NIOSH HEALTH HAZARD EVALUATION REPORT:

HETA 2001-0081-2877
Glass Masters Neon
Savannah, Georgia

May 2002

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Lynda M. Ewers, Elena H. Page, and Vincent D. Mortimer, Jr. of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by DataChem Laboratories. Desktop publishing was performed by David Butler. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of a Small Neon Sign Manufacturing Shop

In January 2001, NIOSH representatives conducted a health hazard evaluation at Glass Masters Neon. We looked into the owner's concerns about exposures to mercury, lead, and cadmium.

What NIOSH Did

- **We collected air samples and tested them for mercury, lead, and cadmium.**
- **We tested the air in many areas of the shop for mercury vapor.**
- **We wiped surface dust from the work tables and tested it for lead and cadmium.**
- **We reviewed a doctor's report of a test of the sole worker's urine for mercury, lead, and cadmium.**

What NIOSH Found

- **We found that the mercury level in the breathing zone air was above one occupational exposure limit.**
- **We found mercury contamination in some areas of the shop, especially near the air compressor and the floor mat.**
- **We found lead and cadmium on work surfaces but did not detect any in the air.**
- **The report of the worker's urine showed levels of mercury and cadmium below occupational criteria. No lead was detected in the worker's urine.**

What Glass Masters Neon Owner Can Do

- **Improve ventilation in area where mercury is added to the neon bulbs by using a booth and local exhaust ventilation.**
- **Add a mercury trap to the air compressor.**
- **Add mercury traps to ducts carrying exhaust air to the outside.**
- **Make work surfaces and flooring smooth with no cracks so they can be easily cleaned.**
- **Keep containers of disposed mercury-containing glass closed.**
- **Use a special vacuum for mercury to safely clean any spills.**
- **Use a respirator and disposable clothing, including shoe covers and protective gloves.**
- **Keep food, personal supplies, animals, and visitors out of the shop.**
- **Continue medical screening with a doctor who is qualified in occupational medicine.**
- **Measure worker exposures after changes are made to ensure exposures are below guidelines.**

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2001-0081-2877

Health Hazard Evaluation Report 2001-0081-2877
Glass Masters Neon
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Lynda M. Ewers, Ph.D., C.I.H.
Elena H. Page, M.D., M.P.H.
Vincent Mortimer, Jr., M.S., P.E.

SUMMARY

On November 11, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from the owner of Glass Masters Neon in Savannah, Georgia, a small business which manufactures and repairs neon tubes for commercial signs and artwork. The owner, who was also the sole worker, was concerned about the health risks of his exposures to mercury, lead, and cadmium. In response to this request, a NIOSH industrial hygienist conducted a site visit on January 23, 2001. Full-shift, personal-breathing zone (PBZ) air samples for mercury vapor, lead, and cadmium were collected. Real-time air monitoring for mercury vapor was conducted throughout the shop area. Surface wipe samples of the work-tables were collected using moist cloth wipes for analysis of lead and other elements. In addition to the site visit, the owner's medical records were reviewed by a NIOSH physician.

The worker's full-shift time-weighted average (TWA) PBZ air sample was 0.03 milligrams per cubic meter (mg/m^3) for mercury, which is below the Occupational Safety and Health Administration (OSHA) 8-hour TWA permissible exposure limit (PEL) of 0.1 mg/m^3 and the NIOSH recommended exposure limit (REL) of 0.05 mg/m^3, but it is above the American Conference of Governmental Industrial Hygienists' (ACGIH®) threshold limit value (TLV®) 8-hour TWA of 0.025 mg/m^3. Lead and cadmium were not detected in the 8-hour PBZ air sample. Real-time monitoring indicated that mercury contamination was present in the neon glass room, especially in areas where mercury was added to glass tubes. Particularly high air concentrations of mercury were found above a floor mat.

A difference existed between the amount of metals found on two work surfaces from which wipes samples were collected. The location designated as side A in this report was an area where cutting, heating, and other manipulations of the glass were performed; side B was an area where primarily glass cutting occurred. Side A had a much higher range of lead levels (120–170 micrograms per square foot (μg Pb/ft^2) of surface wiped) than side B (16–21 μg Pb/ft^2 of surface wiped). Cadmium levels were also elevated over background (side A = 1.1–2.9 μg Cd/ft^2 of surface wiped; side B = 0.43–0.69 μg Cd/ft^2 of surface wiped.). No occupational standards or recommendations exist for lead or cadmium or the other elements on surfaces.

A medical record of the worker's urine, collected by his private physician, reported a mercury level of 22 micrograms per gram creatinine ($\mu g/g$ creat.), which is below the ACGIH's biological exposure index (BEI®) of 35 $\mu g/g$ creat. No lead was detected in the worker's urine. Urinary cadmium was 0.9 $\mu g/g$ creat., which is consistent with levels found in the general population.

Airborne mercury concentrations exceeded the ACGIH-TLV®. Mercury in the air samples was largely the result of volatization of mercury from surface contamination rather than process aerosolization. Air concentrations of lead and cadmium were low, although there was lead and cadmium contamination of work surfaces. Recommendations were made to clean the shop and prevent further contamination by installing a hood with local exhaust ventilation, adding mercury trapping devices, and improving work practices.

Keywords: SIC Code 3993 (Signs and Advertising Specialties) neon signs, mercury, lead, glass, local exhaust ventilation, decontamination procedures, small business.

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INTRODUCTION

On November 11, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from the owner of Glass Masters Neon in Savannah, Georgia, a small business which manufactures and repairs neon tubes for commercial signs or artwork.

