HETA 99-0144-2797
Case Corporation
Burlington, Iowa

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Preface

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

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Acknowledgments and Availability of Report

This report was prepared by Josh Harney and Doug Trout of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Bradley King and Calvin Cook, DSHEFS. Analytical support was provided by Ardith Grote. Desktop publishing was performed by Denise Ratliff. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Work-related Respiratory Symptoms, and Air Sampling for Welding Fume and Metalworking Fluid

This Health Hazard Evaluation was requested by the union to look at breathing problems in department 680/681 workers at the Case Corporation facility in Burlington, Iowa. These departments include both welding work stations and machining centers that use a synthetic metalworking fluid (MWF).

What NIOSH Did

- # We took air samples for MWF, welding fume, and other chemicals.
- # We took samples of the MWF to check for bacteria, fungi, endotoxin, or dangerous chemicals.
- # We asked employees about their breathing problems.
- # We tested some workers' breathing to see if their problems were connected to work.

What NIOSH Found

- # More welders than machine operators reported breathing problems.
- # Welders were below the OSHA limits for exposure to different metals.
- # Welders were above some recommended limits for exposure to total welding fume, iron, and manganese.
- # Nearly all employees in department 681 were above the NIOSH limit for exposure to airborne MWF.
- # The MWF in the central system is well maintained, and Case has a good MWF management program.

What Case Corporation Managers Can Do

- # Tell workers about changes to the MWF so they know what chemicals they will work with.
- # If more dilution ventilation doesn't lower MWF levels in the air, enclose and/or directly ventilate machining centers and open areas of the MWF circulation system.
- # Teach welders work practices that minimize the welding fume they breathe.
- # Encourage workers to report all work-related health problems to the nurse.

What Case Corporation Employees Can Do

- # Attend all hazard communication and other safety training sessions.
- # Report all work-related health problems to the nurse.

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

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National Institute for Occupational Safety and Health
NIOSH

Health Hazard Evaluation Report 99-0144-2797
Case Corporation
Burlington, Iowa
May 2000

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SUMMARY

In March 1999, the National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation (HHE) request from the International Union, United Automobile, Aerospace, and Agricultural Implement Workers of America (U.A.W.), Local 807, representing workers at Case Corporation, Burlington, Iowa. The request cited concerns about respiratory symptoms and skin rashes among employees who worked with metalworking fluid (MWF) in departments 680 and 681; during the course of the HHE, concerns were also raised regarding the Hazard Communication Program. On November 3-5, 1999, NIOSH representatives conducted medical and industrial hygiene surveys. The medical survey consisted of a questionnaire given to all employees in departments 665, 680, and 681, and follow-up peak expiratory flow (PEF) testing for some participants. The industrial hygiene survey consisted of personal breathing zone (PBZ) air sampling for thoracic particulate (the portion of the particulate that penetrates beyond the larnyx), welding fume, and volatile organic compounds (VOCs), and area air sampling for both thoracic and total particulate. Process and concentrated MWF samples were collected for microbial (culturable fungi and bacteria counts, and endotoxin counts) and amine (triethanolamine and monoethanolamine, as well as nitrosamines) analysis. Issues related to the Hazard Communication Program were also reviewed.

The highest air contaminant concentrations we found during our survey were from air samples from welders in department 680. Several PBZ concentrations exceeded the American Conference of Governmental Industrial Hygienists' Threshold Limit Value® (TLV®) for iron and manganese. All results for aluminum and nickel were at least one order of magnitude below their lowest exposure limits. Based on the cumulative mass concentration of the different metals, and on the thoracic particulate mass samples collected separately, several welders' exposure to welding fume exceeded the TLV of 5 milligrams per cubic meter of air (mg/m^3). NIOSH recommends reducing welding fume exposures to the lowest feasible concentration due to its carcinogenic potential.

The typical exposure of non-welders (primarily machinists) to thoracic particulate on these days was above the NIOSH Recommended Exposure Limit (REL) for MWF of 0.4 mg/m^3. The mean thoracic particulate exposure for welders in departments 680/681 was 4.79 mg/m^3, but because only a small fraction of the particulate was extractable, much of this was likely due to welding fume and not to MWF. Welders in departments 680/681 had a mean extractable exposure = 0.35 mg/m^3, which still indicates a relatively high exposure to MWF aerosol with respect to the REL.

The MWF circulating through the central coolant system in departments 680/681 had very low levels of culturable fungi and bacteria, with concentrations of fungi below 10 colony forming units per milliliter (CFU/mL) of MWF, and bacteria below 110 CFU/mL. Low levels of endotoxin (trace - 137 endotoxin units per milliliter of MWF) present in these samples indicates that in the recent past these culturable fungi and bacteria levels have been low also. A sample taken from a machine with a self-contained MWF sump had the highest level of microbial contamination, 4.6×10^5 CFU/mL bacteria, predominantly Gram-negative species.

One hundred twenty-seven workers participated in the medical component of this survey; participation by department ranged from 82% - 100%. The most frequently reported symptom among all participants was 'sinus problems,' which was reported by 79 (62 %) participants. Among those symptoms reported to be work-related, 'irritation of the eyes, nose, or throat' was reported by the most participants (73%). In general, employees reporting job duties of either welding, or both welding and machining, had higher percentages of reported respiratory symptoms compared to those whose reported job duties included neither welding nor machining. A larger percentage of machinists than welders reported rash or skin irritation.

Of the 10 persons completing PEF testing, one had patterns of decreasing PEF during the workshift with improved PEF measurements away from work, suggesting that decrements in PEF for that person were related to work.

The data from our questionnaire survey suggest that exposure to welding fume (which exceeded the TLV in some cases) may be playing a greater role in the occurrence of respiratory symptoms among department 680/681 workers than exposure to MWF aerosols. In addition, nearly all employees in department 680/681 were exposed to MWF concentrations above the NIOSH REL for MWF. Recommendations are made in this report concerning further evaluation and control of exposures to welding fume and MWF. In addition, improvements in the implementation of the Hazard Communication Program are recommended.

Keywords: SIC 3531 (Construction Machinery and Equipment), MWF, machining fluid, coolant mist, thoracic sampling, microbial analysis, asthma, welding, dermatitis, amines, VOCs

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INTRODUCTION

In March 1999, the National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation (HHE) request from the International Union, United Automobile, Aerospace, and Agricultural Implement Workers of America, Local 807 (U.A.W. Local 807), representing workers at Case Corporation, Burlington, Iowa. The request cited concerns about respiratory (breathing) symptoms and skin rashes among employees in Departments 680 and 681, where welding and machining operations are located. In addition, there were concerns that employees were not being adequately trained regarding the potential hazards of workplace chemicals, with the majority of concerns centered around the metalworking fluid (MWF) in depart-ments 680 and 681. The initial site visit included an opening conference and industrial hygiene walk-through inspection in June 1999. On November 3-5, 1999, NIOSH representatives visited the Case facility to conduct medical and industrial hygiene surveys. Interim reports describing these site visits and presenting preliminary recommendations, dated November 24, 1999, and February, 24, 2000, were sent to management and employee representatives. Notification letters to participants in the medical survey were distributed in November 1999.

