but represent early stages in the development of disease. In recognition of this, voluntary standards and public health goals have established lower exposure limits to protect workers and their children. The ACGIH® TLV® for Pb in air is 50 µg/m^3 as an 8-hour TWA, with worker BLLs to be controlled to ≤ 30 µg/dL. A national health goal is to eliminate all occupational exposures that result in BLLs >25 µg/dL [DHHS 2000]. There is no AIHA WEEL for Pb [AIHA 2007].

Occupational exposure to Pb occurs via inhalation of Pb-containing dust and fume and ingestion from contact with Pb-contaminated surfaces. Symptoms of Pb poisoning include weakness, excessive tiredness, irritability, constipation, anorexia, abdominal discomfort (colic), fine tremors, and "wrist drop" [Saryan and Zenz 1994, Landrigan et al. 1985, Proctor et al. 1991a]. Overexposure to Pb may also result in damage to the kidneys, anemia, high blood pressure, impotence, and infertility and reduced sex drive in both genders. In most cases, an individual's BLL is a good indication of recent exposure to and current absorption of Pb [NIOSH 1978].

Occupational Exposure Criteria for Ni

The NIOSH REL for Ni metal and other compounds (as Ni) is 15 µg/m^3 based on its designation as a potential occupational carcinogen [NIOSH 2005]. The ACGIH® TLV® for insoluble inorganic compounds of Ni is 200 µg/m^3 (inhalable fraction). For soluble inorganic Ni compounds the TLV® is 100 µg/m^3 (inhalable fraction). The TLV® for elemental Ni is 1,500 µg/m^3 (inhalable fraction) [ACGIH 2008]. The OSHA PEL for Ni is 1,000 µg/m^3 TWA [29 CFR 1910.1000]. Metallic Ni compounds cause allergic contact dermatitis [Proctor et al. 1991b]. NIOSH considers Ni a potential occupational carcinogen [NIOSH 2005]. There is no AIHA WEEL for Ni [AIHA 2007].

Occupational Exposure Criteria for Airborne Particulate

The maximum allowable exposure to airborne particulate not otherwise regulated is established by OSHA at 15 mg/m^3 for total and 5 mg/m^3 for the respirable portion [29 CFR 1910.1000]. A more stringent recommendation of 10 mg/m^3 inhalable and 3 mg/m^3 respirable is presented by the ACGIH® which feels that "even biologically inert insoluble or poorly soluble particulate may have adverse health effects" [ACGIH 2008]. There is no AIHA WEEL for these substances [AIHA 2007].

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 [Caplan 1993]. While the OSHA lead standard mandates that surfaces be maintained as free of lead as practicable, there is currently no surface contamination criteria included in OSHA standards [OSHA 2008].[3] The health hazard from these

---

[3] OSHA has referenced a Department of Housing and Urban Development (HUD) lead criteria in documents related to its enforcement of the lead standard [Fairfax 2003].

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 [Caplan 1993]. NIOSH RELs do not address surface contamination either, nor do ACGIH TLVs or AIHA WEELs. Caplan [1993] stated that "There is no general quantitative relationship between surface contamination and air concentrations..." He also noted 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." 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 Five Metals of Primary Interest

Surface Contamination Criteria for Pb

Federal standards have not been adopted that identify an exposure limit for Pb contamination of surfaces in the industrial workplace. However, in a letter dated January 13, 2003 [Fairfax 2003], OSHA's Directorate of Compliance Programs indicated that the requirements of OSHA's standard for Pb in the construction workplace [29 CFR 1926.62(h)(1), 1926.62(i)(2)(i) and 1926(i)(4)(ii)] interpreted the level of Pb-contaminated dust allowable on workplace surfaces as follows: a) All surfaces shall be maintained as 'free as practicable' of accumulations of Pb, b) The employer shall provide clean change areas for employees whose airborne exposure to Pb is above the permissible exposure limit, c) The employer shall assure that lunchroom facilities or eating areas are as free as practicable from Pb contamination, d) The OSHA Compliance Directive for the Interim Standard for Lead in Construction, CPL 2-2.58 recommends the use of HUD's acceptable decontamination level of 200 $\mu g/ft^2$ (21.5 $\mu g/100\ cm^2$) for floors in evaluating the cleanliness of change areas, storage facilities, and lunchrooms/eating areas, e) In situations where employees are in direct contact with Pb-contaminated surfaces, such as, working surfaces or floors in change rooms, storage facilities, lunchroom and eating facilities, OSHA has stated that the Agency would not expect surfaces to be any cleaner than the 200 $\mu g/ft^2$ level, and f) For other surfaces, OSHA has indicated that no specific level can be set to define how "clean is clean" nor what level of Pb contamination meets the definition of "practicable." OSHA notes that "the term 'practicable' was used in the standard, as each workplace will have to address different challenges to ensure that Pb-surface contamination is kept to a minimum. It is OSHA's view that a housekeeping program which is as rigorous as 'practicable' is necessary in many jobs to keep airborne Pb levels below permissible exposure conditions at a particular site" [Fairfax 2003]. Specifically addressing contaminated surfaces on rafters, OSHA has indicated that they must be cleaned (or alternative methods used such as sealing the Pb in place), as necessary to mitigate Pb exposures. OSHA has indicated that the intent of this provision is to ensure that employers regularly clean and conduct housekeeping activities to prevent avoidable Pb exposure, such as would potentially be caused by re-entrained Pb dust. Overall, the intent of the "as-free-as-practicable" requirement is to ensure that accumulation of Pb dust does not become a source of employee Pb exposures. OSHA has stated that any method that achieves this end is acceptable.

In the United States, standards for final clearance following Pb abatement were established for public housing and facilities related to children. However, no criteria have been recommended for other types of buildings, such as commercial facilities. One author has suggested criteria based upon Pb-loading values. Lange [2001] proposed a clearance level of 1000 μg/ft^2 for floors of non-Pb free buildings and 1100 μg/ft^2 for Pb-free buildings, and states that "no increase in BLL should occur for adults associated or exposed within a commercial structure" at the latter level. These proposed clearance levels are based on calculations that make a number of intentionally conservative assumptions such as: a) Pb uptake following ingestion is 35% absorption of Pb in the gastrointestinal system, b) Fingers have a total "touch" area of 10 cm^2 and 100% of the entire presumed Pb content on all 10 fingers is taken up, c) The average 'normal' environmental Pb dose (from 'uncontaminated food/water/air) is 20 μg per day, d) The weight of the exposed person is 70 kg, and e) Daily Pb excretion is limited to an average of 48 μg. Lange [2001] notes that "use of the proposed values would provide a standard for non-child-related premises (e.g. commercial, industrial, office)..." but cautions that, "Further investigation is warranted to evaluate exposure and subsequent dose to adults from surface lead."

Surface Contamination Criteria for Be

A useful guideline is provided by the U.S. Department of Energy, where DOE and its contractors are required to conduct routine surface sampling to determine housekeeping conditions wherever Be is present in operational areas of DOE/NNSA facilities. Those facilities must maintain removable surface contamination levels that do not exceed 3 μg/100 cm^2 during non-operational periods. The DOE also has release criteria that must be met before Be-contaminated equipment or other items can be released to the general public or released for use in a non-Be 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 Be 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 Cd

Like Pb and Be, Cd poses serious health risks from exposure. Cd is a known carcinogen, is very toxic to the kidneys, and can also cause depression. However, OSHA, NIOSH, AIHA and ACGIH® have not recommended criteria for use in evaluating wipe samples. The OSHA Cd standard [29 CFR 1910.1027] mandates that "All surfaces shall be maintained as free as practicable of accumulations of cadmi ," that, "all spills and sudden releases of material containing cadmium shall be cleaned up as soon as possible," and that, "surfaces contaminated with cadmium shall, wherever possible, be cleaned by vacuuming or other methods that minimize the likelihood of cadmium becoming airborne."

Surface Contamination Criteria for Ni

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

Surface Contamination Criteria for Ba

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

C. Noise Exposure Criteria

The OSHA standard for occupational exposure to noise [29 CFR 1910.95] specifies a maximum PEL of 90 dB(A) for a duration of 8 hours per day. The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship, or exchange rate. This means that a person may be exposed to noise levels of 95 dB(A) for no more than 4 hours, to 100 dB(A) for 2 hours, etc. Conversely, up to 16 hours exposure to 85 dB(A) is allowed by this exchange rate. NIOSH, in its Criteria for a Recommended Standard, proposed an REL of 85 dB(A) for 8 hours, 5 dB less than the OSHA standard [NIOSH 1972]. The NIOSH 1972 criteria document also used a 5 dB time/intensity trading relationship in calculating exposure limits. However, the 1998 revised criteria recommends a 3 dB exchange rate, noting that it is more firmly supported by scientific evidence [NIOSH 1998]. The ACGIH® also changed its TLV® in 1994 to a more protective 85 dB(A) for an 8-hour exposure, with the stipulation that a 3 dB exchange rate be used to calculate time-varying noise exposures. Thus, a worker can be exposed to 85 dB(A) for 8 hours, but to no more than 88 dB(A) for 4 hours or 91 dB(A) for 2 hours.

In 1983, a hearing conservation amendment to the OSHA noise standard took effect [29.CFR 1910.95(c)] that requires employers to "administer a continuing, effective hearing conservation program" whenever employee noise exposures equal or exceed an 8-hour TWA of 85 dBA or, equivalently, a dose of fifty percent. The requirements include noise monitoring, audiometric testing, providing hearing protectors, training workers, and recordkeeping.

V. RESULTS AND DISCUSSION

The work described here was conducted in January, 2008 at the USP Lewisburg, UNICOR recycling factory electronic components recycling operations. During this testing air, surface wipe, and noise data were collected in locations where the electronics recycling operations were taking place and measurements were made relating to air flow of the local exhaust ventilation system. The primary purposes of this evaluation were to estimate the potential exposures of inmates and staff to toxic substances and noise encountered during the recycling of electronic components and to recommend remedial measures to reduce exposures if necessary.

A statistical summary of air sampling results is presented in Table 1. Results of personal breathing zone and area air sampling are shown in Table 2 for total particulate and Table 3 for particulate <10 μm diameter. Surface wipe sample results are contained in Table 4; noise measurements are shown in Table 5. As mentioned in Section III above, all samples were analyzed for 31 metals due to the parameters of the analytical method. While the data in these tables represent the results of just the five metals of primary interest in this evaluation, results of all analyses are contained in the appendices. All data indicate levels well below the OELs, even when results for combined exposures as calculated by Equation 1 are considered, although the detection limit for arsenic was not low enough for comparison to the most stringent OEL. Because arsenic was not found in any wipe or bulk samples either, it was not considered a potential hazard at this facility.