The owner, and also the sole worker, of Glass Masters Neon was concerned about possible health effects related to his exposures to mercury, lead, and cadmium. In response to this request, a NIOSH industrial hygienist conducted a site visit on January 23, 2001. Full-shift, personal-breathing zone (PBZ) air samples for mercury, lead, and cadmium were collected. Real-time air monitoring for mercury was conducted throughout the shop area. Wipe samples of the work tables were collected using moist cloth wipes for analysis of lead and other elements. In addition to the site visit, the worker's medical records, including a urine heavy metals screening, was reviewed by a NIOSH physician.

BACKGROUND

Neon tubes, more correctly called vacuum electric discharge tubes, are sealed glass cylinders containing an inert gas (not always neon) under low pressure. The gas emits a brilliant color when excited by an electric discharge. The tubes are manufactured from purchased glass tubing, which the worker heats in an open flame until it is malleable enough to be bent into the desired shape. Electrodes are sealed into the ends of the tubes, and a vacuum is applied to partially evacuate the tube through a smaller, temporary glass duct. Depending upon the color desired, either neon (red) or argon (blue) or a mixture of the two is added to the tube. Some commercial tubes have interior coatings to re-emit light and thereby permit a wider range of colors than are available from the excitation of gases alone. Often a small drop of mercury may be added to enhance the brilliance of the color. A high voltage is applied across the electrodes until the temperature reaches over 500°F to remove impurities from the glass.[1] Finally, the lamp is sealed when the temporary duct is removed. Under normal operating conditions, the lamp glows when it receives 2,000 to 15,000 volts of electricity.[2]

Depending upon commercial demand, the owner of Glass Masters Neon manufactured signs at least five days a week from 9:00 a.m. to 5:30 p.m. Glass Masters Neon produced its speciality product often, but not exclusively, for a larger sign company, which may install the neon tubes within other parts of signs, e.g., the tube may provide back-lighting for metal letters. Sometimes, neon tubes are mounted and displayed without other components, and then may be sold directly to the public by Glass Masters Neon. The owner also repaired used neon glass fixtures, a process that may require replacement of a cracked section of glass or damaged electrodes.

The physical facility consisted of one rented room (approximately 320 square feet) constructed largely of plywood within a building containing a larger sign-manufacturing company. The flooring in the room was wood overlaying concrete with a small rug located near the corner of the room where most of the mercury was used. General ventilation of the neon shop was supplied by a ceiling-mounted propeller fan, which vented to the larger sign manufacturing facility. It was noted that the ceiling fan was not operating efficiently because it was not fitted tightly within the opening designed for it in the ceiling; i.e., there was an opportunity for the air to be short-circuited due to the gap around the fan. In addition, a window air conditioner, installed in the plywood wall, cooled the work area.

Work practices were variable depending upon the types of work available. In general, the manufactured glass tubing was bent into appropriate shapes over gas burners in the center of the room. Glass cutting was performed on the table along the sides of the room. A drop of mercury was added, suction was applied, and the voltage was applied to the tubes in one corner of the room. The artisan did not wear any respiratory or skin protection during production. When pieces of glass, possibly contaminated with mercury, were discarded, they were placed in an open trash container. The owner reported that when the air compressor (used to create the low pressures within the neon tubes) was given its yearly cleaning about a teaspoon of mercury was removed from its oil trap. However, the quantities of mercury present on-site were small because of the small quantity used in each lamp. The owner of Glass Masters Neon estimated that he used about one pound of mercury per year.

Several possible hazards have been reported in the neon glass tube manufacturing environment.[3] Some hazards are chemical in nature: the glass tubing contains lead to aid in softening the glass when heated, the inert gas within the tube often has mercury added to create a more intense color; and the interior coating of the tubes may contain cadmium compounds or other metallic compounds to produce a greater range of colors. In addition, physical hazards may be present due to the high voltages applied to the tubes, and near-ultraviolet radiation (UVA) passing through the glass.

According to the artisan, the day of the NIOSH site visit was typical. Three neon tubes, including the repair of one which had cracked glass, were worked on that day. Tasks included most phases of the production process: cutting of glass tubing, bending of glass over a flame, sealing of electrodes within the tube, introduction of neon gas into tube, injection of mercury, and application of a high voltage to the tube.

METHODS

A full-shift PBZ sample for mercury was collected using tubes containing 200 milligrams (mg) of solid sorbent (SKC Anasorb® C 300) at a nominal flow rate of 200 milliliters per minute (mL/min). The tubes were analyzed using NIOSH Method 6009.[4] In addition, one full-shift, PBZ sample for lead and other metals was simultaneously collected using a closed-face, mixed cellulose ester filter at a nominal flow rate of 2 liters per minute (L/min). This latter sample was digested and analyzed according to NIOSH Method 7300, using an inductively coupled plasma (ICP) emission spectrometer.[4] The ICP provided results for not only the lead but also 27 other elements, including cadmium.

A Jerome® Gold Film Model 411 mercury vapor analyzer was used to obtain real-time measurements of mercury concentration at various locations within the neon glass manufacturing room and immediately outside the room entrance but within the larger sign manufacturing facility.

