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INTRODUCTION

In response to an employee request for a health hazard evaluation (HHE) received on May 29, 1998, the National Institute for Occupational Safety and Health (NIOSH) conducted a site visit at the R.H. Sheppard Co., Inc., facility in Hanover, Pennsylvania. The request asked NIOSH to determine if reported worker health problems were associated with exposure to contaminants in Plant #1 and Department #109, at this automotive power steering unit manufacturer. The reported health problems included allergic reactions, respiratory infections, and skin and eye irritation. Potential exposures identified in the request included metalworking fluids (MWFs), naphtha, and metal dust from grinding. Inadequate ventilation was also noted as a concern.

On August 11, 1998, NIOSH investigators conducted a site visit at the R.H. Sheppard facility. During the site visit, work practices and the use of personal protective equipment in Department #109 were reviewed. Air sampling was conducted to evaluate worker exposure to MWFs and petroleum naphtha solvent. A questionnaire survey was conducted among all Department #109 workers to obtain information on reported health problems.

An interim report describing the actions taken by NIOSH during this site visit, and providing preliminary findings and recommendations, was issued on September 2, 1998.

BACKGROUND

Facility

The R.H. Sheppard Company in Hanover, Pennsylvania, has been in business at this location since 1935 and manufactures power steering gears for the heavy truck industry. Over 850 non–union employees work at the facility, which comprises approximately 500,000 square feet of office and manufacturing space. There are a number of different manufacturing processes, including 2 foundries, at the facility.

In Plant #1, raw material (roll steel) is delivered for machining, shaping, grinding, abrasive blasting (shot peen) of finished parts, inspection, assembly and test. There are 23 separate departments and approximately 200 workers (120 day shift, 80 night shift) in Plant #1. In most areas there are 2 shifts (6:00 a.m. to 5:00 p.m., 5:00 p.m. to 3:30 a.m.), with single 12 hour shifts on Friday, Saturday, and Sunday, although this will change depending on work demand. Plant #1 is a single–story building without air–conditioning. There are ceiling and comfort fans throughout the factory, and the roof is sloped with roof–mounted windows that can be opened during the hotter times of the year.

A safety and health committee that includes employee representation and meets on a monthly basis has been established for Plant #1 and other areas. New employee safety orientation is provided by the safety and health department. A first aid room is available in each plant, and supervisors are required to be first aid and CPR certified.

Department #109

There are seven workstations with 12 Machine Operators (8 day shift, 4 night shift) in Department #109. In this department, stock alloy (primarily carbon steel) is machined via a number of different mechanisms. Processes in Department #109 include lathing, milling, shaping, gear hobbing (imparting a groove and spline shape on the metal part), de–burring, de–greasing, heat treating, and inspection. Two types of MWF are used: straight oil (Cut Max 451) and a semisynthetic fluid (HoCut 715). There have been no process or machine changes in Department #109 for several years. In Department #109, a Machine Operator will generally produce 200–220 parts per shift. Most of the metalworking machines in use are 1970's vintage, although some were manufactured in the 1940's.

The semisynthetic fluid is distributed from a 16,000 gallon central system located in the basement of Plant #1. Fluid is piped directly to the machine and then returned for filtration prior to redistribution; there are no holding sumps at the machines. Biocides are added via an automated dosing system on a daily basis. Quality control of the MWF entails collecting samples every Monday for pH, MWF concentration, bacteria, and tramp oil. An upper control limit of 10^6 colonies per milliliter (CFU/ml) has been established by the company. The target pH range is 8.5–8.6 and the target MWF concentration is 7–10% with water. The semisynthetic concentrate contains 10–30% mineral oil. According to the engineer responsible for this system, the system is cleaned every 6 months. The central distribution system has been in place since 1985. The straight oil (>60% mineral oil) is added directly at each machine by the Machine Operator for those systems using this type of MWF.

A recycled petroleum naphtha is used for cleaning and degreasing parts at most stations. The naphtha is obtained from open 5–gallon containers at the workstations and is replenished daily by a Material Mover who services all departments in Plant #1. During the NIOSH site visit, a hot water–based detergent was being tested at one workstation as a possible naphtha replacement. De–burring is conducted in two ventilated (downdraft) hoods at the Sector Shaft workstation. A hand–held tool is used at this station to remove rough edges from the machined parts.

Each Machine Operator in Department #109 is required to spend the last 10–15 minutes of the work shift for station clean–up; this entails wiping down the machine and sweeping the floor. Metal shavings from the machining operations are generally removed by the night shift (shoveled into a hopper). Workers obtain personal protective equipment (PPE), such as gloves and protective eyewear, from a central stores in Plant

METHODS

On August 11, 1998, an opening conference was held with management and employee representatives to provide information about NIOSH and the HHE program, and to discuss the HHE request. Copies of a recent NIOSH Criteria Document, Occupational Exposure to Metalworking Fluids, were distributed and discussed during this meeting.[1] Following the opening meeting, a walkthrough inspection was conducted in Department #109 to review the production process and operational parameters regarding the use of MWFs, and develop an exposure assessment strategy. During the walkthrough inspection, work practices, and the use of PPE were reviewed and observed.

