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JMS SOUTHEAST, INC
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SUMMARY

On December 22, 1992, the National Institute for Occupational Safety and Health (NIOSH), received a confidential request to conduct a health hazard evaluation (HHE) at JMS Southeast, a temperature measurement device manufacturer in Statesville, North Carolina. The requestors asked NIOSH to evaluate worker exposure to airborne contaminants during the manufacturing process, and assess the effectiveness of the facility ventilation system. The requestors were concerned that contaminants generated during manufacturing may pose a health problem.

On April 1-2, 1993, a NIOSH investigator conducted a site visit at the JMS manufacturing site. The purpose of this visit was to review manufacturing processes and work practices, conduct environmental monitoring to assess exposure to airborne contaminants, and evaluate the effectiveness of controls. Processes evaluated at this 42 employee manufacturing facility included tungsten-inert gas (TIG) welding (stainless steel), metal grinding, buffing and sanding, brazing (silver) and soldering (lead/tin), and degreasing. Full-shift and activity-specific personal breathing zone and area air sampling was conducted for welding and brazing fume; metal dust during grinding, sanding, buffing, and cutting; fluorides during the use of a fluoride containing flux; and 2-butoxyethanol (a component of the degreasing solvent). Surface wipe samples (elements) were collected in various areas (e.g., breakroom) to evaluate contamination levels. Ventilation controls were assessed quantitatively and qualitatively (smoke tube) to evaluate their effectiveness. Chemical handling practices and housekeeping were also reviewed.

Observations included sporadic adherence to the use of personal protective equipment (PPE), and the lack of a formal safety program (MSDSs were not available for all materials, no employee Hazard Communication program). Commercially available shop vacuums are used to ventilate the grinders and tubing cutters, and did not appear to efficiently contain the dusts after collection. Housekeeping, in general, was good. Employees were observed consuming food and beverages in chemical use areas.

The results of the air sampling showed that contaminant levels were below NIOSH recommended exposure limits (RELs) for all substances monitored. Low concentrations of metals (fume and dust) were detected at various workstations, and during both activity-specific and full-shift personal monitoring. The monitoring results did not identify specific workstations or activities that may pose a health hazard to workers. A nickel concentration of 0.007 milligrams per cubic meter (mg/m^3) was found in an area sample at buffing and grinding station # 1. The NIOSH REL for nickel is 0.015 mg/m^3. Fluoride concentrations (particulate and gaseous) were below the limit of detection (less than 0.1 milligram per cubic meter [mg/m^3]) for those activities monitored. The NIOSH REL for inorganic fluorides is 2.5 mg/m^3 as a

10-hour time-weighted average (TWA). At the degreasing station, personal monitoring showed the concentration of 2-butoxyethanol to be below the analytical limit of detection (less than 1.4 parts per million [ppm]) during the sampling period. The NIOSH REL for 2-butoxyethanol is 5 ppm as a 10-hour TWA.

Although the air sampling did not indicate employees were exposed to hazardous levels of contaminants during the monitoring period, there may be considerable day-to- day variability in worker activities and materials used at this facility. This variability will affect the potential for employee exposure to hazardous contaminants. Therefore, the air monitoring results may not be representative of all work conditions at this facility.

Worker exposures were below recommended limits for all airborne contaminants sampled. Worker activities and materials used, however, vary considerably, and these results may not be representative of all conditions. The surface contamination assessment indicates good housekeeping practices. Informal worker interviews did not suggest the presence of any work-related health symptoms. Vacuum cleaner local exhaust systems installed on some process equipment were not intended for this application. Suggestions to improve the level of safety and health at this facility, including ventilation, employee training, and better adherence to the use of personal protective equipment are made in the Recommendation section of this report.

KEYWORDS: SIC 3823 (Industrial Instruments for Measurement, Display, and Control of Process Variables; and Related Products) welding, brazing, soldering fume, fluorides, metal dust, silver, lead, surface contamination, 2-butoxyethanol, ventilation.

INTRODUCTION

NIOSH received a confidential employee request on December 22, 1992, to investigate worker exposures to airborne contaminants generated during the manufacture of temperature measurement devices (thermocouples, resistance temperature devices [RTDs]) at JMS Southeast, Inc., in Statesville, North Carolina. The request also asked NIOSH to evaluate the effectiveness of the facility's ventilation system to control contaminants.

On April 1-2, 1993, NIOSH conducted a site visit to inspect the facility, review work practices, and collect personal and area air samples during the manufacturing process. Quantitative and qualitative assessments of local exhaust systems used to control contaminants were made. Facility safety and health programs were also reviewed. Prior to conducting the site visit, background information regarding the facility, and materials used in the manufacturing area, were reviewed.

BACKGROUND

Facility Description

JMS Southeast, Inc., manufactures both custom and stock temperature measurement devices for industrial applications. Mercury-containing thermometers are not manufactured. The non-union company employs 42 workers, 17 of which are directly involved in the manufacturing operation, with the remainder providing administrative or sales support. The company resides in a single-story metal shell facility, with a 25,000 square foot (ft^2) manufacturing area separated by a wall from the administrative support group (Figure 1). Ceiling height is approximately 20 feet. The building was occupied in 1990. Manufacturing operates on a three shift basis: "A" shift (5 a.m. - 1 p.m.), "Swing" shift (8:30 a.m. - 5:30 p.m.), "B" shift (1 p.m. - 9 p.m.).