Wipe samples for lead in surface dust were collected at two locations on the work surfaces using moist cloth wipes of two types (Ghost wipes™ and Wash'n Dri®). A comparison of the two brands was of scientific interest for possible modifications to present recommended techniques. Collection of samples was done in accord with NIOSH Method 9100, with the exception that six vertical S-strokes, rather than the three recommended, were taken within a 10-inch x 10-inch template. The increased number of strokes was considered necessary because the Ghost wipe is smaller than the more commonly used Wash'n Dri recommended in the NIOSH method. Sample analysis for both types of wipes followed NIOSH Method 7300, using an ICP emission spectrometer, which analysed for 25 different elements, including lead and cadmium but not mercury. However, digestion of the two types of wipes was different. Wash'n Dri wipes were refluxed on hotplates with concentrated nitric acid and water; Ghost wipes were digested in concentrated nitric acid in a microwave.

A VelociCalc® Plus hot wire anemometer (TSI Inc., St. Paul, Minnesota) was used to measure temperature, relative humidity, and air flow in the room. Smoke tubes allowed qualitative observations of air movement.

EVALUATION CRITERIA

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

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[5] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[6] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[7] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

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, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

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

For some substances, a biological marker exists that can be used in workplace exposure investigations or studies. In order to measure these markers, a biologic specimen (e.g., exhaled breath, blood, or urine) must be obtained from the participating worker. A biological marker can measure acute or chronic exposures, provide an estimation of the dose of a substance in the body or an organ, integrate exposures from more than one exposure route into a dose estimation, measure damage to a target cell and/or organ, or indicate the presence of a disease process. Two sources of reference values for biological markers are the ACGIH Biological Exposure Indices (BEIs®)[6] and the various guidelines developed by the World Health Organization (WHO). In addition, the clinical medicine literature contains reference values for tests used by practicing physicians.

Mercury Exposure-Related Health Effects and Exposure Criteria

Since metallic mercury is volatile at ambient temperatures, the majority of human exposure is by inhalation. In fact, inhalation exposure accounts for more than 95% of the absorbed mercury dose, whereas dermal exposure and ingestion contribute only 2.6% and 0.1% to this dose, respectively.[8] Eighty percent of inhaled mercury is retained in the lungs, while the remainder is exhaled. Due to its high degree of lipophilicity (attraction to fat), 74% of inhaled mercury rapidly diffuses across the alveolar membranes into the blood.[9,10,11] This lipophilicity also aids in its distribution to the many tissues and organs throughout the body; it can readily cross the blood-brain and placental barriers, and has a high degree of affinity for red blood cells. Mercury absorbed into the blood and other tissues is quickly oxidized into divalent mercury via the hydrogen peroxide–catalase pathway, and accumulates in the renal cortex of the kidney.[8,12] After a substantial exposure, mercury reaches peak levels within the various tissue reservoirs within 24 hours, except in the brain where peak levels are not reached for 2–3 days.[8,13] In fact, more than 50% of the initially absorbed dose is deposited in the kidneys, with the brain, liver, spleen, bone marrow, muscles, and skin being minor reservoirs for absorbed mercury.[14]

The major pathways for elimination of mercury from the body are via the feces and the urine. The half-life for the whole body is 40–60 days, while the half-life for the lungs is 2 days, the blood is 2–4 days, the brain is 21 days, and the kidneys is 40–60 days.[8] Thus, urine mercury concentrations reflect chronic exposure, while blood mercury concentrations reflect only recent exposure. Urinary mercury levels in the general population generally are less than 5 micrograms per gram of creatinine (µg/g creat.)[15,16] or 10 micrograms per liter of urine (µg/L) to 20 µg/L.[17,18,19] Symptoms are generally not present until levels of 200 to 300 µg/L are reached.[15,16,17,18] The World Health Organization (WHO) recommends a threshold level of 50 µg/g creat.,[20] and ACGIH has set a Biologic Exposure Index (BEI) of 35 µg/g creat.[6] Background mercury levels in the blood are less than 1 µg/dL to 1.5 µg/dL.[16,19]

The lung is the target organ of acute, high level exposures to mercury vapor. Effects include cough, shortness of breath, chest pain, interstitial pneumonitis, bronchiolitis, and pulmonary edema. Nausea, vomiting, fever, stomatitis (sores and blisters around mouth), and gingivitis (inflammation of gums) can also occur.

The nervous system is the target organ of chronic exposures to mercury vapor. Effects include emotional lability, shyness, insomnia, irritability, and memory loss. This symptom complex is called erethism. Tremor and peripheral neuropathy can also occur, as can stomatitis and gingivitis. Other symptoms include fatigue, weakness, loss of appetite, and headache. These symptoms are usually reversible with cessation of exposure.[15,16,17] Mercury accumulates in the kidneys, but rarely produces significant renal injury.[15,16]

OSHA currently enforces a PEL for mercury vapor of 0.1 mg/m^3 as an 8-hour TWA.[7] (Legally, the PEL is designated as a ceiling value, but a directive has been issued by OSHA stating that this designation is incorrect and the value is, in fact, a time weighted average.[21] We are following the directive in this report.) The NIOSH RELs for mercury vapor are 0.05 mg/m^3 as a TWA exposure for up to 10 hours per day, 40 hours per week and a ceiling level of 0.1 mg/m^3, which should not be exceeded at any time. NIOSH and ACGIH have a skin notation, indicating that skin exposure (with vapors or direct skin contact) can be a significant contributor to the overall worker exposure.[5,6] The ACGIH TLV for mercury is 0.025 mg/m^3 (TWA exposure, 8 hours per day, 40 hours per week).

