NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2003-0175-3033
COL-FIN Specialty Steel
Fallston, Pennsylvania

March 2007

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 Chandran Achutan of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS) and Jeffrey Nemhauser, currently with the Radiation Studies Branch, Division of Environmental Hazards and Health Effects, National Center for Environmental Health. Field assistance was provided by Chad Dowell, Manny Rodriguez, and Melissa Finley of HETAB. Analytical support was provided by Data Chem Laboratories, Salt Lake City, Utah. Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

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 National Institute for Occupational Safety and Health (NIOSH) received a request from the United Steelworkers of America Local 9305 for a health hazard evaluation (HHE) at COL-FIN Specialty Steel in Fallston, Pennsylvania. NIOSH was asked to look at potential health hazards throughout the production area of the facility. NIOSH investigators conducted an evaluation of the facility between March 8 and 12, 2004.

What NIOSH Did

- We collected area and personal breathing zone samples for respirable particulates, noise, carbon monoxide, metalworking fluids (MWFs), sulfuric acid, hydrochloric acid, silica, and microbials.
- We interviewed 35 employees.

What NIOSH Found

- Noise levels were high throughout the plant.
- Grinders and shavers were exposed to MWF levels above occupational exposure limits.
- The local exhaust ventilation (LEV) units on the grinders were not operational.
- Many employees reported skin and breathing problems; some of these were consistent with their occupational exposures.
- Many employees were smoking in the workplace.

What COL-FIN Managers Can Do

- Establish a hearing conservation program.
- Ensure all LEV units on grinders are operational.
- Establish a respiratory protection program in the grinding and shaving areas.
- Establish a medical surveillance program for employees exposed to MWFs.
- Ban smoking in the workplace.
- Conduct sampling on workers exposed to MWFs.
- Cover vats containing MWFs.
- Move etching process to fume hood.
- Provide dispenser for soap powders.
- Provide goggles and gloves to employees working with soap powders.

What COL-FIN Employees Can Do

- Stop smoking.
- Practice good personal hygiene such as washing hands if exposed to chemicals.
- Wear goggles, gloves, and ear plugs provided by the company.

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 #2003-0175-3033

Health Hazard Evaluation Report 2003-0175-3033
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SUMMARY

On February 27, 2003, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Steelworkers of America Local 9305 for a health hazard evaluation (HHE) at COL-FIN Specialty Steel (COL-FIN) in Fallston, Pennsylvania. The union was concerned about inadequate ventilation in the pickling and annealing areas and other potential health hazards throughout the whole plant. On November 11, 2003, NIOSH investigators made an initial visit to the facility to meet with union and management representatives, tour the facility to understand the manufacturing process, and observe work practices. Between March 8 and March 12, 2004, NIOSH investigators returned to COL-FIN to conduct environmental sampling and medical interviews with employees.

Area and personal breathing zone (PBZ) air samples for respirable particulates and acids (sulfuric and hydrochloric) were collected during the annealing, pickling, and hot etching of steel coils. Area and PBZ air samples for respirable particulates from soap powder and metal working fluids (MWFs) were collected when employees were drawing, straightening, and grinding the steel coils. Respirable particulate samples were also analyzed for crystalline silica. Spot measurements for carbon monoxide (CO) were taken in the annealing area. In addition, personal noise measurements were made on employees during the annealing, drawing, straightening, and grinding processes. Material handlers, who transport steel coils on gas-powered forklifts throughout the production area were assessed for exposure to noise, respirable particulates, silica, CO, and acids.

A short-term sample for hydrochloric acid collected during the etching process exceeded the NIOSH and Occupational Safety and Health Administration (OSHA) ceiling limits; sulfuric acid levels were below all occupational exposure limits (OELs). Respirable particulate and silica levels were also below all OELs. Spot measurements for CO ranged up to 18 parts per million. Area and PBZ air samples collected in the grinding and shaving areas were above the NIOSH recommended exposure limit (REL) for MWFs; the local exhaust ventilation units for the grinding and shaving equipment were not functioning as intended. The personal noise dosimetry data showed that noise levels for two material handlers exceeded the OSHA action level of 85 decibels on an A-weighted scale. Many employees' noise levels also exceeded the more protective NIOSH REL.

Thirty-five workers were interviewed. Many workers reported respiratory (66%) and skin problems (31%) consistent with exposure to MWFs and other occupational exposures. Over half of interviewed workers were current smokers. Smoking occurred throughout the plant, exposing non-smokers to secondhand smoke.

Exposures to excessive levels of noise and MWFs, as well as exposure to secondhand smoke, constitute a health hazard at COL-FIN. Employees reported respiratory and dermal problems consistent with their occupational exposures. NIOSH investigators recommend enrolling COL-FIN employees in a hearing conservation program and banning smoking inside the facility. NIOSH investigators also recommend servicing the local exhaust ventilation units in the grinding and shaving areas to reduce exposure to MWFs and establishing a medical monitoring program for workers exposed to MWFs.

Keywords: NAICS 331222 (Steel Wire Drawing) and 332111 (Iron and Steel Forging), metalworking fluids, oil mist, acids, noise, dermatitis, respiratory symptoms, secondhand smoke, mixed exposures

Table of Contents

INTRODUCTION

On February 27, 2003, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Steelworkers of America, Local 9305 for a health hazard evaluation (HHE) at COL-FIN Specialty Steel (COL-FIN) in Fallston, Pennsylvania. The union was concerned about inadequate ventilation in the pickling and annealing areas and other potential health hazards throughout the whole plant. On November 11, 2003, NIOSH investigators made an initial visit to the facility. An opening meeting was held between NIOSH investigators and union and management representatives. Following the opening meeting, NIOSH investigators toured the facility to understand the manufacturing process and to observe work practices.