Industrial Hygiene Sampling

Metal Working Fluid

On August 12, 1998, full–shift personal breathing zone (PBZ) air samples for MWF (Cut–Max 451 straight oil and HoCut 715 semisynthetic fluid) were collected on pre–weighed 37–millimeter (mm) polytetrafluoroethylene (PTFE – Zefluor®) filters using battery–powered Gilian air pumps. All samples were collected with a size–selective device (a BGI cyclone, Model GK2–69, BGI Incorporated) to collect the thoracic particulate fraction of MWF. The BGI thoracic sampler captures a mass–median (50%) particulate size of 10 microns aerodynamic diameter. This particle size range represents particles that are deposited within the lung airways and the gas–exchange region. Based on unpublished NIOSH studies, a flow rate of 1.6 liters per minute (L/min) was used because it was found to more accurately collect the thoracic particle size range than the manufacturer–recommended 1.8 L/min. All air sampling pumps were pre– and post–calibrated using a BIOS Dry–Cal Lite primary standard to verify flow rate.

PBZ samples for MWF were collected during the day shift (6:00 a.m. – 5:00 p.m.) at the following workstations in Department #109: Sector Shaft (both stations), Output Shafts (Turning), Output Hobb, OD Grinding (both stations), Landis and Browne & Sharpe Grinders. Each station consisted of 2–3 grinding machines operated by one Machine Operator. Straight oil MWF (Cut Max 451) is used at the Sector Shaft and Output Hobb workstations; the semisynthetic MWF (HoCut 715) is used at the other workstations.

The samples and blanks were shipped to the NIOSH contract laboratory (Data–Chem, Salt Lake City, Utah) for analysis by a provisional American Society for Testing and Materials (ASTM) E34.50 Committee method, modified by NIOSH to separate MWF from co–sampled material.[2] This method removes interferences from contaminating materials, such as environmental dusts and metal particles. In the laboratory, the filters were weighed on a microbalance and extracted using a solvent blend (the solvent blend was selected from solubility tests on the respective MWF). The difference in the weight of the filter before and after sample collection yielded the total particulate mass sampled. The difference in the weight of the filter before and after extraction was the weight of the MWF.

Bulk samples of each MWF (unused) solution (Cut–Max 451 straight oil and HoCut 715 semisynthetic fluid) were collected and shipped separately to the NIOSH contract laboratory. Samples were collected in clean, unused containers.

Naphtha

Full–shift PBZ air samples for petroleum naphtha were collected at all workstations using this solvent (Sector Shaft [both stations], Output Hobb, OD Grinding [one station]). A 2.5 hour PBZ sample was also collected on the Material Mover during the replacement and replenishment of naphtha containers in Plant #1. The samples were collected with SKC model Pocket Pump™ low–flow sampling pumps. Nominal flow rates of 50 cubic centimeters per minute (cc/min) were used to collect the samples. All pumps were pre– and post–calibrated with the BIOS Dry–Cal Lite.

Standard charcoal tubes (100 milligrams [mg] front section/50 mg backup) were used to collect the samples. Because the petroleum naphtha used is a recycled product, a bulk sample of the naphtha was obtained and analyzed by gas chromatography–mass spectroscopy (GC–MS) at the NIOSH analytical laboratory (Cincinnati, Ohio) to identify the primary constituents. After collection, the samples and blanks were placed in a refrigerator until the GC–MS analysis was available, after which they were shipped via overnight delivery to the NIOSH contract laboratory. The major compounds identified in the bulk sample (toluene, ethyl benzene, mixed xylenes) were selected for quantitative analysis on the charcoal tubes.

Metals

Full–shift area samples for analysis of several metallic elements were collected at the de–burring hoods in the Sector Shaft grinding stations. At this station, rough edges and imperfections on the machined parts are removed by a small hand–held grinder or rasp. The samples were collected with Gilian air sampling pumps calibrated to a flow rate of 2 L/min. The samples were collected on 37 mm mixed–cellulose ester filters in three–piece cassettes in the closed–face mode. Following collection, the samples and blanks were shipped to the NIOSH contract laboratory for analysis of the following elements: nickel, iron, molybdenum, manganese, chromium, and vanadium.

pH

The pH of the semisynthetic MWF at each machine using the HoCut 715 coolant was measured with pHydrion Insta–Check paper (Micro Essential Laboratory, Brooklyn, New York). (The wet pH paper is compared to a color chart to determine the pH of the tested material.)

