NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2005-0227-3049
Diamond Chain Company
Indianapolis, Indiana

September 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 Loren C. Tapp and Lynda Ewers of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies. Field assistance was provided by Manuel Rodriguez, Erica Jones, and Sangwoo Tak of HETAB, and Kenneth Brown of the Division of Applied Research and Technology (DART). Analytical support was provided by Kenneth Brown, Pratima Shah, and Sam P. Tucker of DART. Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

 The report may be viewed and printed from the following internet address: http://www.cdc.gov/niosh/hhe. Copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161.

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 union request for a health hazard evaluation (HHE) at Diamond Chain Company in Indianapolis, Indiana. The union submitted the HHE request due to concerns regarding employee exposure to metalworking fluids (MWFs) and skin rash. NIOSH conducted an investigation in July and August 2005.

What NIOSH Did

- We met with union and management representatives and toured the facility.
- We interviewed employees in private and examined their skin rashes.
- We collected bulk samples of new and used MWFs and biocides for chemical analysis.

What NIOSH Found

- Poor maintenance of MWFs.
- Employees had direct skin contact with MWFs.
- Bulk MWFs contained a mix of skin irritants and allergens.
- Some of the used MWF samples contained formaldehyde (a potential human carcinogen following prolonged inhalation exposures).
- Biocides contained triazine, which breaks down into formaldehyde.
- Six of 34 employees examined had rashes consistent with work-related contact dermatitis.

What Diamond Chain Company Managers Can Do

- Establish a comprehensive MWF maintenance program with knowledgeable supervision.
- Substitute MWFs and biocides with less irritating and sensitizing components; avoid formaldehyde-releasing biocides.
- Monitor reported health problems.
- Continue providing easy access to appropriate personal protective equipment (PPE) for employees.
- Educate employees about PPE, good skin care, and the hazards of MWF exposures.

What Diamond Chain Company Employees Can Do

- Avoid skin contact with MWFs.
- Use appropriate PPE (gloves, sleeves, aprons).
- Wash MWFs off skin as soon as possible.
- If skin problems occur, seek medical attention and alert your supervisor.
- Maintain good skin health through proper hygiene and use of moisturizers.

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 #2005-0227-3049

Health Hazard Evaluation Report 2005-0227-3049
Diamond Chain Company
Indianapolis, Indiana
September 2007

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SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from union representatives at Diamond Chain Company, located in Indianapolis, Indiana, on May 4, 2005. The United Steelworkers of America, International Union, made the request because of several complaints of skin rash among manufacturing workers exposed to metalworking fluids (MWFs). In July 2005, NIOSH investigators met with labor and management representatives, conducted a walk-through of the facility, conducted confidential employee interviews, and observed work practices in areas of concern. In August 2005, additional employee interviews were conducted, and bulk samples of used and unused MWFs and biocides from various machines at the plant were obtained for chemical analysis.

Dermal exposure to MWFs was observed to be a major route of exposure among Diamond Chain Company employees due to improper work practices, such as adjusting and cleaning the machines without adequate personal protective equipment (PPE). Employee interviews and medical examinations revealed that 11 employees had a history of rash consistent with workplace exposure to MWFs, and six of the 11 had a visible rash consistent with contact dermatitis on the hands and/or forearms at the time of the site visits. The analysis of the bulk MWF samples revealed a complex mixture of chemicals typical of MWFs, including skin irritants and skin allergens. Several water-based MWFs contained formaldehyde, a known skin and respiratory irritant and sensitizer, and a potential human carcinogen.

NIOSH investigators concluded that dermal exposure to MWFs, chemical components of the MWFs, and a lack of MWF maintenance caused or contributed to the episodes of contact dermatitis in the Diamond Chain Company workforce. Although the focus of this HHE was skin rash, two interviewed employees reported experiencing respiratory symptoms that might be related to MWF exposure. Recommendations are provided to establish a comprehensive MWF maintenance program; monitor and follow-up reported work-related health problems with a physician knowledgeable in occupational diseases; provide worker training in MWF hazards, personal protective equipment (PPE) use, and skin care; and consider substituting current MWFs and biocides with those that contain less irritating and sensitizing components.

Keywords: NAICS 333613 (Mechanical Power Transmission Equipment Manufacturing), chains, metalworking fluids, triazine biocides, formaldehyde, contact dermatitis, respiratory symptoms

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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from union representatives at Diamond Chain Company, located in Indianapolis, Indiana, on May 4, 2005. The United Steelworkers of America, International Union, made the request because of several complaints of skin rash among manufacturing workers exposed to metalworking fluids (MWFs).

On July 7, 2005, NIOSH investigators held an opening meeting with union and management representatives, followed by a general walk-through of the facility. Confidential employee interviews were conducted by the NIOSH medical officer while NIOSH industrial hygienists observed work practices where exposures to MWFs were possible.

On August 24, 2005, NIOSH investigators returned to conduct additional employee interviews of MWF-exposed workers and to obtain bulk samples of used and unused MWFs and biocides from various machines at the plant for chemical analysis.

