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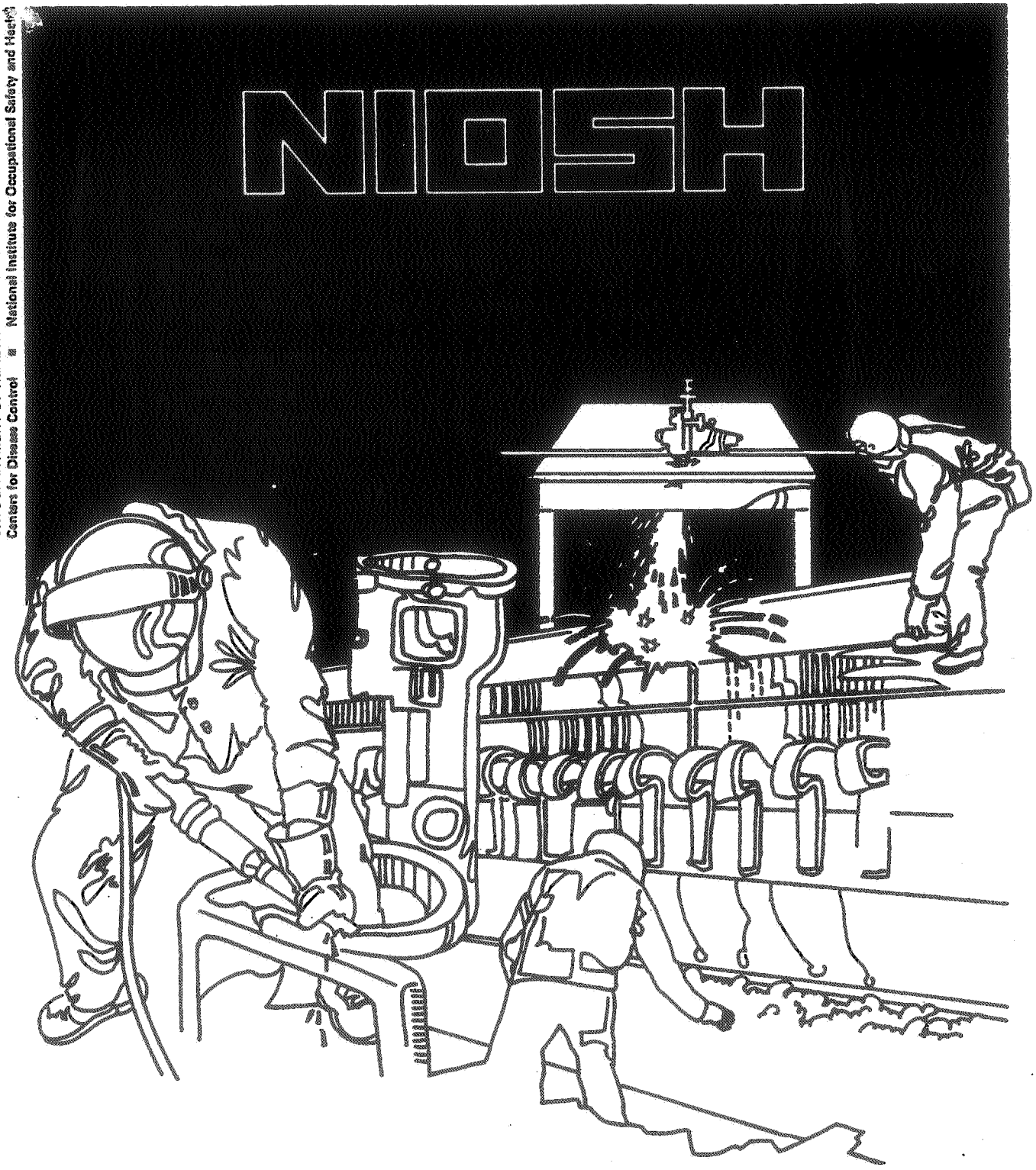

Health Hazard Evaluation Report

HETA 81-455-1229
RED WING SHOE COMPANY
RED WING, MINNESOTA

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 nygiene 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.

HETA 81-455-1229
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RED WING SHOE COMPANY
RED WING, MINNESOTA

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I. SUMMARY

In August, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from the local union at Red Wing Shoe Company to evaluate employee exposures to solvent based adhesives used during the manufacture of shoes in two facilities. The request was prompted by exposure to solvents, lack of control ventilation and what was believed to be an unusual incidence of miscarriages in one group of workers.

An initial environmental/medical survey was conducted on September 21-22, 1981. Personal breathing zone air samples for solvents were collected in the three work areas of concern identified on the request. A questionnaire was also administered to 24 workers to determine work-related health problems. A follow-up environmental/medical/control technology survey was conducted on March 2-3, 1982. Environmental samples for solvents were collected in all departments where solvent based materials were used. In addition, control measures, primarily work related practices and ventilation, were observed and measured. A second questionnaire, designed to ascertain information on reproductive and non-reproductive somatic effects potentially related to solvent exposure, was administered to 45 workers.

Solvent exposures measured on several individuals in both of the company's plants were in excess of the evaluation criteria. In Plant 1, exposures to naphtha in excess of the recommended exposure limit of 350 mg/m^3 were measured (range 19 - 522 mg/m^3). Overexposures to a combination of solvents including heptane, acetone, toluene, ethyl acetate, methyl ethyl ketone and naphtha were also documented on two individuals in Plant 1 (additive effect 1.1 and 1.9 versus criteria of 1). In Plant 2 overexposures to methylene chloride (range 96 - 172 ppm versus criteria of 75 ppm) were measured on three individuals working in one department. Four additional workers were overexposed to a combination of solvents which included isopropanol, methyl ethyl ketone, acetone, tetrahydrofuran, toluene, heptane, ethyl acetate and naphtha.

