CDC Workplace Safety and Health

Evaluation of Contact Dermatitis among Machinists at an Automotive Parts Manufacturer

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The employer shall post a copy of this report for a period of 30 calendar days at or near the workplace(s) of affected employees. The employer shall take steps to insure that the posted determinations are not altered, defaced, or covered by other material during such period. [37 FR 23640, November 7, 1972, as amended at 45 FR 2653, January 14, 1980].

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Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
cm	Centimeter
GC-MS	Gas chromatography-mass spectrometry
HHE	Health hazard evaluation
HP	Hypersensitivity pneumonitis
HPLC	High performance liquid chromatography
Hz	Hertz
IARC	International Agency for Research on Cancer
IEEE	Institute of Electrical and Electronics Engineers
kHz	Kilohertz
LEV	Local exhaust ventilation
µg/mL	Micrograms per milliliter
µT	Microtesla
mg/m^3	Milligrams per cubic meter
MWF	Metalworking fluid
MSDS	Material safety data sheet
NAICS	North American Industry Classification System
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic aromatic hydrocarbon
PEL	Permissible exposure limit
PPE	Personal protective equipment
ppm	Parts per million
psig	Pounds per square inch gauge
REL	Recommended exposure limit
RF	Radiofrequency
SRMF	Sub-radiofrequency magnetic field
STEL	Short-term exposure limit
TLV®	Threshold limit value
TWA	Time-weighted average
VOC	Volatile organic compound
WEEL	Workplace environmental exposure level

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation at Dana Corporation in Bristol, Virginia from the United Auto Workers, Local 9023. Employees were concerned that exposures to chemicals, nylon powder, grinding machine dust, and poor indoor environmental quality were causing rashes, nose bleeds, and breathing problems. There were also concerns that sub-radiofrequency magnetic fields (SRMFs) were causing cancer. Investigators made a site visit in June 2006.

What NIOSH Did

- We met with union and management representatives and toured the plant.
- We talked to employees in private and examined their rashes.
- We took bulk samples of new and used metalworking fluids (MWFs) and biocides for chemical analysis.
- We measured SRMF levels near the induction heaters.
- We took samples for hydrochloric acid mist.
- We checked the ventilation at the nylon powder coating operation and at the acid tanks.

What NIOSH Found

- Most employees we talked to had direct skin contact with MWFs.
- At the time of our visit, 11 employees had a rash that was probably related to work.
- Analyses of bulk MWF samples revealed skin irritants and allergens; including formaldehyde, a potential human carcinogen.
- MWFs were poorly maintained.
- The SRMF levels were low and did not pose a hazard to employees.
- The hydrochloric acid mist concentrations were low and did not pose a hazard to employees.
- Ventilation was adequate in the dip tank and nylon coating operation areas.

What Managers Can Do

- Begin a comprehensive, supervised MWF maintenance program.
- Designate an employee to oversee the MWF program. This person should report to management about MWF issues.
- Thoroughly clean machines prior to adding clean MWF.
- Fix machines that leak hydraulic oil to prevent contamination of MWF.
- Replace MWFs and biocides with less irritating and sensitizing materials. Formaldehyde-releasing biocides should be avoided.

- Do not use compressed air to clean metal parts.
- Start a comprehensive personal protective equipment (PPE) program. Nitrile gloves, chemical resistant sleeves, goggles or faceshields, and aprons should be provided to employees.
- Educate employees about PPE, good skin care, and the hazards of MWF exposure.
- Provide employees training on preventing work-related skin diseases.
- Encourage employees to report all potential work-related skin or respiratory problems to supervisors.
- Use anti-rust spray products in areas that are well ventilated.

What Employees Can Do

- Avoid skin contact with MWFs.
- Use appropriate PPE such as gloves, sleeves, and aprons.
- Wash MWFs off skin as soon as possible.
- Remove clothing soiled with MWFs.
- Seek medical attention and alert your supervisor if skin problems occur.
- Maintain good skin health through proper hygiene and use of moisturizers.

Summary

NIOSH received a request for an HHE at Dana Corporation in Bristol, Virginia from the United Auto Workers, Local 9023. Employees were concerned that poor indoor environmental quality and exposures to chemicals, nylon powder, and dust from grinding machines were causing rashes, nose bleeds, and respiratory problems, and that SRMF levels from induction heaters were causing cancer. Discussions held with union and management representatives determined that dermatitis was the major concern among employees.

NIOSH investigators evaluated employee exposures to nylon powder, SRMF levels, and chemicals in MWFs. We also looked at employee health concerns (dermatitis, nose bleeds, and respiratory problems) to see if the health concerns were related to work exposures. We found poor MWF maintenance, inadequate employee training, and direct skin contact with MWFs that contained sensitizing components. We believe these factors caused or contributed to dermatitis in some Dana Corporation employees. We recommend establishing a comprehensive MWF maintenance program, avoiding MWF and biocides containing irritating and sensitizing compounds, and improving employee training.

On June 13–15, 2006, NIOSH investigators held an opening meeting with management and union representatives and toured the plant to observe work practices. We measured SRMF levels near the induction heaters, collected bulk MWF samples, evaluated potential acid gas exposures, assessed LEV at the nylon coating operation and the acid dip tank, interviewed employees privately, and performed medical evaluations of the skin.

We found machines using MWFs that were not being cleaned between fluid change-out and machines leaking hydraulic oil into MWF reservoirs. Analysis of bulk MWF samples revealed irritant and sensitizing chemical components. Employees had direct skin contact with MWFs, and their training in the safe use and handling of MWFs was inadequate. Of the 72 employees interviewed, 37 reported a prior or current skin problem that they related to work; 11 employees had a rash that was likely work-related at the time of the evaluation. Exposures to SRMFs and acid gases were below OELs. Aerosol cans of antirust spray were used in areas without LEV, and powder had accumulated on horizontal surfaces near the nylon powder coating operation.

We recommend developing a comprehensive MWF maintenance program, repairing machines to avoid oil leakage into MWFs, and avoiding the use of MWFs and biocides with irritating and sensitizing components such as formaldehyde-releasing agents. We recommend that employees report potential work-related health problems to their supervisors. The company should educate employees in the safe use and handling of MWFs, methods to prevent work-related skin disease, and appropriate use of PPE. Ventilation should be improved where antirust spray is used and in the nylon powder coating area when drums are charged.

