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KREISLER INDUSTRIAL CORPORATION
ELMWOOD PARK, NEW JERSEY

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SUMMARY

In response to a confidential request from employees, the National Institute for Occupational Safety and Health (NIOSH) conducted a Health Hazard Evaluation (HHE) at the Kreisler Industrial Corporation (KIC) in Elmwood Park, New Jersey. KIC is a custom machine shop serving the aircraft engine industry. The request, initiated on October 7, 1991, asked NIOSH to determine if health problems experienced by some KIC employees were occupationally related. Reported health problems included pulmonary fibrosis, asthma, heart problems and cancer. The request identified specific chemical substances at the facility that were suspected to be the source of the health problems.

On December 4-5, 1991, NIOSH investigators conducted an initial site visit to review manufacturing processes and chemical-handling practices. Facility local exhaust ventilation systems were inspected and the types of personal protective equipment provided to employees were reviewed. An environmental monitoring strategy was developed by identifying specific chemicals or processes where potential exposures could occur. Copies of Material Safety Data Sheets (MSDSs) and process specifications were obtained for those chemicals and activities targeted for additional monitoring. To help develop the sampling strategy, bulk air samples were obtained in the Electrical Discharge Machine (EDM) room (Department 89) and the Cleaning Department. A bulk sample of the material used in the EDM process, referred to by employees as kerosene, was obtained to identify the constituents of this material.

On January 15-17, 1992, NIOSH investigators conducted environmental monitoring to assess personal exposure to airborne contaminants, evaluated facility ventilation systems, and conducted confidential interviews with 52 production workers. Surface wipe samples were collected to assess the degree of metal dust contamination. Air monitoring was conducted for vapors of solvents used in the cleaning department; metal dust and oil mist during grinding operations; inorganic acids in the cleaning and plating department; and metal fume during welding, low melt alloy use, and brazing activities. Ventilation systems were assessed at the following work stations: nickel plating, acid cleaning tanks, metal grinding, welding, low-melt alloy, and anti-gall. The interviews were conducted to determine the prevalence of adverse health effects that may be occupationally related, and assess the level of health and safety training.

The monitoring results showed that exposures to all contaminants sampled were below NIOSH Recommended Exposure Limits (RELs) during the sampling period. The highest concentration of solvent vapor detected, 8 parts per million (ppm) of 1,1,1-trichloroethane, was obtained from the cleaning operator (REL = 350 ppm). The highest concentration of inorganic acid detected, 0.15 ppm of nitric acid (REL = 2 ppm), was obtained from the Assistant Foreman in the cleaning department.

The two mineral oil-mist concentrations (0.9, 0.18 milligrams per cubic meter [mg/m^3]) were below the REL of 5 mg/m^3. Detectable levels of welding fume were found on both samples when analyzed gravimetrically (0.31, 0.24 mg/m^3); however, element specific analysis only detected the presence of metal fume on one sample (chromium [0.001 mg/m^3]). NIOSH considers welding fume to be a potential occupational carcinogen and recommends controlling exposure to the lowest feasible concentration.

The surface sampling showed the presence of metal fume or dust contamination in the cleaning, deburring, and assembly departments. Although standards have not been established for surface contamination, the levels detected in the cleaning department (1800 micrograms of lead per 100 square centimeter of surface area [$\mu g/100cm^2$], 600 $\mu g/100cm^2$ of cadmium) indicate the potential for exposure and the need for additional housekeeping controls.

The ventilation evaluation, in conjunction with the air monitoring results, indicated that most systems were effectively controlling contaminants. However, some systems need improvement either through increased ventilation capacity (welding stations), design (welding, anti-gall stations) or employee use practices (deburr, low-melt alloy stations).

The employee interviews showed 9 (17%) of 52 production workers experience "tearing or burning of eyes" at least monthly while at work. Seven (13%) workers reported cough occurring at work at least once per month. However, no distinction could be made between symptoms occurring at work caused by other illnesses (e.g., infections) and those attributable to workplace conditions. The medical questionnaires suggest a general lack of serious health problems attributable to workplace conditions. Most (64%) of the 39 employees who said they work with chemicals had not received health or safety training. A review of records indicated that a former employee had been diagnosed with occupational asthma. However, past exposure, or agents causing the asthma, are unknown. A list of deceased former employees provided by the HHE requestor are not suggestive of an unusual cluster of occupationally-related deaths.

Worker exposures were below recommended limits for all airborne contaminants sampled. The surface contamination assessment indicates the need for improved housekeeping and hygiene practices. Other than eye and respiratory tract irritation, the medical evaluation did not identify employee health problems related to workplace conditions. Recommendations to improve the level of safety and health at this facility, to more efficiently use existing controls, and to ensure effective employee training are in the Recommendation section of this report.

KEYWORDS: SIC 3498 (Fabricated Pipe and Pipe Fittings) welding fume, 2-butanone, toluene, xylene, acetone, 1,1,1-trichloroethane, oil mist, metal dust, inorganic acids, sodium hydroxide

INTRODUCTION

NIOSH received a confidential employee request to investigate health complaints at the Kreisler Industrial Corporation in Elmwood Park, New Jersey on October 7, 1991. The reported health problems included occupational asthma, pulmonary fibrosis, heart problems and cancer. The requestors provided a list of 16 former employees, now deceased, and asked NIOSH to investigate the work-relatedness of these deaths. A list of chemical substances, suspected to be the source of the health problems, was provided to NIOSH.

On December 4-5, 1991, NIOSH investigators conducted an initial site visit to review the manufacturing processes, evaluate facility health and safety records, and develop an environmental monitoring strategy. NIOSH investigators conducted a second site visit on January 15-17, 1992 to: assess personal exposures to various process chemicals, evaluate surface contamination in selected areas, conduct a limited local exhaust ventilation assessment, and administer confidential questionnaires to all manufacturing employees. Work practices, chemical safety training, and personal protective equipment use practices were assessed. A thorough building inspection was conducted.

An initial response letter describing preliminary findings, recommendations, and future actions was forwarded to KIC management, union representatives, and the confidential requestors on May 8, 1992.

BACKGROUND

Facility Description

KIC is a custom machine shop serving the aircraft engine industry that is referred to in the trade as a "tubing house." The facility, constructed in the early 1950's, fabricates tubing components (e.g., hydraulic lines) according to customer specifications. About 70% of the products are for the U.S. military. The single story facility comprises approximately 52,000 square feet in an open-shop arrangement with a ceiling height of 20 feet (Figure 1). The company employs 85 workers with about 50 directly involved in production or quality control. The facility operates 5 days a week on a 1-shift basis (7:30 AM - 4:00 PM). The Retail Workers Union Service Local 377 represents employees at this facility.

Process Description

All components are fabricated out of purchased hard metal tubing (316, 321 stainless steel, Inconel®, Hastelloy®, titanium). A summary of the manufacturing process is as follows:

1. Tube Bending: Metal tubes are cut and shaped to specification on hand operated bending machines.

2. Milling: Metal millers (component is held steady and tool rotates) and lathes (tool is held steady and component rotates) are used to fabricate parts from bar stock for subsequent welding to tubes. Mineral oil based cutting fluids are used in these computer controlled machines. Tubing ends are "swaged" to ensure a proper fitting connection.

3. Furnace Brazing: Brazing is conducted in two large vacuum electric furnaces. Argon is used as an inert blanket. The furnaces are computer controlled and loaded via a cart on rails. No flux is used in the furnaces. The customer specifies the brazing temperature (up to 2250°F) and time. The system is backfilled with argon and pumped down prior to opening.

4. Inspection/Adjusting: There are multiple inspection stations to ensure product quality throughout the production process. In the adjusting department, to ensure proper fit, each part is physically connected to a mock-up of the actual application.