Results of the medical questionnaires illustrated no excess of spontaneous abortions among the work population when compared to the U.S. population rates. Over 50% of the workforce reported dry skin, skin rash, and mucous membrane irritation which they associated with solvent exposure.

The control technology assessment in combination with the air sampling results indicated five areas in Plant 1 and four areas in Plant 2 where additional control methods or measures were needed.

Based on the data collected during this study, workers are being overexposed to naphtha, methylene chlorde and combinations of various solvents and are experiencing symptoms consistent with solvent exposure (eye and respiratory irritation and skin problems). The control technology assessment also indicated inadequate ventilation and a need for improved work practices. Recommendations for control of solvent exposures are made in Section VIII of this report.

KEYWORDS: SIC 3143 (Men's Footwear) naphtha, ethyl acetate, methyl ethyl ketone, acetone, toluene, tetrahydrofuran, isopropanol, spontaneous abortions, respiratory irritation, dermatitis.

II. INTRODUCTION

In August 1981 Local 527 of the United Food and Commercial Workers submitted a request to the National Institute for Occupational Safety and Health to evaluate potential exposures to adhesives and solvents used in the process of assembling leather shoes. The request was prompted by exposure to various solvent based materials, lack of control ventilation and what was believed to be an unusual incidence of miscarriages in one group of workers.

Initial findings were distributed in an Interim Report in December 1981. Results of environmental sampling from the follow-up visit in March, 1982 were distributed in a letter in July 1982.

III. BACKGROUND

Red Wing Shoe Company has two separate manufacturing plants. The processes conducted at both facilities are essentially the same with minor variations in the basic materials used. The shoes manufactured in both facilities are leather. Construction of the shoes starts with cutting of the leather hides and continues to the finished product. Depending on the type of shoe, the assembly involves numerous stages including mechanical operations such as shaping and stitching and waterproofing and gluing operations which involve the use of various chemical substances. The types of adhesive, cement or waterproofing used vary from shoe to shoe depending on the desired results and may be either latex or solvent based. Many of these materials are applied by hand using small brushes.

The individual operations in the two facilities are too numerous to discuss in detail individually. Instead, the data collected will be presented in the Tables and in the Results and Discussion Section of this report by plant, department, job description and where appropriate by the identification number of the adhesive, cement or other materials being used. This information will provide sufficient detail as to the process and types of potential exposures.

IV. EVALUATION DESIGN AND METHODS

An initial environmental/medical survey was conducted on September 21-22, 1981. Walk-through surveys were conducted at the company's two plant facilities. Product information and bulk material samples were collected and limited environmental sampling was conducted in the three areas of concern identified on the request: (1) Welt Department, (2) Steel Toe Area and (3) Cement Room.

Two personal breathing zone samples for ethyl acetate, acetone and toluene were collected in the Welt Department (Plant 1). In addition, three personal breathing zone samples for toluene diisocyanate (TDI) were taken in this area. Two personal breathing zone samples for solvents were collected in the Steel Toe Area. These samples were analyzed for hexane, heptane, toluene, xylene and styrene. Three

personal breathing zone samples for toluene and naphtha were collected in the Cement Room and Main Floor (Plant 2). (Sampling and analyses methods are presented in Appendix I).

A questionnaire was distributed to 12 workers (exposed group) in specified areas of the plant (welt department, steel toe area, and cement room) who were known to use various solvent - based materials on a regular basis. In addition, a "control group" consisting of 12 presumed non-exposed workers was selected from the fitting and finishing departments of the plant.

The questionnaire was designed to obtain information on the adverse health effects of primary concern to the labor force, this included a detailed section on pregnancy outcome with many questions related to risk factors which had been identified as possible contributors to the increased risk of spontaneous abortion (smoking history, alcohol use, age, parity, and chemical exposures).

Data collected during the initial survey indicated a discrepancy between the frequency of reported work-related symptoms and the measured solvent exposure levels. It was also indicated to us that solvent exposures were limited to the three departments listed on the request, but discussion with the company and union, and observations made during the survey, revealed that solvent based glues were used extensively throughout the plant and therefore the number of exposed workers was larger than first anticipated, and the original control group was perhaps exposed to some degree. Therefore, a decision was made to conduct a more extensive follow-up survey.

The follow-up survey was conducted on March 2-3, 1982. Personal breathing zone samples for solvents were collected in all departments where solvent based materials were used. In addition, several individuals who were expected to have no direct solvent exposures were sampled to establish background exposure levels. Samples, depending on materials handled, were analyzed for heptane, acetone, toluene, ethyl acetate, tetrahydrofuran, methyl ethyl ketone, naphtha and methylene chloride.

The second questionnaire elicited information about reproductive (pregnancy outcome) and non-reproductive effects potentially related to solvent exposure, individual health history, and pertinent work history. To provide an accurate assessment of the real exposure experienced by the worker, questions concerning the amount of time per day working with glues, the base material of the glue (solvent or water), and the type of contact (direct or indirect) were also included.

The questionnaire was distributed to a cross-section of those workers throughout both plants who were also being evaluated through personal environmental monitoring. There was no effort made to select a separate comparison group since internal control based on calculated

exposure history was utilized. Following group explanation, a total of 45 self-administered questionnaires was distributed. Forty-four (98%) were returned completed, while only one worker chose not to participate in the study.

