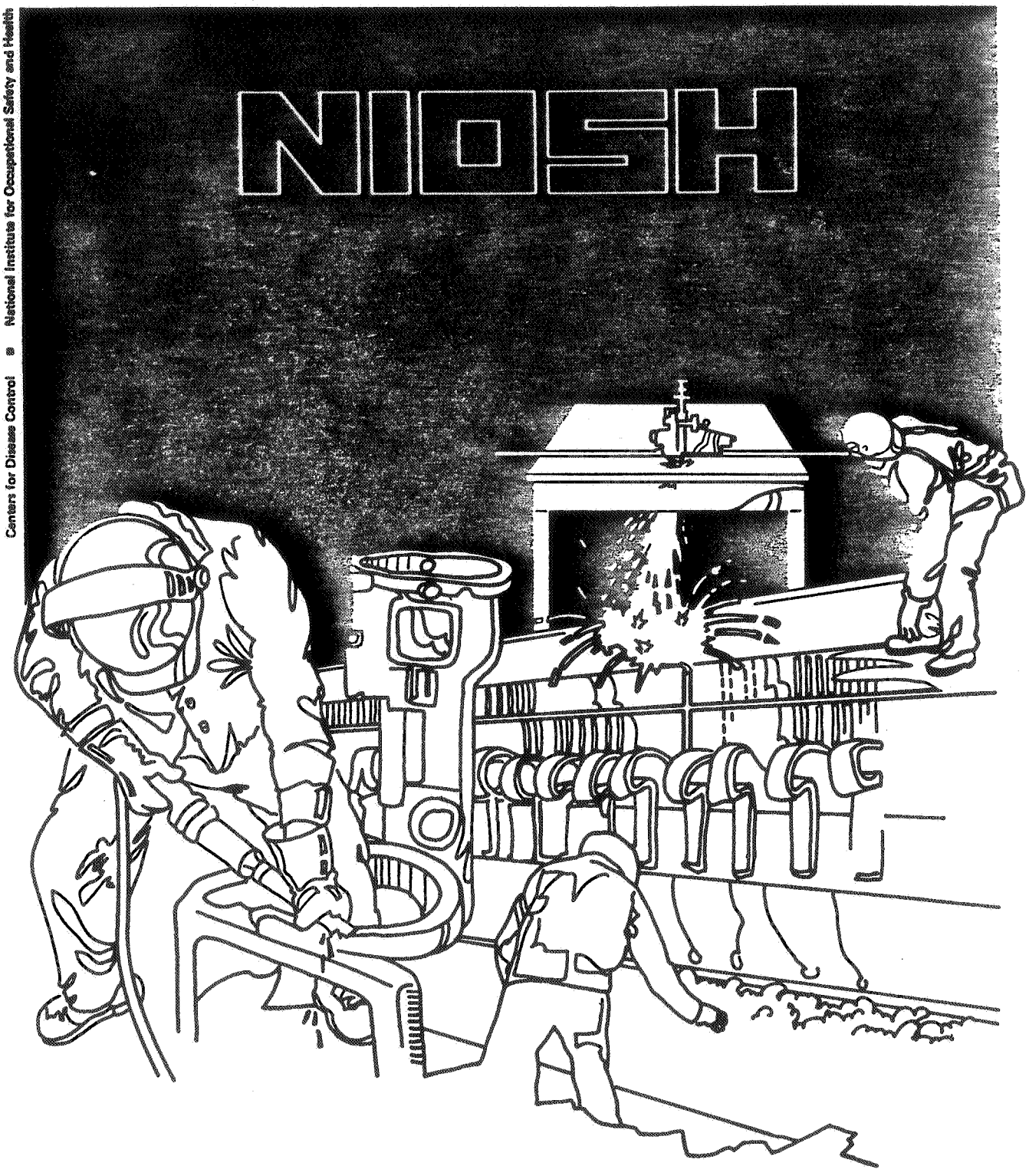
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HHE 80-014-920
SCOTT U.S.A.
CLEARFIELD, UTAH

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HHE 80-014-920
July 1981
Scott, U.S.A.
Clearfield, Utah

NIOSH INVESTIGATORS:
Raymond L. Hervin, IH
Arthur S. Watanabe, Pharm. D.
Raymond L. Ruhe, IH
Mark Kehrberg, M.D.

I. SUMMARY

On January 22-24, 1980, May 8, 1980, and October 2, 1980, the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation at Scott, U.S.A., in Clearfield, Utah, to evaluate potential exposure of employees to various chemicals in the Motorcycle Boot Assembly Area, Ski Boot Assembly Area, Sub-assembly Area, and the RIM Area. The environmental evaluation consisted of obtaining personal breathing zone and area air samples, ventilation survey, and observing production operations. The medical evaluation consisted of employee interview, limited physical examinations, including some pulmonary function testing, and a review of toxicological information on chemicals used in the areas of concern.

The environmental data show that employees in the Ski Boot and Motorcycle Boot Assembly Areas are exposed primarily to methylene chloride (from 2 to 318 mg/M^3), tetrahydrofuran - THF (from none detected to 783 mg/M^3), methyl ethyl ketone - MEK (from 2 to 690 mg/M^3), and toluene (from 0.4 to 53 mg/M^3). The environmental criteria for these compounds are 261 mg/M^3, 590 mg/M^3, 590 mg/M^3, and 375 mg/M^3 (based on an 8 hour time weighted average), respectively. In the Motorcycle Boot Assembly Area, four (maximum 1.41) of 15 personal and/or area air samples exceeded and two samples closely approached (0.98) the environmental criteria of unity or 1 for a mixture of compounds in air which produce similar health effects. In the Ski Boot Assembly Area, one personal air sample (maximum 1.4) out of 13 personal and/or area air samples exceeded the environmental criteria of unity or 1 for mixed exposures. In the Sub-assembly and RIM Areas, all samples for these compounds were less than 80 percent of the environmental criteria of unity or 1 for mixed exposures. Other chemicals evaluated during the investigation were at very low concentrations (less than 5 percent of the environmental criteria) or were below the lower limit of detection for these compounds.

Medical evaluation indicated central nervous system symptoms reported by employees (i.e., headache, lightheadedness/dizziness, sleepiness, fatigue) are attributable to the work environment. The occurence of skin irritation in the Boot Assembly Areas and eye irritation in the RIM areas may be related to contact with certain chemicals. There does not appear to be any excess prevalence of respiratory disease or menstrual disorders as a result of working at Scott, U.S.A. based on this study's findings.