Between March 8 and March 12, 2004, NIOSH investigators returned to COL-FIN to conduct environmental sampling and to conduct medical interviews with employees. At the conclusion of the site assessment, NIOSH investigators made an oral report to management and employee representatives of their observations of work practices and provided initial recommendations to minimize exposures.

BACKGROUND

Company

COL-FIN is a manufacturer of cold-finished steel bars and coils for a variety of industries worldwide. The company opened in 1976 in Glenwillard, Pennsylvania. It moved to its current location in Fallston, Pennsylvania, in 1983. Approximately 50 people work in the production area over three 8-hour shifts. Approximately 30 of these employees work the first shift (7:00 a.m. to 3:00 p.m.), 15 work the afternoon shift (3:00 p.m. to 11:00 p.m.) and five work the night shift (11:00 p.m. to 7:00 a.m.). The job functions are essentially the same for all three shifts.

Process

Annealing

The annealing process changes the molecular structure of steel by heating and cooling the steel coils. The steel coils are placed on bases. The bases are covered with hoods, and the environment within the hood is purged of oxygen by using nitrogen gas. A furnace is moved over the hood to heat the steel coils to temperatures between 1000 degrees Celsius (°C) and 1340°C. The annealed coils are cooled using sand. The process takes 5 to 23 hours depending upon the size of the steel coils. Potential exposures to workers in the annealing area include noise, particulates, carbon monoxide (CO), and silica. Material handlers who transport steel coils on gas-powered forklifts throughout the production area are also potentially exposed.

Pickling and Hot Etching

Annealed steel coils are cleaned with sulfuric (H_2SO_4) and hydrochloric (HCl) acids to remove metal oxides from their surfaces. This process, referred to as pickling, is done in large vats. Cab operators in ventilated, closed forklifts move the coils from one vat of acid to another. The pickled coils are rinsed in water and air dried before they undergo further processing. To determine if there are structural defects in the pickled coils, a sample of the coil is cleaned in 31.5% boiling HCl and examined under a microscope. This process, called hot etching, is done by a laboratory technician. Material handlers in this area are also potentially exposed to H_2SO_4 and HCl.

Drawing, Straightening, and Grinding

The pickled coils are drawn and straightened out by passing them through dies and are then formed into the desired shape, thickness, and size. Lastly, the products are shaved and ground to remove any surface defects. The main exposures to the machining (draw block, straight cut, draw bench, schumag) operators, shavers, and grinders are noise, particulates from soap powder used to lubricate the dies, and

metalworking fluids (MWFs) used in the grinding and shaving processes. According to the product material safety data sheets (MSDS), one of the MWFs used for the shaving and grinding equipment was composed of 85% petroleum distillates/paraffins and 15% proprietary additives. The other was a soluble oil/MWF mix with 3% aqueous triethanolamine as the active ingredient.

METHODS

Industrial Hygiene Evaluation

Noise

Twenty-three employees working the first, second, and third shifts contributed 29 personal noise dosimetry measures. Quest® Electronics (Oconomowoc, Wisconsin) Model Q-300 Noise Dosimeters were worn by employees while they performed their daily activities. A noise dosimeter was attached to the wearer's belt and a small remote microphone was fastened to the wearer's shirt at a point midway between the ear and the outside of the shoulder. A windscreen provided by the dosimeter manufacturer was placed over the microphone during recordings. At the end of an inspection, the dosimeter was removed and paused to stop data collection. The information stored in the dosimeters was downloaded to a personal computer for interpretation with QuestSuite for Windows® computer software. The dosimeters were calibrated before and after the measurement periods according to the manufacturer's instructions.

Sulfuric and Hydrochloric Acids

Eight personal breathing zone (PBZ) and six area air samples (from fixed locations) for H_2SO_4 and HCl were collected using silica gel tubes at a flow rate of 200 milliliters per minute. Except for one short-term (15-minute) area sample, all samples were collected over an entire work shift. Samples were analyzed per NIOSH Manual of Analytical Methods (NMAM) Method 7903.[1] Samples were primarily collected on workers in the pickling area. Three of the PBZ air samples were collected on material handlers who delivered materials to and from the pickling area.

Carbon Monoxide

CO was measured using a direct reading instrument equipped with an electrochemical sensor specific to CO (ToxilogUltra™, Middletown, Connecticut). For full-shift samples, data were recorded at 1-minute intervals by an internal data logger and then downloaded using computer software. Full-shift PBZ measurements were collected on annealers and material handlers. In addition, spot measurements for CO were collected in the annealing department.

Metalworking Fluid Aerosols

Four PBZ and six area air samples for MWF aerosols were collected over the full shift on polytetrafluoroethylene filters at a nominal flow rate of 2.0 liters per minute (Lpm), and analyzed per NIOSH Method 5524. The data are reported as total particulates and oil mist. All samples were collected in the shaving and grinding areas.

Respirable Particulates and Silica

Eighteen full-shift area and PBZ air samples for respirable particulates were collected on polyvinyl chloride filters at a nominal flow rate of 1.7 Lpm, and analyzed per NIOSH Method 0600. Seven of these samples were also analyzed for crystalline silica by NIOSH Method 7500. These samples were collected in the annealing and the draw block areas.

Microbial Contaminants

Bulk samples of used MWFs were collected in glass vials and shipped at room temperature to a contract laboratory for identification of viable microorganisms and quantification of endotoxins (cell wall structures from Gram-negative bacteria). Viable culture identification was performed using selective media (Middlebrook 7H11 and Lowenstein Jensen) and non-selective media (tryptic soy agar media). Endotoxins were analyzed using the limulus amoebocyte lysate (LAL) assay.

Medical Evaluation

On March 8, 2004, the NIOSH medical officer received a list of names of all hourly employees working at COL-FIN from the United Steelworkers of America representative who requested the HHE. On March 8 and March 9, the NIOSH medical officer conducted voluntary, confidential medical interviews with hourly workers named on the list. Workers who declined to be interviewed, were on vacation or leave at the time of the site visit, or were assigned to the night shift, were not interviewed. The confidential medical interview included questions about job history, chemical exposures and medical history with an emphasis on respiratory symptoms and smoking history.