BACKGROUND

This Case facility manufactures backhoes, crawler dozers, and rough terrain forklifts within its 960,000 square foot (ft^2) plant. Departments 680 and 681 perform a variety of welding and machining operations. Of the approximately 96 employees of the two departments, approximately 24 are primarily machinists, and the remainder are primarily welders. Two major types of welding occur in the two departments: metal inert gas (MIG) welding and a smaller amount of submerged arc welding. The machining in these two depart-ments includes drilling, milling, and deburring processes. The machines are served by a 20,000-gallon central MWF system using a synthetic MWF (Trim® WB 164 15G). The machines have no local exhaust; the area is served by general area ventilation. According to the requesters, respira-tory symptoms were more prevalent when a semi-synthetic MWF was used for the 1-2 year period preceding the change to the Trim® product in the Spring of 1999. With the former MWF, monthly additions of MWF on the order of 1200 gallons were needed to maintain the system's volume. With the new MWF, "adds" have been reduced to approximately 300 gallons per month. Weekly monitoring of the MWF quality in the central coolant system is done by the supplier of the fluid. Based on the supplier's recommendations and on the production needs of the plant, a full-time 'coolant technician' accomplishes the day-to-day fluid maintenance tasks. Many characteristics of the MWF are monitored including pH, bacterial and fungal concentration, tramp oil concentration in the MWF, and concentration of the MWF in solution.

Department 665 was chosen as a comparison department because its machining operations (including drilling, deburring, threading, and cutting) also use a synthetic MWF. Most of the machines in that department are enclosed (without local ventilation) and are served by individual 300-500-gallon sumps. Of the 33 employees in depart-ment 665, most are machine operators, and the remainder perform other duties, including welding. All three departments work primarily with mild steel or ductile iron and include both machining centers that use MWF and welding stations, which are often nearby each other.

METHODS

Industrial Hygiene

Metalworking Fluids - air samples

Personal breathing zone (PBZ) samples for thora-cic particulate were collected for workers in the three departments as well as from two machine operators from department 667, which is adjacent to department 665, during second shift on November 3, and during first shift on November 4. Also, paired area air samples for both total particulate and for thoracic particulate (the portion of the particulate that penetrates beyond the larnyx) were collected. It has been estimated that the thoracic particulate fraction (milligrams per cubic meter [mg/m^3]) of a MWF aerosol is 80% of that of the total particulate concentration.[1] PBZ samples for welding fume were collected during first shift operations of November 5. Thermal desorption tube samples were collected on November 3 and 5 from welding centers for qualitative chemical analysis. Bulk samples of MWF were collected for microbial and amine analysis.

PBZ samples for MWF were collected on a 37 millimeter (mm) closed-face cassette containing a tared 2-micrometer (µm) pore-size polytetrafluoroethylene (PTFE) filter attached to either the right or the left lapel area of the worker. A thoracic cyclone was attached to the sampling cassette so that only the thoracic fraction of the aerosol would be collected.[2] Tygon® tubing connecting the sampler and a personal sampling pump allowed air to be drawn through the sampling train at a flow rate of 1.6 liters per minute (Lpm).[3] Co-located area samples were collected with thoracic samplers and traditional total particulate samplers. The total particulate samplers consisted of a 37 mm closed-face cassette with 2 µm pore-size PTFE filters, Tygon® tubing, and a personal sampling pump calibrated at 2 Lpm.[3] The analyses of both PBZ and area samples were conducted in the same manner. The cassettes containing the filters and back-up pads for each sample were placed into a dessicator for at least 16 hours for equilibration.

The particulate mass for each sample was determined by measuring the gross weight of each filter on an electrobalance and subtracting the previously determined tare weight of the filter. This mass was used to calculate 'thoracic particulate concentration' in the tables of this report. The filters for each sample were then extracted using a 1:1:1 blend of dichloromethane, methanol, and toluene. After drying in a vacuum oven for three hours, the filters were reweighed on the electrobalance. The extractable mass was then calculated by subtracting the post-extraction filter weight from the pre-extraction filter weight. If samples collected near welding operations had a high filter mass both before and after extraction, then the aerosol collected was considered mostly non-MWF material. Therefore, it would not be appropriate to evaluate those sample results using MWF exposure limits. If the collected aerosol was largely extractable, then it was presumably MWF.

The instrumental precision of the microbalance is 0.001 milligrams (mg). However, studies on the physical integrity of various PTFE filters have shown that the weight of the filter may vary by as much as 0.01 mg. Because of this factor, the limit of detection (LOD) for the thoracic particulate weight analysis is 0.01 mg, which equates to a minimum detectable concentration (MDC) of 0.014 mg/m^3 of air based on a sample volume of 715 liters (L).

The limits of detection and of quantification (LOQ) for the MWF extraction were determined by using the standard deviation of the five field blanks. The LOD is three times the standard deviation of the field blanks, and the LOQ is ten times the standard deviation of the field blanks. In this case, the LOD for the extractable fraction is 0.03 mg, which equates to an MDC of 0.042 mg/m^3, assuming a sample volume of 715 L. The LOQ is 0.1 mg, which equates to a minimum quantifiable concen-tration (MQC) of 0.14 mg/m^3, assuming a sample volume of 715 L. Results of samples having less MWF than the LOD are reported as not detected (ND). Results of samples having amounts of MWF between the LOD and LOQ are reported as 'trace.'

Metalworking Fluids - bulk sampling

Microorganisms

Bulk process samples of the MWF in departments 680, 681, and 665 were collected in sterile 150-milliliter (mL) specimen vials and shipped overnight in ice-filled containers to a NIOSH contract laboratory for the enumeration and speciation of both bacterial and fungal colonies. Separately, bulk process samples were collected in sterile 50-mL specimen vials and shipped overnight in ice-filled containers to a NIOSH laboratory for endotoxin analysis.

Amines in MWF

Bulk MWF samples were analyzed for monoethanolamine (MEA) and triethanolamine (TEA) by ion chromatography according to NIOSH Method #3509, modified for bulk matrix.[4] A 1-gram (g) aliquot for each sample was desorbed in 10 mL of 2 millimolar hexane sulfonic acid, sonicated for at least 10 minutes, and vortexed. Each aliquot was then analyzed by ion chroma-tography.

Bulk MWF samples were analyzed for volatile nitrosamines by solid phase extraction and gas chromatography-high resolution mass spectrometry (GC-MS). The samples were prepared by the addition of sulfamic acid and methylene chloride before being placed in an ultrasonic bath for at least 10 minutes. The samples were then wetted with pentane and loaded onto solid phase extraction cartridges, washed with pentane and dichloromethane. Any remaining analytes were extracted with acetonitrile. The acetonitrile fraction was then reduced with nitrogen, then all samples were analyzed by GC-MS. The samples were analyzed for the following volatile nitrosamines: N-nitrosodimethylamine, N-nitroso diethylamine, N-nitrosodipropylamine, N-nitrosodibutylamine, N-nitrosopiperidine, N-nitrosopyrrolidine, N-nitosomorpholine.

Welding Fume Metals

The sampling trains used to sample welding fume consisted of a personal sampling pump calibrated at 2 Lpm, Tygon® tubing, and 0.8-µm pore-size cellulose ester membrane filter within a 37 mm polystyrene, closed face cassette. The filter cassettes were attached to either the right or left lapel of each worker sampled. The configuration of the welding masks used by the welders made it impractical to attach the filter cassette directly to the inside of the mask. Therefore, the filter cassettes were placed so that when the welder lowered his mask, the cassette would be behind it. Even with this precaution, some cassettes were observed to sample outside the welding mask during normal work activities.

The filters were prepared for analysis according to NIOSH Method #7300, modified for microwave digestion.[5] The samples were analyzed by the NIOSH contract laboratory using a Fisons ACCURIS inductively coupled plasma emission spectrometer controlled by a Digital DEC Station 466D2LP Personal Computer. This analysis yields quantitative results for the following metals: aluminum (Al), arsenic (As), beryllium (Be), cal-cium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), lithium (Li), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), phosphorus (P), selenium (Se), sodium (Na), tellurium (Te), thallium (Tl), titanium (Ti), vanadium (V), zinc (Zn), and zirconium (Zr). The LOD and LOQ, as well as the MDC and MQC for these elements are listed in Table 4.