BACKGROUND

Diamond Chain Company was founded in 1890 to produce bicycle chains, including ones modified by the Wright brothers for use in the first airplane. At the time of the NIOSH site visit, the facility had the capacity to manufacture 65,000 different types of roller chains in its 600,000 square foot historic building. The chains are used worldwide in industrial manufacturing, agriculture, construction, mining, and material handling. The company employed 520 workers on three shifts (7:00 a.m. – 3:00 p.m.; 3:00 p.m. – 11:00 p.m.; 11:00 p.m. – 7:00 a.m.) 5 days per week. Management estimated that between 30 and 40 workers were directly exposed to MWFs from the numerous tasks performed during chain production, such as punch press operation, metal grinding, and metal machining. Other employees, such as assemblers, had exposure through handling parts coated with MWFs.

While many of the machines at this plant were about 45 years old, some of the milling machines had been replaced with modern computer-controlled equipment. Unlike some plants that have centralized MWF supplies, each machine had its own MWF supply and each department was responsible for maintaining its MWFs and biocides. Management representatives reported that the machines were routinely cleaned prior to the weekend so that the MWFs did not stagnate. However, no quality control laboratory was available for testing MWF samples within the plant.

Most of the company's MWFs are supplied by Fuchs Lubricant Company following a change made approximately 3 years prior to the NIOSH site visits. In September 2003, reports of dermatitis prompted Diamond Chain Company management to request that Fuchs Lubricant Company technicians run a routine MWF analysis on one of Diamond Chain Company's machines using Tufdraw 2806 M 100. Their results indicated that the MWF had separated into layers; the oil layer was too hazy and the free oil percentage was high (18%).[1] According to management representatives, the number of workers with dermatitis at the time of the first NIOSH visit had been reduced to two but, in the prior 3 years, approximately 12 workers had been affected out of the 30–40 workers directly exposed to MWFs. Management had concluded that the primary cause of the dermatitis was exposure to water-based MWFs and poor worker hygiene, although other possible skin irritants were present in the plant, including oil-based MWFs, biocide additives, rust-inhibitors, chalk (calcium carbonate), and soaps (with and without grit).

The following plant areas were visited during the two NIOSH site visits:

- Spray Injection Machining – Tools are made in this area with a modern Haas tool mill, which uses water-based MWFs.

- Punch Press Fabrication – Water-based MWFs predominate in this area, which includes the 50/60 press line. Management representatives identified this area as the current work location of those with dermatitis. The 33 punch press machine reportedly was cleaned using dry-ice blasting about 6–8 months prior to the first NIOSH site visit.
- Grinder – Cutting fluids and water-based MWFs are used in this area.
- Special Products – This area contains Conomatic screw machines, which use oil-based MWFs.
- Heat-treat – Metal parts are heated to 1500°F, followed by washing.

METHODS

Industrial Hygiene

NIOSH investigators observed machine operations, work practices, worker hygiene, and facility hygiene, and discussed MWF maintenance and personal protective equipment (PPE) use with workers. Additionally, they reviewed Material Safety Data Sheets (MSDSs).

Because the main health concern at this plant was dermatitis, NIOSH investigators focused their evaluation on chemicals and contaminants in the MWFs. Bulk samples of all MWFs and biocides (18 samples) were collected, refrigerated, and transported to the NIOSH analytical laboratory. Of the 18 bulk samples, 13 were judged to have a high potential for dermal contact based on our field observations and worker interviews, and were analyzed to determine their major chemical components and additives.

Analysis of organic compounds in the bulk samples utilized two methods: (1) high performance liquid chromatography with ultraviolet light absorption detection and evaporative light scattering detection; and (2) gas chromatography with mass spectrometry detection (GC-MS). During the GC-MS analysis, three modes of mass spectrometry detection were used: (1) electron impact (EI) ionization, (2) positive chemical ionization, and (3) negative chemical ionization modes. Analysis was limited to identification of the major components in each bulk sample, simply defined as component peaks with areas greater than 1% by GC-MS-EI mode. In this report, the major components of each type of MWF are listed in order from greatest to least amount as determined by peak area.

Analysis for formaldehyde was performed on water-based bulk MWF samples using a modified NIOSH Manual of Analytical Methods Method 2016[2] for formaldehyde. Dilutions of the MWF bulk samples were spiked onto silica gel coated with 2,4-dinitrophenyl-hydrazine.

Medical

On July 7, 2005, NIOSH investigators conducted confidential interviews with employees identified by the union as having a history of work-related skin problems. U.S. Department of Labor Occupational Safety and Health Administration (OSHA) Injury and Illness Form 300 logs were reviewed, and medical records were requested of employees with dermatitis. On August 24, 2005, NIOSH investigators conducted on-the-job interviews with Diamond Chain Company employees exposed to MWFs, some with a history of dermatitis.

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) OSHA permissible exposure limits (PELs),[3] (2) NIOSH recommended exposure limits (RELs),[4] and (3) the American Conference of Governmental Industrial Hygienists' (ACGIH®) threshold limit values (TLVs®).[5] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

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

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

Metalworking Fluids

MWFs are complex mixtures that often contain substances such as biocides, corrosion inhibitors, metal fines, tramp oils, and biological contaminants. Inhalation of MWF aerosols may cause irritation of the throat, nose, and lungs and has been associated with chronic bronchitis, asthma, hypersensitivity pneumonitis (HP), and worsening of pre-existing respiratory problems. Dermal (skin) exposure may result from touching contaminated surfaces, handling parts and equipment, splashing fluids, and MWF aerosol mist settling on the skin. Skin contact with MWFs may cause allergic contact dermatitis (ACD), irritant contact dermatitis (ICD), and occupational ("oil") acne.[6]

NIOSH recommends limiting exposures to MWF aerosols to 0.4 milligrams per cubic meter (mg/m^3) for the thoracic particulate mass, as a TWA concentration for up to 10 hours per day during a 40-hour workweek. This REL is intended to reduce respiratory disorders associated with MWF exposure; no exposure limits exist for dermal exposures.

