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IOWA INDUSTRIAL HYDRAULICS
POCAHONTAS, IOWA

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I. SUMMARY

In December 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Association of Machinists Local 2548, District 201, to evaluate dermatitis among machinists and assemblers at the Iowa Industrial Hydraulics Company in Pocahontas, Iowa. The request was prompted by the occurrence of cases of dermatitis throughout the production area in September 1986. The workers believed the dermatitis to be associated with the use of cutting and cooling fluids.

During the preliminary investigation, in January 1987, the NIOSH investigators were informed by the company that the cutting fluid delivered in September 1986, had not contained the proper biocide. This gave rise to increased bacterial growth, a foul odor, and color change in the cutting fluid. It was at this time that many cases of dermatitis were noted. An investigation by the supplier of the cutting fluid found that in most of the machines the concentration of the fluid was higher than the recommended level, and the pH was too low. After the investigation, upon the advice of the supplier, the original cutting fluid (Lubrisyn-plus) was replaced with ICF-31P. Although the use of ICF-31P was started on September 8, 1986, the old cutting fluids were not cleaned from the machines, and new cases of dermatitis continued to occur.

A review of the material safety data sheets for the cutting fluids, solvents, and oils used at Iowa Industrial Hydraulics identified several potential agents capable of causing dermatologic problems through frequent or prolonged contact with the skin.

The NIOSH medical evaluation included three phases: (1) personal interviews and physical examinations in January 1987 to estimate the prevalence rate of dermatitis. The rates were calculated by job and exposure to various coolants; (2) patch testing, in March 1987, of exposed workers with dermatitis to determine if dermatitis was the result of an allergic or irritant contact dermatitis; (3) a questionnaire study, also in March l987, to compare the hand washing habits among patch tested workers (workers with dermatitis) and an equal number of workers non patch-tested (workers without dermatitis), matched for age (within 5 years), gender, and department. Of the 55 workers interviewed and examined, 30 reported having had onset of skin rash (dermatitis) of the hands, arms, or face and neck region between September 1986 and January 1987. Of all the production workers, those exposed to Lubrisyn-plus with its biocide (Ducide 20), Trim-sol, or Marvella had a significantly higher risk of developing dermatitis, compared to non-exposed workers. Among those potentially exposed to Lubrisyn-plus, the NC lathe operators (Relative Risk 1.6) and drill operators (RR 1.7), were at the highest risk of developing dermatitis.
Patch testing of the exposed workers with dermatitis revealed one definite and two possible cases of allergic contact dermatitis.

Results of the questionnaire study showed that patch-tested workers and non-patch tested workers predominantly used soap to wash their hands. However, on the average, patch-tested workers washed their hands 1.9 times more each day than non-patch tested workers. It appears that either frequent use of hand soaps contributed to a worker's risk of developing dermatitis or increased frequency of handwashing reflected heavier exposure to metalworking fluids.

Based on the results presented in this report, the employees at Iowa Industrial Hydraulics were at a greater risk of developing dermatitis if they had been exposed to Lubrisyn-plus, Trim-sol, or Marvella. Recommendations and procedures to minimize skin exposure to metalworking fluids are presented in Section VI.

Key Words: SIC 3549 (Metalworking Machinery), Dermatitis, Cooling fluids, Lubrisyn-plus, ICF 31P.

II. INTRODUCTION

In December 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Association of Machinists, Local 2548, District 201, to investigate an outbreak of dermatitis at Iowa Industrial Hydraulics in Pocahontas, Iowa. The request stated that employees had experienced skin rashes associated with the use of cutting oils, solvents, and other unknown exposures at work.

On January 12-13, 1987, two NIOSH investigators visited Iowa Industrial Hydraulics. An opening conference was held with representatives of the employees and management to explain the extent of the request, NIOSH's role, and to ascertain health problems. This was followed by a tour of the entire facility. After the tour, 55 workers were interviewed and examined. On March 14-15, 1987, two NIOSH physicians applied patch tests. At that time, a questionnaire was administered to all workers patch tested and an equal number of workers not patch tested.