Volatile Organic Compounds

To identify volatile organic compounds (VOCs) possibly liberated from the welding of parts covered with residual MWF, PBZ samples were collected from employees at three welding stations. Sampling and analysis were done according to NIOSH Method #2549.[6] The stainless steel thermal desorption tubes used contained three beds of sorbent material: Carbopack Y (90 mg), Carbopack B (115 mg), and Carboxen 1003 (150 mg). The thermal desorption tube samples were collected in the breathing zone of 3 welders for 7-10 minutes, at a rate of 0.05 Lpm. The samples were then analyzed using a Perkin-Elmer ATD 400 automatic thermal desorption system. This thermal unit was inter-faced directly to an HP6890A gas chromatograph with an HP5973 mass selective detector.

Hazard Communication

In addition to discussing the Hazard Commun-ication Program with management and employee representatives, the written Hazard Communication Program and training session sign-in sheets for 1997 and 1999 were reviewed.

Medical

Starting with the 2nd shift on November 3, and continuing with the following 3rd and 1st shifts, a self-administered questionnaire was given to employees of the three departments. The question-naire, which included questions concerning work and medical history, was given at the beginning of each shift. After the questionnaires were com-pleted, NIOSH representatives evaluated the questionnaires to identify those employees reporting respiratory symptoms (cough, shortness of breath, chest tightness, and wheezing) that seemed to be 'work-related.' A symptom was defined as 'work-related' if it was reported to occur frequently (in repeated episodes or every workday for a month or more) and to potentially improve away from work (a "yes" or "unsure" response to the question, "Does it [the symptom] improve on days off from work?").

A preliminary analysis done to assess the relationship between reported symptoms or illnesses and potential occupational exposure was reported on the interim report dated November 24, 1999. In that interim report, a statistical analysis was done using prevalence ratios to assess the magnitude of the relationships of reported symptoms between welders and non-welders, and also between machinists and non-machinists. In this report, reported symptoms among participants in the questionnaire survey are tabulated by the following job duties: welders, machinists, those who reported both welding and machining, and those who reported neither welding nor machining.

During the site visit, those employees reporting all four work-related symptoms were offered serial peak expiratory flow (PEF) testing for the seven days (including non-work days) following questionnaire administration. In addition, several other employees were also offered PEF testing, including: 1) randomly selected asymptomatic (as assessed by the questionnaire) employees; and 2) three employees who reported respiratory symptoms or illnesses that appeared (based on interviews during the site visit) to be potentially work-related. Participants were asked to obtain measurements five times daily (i.e., upon awaken-ing, shortly after arriving at work, in the middle of the work day [lunchtime or mid-shift break for off-shifts], at the end of the work day, and once four hours after leaving work). Second and third shift workers were given individualized schedules that were compatible with their sleep-wake cycle. Three exhalations were to be performed and recorded each time; the maximum of the three values was accepted as the PEF determination for that session.

PEFs were measured with AirWatch™ (ENACT Health Management Systems, Mountain View, California) peak flow meters. Individuals asked to participate in the PEF testing were instructed in the use of the PEF meters and were given daily logs to use with the meters. During the testing, the individuals were instructed to write down the time of the testing, any symptoms they were experiencing just prior to the testing, and whether they had used any inhaled medication for asthma since the last test. The PEF meters electronically record each of the PEF measurements and the corresponding time. Each participant was asked to complete seven consecutive days of PEF measure-ments, and return the completed logs and peak flow meters in a postage-paid mailer provided by NIOSH. Participants were notified individually of their test results by mail during the week of March 27, 2000.

A participant was considered to have bronchial hyperresponsiveness if the amplitude percent mean (maximum reading for the time period minus the minimum reading for the time period divided by the mean for that time period) PEF was greater than 20%.[7] The serial PEF measurements were ana-lyzed to determine if: 1) variation in daily ampli-tude percent mean >20% was present (presence of bronchial hyperresponsiveness); 2) if so, whether that variation was present on work days and was absent on non-work days; and 3) decreases in PEF were temporally associated with workdays or with discrete periods of time at work (such as the mid-shift or end periods). Positive findings for all three determinations are suggestive of occupational asthma.

EVALUATION CRITERIA

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

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[8] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[2] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[9] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 95–596, sec. 5.(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

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

Welding Fume Components

The composition of welding fume will vary considerably depending on the alloy being welded, the process, and the electrodes used. Many weld-ing processes produce 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 of workers exposed to welding emissions have shown an increased incidence of acute and chronic respiratory diseases, including metal fume fever, pneumonitis, pulmo-nary edema, and lung cancer.[10] Because of the variable composition of welding emissions, and epidemiological evidence showing an increased risk of lung cancer, NIOSH recommends that exposures to all chemicals associated with welding or brazing be controlled to the lowest feasible concentration. Numerical exposure limits for individual chemicals should not be exceeded. Specific exposure limits for the major welding fume components found at Case Corporation during welding on mild steel and ductile iron are listed in Table 5.

Metalworking Fluids

MWF Aerosol

NIOSH recommends that occupational exposures to MWF aerosols be limited to 0.4 mg/m^3 of thoracic particulate mass as a TWA concentration for up to 10 hours (hrs)/day during a 40-hr work week, measured according to NIOSH Method 0500. The 0.4 mg/m^3 concentration thoracic par-ticulate mass corresponds to approximately 0.5 mg/m^3 total particulate mass.[1]

This REL is intended to reduce the respiratory disorders associated with MWF exposures in the workplace. However, concentrations of MWF aerosols should be kept below the REL where possible because some workers have developed work-related asthma, hypersensitivity pneumonitis (HP), or other adverse respiratory effects when exposed to MWFs at lower concentrations.[1] Limiting exposure to MWF aerosols is also pru-dent because certain MWF exposures have been associated with various cancers. In addition, limiting dermal (skin) exposures is critical to preventing allergic and irritant skin disorders related to MWF exposure. In most metalworking operations, it is technologically feasible to limit MWF aerosol exposures to 0.4 mg/m^3 or less.

MWF Aerosol and Asthma

Studies summarized in the NIOSH Criteria Document provide evidence that occupational exposure to MWF aerosols causes symptoms consistent with airways irritation, chronic bron-chitis, and asthma.[1] In many cases, the specific agent(s) responsible for these effects is (are) not known. Additionally, the importance of various acute symptoms consistent with airway irritation is not clear, particularly with respect to the development of occupational asthma. Occupa-tional asthma may be defined in several ways; for the purpose of this HHE, it was defined as asthma caused, or aggravated, by specific agents in the workplace.[11] In general, occupational asthma can be caused by many different types of compounds; some cause asthma via immunologic (which may include ‘allergic’ [IgE-mediated] reactions), others by acting through non-immunologic (which may include irritant-induced reactions) mechanisms.[12] The diagnosis of occupational asthma should include: 1) the diagnosis of asthma by physician; and 2) the establishment of work-relatedness.[11] PEF monitoring can be useful in evaluating the potential work-relatedness of asthma or asthma-like symptoms. PEF is defined as the maximum flow which can be sustained for a period of 10 milliseconds during a forced expiration starting from total lung capacity.[7] PEF is a measure of the initial flows in a forced expiration, and is also a reflection of lung recoil and resistance of the larger airways.

Microorganisms

Historically, microbial contamination of MWF has been a problem primarily because of the microbial growth effects on fluid quality and performance. Fluid degredation from microorganisms may result in changes in fluid viscosity, and the acid products of fermentation may lower the pH of the fluids, causing corrosion of machined parts. Anaerobic bacteria, specifically the sulfate reducers, may produce hydrogen sulfide and other toxic gases. Excessive microbial growth may result in clogged filters and ports and may interfere with the machining operations.