In addition to the environmental sampling and medical questionnaires, control measures, primarily ventilation and related work practices, were observed and measured by an engineer from the Engineering Control Technology Branch, NIOSH.

V. EVALUATION CRITERIA

The environmental evaluation criteria used in this report as related to airborne exposures to toxic substances are (1) NIOSH recommended standards, (2) American Conference of Governmental Industrial Hygienist (ACGIH) Threshold Limit Values (TLV's), and (3) Federal Occupational Health Standards (as promulgated and enforced by the by the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor (29 CFR 1910.1000).

Table 1 summarizes the evaluation criteria for sampled substances along with brief descriptions of their primary health effects.

The tables of results, where appropriate, will contain the calculated additive exposure effect. The additive effect is calculatd where two or more hazardous substances are present which have similar toxicologic effects. In these cases the combined exposure effect, rather than that of each individually, is given primary consideration. If the sum of the following fractions,

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots \frac{C_n}{T_n}$$

exceeds unity, then the threshold limit of the mixture has been exceeded. (C indicates the observed atmospheric concentration, and T the corresponding threshold limit).

VI. RESULTS AND DISCUSSION

A. Initial Survey

1. Environmental

The time-weighted-average (TWA) concentrations for solvents measured on seven individuals are presented in Table 2. Samples were analyzed for ethyl acetate, acetone, toluene, hexane, heptane, xylene, styrene and naphtha. A review of the data will indicate that all measured concentrations were below recommended criteria. Results for exposure to MEK are not

presented as the samples were lost during shipment to the laboratory. Two of three personal samples collected for toluene diisocyanate (TDI) in the Welt Department showed levels of 2 ug/m^3 and 4 ug/m^3, respectively versus TDI criteria of 35 ug/M^3.

2. Medical

The analysis of the questionnaire results for the initial survey were as follows:

DEMOGRAPHIC CHARACTERISTICS OF SAMPLE AND CONTROL GROUPS

Data	Exposed Group	Non-Exposed Group
Number Interviewed*	9.0	12.0
Mean Age	27.0	22.3
Mean No. of Years at Red Wing	3.4	2.7
Total No. of Smokers	7.0	8.0
Total No. of Pregnancies	9.0	12.0
Mean No. of Pregnancies	1.0	1.0
Total No. of Miscarriages	2.0	0.0
Miscarriage Rate	22.0%	0.0%

* An additional 8 male workers were interviewed (3 in exposed group, 5 in non-exposed) but were not included in calculations for this table..

A notably high prevalence of non-reproductive health problems were reported by the workers interviewed. These signs and symptoms were consistent with those reported in the literature as being associated with the specific solvent exposures experienced at these plants.

SUMMARY OF HEALTH COMPLAINTS AS REPORTED BY QUESTIONNAIRE

Reported Health Problem	Number (N = 29)	Percent
Skin-related (itch, rash)	11	37
Headaches	12	38
Upper Respiratory Tract Irritation	13	45
Eye Irritation	12	38

In addition, 83% of those interviewed reported a perceived relationship between the symptoms experienced and some workplace exposure - usually one of the cements regularly used.

Based on these results it was felt that an in-depth evaluation of the health effects suspected to be associated with solvent exposure should be conducted by surveying additional areas of both plants where solvent based adhesives were regularly used. The initial request suggested that solvent exposure was limited to a few small areas of the plant; however, a walk-through survey of the work areas indicated the use of solvent based adhesives to be much more widespread. Observations also suggest the three areas on the request may have the best control measures and could be areas of the least rather than greatest exposure.

B. Follow-up Survey

1. Environmental

Tables 3-8 contain the results of the environmental samples collected during the survey of March 2-3, 1982. Each table contains the location of the individual sampled, the concentrations of the substances measured, the recommended exposure limit for each substance and, where appropriate, the calculated additive exposure effect.

A review of the data will indicate that solvent exposures measured on several individuals in both plants were in excess of the evaluation criteria. In Plant 1, overexposures to naphtha and/or the combination of solvents present were measured in the steel toe area, and during several gluing operations including gluing soles, cementing around welts, gluing doublers and urethane gluing. At Plant 2, concentrations of methylene chloride in excess of the

recommended limit were measured on the 4-part machines in the Lasting Department. Concentrations in excess of the recommended limit for combined solvent exposures were measured during the cementing of heels and soles, gluing soles and on the Cement Line.

2. Medical

The distribution of workers by work area completing the questionnaire (35) appear in Table 9. The total sample can be demographically described as 100% Caucasian, 51% female, with an average age of 35 (34.5) years. Subdivision by plant showed both subsamples in Plants 1 and 2 to be very similar in age (37 yrs. vs. 32 yrs.), and sex (50% female vs. 52% female).

The medical officer determined that several factors including length of exposure in hours/shift, type of glue contact, and ingredients in the glue, had to be considered before allocating a worker into an exposure category. Therefore each worker in the sample was given a rating for these variables and then a cumulative score was calculated. A score of 8 or 9 was considered high exposure; 6 or 7 was moderate; and less than 6 was low (See below).

Explanation of Categorization of Workers into Exposure Groups*

Factor	Measurement	Categories	Score
A	no. of hours/shift working with glue	less than 4 hrs.	1
		more than 4/less 8 hrs	2
		whole shift (8 hrs)	3
B	glue ingredients	no glue use	1
		latex (water) based	2
		solvent based	3
C	type of glue contact	no known contact	1
		indirect contact	2
		direct contact	3

* So, if worker Jane Doe worked directly with solvent based glue #681 for the entire work shift, her score would equal 9 (3 + 3 + 3) which is the high exposure group.