A. Air Sample Results

Air measurements were collected during both normal and non-routine operations in the areas identified, including the glass breaking operation. Data presented here and in Table 2 and 3 are for the duration of the samples rather than for an 8-hour time weighted average since the concentrations of contaminants are so low. Most personal breathing-zone measurements, however, were for five hours duration or greater. Measurements made during the filter change operation are presented at the bottom of Table 2 and discussed separately below since this was not a routine production operation. The full data set of all 31 metals is presented in Appendix B. Results of metal and dust measurements of particle size <10μm diameter are presented in Table 3, with the full data set of all 31 metals in Appendix C.

These data indicate low levels of airborne particulate and metals. Thirty-four samples were taken during normal production during the January, 2008 study. These data can be identified by date in Tables 2 and 3, but the magnitudes of the exposures were not generally different by date. Measurements during routine operations revealed that Ba concentrations ranged between <0.05 and 2 $\mu g/m^3$ and were unremarkable. Be levels also were all below the limit of detection, which varied with sample volume, most being <0.006 $\mu g/m^3$. Cd, Pb and Ni, likewise, were found at low levels ranging up to 0.1, 4, and 0.8 $\mu g/m^3$, respectively. Pb was the metal found in highest quantity, with 13 of 21 samples above the limit of detection and the highest concentration was approximately 10% of the occupational exposure limits. Airborne total particulate concentrations ranged to 650 $\mu g/m^3$ (0.1 to 0.7 mg/m^3). No distinction could be made between samples from different locations within the UNICOR factory or between different jobs, primarily due to the high variability in measured contaminant. Sample durations ranged from approximately 2.5 to 7 hours.

The filter change operation in the glass breaking area, discussed in the Process Description (Section II), was the task of most concern regarding exposures of workers to toxic metals. Visual observations did not indicate high levels of airborne dust, and measurements of metals and particulate confirmed these observations. No airborne levels of any metals were found in excess of the most stringent occupational exposure criteria. Ba ranged from <0.07 to 2 $\mu g/m^3$. No Be was detected (LOD of 0.03 $\mu g/m^3$). Cd ranged from <0.06 to 3 $\mu g/m^3$ with no Cd detected in respirable samples. Again, Pb was the metal in highest concentration ranging from <0.3 to 10 $\mu g/m^3$. All air samples collected during the filter change were approximately 1.5 hours duration.

Airborne total particulate measurements ranged generally between 300 and 650 $\mu g/m^3$, with one sample collected during the filter change operation of 1,100 $\mu g/m^3$. Respirable particulate ranged from 30 to 290 $\mu g/m^3$. While no statistical comparison was made because of the dissimilarity of the sample conditions, a day-by-day comparison of total and respirable particulate and Pb (from Tables 2 and 3 respectively) would suggest that a large portion of the airborne particulate and metals was in the respirable range.

It should be reiterated here that no shredding or melting of components was done at Lewisburg and these processes would be expected to produce a greater potential for exposures to metals than the disassembly processes.

B. Surface Wipe Sample Results

The surface wipe sample results collected during the visit in the electronic recycling operations at the USP Lewisburg are summarized below and in Table 4 for the metals of interest, and the entire surface wipe sample data set is contained in Appendix D. Results of spectrofluorometric analysis for Be only confirmed ICP measurements and are not repeated in the tables.

Wipe samples taken in the UNICOR electronic recycling factory did not indicate levels of Ba on work surfaces at levels of concern as discussed in Section IV above in the surface contamination subsection. The highest Ba concentration detected was 250 μg/sq ft. No Be was detected in samples from the recycling factory; the limit of detection was 0.1 μg/sq ft. Surfaces tested for Pb indicated levels exceeding the OSHA recommended 200 μg/sq ft. in 3 of 11 instances, although 2 of those samples (LMWW-05 & 06) were from CPU fan blades which were presumably contaminated prior to arrival. While an argument could be made as to the applicability of this criterion to these samples, nevertheless it is felt that 200 μg/sq ft is a useful target value for judging the effectiveness of a cleanup operation. While there are no criteria for evaluating Cd surface contamination, the highest Cd measurement was less than 10% of the recommended Pb level (200 μg/sq ft) which arguably could be used as a target for measuring clean-up effectiveness. Ni surface contamination was less than 70 μg/sq ft in all samples.

C. Sound Level Measurements

The data collected with noise dosimeters is presented in Table 5 for the 16 sets of data collected. Four area samples were collected in the glass breaking operation and 12 samples were collected in other locations in the factory. For each day of sampling, each sample is described, and the start and stop times are presented along with the sample duration (run time). Following that, the mean sound pressure level for the duration of the run (TEST AVERAGE DB) and the time weighted average sound pressure level for an eight hour day (TWA DB) is shown. Sound pressure levels are in dB, A weighted, slow response and presented for both the OSHA and NIOSH criteria. Time weighted calculations assume no exposure during the un-sampled time which for 15 of 16 samples was from 1 to 2 hours. Several of the noise samples exceeded the REL and TLV of 85 dBA and are highlighted in bold print in Table 5.

While the REL and TLV are more conservative criteria for protecting workers from over exposure to noise, the OSHA noise standard [29 CFR 1910.95] is legally enforceable. This standard instructs the employer to calculate the allowable noise dose from more than one sample as follows:

> *When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: C(1)/T(1) + C(2)/T(2) C(n)/T(n) exceeds unity, then, the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level, and Tn indicates the total time of exposure permitted at that level.*

This means that, using the OSHA exchange values, none of the samples collected on these two days exceeded the allowable dose to document an overexposure to the PEL of 90 dBA, although measurements above 85 dBA (OSHA criteria) are considered to be an action level which triggers the requirement for a hearing conservation program.

The maximum 8-hour TWA noise measurement during the Lewisburg evaluation was 88 dBA (sample LST-03) on top of the glass breaking booth. The highest personal exposures were the bailers (samples LSW-01 and -05) which were 85 and 84 dBA 8-hour TWA.

D. Local Exhaust System Measurements

The HFMs were designed and manufactured by Atmos-Tech Industries (model HFM24-ST/RF/SP, Ocean City, NJ). Each unit is equipped with a bank of 35% efficient pleated pre-filters and a HEPA filter, a direct-drive 1200 cfm fan with a ½ horsepower motor, and a control panel with a minihelic pressure gauge and variable speed control. Air enters through the pre-filters in the front of the unit, passes through the HEPA filter, and is discharged into the room through a grille at the back of the unit. A frame attached to the front of each unit supports 24-in long plastic strip curtains on the front and sides. The top is enclosed with a sheet of ¼-inch clear polycarbonate plastic. The pre-filters are held in place by a metal grille. Glass breaking is performed on top of an angle-iron grate inside the area enclosed by the strip curtains. Both HFMs are in an area enclosed by a building wall on 3 sides and a curtain composed of plastic strips on the other. Figure IV shows the right HFM, number 1.

The average face velocity measured at HFM-1 (the one on the right when facing them from the front) was 160 feet/minute (fpm), range 150 to 170 fpm; the average air velocity at the side was 140 fpm, range 130 to 150 fpm. The average face velocity measured at HFM-2 was 140 fpm, range 130 to 150 fpm; the average air velocity at the side was 120 fpm, range 110 to 130 fpm.

Because the HFMs discharge into the GBO enclosure (rather than to the outside of the building, for example) and re-circulate the filtered air, the enclosure is not under negative pressure with regard to the rest of the glass breaking booth. Recirculation of air from industrial exhaust systems into workroom air can result in hazardous air contaminant concentrations in the facility if not designed properly [ANSI/AIHA 2007]. The evaluation of this process indicates that the recirculation as it occurred causes no increased exposures to workers in the glass breaking booth. If exhausting to the outside, any ventilation system must be designed to meet applicable fire, safety, or environmental codes that apply to this facility and operations

To provide air circulation between the glass breaking booth and the general workplace, two exhaust fans were placed in the ceiling of the glass breaking booth (which is approximately 5 feet below the ceiling of the general workplace) to move air from the booth, through filters, into the general work area. The assumption was that air would be pulled from the general work area, through the plastic strip curtains forming the front wall of the glass breaking booth (not visible in Figure IV) or other openings. Smoke released at the plastic curtain showed little air flow into the enclosed area indicating that those two exhaust fans placed on top of the glass breaking enclosure were not sufficient to produce significant flow across the pressure drop caused by the plastic curtain.

VI. CONCLUSIONS AND RECOMMENDATIONS

The primary purpose of sampling is to determine the extent of employee exposures and the adequacy of protection. Sampling also permits the employer to evaluate the effectiveness of engineering and work practice controls and informs the employer whether additional controls need to be installed. Values that exceed OELs indicate that additional controls are necessary. This study focused on the evaluation of airborne exposures and noise, with additional data collected on surface contamination. The results of air sampling during this January 2008 survey found that Pb, Cd, and other metals are generated and released during the recycling operations at this facility. No exposures to airborne metals or particulate were found that exceeded the OSHA Action Level for these substances during normal production or during the monthly filter change operation. Recommendations are presented below to assure the continued safe conditions at Lewisburg Federal Correctional facility.

Although there was initial concern about Be and literature that pertains to e-waste recycling report that Be is present in electronic components, none was detected in air or wipe samples collected at this facility. One explanation for this is based on the work of Willis and Florig [2002]. They note that Be "in consumer products is used in ways that are not likely to create beryllium exposures during use and maintenance." The recycling operations (except the glass breaking operation) involve disassembly of electronics and sorting of the components. While some breakage occurs during the disassembly process, the components likely to contain Be are not subject to further processing that might create the potential for Be exposures.

Of the UNICOR recycling facilities evaluated to date, Lewisburg has the most adequate arrangement for donning and doffing personal protective clothing and equipment. While some situations require showers as a part of the decontamination process, this is not considered necessary for the work conducted at Lewisburg since the levels of contaminant are low. The arrangement in its present configuration is deemed adequate. Assurance needs to be made, however, that respirators and clean protective clothing are stored in lockers in the work area, where they are not at risk of contamination.

While the recommendations presented here address certain areas and issues observed during this evaluation, there needs to be a site-specific health and safety program at Lewisburg. Based on the data presented above, the following recommendations are made. These recommendations are divided into 3 categories, described as programmatic issues, procedural issues, and housekeeping issues.