Based on the environmental and medical data obtained in this investigation, NIOSH determined that a health hazard exists as a result of employees' exposure to methylene chloride, tetrahydrofuran, methyl ethyl ketone, and toluene in the Ski Boot and Motorcycle Assembly Areas; and that a health hazard (except eye irritation due to droplets of mold release solution in RIM Area) does not exist in the Sub-assembly or RIM Areas. Exposures of employees to other chemicals did not present a health hazard. Recommendations to improve the working environment have been incorporated into this report.

KEYWORDS: SIC 3949 (Sporting and Athletic Goods, Not Elsewhere Classified)(+) for methylene chloride, tetrahydrofuran, methyl ethyl ketone, toluene and (-) cyclohexane, xylene, ethyl acetate, cellosolve acetate, butyl cellosolve, isopropanol, dimethyl-formamide, 1- methyl 2- pyrrolidone, total nuisance particulate, butylated hydroxy-toluene, diphenylmethane diisocyanate, hexamethylene diisocyanate, and toluene diisocyanate.

II. INTRODUCTION

Under the Occupational Safety and Health Act of 1970, NIOSH investigates the toxic effects of substances found in the workplace. On October 26, 1979, NIOSH received a request from the Executive Vice President of Scott, U.S.A. for a health hazard evaluation of certain production operations and possible menstrual disorders and central nervous system problems of employees. Medical and environmental surveys were conducted on January 22-24, 1980, May 8, 1980, and July 30, 1980; and a follow-up medical survey was conducted on October 2, 1980. An interim report was sent on March 7, 1980 to an employee representative and management. The evaluation was delayed because all operations could not be scheduled at one time due to production constraints.

III. BACKGROUND

Scott, U.S.A. has 70 production employees and 180 administrative, research, sales, and engineering employees at this facility which manufactures ski boots and ancillary sporting equipment. The facility is a one-story building with 130,000 square feet of floor area. Areas of concern covered by this request cover the "RIM" portion of the Sub-assembly, and the Final-assembly Operations involving about 40 employees. Scott, U.S.A. has been operational at this facility for about 5 years.

The RIM injection molding operation involves two large injection molds where a reactive polyol component and polymeric isocyanate are molded according to standard molding procedures into a solid polyurethane boot. The molding operation has been in existence for a few years and employs four to six employees. Potential exposures are to diphenylmethane diisocyanate mold release agents and some organic solvents used for clean-up purposes.

The portion of the Sub-assembly Area covered by the request involves the gluing together of the shoe insert using brush-on glue and heated gun glue techniques. There are four to six employees involved in this operation. Potential exposures are to dimethylformamide and organic compounds in the glue or clean-up solvents used in the operation.

The Final Assembly Area basically involves the ski boot line and the motorcycle boot line. Operational steps in the ski boot assembly involve punch and drilling of cured upper shoe, rivet doubler plate, preparation of sole and glue sole, glue-assemble-install cuff to upper shoe, rivet hardware, install liner, flair cuff, assemble tongue to lower, assemble lower to upper, paint logo, and final clean-up plus polishing. Operational steps in the motorcycle boot assembly line basically are the same as the ski boot line, although the facilities, hardware, and glue are different. Potential exposures are to an aliphatic amide, hexamethylene diisocyanate, dimethyl formamide, methylene chloride, tetrahydrofuran, methyl ethyl ketone, cyclohexane, and toluene. Current production schedules are such that either the motorcycle boot line or the ski boot line is operational, but both lines are not operational at the same time.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Environmental surveys were conducted at Scott, U.S.A. on January 22-24, 1980, May 8, 1980, and July 30, 1980. Personal breathing zone and area environmental samples were obtained in the Motorcycle Boot, Ski Boot, Sub-assembly, and RIM Areas. The primary emphasis of these surveys was to determine exposure of employees to

methylene chloride, tetrahydrofuran - THF, methyl ethyl ketone - MEK, toluene, dimethylformamide, 1- methyl 2- pyrrolidone, toluene diisocyanate, hexamethylene diisocyanate, diphenylmethane diisocyanate, and total nuisance particulate dusts. Of secondary concern was the potential exposure to cyclohexane, xylene, ethyl acetate, cellosolve acetate, butyl cellosolve, isopropanol, and butylated hydroxy-toluene. Collection media, flowrates, and analytical methods are presented in Volumes 1 through 6, "NIOSH Manual of Analytical Methods", DHEW (NIOSH) Publication No. 77-157A through F and are available from the U.S. Government Printing Office, Washington, D.C. 20402.

B. Medical

A questionnaire intended to elicit information on acute effects and menstrual disorders, and brief physical exams were administered in January 1980, during the motorcycle boot production run. Physical exam included blood pressure measurement and evaluation of skin, mucous membranes, and neurological status. The same questionnaire was administered to the workers in May during the ski boot production run. Workers from the Motorcycle Boot, Ski Boot, Sub-assembly, and RIM Operation Areas were interviewed. A female comparison group was selected from office personnel during the May visit for evaluation of menstrual disorders or other complaints.

Follow-up medical studies were conducted on October 2, 1980, of two RIM Area and six Sub-assembly workers, and eight non-exposed workers as a comparison group, and included: questionnaire directed at work history, eye and respiratory symptoms, and medical history; physical examinations (pre- and post-shift) of the head, chest, skin, and nervous system; and pulmonary function tests (pre- and post-shift). Pulmonary function testing was done in the sitting position using an Ohio 842 spirometer with a Hewlett Packard x-y recorder. For each subject, three spirograms were obtained that were within 5 percent of each other. The Intermountain Thoracic Society (Salt Lake City, Utah, 1975) standards were used to predict normal values of forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and forced expiratory flow during the middle half of the FVC (FEF 25-75%). The two groups were comparable with respect to age (mean age 24.4 years vs. 22.8 years) and sex (4 males, 4 females). Mean job durations for the exposed and control groups were 14.1 months vs. 9.4 months, respectively. At the time (October 2, 1980), a new mold release agent was being used called SSI-34 (less than 40% silicone, more than 60% water; mfgr. Specialty Systems, Inc., 1960 Starr-Batt Drive, Rochester, MI 48063).

