NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2004-0399-3007
NTN-Bower Corporation
Hamilton, Alabama

June 2006

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

PREFACE

The Hazard Evaluation 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 employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Manuel Rodriguez and Judith Eisenberg of HETAB, Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS). Field assistance was provided by Elena Page, Ron Hall, and Erica Jones. Analytical support was provided by Jack Pretty, Division of Applied Research, and Technology (DART), and Data Chem Laboratories (DCL). Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

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

Highlights of the NIOSH Health Hazard Evaluation

The United Auto Workers Union Local 1990 asked NIOSH to evaluate dermatitis problems associated with exposure to metalworking fluids (MWFs).

What NIOSH Did

- We interviewed 46 employees.
- We took bulk and air samples for MWFs and contaminants.
- We looked at ventilation systems to see if they were effective in controlling MWF mists.

What NIOSH Found

- Of 46 employees interviewed, four had skin conditions that may be work related.
- Workers have the opportunity to wash hands when necessary.
- Workers were exposed to MWF air concentrations over the NIOSH recommended exposure limit (REL).
- Workers are at risk for developing respiratory problems due to MWF exposures.
- Ventilation systems used to control MWFs mists are ineffective and need maintenance.
- Levels of carbon monoxide (CO) in the Heat Treating area may be hazardous.

What NTN Bower, Hamilton Alabama Managers Can Do

- Repair and maintain ventilation systems, and assure their effective operation.
- Conduct air sampling for MWFs after repairing the ventilation systems.
- Provide workers with appropriate respiratory protection until exposures can be reduced below the NIOSH REL.
- Conduct full-shift and short-term exposure monitoring for CO in the Heat Treating area.
- Install a CO alarm in the Heat Treating area.
- Provide workers with periodic medical evaluations for the early detection of skin and respiratory problems.

What the NTN Bower, Hamilton Alabama Employees Can Do

- Avoid skin contact with MWFs.
- Wash promptly if MWFs touch your skin.
- If respirators are provided, wear them as instructed.
- Turn ventilation systems on when working on metal processing machines.
- Close side panels on metal processing machines.
- Clean MWF spills promptly.
- Do not smoke, eat, or drink in the work area.
- Quit smoking. Smoking may aggravate respiratory disorders caused by MWFs.

CDC Workplace Safety and Health

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #HETA 2004-0399-3007

NIOSH

Health Hazard Evaluation Report 2004-0399-3007
NTN-Bower Corporation
Hamilton, Alabama
June 2006

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SUMMARY

On September 15, 2004, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the United Auto Workers Local 1990 to evaluate dermal exposures to metal working fluid (MWF) at the NTN Bower Corporation facility in Hamilton, Alabama. The request also alleged that management was not allowing employees sufficient time for washing their hands after exposure to MWFs. During the initial site visit to NTN Bower on December 7-8, 2004, NIOSH medical officers interviewed 46 employees regarding their work history, potential dermal exposures, use of personal protective equipment, frequency of hand washing, and history of atopy and skin rashes. Four employees were identified with skin conditions that could be work related. In a questionnaire administered to NTN Bower employees, 36 of the 46 employees responded that they wash their hands five or more times per day. Bulk samples of MWF from the three systems used at the facility were analyzed for metals, bacteria, endotoxins, and polynuclear aromatic hydrocarbons (PAHs). During this initial site visit NIOSH investigators noted MWF mist throughout the production area.

NIOSH investigators returned to NTN Bower on June 20, 2005, and collected personal and area air samples for MWFs, carbon monoxide (CO), ethanolamines, PAHs, and formaldehyde. Fifteen of 18 personal breathing zone (PBZ) air samples for MWFs exceeded the NIOSH Recommended Exposure Limit (REL) of 0.40 milligrams per cubic meter (mg/m^3) of air for thoracic particulate mass. Instantaneous readings of CO in the Heat Treating area ranged from 34 to 86 parts per million (ppm), suggesting that the NIOSH Recommended Exposure Limit-Time Weighted Average (REL-TWA) of 35 ppm could be exceeded. An evaluation of the ventilation systems used to control MWF mists revealed that many of the systems were not in operation. In addition, machines were not properly enclosed, flexible exhaust hoses were disconnected or torn, and the exhaust systems needed maintenance. Airborne levels of ethanolamines, PAHs, and formaldehyde were below applicable occupational exposure limits.

NIOSH investigators concluded that a health hazard existed at the time of this evaluation due to employee's exposures to MWFs above the NIOSH REL. In addition, employees in the Heat Treating area were potentially overexposed to CO, and the ventilation systems used to control MWF mists were ineffective and needed maintenance. Four of 46 employees interviewed by NIOSH Medical Officers had skin conditions that could be work related. Recommendations include the use of respiratory protection until concentrations of MWF mist can be reduced below the NIOSH REL.

Keywords: NAICS 332991 (Ball and roller bearing manufacturing), dermatitis, MWF, metalworking fluid, ventilation, carbon monoxide, ethanolamines, polynuclear aromatic hydrocarbons.

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INTRODUCTION

On September 15, 2004, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the President of the United Auto Workers Local 1990. The request asked NIOSH for assistance in evaluating dermal exposures from contact with metal working fluid (MWF) at the NTN Bower Corporation facility in Hamilton, Alabama. The request also alleged that management was not allowing employees sufficient time to wash their hands. NIOSH investigators visited the facility December 7-8, 2004. During the initial site visit NIOSH medical officers interviewed employees and reviewed medical records. NIOSH investigators conducted a walk-through tour of the facility and noted a petroleum distillates-type odor and visible mist throughout the production area. NIOSH investigators reviewed the OSHA 300 Logs of Work-Related Injuries and Illnesses, observed existing engineering controls and work practices, and collected bulk samples of the MWFs from each of the three MWF systems used by NTN Bower. Based on the findings and observations during the initial site visit, NIOSH investigators determined that there was a need to sample for MWF aerosols. On June 20, 2005, NIOSH investigators returned to NTN Bower to sample for MWFs and possible contaminants and to evaluate the local exhaust ventilation systems.

BACKGROUND

Previous NIOSH Evaluations (1990, 1992)

On September 18, 1989, NIOSH received a union request for an HHE at NTN Bower (HETA 89-0367). The request concerned potential health effects from exposure to solvents and rust preventatives. A specific health effect mentioned was chronic urticaria (hives). During March 13-14, 1990, a NIOSH medical officer reviewed the medical records of 84 employees and identified 11 workers as having a history of urticaria or angioedema (swelling of the soft tissues). Bulk samples of MWFs were collected and analyzed for potential urticariogenic agents, including benzophenone, chloroform, xylene, and alcohol solvents (i.e., butanol, ethanol). Chromium and nickel, which are skin sensitizers, were detected in the bulk samples. Investigators recommended that workers reduce skin contact with cutting oils and lubricants that new employees receive preplacement medical exams, and that employees who develop a skin problem consult a dermatologist for diagnosis.