5. X-Ray/Test: There are three dedicated lead-lined rooms for component X-ray. Every fitting and weld is X-rayed using 155 kilovolt machines. The rooms are equipped with interlocked doors to prevent opening when the X-ray is firing. All radiograph personnel wear X-ray film badges (changed bi-weekly). Leakage surveys around the doors and windows are conducted daily with a Geiger-Mueller meter and records are kept. The finished components are pressure tested with air or water to assess leakage and strength.

At different stages in the production process, components may undergo other manufacturing steps, depending on customer specifications. These other processes are:

(1) component cleaning in acid or water baths,
(2) degreasing in a vapor degreaser using 1,1,1-trichloroethane,
(3) nickel electroplating using the nickel sulfamate process,
(4) resistance welding, orbital welding, or logic welding,
(5) grinding or de-burring of component parts,
(6) induction brazing for parts that cannot be placed in the vacuum furnace, and
(7) low melt alloy, which may contain lead or cadmium, is melted in a babbitt pot for special applications.

EVALUATION PROCEDURES

The NIOSH evaluation consisted of industrial hygiene and medical components with the following elements:

(1) A comprehensive facility inspection to evaluate general housekeeping practices in work areas, chemical storage and use practices, employee adherence to the proper use of personal protective equipment (PPE), and hazard identification of chemical containers.

(2) A review of company records (worker compensation, recordable accident or illness summary).

(3) A limited local exhaust ventilation assessment for processes using ventilation to control worker exposure to contaminants.

(4) Environmental monitoring to assess worker exposure to process chemicals. Surface wipe samples were collected to determine metal dust contamination levels at certain work stations.

(5) Confidential interviews (questionnaire administration) with production employees to assess the general health status of the work force and determine the prevalence of potentially work-related symptoms.

Environmental

Air Sampling

Processes selected for monitoring were based on an assessment of the chemicals in use, employee work practices, and controls utilized. Activities of concern noted by the HHE requestors were also targeted for sampling. Job titles/processes monitored, and the contaminants sampled, are noted in Table 1.

On January 16 and 17, 1992, environmental monitoring was conducted to assess airborne personal exposures to various compounds used in KIC processes. Monitoring was conducted using established analytical protocols (NIOSH analytical methods).[1] Calibrated air sampling pumps were attached to selected workers and connected, via tubing, to sample collection media placed in the employees' breathing zone. Monitoring was conducted throughout the employees' work-shift. After sample collection, the pumps were post-calibrated and the samples submitted to the NIOSH contract laboratory for analysis. Field blanks were submitted with the samples. All results were blank corrected. Specific sampling and analytical methods used during this survey were as follows:

A. **Solvents**

Integrated air samples for solvents were collected using constant-volume SKC model 223 low-flow sampling pumps. Nominal flow rates of 50-100 cubic centimeters per minute (cc/min) were used to collect the samples. Sampling time ranged from 3 to 5 hours. The pumps are 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.

Samples for methyl-ethyl-ketone and acetone were obtained using Ambersorb XE-347 as the collection medium, and analysis was conducted according to NIOSH method 1300. Standard charcoal tubes (100 milligrams front section/50 milligrams backup) were used for the other solvents sampled (1,1,1-trichloroethane, toluene, xylene, isobutyl acetate). Analysis of these samples was conducted according to NIOSH Method 1501.

B. **Inorganic Acids**

Integrated air samples for hydrochloric, nitric, phosphoric and hydrofluoric acids were obtained using SKC low-flow constant-volume pumps. A nominal flow rate of 200 cc/min for 6 to 8 hours was used for sample collection. The samples were collected on a washed silica-gel (400 milligrams front section/200 milligrams backup) sorbent tube (Supelco ORBO® 53) and analyzed according to NIOSH Method 7903.

C. **Mineral Oil Mist**

Sampling for mineral oil mist was conducted using Gilian HFS 513A air sampling pumps. The monitoring was conducted using flow rates of about 2 liters per minute (lpm) and collection periods of 4 hours. The samples were collected on 0.8 micrometer (μm) pore size mixed cellulose ester (MCE) filters and analyzed according to NIOSH Method 5026. A reference bulk sample of the cutting oil was submitted to the analytical laboratory under separate shipment.

D. **Metal Dust**

Air sampling for metal dust was conducted using Gilian HFS 513A sampling pumps with a flow rate of about 2 lpm. Sample times ranged from 3 to 7 hours. The samples were collected on 0.8 μm pore size MCE filters and analyzed according to NIOSH Method 7300.

E. **Welding Fume**

Personal exposures to airborne welding fume were monitored using Gilian HFS 513A sampling pumps. Flow rates of about 2 lpm and collection times of 4 hours were used to obtain the samples. The samples were collected on pre-weighed 5 μm 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.

F. **Sodium Hydroxide**

Exposure to sodium hydroxide dusts and mists were monitored with a Gilian HFS 513A sampling pump at a flow rate of about 2 lpm. Sampling time was about 3 hours. Each sample was collected on a 1.0 μm pore size teflon filter and analyzed according to NIOSH Method 7401.

The EDM (petroleum distillates) and FiberFrax (refractory ceramic fibers) processes initially targeted for monitoring were not operating during the NIOSH survey. Therefore, no sampling was conducted at these stations. Although sampled, the vacuum brazing furnaces were used for heat treating purposes only, and were not fully operational. For all other activities sampled, the employees monitored indicated their activities were consistent with those of a normal work day.

Surface Sampling

Surface wipe samples were collected to determine metal dust surface contamination levels at certain work stations. These samples were collected with 100% cotton gauze pads moistened with deionized water. Surface areas of 100 square centimeters were wiped with each moistened gauze pad. The samples were sent to the NIOSH contract laboratory for analysis. Areas sampled were as follows:

Sample Location	Analytes
Low Melt Alloy Workstation	cadmium, lead, tin, bismuth, indium, antimony
Table opposite Low Melt Alloy station	cadmium, lead, tin, bismuth, indium, antimony
Foremans Desk, Cleaning Department	cadmium, lead, tin, bismuth, indium, antimony
Assembly work station	nickel, chrome, cadmium
Deburr Station	nickel, chrome, cadmium

Ventilation Assessment

A limited ventilation assessment was conducted for those processes monitored that use local-exhaust ventilation for controlling worker exposure to contaminants. A comprehensive characterization of the facility ventilation system was not conducted.

The ventilation assessment consisted of measuring the air velocity at exhaust hood openings (face velocity) or slots (slot velocity). Critical dimensions were measured where necessary (e.g., tank size, hood size, slot dimensions, duct diameters, distance from hood opening to point of contaminant generation), and employee work practices when using these systems were observed (e.g flexible duct placement, damper manipulation).

Air velocity was measured using a Kurz series 490 mini-anemometer. This instrument measures air velocity in feet-per-minute (fpm). For each system evaluated, multiple measurements were obtained and the results averaged to obtain the mean velocity. Local exhaust ventilation at the following workstations were assessed:

Grinders BU4 and BU8 in Induction Braze
Deburr Station in Induction Braze
Slotted hood at Low Melt Alloy station in the Cleaning Department
Resistance Welding Stations
Actacid tank in Cleaning Department
Anti-Gall station
Nickel Plating line

Medical

Review of Illness and Injury Records

An on-site review of the "Employer's First Report of Accidental Injury or Occupational Illness" records for KIC from 1981 to present was conducted. The "Employer's First Report" records provide supplemental information and are required by the New Jersey Department of Labor for all injuries or illnesses that are considered "Recordable." All "Recordable" injuries and illnesses are also required to be reported on federally mandated OSHA-200 forms.

Investigation of Occupational Asthma Case

One case (in a worker no longer employed by KIC) of occupational asthma was recorded in the "Employer's First Report" records. Additional information was obtained regarding this case through a review of medical records and by interviewing the patient's physician.