Medical

A self–administered questionnaire was provided to all 13 employees in Department #109; this included workers on both the first (6:00 a.m. to 5:00 p.m.) and second shifts (5:00 p.m. to 3:30 a.m.). The questionnaire addressed symptoms and medical and occupational history. In addition, the Occupational Safety and Health Administration Log and Summary of Occupational Injuries and Illnesses (OSHA 200 logs), for 1994–1995, were reviewed.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 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 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),[3] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[4] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[5] NIOSH encourages employers to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard.

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 short–term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short–term.

Metal Working Fluids

MWFs are used for lubrication, cooling, and removal of metal chips during machining operations. There are four major types of MWFs – straight oils, water–soluble oils, semisynthetic, and synthetic – and the evaluation of the potential health hazard from exposure to MWFs would vary depending on which type is being used. Straight oils (neat oils) are solvent–refined petroleum oils not designed to be mixed with water. The other three types are water–based MWFs. Semisynthetic MWFs contain small amounts of severely refined lubricant–base oil (5–30% in concentrate), emulsifiers, and water. Acute health effects that have been associated with exposure to MWFs include dermatitis and respiratory health effects. Epidemiologic studies have also found a number of types of cancer to be associated with past MWF exposure. These health effects, and other information relevant to occupational exposure to MWF, are discussed further in the NIOSH booklet, "What You Need to Know About Occupational Exposure to Metal Working Fluids," and also in the recently published NIOSH criteria document, "Occupational Exposure to Metalworking Fluid."[6,1]

To prevent or greatly reduce the risk of adverse health effects due to MWF exposure, NIOSH recommends that airborne exposures to MWF aerosols be limited to 0.5 milligrams per cubic meter air (mg/m^3) for total particulate mass as a TWA for up to 10 hours per day during a 40–hour week.[1] This concentration is approximately equal to 0.4 mg/m^3 as thoracic particulate mass, and is used to approximate the thoracic concentration.[*] This NIOSH REL was established primarily to eliminate or reduce respiratory health effects; other considerations included sampling and analytical feasibility, the selection of an index for assessing MWF exposure, the applicability of the REL to all types of MWFs, and technological feasibility. Concentrations of MWFs should be kept below the REL where possible because some workers have developed work–related asthma, hypersensitivity pneumonitis, or other adverse respiratory health effects when exposed to MWF concentrations less than the REL. Neither OSHA or ACGIH have established exposure criteria for all MWF aerosol, although both have an 8–hour TWA limit of 5 mg/m^3 for mineral oil mist. The ACGIH has also proposed a TLV of 0.005 mg/m3 for the sum total of 15 polynuclear aromatic hydrocarbons (in mineral oil mist) listed as carcinogens by the U.S. National Toxicology Program.[4]

In this evaluation, the extracted MWF concentration was also determined from the air samples. NIOSH is evaluating this extracted MWF method; currently, little or no evidence suggests that measuring "extractable" MWF mass is superior to total particulate mass measurement as a predictor of adverse health effects from MWF aerosols. However, extractable MWF aerosol measurement may be helpful in environments where there are simultaneous exposures to other particulate.[1]

In addition to the REL, NIOSH recommends that a comprehensive safety and health program be developed and implemented as part of the employer's management system.[1] The major elements of a comprehensive, effective safety and health program are (1) safety and health training, (2) worksite analysis, (3) hazard prevention and control, and (4) medical monitoring of exposed workers.

Naphtha/Organic Solvents

Petroleum naphtha is comprised mainly of aliphatic hydrocarbons.[7] Since naphthas are mixtures of aliphatic hydrocarbons, the evaluation criteria are based upon the most commonly available varieties (petroleum ether, rubber solvent, varnish makers' and painters' naphtha, mineral spirits, and Stoddard solvents). The NIOSH REL for petroleum distillates (naphtha) is 350 mg/m^3 of air as a TWA exposure.[3] In addition, a ceiling concentration limit (15 minutes duration) of 1800 mg/m^3 is stipulated.

[*] *Thoracic particulate mass is the portion of MWF aerosol that penetrates beyond the larynx and may be deposited in the lung airways and/or gas exchange region.*

Effects from exposure to these organic solvents are primarily acute, unless significant amounts of substances, such as benzene, that have chronic toxicity are present. Overexposure to refined petroleum solvents (i.e., mineral spirits, Stoddard solvent) and many other organic solvents can cause dry throat, burning or tearing of the eyes, central nervous system depression, mild headaches, dizziness, respiratory irritation, dermatitis, and possible effects on the liver, kidney or other organs.[8,9,10] Exposure to organic solvents such as naphtha can occur through inhalation of the vapors, skin contact with the liquid, or ingestion. As many organic solvents have relatively high vapor pressures and readily evaporate, inhalation of vapors is considered a primary route of exposure. Many industrial solvents are primary irritants and can cause defatting of the skin and dermatitis. Solvents are among the leading causes of occupational skin disease.[10] The ability to detect the presence of a solvent by the sense of smell will vary widely, depending on the specific substance and individual sensitivity. Substances are considered to have good warning properties if an average person with normal sensory perception can detect the presence of the chemical at a level below the recommended exposure limit. The following table summarizes the principle health effects associated with specific solvents identified in the naphtha used at R.H. Sheppard, and lists the NIOSH RELs and odor detection thresholds for these compounds.