. We attempted to relate all findings from the second questionnaire analysis to the reported amount of solvent exposure.

A. Somatic Complaints

Prevalence of reported symptoms was generally similar in both plants: skin problems were the most often reported complaint followed by irritation of the upper respiratory tract, and eye irritation (See Table 10).

When all exposure categories are combined, more than 50% of the workforce complained of skin and throat irritation, while 30 - 32% experienced eye irritation and headaches (See Figure 1).

B. Reproductive

Information obtained about pregnancy outcome since working at Red Wing showed workers at both plants had a combined spontaneous abortion rate (5%) below that expected in the U.S. general population (Table 11).

C. Exposure Analysis

For most workers additive effects of several chemical exposures were calculated and this figure was used to determine overall exposure rather than isolated chemical concentrations. It was felt that this additive value more accurately reflects the real workplace situation which is one of mixed, simultaneous chemical exposures.

No consistent association could be found between the number of symptoms reported (less than 3; more than 3) and the environmental chemical levels(less than half the recommended levels; more than half), or between the environmental exposure levels and the hours/shift (less than 4; more than 4) working with glues.

Frequency of symptoms reported and scores obtained from factors A, B, and C also showed inconsistent findings between groups. Only the low exposure group showed a logical and expected association between the two variables, while both the moderate and high exposure groups demonstated an inverse relationship (Tables 12 and 13).

3. Control Technology Assessment

The observations and measurements made on the control measures which were in effect at the time of the follow-up survey are presented below. This section contains a discussion of the measurements and observations for many of the operations where environmental samples were collected. (The discussion of operations is arranged by sample location in order of appearance in Tables 3-8).

Plant 1

There was no ventilation, other than cooling fans, for the "heel-padding" process using a latex adhesive. Having originally been told there was no solvent involved, no measurements were made at any "bottom fill" stations, other than to note (by using a smoke table) that the control at the face of the booths seemed to be adequate.

The work surface grill of the downdraft ventilated table for the "gluing doublers" process was badly clogged on the day of the survey. The roller coater was located almost a foot above the grill, and the rack on which the coated pieces were placed extended beyond the edge of the ventilated table. These racks were then hung on carts adjacent to this, as well as other, work stations for the adhesive to dry. Area ventilation was provided by four updraft vents positioned about one foot from the floor. At one time during the day of the survey, the fans for both pairs of vents had been turned off. When operating, face velocities ranged from 1000 to 2000 feet per minute, but there was only a mild (<50 fpm) directed flow from the drying racks to the vents. The four vents exhaust a total of approximately 8000 cubic feet of air per minute (when adequate make-up air is available) and essentially comprise the total general ventilation (except for open windows) for this second-floor workroom of approximately 20,000 cubic feet. Based on the measured additive effect of 1.9 for solvent exposure (Table 3), this arrangement seems to be inadequate.

The "urethane gluing" operation which had just been moved to the second floor was also inadequately ventilated. Less than one-third of the grilled work surface had a face velocity approaching 100 fpm. Beyond one foot from the duct end of the table, insufficient capture velocity existed, especially at the height above the surface at which the workers held the shoes to apply the adhesive. The vapors from this process, not removed by ventilation, were generally spread by diffusion and room air currents. However, it appears from the data on workers B and C, that exposures can be somewhat controlled by scheduling, i.e. not having one person apply this adhesive more than a few hours each day.

There was no ventilation specifically for the "steel-toe" area on the third floor. Judging from the concentration of aliphatic naphtha, some local exhaust ventilation is needed.

The "gluing soles" operation involves five work stations. One worker (the one with the highest exposure) performed this operation full time at one of three different stations (two for crepe soles, one for vibram). Another worker filled in as necessary at the other two (both crepe).

The two roller-coater stations for crepe each had a six inch circular duct with the opening (no flange or enclosure) between one and two feet from the point of application of the adhesive. The face velocity was between 1000 and 1300 ft/min, giving a four to six inch capture zone as determined by observing the movement of chemically generated smoke. Additional brushing was accomplished by the worker even further from the ventilation opening before placing the pieces on a rack to dry.

The two brush-on stations for crepe each had a 14 x 24 inch grilled openings on the work table. Flow was sufficient to produce a six inch capture zone above the surface of the table, but the work was done off to the side of the table

The vibram station featured an enclosed, ventilated, overhead drying rack. The adhesive is initially applied by roller-coating and/or manual brushing in front of the 2 x 4 foot opening through which soles are inserted for drying and removed. The roller coater sits on a ventilated work table. In this case, the manual brushing is accomplished close to the ventilation, but control velocities at the face of the opening are only about 50 ft/min.

The "activated glued soles" station had a ventilated enclosure built around the activating unit. However, other processes in this operation were unventilated, and numerous drying racks were standing in this area on the second floor, including those from the adjacent sole-cementing and doubler-cementing operations.

There were two stations for "cementing around welts", each with a local exhaust hood enclosing the applicator. The enclosures seemed well-designed, providing good capture (face velocities from 100 to 900 ft/min) at the point of application. However, in the course of applying the adhesive to the perimeter of the shoe, the newly coated welt passed directly under the worker's breathing zone. Also, once again the racks of drying shoes were positioned alongside the worker.

There was no local exhaust ventilation in the "packing department" where the Picard Oil is applied. Sampled naphtha levels do not indicate a need for ventilation.