Employee Interviews

On-site interviews of all 52 KIC employees who work in production areas of the plant were conducted on January 16 and 17, 1992. Based on the review of the "Employer's First Reports," the interviews focused primarily on skin and respiratory symptoms, using the NJDOH form "Confidential Medical Questionnaire for Suspected Lung Disease." Questions regarding health and safety training and use of personal protective equipment were included in the interview.

EVALUATION CRITERIA

General

As a guide to the evaluation of the hazards posed by work place 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 work place 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 work place 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.[2-4] Often, NIOSH recommendations and ACGIH TLVs may be different from the corresponding OSHA standard. Both NIOSH recommendations and ACGIH TLVs are usually based on more recent information than OSHA standards due to the lengthy process involved with promulgating federal regulations. 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.

Substance Specific Criteria

Organic Solvents

Exposure to organic solvents can occur through inhalation of the vapors, skin contact with the liquid, or ingestion. As many organic solvents have high vapor pressures and readily evaporate, inhalation of vapors is considered a primary route of exposure. Overexposure to many organic solvents can cause irritation, central nervous system depression, headache, nausea, and possible effects on the liver, kidney or other organs.[(5-7)] Many industrial solvents are primary irritants and can cause defatting of the skin and dermatitis. Solvents are among the leading causes of occupational skin disease.[6] Biological effects of exposure can range from nearly non-toxic (e.g., some chlorofluorocarbons) to highly toxic (e.g., carbon tetrachloride) or carcinogenic (e.g., benzene).[7] The ability to detect the presence of solvents by the sense of smell will vary widely, depending on the specific substance and individual sensitivity. Substances are considered to have good warning properties if an average person with normal sensory perception can detect the presence of the chemical at a level below the recommended exposure limit. The following table summarizes the principle health effects associated with the solvents evaluated, and lists the NIOSH RELs and odor detection thresholds for these compounds.

Chemical	NIOSH REL[4]	Odor Threshold & Description[10]	Principle Health Effects[(7-9, 11)]
1,1,1-trichloroethane (methyl chloroform)	350 ppm (C)	390 ppm: sweet/ether like	Central nervous system depression, dizziness, eye irritation
methyl-ethyl ketone (2-butanone)	200 TWA 300 ppm STEL	17 ppm: sweet, sharp	Headache, dizziness, numbness of extremities. Dermal and eye irritation.
toluene	100 TWA 150 ppm STEL	1.6 ppm: sour, burnt	eye/respiratory irritation, fatigue, headache, central nervous system effects
xylene	100 TWA 150 ppm STEL	20 ppm: sweet	eye/respiratory irritation, drowsiness, headache, dermal effects
acetone	250 ppm TWA	62 ppm: sweet, fruity	eye irritation, nausea, headache, central nervous system depression.
isobutyl acetate	150 ppm TWA	1.1 ppm: sweet, ester	eye/respiratory irritation, drowsiness

Note: TWA = time-weighted average concentration for up to 10 hours/day
C = ceiling limit not to be exceeded
STEL= short-term exposure limit - 15 minute average

Note that many solvents have similar toxic effects. When there are exposures to two or more substances that act upon the same organ system, their combined effect should be considered. Unless there is scientific evidence to the contrary, the effects are considered to be additive (as opposed to potentiating, synergistic, or antagonistic) and are calculated as follows:

$$\text{Equivalent Exposure} = \frac{C_1}{REL_1} + \frac{C_2}{REL_2} + \dots \frac{C_n}{REL_n}$$

Where: C = measured atmospheric concentration
REL = corresponding recommended exposure limit

If the sum of the above fractions exceeds unity (1), the equivalent exposure, or combined REL, is considered exceeded.

Inorganic Acids

Inorganic acids are primary irritants and are corrosive in high concentrations. Inorganic acids will cause chemical burns when in contact with the skin and mucous membranes and are a particular hazard if contact with the eye should occur.[12] Vapors and mists are respiratory tract irritants. Discoloration or erosion of the teeth also may occur in exposed workers. Ingestion of inorganic acids will cause severe throat and stomach destruction. The following table lists the inorganic acids evaluated and their corresponding health effects. Hydrofluoric acid (HF), because of its particular hazard properties, will be further discussed in the following section.

Chemical	NIOSH REL[4]	Principle Health Effects [7,12]
Hydrochloric acid	5 ppm (C)	Corrosive to skin, eyes and mucous membranes, respiratory tract irritant.
Nitric acid	2 ppm (TWA), 4 ppm (STEL)	Corrosive to skin and other tissue, pneumonitis, pulmonary edema. May liberate gaseous oxides of nitrogen
Phosphoric acid	1 mg/m^3 (TWA), 3 mg/m^3 (STEL)	Eye, respiratory tract, skin irritant. Concentrated solutions can cause severe burns.
Hydrofluoric acid	3 ppm (TWA), 6 ppm (STEL)	Severe and painful burns on contact. Inhalation may cause delayed pulmonary edema.

Note: mg/m^3 = milligrams of contaminant per cubic meter of air

As with the other inorganic acids, skin contact with concentrated HF will result in marked tissue destruction. However, un-disassociated HF will readily penetrate skin and deep tissue where the corrosive fluoride ion can cause necrosis of soft tissues and decalcification of bone, resulting in excruciating pain.[8] Due to this property, contact with dilute solutions, or minor exposures, can cause delayed reactions which eventually become severe burns. This process of tissue destruction and HF neutralization, unlike other acids, is prolonged for days.[8]

Sodium Hydroxide

Sodium hydroxide, or caustic soda, can cause severe damage to the eyes, mucous membranes, and skin. Skin or eye contact with concentrated solutions, and the resultant rapid tissue destruction, poses the greatest hazard.[8] Because of the low vapor pressure, inhalation is usually a secondary hazard, although dusts or mists can be generated in heated solutions, during agitation, or dispensing. The effects of inhalation will vary from mild nasal irritation to severe pneumonitis, depending on the severity of exposure.[8] The NIOSH REL for sodium hydroxide is 2 mg/m^3 as a ceiling limit.[4]

Mineral Oil Mist

Mineral oil mist refers to the airborne mist of petroleum-based cutting oils. Mineral oil mist is considered to be of low toxicity and epidemiological studies of exposed workers indicated a lack of reported illness related to these exposures.[8] Excessive exposure could result in eye or respiratory tract irritation. The NIOSH REL for mineral oil mist is 5 mg/m^3 as a time-weighted average, and 10 mg/m^3 as a 15 minute short-term exposure limit[4].

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.[2,13] 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. Epidemiological studies and case reports of workers exposed to welding emissions has shown an increased incidence of acute and chronic respiratory diseases.[13] 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.[13] 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.[13] 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.[2,3]

The potential health effects and NIOSH RELs for the major elements that were detected in the environmental samples are shown in the following table. These metals may be present when grinding or deburring various alloys, or at the low-melt allow work station.

Element	NIOSH REL[4] (mg/m^3)	Principle Health Effects[8,14]
Lead	<0.1*	Damage to blood-forming, nervous, urinary and reproductive systems. Symptoms include joint pain, metallic taste, anxiety, colic, tremors
Cadmium	LFC**	pulmonary edema, emphysema, pneumonitis, headache, muscle ache, nausea, vomiting, renal injury
Nickel	0.015	dermatitis, pneumoconiosis, nasal irritation, nasal and lung cancer
Tin	2	benign pneumoconiosis, respiratory irritation
Chromium	0.5***	skin and mucous membrane irritation, possible lung cancer
Molybdenum	NE****	Possible eye and mucous membrane irritant
Manganese	1 (TWA), 3 (STEL)	Headache, irritability, central nervous system effects, metal fume fever
Iron	5	benign pneumoconiosis (siderosis)
Zinc	5 (TWA), 10 (STEL)	metal fume fever (influenza-like illness), dry or irritated throat, metallic taste
Bismuth	NE	considered a "nuisance" dust
Indium	0.1	possible pneumonitis, alveolar edema, lung function impairment

* Air level to be maintained so that worker blood level remains less than 0.060 mg/100 grams of whole blood.