Lead Exposure-Related Health Effects and Exposure Criteria

Lead adversely affects a number of organs and systems in the human body. The four major target organs and systems are the central nervous system, the peripheral nervous system, the kidney, and the hematopoietic (blood-forming) system.[12] Inhalation or ingestion of inorganic lead can cause a range of symptoms and signs including loss of appetite, metallic taste in the mouth, constipation, nausea, colic, pallor, a blue line on the gums, malaise, weakness, insomnia, headache, irritability, muscle and joint pains, fine tremors, and encephalopathy. Lead exposure can result in distal motor neuropathy ("wrist drop"), anemia, proximal kidney tubule damage, and chronic kidney disease.[22,23] Lead exposure is associated with fetal damage in pregnant women.[12,23] Finally, elevated blood pressure has been positively related to blood-lead levels.[24,25]

Under the OSHA general industry lead standard (29 CFR 1910.1025), the PEL for airborne exposure to lead is 0.050 µg/m^3 (8-hour TWA).[26] The standard requires lowering the PEL for shifts exceeding 8 hours, medical monitoring for employees exposed to airborne lead at or above the action level of 30 µg/m^3 (8-hour TWA), medical removal of employees whose average blood lead level (BLL) is 50 µg/dL or greater, and economic protection for medically removed workers. Medically removed workers cannot return to jobs involving lead exposure until their BLL is below 40 µg/dL. ACGIH has a TLV for lead of 50 µg/m^3 (8-hour TWA), with worker BLLs to be controlled at or below 20 µg/dL, and designation of lead as an animal carcinogen.[6]

Cadmium Exposure-Related Health Effects and Exposure Criteria

Early symptoms of cadmium 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 cadmium 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.[23] Long-term exposure effects of cadmium may include loss of the sense of smell, ulceration of the nose, emphysema, kidney damage, mild anemia,[23] an increased risk of cancer of the lung, and possibly of the prostate.[27,28] The OSHA PEL (29 CFR 1910.1027) for cadmium is 5 µg/m^3 TWA.[29] ACGIH has a TLV for cadmium of 10 µg/m^3 (8-hour TWA), with worker cadmium blood level to be controlled at or below 5 µg/dL and urine level to be bleow 5 µg/g creat., and designation of cadmium as a suspected animal carcinogen.[6] NIOSH recommends that cadmium be treated as a potential occupational carcinogen and that exposures be reduced to the lowest feasible concentration.[30]

RESULTS

Medical

A review of the worker's medical records revealed no documentation of symptoms related to occupational exposures. A heavy metal screen on urine collected on 10/11/00, showed a urine mercury level of 22 µg/g creat., which is below the BEI. Urinary cadmium was 0.9 µg/g creat., which is consistent with levels found in the general population.[16] No lead was detected in the worker's urine. While blood is the preferred method used to monitor recent lead exposure, the fact that no lead was detected in urine indicates there was not excessive recent exposure to lead. However, the lead measurement may not be indicative of past exposures or may not correlate with the total body burden of lead.

Industrial Hygiene

The full-shift TWA personal air sample had a concentration of 0.03 mg/m^3 mercury vapor, which is below the OSHA PEL of 0.1 mg/m^3 and the NIOSH REL of 0.05 mg/m^3, but above the ACGIH TLV 8-hour TWA of 0.025 mg/m^3. Lead and cadmium were not detected in the 8-hour personal air sample. The minimum detectable concentrations were 0.04 µg Pb/m^3 and 0.008 µg Cd/m^3 for this sample. The averages of three real-time samples each taken in various locations using the Jerome mercury vapor analyzer are presented in Table 1. Real-time monitoring indicated that mercury vapor up to 0.108 mg/m^3 was present in the neon glass room, especially in areas where mercury was added to glass tubes (Side A). The highest concentrations of mercury vapor (0.108 mg/m^3) were found above a floor mat on side A. While this area air sample was obtained near the floor and not in the breathing zone of the artisan, it exceeded the NIOSH recommended ceiling value of 0.1 mg/m^3.

The test of the two types of surface wipes (Wash'n Dri versus Ghost Wipes) revealed no differences between the two types with regard to the amount of Pb that was collected from a standard area (lead loading). However, a marked difference existed between the two work surfaces sampled (see Table 2). The location designated as side A in this report was an area where cutting, heating, and other manipulations of the glass were performed; side B was an area where primarily glass cutting occurred. Side A had a much higher range of lead levels (120–170 µg Pb/ft^2 of surface wiped) than side B (16–21 µg Pb/ft^2 of surface wiped). Cadmium levels were also elevated over background (side A = 1.1–2.9 µg Cd/ft^2 of surface wiped; side B = 0.43–0.69 µg Cd/ft^2 of surface wiped.) Other common elements that were found to be elevated in the wipe samples included the following: alumimum, iron, magnesium, phosphorus, zinc, cobalt, chromium, manganese, nickel, and other less common elements. No occupational standards or recommendations exist for lead, cadmium or other elements on surface wipes.