The primary temperature sensing devices made at JMS Southeast are thermocouples and RTDs. Thermocouples operate on the principle that when two dissimilar metals are joined at both ends, and one of the ends is a different temperature, a measurable and repeatable voltage differential is produced. Thermocouples come in a variety of sizes and consist of two wires of different metals, each of which is insulated with a mineral sheath, placed inside a metal tube packed with magnesium oxide. A variety of wire sizes, mineral sheath materials, and metal (stainless steel is the most common) tubes are used. RTDs operate on the principle that there is a positive correlation between the electrical resistance of a metal conductor and changes in temperature. Platinum is the most common resistance element, which is placed inside metal tubing packed with aluminum oxide powder.

There are five air-handling units (AHUs) spaced along the outside wall of the manufacturing area that provide heating and cooling. These units are recirculation-only systems with no provisions for outside air. There are six industrial air filtersystems (Model F70-R, Airflow Systems, Inc.) suspended from the ceiling approximately 15 feet above the floor. These are particulate-only, dual filter units, each of which is designed to move 2500 cubic-feet per minute (CFM) of air. According to the manufacturer, the 2-inch thick polyester pre-filter is designed with an 88% efficiency, and the second stage multi-pocket bag filter has a 98% efficiency for removing smoke and other sub-micron size particles. The units provide only general filtration and recirculation, and not source, or local, exhaust control of contaminants. At certain stations (grinding, buffing, cutting), wet/dry shop vacuums have been installed to collect contaminants generated during these tasks. The only local exhaust system discharging air directly outside is a fume hood in the QA laboratory.

Smoking is not permitted in the facility. There are no tasks that require the use of respiratory protection, and a formal respiratory protection program has not been established.

Process Description

A wide variety of industrial temperature measurement devices are manufactured at JMS. All devices are hand-crafted to conform to customer specifications. Each employee is tasked with constructing temperature measurement devices from "scratch" according to customer requirements. Therefore, employees work at all of the various stations each day, as opposed to being assigned a specific activity (e.g., welding). The potential for exposure varies considerably depending on the job assignment, the alloys specified by the customer, and the length of time necessary at each station. A summary of the manufacturing steps are as follows:

1. Sheath material is selected, straightened and cut to size with a powered disc saw. Sheath material consists of a pair of thermocouple wires inside a metal tube packed with magnesium oxide. JMS purchases pre-made sheath material in a wide variety of diameters and alloys. The saw is equipped with a shop vacuum with the suction hose positioned near the cutting disc.

2. Temperature measurement devices are sanded, buffed, and ground with powered table-mounted machines. These units are also connected to shop vacuums which provide local exhaust at the point of contaminant generation. Polishing may also take place between other process steps.

3. TIG welding is periodically performed at one of two welding stations. Argon is used as the inert gas and a grinder is occasionally used to sharpen the tungsten. There is no local exhaust ventilation at the welding stations. Barriers have been erected to shield other workers from the welding flash.

4. Brazing takes place throughout the manufacturing process to join transition wires, etc. Silver is the most common brazing material, although other metals (cadmium) have occasionally been used. Many of the fluxes contain fluorides. There are

5 oxy-acetylene brazing stations and one supplemental brazing area, referred to as the "water welder," where a hydrogen generator provides fuel for the flame. Soldering (tin/lead) may also be conducted depending on the type of device being constructed.

5. Abrasive blasting in an enclosed blaster may occasionally be necessary. Glass beads are used as the blasting agent.

6. Small amounts of glues, epoxies, and sealers are used intermittently to join parts, and seal the devices. These are dispensed from small containers.

7. A methylene chloride-based paint stripper is used to clean the suppliers' ink stamp on the outside of the metal tube. Workers will dispense a small volume of stripper on a cloth rag and wipe the metal sheath.

8. Depending on the device and customer's requirements, TC wires may need to be exposed. To accomplish this, the welding unit is used to cut the tube, and the packed magnesium oxide is removed.

9. Aluminum oxide is dispensed into hollow tubes during the construction of RTDs. The tube is held with a vibrator and the aluminum-oxide is manually added.

10. Plugs are added to the devices and the performance of the finished product checked with steam to ensure proper function. The device is then turned over to the QA Department for final testing prior to packing and shipping to the customer.

11. A machine shop operation (2 employees) supports the manufacturing process. There is one milling machine and several metal lathes available in this area. An unventilated degreasing tank is located in one corner of the machine shop. This degreasing tank is only occasionally used.

EVALUATION PROCEDURES

The NIOSH investigation consisted of the following elements:

1. A facility inspection to review all manufacturing processes and chemicals used. Assessment of chemical handling practices, and the use of personal protective equipment. A review of industrial hygiene-related programs (hazard communication, employee training).
2. Environmental air monitoring to assess worker exposure to process chemicals for the following tasks:

   - TIG welding
   - Brazing
   - Soldering
   - Grinding, sanding, buffing
   - Cutting metal sheath
   - Degreasing

3. Surface monitoring to determine metal dust contamination levels at certain work stations, and the employee break room.

4. A limited assessment of the facility ventilation system (local exhaust and general dilution), both quantitatively and qualitatively.

Air Sampling

Based on observation of work practices, chemicals used, and scheduled manufacturing activity, a sampling strategy to monitor workers with the highest potential for exposure was developed. Activities of concern to the HHE requestors were also targeted for sampling. Both activity-specific and full-shift air monitoring was conducted for metal dust. This was done to determine the contribution of each task to the overall exposure. This information is useful for targeting and prioritizing control efforts.