Water-based MWFs are excellent nutritional sources for many kinds of bacteria and fungi. The predominant species routinely recovered from MWFs are virtually identical to those routinely recovered from natural water systems. Many spe-cies that grow in MWFs secrete waste products that serve as a nutritional substrate for organisms with more restrictive nutritional needs. Well-maintained MWFs should have bacterial concen-trations below 10^6 colony forming units per mL (CFU/mL) of fluid.[13]

Some individuals manifest increased immunologic responses to microorganisms, or their metabolites, in the environment. Although microbial contami-nation of MWFs poses an occupational hazard, there are insufficient data to determine acceptable levels of microbial contamination in the air. In addition, allergic or hypersensitivity reactions can occur even with relatively low air concentrations of allergens, and individuals differ with respect to immunologic susceptibilities. Although some pathogenic organisms have been identified in oil emulsion MWFs in the past,[14,15] most pathogens do not persist well in most MWFs.[16,17,18,19]

Endotoxin

Bacterial endotoxin is a heat stable, lipopolysaccharide compound from the outer cell wall of Gram–negative bacteria, which normally occur abundantly in MWFs. Endotoxin exposure can cause fever and malaise, changes in white blood cell counts, respiratory distress, shock, and death. Endotoxin can also act as a stimulant to the immune system.[20,21] While some exposure guide-lines exist for airborne endotoxin, insufficient data exist to promulgate guidelines for endotoxin levels in bulk process MWFs.

Amines in MWF

TEA and MEA are colorless, viscous liquids with a slight ammonia odor and are present in many synthetic MWFs.[22] They are ingredients of the MWF used in departments 680/681, are not very volatile at ambient temperatures, and depending on use conditions, are likely to be airborne in greater concentrations as an aerosol than a vapor.[23] Ethanolamines are moderate irritants to the eyes and skin, and have been shown to cause both allergic and contact dermatitis.[24,25] OSHA has not established a PEL for TEA or MEA, nor has NIOSH established a REL. The ACGIH has a TLV-TWA of 5 mg/m^3 for TEA and 7.5 mg/m^3 for MEA.[2] There are no such guidelines for the amount of these substances in a bulk MWF, but based on the MWF Material Safety Data Sheet (MSDS) at Case Corporation and the amount the concentrate is diluted before its use, they should be present in the process samples in a concentration <1%.

Potentially carcinogenic nitrosamines have been identified in MWFs studied in the 1970s and early 1980s. The Environmental Protection Agency (EPA) prohibited the addition of nitrosating agents to MWFs containing many different amide salts in order to minimize the production of nitrosamines in process.[26] Because employees were specifically concerned about exposure to this class of MWF contaminants, bulk analysis of the MWF for nitrosamines was conducted. Of the nitrosamines analyzed, only N-nitrosodimethylamine is listed among the evaluation criteria of NIOSH, ACGIH, or OSHA. NIOSH lists it as a carcinogen, recom-mending that levels be reduced to the lowest feasible concentration and refers to the OSHA Standard for regulated carcinogens (29 CFR 1910.1016). However, this OSHA standard is not applicable for mixtures containing less than 1% (by volume or weight) N-nitrosodimethylamine. ACGIH lists it as a confirmed animal carcinogen, with unknown relevance to humans. With the exception of N-nitrosodimethylamine, insufficient data exist to promulgate guidelines for these compounds in bulk process MWFs.

RESULTS

Medical

Questionnaire Survey

One hundred twenty-seven employees completed the questionnaire survey; 118 of the participants were from departments 665, 680, or 681. The other nine employees were from various other departments; most of those employees participated because they worked in the areas of departments 665, 680, or 681 even though they were admin-istratively assigned to another department. Participation by department was: 1) 665: 27 (82%) of 33; 2) 680: 59 (92%) of 64; and 3) 681: 32 (100%) of 32.

Characteristics of the 127 participants, grouped by department (665, 680, 681, or other), are listed in Table 1. Table 1 reports the primary job task re-ported by the participants (welding [positive response to the question: in your job, do you perform a welding operation?] or machining [positive response to the question: do you work with MWF in your current job?]). Thirteen participants reported both welding and machining; 16 participants reported doing neither. A larger per-centage of welders (33%) than machinists (14%) reported currently smoking cigarettes.

Table 2 presents the numbers and percentages of participants reporting symptoms, episodes of chest flu (defined as fever, cough, aches) or pneumonia, current asthma, and symptoms consistent with chronic bronchitis (defined as cough with phlegm occurring on most days more than three months out of the year for more than two years). Table 2 also presents, for each symptom, the number and percentage which met the definition of work-related. The most frequently reported symptom was 'sinus problems,' reported by 79 (62%) of the participants. The most frequently reported work-related symptom was 'irritation of the eyes, nose, or throat,' (73%).

Table 3 presents the numbers and percentages of participants reporting work-related symptoms based on primary job task (welding, machining, both, or neither). In general, employees reporting either welding or both welding and machining had higher percentages of reported respiratory symptoms compared to those whose reported job duties included neither welding nor machining. The prevalence of respiratory symptoms among machinists was more similar to that among the group reporting neither welding nor machining. The pattern of reported rash or skin irritation appeared to differ from the pattern of respiratory symptoms, in that the welders reported the lowest percentage of skin problems. The data in Table 3 support the finding given in the interim report that, among the participants of our survey, welders were more likely to report respiratory symptoms (not including sinus problems) than machinists. The data in Table 3 of this report do not take into consideration current cigarette smoking status, although the analysis provided in the interim report found that current cigarette smoking status did not alter the finding that welders reported more respiratory symptoms than machinists.

PEF Testing

The 11 participants who reported all four respiratory symptoms being work-related were offered PEF testing. Eight others, as described in Methods, were also offered PEF testing. Thirteen (68%) of the 19 agreed to participate. Of those 13, 10 persons completed the PEF testing; two did not perform the testing for unknown reasons, and the battery of the remaining PEF meter failed. Participants included workers from all three shifts. Eight of the ten who completed the testing were welders, one a machine operator, and one an employee who did not weld or machine. Seven of the 10 were from department 680.

One of the participants reported signs and symptoms of an acute respiratory infection during the week of testing and reported physician treatment (including frequent use of inhalers) for those symptoms. Bronchial hyperresponsiveness was present on both work days and non-work days. No conclusive pattern of decreased PEF associated with presence at work was observed for this employee.

Of the remaining nine participants, most worked six of the seven testing days (one person reported several non-work days for reasons not reported). Six of the nine demonstrated bronchial hyper-responsiveness on more than one day during the week of testing; all of those six demonstrated bronchial hyperresponsiveness on both work and non-work days. However, one of those six participants (a welder) had patterns of decreasing PEF during the workshift with improved PEF measurements when away from work, suggesting that decrements in PEF for that individual were related to work. The other participants, including the other five with bronchial hyperresponsiveness and the three without bronchial hyperrespon-siveness, did not have patterns suggestive of work-related changes. Eight of the nine reported no use of inhaled medication during the testing period; one person reported one instance of inhaler use, with no detectable difference in the PEF recorded from around that time. Seven of the nine participants (including two of the persons without findings of bronchial hyperresponsiveness) reported multiple respiratory symptoms occurring throughout the time period of the PEF testing.

Industrial Hygiene

Hazard Communication

Review of the written Hazard Communication Program revealed that the Program adequately addresses the requirements of the OSHA hazard communication standard (29 CFR 1910.1200). However, several issues regarding hazard communication were discussed with NIOSH representatives. For example, according to third shift workers, the central MSDS file is kept within the locked nurse's office during third shift operations and is therefore inaccessible. Also, workers were concerned about a detergent that was added to the central MWF system in the Spring of 1999, in preparation for changing types of MWF. Regarding this latter issue, discussions with management representatives revealed that prior to the addition of this detergent, the Case Plant Environmental Manager discussed the addition of detergent and subsequent coolant change with area supervisors during their weekly Monday safety meeting.