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 increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[3] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[4] Employers are encouraged to follow, the NIOSH RELs, the ACGIH TLVs, the OSHA PELs 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)]. Employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). Thus 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 STELs or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Noise

Noise-induced loss of hearing is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically.[5] While loss of hearing may result from a single exposure to a very brief impulse

noise or explosion, such traumatic losses are rare. In most cases, noise-induced hearing loss is insidious. Typically, it begins to develop at 4000 or 6000 Hertz (Hz) (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have still higher frequency components.[6]

The A-weighted decibel (dBA) is the preferred unit for measuring sound levels to assess worker noise exposures. The dBA scale is weighted to approximate the sensory response of the human ear to sound frequencies near the threshold of hearing. The decibel unit is dimensionless, and represents the logarithmic relationship of the measured sound pressure level to an arbitrary reference sound pressure (20 micropascals, the normal threshold of human hearing at a frequency of 1000 Hz). Decibel units are used because of the very large range of sound pressure levels which are audible to the human ear. Because the dBA scale is logarithmic, increases of 3 dBA, 10 dBA, and 20 dBA represent a doubling, tenfold increase, and hundred-fold increase of sound energy, respectively. It should be noted that noise exposures expressed in decibels cannot be averaged by taking the simple arithmetic mean.

The OSHA standard for occupational exposure to noise (29 CFR 1910.95)[7] specifies a maximum PEL of 90 dBA for a duration of 8 hours per day. The regulation, in calculating the PEL, uses a 5-dB time/intensity trading relationship, or exchange rate. This means that a person may be exposed to noise levels of 95 dBA for no more than 4 hours, to 100 dBA for 2 hours, etc. Conversely, up to 16 hours exposure to 85 dBA is allowed by this exchange rate. The duration and sound level intensities can be combined in order to calculate a worker's daily noise dose according to the formula:

$$\text{Dose} = 100 \text{ X } (C_1/T_1 + C_2/T_2 + ... + C_n/T_n),$$

where C_n indicates the total time of exposure at a specific noise level and T_n indicates the reference duration for that level as given in Table G-16a of the OSHA noise regulation. During any 24-hour period, a worker is allowed up to 100% of his daily noise dose. Doses greater than 100% exceed the OSHA PEL.

The OSHA regulation has an additional action level (AL) of 85 dBA; an employer shall administer a continuing, effective hearing conservation program (HCP) when the 8-hour TWA value exceeds the AL. The program must include monitoring, employee notification, observation, audiometric testing, hearing protection devices (HPDs), training, and record keeping. All of these requirements are included in 29 CFR 1910.95, paragraphs (c) through (o). Finally, the OSHA noise standard states that when workers are exposed to noise levels in excess of the OSHA PEL of 90 dBA, feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels.

NIOSH, in its Criteria for a Recommended Standard,[8] and ACGIH, propose exposure criteria of 85 dBA as a TWA for 8 hours, 5 dB less than the OSHA standard. The criteria also use a more conservative 3 dB time/intensity trading relationship in calculating exposure limits. Thus, a worker can be exposed to 85 dBA for 8 hours, but to no more than 88 dBA for 4 hours or 91 dBA for 2 hours. The NIOSH REL for a 12-hour exposure is 83 dBA or less.

Sulfuric and Hydrochloric Acids

H_2SO_4 is a severe irritant to the eyes, mucous membranes, and skin. Concentrated sulfuric acid can cause severe burns on contact. Sulfuric acid mists can result in eye, nose, and throat irritation, and dental erosion. The extent of respiratory irritation depends on factors such as air concentration, particle size, temperature, and humidity.[9] Epidemiologic studies have indicated

that exposure to sulfuric acid mist and other acid mists are associated with cancer. After review of these studies, the International Agency for Research on Cancer (IARC) determined that there is sufficient evidence that occupational exposure to strong inorganic acid mists containing H_2SO_4 is carcinogenic.[10] This determination was based on the demonstration of epidemiologic associations between occupational exposures to strong acid mists (mostly H_2SO_4 mists) and excess risks for laryngeal cancer[11,12,13,14] and lung cancer.[15,16,17]

Environmental evaluation criteria for H_2SO_4 have been established by OSHA and NIOSH at 1 milligram per cubic meter (mg/m^3) for up to an 8- (OSHA) or 10- (NIOSH) hour TWA. ACGIH has established an 8-hour TWA of 0.2 mg/m^3 based on the thoracic fraction. The thoracic fraction refers to chemicals that are hazardous when deposited anywhere within the airways and the gas-exchange region of the lungs.

HCl, the aqueous form of hydrogen chloride, is irritating and corrosive to any tissue it contacts. Brief inhalation exposure to low concentrations can cause throat irritation. Long-term exposure to low levels can cause respiratory problems, eye and skin irritation, and discoloration of the teeth. Exposure to relatively high concentrations of HCl can result in rapid breathing, narrowing of the bronchioles (airways in the lungs), and accumulation of fluid in the lungs.[18]

NIOSH and OSHA have also established evaluation criteria for HCl at 5 parts per million (ppm) as a ceiling limit; the ACGIH ceiling limit for HCl is 2 ppm.

Carbon Monoxide

CO is 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 include headache, drowsiness, dizziness, nausea, vomiting, collapse, myocardial ischemia, and death.[19] The NIOSH REL for CO is 35 ppm for up to a 10-hour TWA. NIOSH also recommends a ceiling limit of 200 ppm, which should not be exceeded at any time during the workday. The ACGIH TLV for an 8-hour TWA is 25 ppm; the OSHA PEL for an 8-hour TWA is 50 ppm.

