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CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH HEALTH HAZARD EVALUATION REPORT

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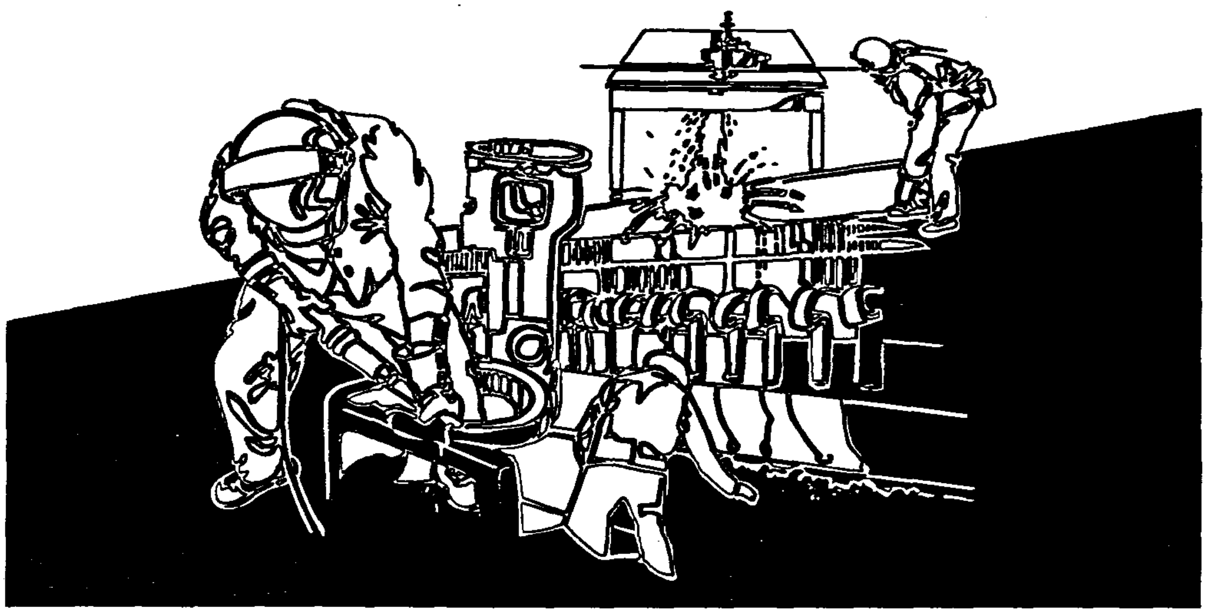
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA



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

PREFACE

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

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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I. SUMMARY

On June 10, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from civilian employees of the United States Air Force Logistics Command at Tinker Air Force Base (TAFB) in Oklahoma City, Oklahoma. The request expressed concerns about potential health effects from overexposures to cobalt, chromium, and nickel metal in the Nozzle Shop area. These concerns arose following an investigation by the Occupational Safety and Health Administration (OSHA) which documented overexposures to these metals. On August 7-8, 1992, NIOSH representatives visited TAFB. During that visit, the NIOSH industrial hygiene team surveyed the work area and reviewed OSHA and Air Force environmental monitoring data, while NIOSH medical officers spoke with employees and occupational health physicians. After the visit, additional environmental and medical data was received and reviewed by the NIOSH investigators.

Samples of pulmonary function tests conducted by TAFB medical staff over three time intervals were reviewed and showed continuing improvement in technical characteristics (according to guidelines from NIOSH and the American Thoracic Society). Although some problems remained, evaluations and recommendations were provided at each interval. Since then the TAFB medical clinic has adopted a new spiromentry system.

Several control measures, including ventilation, personal protective equipment, and work practices, have been implemented by TAFB management. Results from air monitoring performed by OSHA and TAFB following the implementation of these control measures, indicate that metal exposures have been substantially reduced.