III. BACKGROUND

Iowa Industrial Hydraulics, Inc., Pocahontas, Iowa, is engaged in the manufacture of hydraulic pumps, mostly for farm machinery. At the time of our initial survey, approximately 140 production employees were employed at this plant. The process involved cylinder manufacturing (cutting steel pipes to a desired size, boring, and finishing the inside), producing two valves for either side of the cylinder (cutting, boring holes, and threading on grey iron parts), manufacturing pistons and rods, testing and packing. The manufacturing of different parts is accomplished with drills, lathes, and chuckers. Somes of these machines are more mechanized (computer controlled for a high degree of precision) than are others. The entire operation was conducted under one roof.

The major exposures of interest were nine different types of cutting fluids with their biocides, solvent-based floor cleaners (Marvella), mineral spirits, two hand cleaners (pink liquid soap, bar soap), oils used for lubrication of machines, and metal chippings.

During the machining process, heat is generated, which, if not dissipated, can damage the machine and the work piece. During the grinding process, coolant is flooded over the parts being machined. Cutting and grinding fluids, also known as coolants, have three primary functions: a) to cool the work piece and the tool, thus preventing heat damage; b) to flush away chips and swarf; and c) to protect the work piece against rust.

At Iowa Industrial Hydraulics, the majority of the machines were supplied coolant from a central system. At this central location, water was de-ionized and added to the concentrated coolant in the desired proportions. Biocides were also added here. Once coolant was supplied from the central system to the machine, there was no mechanism to clean the coolant and no regular monitoring was conducted for coolant concentration, pH, or bacterial or fungal counts. Furthermore, addition of various biocides, water, and new coolant was not monitored.

According to the company, for 3-4 months beginning in September 1986, 35 workers had experienced dermatitis. At the time of the outbreak in September 1986, the coolant in most machines had become very dense, green to brown in color, and had a foul odor because the supplier reportedly supplied the coolant without the biocide normally present in it.

An on-site investigation done by the supplier revealed that the coolant in most machines was concentrated up to ten times the recommended amount and contaminated with lubricating oils. Samples for bacterial and fungal counts were taken, but the results were never reported. At the advice of the supplier, the Lubrisyn-plus was replaced with ICF-31, starting on September 8, 1986, without discarding or cleaning the old coolant from the machines. The cases of dermatitis continued to develop.

Material safety data sheets for the cutting and cooling fluids used at Iowa Industrial Hydraulics indicated that all of the cooling and cutting fluids have the potential to cause skin or respiratory irritation from contact with the liquid, vapor, fume, or mist. Some of the coolant(s) contain ingredients that are known to cause skin sensitization following repetitive exposure.

IV. METHODS

During our initial visit on January 12-13, 1987, 55 employees from three shifts were interviewed and examined. These workers included (a) 35 employees identified by the company as reporting an acute onset of skin rash within six months of our visit, (b) all 16 full-time temporary workers, and (c) 4 others, not identified by the company, who thought that their dermatitis was work-related. The workers were asked about individual exposures, work practices and medical and occupational history with respect to their current job. For all 55 workers, the areas of the body likely to be exposed to coolants (hands, arms, face, head and neck), as well as other areas reported to be affected, were examined.

After the initial visit a list of all employees, their job categories, and chemical exposures was obtained from the company. The information on chemical exposures and development of dermatitis were analyzed by logistic regression[1] to identify the chemicals most likely to have caused the dermatitis.

In March 1987, patch tests were applied on 26 of the 34 workers who had reported a rash (5 had been laid-off and 3 chose not to participate) to see if these workers had developed an allergic contact dermatitis. The patch test solutions and their concentrations are given in Table I. All the coolants and the biocides shown in Table I were diluted in petrolatum. These patches were then applied to the outer aspect of the upper arm.[2] Patch tests were read by a NIOSH dermatologist 72 hours after application.

A questionnaire was also administered to the 26 workers who were patch tested, and to an equal number of workers not patch tested. The non-patch-tested workers were matched with the patch-tested workers for age (within 5 years), sex, race and department. The purpose of the questionnaire was to determine if handwashing with soap, solvents, or Marvella contributed to a worker's risk of developing dermatitis. Handwashing habits before, during, and after the period of the epidemic were also examined. Mean differences in hand washing habits between cases and controls were evaluated by a paired t-test.[3]

V. TOXICOLOGY

A. Occupational Dermatitis

There are two types of contact dermatitis: irritant contact dermatitis and allergic contact dermatitis. Most occupational dermatitis (80%) is caused by primary irritant chemicals.[4] Almost any normal skin will be damaged by a primary irritant if the intensity or the quantity of the agent and the length of contact time are sufficient. Strong irritants like sulphuric acid and sodium hydroxide will produce immediate effects. Weak or marginal irritants such as acetone, soap, and mineral oils may require several days before recognizable effects occur. The mechanism by which the primary irritants insult the skin are not fully understood. Strong acids form acid albumates on the skin, which resemble a thermal burn. Strong alkaline irritants, which include some cutting fluids, produce a subtle dehydration of keratin by loss of cell cohesion, cracking, and loss of continuity.

