# SOLVENT EXPOSURES IN THE SHOE MANUFACTURING INDUSTRY

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Industrial hygiene surveys of solvent exposures in shoe manufacturing (SIC-3140) industries were summarized. Walk through surveys at 13 facilities and in depth studies at 3 shoe manufacturers were conducted. Personal and area air samples were analyzed for toluene (108883), benzene (71432), other organic solvent vapors, and total dust concentrations in the in depth surveys. All toluene concentrations were below the OSHA standard of 200 parts per million (ppm). All benzene samples were below the OSHA standard of 10ppm; however, 10 samples exceeded 1ppm. Most of the elevated benzene concentrations were observed in manual operations such as washing and cleaning in the finishing areas. Other organic solvents and particulate concentrations were below the relevant federal standards. The authors conclude that toluene does not constitute a health risk in the surveyed facilities. The unexpected elevated benzene concentrations that were observed probably arose from impurities in the toluene or other materials. It is recommended that a systemic search be made for the source of the benzene contamination and an effort be made to remove it.

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# ABSTRACT

A study on occupational exposures to toluene and epidemiological assessment of these exposures has been undertaken by NIOSH. As part of the study, a selection of the most significant industries using toluene was made. Employment of a scientific process and preliminary survey of several industry groups in the shoe manufacturing industry was selected as the best candidate for evaluation of occupational toluene exposure studies.

Following preliminary walk-through industrial hygiene surveys of thirteen typical toluene using plants, in-depth studies of three shoe manufacturing plants involving extensive air sampling and other environmental measurements were made. The objective of this report is a composite evaluation of environmental data for these three facilities. In all cases, toluene exposures were well below permissible levels. Other organic solvents were also surveyed and found mostly within acceptable levels.

Specific occupations within the industry with potential for increased risk were identified for closer control.

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# INTRODUCTION

NIOSH has been granted the authority and responsibility under the Occupational Safety and Health Act of 1970 to develop needed information regarding worker exposure to potentially toxic substances in industry. NIOSH contracted with SRI International to investigate industries with agents that are newly suspected as occupational health hazards. Toluene was selected as one of those agents for study because it is chemically similar to benzene (toluene is a methylated benzene) which is reported to be a human carcinogen; it is widely used with estimates of almost five million workers exposed. Various uses of toluene are presented in the following listing.

Electronic industry and cleaning parts
Plating
Munitions
Auto machinery
Gasketing
Brake shoe manufacturing
Cleaning window frames
application of resin on paper
Paints, lacquers and vehicles
Molding (spray)
Cloth manufacturing
Pressure-sensitive adhesive levels
Scotch tape
Medical and surgical tape manufactures
Flexible packaging manufacturers
Glazing industry
Woodbonding and veneering
Construction
Mobile home manufcturing
Shoe manufacturing
Insulation manufacturing
Electrical insulation
Automotive industry
Book binding
Household furniture
Cabinet making
Paperboard containers
Converted paper products

Several industries using toluene were considered in an attempt to isolate a "pure" exposure to toluene, that is, with as few other solvents present as possible. Considered were adhesive manufacturing, shoe manufacturing, leather manufacturing, bookbinding, household furniture industry, cabinet makers, lacquer and thinner manufacturing, munitions, and the rubber industry. The shoe manufacturing industry was finally selected as a toluene adhesive user for several reasons: 1) no industry was identified as using only toluene, 2) the exposures to other chemicals appeared minor, 3) the industry has not been well studied in terms of occupational safety and health problems, and 4) the industry was well suited for both an epidemiologic and detailed industrial hygiene studies. Plants were selected based on type of adhesive used, number of years of use of the adhesive or toluene, number of workers exposed, average percent employee turnover rate, availability and completeness of current and terminated employee record, history of production and use, no prior benzene use, and geographical location. An epidemiologic study is to be conducted by NIOSH for facilities which are best suited, based on above criteria.

Over 20 adhesive, cement, and sealant manufacturers were surveyed by telephone. They were selected from a computer printout of 25 adhesive manufacturers (obtained via the Economic Information System Terminal at SRI) and from the Adhesive Redbook, an industry listing. Ten of the companies made adhesives that contained toluene. The remainder involved exposures to other solvents such as styrene, ethyl acetate, acetone, benzene, xylene, and aliphatic naphtha.