Programmatic issues:

1. The respiratory protection program for this facility should be evaluated for this operation in order to ensure that it complies with OSHA regulation 1910.134.
2. A hearing protection program should be implemented and compliance with all provisions of the OSHA standard for occupational exposure to noise [29 CFR 1910.95] should be verified.
3. Training of workers should be scheduled and documented in the use of techniques for dust suppression, the proper use of local ventilation, personal protection equipment (e.g., coveralls, respirators, gloves) and hazard communication.
4. Frequently while conducting the on-site work, NIOSH researchers observed tasks being conducted in a manner that appeared to be very awkward. Tasks should be evaluated to determine if there are excesses in repetitive stress trauma and if modifications in procedures or equipment would provide benefit to this workplace.
5. Heat stress should be periodically evaluated during hot weather (e.g., the summer months).
6. All UNICOR operations, including but not limited to recycling should be evaluated from the perspective of health, safety and the environment in the near future.
7. A program should be established within the Bureau of Prisons to assure that these issues are adequately addressed by competent, trained and certified individuals. While a written program to address these issues is necessary at each facility, adequate staffing with safety and health professionals is required to ensure its implementation. One indication of adequate staffing is provided by the United States Navy, which states "Regions/Activities with more than 400 employees shall assign, at a minimum, a full time safety manager and

adequate clerical support" [USN 2005]. That document also provides recommended hazard-based staffing levels for calculating the "number of professional personnel needed to perform minimum functions in the safety organization."

8. A comprehensive program is needed within the Bureau which provides sufficient resources, including professional assistance, to assure each facility the assets needed to assure both staff and inmates a safe and healthy workplace.

Procedural issues:

9. The use of an alternative method (e.g., static pressure drop) should be investigated to determine frequency of filter change. The manufacturer of this system may have guidelines in this regard.
10. Workers performing the filter change operation should continue to utilize respiratory protection as part of a comprehensive respiratory protection program. The PAPRs used provide adequate protection for the filter change operation.
11. Because the facility already provides uniforms to its workers, management should evaluate the feasibility of providing and laundering work clothing for all workers in the recycling facility, instead of the current practice of providing disposable clothing for glass breaking workers only. Contaminated work clothing must be segregated from other clothes and laundered in accordance with applicable regulations.
12. The use of alternative methods to break cathode-ray tubes should be investigated by Lewisburg management to determine if further improvements are feasible. Lee et al. [2004] present different methods to separate panel glass from funnel glass in CRT recycling (sec 2.1) and for removing the coatings from the glass (sec 2.2). The hot wire and vacuum suction methods (supplemented with local exhaust ventilation) described by Lee et al. may produce fewer airborne particulates than breaking the glass with a hammer. The authors [Lee et al. 2004] describe a commercially-available method in which an electrically-heated wire is either manually or automatically wound around the junction of the panel and funnel glass, heating the glass. After heating the glass for the necessary time, cool (e.g., room temperature) air is directed at the surface, fracturing the glass-to-glass junction using thermal shock. The separated panel and funnel glass can then be sorted by hand. They also describe a method wherein a vacuum-suction device is moved over the inner surface of the panel glass to remove the loose fluorescent coating [Lee et al. 2004]. The vacuum used must be equipped with HEPA filtration. Industrial central vacuum systems are available; they may cost less in the long run than portable HEPA vacuum cleaners. These modifications may also reduce the noise exposure to glass breakers.
13. Because of the noise levels found in the glass breaking operation, engineering controls should be designed or selected using noise reduction as a criterion. Until noise in the glass breaking operation can be reduced through engineering controls, a hearing conservation program including noise monitoring, audiometric testing, providing hearing protectors, training workers, and recordkeeping must be implemented for workers in the glass breaking operation.

Housekeeping:

14. Due to the levels of surface contamination of Pb measured in the recycling facility, workers should wash their hands before eating, drinking, or smoking.
15. Given the concentrations of Pb and Cd detected in the surface wipe samples and air measurements, periodic industrial hygiene evaluations and facility inspections are

recommended to confirm that exposures are maintained below applicable occupational exposure limits.

16. Daily and weekly cleaning of work areas by HEPA-vacuuming and wet mopping should be continued, taking care to assure no electrical or other safety hazard is introduced. The BG/BIA guidelines [2001] recommend daily cleaning of tables and floors with a type-H vacuum cleaner. Type H is the European equivalent of a HEPA vacuum, where the H class requires that the filter achieve 99.995% efficiency, where 90% of the test particles are smaller than 1.0 um and pass the assembled appliance test, 99.995% efficiency where 10% of the particles are smaller than 1.0 um, 22% below 2.0 um, and 75% below 5.0 um. While some surface contamination was measured in work areas, this would be much greater if it were not for the good housekeeping practices in effect in all locations observed. Other practices not observed during the time of this evaluation, but which have been observed at other facilities should be discouraged; these include the use of compressed air to clean parts or working surfaces, and the consumption of food, beverage or tobacco in the workplace.

REFERENCES

ACGIH [2008]. Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

AIHA [2007]. Workplace environmental exposure levels. Fairfax, VA: American Industrial Hygiene Association.

ANSI/AIHA [2007]. American national standard for recirculation of air from industrial process exhaust systems. Fairfax, VA: American Industrial Hygiene Association.

ASTM [2002]. Standard practice for collection of settled dust samples using wipe sampling methods for subsequent determination of metals. West Conshohocken, P. .STM International.

Berges M (Markus.Berges@dguv.de)[2008a]. WG: Project-Nr. BIA3058: Dust emission during release of vacuum from cathode-ray tubes. Private e-mail message to Alan Echt (AEcht@cdc.gov), June 16.

Berges M (Markus.Berges@dguv.de)[2008b]. AW: BG.BIA-Empfehlungen zur Uberwachung translated. Private e-mail message to Alan Echt (AEcht@cdc.gov), June 27.

BG/BIA [2001]. Recommendations for monitoring work areas – manual disassembly of monitors and other electrical equipment.

BIA [2001]. Project-Nr. BIA 3058 Dust emission during release of vacuum from cathode- ray tubes. Berufsgenossenschaftliches Institut für Arbeitssicherheit –BIA, Berufsgenossenscheft der Feinmechanik und Elektrtechnik. Available on-line at http://www.hvbg.de/e/bia/pro/pro1/pr3058.html. Accessed June 13, 2008.

Caplan KJ [1993]. The significance of wipe samples. Am Ind Hyg Assoc J *53*:70–75.

CFR. Code of Federal regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Chepesiuk R [1999]. Where the chips fall: environmental health in the semiconductor industry. Environ Health Perspect. *107*:A452–A457.

Cui J, Forssberg E [2003]. Mechanical recycling of waste electric and electronic equipment: a review. J Hazard Mater. *99*:243–263.

DHHS [2000]. Healthy people 2010: *Understanding and Improving Health. 2nd ed.* Washington, DC: U.S. Department of Health and Human Services. Available on the internet at: www.health.gov/healthypeople/Document/default.htm

EPA [2008]. eCycling. Available on-line at http://www.epa.gov/ecycling/. Accessed June 3, 2008.

Fairfax RE [2003]. Letter of January 13, 2003 from RE Fairfax, Director, Directorate of Compliance Programs, OSHA, to Frank White, Vice President, Organization Resource Counselors, Inc. Available at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=25617. Accessed May 12, 200

Goyer RA [1991]. Toxic effects of metals. In: Amdur ML, Doull J, Klaassen CD (eds.) Casarett and Doul's Toxicology, pp. 623–680.

IARC [1993]. IARC monographs on the evaluation of carcinogenic risks to humans: beryllium, cadmium, mercury, and exposures in the glass manufacturing industry. Vol. 58. Lyon, France: World Health Organization, International Agency for Research on Cancer.

Landrigan PJ, Froines JR, Mahaffeyet KR [1985]. Body lead burden: summary of epidemiological data on its relation to environmental sources and toxic effects. In: Dietary and environmental lead: human health effects. Amsterdam: Elsevier Science Publishers.

Lange JH [2001]. A suggested lead surface concentration standard for final clearance of floors in commercial and industrial buildings. Indoor and Built Environment *10*:48–51.

Lee C-H, Chang C-T, Fan K-S, Chang T-C [2004]. An overview of recycling and treatment of scrap computers. J Hazard Mater. *114*:93–100.

McCawley MA, Kent MS, Berakis MT [2001]. Ultrafine beryllium number concentration as a possible metric for chronic beryllium disease risk. Appl Occup Environ Hyg. *16*:631–638.

NARA [2008]. Executive Order 12196--Occupational safety and health programs for Federal employees. College Park, MD:U.S. National Archives and Records Administration. Available on-line at: http://www.archives.gov/federal-register/codification/executive-order/12196.html. Accessed June 6, 2008.

NIOSH [1972]. NIOSH criteria for a recommended standard: occupational noise exposure. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS(NIOSH) Publication No. 73-11001.

NIOSH [1978]. Criteria for a recommended standard: occupational exposure to inorganic lead. Revised criteria – 1978. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 78-158.

NIOSH [1984]. Current intelligence bulletin #42: Cadmium. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 84-116.

NIOSH [1989]. Occupational health guidelines for chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH)/DOL (OSHA) Publication No. 81-123 and supplements 88-118, 89-104

NIOSH [1990]. NIOSH testimony on the Occupational Safety and Health Administration's proposed rule on occupational exposure to cadmium, July 17, 1990, OSHA Docket No. H-057A. NIOSH policy statements. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control, National Institute for Occupational Safety and Health. p.16.

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

NIOSH [1994]. NIOSH Manual of Analytical Methods (NMAM®), 4th ed. Schlecht, P.C. & O'Connor, P.F. eds. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication 94-113 (August, 1994), 1st Supplement Publication 96-135, 2nd Supplement Publication 98-119, 3rd Supplement 2003-154.

NIOSH [1998]. NIOSH criteria for a recommended standard: occupational noise exposure. Revised criteria 1998. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS(NIOSH) Publication No. 98-126.

NIOSH [2005]. NIOSH pocket guide to chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for

Occupational Safety and Health, DHHS (NIOSH) Publication No. 2005-149. Available on-line at http://www.cdc.gov/niosh/npg/. Accessed June 6, 2008.

Nordberg G, ed. [1998]. Barium. In: Metals: chemical properties and toxicity. Chapter 63. In: Stellman, JM, ed. Encyclopedia of occupational health and safety. 4th ed. Vol. 2. Geneva: International Labor Office. Pp. 63.8-63.9.

OSHA [2004]. Cadmium. Washington, DC: U.S. Department of Labor Occupational Safety and Health Administration OSHA 3136-06R. Available on-line at: http://www.osha.gov/Publications/osha3136.pdf. Accessed June 4, 2008.

Pettersson-Julander A, van Bavel B, Engwall M, Westberg H [2004]. Personal air sampling and analysis of polybrominated diphenyl ethers and other bromine containing compounds at an electronic recycling facility in Sweden. J Environ Monit. *6*:874–880. Epub 2004 Oct 21.

Proctor NH, Hughes JP, Fischman ML [1991a]. Lead. In: *Chemical hazards of the workplace. 3rd ed.* Philadelphia, PA: J.B. Lippincott Company, Philadelphia, pp 353-357.