V. EVALUATION CRITERIA

A. Environmental Standards

To assess the concentrations of air contaminants found in the place of employment, three primary sources of criteria were used: (1) NIOSH criteria for recommended standards for occupational exposure to substances (Criteria Documents); (2) recommended and proposed Threshold Limit Values (TLV's) and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH)(1979); and (3) occupational health standards as promulgated by the U.S. Department of Labor (29 CFR 1910.1000).

In the following tabulation of criteria, appropriate values are presented:

Substance	NIOSH Recommended Criteria mg/M^3*	ACGIH TLV mg/M^3*	OSHA Standard mg/M^3*
Methylene Chloride	261	670	1,740
Tetrahydrofuran (THF)	--	590	590
Methyl Ethyl Ketone (MEK)	590	590	590
Toluene	375	375	750
Total Nuisance Particulate Dusts	--	10	15
Toluene Diisocyanate (TDI)	0.035	0.04	0.14
Diphenylmethane Diisocyanate (MDI)	0.050	0.2	0.2
Hexamethylene Diisocyanate (HDI)	0.035	--	--
Dimethylformamide (DMF-skin)	--	30	30
1- Methyl 2- Pyrrolidone (MPD)	--	--	--

*mg/M^3--milligrams of substance per cubic meter of air
-- no criteria established

Other criteria for chemicals evaluated in the survey are not listed above due to the low concentrations found and they are not considered a potential hazard. The above values are based upon an 8 hour time weighted average of concentrations. In case of a mixture of air contaminants which produce the same health effects, particularly with organic solvents, the overall effects are considered as additive. An employer shall compute equivalent exposure as follows:

$$Em = \frac{C_1}{L_1} + \frac{C_2}{L_2} .. \frac{C_n}{L_n} 1$$

Where:

Em is the equivalent exposure for the mixture.
C is the concentration of a particular contaminant.
L is the environmental criteria for that contaminant.

The value of Em shall not exceed unity or 1.

B. Physiological Effects

Methylene chloride, tetrahydrofuran, methyl ethyl ketone, toluene, and dimethylformamide can cause headache, central nervous system depression (sleepiness, fatigue, dizziness) as well as eye and mucous membrane irritation (Proctor and Hughes, 1977). Methylene chloride can cause more severe respiratory irritation with pulmonary edema

as a complication (Hughes, 1954) at high concentrations. Dimethylformamide can cause nausea, vomiting, abdominal pain, facial flushing, skin irritation, and altered liver function (Masman, 1956; Potter, 1973). These solvents are irritating to the skin on repeated or prolonged contact.

Isocyanates (TDI, MDI, and HDI) are strong irritants of the eyes, skin and mucous membrane, and are potential sensitizers of the respiratory system. The onset of sensitization symptoms is insidious. Breathing difficulties become progressively worse with continued exposure. Initial symptoms include nightly shortness of breath and cough with progression to asthmatic bronchitis. When the respiratory illness becomes incapacitating, resulting in lost work time, a return to work causes an acute asthmatic attack almost immediately. Those persons sensitized must not be exposed to any concentrations and removed from any work involving MDI or TDI.

Tests exposing rats to air saturated with 1- methyl 2- pyrrolidone (above 1,500 mg/M^3) for 10 days (6 hours/day) showed no evidence of toxic effects. However, MPD is considered a mild skin irritant and a severe eye irritant. The acute internal toxicity expressed as the LD_{50} for white rats is 4.2 gm/kg.

VI. EVALUATION RESULTS AND DISCUSSION

A. Environmental

1. Motorcycle Boot Assembly Area

Table IA contains the results of 15 personal and area air sample results for methylene chloride (from 12 to 319 mg/M^3), Tetrahydrofuran - THF (none detected to 33 mg/M^3, methylethylketone - MEK (from 21 to 690 mg/M^3), and toluene (from 47 to 53 mg/M^3). Two samples exceeded the environmental criteria of 261 mg/M^3 for methylene chloride and one sample exceeded the environmental criteria of 590 mg/M^3 for MEK. Four samples exceeded (maximum 1.41) and two samples closely approached (0.98) the environmental criteria of unity or 1 for Em (equivalent exposure for the mixture of compounds). Other samples may have exceeded the environmental criteria of 1 when considering the values for methylene chloride as minimum concentrations.

Table IB contains the results of 17 personal and area air sample results for dimethylformamide - DMF (none detected to 2.9 mg/M^3) and 1- methyl 2- pyrrolidone - MPD (none detected to 5.0 mg/M^3). No sample exceeded the environmental criteria of 30 mg/M^3 for DMF and no environmental criteria has been established for MPD.

Five personal and area samples were obtained for diphenylmethane diisocyanate - MDI, and six personal and area air samples were obtained for hexamethylene diisocyanate - HDI. These compounds were not detected and not considered a hazard.

2. Ski Boot Assembly Area

Table IIA contains the results of 13 personal and area air sample results for methylene chloride (from 2 to 131 mg/M^3), THF (from 14 to 784 mg/M^3), MEK (from 2 to 47 mg/M^3), and toluene from 0.4 to 7.1 mg/M^3). One sample exceeded the environmental criteria of 590 mg/M^3 for THF. One sample exceeded (1.4) the environmental criteria of unity or 1 for Em.

Table IIB contains the results of four personal and area air sample results for DMF (none detected to 1.5 mg/M3) and MPD (none detected). All sample results were well below the environmental criteria for these compounds.

Four personal and area air samples were obtained for MDI and four personal and area air samples were obtained for toluene diisocyanate - TDI. These compounds were not detected and not considered a hazard.

3. Sub-assembly Area

Table IIIA contains the results of eight personal and area air sample results for methylene chloride (from 19 to 70 mg/M^3), cyclohexane (none detected to 51 mg/M^3), THF (from 1 to 369 mg/M^3), MEK (from 20 to 87 mg/M^3), toluene (none detected to 2.8 mg/M^3). All samples were below (maximum sample was 75 percent of) the environmental criteria of unity or 1 for Em.

Table IIIB contains the results of two personal and area air samples for DMF and MPD. These compounds were not detected and not considered a hazard. One bulk air sample was obtained and analyzed for butylated hydroxytoluene which was not detected.

4. RIM Area

Table IVA contains the results of six personal and area air sample results for methylene chloride, cyclohexane, THF, MEK, and toluene. All sample results were less than 40 percent of the environmental criteria for these compounds and for Em.