On April 1-2, 1993, environmental monitoring was conducted to assess airborne personal exposures to various compounds using established analytical protocols (NIOSH analytical methods).[1] Area samples were also collected to assess general workroom conditions. Calibrated air sampling pumps were attached to selected workers and connected, via tubing, to sample collection media placed in the employees' breathing zone. After sample collection, the pumps were post-calibrated and the samples submitted to the NIOSH analytical laboratory, or NIOSH contract laboratory (Data Chem, Salt Lake City, UT), for analysis. Field blanks were submitted with the samples. Specific sampling and analytical methods used during this survey were as follows:

Metal Dust

Air sampling for metal dust was conducted using Gilian HFS 513A sampling pumps with a flow rate of approximately 2 liters per minute (l/m). Sample times ranged from 3 to 7 hours. The samples were collected on 0.8 micrometer (µm) pore size mixed cellulose ester (MCE) filters and analyzed according to NIOSH method 7300.

Welding and Brazing Fume

Personal exposure to airborne welding fume was monitored using Gilian HFS 513A sampling pumps. Flow rates of approximately 2 l/m and collection times of 1-2 hours were used to obtain the samples. The samples were collected on 5 µm pore size poly-vinyl chloride (PVC) filters and analyzed gravimetrically to determine the total welding fume concentration according to NIOSH method 0500. An element-specific analysis was also conducted on the samples, according to NIOSH method 7300, to differentiate and quantify the different metal species.

Fluoride

Personal exposure to particulate and gaseous fluoride compounds were monitored using Gilian HFS 513A sampling pumps at flow rates of approximately 1.5 l/m. Sampling times varied depending on the task monitored. The samples were collected on 0.8 µm pore size MCE filters (particulate fraction) followed by a sodium carbonate treated cellulose pad in a 37 mm sampling cassette (gaseous fraction). Sample collection and analysis was conducted according to NIOSH method 7902.

2-Butoxyethanol

An integrated air sample for 2-butoxyethanol was collected using a constant-volume SKC model 223 low-flow sampling pump. A standard charcoal tube (100 milligrams front section/50 milligrams backup) was used as the collection media. A flow rate of 100 cubic-centimeters per minute (cc/min) was used to collect the sample. Sampling time was 15 minutes. The pump is equipped with a pump stroke counter and the number of strokes necessary to pull a known volume of air was determined during calibration. This information was used to calculate the air per pump-stroke "K" factor. The pump stroke count was recorded before and after sampling and the difference used to calculate the total volume of air sampled. Analysis was conducted according to NIOSH method 1403.

Surface Sampling

Surface wipe samples were collected to determine the extent of metal dust surface contamination at certain work stations and in the employee break room. These samples were collected with Wash & Dri pre-moistened towlettes. 100 square centimeters (cm^2) of surface area, determined with a template, was wiped with each towlette. The samples were collected according to the surface sampling protocol described in the Occupational Safety and Health Administration (OSHA) Industrial Hygiene Technical Manual, and NIOSH method 0700 (Draft), Lead in Surface Wipe

Samples.[2] After collecting the samples, the towlettes were placed in individually labeled plastic bags and submitted, with blanks, to the NIOSH analytical laboratory for analysis. Areas sampled were as follows:

Sample Location	Analytes
Counter adjacent refrigerator, Breakroom	Elements
Center Table, Breakroom	Elements
Table adjacent lead solder station	tin, lead
Desk - Supervisor Station	Elements
Worktable - center of Fabrication area	Elements

Ventilation Assessment

A limited local exhaust ventilation assessment was conducted for those processes monitored that utilize ventilation for controlling worker exposure to contaminants. The assessment included the measurement of air velocity at the exhaust hood opening (face velocity) of the QA laboratory hood. Critical dimensions were measured (hood size, distance from hood opening to point of contaminant generation), and work practices of employees regarding the use of these systems were observed. Qualitative assessments of the local exhaust systems on the grinders, buffers, sanders, and metal sheath cutters were made by generating visible smoke and subjectively evaluating capture efficiency.

Air velocity measurements were obtained with a TSI VelociCalc 8360 anemometer. This instrument measures air velocity in feet-per-minute (fpm). Multiple measurements were obtained and the results averaged to obtain the mean velocity.

EVALUATION CRITERIA

General

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff generally use established environmental criteria for the assessment of a number of chemical and physical agents. These criteria 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 should be noted, however, that not all workers will be protected from adverse health effects if their exposures are below the applicable limit. A small percentage may experience adverse symptoms due to individual susceptibility, pre-existing medical conditions, and/or hypersensitivity (allergy).
Some hazardous substances or physical agents may act in combination with other workplace exposures or the general environment to produce health effects even if the occupational exposures are controlled at the applicable limit. Due to recognition of these factors, and as new information on toxic effects of an agent becomes available, these evaluation criteria may change.

The primary sources of environmental evaluation criteria for the workplace are:
(1) NIOSH Criteria Documents and recommendations, (2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), and (3) the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) standards.[3-5] Often, NIOSH recommendations and ACGIH TLVs may be different from the corresponding OSHA standard. OSHA standards also may be required to consider the feasibility of controlling exposures in various industries where the hazardous agents are found; the NIOSH recommended

exposure limits (RELs), by contrast, are based primarily on concerns relating to the prevention of occupational disease.