Environmental sampling data collected before and after the installation of engineering controls showed reductions of personal exposure levels to below the OSHA permissible exposure limits (PEL) for cobalt, chromium, and nickel metals. With the exception of nickel, which NIOSH considers to be a potential occupational carcinogen, exposures measured during the most recent OSHA survey were also below the NIOSH recommended exposure levels (RELs). The investigators recommend that exposures be reduced such that all exposure levels remain below the RELs, and provide suggestions for attaining that goal. Recommendations are also made to assure continuing validity of medical screening conducted in the Occupational Health Clinic.

KEYWORDS: SIC 3721 (Aircraft), grinding, welding, chromium, cobalt, nickel, biological monitoring, pulmonary function testing, respirators.

II. INTRODUCTION

On June 10, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from civilian employees of the United States Air Force Logistics Command at Tinker Air Force Base in Oklahoma City, Oklahoma. The request expressed concerns about potential health effects from overexposures to cobalt, chromium, and nickel metal in the Nozzle Shop area. These concerns arose following an investigation by the Occupational Safety and Health Administration (OSHA) which documented overexposures to these metals. On August 7-8, 1992, NIOSH representatives visited Tinker Air Force Base. During that visit, the NIOSH industrial hygiene team surveyed the work area and reviewed OSHA and Air Force environmental monitoring data, while NIOSH medical officers spoke with employees and occupational health physicians. After the visit, additional environmental and medical data were received and reviewed by the NIOSH investigators. This final report includes material which has previously been reported to Tinker AFB medical staff and to the requestors.

III. BACKGROUND

The Air Force Logistics Command (AFLC) at Tinker AFB refurbishes Air Force jet aircraft by inspecting the parts and repairing them as needed. Jet engine nozzles are refurbished in the Nozzle Shop, where damaged vanes are removed from the nozzle frame by grinding off the connecting weld using hand-held portable grinders. The repair is completed by welding new vanes in place using gas-tungsten-arc-welding (TIG).

The nozzles are composed of metal alloys that contain cobalt, chromium, and nickel. Reworkers (the title of those workers who perform grinding), welders, and machinists may be exposed directly to these metals. Other workers in the Nozzle Shop, including nondestructive inspection (NDI) personnel, may also be exposed to metal dust or fume that is generated during grinding, welding, or machining.

IV. EVALUATION CRITERIA

A. Environmental criteria

General

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

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs),[1] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[2] and (3) the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) for general industry.[3] The OSHA exposure limits may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that employers are legally required to comply with OSHA standards and meet those levels specified by OSHA PELs.

An 8-hour time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STELs) or ceiling values (C) which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures. STELs are defined as 15 minute TWA exposures which should not be exceeded at any time during the workshift. Ceiling values are limits for instantaneous exposures which should not be exceeded at any time during the work shift.

In comparing the air sampling results to the exposure criteria, the reader should be aware that the exposure criteria are intended to be used as general guidelines and do not define an exact level of safety. It is also important to remember that air sampling was conducted over a relatively short period of time and that the actual concentrations of contaminants are likely to vary. The results obtained in a short-term evaluation of this type should not be considered definitive and may not allow a precise measurement of employee exposures. In summary, airborne concentrations of chemicals that approach or exceed exposure criteria indicate the need for improved industrial hygiene.

Chromium

Chromium (Cr) is a naturally-occurring element which is ubiquitous in nature. Chromium can occur in valences (a valence is a measure of the electrical charge on an atom); chromium metal is Cr^0, but the forms of Cr^{2+}, Cr^{3+}, Cr^{4+}, Cr^{5+}, and Cr^{6+} are also known. Naturally occurring chromium occurs almost exclusively in the trivalent form (Cr^{3+}). Divalent chromium (Cr^{2+}) rapidly oxidizes to trivalent chromium (Cr^{3+}), while tetravalent (Cr^{4+}) and pentavalent (Cr^{5+}) forms are unstable and exist primarily as intermediates in chemical processes.[4]