DISCUSSION

On the day of the NIOSH site visit, PBZ air sampling revealed a mercury concentration that was below the OSHA PEL and NIOSH REL but above the ACGIH-TLV®. One important limitation of these data is related to the fact that temperature has an effect on the amount of mercury vapor in the air. For example, studies have shown that increasing the temperature of mercury from 75°F to 90°F almost doubles its air concentration (from 18 mg/m^3 to 34 mg/m^3).[31] The temperature recorded in the air-conditioned neon shop the day of sampling averaged 73°F, but, according to the owner, that temperature is often exceeded during the summer. Consequently, even with no increase in mercury surface contamination, it is reasonable to expect seasonally elevated air concentrations in the work area. When a tube containing mercury is heated in a flame, such as might occur if a broken neon tube was being repaired, mercury might reach excessive concentrations in the breathing zone. With these considerations, it is prudent to reduce general mercury exposures. OSHA has provided occupational safety and health guidelines for reducing mercury vapors. Recommendations include engineering controls, administrative controls, and use of personal protective clothing and equipment (including respirators); specific recommendations are made in the following sections of this report.[32]

CONCLUSIONS

The primary concern at this worksite was the presence of mercury, which is volatile at room temperature. Mercury can enter the body through the skin, though the primary route of exposure is inhalation. Residual mercury on surfaces may be a significant contributor to airborne mercury levels. Decontamination of mercury requires special procedures and skin protection. Full-shift PBZ concentrations of lead and cadmium were low at the shop, although there was contamination of work surfaces with these and other elements. It is possible that this contamination might be due to the breaking of the glass on these surfaces. Sealing and cleaning these surfaces requires some precautions because the lead or cadmium can be transported to the mouth through hand or food contact. However, lead and cadmium are not volatile at room temperature.

Medical record review from the single employee revealed that urine concentrations of mercury and cadmium were below occupational criteria, and lead was not detected.

RECOMMENDATIONS

1. Engineering controls. Engineering controls are generally the most effective way to reduce exposures, and ventilation can be improved at this shop. The existing ceiling fan is not an effective method to remove contaminants because the air is not cleaned of mercury vapor before it is released into the surrounding work area. Use of smoke tubes during the site visit demonstrated that the ceiling fan provided little air movement at the position of the worker. Even if air leaks around the fan were sealed to improve its efficiency, the fan's overhead location was such that any resulting movement of toxic vapors would be pulled through the worker's breathing zone. Instead, there should be a properly designed ventilation hood, which both encloses the process and provides local exhaust ventilation (LEV) to remove the contaminant at the source before it mixes with the room air. The hood would also provide employee protection from the mercury vapor as well as eye and skin protection from breaking glass when installed in the area where mercury is added to the tubes and the high voltage is applied.

We suggest that the owner consult with an experienced HVAC professional to adapt the following general plans into a specific design for this work space. Although the operation does not involve paint or spraying, a small table-top booth design, similar to the paint spray booths present in drawing VS-75-02 in the ACGIH Industrial Ventilation Manual,[33] may be a practical way of providing protection. (See Figure 1.) The booth needs to be approximately 12 inches wider and 12 inches higher than the work size needed. In setting the height of the top of the booth, the position and the height of the worker should be considered. A typical booth is shown in the figure, but a differently sized booth will work as long as adequate ventilation is maintained. An added shatterproof barrier at the entrance to the hood could be utilized for physical protection when high voltages are applied during testing of the glass tubes. For a small booth, a minimum flow rate of 150 cubic feet per minute (CFM) for each square foot of open area is recommended.

The outlet of the booth must exit through the roof, sufficiently distant and downwind from any air intakes so that exhausted vapors do not re-enter the building. Use a rain protection design similar to Figure 2, rather than an obstructing rain cap, and size the diameter of the stack so that the discharge velocity is 2,500 feet per minute.[34] Notice that there is a baffle (dashed line in the figure), angled within the booth, which aids in the proper air flow distribution. Booths using "Paint Collector" filters, which reduced the area through which air was exhausted at the back of the booth to approximately half the open area at the face of the booth, have been effective without a baffle.

After the addition of local ventilation, the general ventilation within the room must be balanced with make-up air. The owner of this shop was concerned with mercury being deposited in the outside environment, which was the reason he did not wish to vent the exhaust system to the outdoors. However, typically an indoor hazard is greater because the workspace is enclosed, and, with appropriate air cleaning, the ventilation can be to outdoor areas in accordance with state and local requirements. All air exhausting the building should be routed through a mercury scrubbing device, such as using a sulfur or iodine impregnated carbon pack or by bubbling the air into a tank that contains a mercury complexing agent in conjunction with a de-mister. Mercury tends to condense in ventilation ducts, and this condensation should be controlled by having smooth-walled ducts that slope toward a gravity collection trap.[35]

Real-time monitoring for mercury corroborated information provided by the owner that mercury accumulated in the oil of the air compressor and was an important source of contamination in that area. Because the compressor creates a negative pressure within the tube, the mercury within it will volatize more rapidly than at normal room pressure. A mercury gravity trap can be installed before the air enters the compressor, which would help prevent the contamination of the compressor and allow easy monitoring of mercury accumulation and cleaning.

2. Work practices. Changes in work practices and the work environment can aid in minimizing mercury exposures.[36] For example, simply maintaining a low room temperature (below 68°F) will reduce volatization of mercury and, therefore, reduce exposure. However, because it is more effective in the long-term to prevent mercury contamination, physical modifications to the environment will make prevention easier. Work table surfaces, especially any joints, should be impermeable (stainless steel), with a drainage trough along the front surface sloped to a collection bottle and a lip along the other sides to prevent spillage. It is necessary for floors to be smooth and impermeable (epoxy, polyurethane, vinyl sheeting) so that the mercury is not absorbed into them; wood, carpeting or doormats should be avoided. Dark colors are advised to more easily see mercury if accidentally spilled. Caulk around table legs, joints between floors and walls, or other crevices. Store broken glass, possibly contaminated with mercury in a receptacle that does not allow mercury vapors or liquid to escape into the room. Do not repair any used neon tubes that may contain mercury.