Keywords: NAICS 336350 (Motor Vehicle Transmission and Power Train Parts Manufacturing), metalworking fluids, contact dermatitis, respiratory, nylon powder, electromagnetic fields

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Introduction

On February 28, 2006, NIOSH received a request for an HHE at Dana Corporation in Bristol, Virginia from the United Auto Workers, Local 9023. The HHE requestors were concerned that poor indoor environmental quality and exposures to chemicals, nylon powder, and dust from grinding machines were causing dermatitis, nose bleeds, and respiratory problems and that SRMF levels from induction heaters might be causing cancer. Discussions held with union and management representatives determined that dermatitis was the major concern among employees.

On June 13–15, 2006, NIOSH investigators conducted an evaluation that included an opening conference with management and union representatives, a tour of the plant, observations of work practices, and exposure and health assessments. We measured SRMF levels near the induction heaters, collected bulk MWF samples, evaluated potential acid gas exposures, assessed LEV effectiveness at the nylon powder fluidized bed coating operation and the acid dip tank, interviewed employees, performed medical evaluations of the skin, and took photos of skin conditions. Because the Bristol plant was slated to close in January 2007 and most of the machinery was to be moved to another plant, an interim report was sent to management and union representatives on September 22, 2006. The interim report provided results of the SRMF and ventilation assessment, observations of work practices and PPE, and preliminary results describing employee symptom prevalence. This final report includes information from the interim report as well as results from chemical analysis of the MWFs, employee interview data, medical record review, and final recommendations. We encourage Dana Corporation to use our recommendations at other facilities that may have similar exposures or problems.

Process Description

Dana Corporation began operating its Bristol, Virginia, plant in 1989. At the time of the NIOSH evaluation the Bristol plant employed over 200 employees on three shifts: 7:00 a.m. – 3:00 p.m., 3:00 p.m. – 11:00 p.m., and 11:00 p.m. – 7:00 a.m., 7 days a week. Allowable time off from work coincided with machine breakage or was given with management approval during the time that the plant was readying for closure. Maintenance of MWFs was contracted to Chemtool Incorporated (Crystal Lake, Illinois). Three Chemtool technicians (one per shift) and one manager (day shift only) were present at this plant. During the NIOSH evaluation, Departments 3, 5, 28, and 40 were considered by union and management representatives to be locations of highest MWF exposures, therefore, the main focus of our evaluation.

Department 3 included two lines, the slip yoke line (12–13 employees) and the lost foam line (2–3 employees). Nickel-coated parts had been machined in this department previously, but this operation was terminated at least 2 months prior to the NIOSH visit. Machines in this area used Nusol 21HP, a soluble MWF, having switched from Lubricut 4265 approximately a year before this evaluation. These machines had individual MWF reservoirs, and old MWF was reclaimed and reused.

Department 5 consisted of both light duty (smaller) parts grinding machines (eight employees), and heavy duty (larger) parts grinding machines (five employees). Both light and heavy duty processes used Lubricut 4265 and had their own central MWF system. About 3–4 months prior to the NIOSH evaluation, Dana Corporation management tried Nusol 21HP in the light duty central MWF system, but use of Lubricut 4265 was resumed. Management representatives reported that no biocides or emulsifiers were necessary in the two central systems because the MWF was changed every 3 days and not recycled; therefore, microbial growth was minimal. At the time of the evaluation the Department 5 rough-turn station, an operation that the union reported often generated visible airborne MWF mist, had not operated for 2 days due to a missing part.

Department 28 (nine employees) included one induction heater for heating parts before dipping in a nylon powder and limestone mixture (Corvel™ Blue). In this process, the nylon powder and limestone mixture is dispensed from a 55-gallon drum, fluidized, and then melted to the metal parts to form a protective coating. Lubricut 1050 (semi-synthetic MWF) was used on aluminum parts (most of Department 28 machines) and Nusol 21HP on non-aluminum parts in the Citi 1 and Citi 4 machines. All machines in Department 28 had individual MWF reservoirs.

In Department 40, four induction heaters were used to harden metal parts. Following hardening, metal parts were cleaned by dipping in a hydrochloric acid bath, then transferred to the nylon coating operation. Coated parts were cooled in a water bath and packaged. Two employees per shift operated the four induction

Introduction (continued)

heaters, and five employees per shift operated the nylon coating line. The induction heaters used Aquaquench 365 as a MWF; other machines in Department 40 used Nusol 21HP MWF. All machines had individual MWF reservoirs.

Both Nusol 21HP and Lubricut 1050 were reclaimed by filtering, skimming off fugitive hydraulic oil, and adding small amounts (8 ounces) of the biocides Kathon® 886 and Busan® 77 to the MWF. The biocides were only used in reclaimed MWFs, and management reported that fluids in machines using reclaimed MWFs were changed every 30 days.

Assessment

Metalworking Fluids

We collected eight bulk samples of MWF (four unused and four used) from Departments 3, 5, 28, and 40. In addition, five bulk samples of machine lubricating oils were collected because they often leak into the MWFs, and employees thought these oils worsened their dermatitis. Two of the five lubricating oil samples were unused samples of Way Lube and AW Hydraulic, the two most commonly used machine lubricating oils at the plant. Finally, unused samples of Kathon 886 and Busan 77, two biocides added to the recycled MWFs, were collected. Bulk samples of MWFs, lubricating oils, and biocides were submitted for chemical analysis. We did not collect air samples of MWF because the main concern associated with MWFs was dermatitis and because we considered the working conditions to be atypical in MWF areas due to the pending closure of the plant. Appendix A describes the MWF collection and analysis methods, while Appendix B provides a detailed discussion of MWF and MWF additive health effects and OELs.

Sub-radiofrequency Magnetic Fields

A calibrated 3-axis SRMF meter with an isotropic probe (Model 3637, Holaday Industries, Inc., Eden Prairie, Minnesota) was used to measure magnetic flux density in µT. Measurements were made during the day shift around four induction heaters (referred to as Cells 1, 2, 4 and 5) in Department 40 and one induction heater in Department 28. Operators set up the parts in an induction heater, started the run cycle, then moved to the next induction heater and began setting up another batch of parts. Because the operator was not close to any given induction heater during a run cycle, we measured SRMF strength near the center of Department 40 to approximate employees' exposures when several induction heaters were operating.