** NIOSH considers cadmium to be a potential human carcinogen and recommends controlling exposure to the lowest feasible concentration (LFC).

*** 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]

**** NIOSH has not established a REL for molybdenum. The OSHA permissible exposure limit is 5 mg/m^3 for soluble molybdenum and 10 mg/m^3 for insoluble molybdenum

Surface Contamination

Standards defining "acceptable" levels of surface contamination have not been established for any of the substances evaluated. However, wipe samples can provide information regarding the effectiveness of housekeeping practices, the potential for exposure to contaminants from other exposure routes (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

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, are warranted. Ventilation data can also be used to explain variations observed in air quality measurements.

RESULTS AND DISCUSSION

A. Workplace Observations

1. Housekeeping

In general, housekeeping appeared orderly throughout the manufacturing facility. Work aisles were clear and the work stations were in good condition. Chemical containers were capped and maintained in cabinets.

2. Personal Protective Equipment

Employee adherence to the use of proper personal protective equipment (PPE) was sporadic. Procedures or policies have not been implemented requiring the use of PPE at the facility. Employees were observed using the vapor degreaser and working at the Anti-Gall station without wearing protective gloves, aprons or eye protection. The employee working at the Actacid tank wore cotton gloves, which afford little or no protection against the acid in this tank. Similarly, the plating operator was observed at the plating line on different occasions both with and without proper PPE (gloves, apron, faceshield, eye protection). Note that a face shield will not provide unlimited protection from chemicals. Proper goggles should be worn in combination with face shields where chemical splash hazards exist.

Disposable 3M 8710 Dust/Mist respirators (TC 21C-132) are provided to any employee who wants one. A respiratory protection program (employee training, fit-testing, respirator selection, etc.) has not been implemented at the facility. It was observed that employees at the Actacid station, the degreasing station, and the nickel plating line were wearing disposable respirators. These types of respirators will afford no protection against the contaminants that may be generated at these stations (acid mists, solvent vapors).

3. General Hygiene

Although a break room has recently been constructed for KIC employees, food and beverages were consumed at some work stations where chemicals are used (Cleaning Department, Low-Melt Alloy station). Eating and drinking in chemical use areas can result in cross-contamination and potential exposures via ingestion. Compressed air is used throughout the facility for cleaning or drying of parts (e.g., when parts are removed from the degreaser) and workstations. When not controlled, the use of compressed air can generate airborne contaminants (e.g., metal dusts).

The facility has developed a chemical tracking and labeling system. Many containers have been identified. However, in some areas, labeling improvements are still necessary. These areas include the Cleaning Department (acid tanks) and the nickel plating line.

B. Ventilation Assessment

1. Grinders BU4 and BU8 in Induction Braze

These grinders (wheel size 6") are used daily to lightly grind, deburr or smooth weld seams on a variety of high-strength metal alloy components (primarily stainless steel). There is no heavy grinding of metal components at these stations. The two dual-wheel grinders are stationed next to each other and each wheel is provided with a semi-enclosing exhaust hood. The grinding wheel is partially recessed into the hood. The front and sides of the grinding wheel are accessible. Each hood is connected, via rigid sheet metal duct work, to a common main ventilation duct. The fan and exhaust stack are located outside of the building. Each connecting duct is provided with a sliding-gate damper that is not locked in any fixed position. The hood dimensions were the same for all four grinding wheels.

Velocity measurements were obtained at the point where the air stream enters the hood. Due to the location of the grinding wheel, this measurement also closely approximates the capture velocity of the system. Capture velocity is the air velocity at the point of contaminant generation.

Hood dimensions = 4" X 11" (area (A) = 0.31 ft^2)
Volumetric flow rate in cubic feet per minute (CFM) = velocity (fpm) X A

HOOD BU4: Right Side = 400 fpm, 122 CFM
Left Side = 700 fpm, 214 CFM

HOOD BU8: Right Side = 200 fpm, 61 CFM
Left Side = 400 fpm, 122 CFM

2. Deburr Station in Induction Braze

At this station, a flexible duct with a cone shaped tapered hood inlet is used to control contaminants generated during deburring. The operator uses a small hand-held tool with an abrasive wheel to "fine-tune" and polish metal components at a work table. The operator can position the duct as needed to optimize contaminant capture. It was observed that the operator usually positions the hood within 6-12" of the deburring work.

Hood dimensions = 5.5" diameter, A = 0.165 ft^2
Average face velocity = 900 fpm
Volumetric flow rate = 900 fpm X 0.165 ft^2 = 148 CFM

Capture velocity for an unflanged hood on a bench is determined by the formula:
$Q = V(5X^2 + A)$, where:

Q = volumetric flow rate in CFM
V = capture velocity at distance X
X = distance from hood face to farthest point of contaminant release, in feet.

Using this formula, capture velocities for the observed work distances from the hood opening are as follows:

X = 6", V = 105 fpm
X = 12", V = 29 fpm

3. Slotted hood at Low Melt Alloy Station

At this station, located in the Cleaning Department, molten alloy (combination of antimony, tin, cadmium, lead, indium and bismuth) is dispensed into small metal components. This is a full-time activity. The metal is heated in a 5-gallon babbitt pot maintained at 160°F. Molten material is then transferred to an automatic dispenser and a series of small metal components called "veins" are filled. The "veins" are then moved back to the area where the babbitt pot is located where they are topped off with the molten alloy using a ladle. The worker stands in an aisle-way between the auto-dispense system and the babbitt pot. Anti-oxidant oil is also applied to the top of the "veins" after they are filled. The "veins" are then submerged in water to cool.

A slotted exhaust hood has been installed at a table behind and 2 feet below the auto-dispensing system. On the side closest to the auto-dispense system, approximately 15" of the slot has been blocked off. Work practice observations indicated that most tasks involving the molten alloy are conducted 3-5 feet away from this hood.

Hood Dimensions: slot size = 1.25" X 54" = 0.469 ft^2
Average slot velocity = 1400 fpm
Volumetric flow rate = 1400 fpm X 0.469 = 657 CFM

Slot velocity was uniform across the length of the slot, indicating that the plenum was functioning properly.

4. Resistance Welding Stations

There are two welding stations located in a separate room (ceiling height about 9 feet) in the manufacturing area. Welding of various high-strength alloy (stainless steel) parts is a full-time job for the two employees who work in this room. All welding conducted is tungsten inert gas (TIG), where the arc is established between a nonconsumable tungsten electrode and the item to be welded using an electrical energy source (25 amps, direct current). Argon is the inert gas shield. Occasionally filler metals (e.g., inconel) may be used. Each welding station is provided with a 4" flexible exhaust duct ($A = 0.087\ ft^2$) intended to remove contaminants generated during welding.

Welding Workstation #1 (adjacent door to final inspection station):

The duct is suspended about 3 feet above the work table and the hood face is perpendicular to the table. The ductwork does not appear to be long enough to reach all areas of the welding work table. During welding, the workers breathing zone is between the workpiece being welded and the exhaust duct.

Average hood face velocity = 225 fpm
Volumetric flow rate = 225 fpm X $0.087\ ft^2$ = 20 CFM

Welding Workstation #2 (adjacent titanium welding system):

The duct is suspended about 12 inches above the work table and 2 feet from the area on the table where welding was observed to take place. The hood face was toward the work table.