On June 1, 1992, NIOSH received an HHE request (HETA 92-0280)[1] from the UAW asking for assistance in evaluating the cause of urticaria and dermatitis among NTN Bower workers. NIOSH investigators conducted a site visit to the facility December 7-9, 1992, and collected bulk and air samples for potential contaminants. Chromium and nickel were found in the bulk samples. NIOSH investigators inspected the HVAC units and found oil on the filters and coils. A review of company medical records indicated a decrease in reported work-related skin problems from 63 in 1989 to 18 in 1992. NIOSH investigators found that although gloves were available, some employees with exposure to MWF did not wear them because of decreased dexterity or discomfort. NIOSH recommendations included re-evaluation of the types of gloves used for each operation, improved maintenance of the ventilation system, maintaining a log of skin complaints, and referring employees with skin conditions to a dermatologist.

Previous Company Evaluation

On May 27 and 28, 2003, NTN Bower Corporate Environmental Health and Safety Management personnel conducted personal air sampling for oil mist and area sampling for ethanolamines. Seven personal samples for oil mist were collected on tared polyvinyl chloride filters per NIOSH Manual of Analytical Methods (NMAM) 0500 and analyzed gravimetrically for total particulates. Two of the sample results were over one milligram per cubic meter (mg/m^3), indicating that employees had been exposed over the NIOSH Recommended Exposure Limit (REL) of 0.4 mg/m^3 thoracic particulate mass, which corresponds to approximately 0.5 mg/m^3 total particulate mass of MWF. Ethanolamines were not detected.

Process Description

The 375,000 square foot NTN Bower facility employs approximately 250 persons in the manufacture of tapered steel roller bearings for use in industrial and agricultural equipment. Work schedules are divided into three 8-hour shifts. NTN Bower receives carbon steel metal stock which is drawn, formed, or stamped into the desired shape. The bearing components manufactured at NTN Bower consist of cups and cones (called raceways), rollers, and retainers. A cone, along with rollers and a retainer, are used to make a cage assembly. The cones are cylinders with a tapered outer surface, whereas cups are cylinders with a tapered inner surface. The customer forms a complete tapered bearing by placing the cup over the bearing cage assembly. The outer surfaces of the components are finished at various metal processing machines by grinding or honing. Honing is a surface finishing operation used to achieve the desired tolerance and smoothness. Each process is conducted in a separate area. Rollers are ground in the Roll Grind area, and cups and cones are ground in the Race Grind area. Other departments include Cold Header, Turning, Heat Treating, and Assembly and Inspection (A&I). Cold Header describes the heading process, which entails taking a piece of stock and pressing it into a die to give it the desired shape. Turning is an operation performed on cylindrical parts to remove surface material. The part is rotated on a spindle and a tool is fed into the part to remove metal.

All components except the retainers are heat treated at the plant. After heat treating, the cups and cones are quenched in oil, while rollers are quenched in water. After grinding, the races and rollers are honed, washed with a temporary rust preventative (mineral oil distillates), and sent to final assembly. Coiled flat steel is processed through a series of die presses where it is shaped and cut to form the retainers. After pressing, the retainers are washed, de-burred, sprayed with rust preventative oil, and sent to the final assembly area. The retainers are similar in shape to the cones but thinner with rectangular holes to hold the rollers.

In the A & I department, all the components are inspected and then assembled. The cage assembly is produced by placing a cone upside down on a table in a nesting device, placing a retainer around it; then feeding rollers into place between the retainer and the cone. The entire retainer assembly is then placed in a small press where a die crimps it together. After assembly the retainers are sprayed with rust preventative oil.

Metal processing machines are contained within metal enclosures with removable panels. Each machine is equipped with a Mistkop® mist collector suspended from the ceiling above the machine. The mist collectors consist of a cylindrical canister lined with a fiberglass filter, a fan and motor mounted on top of the canister, and a flexible duct attached to the fan housing and the metal processing machine enclosure. Air is drawn from the enclosure, forced into the canister, through the fiberglass filter, and then recirculated back into the plant. Oil accumulating on the filter drains to the bottom of the canister and is returned to the metal processing machine via a hose. Exhaust ventilation for the oil quenching operation is provided by a canopy hood located about 10 feet above the quenching oil.

Because metal processing generates a great amount of heat due to the friction between the cutting tool and the metal stock, MWFs are used to cool the cutting tool and the stock. MWFs are stored in large pits and piped to the various metal processing machines in the plant by three MWF systems. Roll Grind and Turning utilizes a synthetic MWF, whereas Race Grind utilizes a semi-synthetic fluid.

METHODS

Industrial Hygiene Evaluation

Metal Working Fluid Air Samples

NIOSH investigators collected 18 full-shift personal breathing zone (PBZ) and four area air samples for MWF during June 21-22, 2005. Samples for MWF aerosol were collected using 37-millimeter (mm) closed-faced 3-piece cassettes containing a tared 2 micrometer (µm) pore-size polytetrafluoroethylene (PTFE) filter and the supporting pad. The sampling train consisted of a 37-mm cassette, a BGI thoracic cyclone, and Tygon® tubing connecting the sampling assembly to a personal pump. A sampling rate of 1.6 liters per minute (Lpm) was used so that only the thoracic fraction of the aerosol would be collected. The samples were analyzed by gravimetric analysis for the thoracic fraction of MWF particulates per NMAM 5524.[2]

Metal Working Fluid Bulk Samples

NIOSH investigators collected three bulk samples of MWF from each of the three systems supplying the metal processing machines. For each system one sample was analyzed for Gram negative bacteria, fungi, and endotoxins, the second for ethanolamines, and the third for metals. Ethanolamines are a MWF additive to stabilize pH or inhibit corrosion, and the others are potential contaminants. Viable culture identification was used to identify both bacterial and fungal organisms at the genus or species level and to obtain colony forming unit (CFU) counts. Analysis for endotoxins was performed by filtering the MWF and analyzing the filters for endotoxin content using a Kinetic-QCL Limulus Amebocyte Lysate (LAL) assay.[3] Results were reported in endotoxin units (EU). Analysis for ethanolamines was performed per modified draft NMAM 3509. Laboratory analysis for metals was performed per NMAM 7300. Samples of neat (unused) and used oil were submitted for laboratory analysis for PAHs and analyzed by gas chromatography and mass spectrometry. Samples of the neat and used MWF fluids were also analyzed for hexahydro-1,3,5-tris(2-hydroxyethyl)-s-triazine (commonly referred to as "triazine") by a NIOSH research chemist.[4]

Carbon Monoxide

Carbon monoxide was being used in the Heat Treating area as part of the heat treating process and was also a combustion byproduct. Employees may be exposed to CO smoke from the furnaces if the furnaces are not properly vented. NIOSH investigators used a calibrated TSI Q-Track™ Plus Indoor Air Quality Monitor to measure CO in the Heat Treating area and other parts of the plant. The TSI Q-Track uses a chemical sensor to measure CO in a range of 0-500 parts per million (ppm).