Specific

Welding and Brazing Fume/Metals

The composition of welding fume will vary considerably depending on the alloy being welded, the process, and the electrodes used.[3,6] Many welding processes also produce other hazards, including toxic gases such as ozone or nitrogen oxides, and physical hazards such as intense ultraviolet radiation. Of particular concern are welding processes involving stainless steel, cadmium or lead-coated steel, and metals such as nickel, chrome, zinc, and copper. Fumes from these metals are considerably more toxic than those encountered when welding iron or mild steel. Epidemiologic studies and case reports of workers exposed to welding emissions have shown an increased incidence of acute and chronic respiratory diseases.[6] These illnesses include metal fume fever, pneumonitis, and pulmonary edema. The major concern, however, is the increased incidence of lung cancer among welders. Epidemiological evidence indicates that welders generally have a 40% increase in relative risk of developing lung cancer as a result of their work.[6] Because of the variable composition of welding emissions, and epidemiological evidence showing an increased risk of lung cancer, NIOSH recommends that exposures to all chemical and physical agents associated with welding or brazing be controlled to the lowest feasible concentration.[6] Exposure limits for each chemical or physical agent should be considered upper boundaries of exposure. The ACGIH TLV and OSHA PEL for total welding fume, which applies only to manual metal-arc or oxy-acetylene welding of iron, mild steel or aluminum, is 5 mg/m^3 as an 8-hour time-weighted average.[3,4]

The potential health effects and NIOSH RELs for the major elements that were detected in the air samples are shown in the following table. These metals may be present when grinding, cutting, or welding various alloys.

Element	NIOSH REL[5] (mg/m^3)	Principle Health Effects[(7,8)]
Copper	0.1 Fume 1.0 Dust	Upper respiratory irritation, metal fume fever, metallic or sweet taste in mouth
Magnesium	10*	Eye and nose irritation
Nickel	0.015	dermatitis, pneumoconiosis, nasal irritation, nasal and lung cancer
Silver	0.01	*Argyria*, a blue-grey discoloration of the skin, lung damage
Chromium	0.5**	skin and mucous membrane irritation, possible lung cancer
Iron	5	benign pneumoconiosis (siderosis)
Zinc	5 (TWA), 10 (STEL)	metal fume fever (influenza-like illness), dry or irritated throat, metallic taste

* OSHA PEL for magnesium oxide fume; NIOSH has not adopted a REL for magnesium. NIOSH concludes that health effects can occur below the OSHA PEL.

** Chromium can occur in various oxidation states. Certain hexavalent chromium compounds (chromic acid and chromates) are carcinogenic and NIOSH recommends controlling exposure to hexavalent chromium to the LFC. Chromium associated with grinding stainless steel would not be expected to be hexavalent. Hexavalent chromium compounds have been detected in certain welding processes (shielded metal arc, gas tungsten arc).[13]

Fluorides

Inorganic fluorides may be a component of brazing fluxes and certain types of welding rods.[(6,9,10)] When fluoride-containing materials are present, both particulate and gaseous forms of fluoride can be liberated during the brazing or welding process. Exposure to fluorides can cause irritation of the eyes and respiratory tract, and long-term absorption of excessive amounts has caused fluorosis.[10] Carcinogen studies, conducted primarily to evaluate the effect of water fluoridation, indicate that there is inadequate evidence for carcinogenicity in humans.[11] The NIOSH REL for inorganic fluorides is 2.5 mg/m^3 as a 10-hour time-weighted average (TWA), and is intended to prevent skeletal fluorosis (osteosclerosis, increased bone density due to excessive absorption of fluoride).[5,9]

2-Butoxyethanol

2-Butoxyethanol, also known as ethylene glycol monobutyl ether, or butyl Cellosolve®, is a colorless liquid solvent with a reported odor threshold (mild ether-like) of 0.1 ppm.[12] 2-butoxyethanol is a widely used solvent and cleaning agent. Toxic effects associated with human exposure to 2-butoxyethanol include eye and nasal irritation, headache, vomiting, and disturbed taste.[7,10,12] The material is harmful if inhaled, ingested or absorbed through the skin. Animal studies have demonstrated that 2-butoxyethanol is a hemolytic agent, and has caused blood changes in the animals studied.[12] This effect appears to be more pronounced in animals than humans. The low vapor pressure of 2-butoxyethanol (0.88 mmHg) is such that high air concentrations are unlikely, however the material can be absorbed through the skin. The NIOSH REL for 2-butoxyethanol is 5 ppm as a 10-hour TWA.

Surface Contamination

Standards defining "acceptable" levels of surface contamination have not been established. However, wipe samples can provide information regarding the effectiveness of housekeeping practices, the potential for exposure to contaminants from routes other than inhalation (e.g., surface contamination on a table that is also used for food consumption), the potential for contamination of worker clothing and subsequent transport of the contaminant, and the potential for non-process related activities to generate airborne contaminants (e.g. custodial sweeping).