Table IVB contains the results of four personal and area air sample results for DMF (none detected) and MPD (from 1.1 mg/M^3 to 1.9 mg/M^3). No environmental criteria has been established for MPD.

MDI was not detected in 13 personal and area air samples and hence, not considered a hazard. Four personal and area air samples were obtained and analyzed for total particulate weight. All air samples were less than 0.5 mg/M^3 and well below the environmental criteria of 10 mg/M^3 for nuisance particulate dusts which were used for the evaluation of the polysilicone mold release agent. Apparently, employees occasionally get small droplets of this compound in their eyes which become irritated.

5. General Information

Ventilation and work practices were also evaluated. Several deficiencies were noted. The ventilation system for the two RIM molding machines appeared adequate but was not operational at the time of the survey. Other ventilation systems (e.g., hoods, etc.) were not considered adequate for the intended purpose. For instance, the ventilation system provided to the cuff operator blew the fumes back into the operator's face. Also, the tongue operator has little or no ventilation. No smoking was enforced in the work areas, but food and drink were allowed. There were open, unmarked containers of flammable materials and solvents. Protective clothing (e.g., protection of eyes, skin, etc.) was not used for some operations. There was no employee educational program concerning the hazards involved in handling the chemicals used, the proper precautions to be followed in handling the chemicals, and good personal hygiene practices.

B. Medical

1. Background

Average monthly personnel turnover for Scott, U.S.A. (total company excluding Mexico operations) is approximately 9.5 - 10.0 percent. For Factory Direct Department (includes boot assembly, sub-assembly, pole production, RIM, thermo-forming, and injection molding) the turnover average ranges 9.9 - 10.4 percent. During the past 2-1/2 years, peak worker populations were: 1978 = 455; 1979 = 384; 1980 = 274. At the time of NIOSH's survey in January 1980, worker population was 274 and at the time of the May 1980 survey, 206. Review of the OSHA 200 Form for 1980 revealed 15 cases of trauma-associated injury and one case each of burn and smoke inhalation. Only one reported case of trauma occurred in the Boot Assembly Area and none in the RIM Operations Area. The company provides no routine medical surveillance. There is no on-site dispensary or on-site health professional; a local community medical clinic is located nearby and is the primary medical facility used.

2. Questionnaire Results

Table V lists the demographic data of those interviewed by worker group and shows that all groups had generally comparable job durations. Tables VI and VII demonstrate that, although the numbers of the sub-assembly and RIM worker groups were relatively small, all groups reported a high frequency of acute symptoms and that central nervous system (CNS) symptoms (headache, lightheadedness, dizziness, sleepiness), skin, and eye symptoms were most prevalent. Only two female workers reported menstrual disorders developing after starting work at Scott, U.S.A. This was not a statistically significant difference from the control group (see Table VIII).

3. Physical Examination Results

Physical exams conducted in January 1980 revealed no significant abnormalities with respect to blood pressure, skin, or neurological findings. Fourteen persons were found to have inflamed conjuctiva; these included three (60%) in the RIM Area and 11 (40.7%) in the Boot Assembly/Sub-assembly Area. One case of skin irritation, an erythematous rash on the upper chest, was observed during the May 1980 visit.

4. Follow-up Survey and Pulmonary Function Testing

Analysis of questionnaire and physical examination data revealed no statistically significant difference between exposed and non-exposed groups except for eye complaints of photophobia, excessive blinking, redness, and itching. There were no statistically significant differences between pre- and post-shift pulmonary function tests (i.e., FVC, FEV1, and FEF 25-75) in either the study or control group or between study and control groups (Table IX). Four persons were found to have low FEF 25-75 values but all were current cigarette smokers.

C. Discussion of Environmental and Medical Results

Based on the environmental results, NIOSH determined that a health hazard exists as a result of employees' exposure to methylene chloride, THF, MEK, and toluene in the Motorcycle Boot and Ski Boot Assembly Areas. Employees in the Sub-assembly and RIM Areas are not exposed to air concentrations of various chemicals which would be considered a hazard. It should be noted that this survey was accomplished at times when certain operations (e.g., motorcycle boot, tongue, cuff, etc.) were

scheduled and all operations were not conducted at the same time due to a curtailment in the production of motorcycle and ski boots. Hence, higher concentrations of the various chemicals would be expected with increased production and all operations being conducted at the same time with an increase of personnel in the assembly areas.

There is no environmental criteria established for MPD, and information generated from this survey is not sufficient to suggest a Threshold Limit Value. The maximum concentration found was 5.0 mg/M^3 for MPD which should not present a hazard to employees.

All worker groups surveyed reported a high prevalence of symptoms, although the numbers surveyed in the Sub-assembly Area are probably too small to be representative of that area. Most of the symptoms reported by the workers are known to be toxic effects of exposure to compounds found in the workplace.

Although some airborne concentrations of chemicals were found to exceed the NIOSH recommended criteria, transient higher exposures, as might be expected during close contact or handling of these substances, or possibly cumulative effects of multiple agent exposures, may account for the symptoms reported by these workers. There was no obvious association between excessive symptom prevalence and either place or job area or the January environmental findings. It is possible that additive effects of differenct solvents and glues may have accounted for some symptomatology. It is difficult to sort out chemical-related symptoms among exposed workers from other causes of symptoms such as those seen in office workers (see control group, May 1980, Table VII). It is apparent that there is a higher prevalence of skin and eye irritation in production groups than in the office workers. Eye complaint findings were confirmed by the follow-up survey.

It was noted in interviewing boot assembly workers that they would frequently remove glue from their hands with the available solvents, with ensuing skin irritation. RIM workers described eye irritation characterized as redness, burning, visual blurring, and a "film sensation on the eyes." Workers attributed this to the silicone spray mist in the air. Shortness of breath was a complaint of two RIM workers. Isocyanates are known respiratory sensitizers. Although no isocyanates were detected during the three environmental surveys, small, undetectable quantities can cause symptoms in sensitized persons. Menstrual disorders which developed after starting employment at Scott, U.S.A. were evaluated by asking female production workers and office workers about the presence of irregular or missed periods, abnormal or spot bleeding, and abnormal menstrual pain. There were only two such cases out of 21 females in the boot work areas.