The distinction between the various forms of chromium is important because there are different health effects associated with exposures to the different forms. Chromium metal is relatively nontoxic, Cr^{3+} can be a skin irritant, but less so than Cr^{6+}, hexavalent chromium. Skin exposure to chromium can also result in allergic sensitization, particularly from skin contact with Cr^{6+}.[1,5]

The most serious health effects of chromium exposure are associated with Cr^{6+}. Exposure to Cr^{6+} has been associated with the development of lung cancer. It appears that Cr^{3+} is the actual carcinogen, but Cr^{3+} does not pass through the cell membrane, and therefore, does not reach the cell's genetic material. On the other hand, Cr^{6+} is able to cross cell membranes and enter the cell, after which it is reduced to Cr^{3+}. If Cr^{3+} is close enough to the cell's DNA, alterations resulting in carcinogenic transformation may result.[1]

The current NIOSH REL, OSHA PEL, and ACGIH TLV for chromium metal as an 8- to 10-hour TWA are 0.5, 1, and 0.5 mg/m^3 respectively. In metal alloys, chromium appears as C^0. [6] However, Cr^{6+} may be formed when welding chromium-containing alloys. In several studies, shielded metal arc welding on stainless steel was associated with the highest exposures to Cr^{6+}; lower exposures were noted for gas tungsten arc welding and gas metal arc welding.[7] The current NIOSH REL and ACGIH TLV for Cr^{6+} as an 8- to 10-hour TWA are 0.001 and 0.05 mg/m^3 respectively. There is also an OSHA ceiling limit of 0.1 mg/m^3. NIOSH considers Cr^{6+} to be a potential occupational carcinogen, and therefore, recommends that exposures be reduced to the lowest feasible concentration. The carcinogenic potential of Cr^{6+} has also been recognized by ACGIH, which considers it to be a confirmed human carcinogen.[2]

Cobalt

Cobalt (Co) is a silvery bluish-white metal. It is an essential nutrient for humans as part of vitamin B_{12}. In industry, cobalt is used in alloys to add strength and resistance to oxidation and high temperatures. Cobalt is also used as a binding matrix in the formation of tungsten carbide (also known as "hard metal"), used for grinding and cutting tools.[8]

The most serious health effects from cobalt exposures occur from inhalation. A lung disease called "hard metal disease," has been reported with exposure to tungsten carbide, either in the manufacture of tungsten carbide tools or with grinding processes using those tools. Hard metal disease is characterized by the formation of fibrous tissue in the lungs (interstitial fibrosis), which limits the amount of air the lung can hold and the ability to exchange oxygen in the lung. The symptoms are cough and shortness of breath. Exposures to hard metal dust can also cause an asthma-like syndrome with cough and chest tightness, which resolves when the exposure is stopped. Although there is some controversy, the cobalt component of tungsten carbide appears to be the cause of these diseases.[9,10,11]

Cobalt exposure has also been associated with heart disease. The most common reports described disease of the heart muscle (cobalt cardiomyopathy) which was caused by drinking beer to which a cobalt compound, cobalt sulfate, had been added to reduce foaming. The disease was eliminated when cobalt sulfate was no longer added to beer.[12] Additionally, a case of cobalt cardiomyopathy was reported in a worker who mixed tungsten carbide and cobalt powder in a plant where hard metal was manufactured.[13]

The current NIOSH REL, OSHA PEL, and ACGIH TLV for cobalt metal as an 8- to 10-hour TWA are 0.05, 0.1, and 0.05 mg/m^3 respectively. The ACGIH is currently proposing that cobalt be considered an animal carcinogen, and that the TLV be lowered from 0.05 to 0.02 mg/m^3.[2]

<u>Nickel</u>

Nickel (Ni) is a silvery white metal that occurs throughout the environment. Besides the use of metallic nickel in steels and alloys, nickel compounds are used in electroplating, batteries, ceramics, and catalysts.