Proctor NH, Hughes JP, Fischman ML [1991b]. Nickel and inorganic compounds. In: *Chemical hazards of the workplace. 3rd ed.* Philadelphia, PA: J.B. Lippincott Company, Philadelphia, pp 422-424.

Saryan LA, Zenz C [1994]. Lead and its compounds. In: *Occupational medicine. 3rd ed.* Chicago, IL: Mosby-Year Book, Inc.

Schmidt CW [2002]. e-Junk explosion. Environ Health Perspect. *110*:A188–A194.

Sjödin A, Carlsson H, Thuresson K, Sjölin S, Bergman A, Ostman C [2001]. Flame retardants in indoor air at an electronics recycling plant and at other work environments. Environ Sci Technol. *35*:448–454.

Thun MJ, Elinder CG, Friberg L [1991]. Scientific basis for an occupational standard for cadmium. Am J Ind Med. *20*:629-42.

Willis HH, Florig HK [2002]. Potential exposures and risks from beryllium-containing products. Risk Anal. *22*:1019–1033.

Table 1

Summary Statistics for Airborne Metal Measurements*
Collected at USP Lewisburg
(Concentration unit for means is μg/m³)

	Particulate	Ba	Be	Cd	Pb	Ni
15 total particulate samples collected in recycling operations (excluding GBO)						
Ar. Mean	540	0.262	0.004	0.031	0.451	0.157
Ar. St. Dev	147	0.126	0.001	0.020	0.278	0.109
Geo Mean	521	0.235	0.003	0.024	0.380	0.130
GSD	1.378	1.630	1.254	2.315	1.836	1.824
5 total particulate samples collected in GBO, normal operation						
Ar. Mean	463	1.117	0.003	0.077	2.427	0.322
Ar. St. Dev	221	0.642	0.001	0.039	1.479	0.140
Geo Mean	373	0.710	0.003	0.067	1.822	0.298
GSD	2.480	4.347	1.192	1.851	2.797	1.570
4 respirable samples collected in GBO, normal operation						
Ar. Mean	95	0.232	0.003	0.030	0.518	0.137
Ar. St. Dev	49	0.166	0.000	0.000	0.180	0.082
Geo Mean	83	0.159	0.003	0.030	0.495	0.119
GSD	1.924	3.381	1.174	1.000	1.415	1.866
4 total particulate samples collected during filter change operation						
Ar. Mean	451	0.621	0.013	0.886	3.096	0.692
Ar. St. Dev	435	1.078	0.000	1.373	4.792	0.230
Geo Mean	340	0.149	0.013	0.376	1.370	0.653
GSD	2.240	7.120	1.000	4.099	3.833	1.519
4 respirable samples collected during filter change operation						
Ar. Mean	163	0.248	0.010	0.110	0.856	0.349
Ar. St. Dev	90	0.247	0.002	0.020	0.587	0.125
Geo Mean	147	0.142	0.010	0.109	0.741	0.334
GSD	1.672	3.960	1.202	1.183	1.795	1.395

*Ar. Mean = arithmetic mean
Ar. St Dev = arithmetic standard deviation
Geo Mean = geometric mean
GSD = geometric standard deviation
All "non-detected" samples were set at half the limit of detection for statistical calculations.

Table 2
Lewisburg Federal Penitentiary
Personal Breathing Zone and Area Air Sample Results for Total Particulate (TP), Barium (Ba), Beryllium (Be), Cadmium (Cd), Lead (Pb), and Nickel (Ni)

Sample Number	Job Description/ Work Location	Sample Date	Sample Time (min.)	Sample Type*	TP Conc. (µg/m³)	Ba Conc. (µg/m³)	Be Conc. (µg/m³)	Cd Conc. (µg/m³)	Pb Conc. (µg/m³)	Ni Conc. (µg/m³)
LMTM-01	Runner	1/29/2008	152	P	na	na	<0.013	na	na	na
LMTM-04	Disassembly	1/29/2008	327	P	na	na	<0.006	na	na	na
LMTM-08	Disassembly outside glass break room	1/29/2008	326	P	na	0.19	<0.007	<0.06	0.81	<0.20
LMTT-01	Glass breaker/feeding glass	1/29/2008	349	P	506	1.15	<0.007	0.09	2.01	0.42
LMTT-03	Feeding glass/glass breaking (GB)	1/29/2008	320	P	608	1.78	<0.007	0.12	4.40	0.26
LMTT-04	Disassembly (cable boxes)	1/29/2008	331	P	652	0.42	<0.007	0.08	0.75	0.36
LMTT-05	Disassembly outside glass break room	1/29/2008	354	P	585	0.54	<0.007	<0.08	1.13	0.37
LMWM-05	Breaking hard drives	1/30/2008	304	P	na	0.15	<0.008	<0.07	<0.55	<0.22
LMWM-06	Disassembly outside glass break room	1/30/2008	166	P	na	0.22	<0.014	<0.12	<1.01	<0.40
LMWT-01	Feeding glass/GB	1/30/2008	300	P	534	1.33	<0.008	0.10	2.56	0.51
LMWT-03	Disassembly of CPUs in middle building	1/30/2008	308	P	597	0.38	<0.008	<0.09	<0.43	0.25
LMWT-04	Glass breaker/feeding glass	1/30/2008	316	P	593	1.27	<0.007	<0.08	2.86	0.25
LMTM-02	On work bench in disassemble area outside GB room	1/29/2008	381	A	na	na	<0.005	na	na	na
LMTM-03	Work bench in monitor testing area	1/29/2008	410	A	na	na	<0.005	na	na	na
LMTM-05	Memory testing area, 5 feet from workers	1/29/2008	412	A	na	na	<0.005	na	na	na
LMTM-06	Work bench outside GB room	1/29/2008	391	A	na	0.17	<0.006	<0.06	0.62	<0.17
LMTM-07	Memory testing area, 5 feet from workers	1/29/2008	412	A	na	0.23	<0.006	<0.05	0.41	<0.16
LMTM-09	Work bench outside GB room	1/29/2008	391	A	na	0.10	<0.006	<0.05	0.43	<0.17
LMTM-10	Work bench in monitor testing area	1/29/2008	410	A	na	0.29	<0.006	<0.05	0.41	<0.16
LMTT-02	On top of GB booth, center 1 foot from front	1/29/2008	432	A	74	0.05	<0.005	<0.06	0.31	0.16
LMWM-01	Work shelf in printer/monitor testing area	1/30/2008	378	A	na	0.41	<0.006	<0.05	<0.44	<0.18
LMWM-02	On shelf in wire area	1/30/2008	387	A	na	0.10	<0.006	<0.05	<0.43	<0.17
LMWM-03	On work shelf near CPU disassembly	1/30/2008	386	A	na	0.28	<0.006	<0.05	0.46	<0.17
LMWM-04	Work bench in CPU testing area	1/30/2008	381	A	na	0.21	<0.006	<0.05	<0.44	<0.18
LMWP-02	In laptop area near work desk	1/30/2008	383	A	na	na	<0.005	na	na	na
LMWP-03	On work shelf near CPU disassembly	1/30/2008	386	A	na	na	<0.005	na	na	na
LMWP-04	On shelf in wire area	1/30/2008	389	A	na	na	<0.005	na	na	na
LMWT-02	BZ level on work shelf directly opposite of glass break booth	1/30/2008	411	A	324	0.22	<0.006	<0.06	<0.32	0.30
LMHT-01	On work shelf opposite GB booth	1/31/2008	93	A	199	<0.07	<0.025	<0.29	<1.44	0.79
LMHT-02	On work shelf opposite GB booth	1/31/2008	91	A	202	<0.07	<0.026	<0.29	<1.47	0.77
LMHT-03	GB booth cleaning and filter changing	1/31/2008	96	P	1099	2.23	<0.025	2.94	10.3	0.85
LMHT-04	Outside documenting cleanup/filter change procedure	1/31/2008	95	P	303	0.18	<0.025	0.30	<1.42	<0.71

* P = personal sample
A = area sample

Table 3
Lewisburg Federal Penitentiary
BGI Cyclone Respirable Air Sample Results for Respirable Particulate (RP), Barium (Ba), Beryllium (Be), Cadmium (Cd), Lead (Pb), and Nickel (Ni)

Sample Number	Job Description/Work Location	Sample Date	Sample Time (min.)	Sample Type*	RP Conc. (µg/m^3)	Ba Conc. (µg/m^3)	Be Conc. (µg/m^3)	Cd Conc. (µg/m^3)	Pb Conc. (µg/m^3)	Ni Conc. (µg/m^3)
LMTR-01	Feeding glass/glass breaking	1/29/2008	311	P	150	0.43	<0.007	<0.06	0.73	0.17
LMTR-02	Glass breaker/feeding glass	1/29/2008	349	P	110	0.26	<0.007	<0.06	0.37	<0.14
LMTR-03	Disassembly of CPUs in middle building	1/29/2008	329	P	230	0.22	<0.007	<0.06	0.29	0.23
LMWR-01	Disassembly of CPUs in middle building	1/30/2008	396	P	132	0.27	<0.003	<0.03	0.27	0.10
LMWR-02	Feeding glass/glass breaking	1/30/2008	305	P	86.6	0.21	<0.006	<0.06	0.60	0.24
LMWR-03	Glass breaker/feeding glass	1/30/2008	325	P	33.0	0.027	<0.005	<0.06	0.37	<0.15
LMHR-04	Glass breaking booth cleaning and filter changing	1/31/2008	97	P	87.5	0.57	<0.018	<0.20	1.72	0.52
LMHR-01	Glass breaking booth cleaning and filter changing	1/31/2008	70	P	158	0.30	<0.025	<0.28	<1.40	<0.70
LMHR-02	On work shelf opposite glass breaking booth	1/31/2008	93	A	117	<0.05	<0.018	<0.21	<1.04	<0.52
LMHR-03	On work shelf opposite glass breaking booth	1/31/2008	92	A	291	0.10	<0.019	<0.21	<1.06	<0.53

* P = personal sample
A = area sample

Table 4
Lewisburg Federal Penitentiary
Surface Wipe Sample Results for metals of primary interest, in µg/sq ft

Sample Number	Sample Location	Sample Date	Ba	Be	Cd	Pb	Ni
LMTW-04	Work bench canvas surface outside glass breaking booth	1/29/2008	91	<0.1	8	279	35
LMTW-05	Coated surface from LED plastic screen	1/29/2008	1	<0.1	<1	<8	<5
LMTW-06	Uncoated surface from LED plastic screen	1/29/2008	3	<0.1	<1	<8	<5
LMTW-07	Coated surface from LED plastic screen	1/29/2008	7	<0.1	<1	33	<5
LMTW-08	Uncoated surface from LED plastic screen	1/29/2008	1	<0.1	<1	19	<5
LMTW-09	Rubberized mat on work bench in middle building	1/29/2008	39	<0.1	5	58	31
LMTW-10	Metal surface of work bench in middle building	1/29/2008	6	<0.1	3	20	6
LMWW-05	Fan blades from fan removed from a CPU	1/30/2008	250	<0.1	14	7068	89
LMWW-06	Fan blades from fan removed from a CPU	1/30/2008	101	<0.1	14	512	64
LMWW-07	Inside surface of a CPU case	1/30/2008	3	<0.1	<1	<8	<5
LMWW-08	Inside surface of a CPU case	1/30/2008	22	<0.1	1	36	51