Chemical	NIOSH REL	Odor Threshold & Description[11]	Principle Health Effects[3,12]
toluene	100 TWA 150 ppm STEL	1.6 ppm: sour, burnt	eye/respiratory irritation, fatigue, headache, central nervous system effects
xylene	100 TWA 150 ppm STEL	20 ppm: sweet	eye/respiratory irritation, narcosis, headache, skin effects
petroleum distillates (naphtha)	350 mg/m3 TWA		Eye, nose, throat irritation; dermatitis, nervous system effects
ethyl benzene	100 TWA 125 ppm STEL	0.6 ppm, oily	eye, skin, upper respiratory irritation

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

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

$$\text{Combined REL} = \frac{C_1}{REL_1} + \frac{C_2}{REL_2} + \ldots \frac{C_n}{REL_n}$$

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

If the sum of the above fractions exceed unity, the combined REL is considered to be exceeded.

Metals

Metals comprise the majority of the known elements and have widespread natural occurrence in the environment. Aluminum, for example, is the third most abundant element in the earths' crust.[13] Metals have a wide range of properties, uses, and toxicity. Some metals are essential for life, while others have no known biologic function. Other metals are capable of producing disease. Some metals that are essential nutrients can be toxic at higher concentrations. Allowable daily intake (food), maximum contaminant level (drinking water), and industrial exposure (e.g., NIOSH RELs) guidelines and regulations have been established for a number of metals.

Inhalation is usually the exposure pathway of concern in industry. However, skin contact with some metals (e.g., nickel, beryllium, arsenic) can cause skin effects, or, if the metal is in a certain form (e.g., alkyl lead), it can be absorbed through the skin.[14] The toxicity of a metal, and the mode of toxicity, are influenced significantly by its chemical state with organic compounds having different effects than inorganic compounds. The elemental form of a metal, for instance, is generally less toxic than other compounds, although the elemental forms of some metals (e.g., mercury) are converted to more toxic states.[14] Metal hydrides (e.g. arsine) are generally far more acutely toxic than other forms. Soluble salts of metals are usually more readily absorbed and are possibly more hazardous.

Despite these differences, there are some toxicologic similarities among metals. Many absorbed metals will accumulate in the kidneys and the bones, and many have long biologic half–lives.[13] Inhalation of high concentrations of metals is irritating and may result in severe respiratory tract damage, including bronchitis, chemical pneumonitis, and pulmonary edema.

RESULTS

Industrial Hygiene

Workplace Observations

Housekeeping was fair in most areas inspected. Aisle ways were clear, however there was some build–up of clutter at some workstations. Evidence of oil and naphtha spills was present in Department #109; oil absorbent was present on the floor at most machining stations and is routinely used by workers for clean–up of minor spills.

The use of protective gloves when handling chemicals was sporadic throughout Department #109. Different glove types are provided, although the Stanisolv® nitrile glove is the most commonly used type. Many of the Machine Operators either did not use gloves when dispensing/using solvents or handling contaminated parts, or used them improperly. Gloves in poor condition were observed in several areas. The Material Mover was wearing an improper glove type (canvas – not solvent resistant) that had become soaked with naphtha, resulting in continuous skin contact with this solvent.

Direct, intentional, and prolonged contact with the naphtha was observed at several stations as some Machine Operators routinely cleaned their hands in this solvent. In some areas, gloves were re–used repeatedly without proper decontamination and inspection, which may result in additional exposure. Informal discussions with workers indicated a general lack of awareness for the need to prevent skin contact with MWF and naphtha.

Smoking, as well as food and beverage consumption is permitted in work areas. Compressed air is routinely used to clean off machinery and parts after grinding and degreasing. Department #109 employees are required to wear safety shoes and glasses.

Hearing protection, aprons and barrier creams (SBS 44® protective cream, Clear Shield® spray on) are also provided, but their use is optional. A program to provide work uniforms has been established, but most workers choose to wear their own clothing.

The use of naphtha in open containers at many of the machining workstations presents a potential fire–hazard. The material safety data sheet (MSDS) for this solvent indicates a flash point of 50°F. The flash point is the lowest temperature at which a liquid gives off enough vapor to form an ignitable mixture with air and produce a flame when a source of ignition is present. In addition to potential spark–producing activities (grinding, de–burring, electrical switches on machinery) at the machining workstations, smoking is permitted on the shop floor. As noted above, the handling and use of this flammable solvent is not well controlled. Volatile solvents in open containers will also result in considerable evaporative loss. At one workstation, a hot–water detergent–based degreasing fluid is being used. R.H. Sheppard representatives indicated that the use of naphtha will be phased out and replaced by the water–based material.