Nickel is one of the most common causes of allergic dermatitis (skin irritation); the condition has been seen following skin contact with nickel-bearing steels and alloys in wristwatches, jewelry, and metal clothing fasteners. Once a person is sensitized to nickel, that sensitivity persists after the exposure is removed, and skin irritation will recur with subsequent exposure to nickel.[14] Allergic asthma has also been associated with nickel exposure.[15]

The major route of exposure to nickel is through inhalation. Industrial exposures to nickel have been associated with cancer of the lung and of the nasal sinuses in workers employed in nickel refineries and smelting plants.[16]

The current NIOSH REL, OSHA PEL, and ACGIH TLV for nickel metal as an 8- to 10-hour TWA are 0.015, 1, and 1 mg/m^3 respectively. NIOSH considers nickel to be a potential occupational carcinogen and therefore, recommends that exposures be reduced to the lowest feasible concentrations. The REL of 0.015 mg/m^3 is based on the lowest concentration that is reliably detectable over a single workshift.

The carcinogenic potential of nickel has also been recognized by ACGIH, which is currently proposing that nickel be considered a confirmed human carcinogen, and that its TLV should be lowered from 1 to 0.05 mg/m^3.[2] Although an international research committee recently concluded that there "was no evidence that metallic nickel was associated with increased lung and nasal cancer risks,"[17] NIOSH includes metallic nickel in its recommendations that the lowest feasible limit of exposure be achieved.

B. Environmental Monitoring

The primary concern of the employees as expressed in the original request for a health hazard evaluation, and in our subsequent site visit, involved long term health effects resulting from occupational exposure to chromium, cobalt, and nickel metal. Some employees asked whether biological monitoring for these metals could be useful in assessing whether the employees were at risk for long-term health effects.

It is helpful to use an example to clarify the terms used in this discussion. If a worker is employed in a thermometer manufacturing plant where there are no environmental controls, there may be mercury vapor in the air. This would be a hazardous exposure, because the worker is exposed to the mercury. However, this exposure only causes a health problem if the worker absorbs the mercury into his or her body by breathing the vapor. The amount of mercury the worker has absorbed can be measured by a urine test; because mercury which is absorbed in the body remains for years, the test measures long-term mercury absorption. Elevated urine mercury levels are associated with adverse health effects; if the worker is discovered to have a high urine mercury level, this can be treated by controlling further exposures and administering drugs which help the body to excrete the mercury. In this situation, biological monitoring in the workplace would be useful because an abnormally high result (1) indicates long-term exposure; (2) indicates risk of illness; and (3) reveals a condition that can be treated to prevent health effects.

It has been suggested that biological monitoring tests for chromium, cobalt, and nickel are not useful measures of long-term exposure to these metals. Rather, urine measurement of chromium, cobalt, or nickel has been considered a measure of short-term absorption, such as that occurring over a single workshift.[18] NIOSH and others have reported their experiences in conducting biological monitoring for worker absorption of these metals. In a study of welders in a stainless-steel fabricating plant, welders had elevated urine and serum chromium levels on Monday morning compared to unexposed workers, and showed increases across the workshift. Urine and serum nickel levels, although elevated for welders (compared to the other workers), did not significantly change across the shift.[19] In a NIOSH investigation of workers employed in the manufacture of permanent magnets, urine cobalt measurements returned to pre-shift baseline levels within 16 hours after the end of the shift, again indicating that this measurement is best suited for short-term assessments. Although some workers were exposed to levels of nickel in excess of the NIOSH recommended exposure limit (REL), urine nickel concentrations among the participating workers were low and did not vary across shifts.[20] A study of Danish welders found increased urine and blood chromium in those welding mild steel and those welding stainless steel by tungsten inert gas method, but did not find cross-shift increases in biological chromium levels.[21]

These studies indicate that the results of routine biological monitoring for increased body burden due to long-term exposures to metals will be difficult to interpret given the uncertainty of the effects of long-term versus short-term exposures. We therefore do not believe that workers will be additionally protected by including routine biological monitoring for chromium, cobalt, and nickel in the scheduled physical examination.