Ethanolamines

NIOSH investigators collected 12 full-shift area air samples for ethanolamines. Area air samples for ethanolamines were collected with a midget impinger containing 15 milliliters (ml) of 2 millimolar (mM) hexanesulfunic acid. The impinger and a trap were connected to a personal sampling pump set to a flow rate of 1.0 Lpm. The samples were analyzed for monoethanolamine (MEA), diethanolamine (DEA), and triethanolamine (TEA) per NMAM 3509.[2]

Formaldehyde

NIOSH investigators collected 20 PBZ and 5 area full-shift samples for formaldehyde using SKC UMEx 100 passive badges attached to the workers' collars. The UMEx badge can detect formaldehyde in a range of 5 parts per billion (ppb) to 5 ppm.[5] The badges contain a tape impregnated with 2,4-dinitrophenylhydrazine (DNPH), which forms DNPH-hydrazone when exposed to formaldehyde. Samples were submitted for laboratory analysis per NMAM 2016.[2]

Polynuclear Aromatic Hydrocarbons

NIOSH investigators collected five full-shift PBZ and three area air samples for PAH. Samples were collected with an OSHA Versatile Sampler (OVS) tube containing a glass-fiber filter and XAD-7 resin connected with Tygon® tubing to a personal sampling pump set to a flow rate of 2 Lpm. OVS tubes allow the simultaneous collection of aerosols and vapors in one tube. The sample tubes were wrapped in aluminum foil to protect them from ultraviolet light and submitted to a laboratory for analysis per draft NMAM 5528.[2]

Ventilation

An evaluation of the local exhaust ventilation systems (Mistkop® mist collectors) was performed by visually observing airflow patterns, the location of the exhaust hoods relative to the point of contaminant generation, and the general condition of the systems. A note was made of metal processing machine enclosures with missing panels or open panels that interfere with their capability to maintain negative pressure. Airflow and pressure characteristics for each machine enclosure or exhaust hood were evaluated with air current tubes. Air flowing into an enclosure indicated the enclosure was under negative pressure. NIOSH investigators also conducted visual inspections of the heating ventilation and air-conditioning (HVAC) units located on the roof that serviced the non-production areas.

Ultrafine Particle Count

NIOSH investigators used a TSI Condensation Particle Counter (CPC) Model 3007 as a tool in assessing air quality at the NTN Bower facility. The CPC counts particles in a size range from 0.01 to greater than 1 micrometer. The meter was allowed to stabilize for 10 minutes and a zero check was performed with a high efficiency particulate air (HEPA) filter. A background reading was taken outdoors for comparison with readings within the facility. Typically unless there is an internal source of ultrafine particles (UFPs) the indoor particle count should be lower than outdoors due to air filtration by the HVAC system. NIOSH investigators walked through the facility and noted the UFP counts. It was expected that particle counts in production areas would be higher than outdoors due to MWF mist generation, and in the administrative areas the count would be lower.

Medical Evaluation

During the initial site visit on December 7-8, 2004, NIOSH medical officers interviewed 46 current and one retired employee. The union provided a list of 20 current employees who felt they had work-related dermatitis. Due to time constraints and a concern for protecting their identities, 14 of the employees mentioned in the list were included in our interviews as well as 32 additional employees who were randomly selected from each of the involved departments. Twelve of the 20 employees identified by the union worked in the A&I department, and six worked in the grinding departments. Because the concerns regarding dermatitis were centered on A&I and the grinding departments, the interviewed employees were primarily selected from these areas. Sixteen employees were selected for interviews on each shift. Half (8) were randomly selected from the A&I department. The other eight slots were filled primarily from the grind departments as this was the next most common area from which complaints arose. These interviews included questions regarding work history within the plant, potential exposures, use of personal protective equipment, frequency of hand washing, and medical history including history of atopy and skin rashes. Photographs were taken of rashes present at the time of interview for review by a NIOSH dermatologist; informed consent was obtained for the photographs.

Signed medical record release forms were obtained from eight current and one retired employee. Medical records were received from private physicians of seven employees. OSHA 200/300 logs were also reviewed for the years 2000-2005.

EVALUATION CRITERIA

General

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

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[6] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[7] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[8] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

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

Industrial Hygiene

Metal Working Fluid

Metal removal processes generate a great deal of heat. MWF are used during grinding, cutting, or boring of metal parts to cool and lubricate the cutting tools and the metal parts. The MWF also provides corrosion protection for the machined parts, prevents smoking, and increases the life of the cutting tools. MWFs help remove chips and fine metal and abrasive particles from the cutting zone. There are four types of MWF: straight oil, soluble oil, semi-synthetic, and synthetic.[9] With the exception of straight oils, MWFs are generally mixed with water for use. Semi-synthetic fluids contain some oil, while synthetic fluids are totally water based. The MWF may contain a mixture of substances including biocides, corrosion inhibitors, metal fines, tramp oils, bacteria, and other biological contaminants. Adding excessive amounts of biocides to cutting fluids may cause skin and/or respiratory irritation.

Exposure to MWF can result from inhalation of the MWF aerosols, or from skin contact with the fluids due to settling of aerosols, contact with parts and equipment, and splashing.[10] MWF may cause employees to experience respiratory problems if the airborne concentration is above the NIOSH RELs; some employees may experience health effects at concentrations below these limits. Inhalation of MWF mist or aerosols may cause irritation of the throat, nose, and lungs resulting in symptoms such as sore throat, eye irritation, runny nose, nosebleeds, cough, wheezing, increased phlegm production, and shortness of breath. Exposure to MWF has also been associated with asthma, and smoking may worsen the respiratory effects of MWF aerosols.

Microbial Contaminants

Synthetic and semi-synthetic MWFs, the types used at NTN Bower, are diluted with water. Hence they can be a breeding ground for bacteria if an inadequate amount of biocide is added. High temperature and pH, and the presence of metals can favor bacterial growth. Levels of microbial contamination are an indication of the cleanliness or degree of maintenance of the MWF. However, adding too much biocide may result in biocide-resistant strains of bacteria. Inhalation of MWF aerosols containing bacteria may result in respiratory problems. Workers with broken skin may develop skin infections if they have contact with MWF contaminated with bacteria. The outer cell walls of Gram-negative bacteria in MWFs may release lipopolysaccharide compounds called endotoxins when the bacteria die or multiply.[11] Endotoxins are believed to cause adverse respiratory effects such as chronic bronchitis and asthma. Adding biocides to water contaminated with bacteria may result in release of endotoxins by dead organisms.

Insufficient data exist to determine what constitutes a safe level of microbial contamination in MWF-either in terms of species present, absolute number of colony forming units, or microbial components. Rylander and Jacobs have suggested an occupational threshold concentration equivalent to 100 endotoxin units/m^3 of air to prevent airway inflammation.[12] However the concentration of endotoxins in bulk samples of MWF cannot be extrapolated to an airborne concentration because the airborne concentration depends on how much of the MWF is aerolized. Contaminated water in MWF may also contain fungi. Fungi may infect susceptible hosts such as immunocompromised persons. Cephalosporium, a genus commonly isolated from MWFs, has reportedly caused hypersensitivity pneumonitis (HP). HP, also known as allergic alveolitis, involves an immunologic reaction to inhaled antigens, generally airborne microbes, and is characterized by inflammation in and around the alveoli and bronchioles. Penicilium and aspergillus, which have been implicated in the development of HP, are also common MWF contaminants.[10] Fungi may also produce toxic metabolites called mycotoxins. When contaminated MWF is replaced, some of the bacteria may remain and proliferate within a short period if the system is not adequately cleaned.[13] At this time there is insufficient health data to recommend a specific limit for bacterial or fungal contamination in MWFs.[14]

Chemical Contaminants

MWFs may cause irritant or contact dermatitis depending on the chemical composition of the fluid. Certain chemicals such as those with a low or high pH irritate the skin upon direct contact. Strong detergents and hand cleansers may also cause dermatitis or aggravate an existing condition. Chemicals that are sensitizers elicit an antibody immune reaction. Another skin condition caused by petroleum based products is occupational acne.[15] Depending on the type of MWFs and the machining process being used, metals such as aluminum, nickel, chromium, zinc, and cobalt may contaminate MWFs. Some of these metals, such as nickel and chromium, are sensitizers.