In addition to measuring SRMF strength in the center of the induction heating area, we attempted to evaluate the SRMF strength from each induction heater. The SRMF meter was held at a height of 110 cm from the ground and approximately 120 cm from the shielding door of the induction heater being evaluated. Three readings were taken at the location and were averaged. A series of similar measurements were taken at decreasing 30 cm distances to an induction heater door, with the closest adjacent induction heater turned off. For example, when the SRMF strength measurements were made near Cell 1, Cell 5 (the nearest induction heater) was off. The operating frequency of each of the induction heaters was also noted during these measurements. Appendix B provides a detailed discussion of potential SRMF health effects and OELs.

Hydrochloric Acid, Nylon Powder, and Ventilation

Dräger® (Dräger Safety Inc., Pittsburg, Pennsylvania) colorimetric detector tubes were used to monitor for hydrochloric acid in Department 40 where employees worked near a hydrochloric acid bath. We also used ventilation smoke tubes as visual air flow indicators to evaluate the effectiveness of LEV at the nylon powder fluidized bed coating operation and the acid dip tank.

Other Health and Safety Issues

We observed work practices, PPE used by employees, and types of hand cleaners and barrier creams used by employees. We discussed MWF maintenance procedures and reviewed MWF maintenance records with the consulting MWF technician.

Medical

Confidential interviews and medical examinations of the skin were conducted among employees on first and second shifts from Departments 3, 5, 28, and 40. We spoke to all employees in Departments 3 and 5 and to employees in Departments 28 and 40 who were available on the days of our evaluation. Interviews focused on medical and occupational history and work-related symptoms. If the employee gave his/her permission, photos of the employee's skin rashes were taken after the interview for documentation and teaching purposes.

We defined work-related contact dermatitis as meeting five of the following seven criteria described by Mathias [Mathias 1989]:

1. Is the clinical appearance consistent with contact dermatitis?
2. Are there workplace exposures to potential cutaneous irritants or allergens?
3. Is the anatomic distribution of dermatitis consistent with the form of cutaneous exposure in relation to the job task?
4. Is the temporal relationship between exposure and onset consistent with contact dermatitis?
5. Are non-occupational exposures excluded as likely causes?
6. Does removal from exposure lead to improvement of dermatitis?
7. Do patch tests or provocation tests implicate a specific workplace exposure?

The OSHA 300 Logs of Work-Related Injuries and Illnesses for years 2005 and 2006 were reviewed. Medical records of employees with dermatitis who had seen a medical professional for this problem, along with information on employee hand-cleaning agents and PPE provided by management were also reviewed.

RESULTS AND DISCUSSION

Metalworking Fluids

Components identified in the chemical analyses of bulk MWF samples are presented in Table 1. They included triethanolamine, neodecanoic acid, hexanol, sulfurized hydrocarbons, mineral oil, and C10, C12, and C14 alcohols. Neither of the two biocides used at Dana Corporation (Kathon 886 and Busan 77) were in the MWFs that we sampled, but formaldehyde was identified in three of the samples.

Table 1. Organic Chemicals Identified in New and Used MWFs or Additives

Sample No.	MWF type	Fomaldehyde* (µg/mL)	Other Organic Chemicals	Biocides
1	Soluble, used	ND**	Triethanolamine	None
2	Synthetic, used	13.2	Triethanolamine; neodecanoic acid	None
3	Synthetic, used	ND	Triethanolamine; hexanol	None
4	Synthetic, used	ND	Triethanolamine	None
5	Soluble, new	ND	Triethanolamine	None
6	Synthetic, new	392	Triethanolamine; neodecanoic acid	None
7	Soluble, new	724	C10, C12, C14 alcohols; sulfurized hydrocarbons	None
8	Synthetic, new	ND	Triethanolamine	None
9	Straight, new		Mineral oil	None
10	Straight, new	Analytical	Mineral oil	None
11	Biocide, new	problem †	Kathon 886	Kathon 886
12	Biocide, new		Busan 77	Busan 77

*Formaldehyde identified by HPLC.
**For samples 1, 3, 4, 5, and 8 the Limit of Detection for formaldehyde was 4 µg/mL.
† The lack of information on partition coefficients caused uncertainty in the formaldehyde results.

Sub-radiofrequency Magnetic Fields

The SRMF measurements recorded in Department 40 are listed in Table 2.

Table 2. SRMF Measurements in Department 40

Distance to Induction Heater Door (cm)	SRMF Average (µT)			
	Cell 1	Cell 2	Cell 4	Cell 5
0	103.33	120	205	106.67
30	23.33	26.67	40	19.33
60	7.93	9.33	14.25	6.17
90	3.73	3.6	5.75	3.23
120	1.73	1.8	3.1	1.47
ACGIH TLV	200 µT			

The operating frequency for Cells 1, 2, and 5 was 9.6 kHz.
The operating frequency for Cell 4 was 3.2 kHz.

The SRMF measurement near the center of Department 40, approximately equidistant from the four induction heaters, was 0.6 µT. Based on our observation of work practices, we believe that the SRMF measurements taken at this Department 40 location best approximated employees' potential exposures. The SRMF level of 0.6 µT was measured when either two or three cells were simultaneously operating (Cells 1, 5, and 4; Cells 1 and 5; or Cells 5, 2, and 4). We did not observe a time when all four cells operated simultaneously.

Results and Discussion (continued)

The induction heater in Department 28 was operated at an output frequency of 10,000 Hz. The SRMF measurements were taken during daytime and are tabulated in Table 3.

Table 3. SRMF Measurements in Department 28

Distance to Induction Heater Door (cm)	SRMF Average (μT)
0	70
20	28.67
40	13.33
60	6.33
80	3.93
ACGIH TLV	200 μT

Few measurements on induction heaters have been reported in the scientific literature, but available results suggest that induction heater operators can be exposed to SRMF levels that are high relative to applicable OELs [Lovsund et al. 1982; Stuchly and Lecuyer 1985; NIOSH 1992; Decat et al. 2006]. Our review of this limited literature also suggests that the hands received the highest exposure while, in most cases, the total body exposure was low. In these published case reports the induction processes were not shielded, and parts were handled manually by the operators. In contrast, the induction heaters at Dana Corporation were shielded and the heat-treated parts were handled by an automated process, which likely contributed to the low SRMF measurements at this plant.