Some of the grinding machines (Fellows, Matrix) are equipped with local exhaust ventilation (LEV) and mist–eliminators to control emissions during the machining process. The other machines inspected (Norton, Barber–Coleman, Warner and Swassey, Landis, Browne and Sharp) in Department #109 were not equipped with LEV. Observation of the Fellows and Matrix machines suggest that the ventilation controls are not optimal, and that MWF mist generated during grinding is not fully captured. R.H. Sheppard management indicated that engineering consultants had been obtained to design appropriate LEV systems for the grinding machines.

The pH of the water–based semisynthetic MWF, which is diluted with water to a 7–10% solution prior to use, was found to be between 9 and 10 (alkaline) at all machines in Department #109 using this coolant. Quality control specifications have been established to ensure appropriate maintenance of the MWF and the central delivery system (vacuum filtration, pH, biocide, weekly microbial check, tramp oil, and concentration). The absence of sumps at machines using the semisynthetic fluid (continuous recirculation) reduces the potential for stagnant accumulation of MWF, which could foster excess microbial growth and spoilage. Some workers indicated that occasionally odors from the MWF are noted, and it is likely these are from pools of fluid that have spilled at the machines and were not cleaned up properly.

Air Sampling Results

The results of the air sampling are shown in Table 1 (MWF) and Table 2 (Solvents). On the day of the monitoring, R.H. Sheppard personnel indicated that due to business demand, production activity was higher than normal. PBZ samples for MWFs were collected from seven Machine Operators; four operators worked with the semisynthetic MWF and three worked with the straight oil MWF. Two samples, both from employees using the semisynthetic MWF on Norton/Matrix grinding machines exceeded the NIOSH REL of 0.4 mg/m^3 for the thoracic fraction. These samples showed full–shift exposures of 0.61 mg/m^3 and 0.68 mg/m^3. Samples collected at the other two semisynthetic MWF stations were below the NIOSH REL (0.25 mg/m^3 and 0.27 mg/m^3). All of the samples collected from Machine Operators working with straight oil MWF were below the analytical limit of detection (LOD).

Because the gravimetric analytical technique is non–specific, it is susceptible to interference from non–MWF contaminants such as dusts. As such, methods to determine the component of the total particulate sample that can be attributed to MWF are useful. The ratio of the extracted–MWF (EMWF) concentration to the total particulate (TP) concentration provides information on the relative contribution of MWF aerosol on the sample. For example, if the TP concentration is significantly greater than the EMWF concentration then it is likely that there is another particulate source in the work area.

At those stations using the semisynthetic MWF, the relative contribution of EMWF to the thoracic particulate concentration ranged from 84% to 98%, suggesting that MWF aerosol was the primary contributor to the concentration measured.

PBZ samples for solvents were collected from four Machine Operators (full–shift) and one Material Mover (activity specific – 2 hour sample). Toluene, xylene, and ethyl benzene were the major components determined from the bulk sample analysis, and each air sample was analyzed for these compounds as well as total hydrocarbons. The highest full–shift total hydrocarbon concentration (222.8 mg/m^3 [REL = 350 mg/m^3]) detected was from the Machine Operator working at the Output Hobber station. The Material Mover worked extensively with the naphtha (replenishing and transferring) for the sampling period and a total hydrocarbon concentration of 329 mg/m^3 was measured during this activity. This worker indicated that servicing the solvent containers at various Plant #1 stations was a daily task and the only activity involving naphtha that is conducted during his workday. This worker replenished thirty–five 5–gallon containers of naphtha during the monitoring period. As shown in Table 2, all xylene, toluene, and ethyl benzene concentrations measured were well below the respective NIOSH REL.

No elements (chromium, iron, nickel, molybdenum, manganese, vanadium) were detected on the area air samples collected at the De–burring hood in the Sector Shaft workstation. Several alloys are used as the starting stock material that is machined, including carbon steel (98–99% iron, with small amounts of various other elements [vanadium, manganese, etc.]), and other alloy similar alloys.

Medical

All twelve Machine Operators and one Quality Control Inspector who worked in Department #109 at the time of the NIOSH site visit completed the questionnaire. The median age of all participants was 39 years (mean: 40, range: 23–59). All but one of the workers completing the questionnaire was male. The mean time working in Department #109 was 7.4 years, although there were several workers who had just recently transferred to this department (median time in Department #109 was 2 years). Most participants had previously worked in other areas of the factory (mean employment at R.H. Sheppard was 11 years [range 0.5–21 years]) prior to working in Department #109. Four (30%) of the participants reported currently smoking cigarettes.

Table 3 presents the numbers and percentages of participants reporting symptoms. The most frequently reported symptoms (during the preceding six months) were breathlessness and skin rash, each of which was reported by 5 (38%) of the employees. Wheezing and chest tightness were each reported by 4 (39%) of the employees.