For more detailed information about MWFs and MWF additives, including mineral oils, ethanolamines, formaldehyde-releasing biocides (e.g., triazine), and chlorinated paraffins, please see Appendix A.

RESULTS

Observations

Several health and safety programs were in place at the plant, including pre-employment medical exams and a hearing conservation program. Management representatives reported that respirator use was not mandatory, but some workers voluntarily wore dust masks. Nitrile gloves, heavy cotton over-gloves, and Tyvek® sleeves had recently been made available. Pro-Q™ cream, a non-prescription product, had been purchased as a barrier cream. Two formulations of GoJo® soap products (MultiGreen® with grit and Rich Pink antimicrobial) were available to the workers. Showers were available in two

locations within the plant, but according to employee and management representatives they were rarely used.

Overall, the machines in the plant were not enclosed and had no local exhaust ventilation. Most machines were covered in oil and grime; some had dirty oil at their base. A variety of work practices were observed; some employees used their bare hands when changing out oil-covered parts (cleaning their hands with cotton rags they reused throughout the day, or using throw-away paper towels) while others wore latex or nitrile gloves. A few workers wore Tyvek® sleeves. No workers were observed wearing dust masks or respirators. All employees wore dark blue coveralls and safety glasses. Washing facilities were not convenient to workers; restrooms were at the perimeter of the building. Additionally, at the time of the NIOSH visit, no training of the workforce in proper use of PPE and skin hygiene was taking place.

MWF maintenance was performed by the machine operator of his/her machine; no guidance on MWF maintenance was available, nor were logs kept to document additions of water or biocide to the MWF reservoirs. Discussions with workers on the floors indicated a lack of uniformity and/or training on appropriate methods to dilute MWFs and add biocides. MWF exchanges were to occur during the second shift on the last day of the work week, at which time the machines were rinsed with water, but no written records were kept of maintenance procedures.

Industrial Hygiene

The major components and additives found in the 13 bulk samples of MWFs are presented in Table 1. Of the 13 MWF samples analyzed, five contained triethanolamine (TEA) and four contained triethanol triazine. Triazine compounds typically decompose to formaldehyde. Three of the four MWF samples that contained triethanol triazine also contained formaldehyde; the fourth sample was an unused biocide sample. Five of the six MWF samples analyzed for formaldehyde had detectable levels, ranging from 14.3 to 2474 micrograms per milliliter (µg/mL) (Table 1).

The complex nature of MWFs is demonstrated by sample #9, which was collected from a machine in an area of the plant that management identified as having dermatitis cases. This sample was a combination of sample #1, a soluble oil, and sample #2, a biocide. Prior to laboratory analysis, sample #9 had separated into three layers: 1) a lower aqueous layer, 2) a middle emulsion layer, and 3) an upper oil layer; these layers were separately analyzed. The aqueous layer contained triethanolamine borate, triisopropyl boric acid ester, fatty acid methyl esters, chloroparaffin, and formaldehyde. The middle emulsion layer and upper oil layer contained chloroparaffin, mineral oil, fatty acid methyl esters, 2,6-bis[dimethylethyl]-phenol, and formaldehyde. Formaldehyde was found at 207 µg/mL in the aqueous layer and 14.3 µg/mL in the oil layer. The middle emulsion layer was not analyzed for formaldehyde.

MSDSs were not available for all MWF samples. For those that were available, NIOSH investigators compared the components listed on the MSDS with the chemical analysis results and found conflicting results for some samples. Sample #2 (a biocide) contained TEA, octanoic acid, and triethanol triazine; the MSDS only listed TEA. The major component of sample #4 (a detergent hydraulic oil) consisted of heavy mineral oil equivalent n-alkane. An antioxidant, 2,6-bis[dimethylethyl]-phenol, was found as a minor component; the MSDS listed one component, mineral oil.

Medical

During the first site visit, union representatives identified eight employees with a history of skin problems; six were willing to be interviewed by the NIOSH medical officer. During the second site visit, NIOSH investigators interviewed 28 additional workers on the plant floor at their work stations, focusing on employees working the 50/60 press line because this was the area of most concern, but also including other workers in different departments who either had a history of a skin problem or were chosen because of

their availability. A total of 34 workers were interviewed; nine female and 25 male. Of these 34 employees, 19 worked in the 50/60 press line, five in the 80/100 press line, two in large pitch, two in the machine shop, two in special punch press, two in special products, one in grinding, and one in small pitch. Twenty-eight worked on first shift, five on second, and one on third. For those interviewed, the average number of years worked at Diamond Chain Company was 9.5, ranging from 2.5 to 24 years; the average number of years working their current job at Diamond Chain Company was 7, ranging from 1 month to 19 years.

Of the 34 interviewed employees, 12 had a history of skin problems. Of the 12, four worked in the 50/60 press line, two worked in the 80/100 press line, two in special products, two in special punch press (one had previously worked in the 50/60 press line and the other had worked with 60 press line parts when the rash began), one in machine shop, and one in grinding. Eleven of the 12 reported that their rash (previous or current) involved either one or both hands, fingers, forearms, wrists, and/or fingernails. The remaining worker reported that the rash occurred wherever the MWF touched the skin.