Contact cements contain considerable amounts of toluene, and specific end uses include:

Pressure-sensitive adhesive labels
Scotch tape

Medical and surgical tape manufacturers

Flexible packaging manufacturers
Glazing industry (factory-built windows)
High pressure laminates used in woodbinding
Shoe manufacturing
Electrical insulation
Insulation manufacturing
Automotive industry (bonding of hoods and vinyl roofs).

Other adhesives are used in:

Refrigerators and other appliances
Aircraft
Electrical equipment
Book binding
Textiles
Packaging.

In general, two types of adhesives contain toluene, natural and reclaimed rubber adhesives and neoprenes. Natural and reclaimed rubber are used in construction and to make pressure-sensitive adhesives such as masking tapes and paper labels. Neoprenes are used as structural adhesives, i.e., binding metal to metal, as formica adhesive, as consumer adhesive, and in the automotive industry.

In a telephone survey of six shoe manufacturers selected in a manner similar to the adhesive manufacturers, exposures to only toluene were found in the use of neoprene glues to cement the shoe and sole. Two of the major suppliers of neoprene cements to the shoe industry sell products which contain 50% toluene, 35% heptane or hexane, and 10 to 14% ethyl acetate.

## OBJECTIVES AND SCOPE

The objectives of this industrial hygiene study were to:

Review and summarize toxic effects of toluene through a correlative study of environmental evaluations and epidemiological investigations.

Document and describe selected workplaces including information on the extent of use of toluene in the presence of other environmental agents.

Identify job types and describe specific jobs.

Describe current industrial hygiene or safety practices and controls, including engineering controls, work practices, administrative controls, biological and environmental sampling and control procedures.

Document job function exposures.

Describe analytical producedures.

Detailed industrial hygiene surveys reflecting these objectives were conducted at three shoe manufacturing facilities in the United States where toluene and toluene-based adhesives are used. These detailed surveys, all of which have been preceded by preliminary surveys, were conducted from November 1979 to May 1980.

STUDY CONSTRAINTS

The industrial hygiene surveys conducted during this study represent singular evaluations of worker exposures to toluene and do not reflect possible variations in exposure due to seasonal or operational changes. These studies were conducted during periods of normal production. The possibility of encountering a highly unusual exposure situation during a sampling period was remote and therefore the sampling results can be considered to represent those exposures associated with normal working conditions.

One of the difficult problems in identifying a relatively "pure" exposure to toluene is that it is, as described above, often used in combination with other solvents such as xylene and acetone. Much of the toluene still being used contains small quantities of benzene. These confounding factors were considered as much as possible in selecting the facilities studied.

## BACKGROUND

NIOSH estimates that almost five million persons are occupationally exposed to toluene in the United States, ranking number six in over 7,000 substances most often observed in its National Occupational Hazard Survey (NOHS). Toluene is produced in large volumes with an annual production rate in excess of five billion pounds. Toluene has often been used as a substitute for benzene because the carcinogenic potential of benzene was shown. However, because toluene is a methylated benzene and, because of its similar chemical structure, it is of concern that it may have health effects similar to those of benzene.

## TOLUENE DESCRIPTIVE DISCUSSION

### Chemical and Physical Properties

Toluene is a clear, colorless, noncorrosive liquid with a sweet odor similar to that of benzene. The chemical formula and some chemical and physical properties of the compound are given in Table 1.

Table 1. Chemical and Physical Data for Toluene

Synonyms: Toluol, Methylbenzene, Methylbenzol, Phenylmethane

Chemical formula: $C_6H_5CH_3$

Some chemical and physical properties

| | |
|---|---|
| Molecular weight: | 92.13 |
| Boiling point: | (760 mm Hg): 110.60°C(231°F) |
| Freezing point: | -95°C |
| Specific gravity (20°C): | 0.866 |
| Vapor density (air=1): | 3.14 |
| Vapor pressure (25°C, 77°F): | 28 mm Hg |
| Flash point (closed cup): | 4.4°C (40°F) |
| Flammability limits (in air): | 1.27 - 7.0% |
| Solubility: | not soluble in water (0.5g/100ml) but soluble in most organic solvents |

Sources: References (15 & 18)

## Production and Uses

Approximately 70% of all toluene that is produced is converted to benzene. Another 15% is consumed in the production of other chemicals. The remainder is used as a solvent, as a gasoline additive and in many household and industrial uses. Highly purified toluene (Reagent Grade and Nitration Grade) is presently used for many commerical purposes and contains less than .01% benzene. However, toluene of high purity was not available until about 1940, so that experimental data before that time are open to question because benzene content may have been as high as 25% (as reported by the Manufacturers' Chemist Association).