Table 5
Noise Exposure Measurements*
January 29, 2008

Sample I D	**LST-02**		**LST-09**		**LST-03**	
Description	Area - on top of glass breaking booth		Area - on operators desk near bailer		Area - on top of glass breaking booth	
Run Time	6:16:22		5:14:37		6:17:51	
Evaluation criteria	OSHA	NIOSH	OSHA	NIOSH	OSHA	NIOSH
Test Average (dB)	87.9	91.2	77.2	82.5	90.4	94
TWA Average (dB)	86.2	**90.2**	74.2	80.7	88.7	**93**

Sample I D	**LST-01**		**LST-06**		**LST-08**	
Description	Worker disassemblying in glass breaking area		Disassembly worker in center of middle room		Area - workbench in memory testing	
Run Time	6:12:20		6:07:25		6:16:18	
Evaluation criteria	OSHA	NIOSH	OSHA	NIOSH	OSHA	NIOSH
Test Average (dB)	78.7	85.3	83.6	87.4	57.4	74.8
TWA Average (dB)	76.9	84.2	81.7	**86.2**	55.7	73.8

Sample I D	**LST-07**		**LST-04**		**LST-05**	
Description	Disassembly worker at far end of middle room		Area - on workbench outside glass breaking booth		Disassembly worker near end of center room	
Run Time	6:09:20		6:06:20		6:08:13	
Evaluation criteria	OSHA	NIOSH	OSHA	NIOSH	OSHA	NIOSH
Test Average (dB)	78.6	86	64.1	76.1	84.4	89.7
TWA Average (dB)	76.7	84.8	62.2	74.9	82.5	**88.5**

Table 5 (Continued)
Noise Exposure Measurements
January 30, 2008

Sample I D	LSW-08		LSW-05		LSW-09	
Description	Area - on top of panel breaking booth		Bailer		Worker in aluminum area	
Run Time	6:19:47		6:02:28		6:31:20	
Evaluation criteria	OSHA	NIOSH	OSHA	NIOSH	OSHA	NIOSH
Test Average (dB)	88.8	92.2	86.1	92	79	84.2
TWA Average (dB)	87.1	**91.2**	84.1	**90.8**	77.6	83.3

Sample I D	LSW-06		LSW-04		LSW-07	
Description	Worker disassemblying opposite glass breaking booth		Worker disassembling misc. devices in middle room		Area - on top of funnel breaking booth	
Run Time	6:55:28		6:36:12		6:20:17	
Evaluation criteria	OSHA	NIOSH	OSHA	NIOSH	OSHA	NIOSH
Test Average (dB)	76.1	81.8	76.5	84.3	87.7	90.9
TWA Average (dB)	75	81.2	75.1	83.5	86	**89.9**

Sample I D	LSW-01	
Description	Bailer operater	
Run Time	6:04:43	
Evaluation criteria	OSHA	NIOSH
Test Average (dB)	87.3	92.2
TWA Average (dB)	85.3	**91**

*Numbers in **bold** indicate overexposures.

Appendix A

Occupational Exposure Criteria for Metal/Element

ELEMENTS (ICP): METHOD 7300, Issue 3, dated 15 March 2003 - Page 6 of 8

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	YW2400000	–	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

NIOSH Manual of Analytical Methods (NMAM), Fourth Edition

Appendix B
Lewisburg Federal Penitentiary
Personal Breathing Zone and Area Air Sample Results for Total Particulate (TP) and Thirty-one Elements

Sample Number	TP Conc. (µg/m³)	Al Conc. (µg/m³)	Sb Conc. (µg/m³)	As Conc. (µg/m³)	Ba Conc. (µg/m³)	Be Conc. (µg/m³)	Cd Conc. (µg/m³)	Ca Conc. (µg/m³)	Cr Conc. (µg/m³)	Co Conc. (µg/m³)	Cu Conc. (µg/m³)	Fe Conc. (µg/m³)	La Conc. (µg/m³)	Pb Conc. (µg/m³)	Li Conc. (µg/m³)
LMTT-01	506	3.25	0.57	<2.87	1.15	<0.007	0.09	44.9	0.24	<0.03	0.15	9.56	<0.02	2.01	<0.004
LMTT-02	74	0.65	<0.31	<2.33	0.05	<0.005	<0.06	8.55	<0.08	<0.02	<0.04	<1.6	<0.02	0.31	<0.003
LMTT-03	608	4.71	<0.42	<3.14	1.78	<0.007	0.12	32.5	0.23	<0.03	0.12	10.48	0.04	4.40	<0.004
LMTT-04	652	3.91	0.46	<3.01	0.42	<0.007	0.08	54.2	0.14	<0.03	0.43	22.07	<0.02	0.75	0.005
LMTT-05	585	3.68	0.77	<2.83	0.54	<0.007	<0.08	40.6	0.24	<0.03	0.32	29.27	<0.02	1.13	<0.004
LMTM-01	na	na	na	na	na	<0.013	na	na	na	na	na	na	na	na	na
LMTM-02	na	na	na	na	na	<0.005	na	na	na	na	na	na	na	na	na
LMTM-03	na	na	na	na	na	<0.005	na	na	na	na	na	na	na	na	na
LMTM-04	na	na	na	na	na	<0.006	na	na	na	na	na	na	na	na	na
LMTM-05	na	na	na	na	na	<0.005	na	na	na	na	na	na	na	na	na
LMTM-06	na	1.62	<0.34	<2.55	0.17	<0.006	<0.06	28.9	0.09	<0.08	0.11	5.96	<0.01	0.62	<0.005
LMTM-07	na	1.70	<0.32	<2.43	0.23	<0.006	<0.05	16.2	0.07	<0.07	0.13	6.98	<0.01	0.41	<0.005
LMTM-08	na	2.45	<0.41	<3.06	0.19	<0.007	<0.06	29.6	0.16	<0.09	0.28	9.39	<0.01	0.81	<0.006
LMTM-09	na	1.28	<0.34	<2.56	0.10	<0.006	<0.05	14.5	0.07	<0.08	0.09	<4.3	<0.01	0.43	<0.005
LMTM-10	na	1.80	<0.33	<2.47	0.29	<0.006	<0.05	19.6	0.09	<0.07	0.18	8.19	<0.01	0.41	<0.005
LMWT-01	534	3.34	<0.44	<3.34	1.33	<0.008	0.10	50.0	0.19	<0.03	0.11	10.34	<0.02	2.56	<0.004
LMWT-02	324	2.27	<0.32	<2.43	0.22	<0.006	<0.06	49.4	<0.08	<0.02	0.11	8.91	<0.02	<0.32	<0.003
LMWT-03	597	4.34	<0.43	<3.26	0.38	<0.008	<0.09	43.4	0.13	<0.03	0.45	23.89	<0.02	<0.43	0.005
LMWT-04	593	3.71	0.81	<3.18	1.27	<0.007	<0.08	71.0	0.19	<0.03	0.14	10.59	<0.02	2.86	<0.004
LMWP-02	na	na	na	na	na	<0.005	na	na	na	na	na	na	na	na	na
LMWP-03	na	na	na	na	na	<0.005	na	na	na	na	na	na	na	na	na
LMWP-04	na	na	na	na	na	<0.005	na	na	na	na	na	na	na	na	na
LMWM-01	na	2.49	<0.36	<2.66	0.41	<0.006	<0.05	23.1	0.08	<0.08	0.27	15.09	<0.01	<0.44	0.007
LMWM-02	na	<0.87	<0.35	<2.60	0.10	<0.006	<0.05	13.0	0.07	<0.08	0.07	<4.3	<0.01	<0.43	<0.005
LMWM-03	na	3.36	<0.34	<2.59	0.28	<0.006	<0.05	31.9	0.21	<0.08	0.22	11.20	<0.01	0.46	<0.005
LMWM-04	na	1.66	<0.35	<2.63	0.21	<0.006	<0.05	10.5	0.07	<0.08	0.11	5.86	<0.01	<0.44	<0.005
LMWM-05	na	1.43	<0.44	<3.31	0.15	<0.008	<0.07	8.82	0.09	<0.10	0.09	<5.5	<0.01	<0.55	0.019
LMWM-06	na	3.64	<0.81	<6.06	0.22	<0.014	<0.12	46.5	0.16	<0.18	0.38	<10.1	<0.02	<1.01	<0.012
LMHT-01	199	1.23	1.84	<10.8	<0.07	<0.025	<0.29	11.6	0.36	0.13	<0.18	<7.2	<0.07	<1.44	<0.015
LMHT-02	202	1.72	2.68	<11.0	<0.07	<0.026	<0.29	16.9	0.48	<0.11	<0.18	<7.3	<0.07	<1.47	<0.015
LMHT-03	1099	6.03	<1.42	<10.6	2.23	<0.025	2.94	17.4	0.46	<0.11	<0.18	8.51	<0.07	10.28	<0.014
LMHT-04	303	2.35	<1.42	<10.7	0.18	<0.025	0.30	27.0	0.75	<0.11	<0.18	11.03	<0.07	<1.42	<0.014

Appendix B cont.
Lewisburg Federal Penitentiary
Personal Breathing Zone and Area Air Sample Results for Total Particulate (TP) and Thirty-one Elements