V. INVESTIGATION

A. General

The NIOSH investigators arrived on the base on Wednesday, August 7, and after initial meetings we were given a tour of the Nozzle Shop area. On August 8, the investigators returned to conduct more extensive medical and industrial hygiene investigations. A closing conference was convened that afternoon.

B. Medical

The medical evaluation consisted of:

(1) medical interviews of 15 grinders and 8 welders, who were asked about workplace exposures, health symptoms, and use of personal protective equipment;

(2) a review and evaluation of the pulmonary function testing program. Pulmonary function tests were requested for a sample of the employees interviewed during the NIOSH visit. These employees were selected by choosing at regular intervals from an alphabetical list; and

(3) A review of the medical screening program.

C. Industrial Hygiene

Prior to the field survey, the NIOSH industrial hygiene team reviewed exposure monitoring data which had been collected by OSHA and Bioenvironmental Engineering Division (SGB) between June 1990 and March 1991. During the August field survey, the NIOSH team toured the Nozzle Shop, observed work practices, spoke with workers, and reviewed plant records of (1) environmental monitoring and (2) plans for engineering controls . The team reviewed additional information received from SGB in November 1993. This information included a chronological review of the OSHA investigations, the exposure controls implemented by TAFB, and the results from air monitoring performed by SGB both before and after the implementation of controls.

During the NIOSH field survey in August 1991, environmental monitoring was not performed for the following two reasons: (1) Overexposures prior to ventilation controls (down-draft tables and push-pull grinding booths) had previously been documented by both OSHA and SGB; therefore, further testing to document pre-control levels would have been redundant, and (2) ventilation controls could not be evaluated in August 1991, because they were not yet functional.

VI. RESULTS-DISCUSSION

A. Medical

1. Interviews

Most interviewed employees reported sinus problems. Seven employees described dyspnea on exertion, while two reported shortness of breath. At the time of the interview, 10 workers said they were wearing respirators which were recently issued. Eleven of the 23 (48%) workers complained of skin rashes which varied in description and location. None of the rashes were ulcerative in nature, and the NIOSH medical officers did not feel that these were related to chromium exposure.

2. Pulmonary Function Testing

None of the 10 pulmonary function tests received in October 1991 met the spirometry standards issued by NIOSH and the American Thoracic Society (ATS). Critiques and suggestions for improvement were sent to the medical personnel at Tinker AFB. A new set of pulmonary function tests was received in April 1992. Several faults were still noted, but the quality of the tests was improved.

A third group of eight pulmonary function test results was reviewed in October 1993. There were two types of tests in this group. The first three had been conducted in 1992 using the same pulmonary function testing apparatus as the previous tests. These tests demonstrated some of the same inadequacies as had been noted in earlier tests. The remaining five tests were conducted in 1993 using a different testing system for which NIOSH was unable to determine compliance with NIOSH and ATS spirometry standards.

3. Medical Screening

During our visit and in subsequent communications we also reviewed the medical screening program in use at Tinker AFB. The screening examination being used at the Occupational Health Clinic begins with a baseline examination for new employees consisting of the following: a medical history, physical examination, blood pressure measurement, pulmonary function tests, postero-anterior chest X-ray, audiometry, complete blood count with differential, liver function tests (SGOT, SGPT, and alkaline phosphatase), urinalysis with microscopic examination, and an electrocardiogram for employees who are at least 40 years old. Subsequent annual examinations include all of the above tests except the chest X-ray; the examination upon termination of employment includes the chest X-ray but not the electrocardiogram. No routine measures of workplace exposures, such as urinalysis for metals, are conducted. This screening program seems to be more than adequate in that it includes procedures and tests beyond those that we would otherwise recommend for the specific hazards employees might encounter in the Nozzle Shop. We could not identify additional screening procedures that would detect health effects from the exposures we have considered.

B. Industrial Hygiene

The OSHA results from environmental monitoring of chromium, cobalt, and nickel, are summarized in Table 1. These are personal breathing zone (PBZ) exposures of Nozzle Shop employees. Table 1 provides the OSHA inspection number, the date that the sample was collected, and the job title of the employee who the sample was collected from.