Since the initial NIOSH site visit, the MSDS for the MWF used in departments 680 and 681 has been displayed on a bulletin board next to the central coolant reservoir, in addition to the copy kept in the central MSDS file. This is a favorable improvement according to several department 681 employees who we interviewed.

Welding Fume

The toxicologically significant metals that had quantifiable concentrations are shown in Table 5. The metals not listed in the table were present only at concentrations well below relevant occupational exposure limits; most metals were below their respective LOQ. The highest metal concentrations were encountered by welders in department 680.

Three exceeded the REL and TLV for Fe. Four also exceeded the TLV for Mn. All results for Al and Ni were at least one order of magnitude below their lowest exposure limit. Based on the cumu-lative mass concentration of the different metals, and on the thoracic particulate mass samples listed in Tables 6-7, several welders' exposure to welding fume exceeded the ACGIH TLV of 5 mg/m^3.

Because of the design of the protective welding masks used by the welders, it was not practical to affix the sampler to the inside of the mask as NIOSH recommends.[10] Instead, the sampler was attached to the lapel area of the welders, in their breathing zone. In many cases, when the welders lowered their mask in front of their face to weld, the cassette lay behind the mask in a location similar to being attached to the inside of the mask itself. Since the difference between the airborne contaminant level inside a mask versus outside a mask can vary, the welders' true exposures with the mask in place may be slightly different than those presented in this report.[27]

Volatile Organic Compounds

PBZ thermal desorption tube samples were collected on a tack and chassis welder in department 680, on a spud welder in department 665, and on a welding robot operator in department 681. Very small amounts of tetrafluoroethane, 1,1,1-trichloroethane, trichloroethylene, perchloroethylene, hexane, heptane, and alkyl benzenes were detected. Based on a comparison to a spiked thermal desorption tube containing benzene, toluene, and xylene, contaminant concentrations detected on these samples were too low to distinguish any significant difference between the sample tubes and the field blanks. This method is highly sensitive for contaminant detection and identification. But because it is qualitative in nature, the concentration of each contaminant has not been estimated.

Metalworking Fluids

The results of PBZ samples collected for thoracic particulate are listed in Tables 6-7. Results from paired area samples can be found in the Appendix. The range of thoracic particulate exposures (Tables 6-7) for the 9 non-welders in departments 665 and 667 measured over two days was trace - 1.61 mg/m^3, with a mean = 0.37 mg/m^3. The exposures to 5 welders in these departments ranged from 0.15 - 0.48 mg/m^3, with a mean = 0.31 mg/m^3.

For 11 non-welders in departments 680 and 681, the range of exposures was 0.25 - 1.11 mg/m^3, with a mean = 0.61 mg/m^3. This indicates that the typical exposure of non-welders to thoracic particulate in these departments on the days we sampled was likely to be above the REL of 0.4 mg/m^3. The extractable fraction of the samples collected on non-welders was generally a high percentage of the overall sample mass, indicating that the amount of non-MWF material in these samples was a small percentage of the total sample mass.

For 6 welders in departments 680 and 681 on these two days, the range of thoracic particulate exposures was 2.82-7.92 mg/m^3, with a mean = 4.79 mg/m^3. The extractable mass from the welders' samples was a much smaller fraction of the total sample mass than that of the machine operators. This indicates that a large portion of the sample mass probably came directly from the welding fume. This result was anticipated, as NIOSH researchers viewed welding fumes rising directly through the breathing zones of welders. For those employees who are exposed to both welding and machining processes, the extractable MWF results indicate that non-MWF particulate made up a substantial portion of the thoracic particulate concentration. It is therefore not appro-priate to interpret these thoracic particulate sampling results solely with regard to the MWF REL. In these cases, the concentration of the extractable fraction of the sample may give a more accurate reflection of the welders' exposure to MWF aerosol. Welders in departments 680 and 681 had a mean extractable particulate exposure = 0.35 mg/m^3, which still indicates a relatively high exposure to MWF aerosol with respect to the REL.

Microbial Analysis of Bulk MWF

Table 8 details the concentration of endotoxin, and of viable bacteria and fungi in the MWF. The MWF circulating through the central coolant system in departments 680 and 681 supported very low levels of each, with concentrations of fungi below 10 CFU/mL of MWF, and bacteria below 110 CFU/mL. The low levels of endotoxin present in these samples indicates that in the recent past these levels of culturable microbes have been low, i.e., if the population of bacteria had recently bloomed and then died off, then one would expect much higher concentrations of endotoxin to be present. Sample 5 was taken from a machine in department 665 with a self-contained MWF sump; it had the highest level of microbial contamination, with 4.6 x 10^5 CFU/mL bacteria, predominantly Gram-negative species. This was the only sample from which *Mycobacterium chelonae* was isolated. Samples 7 and 8 were collected from bulk containers of concentrated virgin MWF. Sample 7 supported no growth of culturable bacteria. The portion of sample 8 that was sent to the laboratory for culturable bacteria and fungi analysis did not arrive intact, therefore its results were voided.

Amine Analysis of Bulk MWF

Table 9 details the amine content of the bulk MWF samples. There were no nitrosamines detected in any of the process MWF samples. Concentrations of MEA and TEA were below 1% in the process samples. The MEA and TEA concentrations of the concentrated unused MWF used in department 680/681 were within the range stated on the MSDS.

DISCUSSION

General

Among the participants of our survey, those reporting welding alone, or both welding and machining, had higher percentages of reported respiratory symptoms (particularly shortness of breath and cough), as well as higher percentages of irritation of eyes, nose, and throat. This suggests that exposure to welding fumes may be playing a greater role in the occurrence of respiratory, upper respiratory, and mucous membrane symptoms among the surveyed workers than exposure to MWF aerosols. This was an unexpected finding given that the HHE request indicated that respiratory symptoms of machinists were the primary issue. However, it is well known that exposures to MWF[1] and welding fume[10] at other workplaces have been associated with a variety of respiratory (and other) health effects. Because we did not specifically evaluate workers outside the welding and machining areas, we cannot comment on whether both the welders and machinists at Burlington have more respiratory symptoms than other, "unexposed," workers; it is possible that both groups surveyed are experiencing more respiratory symptoms than workers at Burlington who have less exposure to respiratory irritants.

PBZ air samples collected from welders indicate that some employee exposures exceeded exposure limits set for total welding fume, iron, and manganese. For two samples (MCE 6 and MCE 11, Table 5), however, the sample cassette was observed to sample outside the welding mask, thus the measured concentrations may not reflect actual exposures. Nevertheless, our observations of some of the welders suggested that some of the air sampling results reflecting exposure above the relevant exposure limits may in part have been due to the work practice of not moving one's head out of the plume of welding fume when possible.

Regarding the MWF sampling, the PBZ sampling done for thoracic particulate and the corresponding extraction analyses indicate that workers are receiving exposures above the MWF REL whether they work directly with machines or in the general vicinity of machining centers (as the parts hangers do). Enclosure of the machining centers, with direct ventilation, is the control technology which should provide the greatest degree of control of MWF aerosols. Enclosure may be difficult at Case due to the large size of the centers and the presence of machining platforms that move across wide areas. Other options for MWF aerosol con-trol that were discussed during our site visit and that should be investigated include minimizing the contribution to background levels of MWF aerosol by the high-velocity re-circulation jets in uncovered floor sloughs and by the central MWF pit itself.