Sample Number	Mg Conc. (µg/m³)	Mn Conc. (µg/m³)	Mo Conc. (µg/m³)	Ni Conc. (µg/m³)	P Conc. (µg/m³)	K Conc. (µg/m³)	Se Conc. (µg/m³)	Ag Conc. (µg/m³)	Sr Conc. (µg/m³)
LMTT-01	2.29	0.15	<0.19	0.42	7.84	1.72	<4.78	<0.03	0.21
LMTT-02	0.54	<0.04	<0.16	0.16	<5.44	0.46	<3.89	<0.02	0.03
LMTT-03	2.10	0.10	<0.21	0.26	<7.33	2.20	<5.24	<0.03	0.31
LMTT-04	3.61	0.22	0.21	0.36	<7.02	2.61	<5.02	<0.03	0.16
LMTT-05	2.27	0.53	<0.19	0.37	<6.61	1.42	<4.72	<0.03	0.23
LMTM-01	na	na	na	na	na	na	na	na	na
LMTM-02	na	na	na	na	na	na	na	na	na
LMTM-03	na	na	na	na	na	na	na	na	na
LMTM-04	na	na	na	na	na	na	na	na	na
LMTM-05	na	na	na	na	na	na	na	na	na
LMTM-06	1.28	<0.17	<0.17	<0.17	<4.26	0.85	2.30	<0.03	0.10
LMTM-07	1.14	<0.16	<0.16	<0.16	<4.06	0.81	<1.62	<0.03	0.07
LMTM-08	1.74	<0.20	<0.20	<0.20	<5.10	1.43	<2.04	<0.04	0.15
LMTM-09	0.72	<0.17	<0.17	<0.17	<4.26	0.85	1.88	<0.03	0.05
LMTM-10	0.21	<0.16	<0.16	<0.16	<4.09	0.98	<1.64	<0.03	0.10
LMWT-01	2.45	0.11	0.22	0.51	<7.78	2.45	<5.56	<0.03	0.27
LMWT-02	2.51	0.09	<0.16	0.30	<5.67	1.21	5.02	<0.02	0.13
LMWT-03	3.15	0.26	<0.22	0.25	<7.60	1.95	<5.43	<0.03	0.17
LMWT-04	3.50	0.17	<0.21	0.25	<7.42	2.33	<5.30	<0.03	0.28
LMWP-02	na	na	na	na	na	na	na	na	na
LMWP-03	na	na	na	na	na	na	na	na	na
LMWP-04	na	na	na	na	na	na	na	na	na
LMWM-01	1.78	0.20	<0.18	<0.18	<4.44	1.42	<1.78	<0.04	0.36
LMWM-02	0.79	<0.17	<0.17	<0.17	<4.34	0.54	<1.74	<0.03	0.04
LMWM-03	2.24	<0.17	<0.17	<0.17	<4.31	1.55	4.31	<0.03	0.11
LMWM-04	0.82	<0.18	<0.18	<0.18	<4.38	0.96	<1.75	<0.04	0.06
LMWM-05	0.73	<0.22	<0.22	<0.22	<5.51	<0.44	<2.21	<0.04	0.03
LMWM-06	1.98	<0.43	<0.40	<0.40	<10.1	<0.81	5.66	<0.08	0.13
LMHT-01	1.44	<0.18	<0.72	0.79	<25.7	<0.72	<18.1	<0.11	0.03
LMHT-02	1.25	<0.18	<0.73	0.77	<25.7	0.73	<18.3	<0.11	0.04
LMHT-03	1.52	<0.18	0.78	0.85	<24.8	4.26	<17.7	<0.11	0.60
LMHT-04	1.67	<0.18	<0.71	<0.71	<24.9	<0.71	<17.8	<0.11	0.10

Appendix B cont.
Lewisburg Federal Penitentiary
Personal Breathing Zone and Area Air Sample Results for Total Particulate (TP) and Thirty-one Elements

Sample Number	Te Conc. (µg/m³)	Tl Conc. (µg/m³)	Sn Conc. (µg/m³)	Ti Conc. (µg/m³)	V Conc. (µg/m³)	Y Conc. (µg/m³)	Zn Conc. (µg/m³)	Zr Conc. (µg/m³)
LMTT-01	<0.38	<0.96	<0.96	0.04	0.04	12.4	22.9	<0.19
LMTT-02	0.42	<0.78	<0.78	<0.02	0.02	0.04	1.55	<0.16
LMTT-03	0.76	<1.05	<1.05	0.03	<0.03	48.2	72.3	<0.21
LMTT-04	0.41	<1.00	<1.00	0.08	0.03	0.07	9.13	<0.20
LMTT-05	<0.38	<0.94	<0.94	0.15	0.04	0.67	6.33	<0.19
LMTM-01	na	na	na	na	na	na	na	na
LMTM-02	na	na	na	na	na	na	na	na
LMTM-03	na	na	na	na	na	na	na	na
LMTM-04	na	na	na	na	na	na	na	na
LMTM-05	na	na	na	na	na	na	na	na
LMTM-06	<0.60	<0.68	<0.68	<0.09	<0.03	0.22	2.47	<0.03
LMTM-07	<0.57	<0.65	<0.65	<0.08	<0.02	<0.005	0.75	<0.03
LMTM-08	<0.71	<0.82	<0.82	0.14	<0.03	0.21	5.10	<0.04
LMTM-09	<0.60	<0.68	<0.68	<0.09	<0.03	0.01	1.28	<0.03
LMTM-10	<0.57	0.82	<0.57	0.13	<0.02	0.01	0.81	<0.03
LMWT-01	<0.44	<1.11	<1.11	0.03	<0.03	14.5	24.5	<0.22
LMWT-02	<0.32	<0.81	<0.81	0.03	0.04	0.25	2.83	<0.16
LMWT-03	<0.43	<1.09	<1.09	0.11	<0.03	0.09	8.25	<0.22
LMWT-04	0.66	<1.06	<1.06	0.04	0.03	8.69	17.0	<0.21
LMWP-02	na	na	na	na	na	na	na	na
LMWP-03	na	na	na	na	na	na	na	na
LMWP-04	na	na	na	na	na	na	na	na
LMWM-01	<0.62	0.82	<0.62	0.33	<0.03	0.01	1.07	<0.04
LMWM-02	<0.61	<0.70	<0.70	<0.09	<0.03	0.01	1.04	<0.03
LMWM-03	<0.60	<0.69	<0.69	0.17	<0.03	0.01	3.62	0.04
LMWM-04	<0.61	<0.70	<0.70	0.13	<0.03	<0.005	0.96	0.04
LMWM-05	<0.77	<0.88	<0.88	<0.11	<0.03	<0.007	0.55	<0.04
LMWM-06	<1.42	2.43	1.52	<0.20	<0.06	0.40	13.1	<0.08
LMHT-01	<1.44	<3.61	<3.61	<0.07	<0.11	0.30	5.06	<0.72
LMHT-02	2.09	<3.67	<3.67	<0.07	<0.11	0.36	5.87	<0.73
LMHT-03	<1.42	<3.55	<3.55	<0.07	<0.11	95.7	174	<0.71
LMHT-04	<1.42	<3.56	<3.56	<0.07	<0.11	4.27	12.8	<0.71

Appendix C
Lewisburg Federal Penitentiary
BGI Cyclone Respirable Air Sample Results for Respirable Particulate (RP) and Thirty-one Elements

Sample Number	RP Conc. (μg/m³)	Al Conc. (μg/m³)	Sb Conc. (μg/m³)	As Conc. (μg/m³)	Ba Conc. (μg/m³)	Be Conc. (μg/m³)	Cd Conc. (μg/m³)	Ca Conc. (μg/m³)	Cr Conc. (μg/m³)	Co Conc. (μg/m³)	Cu Conc. (μg/m³)	Fe Conc. (μg/m³)	La Conc. (μg/m³)	Pb Conc. (μg/m³)	Li Conc. (μg/m³)
LMTR-01	117	0.86	0.45	<2.34	0.34	<0.005	<0.06	6.80	<0.08	<0.02	<0.04	<1.6	0.02	0.73	<0.003
LMTR-02	79	0.67	0.34	<2.15	0.19	<0.005	<0.06	4.16	0.07	<0.02	<0.04	<1.4	<0.01	0.37	<0.003
LMTR-03	168	1.53	<0.29	<2.19	0.16	<0.005	<0.06	14.6	0.07	<0.02	0.09	5.8	<0.01	0.29	<0.003
LMWR-01	132	1.11	0.34	<1.28	0.12	<0.003	<0.03	10.7	0.04	<0.01	0.06	6.0	<0.01	0.27	<0.002
LMWR-02	87	1.02	<0.31	<2.36	0.17	<0.006	<0.06	7.32	0.08	<0.02	<0.04	1.8	<0.02	0.60	<0.003
LMWR-03	33	0.34	<0.29	<2.20	0.02	<0.005	<0.06	2.12	0.07	<0.02	<0.04	<1.5	<0.01	0.37	<0.003
LMHR-01	158	2.03	1.44	<10.5	0.30	<0.025	<0.28	<1.75	0.46	<0.11	<0.18	<7.0	<0.07	<1.40	<0.014
LMHR-02	117	1.09	<1.04	<7.77	<0.05	<0.018	<0.21	6.48	0.26	<0.08	<0.13	<5.2	<0.05	<1.04	<0.010
LMHR-03	291	1.37	1.51	<7.93	0.10	<0.019	<0.21	11.9	0.26	<0.08	<0.13	<5.3	<0.05	<1.06	<0.011
LMHR-04	87	2.27	<1.00	<7.50	0.57	<0.018	<0.20	4.00	0.25	<0.07	<0.12	<5.0	<0.05	1.72	<0.010

Sample Number	Mg Conc. (μg/m³)	Mn Conc. (μg/m³)	Mo Conc. (μg/m³)	Ni Conc. (μg/m³)	P Conc. (μg/m³)	K Conc. (μg/m³)	Se Conc. (μg/m³)	Ag Conc. (μg/m³)	Sr Conc. (μg/m³)
LMTR-01	0.40	<0.04	<0.16	0.17	<5.48	0.50	<3.91	<0.02	0.16
LMTR-02	0.35	<0.04	<0.14	<0.14	<5.02	0.34	<3.59	<0.02	0.04
LMTR-03	1.09	0.05	<0.15	0.23	<5.10	0.95	<3.64	<0.02	0.05
LMWR-01	0.85	0.05	<0.09	0.10	<2.98	0.64	<2.13	<0.01	0.04
LMWR-02	0.54	<0.04	<0.16	0.24	<5.51	0.43	<3.94	<0.02	0.09
LMWR-03	0.21	<0.04	<0.15	<0.15	<5.13	<0.15	<3.66	<0.02	0.01
LMHR-01	<0.70	<0.18	<0.70	<0.70	<24.5	<0.70	<17.5	<0.11	0.13
LMHR-02	0.62	<0.13	<0.52	<0.52	<18.1	<0.52	<13.0	<0.08	<0.02
LMHR-03	0.95	<0.13	<0.53	<0.53	<18.5	<0.53	<13.2	<0.08	0.04
LMHR-04	0.80	<0.12	<0.50	0.52	<17[illegible]	1.12	<12.5	<0.07	0.20

Appendix C cont.
Lewisburg Federal Penitentiary
BGI Cyclone Respirable Air Sample Results for Total Particulate (TP) and Thirty-one Elements