Ventilation

Local exhaust ventilation (LEV) is commonly used to control contaminants at the point of generation to reduce the potential for employee exposure. Ventilation assessments, in conjunction with exposure monitoring results, help determine the adequacy of controls at a workstation. This information also assists with deciding if additional controls, or modification of existing controls, is warranted. The principle design parameter for LEV systems is capture velocity. Capture velocity is the velocity necessary to overcome opposing air currents and capture contaminated air by causing it to flow into the exhaust hood. Recommended capture velocities will vary depending on the contaminants toxicity and volatility, the manner in which the material is used (e.g., heated, agitated), and room conditions (e.g., air currents). Criteria commonly used for evaluating LEV systems is from the ACGIH publication, *Industrial Ventilation: A Manual of Recommended Practice*.[13]

RESULTS AND DISCUSSION

Workplace Observations/Industrial Hygiene Programs

Housekeeping practices, with a few exceptions, appeared to be good throughout the facility. Work tables were clean and aisles were clear. In the machine shop area, considerable scrap metal was on the floor, and in some areas a large amount of dust had accumulated around the vacuum cleaners used to ventilate the metal cutting, grinding, and sanding equipment. Abrasive blasting material had also spilled and needed to be cleaned up.
No formal safety program exists at the facility. Although material safety data sheets (MSDSs) were available for some chemicals, a comprehensive hazard communication program has not been implemented (written program, MSDS collections, employee training, hazardous materials labeling). MSDSs were not present for some commonly used chemicals (abrasive blasting beads, cutting fluid).

Adherence to the proper use of personal protective equipment (PPE) was sporadic. Safety glasses are required in the manufacturing department; however, some employees were not wearing safety glasses in this area. Workers were also using the degreasing tank and the methylene-chloride based paint stripper without wearing gloves to prevent skin contact.

A break room separate from the manufacturing area is available to employees. However, some employees were consuming food and beverages at their work stations. Some of these areas are potentially contaminated with toxic materials.

Informal interviews with employees did not identify any work-related adverse health symptoms. Activities of concern to some employees were the removal of magnesium oxide from metal sheathing (recovery) and the use of the Tetra-Etch etchant that is required for certain types of devices. Tetra-Etch etchant is a volatile, odorous material containing sodium naphthalene and ethylene glycol dimethyl ether. Neither of these activities took place during the NIOSH investigation. Additionally, depending on customer specifications, other hazardous materials may be used, such as ceramic fibers or different types of alloys.

Environmental Monitoring

The results of the environmental monitoring are shown in Tables 1-5. As previously noted, the sampling strategy included monitoring to identify the relative contribution of specific activities to overall contaminant levels, as well as assessing full-shift exposures of workers conducting a variety of tasks. All sample results showed employee exposures to be well below NIOSH RELs during the monitoring period. The employees monitored indicated there was a normal level of activity during the monitoring period. However, the nature of the tasks conducted (e.g., the length of time necessary at each work station, materials used) varies on a daily basis.

Tables 1, 2, and the first entry in Table 3 show the results of the activity specific personal monitoring. Most of this sampling only entailed a short period of time (15-65 minutes) as these tasks are not conducted on a continuous basis, and vary considerably depending on the type and number of products being manufactured. Short sampling times tend to increase the variability associated with the results due to the low volume of air sampled.

Low concentrations of chromium (0.01 mg/m^3), iron (0.08 mg/m^3), aluminum (0.08 mg/m^3), and zinc (0.95 mg/m^3) were detected on personal samples obtained during the use of the TIG welder. No detectable levels (less than [<] 0.008 mg/m^3 per element analyzed) of metal fume were found on the personal samples collected at the oxy-acetylene or hydrogen brazing stations, or on the personal sample collected during the cutting of stainless steel (< 0.03 mg/m^3). No lead (< 0.02 mg/m^3) or tin[3] was detected on the personal sample obtained at the soldering station. The tin analysis is not considered quantitative as the recovery efficiency was poor (10%). Therefore, since tin was not detected in any of the samples, it does not necessarily mean that low levels of tin were not present. Low levels of magnesium (0.15 mg/m^3), zinc (0.04 mg/m^3), and iron (0.06 mg/m^3) were, however, found on this sample; it is likely these contaminants were generated at nearby work areas, and not at the soldering station. The fluoride monitoring results showed concentrations to be less than the detection limit (< 0.1 mg/m^3) for both particulate and gaseous fluoride at all stations evaluated (brazing, soldering).

Full-shift samples collected from manufacturing technicians on both the "A" and "B" shift showed the levels of airborne metals (fume and dust) workers were exposed to were well below NIOSH RELs. Employees were asked to note the time spent at or near each work station while being monitored. This information is noted in the results shown on Table 3. As both the activity specific, and full-shift personal sampling results showed exposures to be low (and in some cases below the detection limit), the information collected is not sufficient to rank activities or work stations by their potential for generating contaminants.

The results of the area air monitoring are shown in Table 4. Area samples were collected at the metal tube cutting station, and between the metal buffer/grinder and sander at stations # 1 and # 2. Although some of these samples found more types of metals to be present, the results were all below NIOSH RELS. An airborne nickel concentration of 0.007 mg/m^3 was detected at metal buffing and sanding station 1, and a level of 0.004 mg/m^3 nickel was found at station 2. The NIOSH REL for nickel is 0.015 mg/m^3; NIOSH considers nickel to be a potential human carcinogen and recommends maintaining exposures at the lowest feasible level.[5] Note that these area samples are not representative of worker exposure, and these samples were obtained at stations that had multiple users throughout the monitoring period.