The PEF testing performed in this survey detected one person with decreases in PEF occurring in a pattern suggesting a work-related cause. The in-formation collected in this evaluation does not allow a determination whether individual em-ployees do or do not have specific respiratory conditions such as asthma. A number of limita-tions of the PEF testing may have played a role during our survey and therefore limited the usefulness of that testing. Although we recognized this ahead of time, the most important limitation likely involved insufficient training for each of the participants in obtaining reproducible, maximal PEF measurements. It may be difficult to achieve the level of training and follow-up needed for effective PEF testing during the short time spent on-site for this HHE. For example, it has been recommended as an indication of accuracy and appropriate technique that the two best PEF readings among those taken at a particular time should be within 20 Lpm of each other; that requirement was rarely met in the testing conducted during this survey. Given the variability present in the measurement taken during the PEF testing, the clinical significance of the bronchial hyper-responsiveness detected is not clear.[11]

Union and management representatives reported that no workers have been medically restricted from the machining or welding areas. However, during our interviews with individual employees, we learned of at least one employee who "bid out" of those areas primarily for health reasons. This survey was not able to assess symptoms among those workers who may have experienced health effects in the areas surveyed but have since moved out of those areas (for example, to another job in the Burlington plant).

The concern for welding on parts that had residual MWF on them was the reason for sampling volatile organic compounds. No specific irritant likely linked to respiratory symptoms was identified as a result of this sampling, although the MSDS lists among the MWF combustion byproducts oxides of nitrogen, which can be irritating. The most con-servative work practice would be to remove as much MWF from the parts as possible before welding on them, although the need for this practice cannot be specifically supported by the results of this study. Care should be taken in selecting a cleaner that does not introduce more hazards than are now present.

MWF Maintenance

In general, Case is taking a pro-active approach to their MWF management. Employing a full-time MWF technician, closely monitoring the different MWF parameters, and cleaning the tramp oil out at regular intervals are all important steps to effective MWF maintenance. Samples of weekly records from April through mid-October 1999 indicate fairly constant levels of the monitored charac-teristics, with microbial analyses indicating no detectable fungi and less than 10^3 CFU/mL bacteria. The low levels of culturable bacteria and fungi found in the central coolant system during this HHE indicate that microbial growth was under control at the time of this visit. The low levels of endotoxin indicate that this had been the case at least for the recent past as well. The comparatively higher levels found in the single stand-alone machine sampled in department 665 may indicate that these stand-alone machines should be included in periodic microbial sampling efforts similar to what is done for the central MWF system in department 681. The levels of TEA and MEA in the MWF were as low as expected, and no nitrosamines were found in any of the samples.

CONCLUSIONS

Several welders in 680/681 were exposed above the TLV for total welding fume. This is consistent with the findings of the questionnaire survey, which suggest that exposure to welding fumes is associated with more respiratory symptoms than is exposure to MWF aerosols. Although a larger percentage of machinists than welders reported rash or skin irritation, from the data collected in this survey we can make no definitive conclusions concerning the type or etiology of skin problems among the survey participants.

Nearly all the employees in department 681 were exposed to thoracic particulate at concentrations above the NIOSH REL for MWF. For those employees who are exposed to both welding and machining processes in departments 680 and 681, it is not appropriate to interpret the thoracic particulate sampling results solely with regard to the MWF REL. In these cases, the concentration of the extractable fraction of the sample may give a more accurate reflection of the exposure to MWF aerosol. Based on the concentration of extractable thoracic particulate alone, workers who worked close to both welding stations and machining centers were exposed to a relatively high concentration of MWF aerosol.

Although the Case Hazard Communication Program adequately addresses the requirements of the OSHA hazard communication standard, it appears that information regarding a planned MWF change was not effectively communicated to all affected employees. Improvements in the Program's implementation are necessary to help effectively communicate appropriate information to all affected employees.

RECOMMENDATIONS

1. Greater attention should be given by Case Corporation to the effective dissemination of information regarding any major changes to the central MWF system. The use of the bulletin board to display hazard communication materials is an important improvement. Perhaps in the future, for example, if a detergent is to be added to the MWF system or other maintenance activities are planned, a notice could be posted to this effect in order to supplement the company's regular hazard communication practices. The importance of timely, clear, concise communication among all involved parties cannot be overemphasized with regard to avoiding any unneeded tension between those who make process change decisions and those who the decisions directly affect.

2. To more fully characterize their typical exposure, further air sampling should be done on welders in departments 680 and 681, for total welding fume and for individual metals

in the fume. Based on the limited sampling done during this HHE, welder exposures to total welding fume, and to Fe and Mn can exceed the TLV and/or the REL. Engineering or other controls should be imple-mented where possible to assure exposures are below the most protective exposure limit. Where possible, welders should work in a way such that their breathing zone is not located directly within the welding plume. In some situations where fixed local exhaust is not feasible due to the nature of welding being done (welders moved frequently within the same work station) a movable hood with a flexible duct may be used. For gas-shielded arc welding processes, contaminants can be removed by means of a low-volume, high-velocity extraction gun.

3. The company and the union should investigate which engineering and administrative controls (local/general ventilation, enclosure, work prac-tices) would be most effective in reducing these exposures in department 681 and in other areas where MWF exposures exceed the REL. Examples of possible controls include enclosing those areas of the MWF circulation system that are not fully covered, such as the central MWF reservoir and MWF return channels under operator stations. The feasibility of enclosing and/or venti-lating the machining centers should be investigated as well. If engineering or other controls are not feasible, or prior to the implementation of such controls, workers whose exposure exceed the NIOSH REL should use respiratory protection. Because measured exposures were less than 10 times the REL, a particulate respirator, with an assigned protection factor of 10 will provide sufficient protection. A P-series (oil-proof) filter certified under 42 CFR Part 84 should be used; the minimally protective filter would be designated P-95. Respirators should only be used within the constraints of a comprehensive respiratory protec-tion program.[28] Users must be trained, fit-tested, and medically cleared for their assigned respirator.

4. In the areas where the PBZ air concentrations of MWF exceeded one-half of the NIOSH REL, additional sampling to evaluate worker exposures to MWF should be conducted every 6 months.[1] The sampling strategy should focus on workers that are expected to have the highest exposures (e.g., high production or poorly controlled areas). Area sampling can help augment the personal exposure monitoring. The objectives of an envi-ronmental monitoring program are to evaluate the effectiveness of work practices and engineering controls, ensure that exposures are below the REL, and identify areas where further reduction in exposures is possible.

5. Prevention of skin contact, and the reduction of opportunities for skin contact, should be a primary focus of a MWF safety and health program. Dermal contact with MWFs should be reduced as much as possible by modification of work practices and the use of appropriate personal protective equipment.

6. Machines with their own MWF sump should be included in the microbial sampling practices of the central MWF system in department 681 so that microbial contamination does not become exces-sive.

7. Employees should be encouraged to report all potential work-related health symptoms to appro-priate health care personnel. Case Corporation should monitor reported health problems in a systematic manner designed to identify particular job duties, work materials, machines, or areas of the plant which may be associated with particular health effects. A discussion of an occupational safety and health program pertaining to welding is contained in the NIOSH Criteria Document "Welding, Brazing and Thermal Cutting."[10] A discussion of an occupational safety and health program pertaining to MWF, including

medical monitoring, fluid maintenance, engineering con-trols, and environmental surveillance, is contained in the recently published NIOSH Criteria Docu-ment "Occupational Exposure to Metalworking Fluids." Copies of either document may be obtained by calling NIOSH at 1-800-35-NIOSH (800-356-4674).