Sample Number	Te Conc. (µg/m³)	Tl Conc. (µg/m³)	Sn Conc. (µg/m³)	Ti Conc. (µg/m³)	V Conc. (µg/m³)	Y Conc. (µg/m³)	Zn Conc. (µg/m³)	Zr Conc. (µg/m³)
LMTR-01	<0.31	<0.78	<0.78	<0.02	<0.02	0.94	3.51	<0.16
LMTR-02	0.29	<0.72	<0.72	<0.01	<0.02	0.40	2.01	<0.14
LMTR-03	<0.29	<0.73	<0.73	0.02	0.03	0.07	3.28	<0.15
LMWR-01	<0.17	<0.43	<0.43	0.02	0.01	0.16	2.56	<0.09
LMWR-02	0.33	<0.79	<0.79	<0.02	<0.02	0.30	1.89	<0.16
LMWR-03	0.39	<0.73	<0.73	<0.01	<0.02	0.13	1.17	<0.15
LMHR-01	<1.40	<3.51	<3.51	<0.07	<0.11	2.52	9.47	<0.70
LMHR-02	1.30	<2.59	<2.59	<0.05	0.10	<0.016	3.37	<0.52
LMHR-03	<1.06	<2.64	<2.64	<0.05	<0.08	0.40	5.29	<0.53
LMHR-04	1.55	<2.50	<2.50	0.16	<0.07	1.45	7.00	<0.50

Appendix D
Lewisburg Federal Penitentiary
Surface Wipe Sample Results for Twenty-three Elements

Sample Number	As (µg/100cm²)	Ba (µg/100cm²)	Be (µg/100cm²)	Cd (µg/100cm²)	Cr (µg/100cm²)	Co (µg/100cm²)	Cu (µg/100cm²)	Fe (µg/100cm²)	La (µg/100cm²)	Pb (µg/100cm²)	Mn (µg/100cm²)	Mo (µg/100cm²)
LMTW-04	<3	9.78	<0.01	0.9	2.90	0.24	410	450	0.13	30	9.1	0.25
LMTW-05	<3	0.08	<0.01	<0.1	0.10	<0.09	1.1	8.4	<0.03	<0.9	0.14	<0.1
LMTW-06	<3	0.32	<0.01	<0.1	0.10	<0.09	0.58	15	<0.03	<0.9	0.19	<0.1
LMTW-07	<3	0.73	<0.01	<0.1	0.27	<0.09	0.80	31	<0.03	3.6	1.2	<0.1
LMTW-08	<3	0.15	<0.01	<0.1	<0.06	<0.09	<0.5	14	0.041	2.0	0.30	<0.1
LMTW-09	<3	4.18	<0.01	0.5	1.60	<0.09	12	220	<0.03	6.2	2.9	<0.1
LMTW-10	<3	0.65	<0.01	0.3	0.54	<0.09	2.9	59	<0.03	2.1	0.76	<0.1
LMWW-05	<3	26.9	<0.01	1.5	7.30	0.58	52	2400	<0.03	760	25	2.0
LMWW-06	<3	10.9	<0.01	1.5	5.70	0.37	47	1400	<0.03	55	15	1.6
LMWW-07	<3	0.33	<0.01	<0.1	0.27	<0.09	<0.5	8.1	<0.03	<0.9	0.12	<0.1
LMWW-08	<3	2.38	<0.01	0.2	5.60	0.10	13	270	<0.03	3.9	2.1	0.39
LMWW-15	<3	0.16	<0.01	<0.1	0.56	<0.09	0.50	8.3	<0.03	<0.9	0.22	0.19
LMWW-16	<3	0.085	<0.01	<0.1	0.08	<0.09	<0.5	3.6	<0.03	<0.9	0.094	<0.1

Sample Number	Ni (µg/100cm²)	P (µg/100cm²)	Se (µg/100cm²)	Ag (µg/100cm²)	Sr (µg/100cm²)	Te (µg/100cm²)	Tl (µg/100cm²)	Sn (µg/100cm²)	V (µg/100cm²)	Y (µg/100cm²)	Zn (µg/100cm²)
LMTW-04	3.8	170	<5	0.89	4.3	<1	<1	33	0.055	1.1	200
LMTW-05	<0.5	<40	<5	<0.03	0.11	<1	<1	<3	<0.04	0.057	<20
LMTW-06	<0.5	<40	<5	<0.03	0.095	<1	<1	<3	<0.04	0.025	<20
LMTW-07	<0.5	<40	<5	0.064	0.62	<1	<1	<3	<0.04	0.087	<20
LMTW-08	<0.5	<40	<5	<0.03	0.11	<1	<1	<3	<0.04	0.87	<20
LMTW-09	3.3	<40	<5	0.38	1.3	<1	<1	8.6	<0.04	0.099	110
LMTW-10	0.66	<40	<5	0.068	0.34	<1	<1	3.3	<0.04	0.048	21
LMWW-05	9.6	120	<5	1.2	6.6	<1	<1	13	1.2	0.79	220
LMWW-06	6.9	150	<5	1.1	4.7	1.1	<1	20	0.72	0.51	480
LMWW-07	<0.5	<40	<5	<0.03	0.20	<1	<1	<3	<0.04	<0.008	<20
LMWW-08	5.5	<40	<5	0.14	1.0	<1	<1	3.2	0.11	0.053	2000
LMWW-15	<0.5	<40	<5	<0.03	0.16	<1	<1	3.6	<0.04	0.010	<20
LMWW-16	<0.5	<40	<5	<0.03	0.069	<1	<1	<3	<0.04	<0.008	<20