All 12 employees with a history of skin problems reported the onset of their rash coincided with the facility changing MWF types (about 3 to 3½ years prior to the initial site visit). Seven reported seeing a medical provider because of the rash; six reported being seen by the medical contractor for the company, and one reported seeing his family doctor. All six of the employees seen by the medical contractor reported being diagnosed with and treated for contact dermatitis; three of the six reported being referred to a dermatologist for further evaluation. Two of the three reported having skin patch testing; one reported being diagnosed with allergic contact dermatitis from the patch test results (see results of Medical Record Review). Three reported changing their work area because of the rash. Two reported a history of skin rash before adult age, one with atopic eczema and one skin reaction to a degreaser as a teen.

Six of these 12 employees had an active rash that was examined by the NIOSH medical officer; three had skin changes consistent with chronic contact dermatitis, with dry, cracked, reddened, thickened skin on fingers, front and back of hands, and/or forearms. One of the six employees had reddened papules and/or pustules in addition to dryness of fingers, i.e., skin changes consistent with subacute contact dermatitis, and one had acute contact dermatitis changes of red, raised papules and vesicles of the skin under a ring. One employee reported almost complete resolution of rash, and had, on examination, only a few small papules around one wrist that were not inflamed.

Six of the 12 employees wore cloth gloves with palm protection only when loading steel; the other six regularly wore nitrile or vinyl gloves alone or under cloth gloves. Two employees wore protective sleeves to prevent MWF exposure to arms. Eleven employees reported their rash improved or resolved with one or more of the following: time away from MWF (weekends, vacations, or when medically transferred to a "dry" job); MWF avoidance including glove use, frequent and thorough hand washing, and immediate washing of skin when exposed to MWF; and prescription skin creams and ointments. One employee additionally reported that diluting the MWF helped to resolve the rash. Eleven of the 12 employees had occupational and medical histories consistent with work-related contact dermatitis.

Of the 12 employees, two also reported respiratory symptoms they felt were due to airborne MWF exposure. One reported being diagnosed with asthma in January 2005.

Medical Record Review

Two of three employees' medical records that were requested were received. One employee had an initial diagnosis of irritant contact dermatitis, and was further evaluated with patch testing that was positive for colophony rosin and abeitic acid (common components of MWF) and Bioban™ (a common component of biocides). These positive findings indicated that this employee had an allergy to these substances.

Negative findings from the patch testing were not reported, so no comment can be made regarding formaldehyde or triazine allergy. A final diagnosis was made of allergic and irritant contact dermatitis. One physician's record for this employee also documented respiratory symptoms that the employee felt to be work-related. The second employee's medical record (from an ear, nose, and throat physician) noted a diagnosis of asthma, but the record did not mention a work-related component. This employee's family physician records were requested but not received.

DISCUSSION

At the time of the NIOSH evaluation, MWF maintenance was a major problem at this plant. Written guidance on how to maintain MWFs, protocols to evaluate MWFs, and documentation of additions of water and/or biocides to MWFs did not exist. The latter is important because evaporation of water from MWFs typically causes them to become more alkaline and corrosive to skin. A 2003 report by a MWF manufacturing consultant for Diamond Chain Company indicated that tested fluids at the plant were too hazy and had separated. Such separation of oils and water should not occur and indicates an imbalance in the MWF components. Analysis of bulk sample #9, a used MWF, revealed a separation of oil and water, suggesting that MWF maintenance problems had not been solved at the time of the NIOSH site visits. Discussions with workers also indicated a lack of training on appropriate methods to dilute MWFs and add biocides.

Analysis of the bulk MWF samples revealed a typical complex chemical mixture. Several water-based MWFs (i.e., all MWFs except those identified as straight oils) contained formaldehyde and formaldehyde-producing chemicals (e.g., triazines), which are known to cause skin irritation and, for some workers, allergic reactions. Formaldehyde is considered a potential human carcinogen by inhalation exposure; airborne exposures were not evaluated by the NIOSH investigators. MWFs and MWF additives contain multiple irritants and sensitizing chemicals that can lead to skin and respiratory health effects if not maintained and handled properly.

At the initial meeting, management representatives stated that younger workers appeared to be more affected by dermatitis than more experienced workers and speculated that poor personal hygiene might be a cause of this perceived difference. The NIOSH investigators observed that most of the plant workers used cotton rags to repeatedly wipe their hands after handling oil-covered parts, but one older worker used a paper towel to clean his hands and then threw it away without reuse. Such small differences in work practices may have some effect on dermatitis rates. Younger workers may be less aware of the need for caution when contacting MWFs.

The company purchased Tyvek® sleeves shortly before the initial NIOSH visit. Management also attempted to alleviate dermatitis complaints by providing a "barrier cream" (Pro-Q™). Literature on this product indicates that it is designed to help maintain the natural balance of lipids in the stratum corneum of the skin, thereby assisting in restoring the natural skin barrier.[7] The product does not appear to be a true barrier cream designed to prevent MWFs from contacting the surface of the skin. Because the provision of Tyvek sleeves and barrier creams was a recent addition to the available PPE, training of the workforce in their proper use (or even knowledge of their existence) had not yet occurred at the time of our first visit.

Skin contact with MWFs is common in Diamond Chain Company employees. In addition, employee interviews revealed that at least 11 of the approximately 40 employees with MWF skin exposure had developed contact dermatitis consistent with workplace exposure in the 3 years prior to the NIOSH site visits.