Average hood face velocity = 135 fpm
Volumetric flow rate = 135 X $0.087\ ft^2$ = 12 CFM

The capture velocity for a freely suspended unflanged hood is calculated by the formula: $Q = V(10X^2 + A)$, where

Q = volumetric flow rate in CFM
V = capture velocity at distance X
X = distance from hood face to farthest point of contaminant generation

Using this formula, capture velocities for the observed work distances at these stations are as follows:

Workstation #1, X = 3', V = 0.2 fpm
Workstation #2, X = 2', V = 0.3 fpm

5. Actacid Tank

The Actacid Tank (heated >30% hydrochloric acid) is in the rear of the cleaning department and is used for cleaning metal parts. Parts are dipped in the tank for short periods of time (<5 minutes) and then rinsed. The Actacid tank is not continuously in operation but is used on an as-needed basis. The round tank, located in a bench against the back wall, is ventilated via a slotted hood attached to the back of the bench. The slot is 4" behind and 8" above the Actacid tank. The liquid level is within 4" of the top of the tank. A portion of the slot that is not directly behind the tank has been blocked off. Visible vapor emissions were noted emanating from a seam in the polypropylene bench cover on the right side of the tank.

Tank dimensions = 21" diameter (tank area = 2.4 ft^2)
Hood dimensions = 1.5" slot width, 27" slot length (A = 0.281 ft^2)
Average slot velocity = 1100 fpm
Volumetric flow rate = 1100 X 0.281 ft^2 = 309 CFM

6. <u>Anti-Gall Station</u>

At the Anti-Gall Station, metal fittings are manually coated, using a small paint brush, with a solvent-based material dispensed from pint-sized jars. The Anti-Gall is applied to ensure non-silver coated fittings remain tight when connected. There is one operator at the work station where the Anti-Gall is applied. A thinner (toluene) is frequently added to maintain the right viscosity. Acetone and toluene are also used for clean-up purposes. A perforated 4" PVC pipe located on the work table is used to ventilate the solvent vapors away from the worker. The PVC pipe is connected to a commercial-type portable exhaust with a fabric filter installed behind the work table. These types of systems, designed for particulate control, are ineffective for solvent vapors as the vapors will pass through the filter back into the workroom environment.

7. <u>Nickel Plating Line</u>

The nickel electroplating process is along a wall in a separate room adjacent the Cleaning department. Metal components are plated (referred to as "flash" plating by KIC employees) in a series of tanks to enhance the "wettability" of certain metal parts for brazing. This is a low-volume operation entailing about 50% of one employee's work-shift time. Components are manually moved through the process to plate the tubing ends with nickel.

The nickel plating line (nickel sulfamate process) used at the KIC facility has the following steps:

1. Cleaning in Tank P-9, containing heated (140° 160° F) sodium hydroxide (Clepo 166) for 2-3 minutes, followed by a water rinse.

2. Activation in Tank R-3, containing 30% hydrochloric acid at room temperature, for 10-45 seconds, followed by a water rinse.

3. Nickel Strike (Woods Nickel Strike), a solution of nickel chloride and hydrochloric acid at room temperature for 2-4 minutes with 60 amperes of current per square foot, followed by a water rinse.

4. Plating with nickel sulfamate solution at 130° F with 25-75 amperes of current per square foot, followed by a water rinse.

The cleaning, activation, nickel strike and plating tanks are equipped with slotted hoods at the back of each tank. The hoods are constructed of polypropylene for corrosion resistance and are connected to a common main exhaust duct.

Cleaning Tank

Tank dimensions = 25" long, 21" wide. width/length ratio = 0.84
slot width = 2"
slot length = 27"
slot area = 0.375 ft^2

average slot velocity = 1100 fpm
volumetric flow rate = 412.5 CFM

The slotted hood is directly behind and 15.5" above the tank. The liquid level in the tank was 4" below the top of the tank.

Activation Tank

Tank dimensions = 25" long, 21" wide. width/length ratio = 0.88
slot width = 1"
slot length = 27"
slot area = 0.1875 ft^2
average slot velocity = 700 fpm
volumetric flow rate = 131 CFM

The slotted hood is directly behind and 4" above the tank. The liquid level in the tank was 5" below the top of the tank.

Nickel Strike Tank

Tank dimensions = 25" long, 23" wide, width/length ratio = 0.92
slot width = 2"
slot length = 27"
slot area = 0.375 ft^2
average slot velocity = 1100 fpm
volumetric flow rate = 412.5 CFM

The slotted hood is directly behind and 21" above the tank. The liquid level in the tank was 5" below the top of the tank.

Nickel Sulfamate Tank

Tank dimensions = 36" long, 23" wide, width/length ratio = 0.64
slot width = 2"
slot length = 27"
slot area = 0.375 ft^2
average slot velocity = 1000 fpm
volumetric flow rate = 375 CFM

The slotted hood is directly behind and 21" above the right side of the tank. The liquid level in the tank was 2" below the top of the tank.

C. Environmental Monitoring

1. Solvent Sampling

The results of the solvent sampling are depicted in Table 2. All measured contaminants were well below acceptable levels. The highest concentration detected for the Anti-Gall operator was toluene (1.79 ppm) found on the afternoon sample. In the Cleaning Department, the highest contaminant concentration detected was 7.69 ppm of 1,1,1-trichloroethane, found on the afternoon sample collected from the cleaning operator. Time-weighted average concentrations of 1,1,1-trichloroethane for the two employees sampled in the cleaning department were 4.36 ppm, (cleaning operator) and 1.92 ppm, (Assistant Foreman).

2. Inorganic Acids/Sodium Hydroxide

The personal sampling results for inorganic acids and sodium hydroxide are shown in Table 3. For the electroplater, all contaminants sampled were below the analytical limit of detection. Exposure to hydrochloric acid for both the cleaning operator and Assistant Foreman were above the limit of detection but below the level of quantification. Nitric acid concentrations averaged 0.09 ppm for the cleaning operator and 0.15 ppm for the Assistant Foreman during the sampling period. It was noted that the Assistant Foreman was periodically working at the Actacid tank (30% hydrochloric acid) which is adjacent a small (1-2 gallons) cleaning tank containing nitric acid.

3. Welding Fume, Metal Dust, Low Melt Alloy, Electroplating

Detectable levels of chromium (0.001 mg/m^3), manganese (0.002 mg/m^3), zinc (0.002 mg/m^3) and iron (0.002 mg/m^3) were found on the personal sample taken from resistance welding station #1 (Table 4). No detectable concentrations of the elements analyzed were found on the personal sample taken from resistance welding station #2. The results, both element specific and gravimetric, were below applicable exposure criteria. The valence state of the chromium was not determined; however it is possible that the chrome was in the hexavalent state as hexavalent chrome has been detected in welding fume.[13] Because the workers monitored only welded sporadically through the day, and frequently went to other stations or performed other tasks, the samples were not collected inside the welding helmet. Therefore, the results are considered to represent a "worst-case" potential exposure, and not a true representation of personal exposure.

No detectable levels of metal fume were found on the personal samples collected from the low melt alloy station (Table 5). It is likely that the relatively low temperature used (160°F), lack of agitation of the molten material, and the anti-oxidant oil reduce the potential for fume generation.

Low concentrations of iron (0.002 mg/m^3), molybdenum (0.008 mg/m^3) and zinc (0.001 mg/m^3) were detected on the personal sample taken at the Deburring station in the Induction Braze department. The only metal detected on the personal sample taken from the grinder was iron (0.001 mg/m^3). No detectable concentrations of metal dust were found on the personal sample collected from the Lead Man in the Induction Braze. This individual spent most the work-shift at the metal grinding station.

The results of the personal sample collected from the electroplater indicate a concentration of 0.007 mg/m^3 of nickel during the monitoring period. This is approximately one-half of the NIOSH REL for nickel (0.015 mg/m^3). Note that NIOSH considers nickel to be a potential human carcinogen and recommends maintaining exposures at the lowest feasible concentration.[4]

No metal fume was detected on the personal samples collected from the Furnace Braze operator or the Electrode (Logic) welder. As previously mentioned, the brazing furnace was not fully operational, and was only used for heat treating purposes during the sampling period. As such, the results are not representative of this task at full capacity.

4. Mineral Oil Mist

The results of the air samples collected at the metal milling and lathing areas are shown in Table 6. The monitoring indicates exposures were below the applicable exposure criteria during the sampling period for both the milling (0.18 mg/m^3) and lathing (0.09 mg/m^3) operation.