Following a survey in June 1990, OSHA documented overexposures of reworkers to cobalt, chromium, and nickel during the grinding of "15-2" nozzles. In October 1990, OSHA issued a notice of unsafe working conditions to TAFB for the following: (1) overexposures of workers to chromium, cobalt, and nickel, (2) failure to provide suitable respirators, and (3) failure to determine and implement feasible engineering controls to achieve compliance with prescribed limits. Exposures of welders were below the PELs. Neither machinists nor NDI personnel were monitored during the survey.

As an interim response to the OSHA citation, SGB required reworkers grinding 15-2 nozzles to wear various personal protective equipment (PPE) including Tyvek® coveralls, gloves, head covers, and full-face respirators containing high efficiency particulate air (HEPA) filters. Personnel from SGB reported that prior to being issued a respirator, these workers were fit tested and received a medical exam. Fit testing was performed to insure that an adequate seal could be achieved between the worker's face and the mask of the respirator. Medical exams were performed to insure that workers were medically fit to wear the respirator model that was issued. Also at that time, SGB began designing a ventilation system for controlling metal exposures.

In February 1991, OSHA conducted a second industrial hygiene survey. The report from this survey, sent to TAFB in November 1991, issued a second notice of unsafe working conditions for the following: (1) not providing suitable respirators and respirator training, (2) permitting employees to eat and drink in areas exposed to toxic materials, and (3) not adequately communicating work hazards to reworkers. During this survey, reworkers of nozzles other than 15-2 nozzles were documented as having been overexposed to cobalt, chromium, and nickel metals. Personnel from SGB reported that by the time they received the second notice, all reworkers had already been issued respirators based on results from in-house monitoring.

In July 1991, eight down-draft tables and three grinding booths were installed in the Nozzle Shop. In August 1991, PBZ monitoring was performed by SGB in order to assess the effectiveness of these ventilation controls. The results indicated that the down-draft tables were effective at controlling exposures during rework of smaller parts but were less effective for 15-2 nozzles (one of eight TWA exposures was greater than the PEL for cobalt). Monitoring of reworkers inside booths resulted in one of four being exposed to cobalt at levels above the PEL (monitoring was only performed during rework of 15-2 nozzles). All but one of the samples was collected on the worker's shirt collar. The remaining sample was collected inside a full-face grinding shield. Based on these results, SGB removed the requirement of wearing respirators for reworkers at down-draft tables. Respirators remained available for those employees who chose to wear them. Respirators continued to be required for workers inside booths.

In the summer of 1991, SGB began to provide HEPA vacuums for cleaning. Prior to this, cleaning was performed using compressed air and dry sweeping. During the fall of 1991, eight new downdraft tables (Downtron™) and four booths (Dustron™) were installed in the nozzle shop. These were designed according to USAF specifications to provide an air velocity of approximately 400 feet per minute (fpm) across the grinding surface.

A third inspection, which included site visits in November 1991 and January 1992, was conducted by OSHA. In November, exposures above the PELs for cobalt, chromium, and nickel were documented for one reworker who was grinding 15-2 nozzles inside a Dustron™ booth (Table 1). Exposures of two other reworkers who were v-grooving (a less abrasive form of grinding that is performed to prepare a surface for welding) 15-2 nozzles at down-draft tables were below the PELs. In January, OSHA monitored three reworkers who were grinding 15-2 nozzles inside Dustron™ booths. Their exposures were below the PELs (Table 1). Following this investigation, OSHA determined that the Nozzle Shop was in compliance with all OSHA regulations that pertained to the notices of unsafe working conditions which were issued in October 1990, and November 1991.

In summary, TAFB has taken the following steps toward reducing workers' exposures to metals in the Nozzle Shop:

(1) Implemented engineering controls-downdraft tables and booths.

(2) Implemented the use of PPE, including full-face respirators.