Of all the SRMF measurements collected during our evaluation, only a single measurement (recorded at the shielding door of Cell 4) exceeded the ACGIH TLV of 200 μT. However, this location is not representative of a personal exposure because employees would not spend long periods of time near the cells while they were operating. None of the SRMF measurements we collected exceeded the applicable IEEE standards listed in Table B1 (see Appendix B). Finally, the maximum SRMF measurement taken at the approximate center of the induction heating area in Department 40 was 0.6 μT, well below the ACGIH TLV of 200 μT. Likewise, in Department 28 the maximum SRMF measurement was 70 μT, also below the ACGIH TLV.

Hydrochloric Acid, Nylon Powder, and Ventilation

Hydrochloric acid was not detected by detector tubes used in the breathing zone of the employee closest to the dip tank. Detector tubes have an accuracy of +/– 25%–30% and a measuring range of 1–10 ppm. Visual inspection of smoke patterns generated by smoke tubes showed that the LEV system for the acid dip tank was exhausting acid mist away from the employee.

The smoke patterns around the fluidized bed where nylon was coated onto the parts suggested that the LEV was effective in capturing particulates during normal operations. Because we did not observe employees changing the bulk nylon powder/limestone supply, we cannot comment on the effectiveness of the LEV during this activity. However, we did notice a blue powder that had settled on horizontal surfaces surrounding the fluidized bed coating operation. In addition, we observed that the drum containing the bulk nylon powder/limestone mixture was uncovered on the second day of our visit. Release of the nylon powder is of special concern because the MSDS for this product noted a risk of a dust explosion (lower explosive limit of 30%–70% by volume).

Other Health and Safety Issues

We observed employees using compressed air to blow particulates off metal parts. Not only are flying metal chips a safety hazard, but MWF aerosols generated during this activity could be inhaled and clothing could become soaked with MWF. OSHA requires that compressed air used for cleaning be reduced to less than 30 psig, and it should only be permitted with effective chip guarding and PPE to protect employees from the hazards of the release of compressed air and flying debris [29 CFR 1910.242(b)].

At a parts cleaning operation in Department 28, we observed abrasive slag-grit visibly leaking out of the ductwork and accumulating on the floor.

Employees in Departments 3 and 5 were observed using a solvent-based, anti-rust spray (Anticorit SL® 306-B, Fuchs Lubricant Co. Harvey, Illinois) without LEV, potentially exposing employees to VOCs. We observed hydraulic oil layered on top of the MWF in several machine reservoirs, indicating machine and MWF maintenance was inadequate.

We observed all employees using safety glasses and hearing protection, which were required in the production areas. Although not required by the company, employees generally wore 15-millimeter, flock-lined, wrist-length nitrile gloves. A small number of employees also chose to wear Tyvek® sleeves and aprons for further protection from MWFs. Many employees wore shorts and short-sleeve shirts because of the warm temperatures (approximately 90°F) in the plant. Employees wore N95 particulate respirators on a voluntary basis when changing out drums of nylon powder. These respirators were not easily accessible to employees, i.e., when a management representative was asked to locate a respirator for NIOSH investigators to inspect, the respirators were not in the immediate work vicinity.

Medical

Confidential interviews were conducted with employees working in Departments 3, 5, 28, and 40 during first and second shifts on June 14–15, 2006. Of the 94 first- and second-shift employees, a total of 71 (76%) were interviewed as follows: 22 of 22 (100%) in Department 3; 24 of 25 (96%) in Department 5; 15 of 27 (56%) in Department 28; and 10 of 20 (50%) in Department 40. In addition, one maintenance employee was interviewed. Among the 72 interviewees, the average age was 46 (range: 21–61 years), and the average number of years working at Dana Corporation was 11 years (range: 0.5–18 years).

Of the 72 interviewees, 37 (51%) reported a prior or current skin problem that they related to their work. Fifteen of the 37 (42%) had seen a medical provider because of the skin rash. Of the 72 interviewed employees, 15 had rashes on the day of the evaluation and were examined by a NIOSH physician; these included 12 machine operators, two induction machine operators, and one maintenance employee. Of these 15, eight reported seeing a medical provider because of their rash, and three reported a diagnosis of contact dermatitis. Two of the 15 employees reported having a skin condition before working at Dana Corporation, two reported a diagnosis of asthma, one reported a diagnosis of sarcoidosis, and six reported environmental allergies (including allergic rhinitis, food allergies, and poison ivy contact dermatitis). Table 4 lists the rash characteristics, PPE use, and preventive measures followed by these employees.

Table 4: Interview Data from Employees With a Current Skin Rash (N=15)	
Rash Characteristic or Preventive Measure	Number (%) Reporting "Yes"
Rash developed in past 2 years (new onset)	9 (60%)
Rash on fingers, hands, wrists, forearms, and/or arms	13 (87%)
Rash improved away from work	7 (47%)
Saw a medical provider for rash	8 (53%)
Changed work area due to rash	3 (20%)
Wore gloves >75% of time at work	14 (94%)
Wore sleeves regularly	3 (20%)
Used barrier creams	4 (27%)
Predominantly used GOJO® Multi-Green Hand Cleanser with Scrubbing Particles	6 (40%)
Predominantly used GOJO® Pink antimicrobial Lotion Soap	3 (20%)

Using criteria for establishing occupational causation [Mathias 1989], information from individual employee skin examination, and medical and work history, we determined that 11 of the 15 employees with rash at the time of the evaluation had findings consistent with work-related contact dermatitis. One employee had a pre-existing skin condition that was probably made worse by work exposures. Three employees had rashes that did not have work-related characteristics.

Skin contact with MWFs (and MWF additives, including biocides) may cause both allergic and irritant contact dermatitis. Additional factors include how well MWFs are maintained, work practices, type and use of PPE, employee knowledge of the importance of maintaining healthy skin, and type of hand cleansers and lotions used. Appendix C provides a discussion about contact dermatitis, its relationship to work, and ways to prevent contact dermatitis.