Metalworking Fluid Aerosols

The term MWF aerosol refers to the mist generated during grinding and machining operations and the contaminants present in the mist. It may contain a variety of substances, including any component of the MWF, additives to the MWF, contaminants of the MWF such as tramp oils or metals, and biological contaminants such as bacteria and fungi, as well as their byproducts such as endotoxins, exotoxins, and mycotoxins.[20]

There are four major classes of MWF:

1. Straight or neat oil MWFs are severely solvent-refined petroleum oils or other marine, vegetable, or synthetic oils used alone or in combination, with or without additives. They are not diluted with water.
2. Soluble or emulsifiable oil MWFs are composed of 30% to 85% severely solvent-refined petroleum oils and emulsifiers that are diluted with water, and may include performance additives.
3. Semisynthetic MWFs have 5% to 30% severely solvent-refined petroleum oils, a higher proportion of emulsifiers, and 30% to 50% water.
4. Synthetic MWFs contain no petroleum oils, and may be water soluble or water dispersable. They are diluted with water.

Workers are exposed to MWFs either through skin contact (splashes and aerosols, or handling equipment covered with MWF) or via inhalation of aerosols. The primary health effects are dermal (skin) and respiratory.

Respiratory conditions associated with exposure to MWFs include asthma, hypersensitivity pneumonitis (HP), hard metal disease (if the MWF is contaminated with cobalt), acute respiratory irritation, chronic bronchitis, and rarely, lipid pneumonia and Legionellosis. HP is an illness in which inflammation occurs in lung tissue as a result of inhaling a substance to

which a person is allergic. The clinical signs of HP are variable and may be of acute, subacute, or chronic form. In the acute form, flu-like symptoms are typical, with cough, chest tightness and shortness of breath being common. Pulmonary function tests typically reveal restriction (i.e., a decreased ability to fully expand the lungs). In the subacute and chronic forms of HP, the classic symptoms are shortness of breath on exertion, chest tightness, cough (often with sputum production), fatigue, and weight loss. The acute illness usually resolves on cessation of exposure to the causative substance, and can recur on re-exposure. Continued exposure can lead to pulmonary fibrosis, a permanent lung condition that can be associated with severe disability. Many substances are known to be associated with development of HP. Usually they are organic in nature. Examples include fungal spores, various bacteria, animal proteins, and certain organic chemicals. Over the past ten years, several outbreaks of HP have occurred in workers exposed to MWFs. The agent in the fluids responsible for these outbreaks was not determined, but attention focused on the microbial contamination of the fluids, especially unusual contaminants such as mycobacteria, Gram-positive bacteria, and/or fungi. Several of these outbreaks were associated with high numbers of *Mycobacterium chelonae* being present in water-based MWFs.[21] Water-based MWFs are excellent nutritional sources for many kinds of bacteria and fungi. Many species that grow in MWFs secrete waste products that serve as a nutritional substrate for organisms that have more restrictive nutritional needs. Some researchers have suggested that well-maintained MWFs should have bacterial concentrations below 10^6 colony forming units per milliliter of fluid.[22] There are insufficient data to determine acceptable levels of microbial contamination in the air.

Straight oils can cause folliculitis (inflammation of the hair follicles), oil acne, oil keratosis, and squamous cell carcinoma on parts of the body contacting the MWF. The water-based oil emulsions and synthetic MWFs most commonly cause irritant contact dermatitis, and can occasionally cause allergic contact dermatitis. Dermatitis can continue despite removal from exposure.

To prevent or greatly reduce the risk of adverse health effects due to MWF, NIOSH recommends in a published criteria document, *Occupational Exposure to Metalworking Fluids,* that airborne exposures to MWF aerosol be limited to 0.4 mg/m^3 for thoracic particulate mass as a TWA for up to 10 hours per day during a 40-hour week. The 0.4 mg/m^3 concentration corresponds to approximately 0.5 mg/m^3 for total particulate mass in most workplaces. The NIOSH REL is based on evaluation of the health effects data, sampling and analytical feasibility, and technological feasibility. However, concentrations of MWFs should be kept below the REL where possible, because some workers have developed work-related asthma, HP, or other adverse respiratory health effects to MWFs when exposed at lower concentrations. There are no OSHA or ACGIH criteria for MWF aerosol. The OSHA PEL for oil mist is 5 mg/m^3 as an 8-hour TWA.

Respirable Particulates and Silica

Respirable particulates refer to those dust particles that are small enough to penetrate the nose and upper respiratory system and travel deep into the lungs. Particles that penetrate deep into the respiratory system are generally beyond the body's natural clearance mechanisms of cilia and mucous and are more likely to be retained.[23] Excessive exposure to respirable particulates can lead to respiratory diseases.[24,25,26] The OSHA PEL for respirable particulates not otherwise classified is 5 mg/m^3. The ACGIH TLV for particulates is 3 mg/m^3 as an 8-hour TWA.

Occupational exposures to respirable crystalline silica (quartz and cristobalite) have been associated with silicosis, lung cancer, pulmonary tuberculosis, and airway diseases.

Microbial Contaminants

As mentioned earlier, vats containing MWFs can be a reservoir for a multitude of microorganisms harmful to human health. These include many species of bacteria, fungi, and endotoxins.

Endotoxins are part of the outer membrane of the cell wall of Gram-negative bacteria such as *Pseudomonas, Burkholderia, Klebsiella,* and *Salmonella*. The biological activity of endotoxin is associated with the lipopolysaccharide (LPS). LPS consists of a hydrophilic polysaccharide and a hydrophobic lipid, lipid A. The toxic effects produced by endotoxins have been attributed mostly to the lipid A component.[27] The cell wall antigens of Gram-negative bacteria are components of LPS. LPS elicits a variety of inflammatory responses in animals.[28,29] There is no OSHA PEL or NIOSH REL for endotoxins. A study looking at 45 bulk samples of soluble MWF from machine sumps found an average endotoxin level of 73,000 endotoxin units per milliliter (EU/mL) of fluid.[30]

RESULTS

Industrial Hygiene Evaluation

Noise

Table 1 summarizes the personal dosimetry measurements. Ten of the 29 measurements exceeded the NIOSH REL of 85 dBA. Of these, two also exceeded the OSHA AL of 50% of the daily allowable noise dose. Both of these samples were collected on material handlers working the first and second shifts.