A 15-minute sample collected during the use of the degreasing station showed the concentration of 2-butoxyethanol to be below the limit of detection (< 1.4 ppm). As noted previously, this tank is used infrequently, and for short periods of time. The use of the methylene chloride-based paint stripper to clean tubing is only conducted intermittently and for short (< 1 minute) periods of time, and was not monitored.

The results of the surface sampling (Table 5) indicate the presence of various metal residues on the surfaces sampled. The highest contamination levels were detected on workstations in the manufacturing area. Only very low levels of metal residues were found in the breakroom. Although standards regarding surface contamination have not been established, these levels do not suggest a problem with contaminant migration into the breakroom as only trace levels of materials were detected in this area. The levels found in the manufacturing area indicate that food and beverage consumption should be confined to the breakroom. Eating and drinking in chemical use areas can result in cross-contamination and potential ingestion. Surface sampling can also provide information regarding the potential for inhalation exposure due to worker activities. As housekeeping practices do not include the use of compressed air or excessive agitation of the work surfaces, it does not appear likely that the levels found in the surface samples could result in significant airborne concentrations.

Ventilation Assessment

In the Quality Control Department, heated (100° C) oil tanks used for thermocouple testing are housed in a ventilated laboratory fume hood that exhausts directly outside. The ventilation is provided to capture any vapors or mists generated from the oil tanks. The sash on this hood is kept fully open (24 inches) so the test probes can fit inside the tanks. An average of 7 measurements obtained with the TSI VelociCalc® showed a velocity of 41 feet-per-minute (fpm) across the face of the hood. This velocity is insufficient to overcome opposing eddies and currents. A range of 50-100 fpm capture velocity is a general recommendation for operations such as this (contaminants released with practically no velocity into still air).[13] As this operation is only used on a limited basis, with minimal effect from room air currents, a capture velocity at the lower end of the recommended range should provide sufficient control.

Six-gallon capacity household/workshop wet-dry shop vacuums have been permanently installed at the two metal tube cutting stations, the metal grinder/sander adjacent the welding station, and at grinding/sanding stations #1 and #2. The vacuum hose (3" diameter) has been fixed near the point of contaminant generation, and the vacuums are configured to activate when the cutting or abrasive machinery is operated. These vacuums are equipped with standard foam and dry-particulate filters. High efficiency particulate (HEPA) filters are not provided. These vacuum cleaners were not designed to provide continuous local exhaust control to prevent exposure to hazardous contaminants. The manual for the vacuum cleaners includes a caution to this effect, stating that the cleaner should not be used to vacuum toxic or hazardous materials. Qualitative smoke tests indicated the vacuum was effectively capturing contaminants at both metal tube cutting stations and the grinder/sander adjacent the welding station. The smoke tests demonstrated ineffective capture at grinding/sanding stations #1 and #2. As previously noted, however, the heavy dust build up around the vacuum cleaners indicates that some of the captured contaminants are not effectively contained by the filter and are being exhausted back into the work area. There is no local exhaust control provided at the welding or brazing stations.

It is likely that the ceiling-mounted recirculating air-cleaners effectively contain most of the particulate contaminants that are ventilated through these units. This type of air cleaner, however, is ineffective against gases and vapors, and provides no local exhaust control, as contaminants must reach the air cleaner to be filtered.

CONCLUSIONS

The monitoring results did not show an inhalation hazard for the employees sampled during the monitoring period. However, the processes and tasks conducted at this facility are highly variable and materials of high toxicity may be used (nickel, silver, chromium, lead). Therefore, the results should only be considered representative of the monitoring period, and not all conditions at this facility. This type of variability makes exposure determinations difficult, necessitating a conservative approach when determining appropriate controls. Although there are no standards, the surface contamination levels did not indicate an unusual housekeeping problem. Food and beverage consumption, however, should be restricted away from the chemical use/manufacturing areas.

The potential for exposure during the use of the Tetra-Etch sealant, and during the removal of magnesium oxide from metal sheath, was not assessed during this evaluation. Similarly, the potential for exposure to methylene chloride when cleaning metal tubing could not be monitored as this activity is only conducted for a short time period.

The existing vacuum cleaners that provide local exhaust ventilation on some processes probably help reduce dust levels, but are not efficient or intended for this application. The general room air-cleaners also may help reduce overall particulate levels, but do not provide local exhaust control for specific work stations. The laboratory fume hood in the Quality Control department was found to have insufficient exhaust flow.

Informal employee interviews did not indicate the presence of any work-related unusual health problems. Some employees were concerned with potential exposures associated with certain tasks, specifically the use of the Tetra-Etch sealant.

Adherence to the proper use of personal protective equipment needs improvement. Employees were observed working at various stations without the proper protective equipment. Examples include using the methylene chloride-based paint stripper without using gloves, and inconsistent use of eye protection in manufacturing areas. A formal safety program (hazard communication, training) has not been established at this facility. Implementation of a training regimen would help address the previously noted issues regarding the use of protective equipment.

RECOMMENDATIONS

1. Conduct a complete inventory of chemicals and obtain Material Safety Data Sheets as needed. Establish a formal hazard communication program, as described in Occupational Safety and Health Administration (OSHA) regulations (29 CFR 1910.1200). The general elements of a good program include: written program; MSDS availability for all employees; employee training, and; hazardous material container labeling. Establish a system to ensure MSDSs are reviewed prior to chemical use so appropriate training and precautions can be taken.