Respiratory symptoms were also reported by employees. Sinus problems were reported most often (29 employees), followed by cough (20 employees), shortness of breath (12 employees), wheeze (8 employees), and chest tightness (5 employees). Three employees reported being diagnosed with a respiratory disorder since working at Dana Corporation; one with asthma, one with sarcoidosis, and one with "industrial pneumonia." Inhalation of MWF aerosols (and additives used in MWFs) may cause irritation of the throat, nose, and lungs and may cause asthma or worsening of pre-existing respiratory problems [NIOSH 1998].

Results and Discussion (continued)

We requested employees' medical records from those who had seen a physician for potentially work-related skin and respiratory conditions; ten records were received. Based on these ten medical records, six employees had been diagnosed with contact dermatitis, of which five cases were determined to be work-related (one had no determination of work-relatedness). One of these five employees had skin biopsy and patch testing results consistent with allergic contact dermatitis, with skin allergy to Quaternium-15, a formaldehyde-releasing preservative used in many cosmetics and industrial chemicals. However, management reported that Quaternium-15 is not used at Dana Corporation. This employee was not skin patch tested to specific MWFs, biocides, or mixtures used at work. The other four employees were not diagnosed with work-related problems.

Four of the 24 entries in the 2005 OSHA 300 Logs were for rash, and all were employees working in Department 5. Between January 1 and June 13, 2006, 12 entries were recorded; one of these entries was for rash in an employee working in Department 3.

Hand cleaners available to employees included the following: GOJO® Original Formula Heavy Duty Hand Cleaner, GOJO® Pink Antimicrobial Lotion Soap, GOJO® Multi Green® Hand Cleanser with Scrubbing Particles. The barrier cream supplied to employees with dermatitis was SBS-46 Solvent-Resistant Protective Cream. Table 5 lists the ingredients for these products. In general, the use of hand products containing petroleum distillates and other organic solvents tends to dry the skin and break down the skin's natural protective barrier, which can lead to skin irritation and a greater risk of allergic contact dermatitis. Grit, or pumice, when overused, may lead to the same problem. Many skin products, both for industrial and personal use, contain skin sensitizing ingredients such as d-Limonene, parabens, ethanolamines, and fragrances. The concentration of these ingredients is key; the higher the concentration, the more likely a sensitization reaction may occur. Hypo-allergenic skin products for industrial use have been developed to reduce this risk. Appendix C provides a discussion about contact dermatitis, its relationship to work, and ways to prevent contact dermatitis.

Table 5: Hand Products Used at Dana Corporation and their Major Ingredients

Product	Ingredient(s) Listed in the MSDS
GOJO® Original Formula Heavy Duty Hand Cleaner	Nonionic surfactants (3%–7%), petroleum distillates (40%–70%), propylene glycol (1%–5%)
GOJO® Pink Antimicrobial Lotion Soap	Ethanolamine (<3%), oleic acid
GOJO® Multi Green® Hand Cleanser with Scrubbing Particles	d-Limonene
SBS-46 Solvent-Resistant Protective Cream	Purified water, stearic acid, propylene glycol, talc, cetyl alcohol, bentonite, TEA-Stearate, PEG-75 lanolin, methylcellulose, methylparaben, titanium dioxide, chloroxylenol, propylparaben

Several employees and one MWF technician commented that MWF was changed without the machines first being adequately cleaned, and in some cases scheduled MWF changes were delayed for months. Thorough cleaning of machines is important to prevent recontamination of new MWFs with bacteria and fungi. Proper MWF management is an important part of reducing potential health effects related to working with MWFs.

Conclusions

NIOSH investigators conclude that skin contact with MWFs and improper MWF maintenance caused or contributed to contact dermatitis in the Dana Corporation workforce. We observed employee skin exposure to MWFs, identified irritating or sensitizing chemical components of the MWFs, and found instances where the company failed to follow recommendations for proper MWF maintenance. We also found inadequate employee training in the safe use and handling of MWFs and poor maintenance on machines that used MWFs. Although the focus of this evaluation was skin rash, some interviewed employees reported experiencing respiratory symptoms that might be related to MWF exposure.

Employees were not overexposed to SRMF in the induction heating area or to hydrochloric acid mist in Department 40. The LEV at the nylon powder coating operation appeared adequate to control the particulate being applied to parts. While we did not assess the LEV while the nylon powder drums were being changed, we did notice a layer of the powder on surfaces in the vicinity, suggesting that the LEV may be inadequate during this activity. Anti-rust spray use in some areas without LEV may expose employees to VOCs, and the use of compressed air above 30 psig for cleaning metal parts was a hazardous work practice due to airborne particulate.

Recommendations

Despite this operation's move to Mexico in 2007, we are including these recommendations so that Dana Corporation management may apply them to similar situations at their other facilities. Engineering controls (i.e., substitution, enclosures, mist collectors, improved ventilation) have the most impact on employee health and safety and are the preferred methods for reducing workplace exposures. Administrative and PPE recommendations should be implemented until engineering controls are operational.

1. Maintain MWFs as part of a comprehensive preventive maintenance program as specified in Chapter 9 of the 1998 NIOSH document, "Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids" [NIOSH 1998]. This includes cleaning machines thoroughly prior to adding clean MWF.
2. Fix machines that are leaking hydraulic oil to prevent contaminating the MWF.
3. Do not use compressed air over 30 psig to clean metal parts. Using compressed air above this pressure creates a safety hazard from flying metal chips, could generate aerosols that employees could inhale, and may saturate employees' clothing with MWF.
4. 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.
5. Minimize the use of anti-rust spray, and use only in well-ventilated areas.
6. Establish a safety and health committee composed of employees and management to facilitate communication and ideas to resolve health and safety problems.
7. Encourage employees to report all potential work-related skin problems to their supervisors. 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 employee. 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, employees may have to be reassigned with retention of pay and employment status to areas where exposure is minimal or nonexistent.

8. Encourage employees to report all potential work-related respiratory problems to their supervisors. These employees should be evaluated by a physician knowledgeable about occupational lung diseases. In some cases of allergic occupational asthma and HP, employees may have to be reassigned with retention of pay and employment status to areas where exposure is minimal or nonexistent.

9. 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 that may be associated with certain health effects. (See Chapter 9 in the NIOSH MWF criteria document [NIOSH 1998]).