Exposure to a sensitizing agent can result in an allergic reaction, specific to the given substance. It is estimated that about 20% of occupational contact dermatitis is caused by allergenic materials.[4] Most sensitizers do not produce recognizable cutanenous changes on first contact. The sensitizer produces specific changes in the skin cells, so that after one or many exposures, and after a further incubation period of five to seven days or more, the skin becomes sensitized to the chemical. Once someone is sensitized, further contact with the chemical may result in an allergic dermatitis. Appearances are not sufficient to differentiate between irritant and allergic contact dermatitis.

Differences between primary irritant and allergic contact dermatitis include (1) time required before a response is seen, (2) the mechanism of action, (3) the proportion of those exposed who are affected, and (4) the degree of exposure required to produce a response. In spite of these differences, it might be difficult to distinguish between a marginal irritant and a cutaneous sensitizer, because the marginal irritant also requires a prolonged or repeated contact before a dermatitis appears. Some chemicals, such as organic solvents (i.e., petroleum solvents, perchloroethylene, and methylene chloride) are known to result in both primary irritant and allergic dermatitis.

B. Cutting Fluids

Cutting fluids, as a whole, are among the leading causes of industrial dermatitis, causing both contact irritant and allergic types of skin reactions. These reactions may be stimulated by the fluid itself, metal parts, contaminants in the oil, or additives, such as biocides, used to prevent fluid decomposition and odor formation.[5] In machinists exposed to either emulsified or aqueous metalworking fluids, the prevalence of dermatitis has been reported to be as high as 30%.[6]

While no environmental evaluation criteria exist for airborne concentrations of synthetic and semi-synthetic fluids, specific criteria may exist for additives or specific components of the fluid mixture, and the presence of these components should be considered separately. The substances described below are commonly found in the cutting fluids as components, additives, or impurities.

C. Metals

Various metal particles may be present in cutting fluids as a result of their removal from the work piece or tools. These small particles may cause dermatitis either by direct physical contact or chemical action.

D. Miscellaneous Substances

A wide variety of compounds may be present as a result of their incorporation into the original cutting fluid or their use as additives. Derivatives of alcohols and glycols are groups of substances which are sometimes present in synthetic cutting fluids. Two members of the glycol ether family, 2-methoxyethanol and 2-ethoxyethanol, have been associated with adverse reproductive effects in animals. NIOSH recommends that exposure to these and other structurally related glycol ethers be minimized where possible. Another class of compounds that may be present in cutting fluids are nitrosamines. Certain nitrosamines are suspected of causing cancer. Other fluid additives such as biocides, may also cause a variety of health effects, if present in sufficient concentration. These effects include irritation of the skin, eyes, and respiratory tract, and other systemic effects, depending upon the agent involved. The toxicity of these fluids should be carefully evaluated prior to their use, and their concentrations in the cutting fluids should be maintained according to manufacturers recommendations in order to reduce the potential for adverse health effects.

VI. RESULTS AND DISCUSSION

Fifty-five of the 138 workers were interviewed and examined. Thirty of these workers had an onset of their dermatitis between September 1986 and January 1987. Four others gave a history of having had dermatitis for over a year. These four cases could represent a background prevalence of dermatitis of 7% among the workers occupationally exposed to cutting and cooling fluids at Iowa Industrial Hydraulics. (The prevalence of contact dermatitis in workers occupationally exposed to cutting and cooling fluids has been reported to be as high as 30%.[6])