The "four part machines" in the basement of Plant 1 have local exhaust ventilation on three processes. The enclosure around the methylene chloride applicator provided good control when flow rates were adequate. Average face velocities on the first work station (which was not being used on the day of the survey) were approximately 130 ft/min. On the other two stations, which were in use, the average face velocities were less than 100 ft/min.

The hood above the steam unit seemed fairly effective. It only had to limit the escape of steam, a comfort control measure, as the pad soaked with methylene chloride was placed in the shoe after the shoe was removed from steam unit.

The ventilation slot above the hot-melt applicator unit provide good control. The average face velocity on the first unit was measured to be 840 ft/min and estimated at 560 ft/min on the other three units.

Although generally effective, this ventilation system for the 4-part machine had some design flaws. The exhaust vented on the roof of a covered stairway leading from the basement boiler room to the outside. The ventilation outlet was adjacent to an intake pipe for air to be drawn into the basement and just below windows for the first-floor workroom. The fan for the system was located inside the basement workroom, although all joints were adequately sealed with duct tape. There were some reverse angle entries which disturb flow. These flaws, especially the latter two, could adversely affect the levels and pressure distributions within the main duct around the "crimping machine", which itself (with no inherent potential hazard) had no ventilation.

Plant 2

In Plant 2, the "cementing heels and sole" stations were at the openings to an overhead drying rack. The station where the sample beginning at 7:15 was collected was a roller coating station. Additional manual brushing was not used here, and the worker's movements did not bring her in close proximity to the applied adhesive. The other worker applied the adhesive using a brush while standing in front of the opening to the ventilated drying chamber with the piece directly under her breathing zone. Control velocities at the face of the openings were sufficient, but capture velocities at the point of application were not as good.

Once again, no ventilation measurements were taken for the "bottom fill" stations nor for "welt lasting with 671" other than to observe that control velocities at the face of the enclosures seemed adequate. However, here again, smoothing after the application was done away from the ventilation, and the drying racks were positioned right alongside the worker.

There was no ventilation for "putting in heel pads" with a latex adhesive. At lease one worker did wear gloves, however.

The worker sampled in the "fitting department" used a latex adhesive, but solvent-based cements were being used at adjacent stations, which were ventilated similar to the station in "pre-fit" where 681 was used. In fact, a number of stations in this plant had this arrangement of a ventilated worktable with the exhaust being blown into the workplace area a few feet away from the worker.

At the "pre-fit" station, there was good control of vapors on the work bench, up to eight inches above the grill in some areas. This set-up is clearly better than no ventilation, because it does reduce the vapors passing through the worker's breathing zone. However, it does not remove the vapors from the workplace, relying on diffusion, convection, and general ventilation to keep down the ambient concentration.

The "cement room" has been made into a well-controlled area. The ventilated worktables were exhausted to the outside. They exhibited good captive velocities, approximately 100 ft/min just above face of the grill and between 40 and 90 ft/min at four inches above the surface. There was a drying oven for the 681 adhesive with approximately a 150 ft/min control velocity at the entry and exit openings. In addition, there was a ventilated storage enclosure, tempered make-up air, and a slight negative pressure to keep solvent vapors from escaping from the room.

There was no ventilation for the "backshoe repair" station. Only small quantities of solvent adhesives were occasionally used to rectify manufacturing errors. This person also uses latex adhesives and did other work. Her exposures, along with those of the person in "cutting", chosen to be the non-exposed control, are probably indicative of the background levels in this half of Plant 2.

"Cementing crepe soles" was reportedly done with a latex adhesive, 489. There was no ventilation at this station where the adhesive is both roller-coated and brushed on, but there was an occasionally strong solvent odor. It was learned later that a solvent based activator was used, perhaps consisting predominently of MEK; and that acetone (and perhaps MEK) were used as cleaning solvents. These solvent based solutions were kept in safety-cans; but usually transferred to open containers when being used. The areas where they were used are typically poorly ventilated.

The "cement line" in the lasting department of Plant 2 had the same hoods as the "cementing around welt" stations at Plant 1, except that the exhaust was blown into the workplace air instead of being vented to the outside. Thus, the good control around the applicator head did not cover the movement of freshly coated portions of the shoe under the worker's breathing zone. Additional manual smoothing of the freshly applied adhesive was performed at least one foot away from the ventilation. The racks of recently coated shoes stood along side the worker. Plus, the workplace air was being infused with the vapors captured by the local exhaust hood.

The "gluing soles" operation had two work stations: one applying adhesive and placing the piece on a conveyor belt, and one transferring the coated and partially dried pieces from the belt to a rack. The two workers rotated work stations during the work day. At the adhesive application end, a ventilated hood over the conveyor maintained good control of air flow through the openings. The roller coater was out of the capture zone, but the manual brushing was done close to the ventilation. However, there was no ventilation at the removal end, and the exhaust from conveyor enclosure was blown into the air above this work station.

The "four part machines" in Plant 2 did not have ventilation for the methylene chloride applicator except for one station where it was placed under a ventilated steam hood. Typically, air flow in the unventilated areas was relatively still with random motion mostly due to the movement of people and some thermal currents from hot processes.

VII. CONCLUSIONS

The initial hazard evalution request to NIOSH in August, 1981 focused on the spontaneous abortions (miscarriages) reported by several female employees located in one area of the Red Wing plant as the major issue of concern. Analysis of questionnaire responses from the first survey indicated a higher rate of spontaneous abortions among the chemically-exposed group when compared to the controls. However, as stated in the Interim Report (12/81) there are several points to consider when interpreting this finding, including (a) the difficulty in ascertaining an accurate rate of spontaneous abortions among a population due to "missed abortions", (b) the generality of the expected rate of spontaneous abortions among the general population which is usually set at approximately 15% of all pregnancies, (c) the lack of information on other factors thought to potentially contribute to the risk of spontaneous abortions, and (d) the recognition of the very small number in the sample which compromises any statistical significance.