D. Conclusions

It appears that some central nervous system symptoms (i.e., headache, lightheadedness/dizziness, sleepiness, fatigue) may be attributable to the work environment. The occurrence of skin irritation in the Boot Assembly Areas and eye irritation in the RIM Areas may be related to working with/around certain chemicals. There does not appear to be any excess prevalence of respiratory disease or menstrual disorders as a result of working at Scott, U.S.A. based on this study's findings. In reviewing the environmental data as well as actual operations, one would find that many of the workers would have central nervous system symptoms and other medical findings noted above. This would be particularly true for the Motorcycle and Ski Boot Assembly Areas, and the potential also exists in the Sub-assembly and RIM Areas. One should also consider restricting the work of those individuals who may be more predisposed (e.g., asthma, allergies, sensitive skin, etc.) to problems

arising from exposure to these compounds whether it be from airborne concentrations or from direct contact with chemicals.

VII. RECOMMENDATIONS

1. Workers should be encouraged to avoid skin and eye contact with chemicals and glue. Impervious aprons, gloves, long-sleeved shirts/disposable paper shirts, chemical visors, safety glasses, and a disposable cap to cover the hair should be made available and used by the workers as appropriate.

2. Local exhaust ventilation measures should be instituted to further decrease the potential for chemical and solvent vapor exposures. The use of standing fans should be discouraged since these do not remove worker exposures to chemicals and solvent vapors and may tend to blow offending agents into other workers' faces.

3. Eating and drinking should be prohibited in the work areas covered by this request. Workers should wash hands thoroughly before eating and drinking.

4. The waterless hand cleaners should prove much less harsh than the granular cleansers. Granular cleanser should only be used when exceptionally heavy cleaning is needed, then, as infrequently as possible. Barrier creams may afford some protection to the hands from the action of the solvents and cleansers and are worth a trial. Table X lists three barrier creams which may prove helpful. Equivalent barrier creams and cleansers could also be tried.

5. It would probably prove valuable to have hand cream available for use after cleaning up for the day to return oils to the skin. The use of solvents for removing glue from the skin should be discouraged.

6. Containers with various chemicals should have tight-fitting lids in place when not in use and should be appropriately marked with contents of the container. Also, open trays of solvents should not be allowed. Perhaps small or large liquid spray pump bottles or plunger cans could be used in lieu of open trays. Other work practices should be evaluated towards minimizing potential exposure of employees.

7. Employee education and personal hygiene of employees (e.g., washing hands, changing clothes, etc.), contamination control, and use of protective clothing (i.e., gloves, splash goggles, etc.) should be stressed. Employees should be instructed not to eat, drink, or smoke at work stations due to potential contamination to skin, mouth, and gastrointestinal tract of employees. An improved education program should be instituted so that employees are made aware of the toxicity and hazards associated with the materials handled during operations covered by this evaluation. Good work practices and first aid procedures should also be included in this program.

8. The company should evaluate and modify the respiratory protection program to assure that it is in compliance with requirements described (outlined as 11 criteria for a "minimal acceptable program") in the Occupational Safety and Health Administration Standard, Title 29 or the Code of Federal Regulations, Part 1910, Section 134.

VIII. REFERENCES

1. Proctor Hughes JP: Chemical Hazards in the Workplace, Lippincott, 1977.

2. Hughes, JP: Hazardous Exposures to Some So Called Safe Solvents. Journal American Medical Association 156: 234-237, 1954.

3. Massman, W: Toxicological Investigations on Dimethyl Formamide. British Journal of Industrial Medicine. 13: 51-54, 1956.

4. Potter, H.P.: Dimethylformamide - Induced Abdominal Pain and Liver Injury, Arch Environmental Health, 27: 340-341, 1973.

5. Holthouser, Meatl: Health Hazard Evaluation Report, Scott, U.S.A., HHE 80-014, Rocky Mtn Center for Occupational and Environmental Health, University of Utah, Janauary 1981.

6. GAF Corporation, N.Y., N.Y., 1- Methyl 2- Pyrrolidone Solvent - Properties and Chemical Reactions, 1972.

7. Patty, F.A.: Industrial Hygiene and Toxicology, Second Revised Edition, Vol. 11, Fawcett, D.W., Irish, D.D., eds. John Wiley & Sons, Inc. New York.

8. NIOSH, Criteria for a Recommended Standard, Occupational Exposure to Toluene (NSM) 73-11023.

9. A.C.G.I.H.: Tetrahydrofuran. TLV's for Substances in Workroom Air. Edition III, Cincinnati, Ohio 1976.

10. Proctor, N.H., Hughes, J.P.: Chemical Hazards of the Workplace. J.B. Lippincott Company, Philadelphia, Pennsylvania.

11. NIOSH, Criteria for a Recommended Standard, Occupational Exposure to TDI (HSM) 73-11022.

12. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment, 1979.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:

Raymond L. Hervin
Regional Industrial Hygienist
Kansas City, Missouri

Arthur S. Watanabe, Pharm. D.
Medical Investigator
Cincinnati, Ohio

Evaluation Assistance:

Raymond L. Ruhe
Industrial Hygienist
Cincinnati, Ohio

	Mark Kehrberg, M.D. E.I.S. Medical Officer Salt Lake City, Utah
Laboratory Analysis	Staff Utah Biomedical Test Laboratory Salt Lake City, Utah
	Staff Measurement Support Branch - NIOSH Cincinnati, Ohio
Originating Office:	Hazard Evaluation and Technical Assistance Branch (HETAB) Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS) NIOSH, Cincinnati, Ohio
Report Typed By:	Donna Small NIOSH - Region VII Kansas City, Missouri

XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. 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. Scott, U.S.A.
2. Authorized Representative of Employees
3. NIOSH - Regions VIII and VII
4. Department of Health-Utah
5. OSHA - Region VIII

For the purpose of informing affected employees, a copy of this report shall be posted in a prominent place accessible to the employees for a period of 30 calendar days.

PREFACE TO TABLES I - IV
AIRBORNE CONCENTRATIONS OF VARIOUS CHEMICALS FOUND DURING ENVIRONMENTAL SURVEYS OF THE RIM, SUB-ASSEMBLY, MOTORCYCLE BOOT, AND SKI BOOT AREAS
HHE 80-14
SCOTT U.S.A.
CLEARFIELD, UTAH 84016

The following notes are offered to assist the reader in clarifying the following tables.

ND - None detected at lower limits of detection for specific compound in question.

NA - No analysis made for specific compound due to analytical or other considerations.

mg/M^3 - Milligrams of substance or compound found in a cubic meter of air sampled.