(3) Replaced compressed-air and dry-sweep cleaning methods with HEPA vacuums.

(4) Conducted air monitoring to (1) evaluate worker exposures and (2) test the effectiveness of engineering controls.

To abate the OSHA notices of unsafe working conditions, SGB attempted to reduce exposures to below the OSHA PELs. NIOSH recommends that exposures be reduced to below the NIOSH RELs because they are considered to be more protective of workers' health. With the exception of nickel, which NIOSH considers to be a potential occupational carcinogen, exposures measured during the most recent OSHA survey were below the RELs.

Although welders' exposures to metals were below the RELs (with the exception of one nickel measurement), there is a potential for overexposures to metals and other toxic substances, such as oxides of nitrogen (NOx) and ozone (O_3), if ventilation controls are not operating properly or if work practices are poor. The face velocities of all exhaust hoods, measured during a ventilation survey performed by SGB in February and March 1991, approximated the ACGIH recommendation of 1500 fpm for welding ventilation hoods. Welders should understand that this recommendation is designed for the capture of fumes only if the work piece is near the opening of the hood. Distances can be calculated to determine how close a weld surface needs to be to the hood opening.[22] For example, at an air flow rate of 890 cfm (the average flow rate calculated for the welding hoods), a distance of approximately nine inches or less is needed to maintain a capture velocity of 150 fpm at the weld surface. If flow rates are less than this, the maximum safe distance is reduced. For example, at a flow rate of 700 cfm (the lowest value calculated), the maximum distance is approximately 8 inches. For a flanged hood, which was used on some of the hoods, the maximum distance is slightly larger than for nonflanged hoods.

During the closing meeting of the field survey, NIOSH investigators noted that a potential health hazard existed based on the results of previous monitoring. Once ventilation controls were functioning properly, further monitoring of workers would be necessary to determine if those controls abated the hazard. In November 1993, NIOSH investigators received the results of PBZ air monitoring conducted by OSHA and SGB following the implementation of functional ventilation controls . After reviewing these results, NIOSH investigators have determined that an additional NIOSH field survey is unnecessary. The HHE request resulted from OSHA citations which focused on overexposures of reworkers to chromium, cobalt, and nickel. Based on the reduction in reworkers exposures, evidenced by data from OSHA and SGB, NIOSH investigators are confident that through a cooperative effort between management and employees of the Nozzle Shop, TAFB personnel are capable of adequately reducing workers' exposures to metals. Recommendations are provided below to assist you in this effort.

VII. RECOMMENDATIONS

(1) Further exposure monitoring of reworkers should be conducted in order to confidently determine workers' exposures. NIOSH investigators were recently notified that an environmental consultant has been contracted by TAFB to characterize workers' exposures which will include nozzle shop workers; SGB expected to receive a report from this investigation in May 1994. Suggested sampling strategies for confidently determining exposures are provided by ACGIH[23] and NIOSH.[24] Exposure levels should be compared to the NIOSH RELs to determine if further reductions are required. If further reductions are needed, the following steps are recommended:

(a) Test ventilation performance of downdraft tables and booths to insure that they are operating to design specifications.

(b) If possible, modify the system to increase control effectiveness. For example, increase individual fan speeds to increase airflow rate and capture velocity. (The design capture velocity of the Dustron™ booths and Downtron™ tables, 400 feet per minute [fpm], is less than the target range of capture velocities of 500 to 2000 fpm recommended by ACGIH for controlling grinding emissions).[22]

(c) Insure that work practices are optimal for control effectiveness. For example, determine if worker position relative to air exhausts and intakes can be altered to improve particulate capture without compromising the worker's ability to perform the job.

(d) Investigate the option of equipping the grinder with local exhaust ventilation.

(2) Exposure monitoring of welders should be performed periodically to insure that they are not overexposed to metals or other toxic substances. Monitoring should be performed following changes which might alter exposure levels, including changes in product materials, the welding process, or exposure controls. The mechanical ventilation system should be maintained and tested according to the manufacturer's directions. Welders should be trained in work practices that minimize their exposures. This should include placing the weld surface within an effective capture distance of the ventilation hood.