Most of the workers reported dermatitis of the hands, forearms, or the face and neck region; a few also reported dermatitis in other areas. The physical examinations revealed red, dry, cracked skin in most of the workers. Some of the workers also had lichenification (a type of chronic dermatitis) or eczema (an inflammation-like dermatitis) of the hands and forearms. These findings are more consistent with the irritant or allergic dermatitis that is usually associated with water-soluble cutting oils rather than the folliculitis more commonly associated with insoluble oils. Assuming that all cases of dermatitis occurring from September 1986 through January 1987 were identified, more than 50% of these cases were seen among N.C. lathe operators, auto lathe operators, or drill operators. The rest of the cases were evenly distributed among the other job categories exposed to cutting and cooling fluids. The risk of developing dermatitis was significantly higher among those workers exposed to Lubricoolant, Trim-sol, Ducide 20, or Marvella, with odds ratios of 3.49, 3.49, and 11.52 respectively (Table II; models 1-3). Further modeling adjusted for the presence of combined exposures to Lubricoolant, Trim-sol and Marvella. No significant second or third order interaction terms were identified, so these were dropped from further consideration. Exposure to more than one of these materials affected the size of the odds ratio and provided a better explanation of the relationship between dermatitis and exposure than any single agent (Table II models 4-6). Model 7 accounted for all three agents simultaneously. The adjusted odds ratio in model 7 was 3.16 for Lubricoolant, 4.04 for Trim-sol, and 5.87 for Marvella. Comparison between model 7 and model 6 suggest that there is a large degree of covariance between workers' exposures to Lubricoolant and Trim-sol. Among those potentially exposed to Lubricoolant, the relative risks of developing dermatitis among drill operators and N.C. lathe operators compared to all other production workers were 1.7 and 1.6, respectively, although neither these nor any of the other relative risks had 95% confidence intervals that excluded l (Table III).

Of the 26 workers patch tested, one worker tested positive to Armix 907, the biocide in Armix 20; two other workers had a weakly positive reaction to Lubricoolant 300.

Of the patch-tested workers, 85% reported using soap alone for handwashing, 5% reported using soap and Marvella, 10% reported using soap and solvents, and none reported using all three. Of workers who were not patch tested, 80% reported using soap alone for handwashing, 10% reported using soap and Marvella, 10% reported using soap and solvents, and none reported using all three. Patch tested workers were found to wash their hands (mean= 5.5 times per day) more frequently than workers not patch tested (mean= 3.6); this difference was statistically significant (mean difference = 1.9, p less than 0.01). There was no difference in the frequency of handwashing by the patch tested workers before, during, or after the outbreak of dermatitis. It is possible that either frequent use of hand soaps contributed to a worker's risk of developing dermatitis or increased frequency of handwashing reflected heavier exposure to metalworking fluids.

On the basis of skin examination, interviews, and the patch tests, it was concluded that three workers had an allergic contact dermatitis and that the remaining affected workers probably had an irritant contact dermatitis. This was most likely the result of their exposure to the bacterial contamination and decomposition of various coolants used at Iowa Industrial Hydraulics. Workers exposed to coolants in the central system (Lubricoolant, Trim-sol, and Marvella) were at greatest risk.

VII. <u>RECOMMENDATIONS</u>

Although background prevalence of dermatitis before the outbreak was apparently low at Iowa Industrial Hydraulics, the company should have formal programs in place for the prevention of dermatitis and for coolant maintenance. We recommend the following programs for dermatitis prevention and fluid maintenance and emphasize the need for ongoing efforts on the part of both management and the employees.

A. Fluid maintenance - The company should adhere to the following guidelines for maintaining the coolant supplies.

   1. Regular inspection of central coolant system and individual machines for contamination, proper pH, and concentration, and replacement when necessary.
   2. Periodic cleaning of the entire system when necessary.
   3. Restricting the addition of cutting fluids and additives to employees who are properly trained.
   4. Examination of the toxicity of any fluid additives prior to introduction into the system. This can be done by a review of the information available in the literature. In cases, where enough information is not available in the literature, the manufacture should be asked to provide the same. Whenever a new product is introduced into the work environment, close surveillance of workers for the development of health effects is warranted.

B. Employee Education - Each worker must be aware, through regular training, of the importance of the following:

   1. Using proper work practices and techniques to avoid sustained contact between the cutting fluids and the skin.
   2. Using protective clothing, gloves, splash guards, and any other devices required for the work operation.
   3. Frequently practicing personal hygiene, including regular washing of hands, using moisturizing lotions, laundering of work clothes, and prompt removal of fluid soaked clothes.
   4. Avoiding contamination of cutting fluids with any type of waste matter.
   5. Immediately reporting any skin irritation or disorder to either a plant or private physician.