NIOSH recommends that exposures to MWF aerosols be limited to 0.4 mg/m^3 for the thoracic particulate mass, as a TWA concentration for up to 10 hours per day during a 40-hour workweek. The REL is intended to prevent or greatly reduce respiratory disorders associated with MWF exposure. The sampling method used for this evaluation allows the extraction of MWF from total thoracic particulates. NIOSH considered proposing an REL based on the extractable fraction of MWF; however, there is currently insufficient scientific evidence that extractable MWF is superior to thoracic particulate aerosols as a predictor of adverse health effects from MWF.[10] Some workers have developed work-related asthma, HP, or other adverse respiratory effects when exposed to MWFs at concentrations below the NIOSH REL. Limiting exposure to MWF aerosols is also prudent because certain MWF exposures have been associated with various cancers. In addition, limiting dermal (skin) exposure is critical to preventing allergic and irritant 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.[10] NIOSH also recommends medical monitoring for employees exposed to MWF. Medical monitoring is needed for the early identification of workers who develop symptoms of MWF-related conditions such as HP, asthma, and dermatitis. NIOSH recommends that all workers exposed to MWFs at over half the REL receive medical monitoring. NIOSH publication 98-102 Criteria for a Recommended Standard, Occupational Exposure to Metalworking Fluids, provides guidelines for administering a medical monitoring program.[10]

Carbon Monoxide

A colorless, odorless, tasteless gas that can be a product of the incomplete combustion of organic compounds, CO combines with hemoglobin and interferes with the oxygen-carrying capacity of blood. Symptoms of overexposure can include headache, drowsiness, dizziness, nausea, vomiting, collapse, myocardial ischemia, and death. The NIOSH REL is 35 ppm as a 10-hour TWA, and 200 ppm for a ceiling limit, which should not be exceeded at any time during the workday. The OSHA PEL is 50 ppm as an 8-hour TWA. The ACGIH TLV7 is 25 ppm as an 8-hour TWA. This value is intended to maintain blood carboxyhemoglobin (COHb) levels below 3.5%, to minimize the potential for adverse neurological behavioral changes, and to maintain cardiovascular work and exercise capacities.[16] The time to reach a COHb level of 3.5% at a given CO concentration decreases as the workload increases.[16]

Ethanolamines

Ethanolamines are moderate irritants to the eyes and skin, and have been shown to cause both allergic and contact dermatitis.[17,18] They 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.[19] TEA, a colorless, viscous liquid with a slight ammonia odor, is used as a pH balancer and in a variety of cosmetic products as well as MWF.[20] MWFs diluted with water at a ratio of 10:1 typically contain 0.5% MEA or DEA and 2.5% TEA[10]. There is no OSHA PEL or NIOSH REL for TEA. NIOSH has an REL for MEA of 7.5 mg/m^3 and a STEL of 15 mg/m^3. OSHA has a PEL of 7.5 mg/m^3 for MEA. The ACGIH has a TLV-TWA of 5 mg/m^3 for TEA, 2 mg/m^3 for DEA, and 7.5 mg/m^3 for MEA. The TLV for DEA is based on animal studies that indicated that it may adversely affect the liver, kidneys, skin, and blood. ACGIH has assigned DEA a skin notation indicating that skin contact may contribute to the overall exposure. ACGIH also reports that TEA may induce a contact dermatitis.

Formaldehyde

Formaldehyde is a colorless gas with a strong odor. Exposure can occur through inhalation and skin absorption. The acute effects associated with formaldehyde are irritation of the eyes and respiratory tract, and sensitization of the skin. NIOSH has identified formaldehyde as a suspected human carcinogen and recommends that exposures be reduced to the lowest feasible concentration. NIOSH also lists an REL for formaldehyde of 0.016 ppm for up to a 10-hour TWA exposure. The OSHA PEL is 0.75 ppm as an 8-hour TWA and 2 ppm as a STEL[21]; formaldehyde is an OSHA regulated carcinogen. ACGIH has designated formaldehyde as a suspect human carcinogen and therefore recommends that worker exposure by all routes be carefully controlled to levels "as low as reasonably achievable" below the TLV. ACGIH has set a ceiling limit of 0.3 ppm for formaldehyde.[7] This limit is intended to minimize eye and respiratory tract irritation. ACGIH also considers formaldehyde a sensitizer based on reports of allergic reactions.

Polynuclear Aromatic Hydrocarbons

Polynuclear aromatic hydrocarbons are absorbed by the skin, lungs, and gastrointestinal tract, and are rapidly excreted. There are more than 100 different types of PAHs, generally occurring as a complex mixture. PAHs are formed during the incomplete combustion of coal, oil, gas, and other organic substances. PAHs are present in the air, water, and soil. Background levels in the air are reported to be 0.02-1.2 nanograms per cubic meter (ng/m^3) in rural areas and 0.15-19.3 ng/m^3 in urban areas.[22] Several studies using both chemical analysis and biological assays have reported varying increases in the PAH content of MWFs during use.[23] NIOSH has established an REL-TWA for coal tar products that includes PAHs of 0.1 mg/m^3 for a 10-hour workday, within a 40-hour workweek. OSHA has set a PEL of 0.2 mg/m^3 as an 8-hour TWA for the following PAHs: anthracene, benzo[a]pyrene, phenanthrene, acridine, chryzene, and pyrene.

Ultrafine Particles

UFPs, defined as particles less than 0.1 micrometer in diameter, are often produced by combustion and some chemical reactions.[24] Experimental studies in rats have shown that at equivalent mass doses, insoluble UFPs are more potent than large particles of similar composition in causing pulmonary inflammation and lung tumors.[25] Tobacco smoke, cleaning chemicals, carbon from printers, and pesticides are some sources of UFPs that may be found indoors in non-industrial work environments. Particles may also be introduced into a building through the HVAC outdoor air intake. Unless there is an internal source of UFPs indoors, the particle count should be lower than outdoors due to filtration by the HVAC system's filters. There are no exposure guidelines for UFPs.

Contact Dermatitis

Contact dermatitis is responsible for 90%–95% of all cases of occupational skin disease. Contact dermatitis causes skin inflammation as a result of contact with an inducing agent. A nonimmunogenic reaction to chemical irritants (denoted as irritant contact dermatitis or ICD) accounts for 80% of the cases of contact dermatitis; the remaining 20% are denoted as allergic contact dermatitis or ACD. Any chemical in sufficient concentration and under the right conditions can cause irritation. Only certain chemicals are allergens, substances that trigger allergic reactions, and only a small proportion of people have allergic reactions upon contact with these agents. An allergic reaction that occurs as a single episode indicates that the worker has not been exposed again to the substance that caused the reaction. In sensitized individuals, repeated exposure to a chemical that caused an initial allergic reaction results in repeated allergic reactions that would likely increase in severity. ICD rashes tend to appear in a dose-effect relationship. That is, the greater the exposure, the more severe the rash. An acute ICD rash may appear similar to that seen in ACD, and biopsy slides may even look similar. The most important common factor in both allergic and irritant dermatitis is that avoidance of exposure to the inducing agent(s) is the key to eliminating future symptoms.