10. Provide training to employees in the potential hazards of MWF exposure and work practices that prevent skin exposure (see contact dermatitis discussion in Appendix C). Information on moisturizers, soaps, and skin cleaners should be included because some components (e.g., lanolin and fragrances) are known allergens and may cause allergic contact dermatitis in sensitive individuals.

11. Encourage employees to take prompt action when their skin or clothing contacts MWFs. For example, 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 reuse.

12. Encourage the use of protective goggles and nitrile gloves, sleeves, and aprons when working with MWFs. Exactly which PPE and when it should be used should be determined by the company with employee involvement. 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 according to OSHA requirements [29 CFR1910.132].

13. Evaluate employee exposure to nylon powder during tasks such as opening fresh material containers, dumping material into supply hoppers, cleaning or performing maintenance on equipment, and/or disposing of empty material containers. If exposures are above applicable OELs, provide NIOSH-certified particulate respirators for employees involved in performing these tasks, in conjunction with a respirator protection program, until LEV improvements lower nylon powder exposure to acceptable levels. NFPA 33, Section 13-5 specifies and establishes proper ventilation guidelines [NFPA 2007].

14. Provide facilities for employees to wash nylon powder and MWFs off their exposed skin. Frequent skin washing will help reduce the chance for skin reactions to the powder and MWF exposure. Cleaning the skin with organic solvents, however, should never be encouraged. [Association for Finishing Processes of the Society of Manufacturing Engineers 1993].

15. Nitrile gloves should be easily accessible and worn by employees handling the nylon powder coating material. Glove use will help prevent drying of the skin that can be caused by extensive skin contact with the powder.

16. Incorporate safe operating and maintenance procedures for the powder coating system including: a) storing and handling powder materials; b) spraying parts within a spray booth; c) conveying parts through the spray booth; d) cleaning and maintaining equipment; e) troubleshooting equipment; f) starting up and shutting down the system; g) reading, calibrating, and setting control gages and regulators; h) recording daily critical ventilation pressure readings; i) responding to alarms, interlocks, and system safety oriented control devices; and j) disposing of waste materials. Guidelines for proper safe operating procedures are provided by the NFPA in several publications and have been incorporated into governing OSHA regulations [29 CFR 1910 (General Industry); NFPA 1990; NFPA 33 2007].

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APPENDIX A: METHODS

Metalworking Fluids

Twelve bulk samples of new and used MWFs or MWF additives were collected and stored in 500-milliliter Nalgene™ bottles. The initial analysis requested was for triazine and phenol, organic biocides often found in many MWFs and which are thought to be related to many cases of dermatitis in employees exposed to MWFs. However, qualitative results indicated no triazine and 4-chloro-3-methyl phenol in any samples. The biocides Kathon 886 and Busan 77 were known to be used at the site, and the analytical targets for analysis were changed to these biocides by the analyst.

According to the MSDS, sample 11 (Kathon® 886) and sample 12 (Busan® 77) were biocide additives. Using a pure standard provided by Rohm and Hass, the manufacturer of Kathon® 886, we certified sample 11 to be Kathon® 886. Certified standards of Busan® 77, a polymer, were not obtained; however, the chemical identity of Busan® 77 was confirmed by GC-MS. Samples 11 and 12 were used as standard reference samples for the remaining MWFs. Qualitative analysis was performed for the presence of biocide; the amount of biocide was not quantified.

The MWF samples were analyzed by HPLC with simultaneous ultraviolet absorption and charged aerosol detection. Samples 1, 2, 3, 4, 5, 7, 8, and 13 were analyzed by direct injection into the analytical instrument after centrifuging the samples to remove any dirt. Samples 9 and 10 were straight oils and were dissolved in organic solvent before injection. Ten microliters of each sample were injected into the HPLC solvent flow system. HPLC separated the formulations into their components and, as the components eluted out of the system, the components were detected initially by ultraviolet light absorption and then by charged aerosol ionization. The identity of a component was determined by matching its retention time in the system with that of a known reference standard in another run.

The samples were also analyzed by direct injection to quantitatively detect organic components of the MWFs, using a cool-on-column GC-MS technique. The GC-MS instrumentation was an Agilent 6890 GC & 5973 MS-system. Capillary chromatography is a high resolution technique that can separate the volatile components of a metalworking fluid applied to the column. Mass spectrometry detection can provide mass spectral data for molecular structure identification of the components as they elute off the column. This identified some of the components seen in the HPLC chromatogram.

Analysis for formaldehyde and acetone in the MWF samples was performed using NIOSH Method 2019 [NIOSH 2008]. Acetonitrile (6 milliliter) was mixed with 6 milliliters of each of the 12 field samples in 20-milliliter scintillation vials. Supelco S10 LpDNPH samplers were fortified with the acetonitrile/MWF sample solution and were allowed to stand at room temperature for 2 days. Derivatives formed with formaldehyde and acetone were eluted with acetonitrile and analyzed with HPLC with an ultraviolet detector set at 360 nanometers. Calibration curves were prepared for comparison. This method has been validated for formaldehyde in air but not for formaldehyde in MWFs, and consequently, it remains a research method.

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Appendix B: Occupational Exposure Limits and Health Effects

In evaluating the hazards posed by workplace exposures, NIOSH investigators use both mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents as a guide for making recommendations. OELs have been developed by Federal agencies and safety and health organizations to prevent the occurrence of adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure to which most employees may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. However, not all employees will be protected from adverse health effects even if 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 employee to produce health effects even if the occupational exposures are controlled at the level set by the exposure limit. Also, some substances can be absorbed by direct contact with the skin and mucous membranes in addition to being inhaled, which contributes to the individual's overall exposure.

Most OELs are expressed as a TWA exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended STEL or ceiling values where health effects are caused by exposures over a short period. Unless otherwise noted, the STEL is a 15-minute TWA exposure that should not be exceeded at any time during a workday, and the ceiling limit is an exposure that should not be exceeded at any time.