# PHYSIOLOGICAL EFFECTS OF TOLUENE

## Toxicity

The current standard set by OSHA is 200 ppm with a ceiling level of 300 ppm and a peak of 500 ppm, based on Von Oettingen's work in 1942.(13) The standard is designed to protect the health and safety of workers for an 8-hour day, 40-hour week over a working lifetime; compliance with the standard should therefore prevent adverse effects of toluene on the health and safety of workers. NIOSH's recommended standard is 100 ppm, with a ceiling of 200 ppm. The 1981 ACGIH TLV is 100 ppm for an 8-hour day with a short term exposure limit (STEL) of 150 ppm.

Acute exposure to toluene generally causes irritation of the skin, conjuctivis, and respiratory mucous (ILO, 1971). It depresses the central nervous system as do other hydrocarbons, resulting in headache, paraethesia, nausea, muscular weakness, neuromuscular incoordination, vertigo, dilation of the pupils and, in extremely high exposures (thousands of ppm), coma and death (Von Oettingen, 1942).

The LD50 in the rat is 1640 mg/kg intraperitoneally (Keplinger et al., 1959). Rats exposed to 200, 1000, and 2,000 ppm toluene 8 hours per day for 32 weeks (Takeuchi, 1969) showed no significant changes in body weight, leukocyte count, erythrocyte count, eosinophil count, or hemoglobin levels.

In general, the narcotic effect of toluene is somewhat stronger than benzene, but the effect on the blood forming organs is considerably less severe.

No data was found that toluene is mutagenic in the Ames Salmonella typhimurium test, but Dobrokhotov (1972) reported that toluene alone and when administered with benzene produced chromosome aberrations. One-half of these were breaks and 1/5 to 1/3 were chromatid ruptures. The breaks were noted in 5 to 9% of aberrant metaphases. Dobrokhotov and Enikeev (1977) exposed rats chronically to toluene and found an increase in chromosome lesions in bone marrow cells. When combined in exposure to benzene, the number of lesions was equal to the sum of the number of distrubances for each separate chemical.

## Hematopoietic Effects

Various studies conducted to evaluate the effects of toluene on the hematopoietic system have shown generally no myelotoxic effect in humans; however, some controversy still exists. Greenburg et al. (1942) studied 61 painters exposed from 100 to 1100 ppm toluene for from 2 weeks to 5 years in an airplane factory. Results indicated decreased levels of erythrocyte counts, absolute lymphocytosis, and elevation of the hemoglobin level, and they also observed hepatomegaly and macrocytosis.

Curtis et. al. (1973) reported a case of a 47-year-old worker who was diagnosed as having chronic myeloid leukemia after 4 years of occupational exposure to solvent vapors containing 55 ppm toluene. The man spent 10% of his working hours in the shop and was tranferred 2 years prior to his diagnosis. His wife was also diagnosed as having chronic myeloid leukemia which casts doubt on his occupational exposure.

## Nervous System Effects

Acute exposures to toluene depress the central nervous system as do other hydrocarbons, resulting in headache, nausea, and muscular weakness, neuromuscular deterioration, dilation of the pupils, and in extremely high exposures coma and death. Von Oettingen (1942) showed that at concentrations of 200 ppm for 8 hours, slight but definite impairment of coordination and reaction time resulted which he felt was liable to render affected persons dangerous to their own safety and to the safety of others.

## Kidney Effects

Renal disease resulting from exposure to toluene has been recently reported by Ehrenreich (1977). In addition, O'Brien et al. in 1971 described a case of a 19-year-old male who had been sniffing glue containing 80% toluene for 3 years and who had developed serious but apparently reversible injury to his kidneys. Taher (1974) reported reversible renal tubular acidosis associated with sniffing toluene.