RESULTS

Industrial Hygiene Evaluation

Metal Working Fluid Air Samples

MWF concentrations in 18 PBZ samples ranged from 0.22-5.0 mg/m^3, with 15 exceeding the NIOSH REL of 0.40 mg/m^3 of air for the thoracic particulate mass (Table 1). One sample is not included in the table due to pump failure. With one exception, all samples taken in the Roll Grind, Race Grind, and Cone Grind departments were over the NIOSH REL, ranging from 0.43-5.0 mg/m^3. Overall, 77% of the samples had an extractable MWF fluid concentration greater than 85%, suggesting that most of the thoracic particulates collected by the samplers were MWFs.

Metal Working Fluid Bulk Samples

Of the 27 metals for which the MWF bulk samples were analyzed, the only metals known to cause dermatitis are chromium and nickel. Chromium and nickel were detected in the bulk samples. Sample results for chromium and nickel in the bulk samples of MWFs are presented in Table 2. The highest concentrations of ethanolamines in the bulk samples were 12,000 ppm of TEA in the Roll Grind area, 5,300 ppm of MEA in the Race Grind area, and 440 ppm of DEA in the Roll Grind area. These values are within the limits recommended by the Chemical Manufacturers Association (CMA). Bulk samples results for ethanolamines are presented in Table 3. The highest level of endotoxins (1700 EU/ml), was in the Roll Grind MWF system using synthetic fluid, followed by 970 EU/ml in the Turning MWF system, which also uses synthetic fluid. The lowest level, 220 EU/ml, was in the Race Grind MWF system, which uses semi-synthetic fluid. These sample results represent levels in bulk samples of the fluids and not airborne levels. The levels of endotoxins in air will depend on the process and how much of the MWF is aerolized. Table 4 presents the viable levels of bacteria and fungi from the three MWF systems. The culturable bacteria counts ranged from non-detected to 430 CFU/mL. Well-maintained MWF systems should have bacterial concentrations of less than 10^6 CFU/ml.[26] A level of 10 CFU/mL of fungi was found in the MWF servicing the Turning department. A target level of zero fungi is considered optimal. Low concentrations of triazine, which was found in the Turning department's MWF system, can actually stimulate fungal growth.[27] Six bulk samples of MWF (three of the concentrated fluid and three of the diluted fluids used in the MWF systems) were analyzed for triazine. Although NTN Bower had established a policy of not using triazine in their MWFs, 30,000 ppm (3%) was detected in the MWF system supplying the Turning department. Upon notification by NIOSH, the NTN Bower chemist replaced the MWF in the system and notified his supplier.

Carbon Monoxide

The highest instantaneous CO concentrations (86 ppm and 34 ppm) were detected near the Heat Treating furnaces. Although these are not 8-hour averages, if the CO concentrations remained constant throughout the day and workers remained in the area for 8-10 hours, it is possible their levels could exceed the NIOSH REL-TWA of 35 ppm or the OSHA PEL-TWA of 50 ppm. However, these levels were well below the NIOSH ceiling limit of 200 ppm. No CO was detected in other areas of the plant.

Ethanolamines

Sample results for ethanolamines are presented in Table 5. All air sample results for ethanolamines were below applicable occupational exposure limits. The highest concentrations of ethanolamines were detected in the Race Grind area with two samples at 3 ppm of triethanolamine. The ACGIH TLV-TWA for triethanolamine is 5 ppm.

Formaldehyde

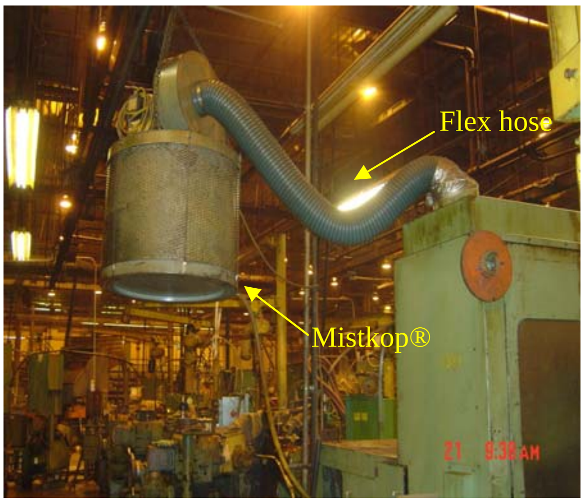
Twenty full-shift PBZ and five area air samples were collected during the 2 days of sampling. Adjusting for the background concentration, only one sample collected in the Turning area (0.06 ppm), exceeded the NIOSH REL-TWA. Sample results for formaldehyde are presented in Table 6.

Polynuclear Aromatic Hydrocarbons

Four personal and three area air samples were collected in the Heat Treating area because this area was thought to have the highest potential for releasing PAHs during oil quenching. All air sample results were below applicable occupational exposure limits.

Ventilation

Most of the metal processing machines at NTN Bower have Mistkop® mist collectors (see Figure 1) but many of the units were not turned on at the time of this evaluation. Some of the flexible hoses on the Mistkop® mist collectors were torn, not connected to the metal processing machine enclosures (see Figure 2), or were placed too far from the location where the mist was being generated.

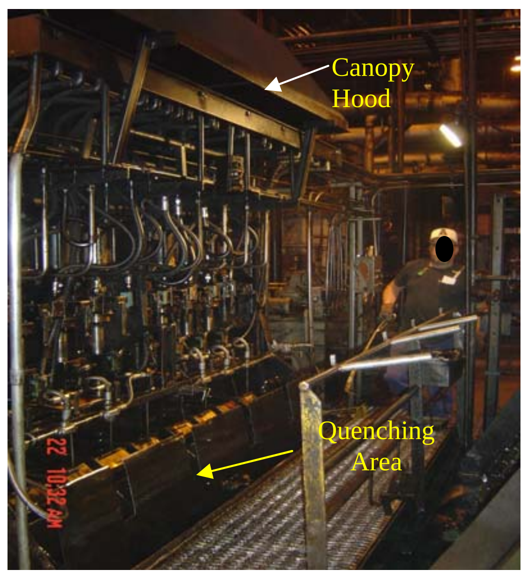


Mistkop Mist Collector
Figure 1

The efficiency of the Mistkop® mist collectors was further diminished if the machine enclosures were missing panels, making it more difficult to keep the enclosures under negative pressure (see Figure 2). Smoke tubes indicated that most enclosures were not under negative pressure. MWF mist was escaping from some machines and puddling on the floor. A ceiling exhaust fan in the Roll Grind area was not in operation.

Metalworking Machine Enclosure
Figure 2

The oil quenching operation was poorly controlled. As the hot bearings entered the oil quenching bath, a cloud of smoke was released that was only partially captured by the canopy hood (see Figure 3) approximately 10 feet away. Smoke could be seen drifting throughout the facility. A ceiling exhaust fan in the Heat Treating department removed most of the smoke but this fan was away from the oil quenching area on the other end of the room.