Rather than just discontinue investigation of this issue however, a follow-up effort was made to collect similar information on reproductive history among the workforce, and the outcome of this survey as reported in Table 11 illustrates no apparent excess spontaneous abortions among this working population when compared to the U.S. general population rates.

The non-reproductive health effects reported in the first survey were re-documented through the follow-up questionnaire. Over 50% of the workforce continues to suffer from dry skin, skin rash, and mucous membrane irritation due to exposure to solvents.

The lack of association demonstrated between the number of hours/shift working with the glue and the number of symptoms reported may in fact suggest that due to the poor ventilation, workers who are not engaged in job tasks requiring solvent exposure are in fact still significantly adversely affected because the surrounding workers are using solvents.

In addition, the prevalence of adverse health effects reported by those workers whose personal environment readings were well below the OSHA recommended safe levels perhaps suggests a need for re-evaluation and possible adjustment of the current TLVs (threshold limit values).

A review of the control technology assessment along with the results of the environmental samples indicate a need for additional controls. The specific operations and recommendations appear in Section VIII below.

VIII. RECOMMENDATIONS

1. Eliminating solvent-based adhesives from the high-exposure operations may be the easiest change to implement, if a suitably performing substitute can be found. This may be doubly beneficial in that some workers' exposures may be more from an adjacent

process than from their own operation. However, it is realized that finding an adhesive which satisfies production specifications and cost criteria may be difficult, so the following specific and general recommendations are offered.

2. In Plant 1, model the "gluing doublers" and "gluing soles" work stations after the "cementing heels and soles" roller-coating station in Plant 2. Design each with sufficient flow rate so that the capture zone extends out into the area of the point of application and the worker's breathing zone.

3. It may be necessary to install adjustable outlets above the workers to supply (fresh) tempered air which can flow down over the workers. Additional air movement is needed to dispense solvent breathing zone concentrations on the "urethane gluing", "steel toes", and "cementing around welts" operations. This will not only keep vapors from infiltrating their breathing zone, but also aid their comfort. It is easier to push air than to draw it, so volume-flow requirements should not be excessive.

4. The brush-on station of the "cementing heels and soles" operation in Plant 2 may need some carefully positioned supply air jets to push solvent vapors toward the ventilation openings if increasing volume flow rate and supplying downward make-up air are not sufficient.

5. The lasting operations, both "welt line" and "cement line", should be fitted with the supply air outlets. Vapors captured by local exhaust hoods should be vented to the outside.

6. The methylene chloride applicator pots for the "four part machines" in Plant 2 should be locally ventilated as are the ones in Plant 1. Due to the heat around this process from the steam unit and the hot-melt adhesive, these workers in both plants would benefit from an adjustable, overhead supply of tempered air, as would the "bottom fill" operators.

7. The Safety Director for Red Wing Shoes indicated the company would like to install more mechanized, ventilated, drying enclosures. Since the racks of drying shoes may now be a significant source of solvent vapor, this action is encouraged.

8. Work practices which keep the source(s) of the solvent vapor close to the opening of the ventilation system should be encouraged. Some minor work station modifications may be necessary to make the procedures efficient and comfortable for the workers.

9. The plant walk-through revealed that the eating/drinking areas for employees are contained within the work areas. It is advisable to enclose these areas and provide separate ventilation to minimize further worker chemical exposure from contamination of their food, drink, cigarettes, etc.

10. Data collected through both questionnaires identified dry skin/rash as occurring in more than 50% of the workforce. Therefore the issuance and use of protective gloves which are impermeable to solvents is recommended.

11. All chemical, adhesives, etc. should be labeled with the trade name, chemical name, and the ingredients.

12. Workers should be educated regarding the health hazards associated with their chemical exposures, as well as available means of protection.

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1. Red Wing Shoe Company, Red Wing, Minnesota
2. UFCW, Local 527, Red Wing, Minnesota
3. NIOSH, Region V
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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 1

Evaluation Criteria

Red Wing Shoe Company
Red Wing, Minnesota
HETA 81-455

SUBSTANCE	EVALUATION CRITERIA	SOURCE	OSHA STANDARD	PRIMARY HEALTH EFFECTS
Ethyl Acetate	400 ppm	OSHA	400 ppm	Irritant to mucous membranes and skin. May cause headaches.
Acetone	750 ppm	ACGIH	1000 ppm	Irritant to eyes, mucous membranes and skin. May cause headaches and light headedness.
Toluene	100 ppm	NIOSH	200 ppm	Irritant to eyes, respiratory tract and skin. May produce headache and dizziness.
Naphtha	350 mg/M^3	NIOSH	2000 mg/M^3	Irritant to skin, conjunctiva and mucous membranes. May cause headaches and nausea.
Heptane	400 ppm	ACGIH	500 ppm	May cause dermatitis and mucous membrane irritation.
Tetrahydrofuran	200 ppm	OSHA	200 ppm	Irritant to eyes, mucous membranes and skin. May cause headache and dizziness.
Methyl Ethyl Ketone	200 ppm	NIOSH	200 ppm	Irritant to eyes, mucous membranes and skin. May cause headaches and light headedness.