* - A significant amount (greater than 1/3 of the reported value) of methylene chloride only was found on the reference portion (B portion) of the charcoal tubes noted with an asterisk. It should be assumed that the value as reported is suspect and that the saturation limit of the charcoal may have been exceeded for methylene chloride. Hence, the values for methylene chloride are considered as minimum values and could pssibly be 30 percent greater than the values reported above because of (1) data acquired during analysis of charcoal tubes in which significant breakthrough did not occur and (2) data contained in a report (DHEW (NIOSH) Publication No. 77-185, Documentation of the NIOSH Validation Tests) on Method S329.

** - In case of a mixture of air contaminants, particularly with organic solvents, the overall effects are considered as additive. An employer shall compute equivalent exposure as follows:

$$Em = \frac{C_1}{L_1} + \frac{C_2}{L_2} .. \frac{C_n}{L_n} 1$$

Where:

Em is the equivalent exposure for the mixture.
C is the concentration of a particular contaminant.
L is the environmental criteria for that contaminant.

The value of EM shall not exceed unity or 1.

It should be noted that a few unknown peaks were found in most silica gel samples analyzed for dimethylformamide and 1- methyl 2- pyrrolidone via gas chromatographic procedures. Several of these samples and bulk samples of various products were also analyzed via gas chromatographic (gc), and gc/mass spectrometric procedures to identify the unknown peaks. In addition, pure standards of isopropanol, methyl ethyl ketone, and tetrahydrofuran were run at conditions approximating those used in the fnitial analysis of dimethylformanide and 1- methyl 2- pyrrolidone. The results of these analyses indicate that the unknown peaks are isopropanol, methyl ethyl ketone and tetrahydrofuran as the relative retention time for these compounds and the unknown peaks were very close to each other from the various samples. In addition, the concentrations of the unknown peaks are approximately the same as those reported in the following tables for these compounds. Hence, further research of the unknown peaks was not deemed necessary or appropriate for purposes of this study.

HHE 80-14
Table IA
AIR CONCENTRATIONS OF ORGANIC COMPOUNDS FOUND IN THE MOTORCYCLE BOOT ASSEMBLY AREA
SCOTT U.S.A.
CLEARFIELD, UTAH

Date	Job Description and/or Location	Time	Methylene Chloride mg/M^3	Cyclo-hexane mg/M^3	Tetrahydro-furan(THF) mg/M^3	Methylethyl-ketone(MEK) mg/M^3	Toluene mg/M^3	Estimated **Equivalent Exposure for the Mixture(E_m)
1/23/80	Lead Lady	0645-1511	81 *	0.6	2	69	11	0.47
1/23/80	Sole Operator A	0705-1514	72 *	0.6	2	131	11	0.52
1/23/80	Sole Operator B	0710-1509	104 *	0.6	3	303	21	0.98
1/23/80	Glue Linner Operator A	0706-1507	12	0.6	2	690	74	1.41
1/23/80	Glue Linner Operator B	0710-1505	62	0.6	4	277	53	0.86
1/23/80	Paint Operator	0700-1514	65 *	0.6	3	265	20	0.75
1/23/80	Linner Area	0830-1535	60	0.7	6	151	25	0.57
1/23/80	Clean-Up Operator	0920-1516	66 *	0.6	ND	21	6	0.31
1/24/80	Lead Lady	0709-1445	319 *	0.6	3	64	10	1.36
1/24/80	Oven Area	0827-1415	164 *	0.5	3	373	26	1.32
1/24/80	Linner Area	0820-1517	121 *	0.6	6	255	32	0.98
1/24/80	Clean-Up Area	0812-1523	300 *	0.7	5	48	11	1.27
1/24/80	Painting Area	0810-1505	132 *	0.6	2	129	17	0.78
1/23/80	Clean-Up Operator A Lower Line	0919-1516		0.6	3		6	0.41
5/8/80	Lower Line-Final Assembly-Area	0828-1454	NA	NA	33		4	0.16
Environmental Criteria			261	1,050	590	590	375	1.0
Lower Limit of Detection: mg per Sample			0.01	0.01	0.01	0.05	0.01	----

NOTE: The above samples were also analyzed for xylene, ethyl acetate, and cellosolve acetate; and there may be trace amounts (0.05 mg per sample or less) of these compounds.

Refer to Preface to Tables I-IV for explanation of ND, NA, *, ** and, mg/M^3

HHE 80-14
TABLE IB

AIR CONCENTRATIONS OF DIMETHYFORMAMIDE (DMF) AND 1- METHYL 2- PYRROLIDONE (MPD)
FOUND IN THE MOTORCYCLE BOOT AREA
SCOTT, U.S.A.
CLEARFIELD, UTAH

Date	Job Description and/or Location	Time	Dimethylformamide mg/M^3	1 Methyl 2-Pyrrolidone mg/M^3
1/23/80	Sole Operator OvenA	0705-1514	0.6	4.7
1/23/80	Glue Liner Operator	0708-1505	2.7	2.7
1/23/80	Paint Operator	0700-1514	ND	2.0
1/23/80	Oven Hood Area	0829-1535	0.5	5.0
1/23/80	Lead Lady	0645-1511	2.4	NA
1/23/80	Sole Operator OvenB	0708-1509	0.8	NA
1/23/80	Gluer Linner Operator	0706-1507	2.9	NA
1/24/80	Lead Lady	0709-1445	0.8	1.6
1/24/80	Oven Area	0726-1415	ND	NA
1/24/80	Liner Area	0819-1314	2.3	NA
1/24/80	Painter Area	0810-1505	ND	NA
1/24/80	Linner Area	0820-1517	1.2	NA
5/08/80	Lower Line - Glue Area	0822-1455	0.5	0.5
5/08/80	Lower Line - Assembly Area	0831-1453	1.1	0.6
7/30/80	Glue Oven Area	0850-1450	ND	ND
7/30/80	Glue Hood Area	0846-1450	0.2	ND
7/30/80	Glue Line Assembly Area	0847-1450	ND	ND
Environmental Criteria			30	Note
Lower Limit of Detection; mg per sample			0.02	0.02

Note: No environmental criteria has been established for 1 methyl 2-pyrrolidone.