Sulfuric and Hydrochloric Acids

All full-shift personal and area air samples for H_2SO_4 collected in the pickling area (Table 2) were below the NIOSH REL and the OSHA PEL of 1 mg/m^3.

NIOSH and OSHA do not have full shift OELs for HCl. However, a short-term area HCl sample taken outside the pickling area exceeded the NIOSH and OSHA ceiling limits of 5 ppm (Table 2). This sample was taken during the etching process, where employees test the quality of the finished product by dipping it in boiling acid. Full-shift HCl exposures for cab operators and area samples that approximate HCl exposures to the breathing zone of the cab operators ranged from 0.01 to 0.05 ppm.

Carbon Monoxide

Data for the full-shift PBZ and area samples are not available because the data files were corrupted when they were downloaded to a computer. Spot measurements of CO in the annealing area ranged from below the instrument's limit of detection to 18 ppm.

Metalworking Fluid Aerosols

Table 3 summarizes personal and area samples taken for MWFs and oil mist. All four personal samples and two of the six area samples exceeded the NIOSH REL of 0.5 mg/m^3; none exceeded the OSHA PEL for oil mist.

Respirable Particulates and Silica

We observed that employees were exposed to particulates as they scooped soap powder from a large drum into a smaller container. The respirable dust concentrations ranged from 0.64 mg/m^3 to 0.72 mg/m^3.

Silica and respirable dust samples collected in the annealing and production areas had concentrations below OELs. Sand is used as a coolant in the annealing process; when the furnace is opened after an annealing operation, the annealer may be exposed to silica present in the sand. Silica was either not detected in the samples or was not present in quantifiable concentrations. The minimum quantifiable concentration for silica is 0.04 mg/m^3 based on a limit of quantification of 0.03 mg and an 8-hour sample volume of 0.82 m^3. The respirable dust concentrations for five PBZ air samples ranged from 0.07 mg/m^3 to 0.18 mg/m^3.

Microbial Contaminants

NIOSH investigators collected four bulk samples of MWFs in the grinding and shaving

areas for analysis of microbial content and endotoxin levels. The microbial identification and concentrations of endotoxins are presented in Table 4. No mycobacteria were present in any of the samples. Although there is no NIOSH REL or OSHA PEL for endotoxins, data from previous research suggest that bulk samples 04 and 05 (taken near grinders 1 and 3) had high levels of endotoxins.

Medical Evaluation

The NIOSH medical officer identified 51 hourly employees represented by the United Steelworkers of America. Of the 51 employees, 35 (69%) consented to participate in a confidential medical interview. Of the 16 who were not interviewed, eight specifically declined to participate, three were on leave, three were working the third shift, and two were present but unavailable for interview.

The median number of years worked at COL-FIN by interviewed employees was 18. Length of employment of interviewed employees ranged from 6 weeks to 24 years. Interviewed employees held a variety of positions at COL-FIN. Twenty-three workers reported doing jobs that involved straightening or drawing coils of wire through a die. Six employees worked as straight cutters; four of six straight cutters also had other jobs in the plant, including two who performed straightening or drawing of wire. Four employees worked in annealing, three operated the shaving machine, and two worked as cab operators. The remaining employees served as material handlers and grinders. Reported exposures differed within job titles, as well as between jobs. Some employees performed more than one job. In addition, several workers reported multiple exposures.

We noted employees smoking in work areas and break rooms throughout the plant, exposing non-smokers to secondhand smoke. Eighteen of the 35 interviewed employees (51%) reported current, regular use of cigarettes. Non-smokers included those who had never smoked cigarettes as well as those employees who had smoked previously.

Respiratory Health History

In summary, 12 (34%) of the 35 employees interviewed denied having any respiratory or breathing problems. Among those 23 employees who reported a history of breathing problems, 14 workers gave a history of nasal congestion or irritation of the nose and sinuses, and of the mucous membranes of the upper airway, six reported being diagnosed with bronchitis, and three reported being diagnosed with pneumonia. Among those reporting past episodes of bronchitis as well as episodic occurrences of cough and respiratory irritation were several draw block operators exposed to MWFs or oils. There were also reports of bronchitis from previously working as a grinder. Two workers provided a history of a worsening of their asthma while working at COL-FIN. Twelve (52%) of the 23 workers with breathing problems reported current, regular tobacco use.

Dermatological Health History

Eleven of the 35 interviewed employees (31%) reported a history of skin irritation or rash. One worker with skin irritation reported exposure to acids. Four other workers with skin irritation reported exposure to MWF, either alone (2/4) or in combination with lubricant soap powders and oils (2/4). A total of seven workers reported exposure to oils, either alone (3/7) or in combination with soap powders (2/7) or with soap powders and MWF (2/7). No worker who reported exposure to only lubricant soap powders reported a history of skin irritation or rash. Similarly, four of eight workers who reported exposure to lubricant soap powders and oils reported a history of skin irritation or rash. No workers reporting exposures to mineral spirits described a history of skin irritation or rash.

DISCUSSION

Noise Exposures

Some of the personal noise dosimetry measures exceeded the OSHA AL and the more protective NIOSH REL. According to OSHA regulations,

employees whose exposures to noise levels exceed the OSHA AL must be enrolled in an HCP. Thus, these employees and those whose exposure to noise levels exceeded the NIOSH REL should be enrolled in an HCP. The elements of the program should, at a minimum, meet the basic requirements of the OSHA hearing conservation amendment (29 CFR 1910.95).