## Other Effects

Toluene is a defatting agent and may remove lipids from the skin resulting in dermatitis, dryness, fissuring, and secondary infection. Toluene has also been shown to cause corneal damage and conjunctival irritation when accidentally splashed into the eye.

There are other factors that may determine the health effects associated with exposure to toluene. These involve the uptake, retention and elimination of inhaled toluene in human subjects. Uptake of toluene depends on the levels being emitted, the duration of exposure and the degree of physical activity.

Although men seem to show a larger uptake of toluene than women, men also excrete the toluene at a much faster rate. In addition, women eliminate toluene in expired air only about one-half as much as men. This is thought to be due to the increased body fat in women because toluene is highly soluble in fat (10,11).

## FACILITIES AND PERSONNEL SURVEYED

In attempting to find an industry or facility with exposures to toluene that were adequate for study both from an industrial hygiene and epidemiological standpoint, seven adhesive manufacturers and five adhesive user facilities were visited for walk-through surveys. Three of the adhesive users were shoe manufacturing plants (Plants A, B, and C), which were surveyed in detail and are the subject of this report. The remaining walk-through surveys provided insight into the extent of exposure to toluene in the other industries and will be briefly described here.

### Adhesive Manufacturers

Seven adhesive manufacturers were visited (Plants D through J). The results of the environmental sampling in these plants are summarized in Table 2 along with relevant data for the plants.

Plant D is an adhesive manufacturing plant making neoprenes and urethanes using toluene. These adhesives are used by the shoe manufacturing industry to cement upper and lower soles together. The processes are described in Figure 1. The toluene levels ranged from less than one to 270 ppm. These variations were seen during the filling of drums with adhesive and near mixing areas with additive barrels.

Plant E is a plant manufacturing pressure-sensitive adhesives for use on lables, i.e., rubber based and acrylic adhesives. About 50% of the products contain lactol spirits which is 5% toluene. A process flow diagram is shown in Figure 2. Charcoal and Draeger samples indicate that exposures are below the TLV with the range between 3 to 32 ppm.

Plant F is a plant manufacturing solvent-based (25% of production) and water-based adhesives. The process operator adds solvents and resins to the mixing tanks, mixes the cement, and then draws it off into drums. Packaging operators fill adhesive into smaller packages from smaller tanks. The process is described in Figure 1. Toluene levels were 8.1 to 51.2, with a mean of 28 ppm. Other solvent exposures include MEK, methylene chloride, hexane, lactol spirits.

Solvent and water based adhesives and solvent-based mastics or sealers are manufactured by Plant G. The process for making solvent-based adhesive consists of mixing neoprene rubber with solvent such as acetone, toluene, water, textile spirits, chloroethane, 1,1,1-trichloroethane, heptane, and hexane. There is also

Table 2. Adhesive manufacturers.