In the U.S., OELs have been established by Federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits, while others are recommendations. The U.S. Department of Labor OSHA PELs [29 CFR 1910 (general industry); 29 CFR 1926 (construction industry); and 29 CFR 1917 (maritime industry)] are legal limits enforceable in workplaces covered under the Occupational Safety and Health Act. NIOSH RELs are recommendations based on a critical review of the scientific and technical information available on a given hazard and the adequacy of methods to identify and control the hazard. NIOSH RELs can be found in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2005]. NIOSH also recommends different types of risk management practices (e.g., engineering controls, safe work practices, employee education/training, personal protective equipment, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects from these hazards. Other OELs that are commonly used and cited in the U.S. include the TLVs recommended by ACGIH, a professional organization, and the WEELs recommended by the American Industrial Hygiene Association, another professional organization. The TLVs and WEELs are developed by committee members of these associations from a review of the published, peer-reviewed literature. They are not consensus standards. ACGIH TLVs are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2007]. WEELs have been established for some chemicals "when no other legal or authoritative limits exist" [AIHA 2007].

Outside the U.S., OELs have been established by various agencies and organizations and include both legal and recommended limits. Since 2006, the Berufsgenossenschaftliches Institut für Arbeitsschutz (German Institute for Occupational Safety and Health) has maintained a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the U.S. [http://www.hvbg.de/e/bia/gestis/limit_values/index.html]. The database contains international limits for over 1250 hazardous substances and is updated annually.

Employers should understand that not all hazardous chemicals have specific OSHA PELs, and for some agents the legally enforceable and recommended limits may not reflect current health-based information. However, an employer is still required by OSHA to protect its employees from hazards even in the absence of a specific OSHA PEL. OSHA requires an employer to furnish employees a place of employment free from recognized hazards that cause 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, NIOSH investigators encourage employers to make use of other OELs when making risk assessment and risk management decisions to best protect the health of their employees. NIOSH investigators also encourage the use of the traditional hierarchy of controls approach to eliminate or minimize identified workplace hazards. This includes, in order of preference, the use of: (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) personal protective equipment (e.g., respiratory protection, gloves, eye protection, hearing protection). Control banding, a qualitative risk assessment and risk management tool, is a complementary approach to protecting employee health that focuses resources on exposure controls by describing how a risk needs to be managed [http://www.cdc.gov/niosh/topics/ctrlbanding/]. This approach can be applied in situations where OELs have not been established or can be used to supplement the OELs, when available.

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 [OSHA 1999]. 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 [NIOSH 1998].

Exposure to MWFs can result from inhalation of aerosols or from skin contact due to contaminated surfaces, handling of parts and equipment, and splashing of fluids [NIOSH 1998]. 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, HP, and worsening of pre-existing respiratory problems [NIOSH 1998]. 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 [CDC 1996; Kreiss 1997; Zacharisen 1998]. 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 [NIOSH 1998]. Petroleum-based products may cause occupational acne [WISHA 1977]. 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, NIOSH recommended limiting exposures to MWF aerosols to 0.4 mg/m^3 for the thoracic particulate mass, as a TWA concentration for up to 10 hours per day during a 40-hour workweek [NIOSH 1998]. 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 employees have developed work-related asthma, HP, or other adverse respiratory effects when exposed to MWFs at lower concentrations [NIOSH 1992]. Limiting exposure to MWF is also prudent because certain MWF exposures have been associated with various cancers. 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 employees at Dana Corporation. 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 a definitive conclusion.

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 evaluations comparing MWF components identified by analysis to components listed on the MWF MSDS have found that MSDSs can be incomplete. Potential reasons for incomplete MSDSs include, among others: (1) certain components are considered proprietary information, (2) a lack of MSDS regulation enforcement, and (3) a lack of analytical methods for some components. 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 in 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) are limited by OSHA PEL and NIOSH REL to 5 mg/m^3. NIOSH also recommends a 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 [Proudfit 1950]. 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 [IARC 1982]. It is thought that the presence of 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, 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 [IARC 1987].

Ethanolamines

Ethanolamines, including monoethanolamine and triethanolamine, 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 [Shrank 1985; Alomar 1985]. At ambient temperatures they are likely to be airborne in greater concentrations as an aerosol than a vapor [O'neil 2006]. Ttriethanolamine, 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 [Hathaway 1996]. No OSHA PEL or NIOSH REL exists for triethanolamine, but the ACGIH has a TLV-TWA of 5 mg/m^3. For monoethanolamine, 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.

Biocides

Antimicrobial agents are often added to water-containing MWFs (soluble oils, semi-synthetic, and synthetic MWFs) because these types of MWFs can support microbial growth. Busan® 77, one of two biocides identified in bulk samples collected at Dana Corporation, contains the active ingredient polixetonium chloride, or poly{oxyethylene(dimethylimino)ethylene(dimethylimino)-ethylene dichloride}

(CAS#31512-74-0), a polymeric quaternary compound. According to the MSDS, this compound is a mild irritant to the skin and eyes. No OELs exist for this compound.

The second biocide is Kathon® 886, a product used to control slime-forming bacteria, fungi, and algae in MWF systems, among other uses. The ingredients listed on the MSDS for Kathon 886 include: 5-chloro-2-methyl-4-isothiazolin-3-one; 2-methyl-4-isothiazolin-3-one; magnesium nitrate; magnesium chloride; and water. Both isothiazolinone compounds have been found to be skin sensitizers [Gruvberger 1997].

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) [Chan-Yeung 1993]. ACGIH designates formaldehyde as a sensitizer. Individuals vary in terms of their tolerance and susceptibility to formaldehyde exposure [NIOSH 1977].

NIOSH recognizes formaldehyde as a potential occupational carcinogen and determined the REL for air exposures to be 0.016 ppm, TWA, with a 15-minute ceiling of 0.1 ppm, based on animal data and the 1981 analytical limits of detection. The OSHA PEL is 0.75 ppm as an 8-hour TWA and 2 ppm as a STEL [OSHA 1992].

Sub-Radiofrequency Magnetic Fields

Electromagnetic radiation is a self-propagating wave that has both electric and magnetic field components oscillating perpendicular to each other and to the direction of propagation of the wave. Electromagnetic radiation is classified based on the frequency of the waves ranging from radio waves to gamma rays. ACGIH defines SRMF as the magnetic field flux density of electromagnetic waves with frequencies below 30 kHz.