Noise levels were higher during the first and second shifts compared to the third shift, probably because production levels slowed down during the third shift. The company provides HPDs (foam earplugs) for employees, but we observed poor compliance with their use. Employees mentioned that the use of HPDs prevents them from hearing the machines, which interferes with troubleshooting the machines and hearing their coworkers.

Chemical Exposures

COL-FIN employees are potentially exposed to a variety of chemicals at the workplace that can result in respiratory and skin problems. These chemicals include acid mists (H_2SO_4 and HCl), MWFs, oils, and soap powders.

MWF exposures to the skin commonly occur during machining operations. Workers frequently handle parts, tools, and equipment covered with MWF. Workers exposed to MWFs have been found to have a high rate of skin diseases. Lists of industries with the highest incidence rates for skin disorders (e.g., fabrication, screw machine products, and general industrial machinery) frequently involve workers with potential MWF exposure.

Several different skin diseases can result from skin contact with MWFs. In general, water-based MWFs are linked with irritant contact dermatitis and, less frequently, with allergic contact dermatitis. Many factors play a role in the development of contact dermatitis and other skin diseases in workers exposed to MWFs. These factors include the MWF class and additives used. For example, biocides (such as isothiazolinone-based compounds) are known causes of allergic contact dermatitis.[31]

Dermatitis prevention is important because workers with MWF dermatitis may continue to have skin problems even after exposure to MWF has stopped; some of these workers become disabled because of their skin disorders. The NIOSH document, *Occupational Exposure to Metalworking Fluids*, outlines measures to help in minimizing work-related skin disorders related to MWF exposure. Although none of the workers who reported exposures to mineral spirits and none of the workers who reported exposures only to lubricant soap powders described having rashes, these chemicals are also capable of causing skin irritation.

Many interviewed workers reported a history of respiratory or breathing problems while employed at COL-FIN. Workers most commonly reported nasal congestion and/or irritation to the nose, sinuses, and upper airway. Two workers reported worsening of their asthma while working at COL-FIN. It is difficult to clearly delineate the cause of these symptoms for several reasons. They are common, non-specific symptoms, many employees smoke, and exposures are often mixed. However, these symptoms are consistent with exposure to MWFs, which exceeded the NIOSH REL, and to acid mists, particulates, and secondhand smoke. While exposures to acid mists and particulates were below applicable OELs, some workers may not be protected by those OELs. Furthermore, the combination of exposures may contribute to these symptoms. In addition, several workers exposed to MWF who reported recurrent bronchitis, pneumonia, and flu-like symptoms may have had HP. HP is often misdiagnosed.

Slightly more than half of the workers in this evaluation reported current, regular cigarette use, in some cases quite heavy usage. This is more than double the smoking rate of 20.9% for the United States adult population.[32] Smoking occurred throughout the workplace, exposing non-smokers to secondhand smoke. Cigarette smoke contains approximately 4000 chemicals of which over 50 are known animal or human carcinogens. The recently released Surgeon General's report on secondhand smoke states that exposure to secondhand smoke causes

cancer and coronary artery disease in adults and is associated with nasal irritation, cough, wheezing, chest tightness, difficulty breathing in asthmatics and healthy persons, and chronic respiratory symptoms.[33] The report notes that separating smokers from non-smokers does not eliminate exposure to secondhand smoke and that no level of exposure is risk-free. Additionally, cigarette smoking can result in hand-to-mouth ingestion of contaminants present in the workplace.

Employees reported that a new exhaust fan was installed in the pickling area approximately a month before the NIOSH evaluation and that they noticed a significant improvement in air quality after the exhaust fan was installed. None of the personal samples collected in the pickling area exceeded any OEL. This may have been due to the new exhaust fan. However, a short-term sample taken near the pickling area during the hot-etching process exceeded the NIOSH and OSHA ceiling limit for HCl. This process occurs in an open space with an appreciable amount of foot traffic. Thus, employees may be exposed to unnecessary levels of HCl. It would be prudent to make the non-functional fume hood in the laboratory next door operational and transfer the etching process there.

The characterization of CO levels at this facility was incomplete because of technical problems when downloading the data. From the spot measurements, the levels of CO appear to be low. However, CO emitted from cigarettes adds to the CO levels from the forklifts and the furnace. Previous research has shown that CO levels from secondhand smoke in homes, vehicles, offices, and restaurants can raise the 8-hour average CO concentration by up to 20–40 ppm.[34]

Employees were concerned that MWFs used in the grinding and shaving processes were stored uncovered in large vats and drums. Although uncovered MWFs do not represent a health hazard on their own, it is not a good work practice to leave chemicals uncovered as they can become contaminated. In addition, the MWFs were being used as a lubricant for the grinders and shavers, so there is a potential for them to become aerosolized during equipment operation. Grinder stations that used MWFs were equipped with local exhaust ventilation (LEV). However, we observed that the LEV did not adequately capture the MWF and oil mist. The results from samples B04-27 and B04-20 (Table 3) illustrate this inadequate capture. Sample B04-27 was taken at the machine and sample B04-20 about 10 feet away. If the LEV was functioning as intended, neither sample should have detectable levels of MWF or oil mist. OSHA does not require employees to be enrolled in a comprehensive respiratory protection program with the levels measured at COL-FIN; however, a respiratory protection program is needed based on MWF concentrations in excess of the NIOSH REL.

Microbial Exposures

Microbial flora in a stagnant vat of MWFs can change over time. Results from the analysis of MWF bulk samples underscore the need to keep vats holding MWFs free from microbial contamination. COL-FIN uses water- and petroleum-based MWFs. Water-based MWFs are excellent nutritional sources for many kinds of bacteria and fungi. The predominant species routinely recovered from MWFs are virtually identical to those routinely recovered from natural water systems. Many species that grow in MWFs secrete waste products that serve as a nutritional substrate for organisms with more restrictive nutritional needs.