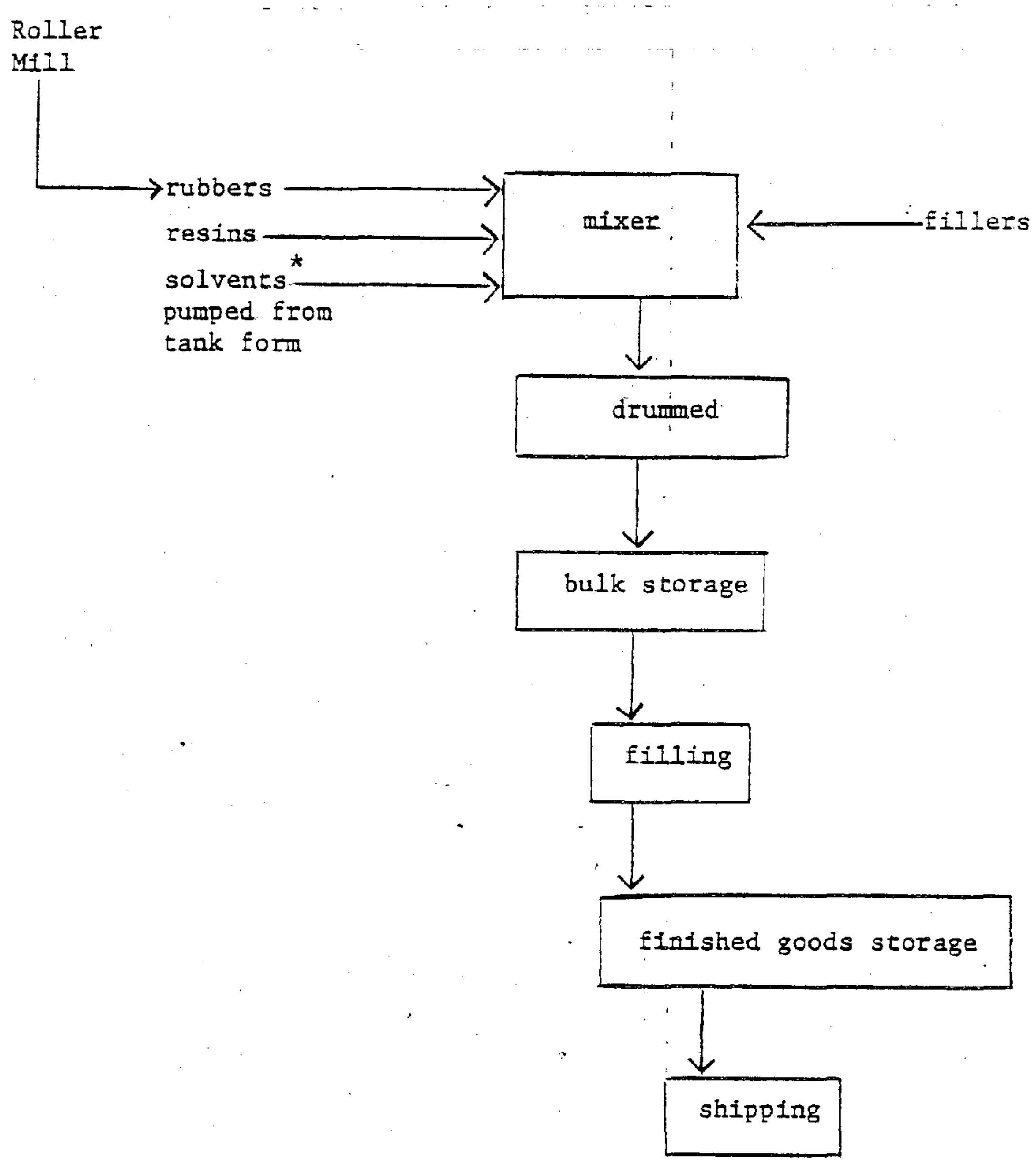
| PLANT | NO. PEOPLE IN PRODUCTION | NO. PEOPLE EXPOSED | PRODUCTS/ PROCESS | EXPOSURES (OTHER THAN TOLUENE) | PAST EXPOSURES PPM TOLUENE | REPRESENTATIVE JOB TITLE | TOLUENE CONCENTRATIONS RANGE (PPM) | MEAN PPM (GEOMETRIC) |
|---|---|---|---|---|---|---|---|---|
| Company D | 15 | 15 | neoprenes, urethanes | heptane, hexane, ethyl acetate, acetone, methyl ethyl ketone & hexane | 14 | loader, draw-off man, material handler | <1 - 270 [a] | 39 |
| Company E | 79 | 18 | rubber-based and acrylic adhesives | lactol spirits textile spirits MEK, pulverized rubber | + | compounder, quality control technician | 3 - 32 [b]<br>trace - 48 [c] | 17.5 [b] |
| Company F | 31 | 19 | solvent-based (neoprenes) and water-based adhesives | acetone, methylene chloride MEK, hexane 1,1,1-trichloroethane heptane, lactol spirits | 2-96 | process operator, packaging operator | trace - 25 [c]<br>8.1 - 51.2 [b] | 28.1 [b] |
| Company G | 22 | 22 | solvent and water-based adhesives, solvent-based mastics or sealers | textile spirits (4% toluene), chloroethane, heptane, 1,1,1-trichloroethane, toluene, hexane, acetone, asbestos | 2-20 [b] | class A operators, mill operator, porter mixer | N.D.C<br>2.8 - 3mg/m3 [b] | 2.9 mg/m3 [b] |
| Company H | 231 | 198 | solvent-based adhesives for labels | hexane, heptane, ethyl acetate, alcohol, ketones, "pigments" | 50-290 | coating machine operator, compounder, line operator, QA technician | 25 - 80 [a]<br>14 - 28 [b] | 38.4 [a]<br>20 [b] |
| Company I | 83 | 83 | solvent-based adhesive (neoprene, urethane) | MEK, acetone, 1,1,1-trichloroethane, hexane, textile spirits, ethyl acetate, naptha xylene, asbestos, acrylonitrile, epichlorohydrin | 25-150 [b] | processor, processor helper, quality-control technician | 1 - 8 [b]<br>11 - 34 [a]<br>trace - 10 [c] | 3.6 [b]<br>18 [a] |