5. Surface Contamination Sampling

The results of the surface sampling (Table 7) indicate the presence of various metal residues on the surfaces sampled. The highest contamination levels were detected in the Cleaning Department. Of particular concern was the presence of 1800 micrograms of lead per 100 square centimeters ($\mu g/100\ cm^2$) and 660 $\mu g/100\ cm^2$ of cadmium at the Low Melt Alloy workstation. Although standards regarding surface contamination have not been established, these levels suggest a need for improved housekeeping in this area. Contaminant migration is evident as both lead and cadmium were detected in the surface samples taken from the table opposite the Low Melt Alloy hood, and on the Foreman's desk in the Cleaning Department. Food and beverage consumption occasionally takes place in these areas, and compressed air is often used for clean up or parts drying, thus presenting a potential exposure pathway via ingestion and/or inhalation.

At the other workstations sampled, both chromium and nickel were detected in the surface samples. The highest level found was nickel (31 µg/100 cm^2) at the workstation in the Furnace Braze Assembly department.

D. Medical

1. Review of Illness and Injury Records

Based on a review of the "Employer's First Report of Accidental Injury or Occupational Illness" (1988-November, 1991), work-related injuries most frequently occurring at KIC included (in order of decreasing frequency), laceration/puncture wounds, musculoskeletal injuries (such as sprains or contusions), and eye injuries. None of these injuries resulted in death or permanent disability. Lacerations or puncture injuries occurred in the Machine Shop (Dept. 96), the Cutting Department (90), and the Tool Room. Musculoskeletal injuries occurred most often in Shipping and Receiving (Dept. 75). Foreign bodies or chemical splashes to the eyes occurred in the Machine Shop (Dept. 96), Assembly Department (99), and Deburring (90). One case of eye burns from reflected light occurred in the welding area. There were two reports of occupational illness. One case of occupational dermatitis occurred in 1989 and was associated with the petroleum distillate used in the EDM process (Dept. 89). One case of occupational asthma was recorded in 1991 for an employee who worked in "EDM and Auto-Weld" (Dept. 89). Other than the date of the injury, no details were available regarding this case.

2. Investigation of Occupational Asthma Case

The treating physician for the former employee reported to have occupational asthma was contacted. The physician indicated that the former employee had asthma and pulmonary fibrosis which he believes are work-related; however, he was not able to suggest a specific causative agent for either condition.

3. Employee Interviews

Employees were asked to indicate how often they have been bothered at work by each of the following symptoms:

nasal stuffiness	runny nose
tearing or burning eyes	sore or dry throat
cough	wheezing
chest tightness	shortness of breath
skin rash	

Of the 52 employees interviewed, 14 (27%) indicated that they had experienced at least one of the above symptoms at least once per month at work. It should be noted that this response does not make any distinction between symptoms experienced at work caused by other illnesses (e.g., upper respiratory tract infections) and those attributable exclusively to workplace conditions. Some of these employees with positive responses indicated that they did not attribute these symptoms specifically to workplace conditions. For instance, in one case, onset of symptoms pre-dated the person's employment at KIC. Table 8 summarizes employee responses regarding the frequency of symptoms.

The most frequently reported symptom was "tearing or burning of eyes." The presence of this symptom could be indicative of exposure to irritating fumes or vapors. Nine (17%) of the employees interviewed indicated they experienced this symptom at work at least monthly. Eye irritation was reported in departments 89, 90, 91, 92, 95, and 96. Situations associated with eye irritation included: deburring, fumes from certain chemicals in Cleaning, using the low-melting alloy, and fumes from the oven when the doors are opened after baking product. Seven (13%) employees reported cough occurring at work at least once per month, and two others indicated that cough occurs "seldom." Three (6%) employees reported experiencing chest tightness and shortness of breath at work at least once per month; however, two of these individuals indicated that they had experienced these symptoms since childhood due to asthma diagnosed prior to starting work. The third attributes the symptoms, which occur about once per month, to unspecified workplace exposures.

Employees were asked whether they had seen a doctor for the following conditions: shortness of breath, sinus problems, skin rash, and asthma. Four (8%) employees indicated that they had been told by a doctor that they had asthma. Of these, three reported they had been diagnosed during childhood, and at least one is currently completely asymptomatic. The remaining employee developed asthma in 1971 and attributes it to a reaction to a prescribed medication. Seven (13%) employees stated that they had seen a doctor for shortness of breath (this includes three of the four individuals who had been treated for asthma). None of these individuals indicated that the condition was clearly related to workplace exposures.

Six (12%) employees reported seeing a doctor for skin rash. Four of the rashes were possibly work-related. None of the 6 employees reported having a chronic condition under treatment by a doctor.

4. Death Certificates

The HHE request included a list of 16 names of former KIC employees who had died since 1979. The causes of death were indicated as "cancer" (8 cases including 3 cases of leukemia, 1 case of "liver cancer", and 4 unspecified), "heart attack" (6 cases), one case of "emphysema", and one case of "gangrene."

The KIC Human Resources Manager was interviewed regarding KIC employees who had died in the past ten years, and the causes of death. He recalled four employees who had died in the last ten years: (1) a Final Inspection Department employee who died of breast cancer at age 64, (2) a Shipping Supervisor who died of renal cell carcinoma at age 61, (3) a Vendor Inspection employee who died in 1990 of a heart attack while on vacation, and (4) a QC employee who died suddenly on the way home from work, apparently suffering from coronary artery disease. These former employees were also identified on the HHE requestors list.

Cancer and heart attacks are common causes of death. Given the time period provided (12 years), and the common causes of death, it appears unlikely that there is an unusual cluster of work-related deaths at this facility.

E. Health and Safety Training

Thirty-nine production employees reported that they work with chemicals while performing their duties. Of this 39, 25 (64%) indicated they had not received any chemical health or safety training. Seven (18%) received training and 7 (18%) reported "some training."

Twenty-two employees reported using a dust-mask respirator during work; 13 employees stated it was a job requirement. Twelve (52%) of the 22 employees using a respirator had been trained. None of the employees using respirators had been fit-tested.

CONCLUSIONS

The monitoring results did not show an inhalation hazard for the employees sampled during the monitoring period. Surface contamination levels, however, especially in the Cleaning department, are such that improved housekeeping and hygiene practices are necessary. The existing ventilation systems, except for the welding and anti-gall stations, appear to be functioning effectively. However, any production increases or process changes, especially in the electroplating department, should be evaluated to ensure contaminants are effectively controlled.

The potential for exposure during the EDM, FiberFrax (refractory ceramic fiber) and Furnace Braze operations were not fully operational and could not be properly assessed during this project.

No indication of unusual health problems attributable to workplace conditions were noted in the employee interviews. There were no current cases of asthma identified among employees considered to be related to work. The employee with a diagnosis of occupational asthma no longer works at the KIC facility and the specific exposure(s) or agent(s) causing the asthma are unknown. The causes of death in the list provided by the HHE requestor, considering the time period during which they occurred, are not suggestive of an unusual cluster of occupationally-related deaths.

Adherance to the proper use of personal protective equipment needs improvement. Employees were observed working with chemicals that pose a skin or eye contact hazard without wearing the proper protective equipment. This is of particular concern where hydrofluoric acid is used, as contact with this chemical can result in delayed, painful outcomes. Respiratory protection was also used improperly in some areas. Workers who are provided respirators without proper training or selection may feel protected when they are not, thus potentially placing themselves in hazardous situations.

Employee training regarding chemical health and safety needs improvement. Most of the employees interviewed had not received any chemical or respirator training. Implementation of a training regimen would help address the previously noted issues regarding the use of protective equipment and respirators.

RECOMMENDATIONS

1. The ventilation system at the Anti-Gall station is ineffective for control of solvent vapors. The exhaust air should be vented outside the building.