2. Define personal protective equipment requirements and enforce the policy. Protective gloves should be used when degreasing parts and stripping paint off metal tubing. There may be other needs that were not observed during this site visit. All chemical handling activities should be reviewed and protective equipment requirements defined.

3. Consider appointing a safety coordinator or committee to ensure a successful, active safety program.

4. Install local ventilation control at the grinders, cutters, and sanders that exhausts contaminants directly outside the facility. Consider installing local exhaust at the two welding stations. Although employee exposures were below NIOSH RELs during the monitoring period, the highly variable nature of the tasks conducted, and materials used, warrants a more efficient ventilation system. The design of the exhaust system should be consistent with those described in the American Conference of Governmental Industrial Hygienists *Industrial Ventilation: A Manual of Recommended Practice.*[13]

5. Although the activity was not observed, worker concern, the hazardous components present, and the manufacturers recommendation indicate that the use of the Tetra-Etch etchant should be conducted under local exhaust ventilation. It may be possible to use the existing QC hood for this task. Additionally, although the removal of magnesium oxide from recycled thermocouples was not observed, this is also an activity of employee concern (regarding the dust that is generated). A thorough evaluation of this task should be conducted and alternative (less dust-producing) magnesium oxide removal methods identified. This could be a Safety Committee activity.

6. The ventilation on the laboratory hood in the Quality Control department should be increased to provide a minimum average capture velocity of 60-75 fpm. Options include increasing fan speed or size, or ensuring that the sash is not opened more than 1.5 feet.

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1. JMS Southeast, Inc.
2. HHE Requestor
3. Department of Labor/OSHA Region IV

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1
Activity-Specific Personal Sampling Results: Welding Fume
JMS Southeast, Inc. Statesville, North Carolina
April 1-2, 1993
HETA 92-0455

Task Monitored	Sample Number	Sample time (min)	Contaminants Sampled	Concentration (mg/m3)[1]
TIG Welding (Carbon, 316 stainless steel) 100 Amp Setting Sampled Inside Welding Helmet	F-27	8:27-8:48 11:05-11:35 (51)	Chromium Iron	0.01 0.08
			Total Weight (gravimetric)	0.27
		Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Cobalt, Copper, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zinc, Zirconium		ND[2,3] (<0.009)
TIG Welding (316 stainless steel) Melting ends of metal with welder. No Welding Helmet Used	F-22	9:17-9:22 10:24-10:47 (28)	Aluminum Zinc	0.08 0.95
			Total Weight (gravimetric)	ND[3] (<0.18)
		Arsenic, Antimony, Barium, Beryllium, Cadmium, Cobalt, Copper, Chromium, Iron, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium		ND[2,3] (<0.018)

1. mg/m3 = milligrams of contaminant per cubic meter of air

2. Various trace quantities of calcium and sodium were detected on both samples

3. None Detected. The detection limit for the elements analyzed was 1 microgram per filter. The detection limit for the gravimetric analysis was 0.01 mg total weight per filter. Values in parentheses indicate the minimum detectable concentration. < = less than.

All samples were field blank corrected

Table 2
Activity-Specific Personal Sampling Results: Brazing, Soldering Fume, Fluorides
JMS Southeast, Inc. Statesville, North Carolina
April 1-2, 1993
HETA 92-0455

Task Monitored	Sample Number	Sample time (min)	Contaminants Sampled	Concentration (mg/m3)[1]
Soldering Station (tin/lead, flux)	AA-4 FL-1 FL-1A	9:45-10:06 (21)	Magnesium	0.15
			Zinc	0.04
			Iron	0.06
			Particulate Fluoride	ND[3] (<0.14)
			Gaseous Fluoride	ND[3] (<0.03)
			Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Cobalt, Copper, Lithium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium	ND[2,3] (<0.02)
Silver Brazing at the "Water Welder" using a fluoride containing flux	AA-9 FL-3 FL-3A	11:13-12:14 (61)	Arsenic, Antimony, Aluminum, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium, Zinc, Particulate Fluoride, Gaseous Fluoride	ND[2,3] (<0.008 Elements, <0.05 Particulate fluoride, <0.01 gaseous fluoride)
Silver Brazing using a fluoride-containing flux and oxy-acetylene torch	AA-8 FL-2 FL-2A	10:44-11:49 (65)	Arsenic, Antimony, Aluminum, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium, Zinc, Particulate Fluoride, Gaseous Fluoride	ND[2,3]

1. mg/m3 = milligrams of contaminant per cubic meter of air
2. Various trace quantities of calcium and sodium were detected on the samples
3. None Detected. The detection limit for the elements analyzed was 1 microgram per filter. Detection limits for fluoride were 5 micrograms (particulate) and 1 microgram (gaseous) per filter. Values in parentheses indicate the minimum detectable concentration. < = less than.