Contact Dermatitis

Contact dermatitis is the most common occupational skin disease. Epidemiologic data show that contact dermatitis makes up 90%–95% of all occupational skin diseases.[8,9,10]

Contact dermatitis (both irritant and allergic) is an inflammatory skin condition caused by skin contact with an exogenous agent or agents, with or without a concurrent exposure to a contributory physical agent (e.g., ultraviolet light; metal fines). It is widely accepted that of all contact dermatitis, 80% is due to a non-immunologic reaction to chemical irritants (irritant contact dermatitis) and 20% to allergic reactions (allergic contact dermatitis). Only certain chemicals are allergens, and only a small proportion of people are susceptible to them. Complete reviews of both irritant and allergic contact dermatitis are available from other sources.[11,12,13,14]

In dermatitis, the skin initially turns red and may develop small, oozing blisters (vesicles) and bumps (papules). After several days, crusts and scales form. Stinging, burning, and itching may accompany the rash. With no further contact, the rash usually disappears in 1 to 3 weeks. With chronic exposure, deep cracking (fissures), scaling, and discoloration of the skin (hyperpigmentation) can occur. Exposed areas of the skin, such as hands and forearms, which have the greatest contact with irritants or allergens, are most commonly affected. If the chemical gets on clothing, it can produce rashes at areas of greatest contact, such as thighs, upper back, armpits, and feet. Dusts can produce rashes at areas where the dust accumulates and is held in contact with the skin, such as under the collar and belt line, at the tops of socks or shoes, and in flexural areas (e.g., front of the elbow, back of the knee). Mists can produce dermatitis on the face and anterior neck. Irritants and allergens can be transferred to remote areas of the body (such as the trunk or genitalia) by unwashed hands or from areas of accumulation (such as under rings or between fingers). It is often not possible to clinically distinguish irritant from allergic contact dermatitis, as both can have a similar appearance and both can be clinically evident as an acute, subacute, or chronic condition. Workers with previous atopic dermatitis (eczema) may be at higher risk for developing occupational skin diseases, usually of an irritant nature.

Extensive lists of irritants and allergens are available in reference books.[11,13] The most frequent causes of irritant contact dermatitis include soaps/detergents, glass fibers (fiberglass) and particulates, food products, cleaning agents, solvents, plastics and resins, petroleum products and lubricants, metals, and machine oils and coolants.[10,15] Causes of allergic contact dermatitis include metallic salts, organic dyes, plants, plastic resins, rubber additives, and germicide/biocide additives.

The work-relatedness of skin diseases may be difficult to prove. The accuracy of the diagnosis is related to the skill level, experience, and knowledge of the medical professional who makes the diagnosis and confirms the relationship with a workplace exposure. The diagnosis is based on the medical and occupational histories and physical findings. The importance of the patient's history of exposures and disease onset is clear. Guidelines are available for assessing the work-relatedness of dermatitis and include the following criteria: (1) clinical appearance is consistent with a dermatitis; (2) workplace exposures to irritants/allergens; (3) an anatomic distribution consistent with reported exposures in the job task; (4) a consistent temporal relationship of exposure and disease; (5) non-occupational exposures excluded as possible causes; (6) clinical improvement of the condition away from the exposure; and (7) skin patch tests or use tests identifying a probable causal agent.[16] In many instances, allergic contact dermatitis can be confirmed by skin patch tests using specific standardized allergens or, in some circumstances, by provocation tests with nonirritating dilutions of industrial contactants. Only some of these criteria were evaluated in this HHE in defining the epidemiologic case definition of a work-related current rash. Further follow-up and diagnostic testing of affected employees would be necessary to meet all of the criteria listed above.

Prevention of Contact Dermatitis

Because people with contact dermatitis can develop long-term dermatologic problems, prevention is key. Strategies in the prevention of contact dermatitis include identifying allergens and irritants, substituting chemicals that are less irritating/allergenic, establishing engineering controls to reduce exposure, using PPE such as gloves and special clothing appropriately, emphasizing personal and occupational hygiene, establishing educational programs to increase awareness in the workplace, and providing health screening.[10,15,17] The most certain method to prevent irritant and allergic dermatitis is to avoid contact with MWFs. Process modification, isolation, and ventilation to reduce MWF exposures are most effective.

Proper training and use of PPE is another way to avoid skin exposure to MWFs. While relying on protective gloves may sometimes be necessary, they can present a safety hazard if they become caught in machinery. The adequacy of machine guarding should be carefully reviewed by safety professionals if gloves are worn by workers. Other, less obvious problems associated with protective gloves include small tears, cracks, and punctures that can develop in glove materials, allowing penetration of the MWF to the skin. Finally, the effectiveness of a glove depends on the rate that chemicals can move through the intact glove material, i.e., the permeation rate. Any contamination inside a glove results in chemicals being trapped on the skin, which may make dermatitis worse. Little information is available for complex mixtures such as MWFs, but NIOSH currently recommends nitrile, Silvershield™, or 4H™ glove materials. The approximate service life for these materials is 4 hours. The Tyvek® sleeves may also aid in protecting the skin. Workers should exchange clothing or glove material contaminated by MWFs with clean clothing/gloves and wash their skin with mild soap.