(Continued)

TABLE 1
(Continued)

SUBSTANCE	EVALUATION CRITERIA	SOURCE	OSHA STANDARD	PRIMARY HEALTH EFFECTS
Methylene Chloride	75 ppm	NIOSH	500 ppm	Irritant to eyes, mucous membranes and skin. Exposure may cause elevated carboxyhemoglobin levels which may be significant in smokers or those exposed to carbon monoxide.
Isopropanol	400 ppm	NIOSH	400 ppm	Mildly irritating to conjunctiva and mucous membranes.
Toluene Diisocyanate	35 ug/M3	NIOSH	140 ug/M3	Irritating to eyes, respiratory tract and skin. Sensitization may occur which causes an asthmatic reaction with wheezing, dyspnea and cough.

TABLE 2

Red Wing Shoe Company
Red Wing, Minnesota
HETA 81-455

September 22, 1981

Welt Department - Plant 1

Sample Location	Sampling Time	Ethyl Acetate (ppm)	Acetone (ppm)	Toluene (ppm)
Employee A	7:12-15:10	32	4.7	41
Employee B	7:03-15:10	9	11	26
PEL		400	750	100

Steel Toe Area - Plant 1

Sample Location	Sampling Time	Hexane	Heptane	Toluene	Xylene	Styrene
Employee A	7:40-15:15	7.5	5.5	15	N.D	N.D.
Employee B	7:45-15:15	8	6.7	18	N.D.	N.D.
PEL		50	400	100	100	50

Cement Room and Main Floor - Plant 2

Sample Location	Sampling Time	Toluene (ppm)	Naphtha (mg/M^3)
Employee A - Cement Room	6:15-14:40	6	--
Employee B - Cement Room	6:22-14:00	3	--
Employee C - Floor	8:00-14:30	12	27
PEL		100	350

TABLE 3

Solvent Concentrations
Red Wing Shoe Company - Plant 1
Red Wing, Minnesota
HETA 81-455

March 3, 1982

Sample Location	Sampling Period	Heptane (ppm)	Acetone (ppm)	Toluene (ppm)	Ethyl Acetate (ppm)	Tetrahydrofuran (ppm)	Methyl Ethyl Ketone (ppm)	Naphtha (mg/M^3)	Additive Effect
Heel Padding	07:06-14:45	1.3	32	3	2	-	-	33	0.17
Bottom Fill	06:30-11:25	6.5	156	13	14	-	-	-	0.40
	11:25-14:32	4.8	150	6.6	6.3	-	-	-	0.30
Gluing Doubles	06:40-14:30	3	23	32	70	-	-	467	1.9
Urethane Gluing (A)	06:54-14:45	-	353	-	25	3	68	81	1.1
Urethane Gluing (B)	06:55-14:44	-	34	-	9.5	27	0.7	98	0.49
Urethane Gluing (C)	07:02-14:40	-	N.D.	-	N.D.	N.D.	45	36	0.33
Environmental Criteria	400	750	100	400	200	200	350	1	

TABLE 4

Naphtha Concentrations
Red Wing Shoe Company - Plant 1
Red Wing, Minnesota
HETA 81-455

March 3, 1982

Sample Location	Sampling Period	Aliphatic Naphtha (mg/M^3)	Aromatic Naphtha (mg/M^3)
Steel Toe (792)	6:25-14:31	428	23
Steel Toe (792)	6:27-14:31	491	23
Gluing Soles (9558)	6:45-14:37	446	N.D.
Cementing Around Welts (9314)	6:35-14:35	522	N.D.
Gluing Soles (9558)	6:45-14:40	45	N.D.
Activating Glued Soles (9558)	6:48-14:37	182	N.D.
Packing Dept. (Picard Oil)	7:25-14:50	19	15
Environmental Criteria		350	---

TABLE 5

Red Wing Shoe Company - Plant 1
Red Wing, Minnesota
HETA 81-455

March 3, 1982

Sample Location	Sampling Period	Methylene Chloride (ppm)	TWA Methylene Chloride (ppm)
4 Part Machine	7:10- 9:20	45	50
	9:20-11:40	54	
	11:40-14:47	50	
4 Part Machine	7:10- 9:27	17	34
	9:27-11:42	13	
	11:42-14:47	61	
Crimping Machine	7:15-11:27	3	9
	11:27-14:48	17	
Environmental Criteria		--	75

TABLE 6

Solvent Concentrations
Red Wing Shoe Company - Plant 2
Red Wing, Minnesota
HETA 81-455

March 2, 1982

Sample Location	Sampling Period	Isopropanol (ppm)	Methyl Ethyl Ketone (ppm)	Acetone (ppm)	Tetrahydrofuran (ppm)	Toluene (ppm)	Heptane (ppm)	Ethyl Acetate (ppm)	Naphtha (mg/M^3)	Additive Effect
Cementing Heels & Soles (718, 334)	7:15-15:00	--	22	16	5	19	--	--	59	0.52
Cementing Heels & Soles (718, 334)	7:16-15:00	--	55	22	11	26	--	--	140	1.0
Bottom Fill	6:57-14:54	--	--	93	--	--	12	--	230	0.81
Lasting Dept - Welt Line (gluing soles with 671)	7:00-14:53	--	65	--	--	69	--	17	504	2.5
Putting in Heel Pads	7:03-14:56	3.3	--	--	--	25	--	--	--	0.26
Environmental Criteria		400	200	750	200	100	400	400	350	1

TABLE 7

Toluene, Methyl Ethyl Ketone and Naphtha Concentrations
Red Wing Shoe Company - Plant 2
Red Wing, Minnesota
HETA 81-455