Refer to Preface to Tables I-IV for explanation of ND, NA, *, **, and mg/M^3

HHE 80-14
Table IIA
AIR CONCENTRATIONS OF ORGANIC COMPOUNDS FOUND IN THE SKI BOOT ASSEMBLY AREA
SCOTT U.S.A.
CLEARFIELD, UTAH

Date	Job Description and/or Location	Time	Methylene Chloride mg/M^3	Tetrahydro-furan(THF) mg/M^3	Methylethyl-ketone(MEK) mg/M^3	Toluene mg/M^3	** Estimated Equivalent Exposure for the Mixture(E_m)
5/8/80	Gluer Operator A	0715-1510	69	15	13	2.5	0.33
5/8/80	Gluer Operator B	0717-1511	131	18	14	1.8	0.56
5/8/80	Installer or Gluer Operator C	0722-1514	28	16	47	7.1	0.24
5/8/80	Final Assembly Operator A	0727-1513	NA	18	14	2.2	0.07
5/8/80	Final Assembly Operator B	0728-1502	NA	20	15	2.5	0.07
5/8/80	Tongue Assembly Operator A	0730-1505	15	90	18	3.3	0.25
5/8/80	Tongue Assembly Operator B	0730-1507	16	164	13	2.5	0.37
5/8/80	Glue Area A	0740-1458	NA	14	19	3.8	0.07
5/8/80	Tongue Assembly Area	0743-1456	27	100	21	4.3	0.30
5/8/80	Glue Area B	0745-1500	2	14	12	2.4	0.06
7/30/80	Cuff Gluer Operator	0710-1510	29	784	6	1.1	1.44
7/30/80	Riverter by Cuff Gluer Operator	0712-1510	15	104	2	0.4	0.24
7/30/80	Cuff Area Sample	0845-1400	NA	50	2	0.5	0.10
Environmental Criteria			261.0	590.0	590.0	375.0	1.00
Lower Limit of Detection: mg per Sample			0.01	0.0.	0.05	0.01	------

Note: The above samples were also analyzed for cyclohexane and butyl cellosolve and there may be trace amounts (0.05 mg per sample or less) of these compounds. Several of the above samples were also analyzed for isopropanol and all results were less than 3 percent of the environmental criteria of 980 mg/M^3 for isopropanol.

Refer to Preface to Tables I-IV for explanation of ND, NA, *, **, and mg/M^3

HHE 80-14
TABLE IIB

AIR CONCENTRATIONS OF DEMETHYFORMAMIDE (DMF) AND 1- METHYL 2- PYRROLIDONE (MPD)
FOUND IN THE SKI BOOT ASSEMBLY AREA
SCOTT, U.S.A.
CLEARFIELD, UTAH

Date	Job Description and/or Location	Time	Dimethylformamide mg/M3	1-Methyl 2-Pyrrolidone mg/M3
5/08/80	Tongue Area	0833-1456	0.5	ND
5/08/80	Glue Area	0835-1501	1.2	ND
7/30/80	Glueing Cuff Operator	0710-1510	ND	ND
7/30/80	Rivetter Operator by Cuff	0712-1510	ND	ND
Environmental Criteria			30	Note
Lower Limit of Detection: mg per sample			0.02	0.02

Note: No environmental criteria has been established for 1- methyl 2- pyrrolidone.

Refer to Preface to Tables I-IV for explanation of ND, NA, *, **, and mg/M3

HHE 80-14
Table IIIA
AIR CONCENTRATIONS OF ORGANIC COMPOUNDS FOUND IN THE SUB-ASSEMBLY AREA
SCOTT U.S.A.
CLEARFIELD, UTAH

Date	Job Description and/or Location	Time	Methylene Chloride mg/M^3	Cyclo-hexane mg/M^3	Tetrahydro-furan(THF) mg/M^3	Methylethyl-ketone(MEK) mg/M^3	Toluene mg/M^3	** Estimated Equivalent Exposure for the Mixture(E_m)
1/23/80	Hot Wax Operator A	0737-1515	22	0	1	87	ND	0.23
1/23/80	Hot Wax Operator B	0739-1515	19	16	369	23	ND	0.76
1/23/80	Hot Wax Table Area B	0747-1543	58 *	42	93	21	ND	0.46
1/23/80	Table Area A	0833-1543	70 *	ND	59	20	ND	0.40
1/24/80	Hot Wax Table Area B	0727-1415	69 *	51	58	20	ND	0.44
1/24/80	Table Area B	0727-1415	67 *	19	39	25	ND	0.39
5/8/80	Table Area A	0738-1503	NA	ND	4	39	1.3	0.08
5/8/80	Hot Wax Table Area B	0738-1503	NA	ND	13	71	2.8	0.15
Environmental Criteria			261	1,050	590	590	375	1.0
Lower Limits of Detection: mg per Sample			0.01	0.01	0.01	0.05	0.01	----

NOTE: The above samples were also analyzed for xylene, ethyl acetate, and cellosolve acetate; and there may be trace amounts (0.05 mg per sample or less) of these compounds.

Refer to Preface to Tables I-IV for explanation of ND, NA, *, **, and mg/M^3

HHE 80-14
TABLE IIIB

AIR CONCENTRATIONS OF DIMETHYFORMAMIDE (DMF) AND 1- METHY 2- PYRROLIDONE (MPD)
FOUND IN THE SUB-ASSEMBLY AREA
SCOTT, U.S.A.
CLEARFIELD, UTAH

Date	Job Description and/or Location	Time	Dimethylformamide mg/M^3	1-Methyl 2-Pyrrolidone mg/M^3
1/23/80	Hot Wax Operator	0737-1615	ND	ND
1/23/80	Sub-Assembly	0745-1457	ND	ND
Environmental Criteria			30	Note
Lower Limit of Detection: mg per sample			0.02	0.02

Note: No environmental criteria has been established for 1- methyl 2- pyrrolidone.