Educational programs should include factors affecting skin integrity as part of comprehensive training on preventing work-related skin disease. These factors include: (1) temperature (too hot [excessive sweating] or too cold), (2) humidity (too much or not enough [dry skin]), (3) ultraviolet light (sunburn), (4) water (too much washing or not enough washing), (5) good personal hygiene (gentle soaps and skin cleansers), and (6) emphasis on good skin care (moisturizers). While frequent hand washing will reduce contact time of MWFs with the skin, training should address the fact that excessive hand washing or harsh soaps can also cause dermatitis.[18] Soaps, skin cleansers, and moisturizers may have components that are skin irritants (e.g., pumice and lye) or allergens (e.g., lanolin and fragrances); the latter may cause allergic contact dermatitis in sensitive individuals. Information regarding moisturizers, soaps, and skin cleaners should be included in the safety training curriculum.

The effectiveness of barrier creams is controversial,[19] and at times workers using barrier creams may have higher prevalence rates of contact dermatitis than those who do not use the creams.[20] A hydrating cream or lotion may be as, or more, effective in preventing mild irritation than barrier creams.

Other Issues

Respiratory Symptoms

Two employees reported work-related respiratory symptoms. Airborne exposure to MWF has been associated with work-related asthma and other respiratory diseases in other facilities. Respiratory symptoms among employees exposed to MWF should be further evaluated by a physician knowledgeable in work-related diseases, and sampling for airborne concentrations of MWF should be considered.

Storage Containers

NIOSH investigators observed one drum container that was labeled "BLASTI TE-BT 10 grit" but were told by a worker that it contained "chalk" (i.e., calcium carbonate). Storage containers should be labeled clearly and appropriately.

CONCLUSIONS

NIOSH investigators concluded that dermal exposure to MWFs, chemical components of the MWFs, lack of an effective MWF maintenance program, and inadequate employee training in the safe use and handling of MWFs have caused or contributed to the episodes of contact dermatitis in the Diamond Chain Company workforce. Although the focus of this HHE was skin rash, two interviewed employees reported experiencing respiratory symptoms that might be related to MWF exposure.

RECOMMENDATIONS

1. Establish a maintenance program for MWFs. Regularly test the MWFs in the individual machines, and assist the workers in accurately maintaining the MWFs. Persons responsible for administering this program should be well trained to evaluate the various types of fluids within the plant. Written maintenance records should be kept. A detailed description of an appropriate maintenance program is found in the "NIOSH Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids," in Chapter 9, Recommendations for an Occupational Safety and Health Program, pp. 173–191. [http://www.cdc.gov/niosh/98-102.html].

2. Substitute MWFs and biocides with less irritating and sensitizing components if proper maintenance of the fluids does not alleviate employee contact dermatitis. Be aware that formaldehyde-releasing agents such as triazines are known sensitizers, but other, less-studied chemicals in this workplace may also cause contact dermatitis.

3. Encourage workers to report all potential work-related skin problems to their supervisors. These should be investigated on an individual basis by the company or consulting health care providers. Because the work-relatedness of skin diseases may be difficult to prove, each person with possible work-related skin problems should be fully evaluated by a physician, preferably one familiar with occupational/dermatological conditions. A complete evaluation would include a full medical and occupational history, a medical exam, a review of exposures, possibly diagnostic tests (such as skin patch tests to detect causes of allergic contact dermatitis), and complete follow-up to note the progress of the affected worker. Individuals with definite or possible occupational skin diseases should be protected from exposures to substances that cause or exacerbate the disease. In some cases of allergic contact dermatitis, workers may have to be reassigned with retention of pay and employment status to areas where exposure is minimal or nonexistent.

4. Encourage workers to report all potential work-related respiratory problems to their supervisors. These workers should be evaluated by consulting health care providers knowledgeable about occupational diseases.

5. Monitor reported health problems in a systematic manner to identify particular job duties, work materials (such as particular MWFs), machines, or areas of the plant which may be associated with certain health effects. (See Chapter 9 in the NIOSH MWF criteria document [http://www.cdc.gov/niosh/98-102.html]).

6. Educate workers to recognize the hazards of MWF exposure and to use work practices that prevent skin exposure to MWFs (see Contact Dermatitis in Discussion section).

7. Educate employees on the need to take prompt action whenever there is skin or clothing contact with MWFs. Exposed skin should be flushed with large amounts of running water or washed with soap and water as soon as possible. Residual soap should be washed off the skin surface. Clothing contaminated with MWFs should be removed and laundered prior to re-use.

8. Use appropriate PPE when contact with MWFs is unavoidable. Provide easy access to appropriate gloves, sleeves, goggles, and aprons. Managers and employees should work together

to determine appropriate PPE requirements. Written procedures should define the necessary PPE and include guidance on proper selection and use. The PPE should also be inspected, cleaned or replaced as needed, and properly stored. OSHA standard 29 CFR, part 1910, subpart I – Personal Protective Equipment provides good guidance.[21]

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TABLE 1

Results of Metalworking Fluid (MWF) and Biocide Analyses
Diamond Chain Company, Indianapolis, Indiana
HETA 2005-0227-3049
August 27, 2005