All samples were field blank corrected

Table 3
Personal Sampling Results: Elements
JMS Southeast, Inc. Statesville, North Carolina
April 1-2, 1993
HETA 92-0455

Task Monitored	Sample Number	Sample time (min)	Contaminants Sampled	Concentration (mg/m3)[1]
Cutting stainless steel tubing	AA-1	8:58-9:13 (15)	Arsenic, Antimony, Aluminum, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium, Zinc	ND[2,3] (<0.03)
Manufacturing Technician (Full Shift Sample) TASKS Welding: 15 min Brazing: 15 min Cutting: 15 min Buffing, Sanding, Grinding: 10 min	AA-10	1:07-7:01 (354)	Chromium	0.003
			Copper	0.001
			Iron	0.012
			Magnesium	0.008
			Zinc	0.002
			Arsenic, Antimony, Aluminum, Barium, Beryllium, Cadmium, Cobalt, Lithium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium,	ND[3] (<0.001)
Manufacturing Technician (Full Shift Sample) TASKS Welding Area: 3 hours Sanding, Grinding, Cutting Area: 2 hours	AA-12	05:35-09:31 10:02-12:14 (358)	Iron	0.004
			Magnesium	0.005
			Arsenic, Antimony, Aluminum, Barium, Zinc, Beryllium, Cadmium, Chromium, Copper, Cobalt, Lithium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium,	ND[2,3] (<0.001)
Manufacturing Technician (Full Shift Sample) TASKS Brazing: 45 min Welding: 45 min Sanding, Grinding, Buffing: 45 min Cutting: 45 min MgO rem: 20 min	AA-3	1:09- 8:14 (425)	Arsenic, Antimony, Aluminum, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium, Zinc,	ND[2,3] (<0.001)

Table 3, Continued
Personal Sampling Results: Elements
JMS Southeast, Inc. Statesville, North Carolina
April 1-2, 1993
HETA 92-0455

Task Monitored	Sample Number	Sample time (min)	Contaminants Sampled	Concentration (mg/m3)[1]
Manufacturing Technician (Full Shift Sample) TASKS Welding: 30 min Brazing: 30 min Cutting: 20 min Buffing, Sanding, Grinding: 30 min	AA-13	05:37-8:58 09:32-12:14 (363)	Iron Magnesium Zinc	0.005 0.002 0.001
		Arsenic, Antimony, Aluminum, Barium, Beryllium, Cadmium, Chromium, Copper, Cobalt, Lithium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium,		ND[2,3] (<0.001)

1. mg/m3 = milligrams of contaminant per cubic meter of air

2. Various trace quantities of calcium and sodium were detected on both samples

3. None Detected. The detection limit for the elements analyzed was 1 microgram per filter. The detection limit for the gravimetric analysis was 0.01 mg total weight per filter. Values in parentheses indicate the minimum detectable concentration. < = less than.

All samples were field blank corrected

Table 4
Area Sampling Results: Elements
JMS Southeast, Inc. Statesville, North Carolina
April 1-2, 1993
HETA 92-0455

Task Monitored	Sample Number	Sample time (min)	Contaminants Sampled	Concentration (mg/m3)[1]
Adjacent Tube Cutting Station	AA-2	9:29-4:06 (397)	Aluminum	0.001
			Iron	0.004
			Magnesium	0.02
		Arsenic, Antimony, Barium, Zinc, Beryllium, Cadmium, Chromium, Copper, Cobalt, Lithium, Manganese, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium, Zinc		ND[2,3] (<0.001)
Between Sander and Buffer: Station # 1	AA-6	9:30-4:07 (397)	Silver	0.002
			Chromium	0.005
			Copper	0.004
			Iron	0.02
			Magnesium	0.005
			Nickel	0.007
			Zinc	0.004
		Arsenic, Antimony, Aluminum, Barium, Beryllium, Cadmium, Cobalt, Lithium, Manganese, Molybdenum, Lead, Phosphorous, Platinum, Selenium, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium,		ND[2,3] (<0.001)
Between Sander and Buffer: Station #2	AA-7	09:33-4:08 (395)	Chromium	0.003
			Copper	0.002
			Iron	0.014
			Magnesium	0.008
			Nickel	0.004
			Zinc	0.002
		Arsenic, Antimony, Aluminum, Barium, Beryllium, Cadmium, Chromium, Cobalt, Lithium, Manganese, Molybdenum, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Vanadium, Yttrium, Zirconium,		ND[2,3] (<0.001)

1. mg/m3 = milligrams of contaminant per cubic meter of air
2. Various trace quantities of calcium and sodium were detected on both samples
3. None Detected. The detection limit for the elements analyzed was 1 microgram per filter. The detection limit for the gravimetric analysis was 0.01 mg total weight per filter. All samples were field blank corrected

Table 5
Surface Sampling Results: Metals
JMS Southeast, Inc. Statesville, North Carolina
April 1-2, 1993
HETA 93-0455

Sample Number	Location	Contaminant Detected	Results (µg/100cm^2)
WS-1	Counter adjacent refrigerator in employee break room	Chromium Copper Iron Nickel	1.7 1.6 8.7 2.6
WS-2	Table in center of employee break room	Copper Iron	1.2 3.0
WS-3	Table adjacent the solder station, manufacturing area	Silver Chromium Copper Iron Magnesium Manganese Nickel Lead Zinc	2.2 17.1 10.9 124.8 113 3.4 28.2 1.9 77.4
WS-4	Supervisors desk, manufacturing area	Cadmium Chromium Copper Iron Magnesium Manganese Molybdenum Nickel Lead Antimony Zinc	2.7 9.0 15.7 131.8 104 2.4 2.6 13.4 2.5 1.4 31.4
WS-5	Workstation table, TC manufacturing area	Silver Chromium Copper Iron Magnesium Manganese Molybdenum Nickel Zinc	6.9 23.1 17.8 119.8 95 3.6 4.4 34.6 32.9

µg/100 cm^2 = micrograms of contaminant per 100 square centimeters surface area

Standards regarding surface contamination for the metals detected have not been established