Oil Quenching
Figure 3

The NTN Bower facility has separate HVAC systems for the administrative areas. NIOSH investigators inspected the HVAC units and noted that they were not providing outside air because the dampers were closed. Oil was noted on the HVAC filters and on air supply diffusers. The ceiling tiles in the administrative areas had yellow stains that appear to have been caused by an accumulation of oil mist.

Ultrafine Particles

The UFP counts in the production area were higher than outdoors (Table 7), likely due to the MWF mist and that personnel were allowed to smoke in the production area. The UFP counts in the administrative areas were higher than outdoors, but much lower than in production areas.

Medical

During the initial site visit, NIOSH medical officers interviewed 46 employees. Of these, 41 had been employed for 20 years or more and 31 had 30 or more years working at the plant. Upon examination 13 employees had rashes, four of which were consistent with contact dermatitis and were on areas of the body that could come into contact with MWFs. Nine had rashes that were unlikely to be work-related, based on the location or characteristics of the rash. Medical records were reviewed for seven employees. One employee's physician responded that there were no records of visits to his office within the time period the employee noted on the medical record release form. Only one was diagnosed with work-related contact dermatitis, and five were diagnosed with non-occupational skin conditions such as cellulitis, psoriasis, rosacea, and tinea corporis. One former employee provided us with photographs of his skin condition, which was not a work-related skin disease.

We identified four employees with skin conditions that could be work related. Five of the eight employees who allowed review of their medical records had multiple non-work related diagnoses for their rashes. Of the three diagnosed with a work-related dermatitis, none of their physicians had identified a particular agent, and none of the workers had undergone further testing to identify the causative agent. The three employees diagnosed with work-related dermatitis all experienced single episodes that resolved with treatments that included antihistamines and corticosteroids.

The HHE request included concern about the impact of new management practices on hand washing frequency. NIOSH investigators cannot make a comparison of current hand washing practices with past hand washing activities because prior investigations did not tally the employees' hand washing frequency, and neither union nor management was able to supply this statistic for prior years. However, the hand washing frequency at the time of our visit did not appear to be insufficient based on responses to our questionnaire, which showed that 39 of 46 employees interviewed washed their hands on average five to eight times or more per work shift. Several employees reported keeping basins by their work stations in order to clean their hands.

Of 46 current employees interviewed, 37 reported using the nitrile gloves provided by the company, while none reported using company-provided coveralls. Thirty-one always wore short sleeves while working, five wore long sleeves and ten wore either, depending on the temperature within the plant. In prior NTN Bower HHEs, NIOSH investigators recommended wearing short sleeved shirts while at work in order to prevent the wicking effect of MWFs. Only two employees reported showering before leaving work. Many commented they did not use the plant's shower facility due to its lack of cleanliness.

NIOSH investigators reviewed the OSHA 300 Logs of Work-Related Injury and Illnesses from 2000-2005. There were three reports of rashes per year from 2000 to 2002, two in 2003, four in 2004, and six in 2005. Most cases of dermatitis reported involved the hands and personnel working in the Race Grind, Roll Grind, and A&I departments.

DISCUSSION

Sample results indicate that workers at NTN Bower were exposed to MWF over the NIOSH REL. The NIOSH REL is intended to prevent 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, HP, or other adverse effects when exposed to MWFs at lower concentrations.[10] There is substantial scientific evidence indicating that workers currently exposed to MWF aerosols have an increased risk of respiratory diseases. These health effects vary based on type of MWF, route of exposure, concentration, and length of exposure.[14]

Occupational safety and health professionals recommend a hierarchy of controls consisting of substituting a hazardous substance or process with one that is less hazardous; using engineering controls such as ventilation systems or enclosures to contain the hazard; and, as a last recourse, providing workers personal protective equipment. The most common method of controlling MWF mists is by enclosing the machines and maintaining them under negative pressure.[10] The Mistkop® mist collectors used at the NTN Bower facility are missing panels or the exhaust ducts are damaged, thus they cannot effectively maintain the negative pressure required to contain the MWF mist. The rate of fluid application influences the generation of MWF mists. The American National Standards Institute Technical report B11 TR2-1997, Mist Control Considerations for the Design, Installation and Use of Machine Tools Using Metalworking Fluids provides directives for minimizing mist and vapor generation. Improvements in engineering controls and work practices can result in a reduction in airborne concentrations of MWFs as evidenced by OSHA's Integrated Management Information System, which compiles air sampling data collected by OSHA inspectors. Before 1980, 63% of the air samples collected contained MWF concentrations greater than 0.5 mg/m^3 (total particulate mass). Between 1991 and 1995 only 27% of the samples collected were over 0.5 mg/m^3.[10]

During the first site visit for this evaluation, NIOSH investigators collected bulk MWF samples for triazine analysis. Triazine is a biocide that is sometimes added to MWF. Triazine can break down into formaldehyde, which is irritating to the eyes, throat, and respiratory system and is classified by NIOSH as a potential occupational carcinogen and by the ACGIH as a suspect human carcinogen. Three percent (or 30,000 ppm) of triazine was detected in the MWF sample from the MWF system servicing the Turning area. Additionally, the highest area sample for formaldehyde (0.06 ppm) was collected on an employee working in this area.

The NIOSH criteria document, Occupational Exposure to Metalworking Fluids, provides guidance on protecting workers from overexposure to MWFs and the handling and maintenance of MWFs. This document contains a model occupational safety and health program that managers can implement for workers exposed to MWFs. The major elements of a comprehensive health and safety program consist of safety and health training, environmental monitoring, hazard prevention and control, and medical monitoring of exposed workers.

Contact dermatitis is responsible for 90%–95% of all cases of occupational skin disease.[28] The fact that most reported cases of dermatitis at NTN Bower involved the hands is an indication that workers may not have been wearing gloves or may have had problems with their gloves being contaminated or MWF getting inside the gloves.

Less common is an allergic reaction that occurs as a single episode, indicating that the worker was not exposed again to the substance that caused the reaction. In a sensitized individuals, repeated exposure to a chemical that caused an initial allergic reaction results in repeated allergic reactions that would likely increase in severity. Irritant contact dermatitis (ICD) rashes tend to appear in a dose-effect relationship. That is, the greater the exposure, the more severe the rash. Neither pattern was documented in the medical records we reviewed, so it was difficult to determine which type of response (allergic vs. ICD) was being observed. An acute ICD rash may appear similar to that seen in ACD, and biopsy slides may even look similar. In cases of chronic exposures resulting from ICD, the skin areas involved may become thickened, red, and cracked. The information contained in the medical records was not sufficient to differentiate between ICD and ACD. There was also no record that any further testing such as patch testing was done to identify the irritant/allergen. The most important common factor in both allergic and irritant dermatitis is that avoidance of exposure to the inducing agent(s) is the key to eliminating future symptoms so identifying the agent is crucial. However, a significant percentage of those with ACD may become sensitized and a will continue to have symptoms despite removal from the initial allergen. As documented in the prior NIOSH HHEs, a number of agents used at NTN Bower are capable of causing irritant and allergic contact dermatitis. These include the metalworking fluids, oils, additives, contaminants, or degradation products formed through heat or bacterial action.