CONCLUSIONS

Some COL-FIN employees are exposed to excessive levels of noise and MWFs. In addition, the facility allows smoking in the work areas, thus exposing non-smokers to secondhand smoke. Levels of particulates and silica were below occupational exposure limits. Full-shift PBZ air samples for H_2SO_4 were below all OELs. A short-term area air sample for HCl exceeded the NIOSH and OSHA ceiling limits. Many workers reported respiratory and skin problems consistent with exposure to MWF and other occupational exposures at COL-FIN.

RECOMMENDATIONS

Based on the observations and the results of this evaluation, the following recommendations are made to improve employee health and safety at COL-FIN. Most of these recommendations were discussed during the closing conference on March 12, 2004.

1. Establish a hearing conservation program for COL-FIN employees. The basic elements of the program should, at a minimum, meet the requirements of the OSHA hearing conservation amendment [29 CFR 1910.95 (c) through (p)]. Other sources for defining effective hearing loss prevention programs are also available.[35,36,37]
2. Both human speech and machine sounds contain high and low frequencies that can be distorted by conventional HPDs. To minimize this distortion and to improve communication, we recommend the use of HPDs that are linear and more moderate in attenuation. Examples of this include Natural Sound Technology™ or NST™, developed by Bilsom (www.bacou-dalloz.com), and the Ultra-Tech or Musician series HPDs, by AEARO (www.aearo.com).
3. Use appropriate enclosures and mist collectors to control all processes that generate MWF aerosols above the NIOSH REL. Ensure that all local exhaust ventilation units on grinders are operational and meet the manufacturer's specifications for airflow. Perform air sampling following installation of any new engineering controls to verify their effectiveness. Areas known to have exposures above one half the NIOSH REL should be sampled every 6 months. More guidance on controlling MWF exposure can be obtained from OSHA.[38]
4. Provide respirators for employees exposed to MWF aerosols until MWF exposures are reduced below the NIOSH REL through the use of engineering controls. Establish a comprehensive respiratory protection program in the grinding and shaving areas for persons exposed to MWFs in accordance with the requirements in the OSHA respiratory protection standard [29 CFR 1910.134].[39] Respirators should be selected by the person who is in charge of the program and knowledgeable about the workplace and the limitations associated with each type of respirator. Any air-purifying, half-mask respirator including a disposable (filtering facepiece) respirator equipped with any P- or R-series particulate filter should be sufficient.
5. Establish a medical monitoring program for MWF-exposed workers. All workers exposed to MWF above half of the NIOSH REL should be included in the medical monitoring, and all workers with exposure may benefit from medical monitoring. The medical monitoring program should be directed by a physician or other health professional who is knowledgeable about the respiratory protection program, and the identification and management of MWF-related respiratory conditions and skin diseases. COL-FIN should provide the medical director with current and previous job descriptions, hazardous exposures and their measurements, the type of personal protective equipment (PPE) used, relevant MSDSs, and applicable safety and health standards. Medical monitoring should be provided at no cost to the employees, and the physician's recommended restrictions and accommodations should be adhered to. The components of a medical monitoring program are provided in the Appendix.
6. Cover the vats containing MWFs when not in use. Ensure that MWFs are treated with biocides in accordance with the manufacturer's recommendations to retard the growth of microorganisms and replace the fluids in a timely manner when they are no longer useable.
7. Designate a person with adequate training, resources, and time to ensure

that proper MWF maintenance is continued.

8. Reduce dermal contact with MWFs as much as possible by the use of appropriate PPE and modification of work practices. The employer should provide and the employees should be required to wear gloves that cover the forearm and a plastic/rubber apron to prevent MWF from saturating their clothing. Nitrile gloves would be suitable because they afford good chemical resistance and are also rated as "excellent" for flexibility and resistance to abrasions, tears, and punctures. Employees should be trained to use work techniques that minimize the amount of MWF that drips, spills, or sprays onto them.
9. Ban smoking in the workplace. We suggest establishing incentives to discourage smoking, offering smoking cessation classes to employees, and providing literature on the harmful effects of cigarette smoke to employees.[40]
10. Make the fume hood in the laboratory operational, and perform the etching process inside the fume hood. Make sure that the baffles inside the fume hood are not blocked because that would compromise its effectiveness. In addition, check the fume hood's face velocity annually to ensure that it is operating properly.
11. Work with soap manufacturers to obtain soap powders in easy-to-dispense containers in order to minimize the risk of inhalation of soap powders.
12. Provide goggles to prevent eye irritation for employees dispensing soap powders.
13. Wash off irritants and allergens that come in contact with the skin as soon as possible, using mild soap and water.

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TABLES

Table 1
Measurements of Noise Levels as Percent Dose

Job Description	Number of Measurements	Percent Dose		
		OSHA AL	OSHA PEL	NIOSH REL
Straight Cut Operator*	5	16.0 – 45.6	1.3 – 3.6	38.9 – 141.8
Shaver**	1	41.8	13.1	129.7
Annealer	4	14.1– 27.3	3.0 – 6.8	43.0 – 90.6
Pickling Cab Driver	2	40.2 – 41.9	2.2 – 2.7	96.6 – 97.1
Materials Handler***	5	21.2 – 79.1	4.4 – 25.3	65.3 – 231.0
Draw Block Operator*	7	20.0 – 36.8	4.6 – 17.0	63.0 – 197.3
Draw Bench Operator	1	28.0	3.3	65.8
½" and 1" Schumag Operators**	3	26.0 – 40.7	4.1–14.1	66.2 – 130.8
Grinder	1	29.1	3.0	73.8

OSHA: Occupational Safety and Health Administration
NIOSH: National Institute for Occupational Safety and Health
AL: Action Level
PEL: Permissible Exposure Limit
REL: Recommended Exposure Limit
* NIOSH REL exceeded twice
** NIOSH REL exceeded once
*** NIOSH REL exceeded 4 times; OSHA AL exceeded twice