2. The welding ventilation systems are ineffective for control of fume. This is due to the low volumetric flow rate and the distance between the point of welding fume generation and the exhaust duct inlet. The exhaust systems should be redesigned to provide a minimum of 100 fpm capture velocity at these work stations. Redesign options include increasing the volumetric flow rate of the existing systems and positioning the hood face closer to the welding, and/or providing an exhausted enclosure for this activity.

3. Repair the Actacid tank holder. Visible emissions were noted coming from seams in this holder that were not effectively captured by the ventilation. The need to heat this liquid should be confirmed and the acid should be used at room temperature if possible. Additionally, the liquid level in the tank should be kept at least 6" below the top of the tank. The tank should be covered when not in use.

4. Eliminate the use of compressed air at the metal grinding and low-melt alloy stations. If compressed air is being used to dry parts removed from the vapor degreaser, it means the parts are not being left in the degreaser long enough. If the part is not allowed to remain in the vapor long enough to reach the temperature of the vapor, solvent can be dragged out. Ensure that employees are properly trained and that parts are kept in the vapor until they reach vapor temperature and are dry. Compressed air use at the metal grinding and Low Melt Alloy stations can cause settled metal fumes and dust to become airborne, creating a potential inhalation hazard.

5. Educate employees regarding the proper use of local exhaust ventilation. For example, the proximity of the work to the hood inlet significantly affects capture, as shown in the description provided for the DeBurr station. Workers should also be cautioned not to stand between the work task and the exhaust hood.

6. Implement housekeeping procedures to ensure surfaces remain as free as possible of metal dust/fume accumulation. Daily workstation cleanups should be instituted using dampened cloth rags or other approved methods (e.g., vacuum cleaner with approved [HEPA] filter). Dry sweeping should not be allowed in the Low Melt Alloy station. Low Melt Alloy employees should be cautioned regarding the potential for transport of surface contamination to other areas, including their residence. One possible solution is to ensure that Low Melt Alloy employees change clothes and shoes before leaving KIC.

7. Re-evaluate the effectiveness of the ventilation systems to control exposures whenever increases in production or process changes occur. For example, the low exposures experienced by the electroplater during the NIOSH monitoring could be primarily due to the low volume of work at this station.

8. All chemical containers (portable and stationary) should be prominently labeled. Labels should include the name of the material and appropriate hazard warnings. Any symbols or number identification systems used should be explained to employees through the facility hazard communication training program.

9. Develop personal protective equipment use criteria for the chemical handling work stations. Ensure all employees adhere to the proper use of personal protective equipment. Posting of these requirements may be one method to help ensure employees wear the necessary safety equipment.

10. Control the use of respirators at the facility. Appropriate respirators should be provided when respiratory protection is necessary. The use of the disposable respirators at stations where they are ineffective should be eliminated (degreasing, cleaning, plating). A respiratory protection program, as defined in

29 CFR 1910.134 (OSHA General Industry Regulations) should be developed and implemented where respirators are used. Employees should be properly trained and fit-tested. This applies even to those situations where employees are using respirators for comfort reasons.

11. Employees should be encouraged to report odors or symptoms to management when they occur so immediate investigation can be undertaken and appropriate action taken.

12. Ensure food and beverage consumption is limited to authorized areas away from chemical use locations. Educate employees regarding the potential for exposure via ingestion.

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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
Air Monitoring Survey
Kreisler Industrial Corporation
January 16-17, 1992
HETA 92-010

Job Title	Process	Contaminants Sampled
Anti-Gall Operator	Anti-Gall Station	methyl-ethyl-ketone, toluene, xylene, acetone, isobutyl acetate
Cleaner	Degreasing, parts cleaning and washing	1,1,1 trichloroethane, hydrochloric acid, phosphoric acid, nitric acid, hydrofluoric acid
Assistant Foreman	Degreasing, parts cleaning and washing	1,1,1 trichloroethane, hydrochloric acid, phosphoric acid, nitric acid, hydrofluoric acid
Electroplater and pressure tester	Nickel Plating	sodium hydroxide, nickel, hydrochloric acid, hydrofluoric acid, phosphoric acid, nitric acid
Machinist	Metal Lathe	mineral oil mist
Machinist	Metal Milling	mineral oil mist
Lead Man	Metal Grinding	metal dust (29 separate elements)
Cleaner	Low Melt Alloy	lead, cadmium, indium, tin, antimony, nickel
Welder	TIG welding	metal fume (29 separate elements), total fume (gravimetric)
Deburrer	Metal Grinding	metal dust (29 separate elements)
Brazer	Furnace Braze	metal fume (29 separate elements)
Welder	Logic Welding	metal fume (29 separate elements)

Table 2
Personal Sampling Results: Solvents
Kreisler Industrial Corporation
January 16-17, 1992
HETA 92-010

Task Monitored	Sample Number	Sample time (min)	Contaminants Sampled	Concentration (ppm)[1]	TWA[2]	EE[3]
Anti-Gall Operator	AMB-1	7:54-11:27 (213)	acetone	<0.35	<0.36	0.02
			methyl-ethyl-ketone	<0.28	<0.29	
	AMB-1A	12:26-3:53 (207)	acetone	<0.37		
			methyl-ethyl-ketone	<0.29		
	CT-3	7:54-11:27 (213)	xylene	<0.19	<0.20	
			toluene	0.44[4]	1.1[4]	
			isobutyl acetate	<0.18	<0.19	
	CT-3A	12:26-3:53 (207)	xylene	<0.20		
			toluene	1.79		
			isobutyl acetate	<0.18		
Cleaning Operator	CT-1	7:57-11:35 (218)	1,1,1-trichloroethane	1.11	4.36	NA
	CT-1A	12:17-3:50 (213)	1,1,1-trichloroethane	7.69		
Assistant Foreman (Cleaning Dept)	CT-2	7:58-11:33 (218)	1,1,1-trichloroethane	1.16	1.92	NA
	CT-2A	12:15-3:45 (210)	1,1,1-trichloroethane	2.69		

NOTES:

1. ppm = parts of gas or vapor per million parts of air
2. TWA = time-weighted average concentration computed as follows:

$$TWA = \frac{(C_1)(T_1) + (C_2)(T_2) + ... (C_n)(T_n)}{T_1 + T_2 + ... T_n}$$

Where: C = Contaminant concentration
T = Corresponding sampling time

3. EE = equivalent exposure, used to assess the combined (additive) affect of exposure to multiple contaminants that have similar toxicological properties. If the sum of the contaminant concentrations divided by the corresponding REL exceeds unity, then the REL for the mixture is considered to have been exceeded.

4. Concentration detected was between the analytical level of detection and the level of quantification

< = Less than (no contaminant detected), the concentration listed is the analytical level of detection

Table 3
Personal Sampling Results: Inorganic Acids/Sodium Hydroxide
Kreisler Industrial Corporation
January 16-17, 1992
HETA 92-010

Task Monitored	Sample Number	Sample time (min)	Contaminants Sampled	Concentration (mg/m3)[1]
Electroplater	IA-1	8:02-11:30 (208)	Hydrochloric acid	<0.07
			Nitric acid	<0.07
			Phosphoric acid	<0.14
			Hydrofluoric acid	<0.07
	4139	9:47-11:30 (104)	Sodium hydroxide	<0.18
Cleaner	IA-2	7:39-11:35 12:17-3:50 (449)	Hydrochloric acid	0.06[2]
			Nitric acid	0.09
			Phosphoric acid	<0.07
			Hydrofluoric acid	<0.04
Assistant Foreman (Cleaning Dept)	IA-3	7:42-11:33 12:15-3:45 (441)	Hydrochloric acid	0.04[2]
			Nitric acid	0.15
			Phosphoric acid	<0.06
			Hydrofluoric acid	<0.03

NOTES:

1. mg/m3 = milligrams of contaminant per cubic meter of air
2. Concentration detected was between the analytical limit of detection and the limit of quantification