The OSHA Log and Summary of Occupational Injuries and Illnesses (Form 200) revealed 2 entries for Department #109 for the years 1994–1995. One entry was for a foreign body in the eye and the other was for a laceration.

DISCUSSION AND CONCLUSIONS

An industrial hygiene evaluation was conducted to help determine if reported health problems (allergic reactions, respiratory infections, and skin and eye irritation) were possibly associated with exposure to MWFs or other contaminants (naphtha, metals) in Plant #1, Department #109, at the R.H. Sheppard Company. During this evaluation, a questionnaire was administered to Department #109 employees, and environmental monitoring was conducted.

Two of the seven full–shift PBZ air samples for MWF exceeded the NIOSH REL (0.4 mg/m^3, thoracic fraction) for the sampling period. PBZ MWF concentrations exceeded one–half the NIOSH REL for all machining operations using the semisynthetic (HoCut 715) MWF. PBZ concentrations of MWF were below the limit of detection at all machine stations using the straight oil (Cut–Max 451) MWF. The NIOSH REL is intended to reduce respiratory disorders associated with MWF exposure. The monitoring results show that the majority of the measured particulate on the samples was due to MWF aerosol and not another particulate source. These results indicate that action should be taken to reduce worker exposure to MWF at those stations using semisynthetic MWF in Department #109. Additionally, a monitoring program should be established to help identify other tasks or processes where reductions in exposure are possible and ensure that exposures are maintained below the NIOSH REL. Because workers in other MWF environments have developed adverse health effects from exposures below the REL, lower exposures are desirable whenever possible.[1]

All measured exposures to the petroleum naphtha, and to selected solvent constituents, were below the applicable NIOSH REL. The sample with the highest full–shift total hydrocarbon concentration (222.8 mg/m^3 [REL = 350 mg/m^3]) was from the Machine Operator working at the Output Hobber station. The Material Mover worked extensively with the naphtha (replenishing and transferring) for the sampling period, and a total hydrocarbon concentration of 329 mg/m^3 was measured during this activity. Although the measured concentrations of naphtha were below the NIOSH REL, improvements in chemical handling and housekeeping practices could be made. These improvements would better control solvent loss, reduce worker exposure to naphtha, and reduce the potential for spills and fire hazard. The results of area air samples collected to evaluate metal contaminants at the two de–burring stations suggest that this process is well controlled and the downdraft ventilation system is working effectively.

PPE (primarily glove use) practices were inadequate in Department #109. Skin contact can be a significant route of exposure to MWFs and solvents, and contact dermatitis of the hands and forearms is a common problem for workers exposed to soluble oil, semisynthetic, and synthetic MWFs.[1] In general, exposure to straight oil MWFs may result in folliculitis (oil acne) and keratoses, while exposure to the water–based MWFs primarily results in irritant contact dermatitis and occasionally allergic contact dermatitis. MWF dermatitis may persist despite treatment and cessation of exposure, so primary prevention of skin contact should be emphasized as the focus for controlling MWF–related skin disorders. During the NIOSH evaluation, skin contact with MWF and naphtha, both intentional and unintentional, was observed, and this contact could be decreased with appropriate work practices and glove use. Skin rash was one of the most frequently reported symptom on the worker questionnaire. There appeared to be a lack of awareness among some employees regarding the need to prevent skin contact with the MWF and naphtha. The skin–protection program was found to be ineffective primarily because of the lack of worker training and failure to uniformly enforce the use of protective gloves at the facility.

Although a comprehensive review of the semisynthetic MWF maintenance program was not conducted, it appears that appropriate parameters have been established to maintain the quality of the MWF and delivery system. Properly maintained filtration and delivery systems can provide cleaner fluids for use, reduce misting, and minimize splashing and emissions.[1] Components of a MWF management program should include diligent maintenance of filtration and delivery systems. MWF systems should be regularly serviced and the machines rigorously maintained to prevent contamination by tramp oil and other materials.

Control of microbial growth is an important aspect of water–based MWF maintenance. Both bacteria and fungi are commonly identified in MWFs, and biocide addition is the most common method for controlling growth. Although insufficient data exist to determine a "safe" level of microbial contamination (number or species), well–maintained MWF systems should have bacterial concentrations of less than 10^6 CFU/ml.[15] This was the upper control limit established by R.H. Sheppard. Although certain organisms are suspected to be associated with specific problems, (e.g., the acid–fast organism *Mycobacteria chelonae* has been found to be present in MWF associated with outbreaks of hypersensitivity pneumonitis), the significance of finding any particular fungal or bacterial species in MWF is not clear at this time.[16]

Some individuals manifest increased immunologic responses to bacteria, fungi, or their metabolites encountered in the environment. Allergic or hypersensitivity reactions can occur even with relatively low air concentrations of allergens (such as microorganisms), and individuals differ with respect to immunogenic susceptibilities.