Table 2
Hydrochloric Acid (HCl) and Sulfuric Acid (H_2SO_4) Concentrations In and Around the Pickling Area

Sample ID	Sample Type	Location	Run Time (min)	Concentrations		
				HCl (mg/m^3)	HCl (ppm)	H_2SO_4 (mg/m^3)
0308-2SG1	Area	Etching	405	0.02	0.01	0.01
0308-2SG2	Personal	Pickling Cab Operator	456	0.02	0.01	0.03
0308-2SG3	Personal	Materials Handler	465	ND	ND	0.01
0309-1SG4	Area*	Etching	15	16	11	ND
0309-1SG5	Personal	Materials Handler	407	0.03	0.02	0.06
0309-1SG6	Personal	Pickling Cab Operator	464	0.01	0.01	ND
0309-3SG7	Area	Pickling Area Door	395	0.02	0.01	0.01
0309-3SG8	Area	Pickling Cab	433	0.02	0.02	0.02
0309-3SG9	Personal	Materials Handler	383	0.01	0.01	0.02
0310-2SG10	Area	Pickling Cab	458	0.08	0.05	0.21
0310-1SG11	Personal	Lab Technician	494	0.04	0.03	0.01
0310-1SG12	Area	Pickling Cab	469	0.03	0.02	0.07
0311-1SG13	Personal	Pickling Cab Operator	443	0.05	0.03	0.23
0311-1SG14	Personal	Lab Technician	507	0.01	0.01	0.01

*Sample exceeded the Occupational Safety and Health Administration and the National Institute for Occupational Safety and Health ceiling limits of 5 ppm for HCl
ND: Not Detected

Table 3
Metalworking Fluid and Oil Mist Concentrations in the Grinding and Shaving Areas

Sample ID	Sample Type	Location	Run Time (min)	Concentration (mg/m^3)	
				Total Particulates	Oil Mist
B04-22	Personal*	Grinder	326	2.6	2.3
B04-13	Area*	Grinder	409	2.1	1.7
B04-25	Personal*	Shaver	394	0.57	0.30
B04-15	Area	LEV in shaving	393	0.31	0.25
B04-2	Personal*	Shaver	446	1.2	1.0
B04-1	Area	LEV in shaving	442	0.35	0.23
B04-14	Personal*	Grinder	407	1.2	1.0
B04-19	Area	Grinder #3	406	0.33	0.25
B04-27	Area*	Grinder #2 near machine	395	2.0	1.8
B04-20	Area	Grinder #2 near work bench	395	0.30	0.13

*Samples that exceeded the National Institute for Occupational Safety and Health Recommended Exposure Limit for metalworking fluid, expressed as 0.5 mg/m^3 total particulate
LEV: Local Exhaust Ventilation

Table 4
Microorganisms and Endotoxin Levels Detected in Metal Working Fluid Samples

Sample ID	Microorganisms Identified	EU/mL
Bulk-02	*Burkholderia glumae, Enterobacter cancerogenus, Salmonella* group 1	1100
Bulk-03	*Burkholderia glumae, Pseudomonas aeruginosa*	31000
Bulk-04	*Pseudomonas pseudoakaligenes, Citrobacter farmeri, Salmonella* group 1, *Photorhabdus luminescens*	110000
Bulk-05	*Aeromonas caviae, Salmonella* group 1, *Klebsiella oxytoca*	420000

APPENDIX

Medical Monitoring Program

Medical monitoring is considered secondary prevention; it is useful for identifying workers who develop symptoms of MWF-related conditions such as asthma or dermatitis. Components of a medical monitoring program are provided below.

1. Initial or pre-placement exams should consist of a standardized symptom questionnaire, medical history, and skin exam, at a minimum. Spirometry would be useful to establish a baseline for future comparison.
2. Periodic exams should include a brief standardized symptom questionnaire. Skin exam and spirometry may also be useful. The frequency of exams should be based on the frequency and severity of health effects at COL-FIN. If workers do experience health effects possibly related to MWF exposure they should be given more detailed exams.
3. Following each exam, the physician should give the worker a written report that includes the results of any tests performed, the physician's opinion about any medical condition that may increase the risk of disease from exposures in the workplace, any recommended restrictions or accommodations, and recommendations for further evaluation or treatment. The physician should provide the employer with a written report that includes any recommended restrictions, a statement that the worker was informed of the results of the exam and of any medical condition that requires further evaluation or treatment. No information regarding specific findings or diagnoses should be released to the employer without a signed release of information from the worker.
4. Workers should be encouraged to continue to report all potential work-related skin problems to the appropriate plant personnel. These problems should be investigated on an individual basis. Because the work-relatedness of skin diseases may be difficult to prove, each person with potentially work-related skin problems should be evaluated by a physician, preferably one with expertise in occupational dermatological conditions. Individuals with definite or possible occupational skin diseases should be protected from exposures that may cause or exacerbate the disease. In some cases, workers may have to be reassigned to areas where exposure is minimized or nonexistent. Workers reassigned because of work-related health effects should retain seniority, wages, and other benefits to which they would be entitled had they not been reassigned.

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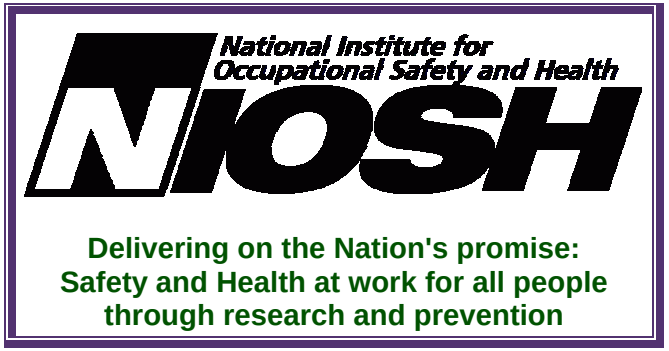

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