C. Hazard Communication - Under compliance with the OSHA hazard communication standard, the workers should be informed of the identity and effects of hazardous substances in the fluids, including skin sensitizers.

D. Personal Protection - Protective clothing should be made readily available to employees to reduce the potential for skin contact with the fluids.

E. Medical Program - In addition to the treatment of each individual employee's rash, the company should pursue an aggressive program designed to decrease the incidence of dermatitis; it should include the following:

1. Log of cases, noting time, machine, department, oil used, and the body parts involved.

2. Follow-up by safety and health personnel to determine the cause of the problem and make recommendations for the correction of the problem.

3. Discussion with the employee involved, to evaluate the feasibility of the recommended changes.

4. Employee transfer from "wet" to "dry" job until the rash has completely disappeared. In order to avoid disincentives to reporting dermatitis, such transfers should not involve reduction of wages or benefits.

The company should also encourage employees to promptly report any new cases of dermatitis which they feel are related to work activities. Where possible, specific machines or operations causing the problems should be identified so that they can be properly evaluated, with proper engineering control as necessary.

VIII. <u>REFERENCES</u>

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Iowa Industrial Hydraulics, Pocahontas, Iowa.
2. DHHS, PHS, DPHS, Region V, Chicago, Illinois.
3. OSHA, Region V, Chicago, Illinois.

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.

TABLE I

<u>SKIN PATCH SOLUTIONS AND THEIR CONCENTRATION</u>

IOWA INDUSTRIAL HYDRAULICS
POCAHONTAS, IOWA

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TEST SUBSTANCE	CONCENTRATION
Ducide 20	0.01%
Ducide 20	0.05%
Armix 907	1.0%
Lubricoolant Synplus	5.0%
Petroleum Jelly	100.0%
Lubricoolant 300	5.0%
Armix 20	5.0%
Trim Sol	5.0%
Garia T	5.0%
Isopropyl Alcohol	100.0%

TABLE II

MULTIVARIABLE MODELS OF THREE CHEMICAL AGENTS AND THE RISK OF DERMATITIS, MAXIMUM LIKELIHOOD ESTIMATES, AND STANDARDIZED REGRESSION COEFFICIENTS (BETA)

IOWA INDUSTRIAL HYDRAULICS
POCAHONTAS, IOWA

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Model	-2 log L MLE*	Lubricoolant		Trim-sol		Marvella	
		OR	BETA	OR	BETA	OR	BETA
0	154.10						
1	144.99	3.49	1.25				
2	150.12			3.49	1.25		
3	143.02					11.52	2.45
4	138.71	4.67	1.48	5.47	1.71		
5	138.85	2.46	0.89			7.38	2.04
6	133.63			2.54	0.96	10.78	2.33
7	134.58	3.16	1.15	4.04	1.40	5.87	1.78

MLE= Maximum Likelihood Estimate.
Each model describes the association between the risk of dermatitis and the exposure variables in the model. When more than one exposure variable is present, the odds ratio (OR) for each is interpreted as the risk from that exposure after accounting for the effect of the other variables in the model. Statistical significance of each model, relative to any other model, is determined by subtracting the MLE of the two models. The difference in MLE follows a X^2 distribution with the degree of freedom equal to the difference in the number of terms.

TABLE III

DERMATITIS CASES IN JOB CATEGORIES WITH POTENTIAL EXPOSURE TO LUBRICOOLANT

IOWA INDUSTRIAL HYDRAULICS
POCAHONTAS, IOWA

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Job Classification	Cases	Non-cases	RR*	95% CI*
N C Lathe Operators	8	10	1.6	0.83-3.0
Automatic Lathe Operators	5	10	1.1	0.5-2.3
Tube Operator	2	3	1.3	0.4-3.95
Drill Operators	5	5	1.7	0.8-3.2
Abrasive Saw Operator	1	5	0.5	0.09-3.2
Bore Milling Machine	1	1	1.6	0.4-6.54
Hone Operator	1	2	1.1	0.2-5.37
Janitor	1	1	1.6	0.5-2.3
Large Lathe Furret	0	1	0	NS
NC Drill Operator	0	4	0	NS
Setup Person	0	3	0	NS
Tie Rod Casting	2	7	0.7	0.2-2.33
Tool & Drill Grinder	0	3	0	NS
Tool Room Machinist	0	3	0	NS

RR= relative risk compared to other workers potentially exposed to lubricoolant.

CI= confidence interval.