RECOMMENDATIONS

1. Establish a comprehensive MWF safety and health program for the R.H. Sheppard plant. A complete discussion of an occupational safety and health program pertaining to MWFs, including medical monitoring, fluid maintenance, engineering controls, and environmental surveillance, is contained in the recently published NIOSH Criteria Document "Occupational Exposure to Metalworking Fluids."[1]

2. Provide LEV for the grinding machines include controlling the source (reducing the release of MWF into the work area). The American National Standards Institute Technical Report B11 TR–2–1997 contains guidelines for ventilating machining and grinding operations.[17] Observations at the various grinding machine stations in Department #109 suggest that ventilation upgrades should focus first on the Norton grinders, followed by the Matrix, Landis, and others. This recommendation is based on qualitative observation of visible mist release during the operation of these machines and the results of the air monitoring. A systematic review and evaluation of maintenance activities in Department #109 to identify tasks that may contribute to elevated concentrations of MWF should be conducted. Examples of potential aerosol–generating activities include nozzle adjustments, use of compressed air, or breaking into MWF containing piping/tubing.

3. Engineering controls (e.g., containment, ventilation) or work practice changes (eliminating use of compressed air, depressurization, etc.) should be a first consideration to reduce the potential for exposure on the Norton Matrix Grinders., Prior to the implementation of controls, or if engineering or other controls are not feasible, workers conducting tasks where exposures could exceed the NIOSH REL should utilize respiratory protection. Because measured exposures were less than 10 times the REL, a particulate respirator, with an assigned protection factor (APF) 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 protection program (29 CFR Part 1910.134). Users must be medically cleared, trained, and fit–tested for their assigned respirator.

4. Glove use should be mandatory for dispensing or using chemicals, including MWFs. The use of solvents to clean skin should be prohibited. Criteria describing when and what type of protective equipment is required should be posted,

and the requirements enforced. Prevention of skin contact, and the reduction of opportunities for skin contact, should be a primary focus of a MWF safety and health program. Skin contact with MWFs should be reduced as much as possible by the use of appropriate personal protective equipment and modification of work practices. Employees should be provided with, and required to wear, rubber gloves that cover the forearm and a rubber–front apron to prevent MWF from saturating their clothing. A comprehensive personal protective equipment program should be implemented. The elements of an effective program include:

Written Procedures: Define the necessary PPE and ensure that it is properly and consistently used and maintained. The use of PPE should be mandatory.

Proper Selection and Use: There are many gloves available which provide adequate protection and still allow considerable dexterity. PPE should be individually assigned.

Inspection and Maintenance: Gloves should be inspected before and after each use, cleaned prior to removal, and replaced frequently (i.e., whenever inspection indicates abrasions, tears, etc., or the inside of the glove becomes contaminated). After cleaning, PPE should be stored properly.

5. Smoking and food and beverage consumption should not be permitted in the shop area.

6. Alternatives to the use of compressed air for parts drying (e.g., ventilated drying table) should be investigated and implemented.

7. Until the naphtha can be replaced by the non–flammable water–based fluid, containers of this solvent should be kept closed except during actual use. The potential hazards (both fire and health) associated with this solvent should be reviewed with employees. Workers should be trained to use the minimum amount of solvent necessary to complete the task.

8. Because 50% of the Machine Operator exposures exceeded one–half of the NIOSH REL, additional sampling to evaluate worker exposures in Department #109 should be conducted every 6 months.[1] The sampling strategy should focus on workers that are expected to have the highest exposures, which is the area where the semisynthetic MWF is used. Area sampling can help augment the personal exposure monitoring. The objectives of an environmental 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 of exposures is possible.

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Table 1 R.H. Sheppard: Department #109 Personal Air Samples for Metalworking Fluids: Thoracic Fraction HETA 98–0246 August 12, 1998								
Sample #	Job Description	Machine # Coolant Type	Sample Time (min)	TP (mg/m^3)	TWA–TP (mg/m^3)	EMWF (mg/m^3)	TWA EMWF (mg/m^3)	% EMWF
98–83	Machine Operator – OD Grinder	Landis, Brown/Sharpe 173, 116 HoCut 715	05:59–11:55 (331)*	0.28	0.25	0.23	0.21	85%
98–102			12:37–15:10 (153)	0.18		0.18		
98–86	Machine Operator – OD Grinder	Norton/Matrix 899, 807 HoCut 715	06:02–10:57 (295)	0.65	**0.61**	0.61	**0.59**	97%
98–89			12:31–15:12 (161)	0.54		0.56		
98–101	Machine Operator – Output Shafts Turning Station	Warner & Swassey 478, 879 HoCut 715	06:16–12:00 (344)	0.28	0.27	0.28	0.26	98%
98–88			12:37–15:18 (161)	0.25		0.23		
98–74	Machine Operator– OD Grinder	Norton/Matrix 639, 415 HoCut 715	06:18–11:53 (335)	0.74	**0.68**	0.57	**0.57**	84%
98–94			12:38–15:20 (162)	0.55		0.57		
98–92	Machine Operator – Sector Shaft	Fellows, Barber–Coleman 612, 808 Cut–Max 451	06:07–11:54 (291)*	<0.002	<0.003	<0.004	<0.006	NA
98–81			12:35–15:15 (159)	<0.004		<0.008		
98–72	Machine Operator – Output Shaft, Hobber	Barber–Coleman 406, 780 Cut–Max 451	06:22–12:00 (338)	**	<0.004	**	<0.007	NA
98–66			12:30–15:21 (174)	<0.004		<0.007		
98–93	Machine Operator – Sector Shaft	Fellows, Barber–Coleman 746, 711 Cut–Max 451	06:31–11:56 (323)	<0.002	<0.003	0.08	0.06	NA
98–56			12:33–15:24 (169)	<0.003		0.01		
NIOSH Recommended Exposure Limit					***0.4***			