It is important to clean any metal contamination promptly. Cleaning procedures which might release mercury into the air, such as vacuuming or dry sweeping should be avoided. A special mercury vacuum that has a gravity trap is commercially available for cleaning small mercury spills. Commercial cleaning kits specifically for mercury are available and convenient, but not necessary, especially if precautions are taken to make spills easy to clean. Beads of mercury can be maneuvered on a smooth surface with a disposable squeegee until they are collected with a dust pan. Smaller mercury drops can be collected within a syringe or an eye dropper. Powdered zinc can amalgamate small amounts of mercury, thereby preventing it from vaporizing. The effectiveness of clean-up procedures can be confirmed with powdered sulfur, which when sprinkled in a mercury contaminated area will turn from yellow to brown.

3. Personal Protective Clothing and Equipment. Both mercury and lead have the potential to be carried into vehicles or the home on work clothes and shoes; such items should not be carried outside of the workplace and should be disposable or washed by a commercial firm that is aware of the nature of the potential contamination. Some examples of materials that provide sufficient protection (mercury breakthrough times of greater than 480 minutes) are Safety4 4H® or Dupont Saranex-23® 2-ply aprons and non-slip foot covering.[37] Pets should not be allowed entry into areas where contamination may be present. Food, beverages, and tobacco products should not be permitted in the work areas. Because mercury can move through the skin into the body, protective gloves are important if skin contact with the mercury is possible. Rubber gloves are not sufficiently protective with mercury; brands such as Saranex ™ and 4H™ are required and have been demonstrated to provide protection for greater than eight hours of mercury contact.[38] Some of these glove materials may not be sufficiently flexible but often a tight fitting neoprene glove over the protective glove will permit finger movement. Finally, a continuous, fixed, mercury monitor will provide assurance that mercury concentrations are at safe levels and should be set at half the PEL. A good source of additional information and a list of commercial firms that provide various products to monitor, control, or clean-up mercury can be found at the website of the New Jersey Department of Health and Senior Services.[36]

If these improvements are made to the shop, we anticipate that mercury exposures should be reduced. At the time of NIOSH sampling, the PBZ exposures exceeded the ACGIH TLV. Thus, a respirator with a cartridge specific for mercury should be worn until the improvements are made and a re-evaluation indicates that worker exposures are reduced below occupational exposure limits. If respirators are used, a complete respiratory protection program should be instituted that complies with the requirements of OSHA's Respiratory Protection Standard [29CFR 1910.134]. A program must include respirator selection, a medical evaluation, training, respirator fit testing, periodic workplace monitoring and regular respirator maintenance, inspection, and cleaning.

4. Environmental Considerations. It appears unlikely that a major mercury spill would occur in this shop because the owner reported that a total of about one pound of mercury was used per year and only a small vial of mercury was on hand. An employer who releases one pound or more of mercury within a 24-hour period in a manner that will expose persons outside the facility must notify the National Response Center immediately (800-424-8802 or 202-426-2675 in Washington, D.C.)

Finally, some consideration should be given to disposal of mercury-contaminated waste glass. According to the owner, this neon sign manufacturing facility generates much less than 100 kilograms (220 pounds) of hazardous waste per calendar month, and, thus, is categorized as a conditionally-exempt small quantity generator of hazardous waste (CESQG).[39] Federal regulations state that CESQGs are not subject to hazardous waste management standards and may choose to send their wastes to a municipal, solid-waste landfill or other facility approved by the state for the management of industrial or municipal non-hazardous wastes [40CFR 261.5]. Streamlined regulations took effect on December 30, 1996, in Georgia, which make voluntary recycling of waste mercury-containing light bulbs an option for CESQGs.[40] Commercial recycling programs are readily available from laboratory safety supply companies. They provide technical advice and usually provide proper disposal containers, which should be used in place of the open container observed at the time of the site visit. We encourage the owner to use one of these programs to dispose of the waste.

5. Medical Evaluations. Because there is a continuing potential exposure to mercury and other metals in your workplace, we recommend that you continue receiving medical evaluations from a qualified occupational medicine physician. Environmental sampling is used to guide medical screening. Medical screening complements environmental sampling and can help detect exposure to mercury, lead, cadmium or other potential occupational hazards. Occupational physicians are trained to perform workplace surveillance. One way to locate occupational physicians in your area is through the Association of Occupational and Environmental Clinics at 202-347-4976 or www.aoec.org. Another source is the American College of Occupational and Environmental Medicine at 847-818-1800 or www.acoem.org. Additional information regarding owner responsibilities if employees are hired at this shop are included in the Appendix.

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Table 1
HETA 2001-0081
Glass Masters Neon
Real-time measurements of mercury vapor concentrations

Location of sample	Hg vapor milligrams/cubic meter
Outside entrance door to neon glass room, but within the larger sign facility	0.001
Immediately inside entrance door of neon glass room	0.024
Side A. Near air compressor, close to the floor	0.037
Side A. Over work table where Hg was added to the tubes	0.049
Side A. Over a floor mat under the work table where artisan stands while adding Hg to tubes	0.108*
Side A. Over floor under the work table where artisan stands while adding Hg to tubes	0.071
Side B. On paper protector on work table opposite where Hg was added to tubes	0.022
Side B. Over wood table opposite where Hg was added to tubes	0.019
Side B. Over floor under work table opposite the side where Hg was added to tubes	0.015
Side B. Over floor under work table opposite the side where Hg was added to tubes	0.023

* Exceeds the NIOSH REL ceiling value of 0.1 mg/m^3.