Many of the observed biological effects of exposure to what is known as microwave and RF radiation can be attributed to a rise in body temperature. The heating effect of microwave and RF radiation depends on the amount of energy absorbed by the body. The rate of absorption is measured in watts per kilogram for the whole body or parts of the body and depends on many factors such as the frequency and intensity of the radiation, size and shape of the exposed employee, and their orientation in the radiation field. These factors influence the extent of heating of internal tissues. Human and animal studies show that exposure to a RF field above OELs may cause harmful biological effects as a result of heating of internal tissues [ACGIH 2001; IEEE 2005]. The thermal effects can manifest as a subjective sensation of warmth on the exposed area or burns ranging from minor sunburn or first degree burn to more extensive tissue damage. With respect to low-level (non-thermal) RF exposure, evidence to date does not show clear or consistent evidence to indicate a causal role of RF exposures in connection with human cancer or other disease [IEEE 2005].

At the present time no OSHA or NIOSH occupational exposure criteria exist for SRMF covering the frequency region from 0.1 to 30,000 Hz. However, ACGIH has published TLVs for SRMF in this frequency region [ACGIH 2001]. The TLV for SRMF in the very-low-frequency band of 300 to 30,000 Hz (a band that covers the frequencies used at this plant) states "routine occupational exposure" should not exceed the ceiling value of 200 µT.

Another standard for occupational exposure to microwave and RF is the IEEE standard published under the auspices of the American National Standards Institute and known as IEEE C95.1-2005 [IEEE 2005]. This standard provides recommendations to minimize aversive or painful electrostimulation in the frequency range of 3,000 Hz to 5,000,000 Hz. Electrostimulation limits apply for frequencies below 100,000 Hz, and thermal limits apply for frequencies above 5,000,000 Hz.

Controlled exposure limits as expressed in IEEE C95.1-2005 apply to persons exposed as a consequence of their employment, provided they are fully aware of the potential for exposure and can exercise control over their exposure. For employees exposed as a consequence of their employment but who lack awareness, safety training, or control over their exposure, the uncontrolled exposure limits prescribed for the general population apply. Regardless of which category is used, the consensus of the scientific community is that exposure to RF radiation below recommended guidelines is safe. The IEEE standards applicable for the frequency ranges in Departments 40 and 28 at the time of this NIOSH evaluation are listed in Table B1. Table B2 provides the formulas to calculate maximum permissible IEEE exposures limits for other frequencies.

Table B1. Applicable Maximum Permissible IEEE Exposure for Occupational Environments

Cell Number	Frequency (Hz)	SRMF (µT) Controlled Environment		SRMF (µT) Uncontrolled Environment	
		Head and Torso	Limbs	Head and Torso	Limbs
Cell 4	3200	643.8	1184.4	214.7	1184.4
Cell 1, 2, and 5	9600	615	1130	205	1130
HIS 100/10	10,000	615	1130	205	1130

Table B2. Calculating the Maximum Permissible IEEE Exposure for a Controlled Occupational Environment*

Frequency (kHz)	SRMF (millitesla)†	
	Head and Torso	Limbs
3 – 3.35	2.06/f	3.79/f
3.35 – 5000	0.615	1.13

* The averaging time for a root mean square SRMF measurement is 0.2 seconds.
† One millitesla is equal to 1000 µT.
f = Kilohertz (equal to 1000 Hz)

Nylon Powder Coating

Corvel® Blue is a thermoplastic nylon powder coating applied to metals to increase durability and resistance to chemicals, solvents, and abrasions, and to facilitate cleaning. Nylon powders are almost all based on type 11 nylon resin and offer tough coatings that have excellent abrasion, wear, and impact resistance with a low coefficient of friction when applied over a suitable primer [Association for Finishing Processes of the Society of Manufacturing Engineers 1993]. Inhalation of the powder may cause irritation of the nose, throat, and lungs; contact to eyes and skin may lead to eye and skin irritation. Powders can be abrasive by continued contact with contaminated clothing or gloves, and proper care should be taken. Problems can be avoided by washing with soap and water.

The nylon powder used at Dana Corporation consisted of 80%–90% nylon and 15%–20% limestone and may form explosive mixtures with air. No specific OEL for nylon powder exists. The OSHA PEL for limestone is 15 mg/m^3 for total particulate, and 5 mg/m^3 for respirable particulate. The NIOSH REL for limestone is 10 mg/m^3 for total particulate, and 5 mg/m^3 for respirable particulate.

Guidelines for proper safe operating procedures for powder coating operations are provided by the NFPA in several publications and have been incorporated into governing OSHA regulations [29 CFR 1910 (General Industry); NFPA 1990; NFPA 33 2007].

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Appendix C: 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 [Fregert 1975; Keil 1983; Mathias 1988]. 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). It is widely accepted that of all contact dermatitis, 80% is due to a nonimmunologic 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 in other sources [Marks 1992; Adams 1993; Reitchel 2001; Rycroft 2001].

In dermatitis, the skin initially turns red and can 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 1–3 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. Employees 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 [Adams 1993; Reitchel 2001]. The most frequent causes of irritant contact dermatitis include soaps/detergents, glass fibers (fiberglass) and particulate dusts, food products, cleaning agents, solvents, plastics and resins, petroleum products and lubricants, metals, and MWFs [Mathias 1988; Mathias 1990]. Causes of allergic contact dermatitis include metallic salts, organic dyes, plants, plastic resins, rubber additives, and germicides/biocides [Mathias 1990].

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. 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) nonoccupational 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 [Mathias 1989]. Only some of these criteria were evaluated in this evaluation 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.

Even with guidelines, the diagnosis may be difficult. 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. In irritant contact dermatitis there are no additional confirmatory tests. Patch tests or provocation tests for irritants are discouraged because of a high false-positive rate. 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 [Reitchel 2001].

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 [Mathias 1988; Mathias 1990; NIOSH 1988]. The introduction of PPE must be considered carefully as it may actually create problems by occluding allergens or irritants or by directly irritating the skin. Similarly, the excessive pursuit of personal hygiene in the workplace may actually lead to misuse of soaps and detergents, which can result in irritant contact dermatitis [Mathias 1986]. The effectiveness of gloves depends on the specific exposures and the types of gloves used. The effectiveness of barrier creams is controversial [Orchard 1984], and at times employees using barrier creams may have higher prevalence rates of contact dermatitis compared to those who do not use the creams [Varigos 1981].

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Acknowledgments and Availability of Report

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Copies of this report have been sent to employee and management representatives at Dana Corporation in Toledo, Ohio and the OSHA Regional Office. 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.

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