#	MWF Type or Biocide	Location (operator in area)	Analytes
1	Soluble oil, unused	33 punch press (50/60 press line)	Chloroparaffin Mineral oil Fatty acids Triethanolamine Formaldehyde not detected
2	Biocide, unused	33 punch press (50/60 press line)	Triethanolamine Octanoic acid Triethanol triazine Formaldehyde 2474 µg/ml
3	Straight oil, unused	Special punch press area	Chloroparaffin Mineral oil Fatty acid esters Not tested for formaldehyde
4	Straight hydraulic oil, unused	Special punch press area	Heavy mineral oil (C_{20} – $C_{44,}$, mean C_{32}) 2,4-bis[dimethylethyl]-phenol (minor component) Not tested for formaldehyde
5	Straight cutting oil from 2nd floor, unused	Special punch press area	Mineral oil (C_{18} – C_{20} , mean C_{25}) Chloroparaffin Not tested for formaldehyde
6	Straight oil, unused	Special punch press area	Chloroparaffin Mineral oil (C_{20}-C_{22}, mean C_{21}) Triethanolamine borate Butoxyethanol Not tested for formaldehyde
7	**Used sample** from punch press (contains samples #1, #2, and a synthetic fluid)	33 punch press (50/60 press line)	Mineral oil Formaldehyde 35 µg/mL
9	**Used sample** from punch press (contains samples #1, #2)	33 punch press (50/60 press line)	Three separated phases See text for details Formaldehyde 14.3 µg/mL (oil layer) Formaldehyde 207 µg/mL (water layer)
13	Straight oil, unused	80/100 press line	Mineral oil (C_{12}-C_{36}, mean C_{19}) Fatty acid methyl esters (C_{16} and C_{18}) Not tested for formaldehyde
14	Unused biocide	80/100 press line (added to soluble oil [#1] about 2X/week)	Triethanol triazine – major component Not tested for formaldehyde
15	Straight oil, unused	78/80 punch press or large pitch	Mineral oil (C_{14} – C_{32}, mean C_{22}) Chloroparaffin Not tested for formaldehyde

#	MWF Type or Biocide	Location (operator in area)	Analytes
17	Semi-synthetic fluid, unused (pink MWF; thought to already contain biocide)	4th floor, machining area	Mineral oil Fatty acids Boric acid Methyl benzoate Triethanol triazine Formaldehyde 894 µg/mL
18	Soluble oil, unused	Miscellaneous area (water coolant in drill machine)	Mineral oil Decyl oleate esters Triethanolamine Triethanol triazine Formaldehyde 1258 µg/mL

APPENDIX A

Metalworking Fluids

Metalworking fluids (MWFs) are complex mixtures used to cool, lubricate, and remove metal chips from tools and metal parts during grinding, cutting, or boring operations. There are four types of MWFs: straight oils, soluble oils, semi-synthetics, and synthetics.[1] Most straight oils (also called neat or non-soluble oils) are highly refined products of petroleum stocks, or animal, marine and vegetable oils. Straight oils do not contain nor are they diluted with water. Other types of MWFs are water-based mixtures that may require dilution. Both soluble oils (oil-based, with emulsifiers) and semi-synthetic fluids (oil emulsion, with large amounts of water) contain some oil, while synthetic fluids are totally water-based products. MWFs often contain a mixture of other substances including biocides, corrosion inhibitors, metal fines, tramp oils, and biological contaminants. Selection of a specific MWF is based on the requirements of the task. For example, straight oils are cutting oils and prevent rusting of the metal, while water soluble oils cool and lubricate the metal parts.[2]

Exposure to MWFs can result from inhalation of aerosols or from skin contact due to touching contaminated surfaces, handling of parts and equipment, splashing of fluids and settling of MWF aerosol on the skin.[2] Inhalation of MWF aerosols may cause irritation of the throat (e.g., sore, burning throat), nose (e.g., runny nose, congestion, and nosebleeds), and lungs (e.g., cough, wheezing, increased phlegm production, and shortness of breath). MWF aerosol exposure has been associated with chronic bronchitis, asthma, hypersensitivity pneumonitis (HP), and worsening of pre-existing respiratory problems. HP is a spectrum of granulomatous, interstitial lung diseases that occur after repeated inhalation and sensitization to a wide variety of microbial agents (bacteria, fungi, amoebae), animal proteins, and low-molecular weight chemical antigens.[3,4,5] Skin contact with MWFs may cause allergic contact dermatitis and/or irritant contact dermatitis depending on the chemical composition of the fluid, types of additives and contaminants contained in the MWFs, type of metal being machined (e.g., nickel or chromium), and the exposed individual's tendency for developing allergies. Petroleum-based products may cause occupational acne.[6] Certain chemicals, such as those with a low or high pH, irritate the skin upon direct contact. Strong detergents and hand cleansers may also cause dermatitis or aggravate an existing condition.

In 1998, the National Institute for Occupational Safety and Health (NIOSH) issued a recommended exposure limit (REL) for MWF aerosols of 0.4 milligrams per cubic meter (mg/m^3) for the thoracic particulate mass, as a time-weighed average (TWA) concentration for up to 10 hours per day during a 40-hour workweek. This REL is intended to reduce respiratory disorders associated with MWF exposure. However, concentrations of MWF aerosols should be kept below the REL where possible because some workers have developed work-related asthma, HP, or other adverse respiratory effects when exposed to MWFs at lower concentrations.[7] Limiting exposure to MWFs is also prudent because certain MWF exposures have been associated with various cancers.[2] Additionally, the sampling method used for MWF aerosols does not take into consideration biological particles that may cause independent health effects. No exposure limits exist for dermal (skin) exposures to MWFs, which was the primary concern of workers at Diamond Chain Company. Limiting dermal exposures is critical to preventing allergic and irritant skin disorders related to MWF exposure.