The requestor's main concern involved the impact of new management practices on hand washing frequency. Based on interviews it appears that workers are able to wash their hands as often as needed. Employees should wash their hands or any part of their body that comes in contact with MWF as soon as possible to prevent future skin reactions by reducing contact time with potential irritants and allergens in the MWFs. However, employees need to be aware that excessive hand washing by itself may dry out the skin and result in dermatitis.

The specific agent(s) causing the cases of dermatitis among employees at the NTN Bower plant remain unclear. The presence of detectable amounts of metals, including nickel and chromium, in bulk cutting fluid samples was not unexpected. As reported in previous NIOSH investigations at NTN Bower, metals are among a number of different substances used at this plant that are potential irritants and allergens. Aside from the MWF itself, other potential agents in the plant that can cause dermatitis include other unidentified contaminants, additives, or degradation products formed through heat or bacterial action.

CONCLUSIONS

NIOSH investigators conclude that MWF exposures at NTN Bower posed a hazard to employees. The ventilation systems used to control MWF mist were ineffective and needed maintenance. NIOSH medical officers identified four employees with skin conditions that could be work related. Employees were allowed to wash their hands when necessary.

RECOMMENDATIONS

1. Replace missing panels on metal processing machine enclosures and close open panels on machines to help contain MWF mist. Repair damaged flexible ducts. Employees should also make sure that exhaust ventilation systems are turned on while working on metal processing machines. After these engineering controls modifications are made, additional sampling for MWFs should be conducted.

2. Evaluate the HVAC system to determine if MWF is entering the system and being transported to administrative work areas. Because exhaust vents for the production areas and the HVAC air handling units are on the roof, exhausted contaminants may drift towards the air handling units and subsequently entrained into the HVAC. Set outside air dampers to settings recommended by the HVAC manufacturer. Providing clean outside air to the production area will help reduce the concentration of MWFs.

3. Repair the ceiling exhaust fan in the Roll Grind department.

4. Install another ceiling exhaust fan in the Heat Treatment Department, near the oil quenching process.

5. Install a CO monitor with an alarm in the Heat Treatment area.

6. Do not use MWFs that contain triazine.

7. Apply a non-skid oil-resistant surface material to walking surfaces.

8. Until you can reduce airborne levels of MWFs below the NIOSH REL, you should implement a respiratory protection program for production workers. At a minimum, provide employees with filtering facepiece (disposable) respirators equipped with any P or R series particulate filter (P95, P99, P100, R95, R99, or R100). Use of respiratory protection requires that you establish a comprehensive respiratory protection program as outlined in the NIOSH Respirator Decision Logic, and the OSHA Respiratory Protection Standard, 29 CFR 1910.134. OSHA requires that employees receive a medical evaluation and fit testing prior to using respirators and that they receive annual training on how to use the respirator; its limitations; and how to clean, repair, maintain, and inspect the respirator.

9. Provide workers training on the use and care of chemical protective gloves when handling MWFs.

10. Smoking, eating, and drinking in metalworking areas should not be allowed. A no smoking policy should be established as smoking may exacerbate the respiratory effects of MWFs.

11. Keep surfaces and machines clean of MWFs to minimize skin contact.

12. Eliminate puddles of cutting fluids or oils from overflowing tanks or other equipment.

13. Educate all workers about health effects of exposure to cutting fluids, oils, and additives.

14. Provide periodic medical monitoring for workers. New employees should be provided a preplacement examination before they are exposed to MWF mists. At a minimum, the examination should consist of a questionnaire to obtain medical history (history of asthma, other serious respiratory diseases, and skin conditions). Baseline spirometry may be useful for comparison with subsequent tests. Periodic examinations should consist of a questionnaire that ascertains the presence or absence of symptoms indicative of possible respiratory conditions (shortness of breath, wheezing, chest tightness, or cough). The periodic examinations should also include a skin exam and spirometric testing. Workers identified as having respiratory problems or skin conditions that may be related to exposure to MWF aerosols should receive a more detailed evaluation. Consult with an occupational health physician to develop a program that meets your needs.

15. Provide training regarding the need to clean skin periodically with gentle soap and water to remove MWFs. While frequent hand washing will reduce contact time of MWFs with the skin, the training address the fact that excessive hand washing or harsh soaps can also cause dermatitis.

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Table 1
HETA 2004-0399-3007
MWFs Thoracic Samples Results
NTN Bower, Hamilton, Alabama

Sample #	Sample Date	Sample Type	Location	MWF Type	Sample Time (min.)	Sample Volume (L)	Thoracic Particulates Mass (mg/m^3)	% Extracted MWF Mass
B05-70	6/21/05	Personal	A&I	Not Used	470	752	**0.47**	85.7
B05-41	6/21/05	Personal	A&I	Not Used	441	701	**0.54**	92.1
B05-44	6/22/05	Personal	A&I	Not Used	445	703	**0.41**	89.7
B05-45	6/22/05	Personal	A&I	Not Used	451	722	**0.50**	88.9
B05-62	6/22/05	Personal	Cone Grind	Semi-synthetic	455	701	**1.00**	94.3
B05-46	6/22/05	Area	Cone Grind	Semi-synthetic	415	664	**1.01**	92.5
B05-52	6/22/05	Personal	Cone Grind	Semi-synthetic	391	618	**0.74**	91.3
B05-63	6/21/05	Personal	Maintenance	Not Used	352	556	**0.61**	97.1
B05-54	6/22/05	Personal	Maintenance	Not Used	420	672	0.22	97.1
B05-58	6/21/05	Personal	Race Grind	Semi-synthetic	474	735	**1.14**	89.3
B05-66	6/21/05	Personal	Race Grind	Semi-synthetic	471	735	**0.91**	88.1
B05-69	6/21/05	Personal	Race Grind	Semi-synthetic	69	110	**5.00**	92.7
B05-50	6/21/05	Area	Race Grind	Semi-synthetic	413	652	**1.01**	95.5
B05-61	6/22/05	Personal	Race Grind	Semi-synthetic	456	711	**1.01**	93.1
B05-68	6/21/05	Personal	Roll Grind	Synthetic	415	656	0.29	63.2
B05-59	6/21/05	Area	Roll Grind	Synthetic	88	141	**1.35**	73.7
B05-53	6/22/05	Personal	Roll Grind	Synthetic	401	630	**0.43**	88.9
B05-60	6/22/05	Area	Roll Grind	Synthetic	431	659	**1.44**	95.8
B05-51	6/22/05	Personal	Roll Grind	Synthetic	408	641	**0.90**	87.9
B05-47	6/21/05	Personal	Tool & Die	Synthetic	401	642	**0.81**	42.3
B05-32	6/22/05	Personal	Tool & Die	Synthetic	463	741	**0.51**	76.3
B05-57	6/21/05	Personal	Turning	Synthetic	394	630	0.25	0.0
NIOSH REL-TWA							**0.40**	

Results in bold indicate the concentration of MWF was over the NIOSH REL of 0.40 mg/m^3. A lower percentage of extracted MWF mass indicates the presence of particles other than MWF.

Table 2
HETA 2004-0399-3007
Metals in Bulk Samples of MWF
NTN Bower, Hamilton, Alabama

Analyte*	System	MWF Type	Concentration µg/L (PPM)
Nickel	Roll Grind	Synthetic	860
Chromium	Roll Grind	Synthetic	69
Nickel	Race Grind	Semi-synthetic	340
Chromium	Race Grind	Semi-synthetic	96
Nickel	Turning	Synthetic	330
Chromium	Turning	Synthetic	400

***** There were other metals present in the bulk samples. Chromium and nickel are reported because they are skin sensitizers.