TABLE 2 (Concluded)

| PLANT | NO IN PRODUCTION | NO EXPOSED | PRODUCTS/ PROCESS | OTHER EXPOSURES (OTHER THAN TOLUENE) | PAST EXPOSURES (PPM) (TOLUENE) | RESPRESENTATIVE JOB TITLE | TOLUENE CONCENTRATIONS RANGE (PPM) | MEAN PPM (GEOMETRIC) |
|---|---|---|---|---|---|---|---|---|
| Company J | 225 | 31 | polymerization, solvent-based adhesives, rubber based solution polymers | vinyl acetate, MEK ethyl acetate, acrylic acid, acrylic monomers, maleic anhydride, methylene chloride, hexane, acetone | 21 ppm | operator, assistant operator, helper | barely detectable to 12[a] | 7.3[a] |

LEGEND:

- a Century Organic Vapor Analyzer samples
- b Area charcoal tube samples
- c Draeger detector tubes
- \+ OSHA survey found levels in compliance




*Toluene, acetone, lactol spirits, acetone, methylene chloride, hexane, heptane, methyl ethyl ketone, chlorothene.

Figure 1. Typical Adhesive Manufacturing

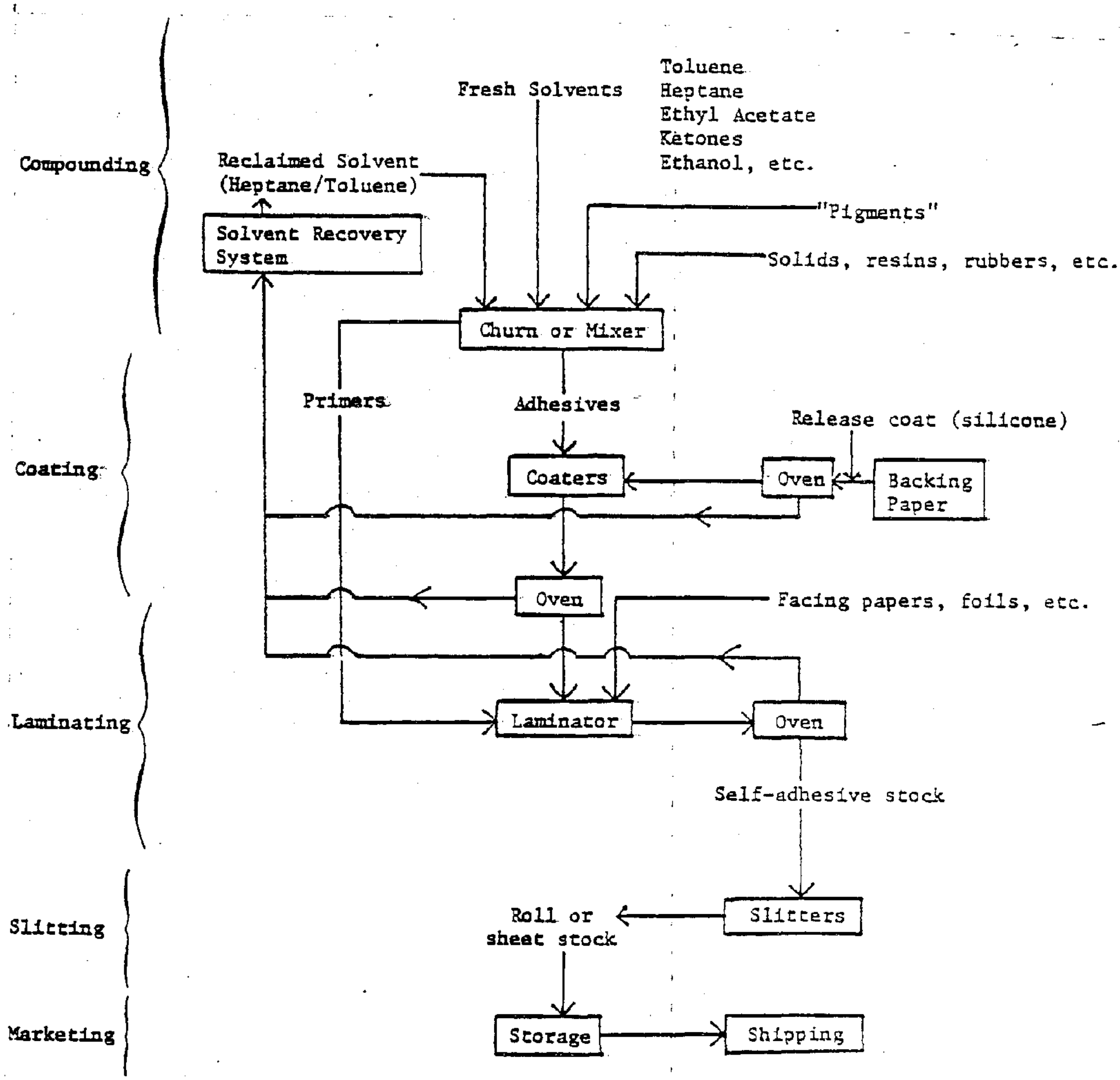



Figure 2. Adhesive Label Manufacturing Process

some synthetic styrene butadiene adhesive produced. Asbestos is used occasionally in making a neoprene and a putty. Levels of asbestos were found to be in compliance by Cal-OSHA. The process is presented in Figure 1. Short term samples showed low levels of toluene with a range of 2.8 to 3 mg/m$^3$ and none detectable with Draeger detector tubes having a detection limit of 5 ppm. Total hydrocarbon as sampled with a TLV Sniffer showed excursions up to 200 ppm near filling areas.