Table 2
HETA 2001-0081
Glass Masters Neon
Lead loading collected using two sequential wipe samples on work surfaces

Side A (Micrograms Pb/ft^2)	Side B
170	21
140	16
160	19
120	21

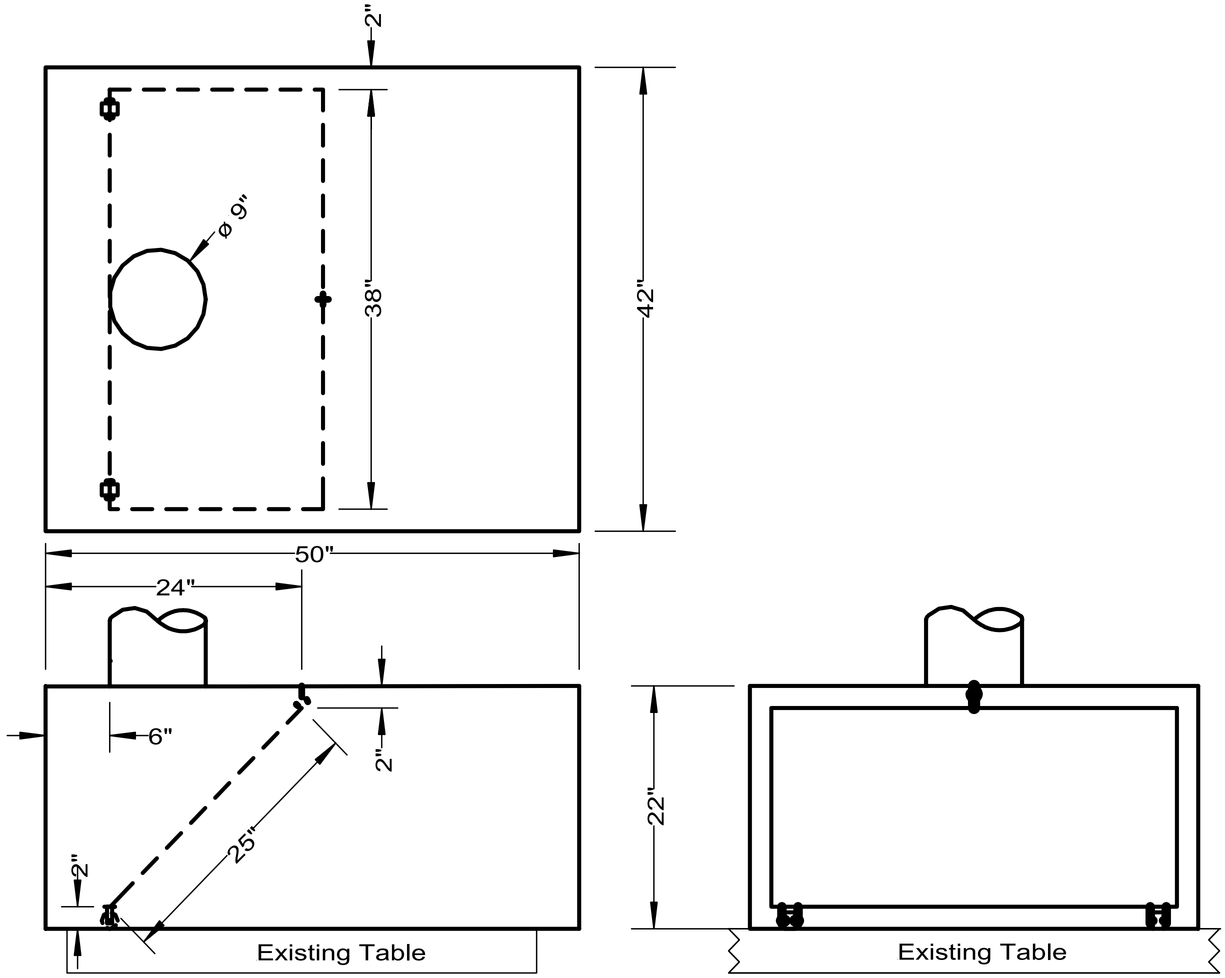

Figure 1
HETA 2001-0081
Glass Masters Neon
Design of a small booth

Adapted from
American Conference of Governmental Industrial Hygienists (ACGIH®), *Industrial Ventilation: A Manual of Recommended Practice, 23rd Edition*. Copyright 1998. Reprinted with permission.