Table 3
HETA 2004-0399-3007
Ethanolamines Bulk Sample Results
NTN Bower, Hamilton, Alabama

Analyte	System	MWF Type	Concentration µg/g (PPM)
Triethanolamine	Roll Grind	Synthetic	12000
Diethanolamine	Roll Grind	Synthetic	440
Monoethanolamine	Roll Grind	Synthetic	3.9
Triethanolamine	Race Grind	Semi-synthetic	2100
Diethanolamine	Race Grind	Semi-synthetic	150
Monoethanolamine	Race Grind	Semi-synthetic	5300
Triethanolamine	Turning	Synthetic	3600
Diethanolamine	Turning	Synthetic	Trace
Monoethanolamine	Turning	Synthetic	3300

Table 4
HETA 2004-0399-3007
Viable Bacteria and Fungi Sample Results
NTN Bower, Hamilton, Alabama
Samples Collected Dec 8, 2004

Bacteria	**MWF System CFU/ml***		
	1A[1]	**1B**[2]	**1C**[3]
Gram-negative Bacteria	260	30	0
Gram-positive Bacteria	170	70	0
Total Bacteria	430	100	0
Fungi Fusarium species	0	0	10

*CFU/ml - Colony forming units per milliliter
[1] Synthetic MWF fluid from Roll Grind system
[2] Semi-synthetic MWF fluid from the Race Grind system
[3] Synthetic MWF from the Turning system

Table 5
HETA 2004-0399-3007
Ethanolamines Sample Results
NTN Bower, Hamilton, Alabama
June 21-22, 2005

Sample #	Sample Date	Sample Type	Location	Sample Time (min.)	Sample Volume (L)	Concentration mg/m^3		
						MEA	DEA	TEA
05N04903	6/21/05	Area	Training Room	457	457	ND	ND	Trace
05N04904	6/21/05	Area	Assembly & Inspection	414	414	ND	0.008	0.867
05N04905	6/21/05	Area	Race Grind	411	411	0.022	Trace	3.160
05N04906	6/21/05	Area	Turning	404	404	0.047	Trace	Trace
05N04907	6/21/05	Area	Retainer	401	401	ND	Trace	Trace
05N04908	6/21/05	Area	Roll Grind	332	332	0.133	0.145	2.320
05N05009	6/22/05	Area	Turning	410	406	0.067	Trace	Trace
05N05010	6/22/05	Area	Training Room	418	415	ND	ND	Trace
05N05011	6/22/05	Area	Retainer	423	415	Trace	Trace	0.128
05N05012	6/22/05	Area	A&I	418	414	ND	0.009	1.015
05N05013	6/22/05	Area	Sample Lost	N/A	N/A	N/A	N/A	N/A
05N05014	6/22/05	Area	Race Grind	417	413	0.023	Trace	3.148
NIOSH REL-TWA						**7.5**	**15**	**None**
OSHA PEL-TWA						**7.5**	**None**	**None**
ACGIH TLV-TWA						**7.5**	**2**	**5**
MDC						**0.003**	**0.002**	**0.049**
MQC						**0.007**	**0.007**	**0.123**

MDC = MDC is the minimum detectable concentration for a given a sample volume. The MDC was calculated by dividing the LOD for the sampling method by the average sample volume.
MQC = MQC is the minimum quantifiable concentration for a given sample volume. The MQC was calculated by dividing the LOQ for the sampling method by the average sample volume.
Trace = Sample result was between the MDC and MQG.
MEA = Monoethanolamine
DEA = Diethanolamine
TEA = Triethanolamine
ND = not detected

Table 6
HETA 2004-0399-3007
Formaldehyde Sample Results
NTN Bower, Hamilton, Alabama

Sample #	Sample Date	Sample Type	Location	Sample Time (min.)	Sample Volume (L)	Concentration PPM
769364	6/21/05	Personal	Heat Treating	483	13.8	**0.02**
769354	6/21/05	Personal	Turning	475	13.6	**0.06**
769373	6/21/05	Personal	Race Grind	479	13.7	Trace
769338	6/21/05	Personal	A & I	469	13.4	Trace
769335	6/21/05	Personal	Surface Grind	472	13.5	Trace
769372	6/21/05	Personal	Roll Grind	464	13.3	Trace
769369	6/21/05	Area	Training Room	455	13.0	Trace
769330	6/21/05	Personal	A & I	444	12.7	Trace
769344	6/21/05	Personal	Roll Grind	419	12.0	ND
769371	6/21/05	Personal	Tool & Die	404	11.6	ND
770721	6/21/05	Personal	Heat Treating	408	11.7	Trace
770769	6/21/05	Personal	Maintenance	355	10.2	**0.02**
770783	6/22/05	Personal	Tool & Die	464	13.3	ND
770787	6/22/05	Area	Training Room	471	13.5	ND
770788	6/22/05	Area	Office	468	13.4	ND
770736	6/22/05	Area	Outdoors	464	13.3	Trace
770727	6/22/05	Personal	Cone Grind	458	13.1	**0.02**
770730	6/22/05	Personal	Race Grind	455	13.0	**0.02**
769365	6/22/05	Personal	Maintenance	432	12.4	Trace
769376	6/22/05	Personal	A & I	448	12.8	Trace
769420	6/22/05	Personal	A & I	450	12.9	ND
769421	6/22/05	Personal	Heat Treating	434	12.4	Trace
769379	6/22/05	Personal	Heat Treating	421	12.0	Trace
769411	6/22/05	Personal	Roll Grind	402	11.5	Trace
769422	6/22/05	Area	Roll Grind	426	12.2	Trace
NIOSH REL-TWA						**0.016 ppm**
OSHA PEL-TWA						**0.75 ppm**

Sample results in **Bold** were over the NIOSH REL-TWA

MDC = 0.006 ppm. MDC is the minimum detectable concentration for a given a sample volume. The MDC was calculated by dividing the LOD for the sampling method by the average sample volume.
MQC = 0.019 ppm. MQC is the minimum quantifiable concentration for a given sample volume. The MQC was calculated by dividing the LOQ for the sampling method by the average sample volume.
Trace = Sample result was between the MDC and MQG.
The level of formaldehyde outdoors was 0.012 ppm. If that value is considered background and subtracted from the sample results, only the sample collected in the Turning area would be over the NIOSH REL.
ND = not detected

Table 7
HETA 2004-0399-3007
Ultrafine Particle Counts
NTN Bower, Hamilton, Alabama

Area	Particles/cubic centimeter of air
Outdoor	5000
Training Room	33,000
Cafeteria	24,000
Office Area	31,000
Roll Grind	155,000-250,000
Turning	135,000-157,000
Heat Treating	310,000-428,000
Cone Grind	118,000
OD Grind	121,000

Note: There are no exposure standards for levels of ultrafine particles. The particle counts listed above provide an indication of the presence of indoor air pollutants. The outdoor reading is used as a baseline and it is expected that the particle count indoors will be less due to air filtration by the HVAC. A higher number indicates an internal source of pollution.

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