March 2, 1982

Sample Location (Material in major use)	Sampling Period	Toluene (ppm)	Methyl Ethyl Ketone (ppm)	Naphtha (mg/M^3)	Additive Effect
Fitting Dept. (Flex-o-fix, Latex)	6:15-14:30	11	5.8	--	0.14
Cement Room (671)	6:17-10:55	9.5	2.4	10	0.10
Cement Room (681)	6:20-14:32	13	2.7	32	0.14
Pre-fit (681)	7:30-15:03	23	9	--	0.28
Backshoe Repair (681, 685, 671)	6:25-14:34	8.4	2.4	33	0.18
Welt Lasting - Cementing Crepe Soles (489)	6:30-14:40	3.4	111	32	0.68
Lasting Dept. - Cement Line (681)	6:30-14:40	35	145	162	1.5
Lasting Dept. - Cement Line	6:25-14:41	51	65	102	1.1
Gluing Soles (682)	7:20-15:01	26	41	--	0.47
Gluing Soles (682)	7:25-15:02	23	41	--	0.44
Cutting	7:25-15:05	8.5	4	40	0.10
Environmental Criteria		100	200	350	1

TABLE 8

Methylene Chloride Concentrations
Red Wing Shoe Company - Plant 2
Red Wing, Minnesota
HETA 81-455

March 2, 1982

Sample Location	Sampling Period	Methylene Chloride (ppm)	TWA Methylene Chloride (ppm)
Lasting Dept. - Welt Line (4 part machine)	6:40-11:00	103	114
	11:00-14:44	127	
Lasting Dept. - Welt Line (4 part machine)	6:45-11:02	106	96
	11:02-14:45	84	
Lasting Dept. - Welt Line (4 part machine)	6:45-11:04	292	172
	11:04-14:48	33	
Environmental Criteria		--	75

TABLE 9

Distribution of Interviewed Workers
(Follow-up Study) by Work Area*

Red Wing Shoe Company
Red Wing, Minnesota
HETA 81-455

Area	Plant 1 (N=15) N
Basement	2
1st Floor	2
Annex	3
2nd Floor	6
3rd Floor	2

Area	Plant 2 (N=20) N
Prefit	1
Cutting	2
Fitting (includes Cement Booth	2
Finishing	1
Sole	4
Lasting (Cement and Welt)	10

*Although 44 workers returned usable questionnaires only those workers on whom personal environmental sampling was also done (N=35) were included in several of the tables.

TABLE 10

Percent of Workforce By Plant Reporting
Symptoms in Follow-up Survey

Red Wing Shoe Company
Red Wing, Minnesota
HETA 81-455

Complaint	Plant 1 (%)	Plant 2 (%)
Skin - dry	27	41
Skin - rash	32	14
	59*	55*
Eye irritation	23	36
Throat irritation	55	50
Headache	23	41
Nausea	5	0

*Percentage of workers experiencing both dryness of skin and irritation

TABLE 11

Pregnancy Outcomes Among Sample By Plant
in Follow-up Survey

Red Wing Shoe Company
Red Wing, Minnesota
HETA 81-455

Pregnancy Outcome	Plant 1	Plant 2
Total No. Pregnancies	17	5
No. Live, Normal Births	16	5
No. Spontaneous Abortions	1	0
Spontaneous Abortion Rate*	6%	0%

* Rate of Spontaneous Abortion in U.S. General Population is approximately 15%.

TABLE 12

Prevalence of Complaints (Percent)
By Exposure Category*

Red Wing Shoe Company
Red Wing, Minnesota
HETA 81-455

Complaint	High (%)		Moderate (%)		Low (%)	
Skin - dry	18	39	46	77	100	50
Skin - rash	21		31		0	
Eye irritation	25		31		66	
Throat irritation	50		54		66	
Headaches (frequent)	32		31		33	
Nausea	0		8		0	

* High = Score of 8 or 9; Moderate = 6 or 7; Low = <6.

TABLE 13

Association Between Frequency Of
Symptoms and Scores

Red Wing Shoe Company
Red Wing, Minnesota
HETA 81-455

Score	Exposure Category	# Symptoms Reported: < 3 Symptoms (%)	# Symptoms Reported: > 3 Symptoms (%)
<6	Low	(33)	(66)
6 or 7	Moderate	(62)	(39)
8 or 9	High	(79)	(21)

Appendix I

Sampling and Analysis Methodology

Red Wing Shoe Company
Red Wing, Minnesota
HETA 81-455

Substance	Collection Device	Flow Rate	Analysis	Reference
Ethyl Acetate	Charcoal Tube	20-50 cc/min	Gas Chromatography	P&CAM 127
Acetone	Charcoal Tube	20-50 cc/min	Gas Chromatography	P&CAM 127
Toluene	Charcoal Tube	20-50 cc/min	Gas Chromatography	P&CAM 127
Naphtha	Charcoal Tube	20-50 cc/min	Gas Chromatography	--
Heptane	Charcoal Tube	20-50 cc/min	Gas Chromatography	P&CAM 127
Tetrahydrofuran	Charcoal Tube	20-50 cc/min	Gas Chromatography	P&CAM 127
Methyl Ethyl Ketone	Ambersorb	20-50 cc/min	Gas Chromatography	S-3
Methylene Chloride	Charcoal Tube	20 cc/min	Gas Chromatography	S-329
Isopropanol	Charcoal Tube	50 cc/min	Gas Chromatography	--
Toluene Diisocyanate	Impinger	1 liter/min	Colorimetric	P&CAM 141

Figure 1

Kinds of Symptoms Reported in Follow-up Survey
by Percentage Among Combined Sample (N=44)