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TABLE 1
Description of Survey Participants
HETA 99-0144-2797, Case Corporation

Department or Potential Exposure	# of Participants	# (%) Male	Mean Age (Years)	Mean # Years in Current Department	# (%) Performing Welding Operation[1]	# (%) Work with MWF[2]	# (%) Current Cigarette Smokers
665	27	25 (93)	45	6	12 (44)	19 (70)	3 (11)
680	59	58 (98)	46	9	47 (80)	8 (14)	20 (35)
681	32	29 (91)	48	9	8 (25)	20 (63)	10 (33)
Other Dept	9	9 (100)	49	10	3 (33)	5 (56)	2 (22)
Welding[1]	70	66 (94)	46	9	70(100)	13 (19)[3]	23(33)
MWF[2]	52	51 (98)	46	9	13 (25)[3]	52 (100)	7 (14)
All Participants	127	121 (95)	47	8	70 (57)	52 (42)	35 (28)

[1] Those employees who responded yes to the question “In your job, do you perform a welding operation?”

[2] Those employees who responded yes to the question “Do you work with machining fluids in your current job?”

[3] Employees reporting both welding and machining duties.

TABLE 2
Self-Reported Symptoms and Illnesses
HETA 99-0144-2797, Case Corporation

Symptom/Illness	Number (% of 127 participants) who reported symptom/illness in the past six months	Number (% of previous column) whose symptom met definition of 'work-related'[1]
Sinus problems	79 (62)	52 (66)
Cough	63 (50)	38 (60)
Irritation of eyes, nose, or throat	62 (49)	45 (73)
Wheezing or whistling in chest	42 (33)	25 (60)
Tightness in chest	36 (28)	25 (69)
Unusual shortness of breath	31 (24)	20 (65)
Rash or skin irritation	30 (24)	21 (70)
Fever or sweats	20 (16)	13 (65)
Chest flu[2] or pneumonia	37 (30)	NA[3]
Symptoms consistent with chronic bronchitis[4]	28 (22)	NA
Current asthma	6 (5)	NA

[1] Work-related symptom defined as: 1) a symptom occurring in repeated episodes <u>or</u> every workday for a month or more; <u>and</u> 2) a 'yes' or 'unsure' response to the question "does it (the symptom) improve on days off from work?"
[2] Chest flu defined as fever, cough, and aches.
[3] Not applicable.
[4] Symptoms consistent with chronic bronchitis, defined as cough with phlegm on most days occurring more than three months out of the year for more than two consecutive years.

TABLE 3
Work-related[1] Symptoms Among Employees by Reported Job Duties[2]
HETA 99-0144-2797, Case Corporation

Symptom	Number of Welders (% of 54) reporting symptom/illness[3]	Number of Machinists (% of 38) reporting symptom/illness [4]	Number of Welder-Machinists (% of 13) reporting symptom /illness[5]	Number of Other Employees (% of 16) reporting symptom/illness [6]
Fever or sweats	7 (13)	2 (5)	4 (31)	0 (0)
Unusual shortness of breath	11 (20)	3 (8)	2 (15)	2 (13)
Cough	20 (37)	7 (18)	7 (54)	3 (19)
Irritation of eyes, nose, or throat	22 (41)	12 (32)	7 (54)	3 (19)
Tightness in chest	11 (20)	7 (18)	3 (23)	2 (13)
Wheezing or whistling in chest	13 (24)	6 (16)	2 (15)	3 (19)
Sinus problems	23 (43)	17 (45)	8 (62)	4 (25)
Rash or skin irritation	5 (9)	8 (21)	5 (38)	3 (19)

[1] Work-related symptom defined as: 1) a symptom occurring in repeated episodes or every workday for a month or more; and 2) a 'yes' or 'unsure' response to the question "does it improve on days off from work?"
[2] Survey participants who answered both questions concerning job duties are included in this table (total of 121).
[3] Positive response to question: "In your job, do you perform a welding operation?"
[4] Positive response to question: "Do you work with machining fluids in your current job?"
[5] Positive responses to questions: "In your job, do you perform a welding operation?" and "Do you work with machining fluids in your current job?"
[6] Negative responses to the two questions noted in footnote 4.

TABLE 4
Analytical Limits for ICP Analysis of Welding Fume Samples
HETA 99-0144-2797, Case Corporation

Analyte	LOD (µg/sample)	LOQ (µg/sample)	MDC* (mg/m^3)	MQC* (mg/m^3)
aluminum	0.8	3	0.0014	0.0052
arsenic	0.9	3	0.0016	0.0052
beryllium	0.007	0.02	0.00001	0.00003
calcium	2	6	0.0034	0.0103
cadmium	0.1	0.4	0.0002	0.007
cobalt	0.2	0.6	0.0003	0.001
chromium	0.5	2	0.0009	0.0034
copper	0.1	0.4	0.0002	0.0007
iron	0.4	1	0.0007	0.0017
lithium	0.03	0.1	0.0001	0.0002
magnesium	0.9	3	0.0016	0.0052
manganese	0.04	0.1	0.0001	0.0002
molybdenum	0.1	0.4	0.0002	0.0007
nickel	0.3	1	0.0005	0.0017
lead	0.9	3	0.0016	0.0052
phosphorus	2	5	0.0034	0.0086
selenium	4	10	0.0069	0.0172
sodium	3	9	0.0052	0.0155
tellurium	2	7	0.0034	0.0121
thallium	2	7	0.0034	0.0121
titanium	0.07	0.2	0.0001	0.0003
vanadium	0.1	0.4	0.0002	0.0007

zinc	0.3	1	0.0005	0.0017
zirconium	0.06	0.2	0.0001	0.0003

**Based on a sample volume of 580 L.*

TABLE 5. PBZ Results for Metals Analysis in Departments 665, 680, 681, November 5, 1999
HETA 99-0144-2797, Case Corporation

Work description	Dept.	Sample time (min.)	Sample #	Mass concentration, mg/m³			
				Al	*Fe*	*Mn*	*Ni*
Robot welder	680	275	MCE 6	trace	2.4	.22	.002
Spud welder, #2427	665	271	MCE 7	trace	.35	.05	nd
Case welder, #1831	665	284	MCE 8	.013	.06	.05	nd
Case welder, #1830	665	273	MCE 9	.006	.03	.02	nd
Spud welder, #5203	665	266	MCE 10	nd	.24	.03	nd
Post-welder, #4506	680	241	MCE 11	trace	5.2	.64	.004
HMC operator, #3758	680	290	MCE 12	trace	.31	.04	nd
Robot operator, #3843	680	278	MCE 13	.011	5.6	.72	trace
Tack welder	680	283	MCE 14	trace	1.4	.18	nd
Robot operator, #3764	680	264	MCE 15	.013	6.8	.81	.002
MDC, mg/m³				*0.0014*	*0.0007*	*0.0001*	*0.0005*
MQC, mg/m³				*0.0052*	*0.0017*	*0.0002*	*0.0017*
NIOSH REL, mg/m³ TWA				**5**	**5**	**1 (3 STEL)**	**0.015***
ACGIH TLV, mg/m³ TWA				**5**	**5**	**0.2**	**1.5**
OSHA PEL, mg/m³ TWA				**15**	**10**	**5**	**1**

**NIOSH considers nickel to be an occupational carcinogen and recommends that airborne levels be kept to the lowest feasible concentration.*
nd = 'not detected', amount of analyte was below the analytical LOD
trace = amount of analyte was between the analytical LOD and LOQ
MDC = 'minimum detectable concentration' based on the analytical LOD and a sample volume of 580 L.
MQC = 'minimum quantifiable concentration' based on the analytical LOQ and a sample volume of 580 L.