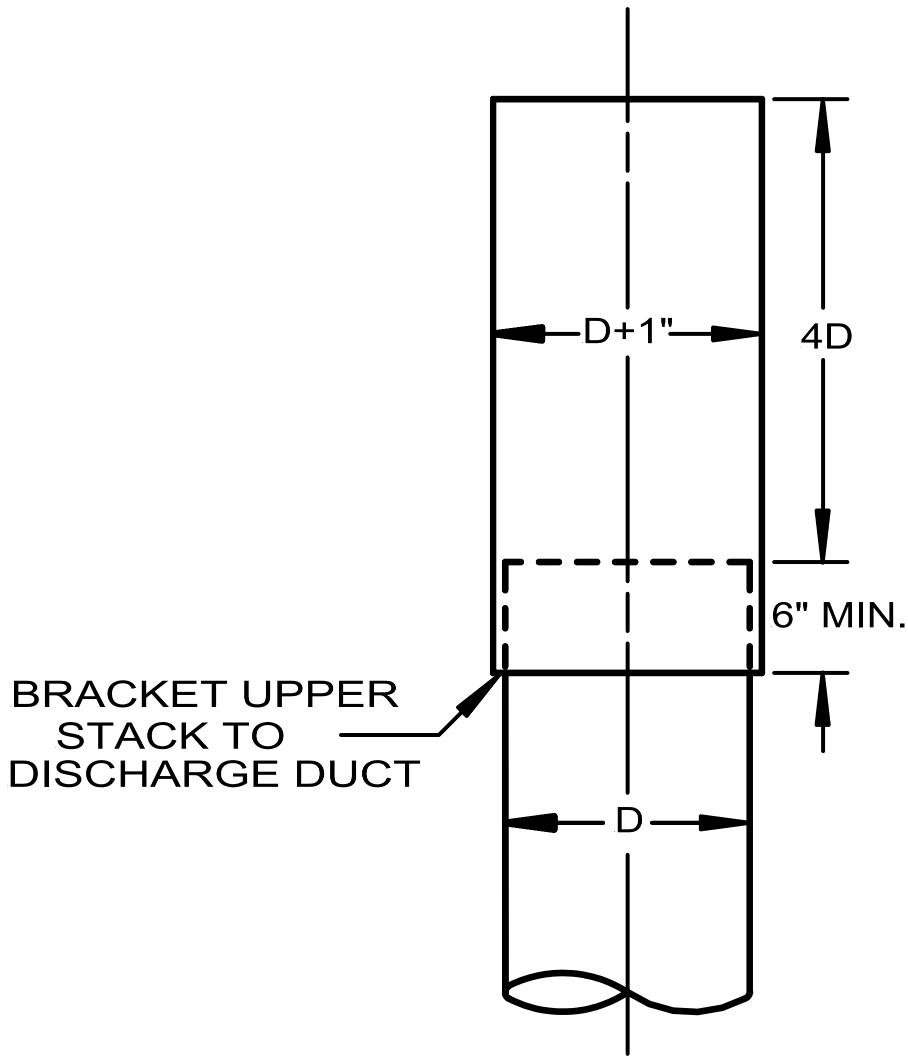

Figure 2.

HETA 2001-0081
Glass Masters Neon
Recommended rain protection stackhead design

From: American Conference of Governmental Industrial Hygienists (ACGIH®), *Industrial Ventilation: A Manual of Recommended Practice, 23rd Edition*. Copyright 1998. Reprinted with permission.

APPENDIX

We recognize that you do not have employees at this time, but, if you expand your operations in the future, the following guidelines should be helpful. Medical surveillance requirements are typically triggered by results of environmental sampling. While NIOSH does not have an official recommendation regarding biological monitoring or medical surveillance for mercury, the following guidelines have been recommended for other workplaces with exposure to mercury.[1] These recommendations are based on existing scientific information and recommendations of other organizations regarding mercury exposure. Medical surveillance for substances other than mercury (i.e. lead) should be performed in accordance with the appropriate OSHA standards.

A. Management has the primary responsibility for setting up mercury hazard controls and for maintaining a proper medical program. Management is also responsible for all costs of biological monitoring and surveillance programs.

B. A program of biological monitoring and medical surveillance should be made available to all employees exposed to inorganic mercury at or above the action level of 20 µg/m^3 (40% of the NIOSH REL[2]) for more than 30 days each year.

C. A pre-placement exam should include a medical evaluation for signs and symptoms associated with mercury toxicity, a spot urine mercury, and urinalysis with microscopic exam.[1] The pre-placement evaluation should also include a history of previous mercury exposure, central nervous system disorders, or renal disease.[3]

D. In addition to the pre-placement examination, the urine mercury level of all employees who are exposed to mercury at or above the action level should be determined at least every 6 months. The frequency of urine monitoring should be increased to at least every 2 months for employees whose last urine mercury level was between 35 and 50 µg/g creat.

E. If the urine mercury level is at or above 50 µg/g creat., the following measures should be taken:
   i) the worker should be removed from exposure until the urine mercury level is below 35 µg/g creat.
   ii) the urine mercury levels should be measured monthly until the level is below 35 µg/g creat.
   iii) an industrial hygiene assessment should be made and measures should be taken to reduce exposure.
   iv) medical testing should include 24-hour urinary mercury levels, serum creatinine, urinalysis with microscopic exam.

F. A medical examination should be done annually on any worker with a urine mercury level above 35 µg/g creat. during the preceding year.

G. Workers with symptoms suggestive of mercury toxicity or a urine mercury level above 35 µg/g creat. should be offered a medical examination.

H. Recent acute exposure to mercury should be assessed by blood mercury levels.[4] This test can be used to assess the worker's short-term exposure after an unplanned or infrequent event, i.e., a spill or maintenance procedure. The ACGIH Biological Exposure Indices (BEI) indicate a reference value for blood mercury of 15g/L.[5]

I. If workers are assigned different job duties because of an elevated urine mercury level or other occupational reasons, they should retain their wages, seniority, and benefits to which they would have been entitled had they not been reassigned. Also, when medically eligible to return to their former jobs, the workers should be entitled to the position, wages, and benefits they would have had, had they not been removed.

J. All employee health information must be kept confidential and in a secure location. This information should be released only when required by law or overriding public health considerations; when needed by other health professionals for pertinent reasons; or when provided to designated individuals at the request of the employee.[6]

K. Physicians qualified in the practice of occupational medicine should provide the expertise for developing a medical surveillance program. The conduct of the medical aspects of such a program may be provided by other physicians or other health care professionals.[7]

L. The data generated under the occupational medical surveillance system should be recorded in a systematic manner. The data should be analyzed periodically in an epidemiologically meaningful manner, such as by job title or work area. The data should be made available for use by OSHA and NIOSH.[8]

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National Institute for Occupational Safety and Health
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