Notes:
HoCut 715 is an undyed semisynthetic metalworking fluid
mg/m3 = milligrams of contaminant per cubic meter of air sampled
Cut Max 451 is a straight (mineral) oil metalworking fluid
TP =thoracic particulate concentration determined gravimetrically
EMWF = Extracted metalworking fluid concentration
% EMWF = the percentage of the thoracic particulate concentration attributed to EMWF
TWA = time weighted average concentration calculated as follows:

$$TWA = \frac{C_1T_1 + C_2T_2}{T_1 + T_2}$$

Where: C and T = concentration detected during the sampling period T
< Less than, not detected above the limit of detection.
All samples were blank corrected
All sampling was conducted with a size selective sampler that collected particles in conformance with the thoracic particulate curve.
* = equipment check at 10:15 found the pump had faulted. The pump was restarted and the run time listed in parentheses was from the pump's internal run–time clock.
** = Sample 98–72 was damaged during collection and the results are considered invalid.

Table 2
R.H. Sheppard: Department #109, Plant #1
Personal Air Samples for Solvents
HETA 98–0246 August 12, 1998

Sample #	Task	Time (min)	Concentration Detected in mg/m³							
			Toluene	TWA	Xylene	TWA	E.Benzene	TWA	Total HC	TWA
CT–1	Machine Operator: Sector OD Norton/Matrix 899 & 807	06:03–12:00 (347)	1.7	1.8	1.8	1.8	0.5	0.5	30.5	30.5
CT–10		12:31–15:12 (161)	1.9		1.9		0.5		30.4	
CT–9	Machine Operator: Sector Shaft, Fellows and Barber Coleman 612 & 808	06:07–11:54 (317)	5.1	4.8	4.8	4.7	1.2	1.2	90.4	86.7
CT–6		12:35–15:15 (120)	4.0		4.5		1.2		76.8	
CT–5	Machine Operator: Output Shaft Hobber, Barber Coleman 406 & 780	06:22–12:00 (338)	10.0	9.4	15	13.8	3.8	3.6	244	222.8
CT–8		12:30–15:21 (171)	8.2		11.4		2.8		181.6	
CT–4	Machine Operator: Sector Shaft, Fellows and Barber Coleman, 746 & 711	06:32–11:55 (323)	3.5	5.2	3.4	4.7	0.9	1.2	57	79
CT–7		12:33–15:24 (169)	8.5		7.1		1.9		120.8	
CT–3	Material Mover, Plant #1	06:25–08:41 (136)	18.8	NA	17.2	NA	4.7	NA	329	NA
NIOSH Recommended Exposure Limit				375		435		435		350

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

NA = Not Applicable. The Material Handler only replenished solvent for the time period sampled.

TWA = time weighted average concentration calculated as follows:

$$TWA = \frac{C1T1 + C2T2}{T1 + T2}$$

Where: C and T = concentration detected during the sampling period T

E.Benzene = ethyl benzene, Xylene = total xylenes, Total HC = total hydrocarbons detected on the sample using octane as a standard reference

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Table 3
R.H. Sheppard: Department #109, Plant #1
Reported Symptoms/Illnesses Among Employees
HETA 98–0246

Symptom/Illness	Number (% of 13) Reporting the Symptom/Illness
Cough (“usually have cough on most days for 3 consecutive months during the year”)	2 (15)
Wheezing or Whistling in Chest	4 (31)
Breathlessness (“shortness of breath when hurrying on level or walking up a slight hill”)	5 (38)
Tightness in Chest	4 (31)
Feverish (weekly/daily)	1 (8)
Chills (weekly/daily)	1 (8)
Unusual Fatigue (weekly/daily)	3 (23)
Flu–like Achiness (weekly/daily)	1 (8)
Eye Irritation	2 (15)
Nose Irritation	3 (23)
Throat Irritation	4 (31)
Dermatitis or Skin Rash in Last 6–months	5 (38)

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
or visit the NIOSH Homepage at:
http://www.cdc.gov/niosh/homepage.html

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