The excess cancer mortality observed in prior studies most likely reflects the cancer risk associated with exposure conditions in the mid-1970s and earlier. Changes in the metalworking industry since that time (e.g., changes in MWF composition, reduction of impurities, and reduction of exposure concentrations) may have eliminated most of the carcinogenic risks, but there is insufficient data at this time to make this conclusion.[2]

NIOSH is currently researching the irritant and allergenic properties of MWF components by identifying and analyzing the major components of bulk MWFs collected from facilities being evaluated. Prior investigations comparing MWF components identified by analysis to components listed on the MWF material safety data sheet (MSDS) have found that MSDSs are often incomplete. Potential reasons for incomplete MSDSs may include: (1) certain components are considered proprietary information; (2) a lack of MSDS regulation enforcement; and (3) inaccurate analytical methods. Our goal is to identify components in MWFs that are likely to cause health effects in order to recommend effective prevention efforts.

Mineral Oils

Mineral oils are major components of many MWFs and can contain a complex mixture of aromatic, naphthenic, and straight- or branched-chain paraffinic hydrocarbons, as well as various additives and impurities. In addition to the general exposure criteria for MWFs cited above, there are criteria specifically for the mineral oil components of MWFs. Occupational exposure to mineral oil concentrations in air (often called mineral oil mists) is limited by the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) and NIOSH REL to 5 mg/m^3. NIOSH also recommends a short-term exposure limit (STEL) of 10 mg/m^3.

Inhalation of mineral oil mist in high concentrations may cause pulmonary effects (e.g., lipoid pneumonitis), although few cases have been reported.[8] Prolonged exposure to mineral oil mist may also cause dermatitis. Persons with pre-existing skin disorders may be more susceptible to these effects. Early epidemiological studies linked cancers of the skin and scrotum with exposure to mineral oils.[9] It is thought that the presence of polycyclic aromatic hydrocarbons (PAHs) and/or additives with carcinogenic properties was responsible for cancer-causation in the older MWFs. Modern mineral oils are highly refined, which has reduced the concentrations of PAHs found in older, poorly refined mineral oils. For uncharacterized mineral oils containing additives and impurities, the International Agency for Research on Cancer (IARC) determined that there is sufficient evidence for carcinogenicity to humans, based on epidemiologic studies; however, IARC has determined that for highly refined mineral oils, there is inadequate evidence for carcinogenicity to humans.[10]

Metalworking Fluid Additives

Ethanolamines

Ethanolamines, including monoethanolamine (MEA) and triethanolamine (TEA), may be added to MWFs to stabilize pH or inhibit corrosion. Ethanolamines are irritants to the eyes and skin, and have been shown to cause both allergic and contact dermatitis.[11,12] At ambient temperatures they are likely to be airborne in greater concentrations as an aerosol than a vapor.[13] TEA, a colorless, viscous liquid with a slight ammonia odor, is used as a pH balancer and in a variety of cosmetic products as well as MWFs.[14] No OSHA PEL or NIOSH REL exists for TEA, but the American Conference of Governmental Industrial Hygienists (ACGIH®) has a threshold limit value time weighted average (TLV-TWA) of 5 mg/m^3. For MEA, NIOSH has an REL of 7.5 mg/m^3 and a STEL of 15 mg/m^3, OSHA has a PEL of 7.5 mg/m^3 and the ACGIH recommends a TLV-TWA of 7.5 mg/m^3.

Formaldehyde-Releasing Biocides

Antimicrobial agents are often added to water-containing MWFs (soluble oils, semi-synthetic, and synthetic MWFs), because they can support microbial growth. Some of these agents release formaldehyde to kill microbes.

Triethanol Triazine

Triethanol triazine (i.e., 1,3,5-triazine-1,3,5-triethanol) is a formaldehyde-releasing biocide/preservative that is often added to MWF. Formaldehyde is a known corrosive and may cause irritant contact dermatitis, in addition to eye irritation.[15] Although animal studies have not found triethanol triazine to be sensitizing (causing an allergic reaction), medical case studies have reported that it has caused allergic contact dermatitis in humans.[16,17,18]

Formaldehyde

Formaldehyde is a colorless gas with a strong odor. Exposure can occur through inhalation and skin contact and absorption. The acute effects associated with formaldehyde are irritation of the eyes, respiratory tract, and skin. Some individuals develop occupational asthma and/or allergic contact dermatitis after repeated exposures (i.e., sensitization or allergy).[19] ACGIH designates formaldehyde as a sensitizer. There is variation among individuals in terms of their tolerance and susceptibility to exposure of the compound.[20]

NIOSH recognizes formaldehyde as a potential occupational carcinogen and has determined an REL for airborne exposures of 0.016 parts per million (ppm), TWA, with a 15-minute ceiling of 0.1 ppm, based on human and/or animal data, analytical limits, and technological feasibility. The OSHA PEL is 0.75 ppm as an 8-hour TWA and 2 ppm as a STEL.[21]

Chlorinated Paraffins

Chlorinated paraffins are used as extreme-pressure additives in some MWFs. The IARC has determined that chlorinated paraffins of average carbon-chain length C_{12} and average degree of chlorination approximately 60% are possibly carcinogenic to humans (Group 2B).[22] No evaluation criteria are available for these compounds.

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