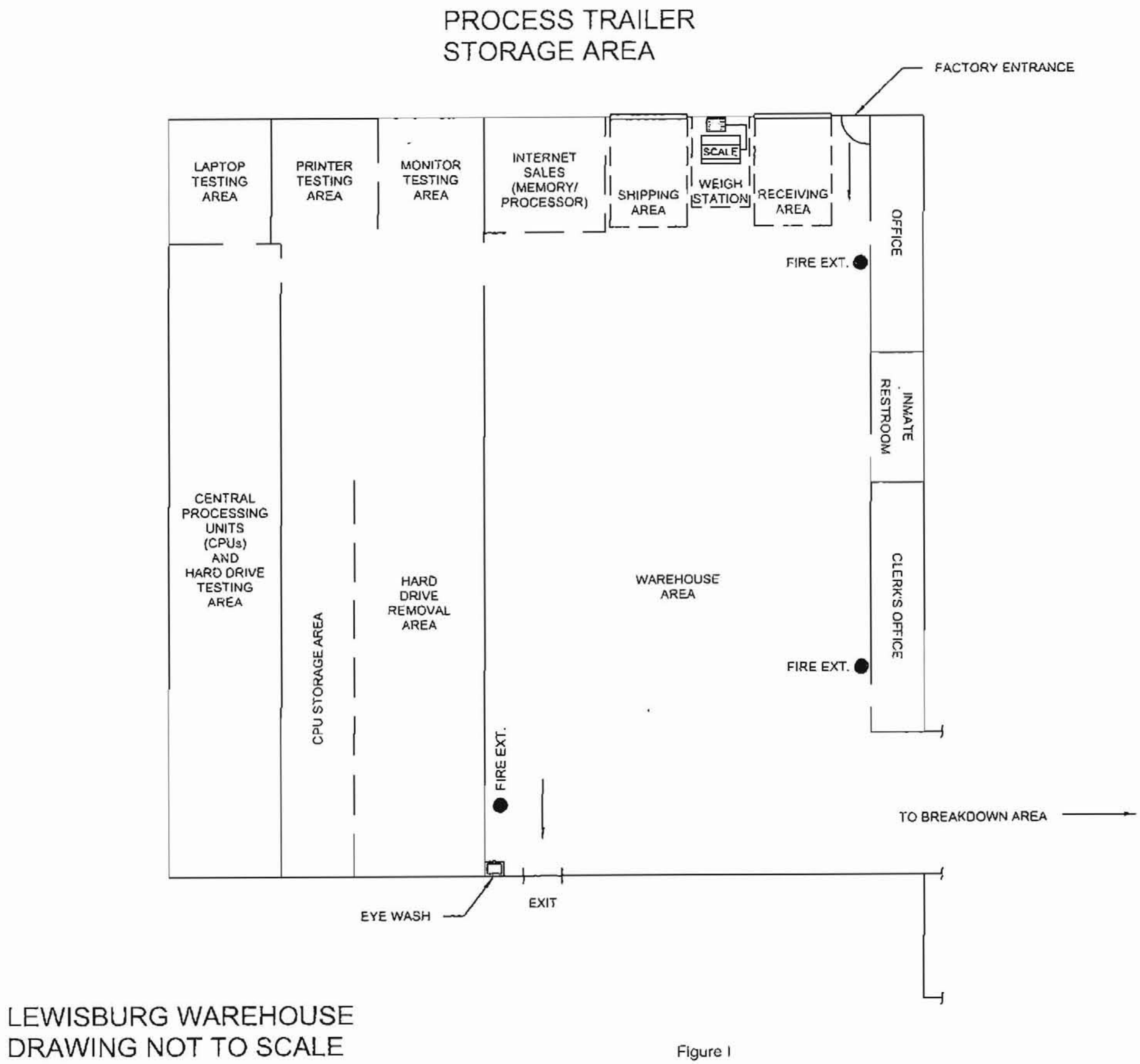
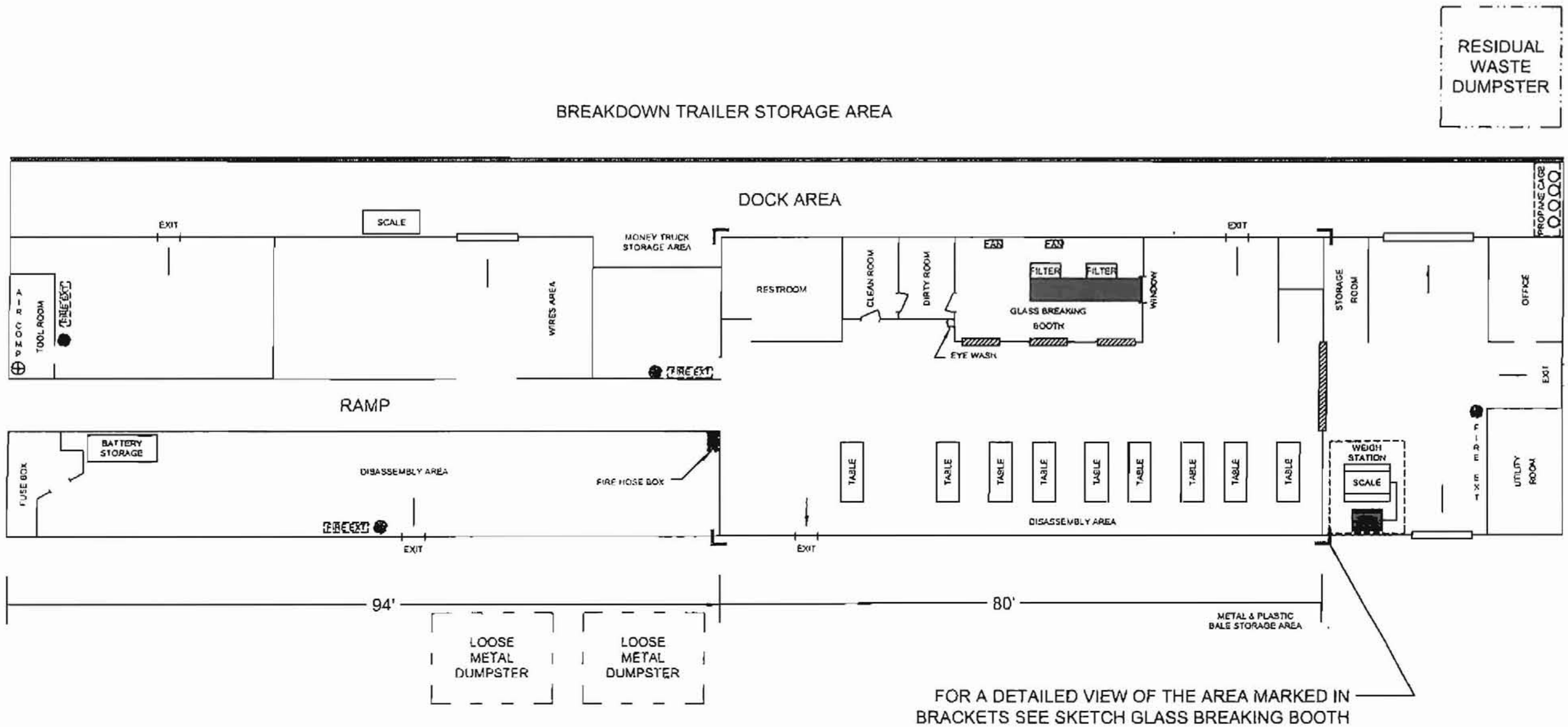
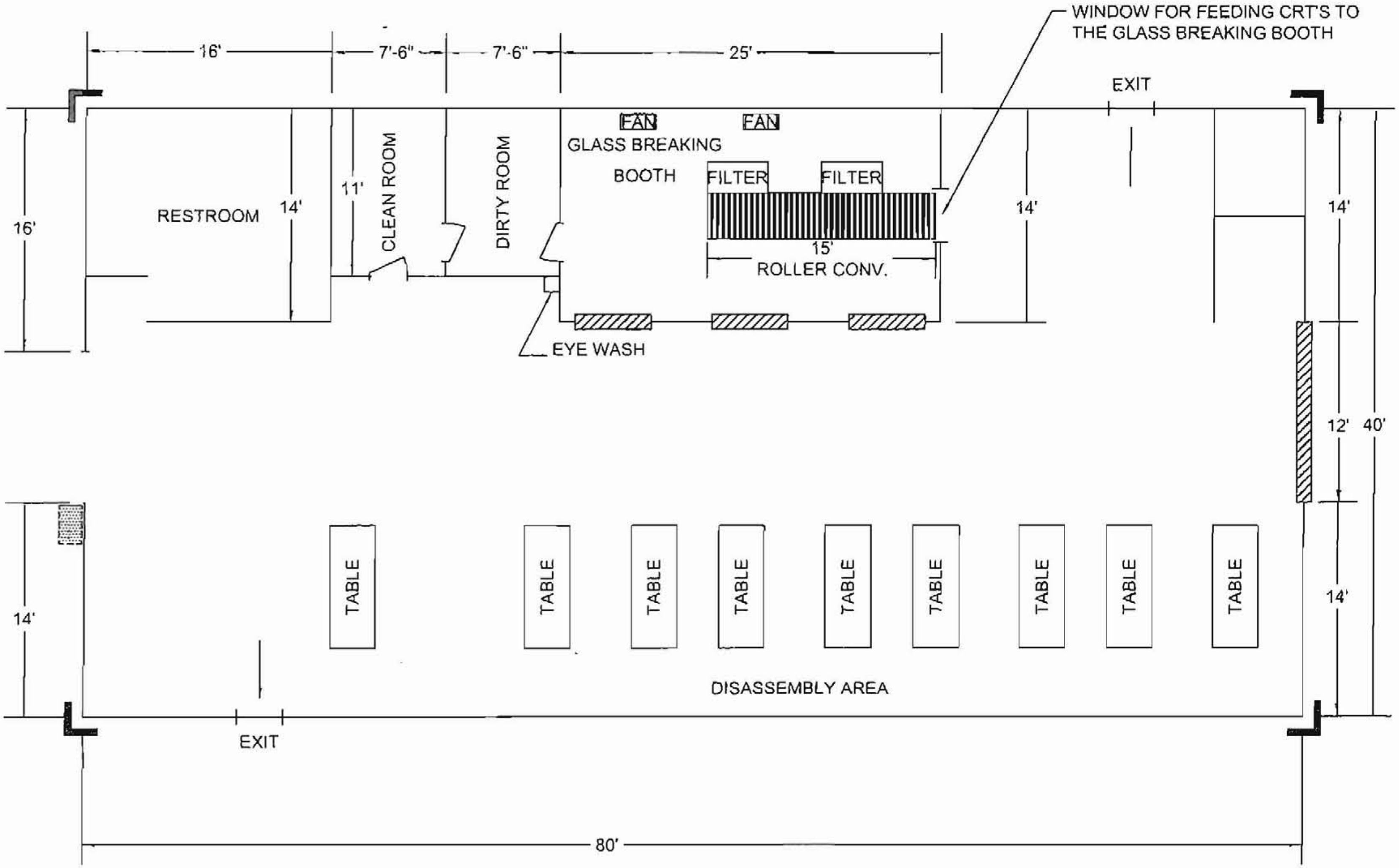

PROCESS TRAILER
STORAGE AREA
FACTORY ENTRANCE
LAPTOP TESTING AREA
PRINTER TESTING AREA
MONITOR TESTING AREA
INTERNET SALES (MEMORY/ PROCESSOR)
SHIPPING AREA
SCALE
WEIGH STATION
RECEIVING AREA
OFFICE
FIRE EXT.
INMATE RESTROOM
CENTRAL PROCESSING UNITS (CPUs) AND HARD DRIVE TESTING AREA
CPU STORAGE AREA
HARD DRIVE REMOVAL AREA
WAREHOUSE AREA
CLERK'S OFFICE
FIRE EXT.
FIRE EXT.
TO BREAKDOWN AREA
EYE WASH
EXIT
LEWISBURG WAREHOUSE
DRAWING NOT TO SCALE

Figure I



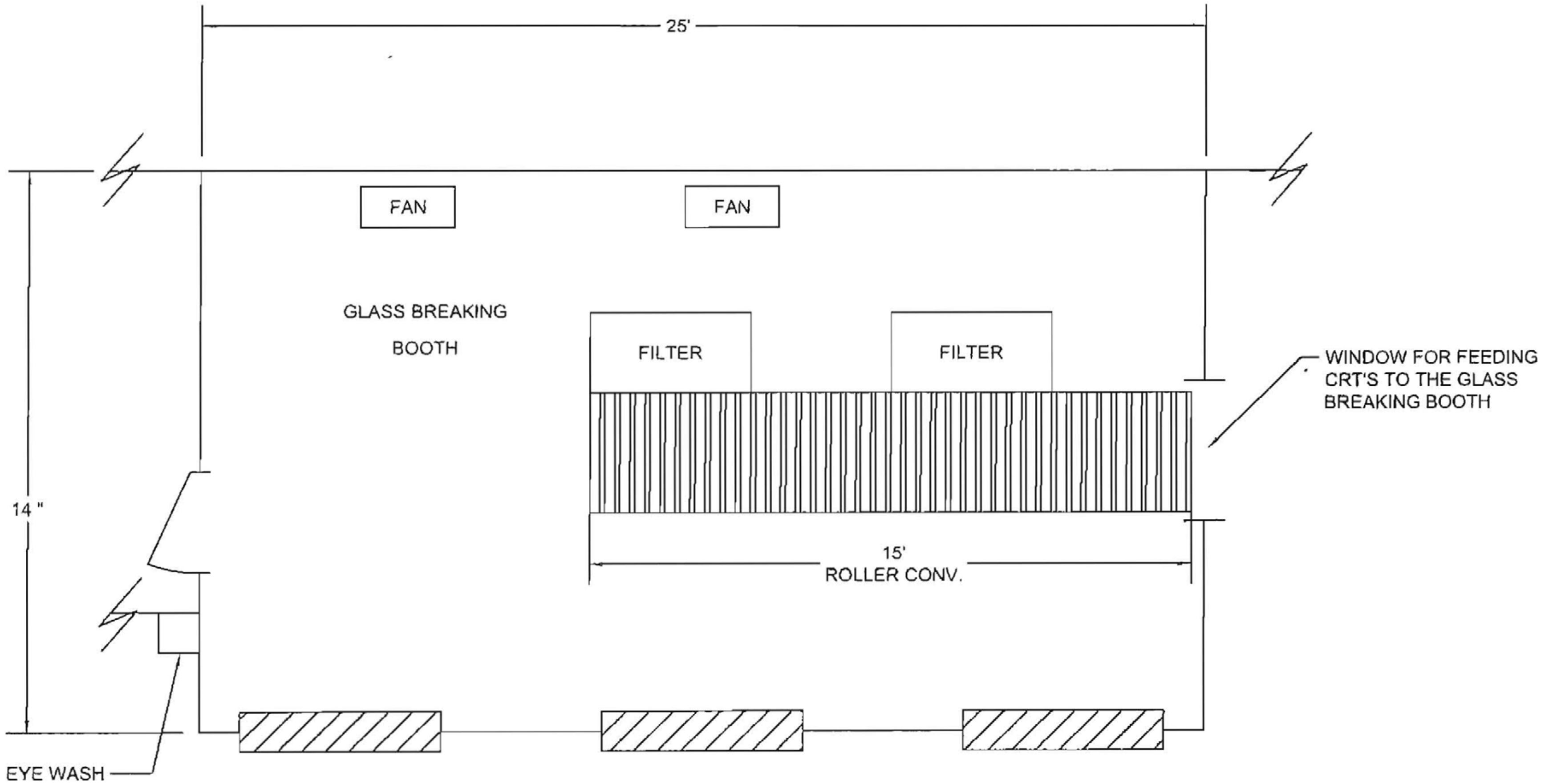
LEWISBURG RECYCLING FACTORY BREAKDOWN AREA
DRAWING NOT TO SCALE

Figure II



GLASS BREAKING BOOTH
DRAWING NOT TO SCALE

Figure III



GLASS BREAKING BOOTH WORK STATIONS
DRAWING NOT TO SCALE

Figure IV