Refer to Preface to Tables I-IV for explanation of ND, NA, *, **, and mg/M^3

HHE 80-14
Table IVA
AIR CONCENTRATIONS OF ORGANIC COMPOUNDS FOUND IN THE RIM AREA
SCOTT U.S.A.
CLEARFIELD, UTAH

Date	Job Description and/or Location	Time	Methylene Chloride mg/M^3	Cyclo-hexane mg/M^3	Tetrahydro-furan(THF) mg/M^3	Methylethyl-ketone(MEK) mg/M^3	Toluene mg/M^3	**Estimated Equivalent Exposure for the Mixture(E_m)
1/23/80	Rim Line Area	0805-1526	43	0.5	ND	7	79	0.39
1/24/80	RIM Operator A	0710-1515	59 *	0.5	ND	11	4	0.25
1/24/80	RIM Operator B	0720-1515	51 *	0.5	ND	8	3	0.21
1/24/80	RIM Operator C	0950-1515	55 *	0.5	ND	11	ND	0.22
7/30/80	RIM Operator	0700-1505	2	0.5	1	1	ND	0.01
7/30/80	RIM Operator	0720-1505	2	0.3	1	1	1	0.01
Environmental Criteria			261	1050	590	590	376	1.0
Lower Limit of Detection: mg per Sample			0.01	0.01	0.01	0.05	0.01	----

NOTE: The above samples were also analyzed for xylene, ethyl acetate, and cellosolve acetate; and there may be trace amounts (0.05 mg per sample or less) of these compounds.

Refer to Preface to Tables I-IV for explanation of ND, NA, *, **, and mg/M^3

HHE 80-14
TABLE IVB

AIR CONCENTRATIONS OF DIMETHYLFORMAMIDE (DMF) AND 1- METHYL 2- PYRROLIDONE (MPD)
FOUND IN THE RIM AREA
SCOTT, U.S.A.
CLEARFIELD, UTAH

Date	Job Description and/or Location	Time	Dimethylformamide mg/M^3	1-Methyl 2-Pyrrolidone mg/M^3
7/30/80	Rim Operator	0700-1505	ND	1.9
7/30/80	Rim Operator	0702-1505	ND	1.5
7/30/80	Rim Area	0835-1430	ND	1.1
7/30/80	Rim Area	0837-1430	ND	1.3
Environmental Criteria			30	Note
Lower Limit of Detection: mg per sample			0.02	0.02

Note: No environmental criteria has been established for 1- methyl 2- pyrrolidone.

Refer to Preface to Tables I-IV for explanation of ND, NA, *, **, and mg/M^3

TABLE V

SCOTT, U.S.A.

CLEARFIELD, UTAH

DEMOGRAPHIC CHARACTERISTICS
OF THE STUDY GROUPS

JANUARY, 1980

	Participants		Mean	Mean
	Male	Female	Age	Job Duration
Boot	3	20	28.9 yrs.	12.9 mos.
Sub-Assembly	0	4	40	22.3
RIM	4	1	23.3	19.8
ALL	7	25	29.6	18.3

MAY, 1980

	Participants		Mean	Mean
	Male	Female	Age	Job Duration
Boot/ Sub-Assembly	1	19	31.4 yrs.	16.7 mo.
RIM	2	5	27.5	20 mo.
ALL				
CONTROL	0	12	25.4	18.3 mo.

TABLE VI

SCOTT, U.S.A.
NUMBER OF WORKERS REPORTING ACUTE SYMPTOMS

	January, 1980	May, 1980
Boot	18 (78.3%)	13 (81.3%)
Sub-Assembly	4 (100%)	2 (50%)
RIM	6 (60%)	7 (100%)
Totals	25 (78.1%)	22 (81.5%)

TABLE VII

SCOTT, U.S.A.
NUMBER OF EMPLOYEES REPORTING SYMPTOMS
BY WORKGROUP

January, 1980

Group (#)	HA	LH/DZ	SL	FA	SK	EYE	SOB	Other
Boot Assembly(18)	11	9	2	2	5	3	3	NA - 3 NB - 2
Sub-Assembly(4)	4	1	1	3		1	1	NA - 2 NB - 2
RIM (3)	1	1		1	3	1		

May, 1980

Group (#)	HA	LH/DZ	SL	FA	SK	EYE	SOB	Other
Boot Assembly(13)	7	4	2	1	6	4	1	NA - 1 NB - 2
Sub-Assembly (2)	2		1	1	1	1	0	
RIM(7)	4	1	5	3	3	5	2	NA - 1
Control(12)	8	3	5	2	1	2	0	NA - 3

KEY

- Number of Symptomatic workers
HA -Headache
LH/DZ - Light-headedness/Dizziness
SL - Sleepiness
FA - Fatigue
SK - Skin Irritation
EYE -Eye Irritation
SOB - Shortness of Breath
NA - Nausea
NB - Nosebleed

TABLE VIII

MENSTRUAL DISORDERS IN FEMALE
SCOTT, U.S.A. EMPLOYEES

May, 1980

	Boot Assembly	Control Group	Total
No. Reporting*	2**	0**	2
No. Not Reporting	19	12	31
Total	21	12	33

* Refers to number of workers who reported the development of menstrual disorders after starting work at Scott U.S.A.

** Difference is not statistically significant.
P= .398, Fisher's exact test

TABLE IX
PRE- AND POST-SHIFT PULMONARY FUNCTION TEST RESULTS
MEASUREMENT VALUES & PERCENTAGE OF PREDICTED VALUES

SCOTT USA
OCTOBER, 1980

TESTING BY THE UNIV. OF UTAH

	MEAN Predicted	% PREDICTED Pre-	Post-
FVC (L)			
Exposed	4.31	113	114
Control	4.40	107	106
FEV1 (L)			
Exposed	3.64	106	105
Control	3.85	98	99
FEF 25-75 (L/sec)			
Exposed	4.72	84	84
Control	4.86	79	80

Differences were not found to be statistically significant using a one-sided t test between pre- and post-shift values nor between exposed and control groups.

TABLE X

RECOMMENDATIONS OF SKIN CLEANSERS & BARRIER CREAMS WHICH COULD BE TRIED

The following barrier creams and cleaners are suggested to protect against the effects of solvents:

(1) Betadine® Skin Cleanser, Purdue Fredrick Company, 50 Washington Street, Norwalk, Connecticut 06856

(2) Phisoderm®, Winthrop Laboratories, 90 Park Avenue, New York, New York 10016

(3) Kerodex No. 51, Ayerst Laboratories, Special Products Department, 685 3rd Avenue, New York, New York 10017 Barrier Cream

(4) PLY No. 9. The Milburn Company, 4246 E. Woodbridge, Detroit, Michigan 48207. Barrier Cream

(5) West Protective Cream No. 411. West Chemical Products, Inc., 42-16 West Street, Long Island City, New York 11101 Barrier Cream

It is recognized that there may be other equally effective products on the market. Mention of these companies or products names, therefore, is not to be considered an endorsement by NIOSH.