(3) Given the natural concern generated by documented overexposures of reworkers to metals, the exposures of machinists and NDI personnel should also be evaluated.

(4) The Occupational Medicine clinic has the technical capability and the equipment needed to provide reliable medical assessment of worker health. If these assessments are to be valid, however, it is imperative that appropriate guidelines (such as those promulgated by NIOSH and ATS for pulmonary function testing) be rigorously followed. We recommend that periodic in-service employee education and appropriate measures of quality control be used to maintain high standards for medical screening.

(5) In general, engineering controls should be the primary method of controlling employee exposures to hazardous substances. The effectiveness of these controls should be verified with environmental monitoring. Selective biological monitoring for short-term exposures may be a useful adjunct to environmental monitoring in order to determine if workers are being exposed due to unrecognized failures in control methods. This may be particularly relevant if the method under consideration involves personal respiratory protection; short-term biological monitoring may be useful to assure that respiratory protection is effective. Screening of this nature been has already been employed by the medical department at Tinker AFB.

This report completes our response to Health Hazard Evaluation 91-259. The parties involved are encouraged to contact NIOSH should additional health concerns arise.

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Copies of this report have been sent to:

1. Tinker Air Force Base
2. Employee representative
3. AFGE Local 916
4. Occupational Safety and Health Administration, Region VIII
5. Utah Occupational Safety and Health Administration, Salt Lake City

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. OSHA sampling results for metals in the Nozzle Shop
Tinker Air Force Base
Oklahoma City, Oklahoma
HETA 91-0259-2420

Inspection Number	Sample Date	Job Title	Cobalt (mg/m³)	Chromium (mg/m³)	Nickel (mg/m³)
106653918	6/13/90	rework	**21**[1]	**14**	**22**
106653918	6/13/90	rework	.006	.027	.069
106653918	6/13/90	rework	.023	.031	.064
106653918	6/13/90	rework	.023	.079	.19
106653918	6/13/90	rework[2]	**32**	**33**	**57**
107502478	2/27/91	rework	**2.2**	**1.1**	**1.1**
107502478	2/27/91	rework	**.27**	.74	**1.9**
107502478	2/27/91	rework	**3.2**	**7.1**	**20**
107502478	2/27/91	rework	**5.3**	**2.5**	**2.4**
107502502	3/13/91	welder	0.00	0.009	0.022
107502502	3/13/91	welder	0.00	0.002	0.006
107502502	3/13/91	welder	0.00	0.00	0.00
107502502	3/13/91	rework	**0.11**	0.11	0.15
107502502	3/13/91	rework	0.005	0.036	0.13
107502502	3/14/91	rework	0.03	0.038	0.10
107502502	3/14/91	rework	**0.21**	0.088	0.054
107502502	3/14/91	rework	**0.13**	0.25	0.75
107502502	3/14/91	rework	**0.20**	0.13	0.14
107502502	3/14/91	welder	0.007	0.005	0.005
107521239	11/26/91	rework [3]	**4.3**	**2.3**	**2.9**
107521239	11/26/91	rework	0.024	0.012	0.01
107521239	11/26/91	rework	0.003	0.002	0.000
107521239	1/30/92	rework [3]	0.045	0.02	0.031
107521239	1/30/92	rework [3]	0.023	0.073	0.20
107521239	1/30/92	rework [3]	0.012	0.039	0.11
	OSHA PEL	current	0.1	1	1
	OSHA PEL	1989-1992	0.05	1	1

[1] The numbers in bold signify concentrations above the current OSHA PEL (as of July 1992).

[2] OSHA noted in their report that this sample appeared to be tampered with.

[3] This employee was reworking in a push-pull booth.

	NIOSH REL		0.05	0.5[4]	0.015
	ACGIH TLV		0.05	0.5[4]	1

[4] This value is for chromium metal.