< = less than (no contaminant detected), the concentration listed is the analytical limit of detection

Table 4
Personal Sampling Results: Welding Fume
Kreisler Industrial Corporation
January 16-17, 1992
HETA 92-010

Task Monitored	Sample Number	Sample time (min)	Contaminants Sampled	Concentration (mg/m3)[1]
Resistance Welding Station #1	FW6923	8:14-11:40 (209)	Chromium	0.001
			Manganese	0.002
			Zinc	0.002
			Iron	0.002
			Total Weight (gravimetric)	0.31
		Aluminum, Arsenic, Barium, Beryllium, Cadmium, Cobalt, Copper, Lithium, Magnesium, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Thallium, Titanium, Tungsten, Vanadium, Yttrium, Zirconium		ND[2,3]
Resistance Welding Station #2	FW6924	8:23-9:30 9:44-11:40 (181)	Total Weight (gravimetric)	0.24
		Aluminum, Arsenic, Barium, Beryllium, Cadmium, Cobalt, Copper, Lithium, Magnesium, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Thallium, Titanium, Tungsten, Vanadium, Yttrium, Zirconium Chromium, Manganese, Zinc, Iron		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 both samples

3. None Detected. Detection limits, in micrograms per filter, for the elements analyzed are as follows:

Aluminum = 2	Arsenic = 2	Barium = 0.5	Beryllium = 0.5
Calcium = 2	Cadmium = 0.5	Cobalt = 0.5	Chromium = 0.5
Copper = 0.5	Iron = 1	Lithium = 0.5	Magnesium = 1
Manganese = 0.5	Molybdenum = 0.5	Nickel = 0.5	Lead = 1
Phosphorous = 3	Platinum = 2	Selenium = 3	Silver = 0.5
Sodium = 5	Tin = 2	Tellurium = 3	Thallium = 3
Titanium = 0.5	Tungsten = 3	Vanadium = 0.5	Yttrium = 0.5
Zinc = 0.5	Zirconium = 2		

All samples were field blank corrected

Table 5
Personal Sampling Results: Elements
Kreisler Industrial Corporation
January 16-17, 1992
HETA 92-010

Task Monitored	Sample Number	Sample time (min)	Contaminants Sampled	Concentration (mg/m3)[1]
Low Melt Alloy	MD-1	8:07-11:36 (186)	Cadmium Nickel Lead Tin Indium Antimony	ND ND ND ND ND ND
	MD-1A	12:20-3:39 (204)	Cadmium Lead Tin Indium Antimony	ND ND ND ND ND
Deburring	MD-2	7:45-11:34 12:18-3:47 (440)	Iron Molybdenum Zinc	0.002 0.008 0.001
		Aluminum, Arsenic, Barium, Beryllium, Cadmium, Cobalt, Copper, Lithium, Magnesium, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Thallium, Titanium, Tungsten, Vanadium, Yttrium, Zirconium, Chromium, Manganese		ND[2]
Electroplating	MD-6	7:45-11:37 (234)	Nickel	0.007
Furnace Braze	MD-3	8:19-11:28 (190)	Iron	0.011
		Aluminum, Arsenic, Barium, Beryllium, Cadmium, Cobalt, Copper, Lithium, Magnesium, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Thallium, Titanium, Tungsten, Vanadium, Yttrium, Zirconium Chromium, Manganese, Zinc		ND[2]

Table 5 continued on the next page

Table 5 (continued)

Task Monitored	Sample Number	Sample time (min)	Contaminants Sampled	Concentration (mg/m3)[1]
Grinding	MD-4	7:47-11:34 12:22-2:50 (418)	Iron	0.001
		Aluminum, Arsenic, Barium, Beryllium, Cadmium, Cobalt, Zinc, Copper, Lithium, Magnesium, Nickel, Lead, Molybdenum, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Thallium, Titanium, Tungsten, Vanadium, Yttrium, Zirconium		ND[2]
Lead Man, Induction Braze	MD-5	7:43-8:15 8:30-11:31 (215)	Aluminum, Arsenic, Barium, Beryllium, Cadmium, Cobalt,	ND[2]
		Copper, Lithium, Magnesium, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Thallium, Titanium, Tungsten, Vanadium, Yttrium, Zirconium, Iron, Zinc, Molybdenum		
Low Melt Alloy	MD-7	7:50-11:33 (224)	Cadmium Nickel Lead Tin Indium Antimony	ND ND ND ND ND ND
Electrode Welding	MD-8	8:25-11:35 (173)	Aluminum, Arsenic, Barium, Beryllium, Cadmium, Cobalt,	ND[2]
		Copper, Lithium, Magnesium, Molybdenum, Nickel, Lead, Phosphorous, Platinum, Selenium, Silver, Tin, Tellurium, Thallium, Titanium, Tungsten, Vanadium, Yttrium, Zirconium Chromium, Manganese, Zinc		

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

2. None Detected. Detection limits, in micrograms per filter, for the elements analyzed are as follows:

Aluminum = 2	Arsenic = 2	Barium = 0.5	Beryllium = 0.5
Calcium = 2	Cadmium = 0.5	Cobalt = 0.5	Chromium = 0.5
Copper = 0.5	Iron = 1	Lithium = 0.5	Magnesium = 1
Manganese = 0.5	Molybdenum = 0.5	Nickel = 0.5	Lead = 1
Phosphorous = 3	Platinum = 2	Selenium = 3	Silver = 0.5
Sodium = 5	Tin = 2	Tellurium = 3	Thallium = 3
Titanium = 0.5	Tungsten = 3	Vanadium = 0.5	Yttrium = 0.5
Zinc = 0.5	Zirconium = 2		

Various trace quantities of calcium and sodium were detected on all samples

All samples were field blank corrected

Table 6
Personal Sampling Results: Mineral Oil Mist
Kreisler Industrial Corporation
January 16-17, 1992
HETA 92-010

Task Monitored	Sample Number	Sample Time (min)	Concentration (mg/m^3)[1]
Machinist: Operates Miller and Lathe	OM-1	7:34-8:15 8:33-11:28 (219)	0.18
Machinist: Operates Mori-Seiki Lathe	OM-2	7:35-11:27 (233)	0.09

1. mg/m^3 = milligrams of contaminant per cubic meter of air sampled

All samples were field blank corrected

Table 7
Surface Sampling Results: Metals
Kreisler Industrial Corporation
January 16-17, 1992
HETA 92-010

Sample Number	Location	Contaminant Detected	Results (µg/100cm²)
WS-1	Workstation table, Low Melt Alloy	Tin Lead Bismuth Indium Cadmium	100 1800 250 5 660
WS-2	Table opposite hood, Low Melt Alloy	Tin Lead Bismuth Cadmium	34 61 77 31
WS-3	Foremans Desk, Cleaning Department	Lead Bismuth Cadmium	5 2 2
WS-4	Deburr Station, Induction Braze	Nickel Chromium	7 11
WS-5	Workstation table, Furnace Braze Assembly	Nickel Chromium	31 7

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

Samples were collected on 3" x 3" cotton gauze pads moistened with deionized water

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

Table 8
Employee Interview Responses to Symptom Questionnaire*
Kreisler Industrial Corporation
January 16-17, 1992
HETA 92-010

SYMPTOM	NEVER	SELDOM	MONTHLY	WEEKLY	DAILY
Nasal Stuffiness	41	7	1	0	3
Cough	43	2	4	1	2
Runny Nose	43	7	1	0	1
Tearing/Burning of Eyes	37	6	4	4	1
Sore of Dry Throat	42	5	3	1	1
Skin Rash	45	5	1	0	1
Wheezing	49	1	2	0	0
Chest Tightness	46	3	3	0	0
Shortness of Breath	46	3	3	0	0

*Response to question: "For each of the following symptoms indicate if you are or have been bothered by the symptom at work."

n = 52