TABLE 6
PBZ Results for Thoracic Particulate, Departments 665, 667, 680, 681, November 3, 1999
HETA 99-0144-2797, Case Corporation

Work location	Dept.	Sample #	Sample time (min.)	Thoracic particulate mg/m^3	Extracted MWF* mg/m^3	% Extracted MWF**
Threader #2014	665	MWF 1	447	1.61	0.35	22
Threader	665	MWF 2	471	0.2	trace	trace
Cylin.wash #3671	665	MWF 3	445	0.18	trace	trace
CNC operator	667	MWF 4	411	0.58	trace	trace
Case welder, #1830	665	MWF 5	406	0.15	trace	trace
CNC operator, #1822, 1821, 2216	667	MWF 6	418	0.19	trace	trace
Case welder, #1831	665	MWF 7	410	0.27	0.17	61
Robot welder	681	MWF 22	363	6.4	1.03	16
Production welder	680	MWF 23	380	4.7	0.35	17
Tack & chassis welder	680	MWF 24	375	3.17	0.42	13
Machine op., #3859	681	MWF 25	403	0.54	0.39	71
Machine operator #8476, 9919	681	MWF 26	402	0.62	0.25	40
HMC operator, #3948, 3947	681	MWF 27	395	1.11	0.74	67
NC operator, #3758, 3759	680	MWF 28	406	0.52	trace	trace
Parts hanger	681	MWF 29	422	0.25	0.15	59
NC operator, near MWF pit	681	MWF 30	417	0.64	0.54	84
MDC **mg/m^3** ***MQC*** **mg/m^3** ***NIOSH REL*** **mg/m^3 *TWA***				0.014 - **0.4**	0.042 0.14 -	

(*) This column shows the concentration of the extractable fraction of the thoracic aerosol sampled. The extracted fraction is only a portion of the MWF aerosol as defined in the NIOSH REL, but can be used as a conservative indicator of MWF aerosol exposure in environments that may include non-MWF processes, such as welding, which may contribute a substantial portion of the particulate mass on the filter.
(**) The percentage of thoracic particulate concentration attributed to extracted MWF.

TABLE 7
PBZ Results for Thoracic Particulate, Departments 665, 667, 680, 681, November 4, 1999
HETA 99-0144-2797, Case Corporation

Work location	Dept.	Sample #	Sample time (min.)	Thoracic particulate mg/m^3	Extracted MWF* mg/m^3	% Extracted MWF**
Spud welder, #5203, 1783	665	MWF 8	443	0.44	0.17	39
Reamer operator, #1779, 3130	665	MWF 9	446	0.24	0.15	63
Threader, #3756	665	MWF 10	443	0.17	trace	trace
Spud welder, #4300	665	MWF 11	442	0.23	trace	trace
Threader, #1849	665	MWF 12	396	0.13	trace	trace
Wash hood, #3671, 3672	665	MWF 13	389	trace	trace	trace
Case welder, #1831	665	MWF 14	390	0.48	0.27	56
MIG welder/robot operator #3766	680	MWF 31	445	3.71	0.59	16
NC operator, #2859	681	MWF 32	433	0.55	0.4	73
MIG welder	680	MWF 33	442	7.92	0.55	7
MIG welder	680	MWF 34	443	2.82	0.47	17
NC operator, #3758, 3759	680	MWF 35	448	0.36	trace	trace
HMC operator, #1998, 0998	681	MWF 36	436	0.39	0.24	62
Parts hanger	681	MWF 37	448	0.82	0.57	70
HMC operator, #2784	681	MWF 38	436	0.88	0.43	49
MDC mg/m^3 ***MQC mg/m^3*** ***NIOSH REL mg/m^3 TWA***				0.014 - **0.4**	0.042 0.14 -	

(*) This column shows the concentration of the extractable fraction of the thoracic aerosol sampled. The extracted fraction is only a portion of the 'MWF aerosol' as defined in the NIOSH REL, but can be used as a conservative indicator of MWF aerosol exposure in environments that may include non-MWF processes, such as welding, which may contribute a substantial portion of the particulate mass on the filter.
(**) The percentage of thoracic particulate concentration attributed to extracted MWF.

TABLE 8
Results of Microbial Analysis of Bulk MWF Samples Collected on November 4, 1999
HETA 99-0144-2797, Case Corporation

Sample#	Sample Location	GNB CFU/mL	Fungi CFU/mL	MB sp. CFU/mL	Endotoxin EU*/mL
1	Machine 2859, dept. 681	110	ng	<10	137
2	Machine 4035, dept. 681	ng	ng	<10	133
3	Machine 8476, dept. 681	100	ng	<10	115
4	Machine 3759, dept. 680	ng	ng	<10	99
5	Machine 3130 reamer, dept. 665	4.7×10^5	ng	>5000	62,109
6	CCS Pit, unfiltered	ng	ng	<10	109
7	Dept. 681 concentrated MWF	ng	ng	<10	< .05
8	Dept. 665 concentrated MWF	**	**	**	< .05

GNB = Gram-negative bacteria
ng = 'no growth', for fungi this is <10 cfu/mL, for GNB this is <110 CFU/mL
MB = *Mycobacterium* species isolated; for sample #5 these organisms were identified as *M. chelonae, ssp.*
abscessus.
* 10 EU = 1 nanogram
** sample voided

TABLE 9
Amine Results of Bulk MWF Analysis Collected on November 4, 1999
HETA 99-0144-2797, Case Corporation

Sample location	Nitrosamines μg/g	MEA, % by weight	TEA, % by weight
dept. 681, machine #2859	nd	0.68	0.22
dept. 681, machine #4035	nd	0.81	0.26
dept. 681, machine #8476	nd	0.59	0.22
dept. 680, machine #3759	nd	0.79	0.22
dept. 665 #3130 reamer	nd	0.61	0.11
dept. 681, central MWF reservoir	not analyzed	0.67	0.24
dept. 681, concentrated virgin MWF	not analyzed	14	5.2
LOD	26-42 ng/sample*	0.007	0.005
LOQ	86-138 ng/sample*	0.02	0.02

*depending on the type of nitrosamine

Appendix

Area Particulate Sampling Results for Case Corporation, Burlington, Iowa
HETA 99-0144-2797
Area Air Sampling Results for MWF, Departments 680, 681
HETA 99-0144-2797, Case Corporation

Sample location	Dept.	Sample pair#	Sample time (min.)	MWF Total particulate mg/m^3 / *Thoracic particulate mg/m^3*	% Extracted MWF*
#8476, above floor flume	681	1	305	0.23	nd
				0.59	*0.25*
N. wall of central MWF pit	681	2	312	1.39	93
				2.60	*94*
Pole AP82 - closest to central MWF pit	681	3	311	0.32	70
				0.62	*74*
#3759 - on work table by control panel	680	4	297	0.24	nd
				0.48	*18*
above flume at Donaldson P551553	681	5	408	0.48	59
				0.86	*63*
crawler conference room	681	6	443	0.03	nd
				0.04	*nd*

(*) The percentage of thoracic particulate concentration attributed to extracted MWF.

The thoracic fraction of an aerosol is a subset of the 'total' fraction. Therefore, it was expected that the thoracic particulate concentration would be less than that of the corresponding total sample for each sample pair. There is no clear explanation for the samples above which revealed thoracic fractions greater than the corresponding 'total' fractions. NIOSH continues to study the relationship between paired 'total' and thoracic samples taken from the same work environment. Overall, the values for these samples do not appear to be dissimilar from either the PBZs collected during this HHE or the air sampling data provided by Case from months past. The samples above were not collected with the intent that they necessarily estimate exposures (several pairs were collected in areas where no workers work), rather, they were collected across the full range of anticipated MWF concentrations from very low (conference room) to very high (MWF pit). The area sample results may best be used qualitatively to identify potential sources of MWF aerosol in addition to the individual machines operated by machinists, for whom PBZs were collected. Based on these area sample results and the PBZ samples collected on both welders and machinists, the MWF appears to be ubiquitous in nature.

For Information on Other
Occupational Safety and Health Concerns

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