In Plant H, an adhesive lable manufacturing plant, there are seven buildings with three active toluene-based adhesive production lines. One end-line was singled out for the walk-through. Raw materials for the process as described in Figure 2 include rubber, resin powders or other similar materials, toluene, hexane, heptane, ethyl acetate, alcohol, ketone, and "pigments", in proprietary combinations. These ingredients are mixed in "drums" and then the adhesive is applied to paper for use as labels. The wet stock is oven-dried, "laminated" to the facing stock (paper, foil), and then transferred to the slitting department where it is cut and sent to storage.

Sampling in the past indicated levels almost as high as 300 ppm prior to 1974. Seven Century Gas Analyzer samples taken during the survey showed a range of 25 to 80 ppm with a mean of 38.4 ppm. Three charcoal tube samples showed a range of 14 to 28 ppm with a mean of 20 ppm. Concurrent charcoal tube sampling by the company showed a range of 13 to 37 ppm and a mean of 17 ppm.

Plant I manufactures a broad range of solvent and water based adhesives, coatings, caulks, and sealants. About one-third of the adhesives made are sold to the shoe industry. Asbestos is used for manufacturing of caulk which occurs in a separate room. The raw materials include neoprene and polyurethane rubbers, phenolic resins, toluene, MEK, acetone, 1,1,1,-trichloroethane, hexane, textile spirits, ethyl acetate, naphtha xylene, and occasionally acrylonitrile and epichlorohydrin. Benzene was used prior to 1958. Past exposures to toluene dating back to 1976 showed a range of 25 to 150 ppm when the caulk hopper was being cleaned. Other toluene concentrations were 55 ppm during mixing, 70 ppm during mixing, and 60 ppm in the middle of the room. Exposure to acrylonitrile in 1978 was 0.1 ppm and epichlorohydrin was < 1 ppm.

Sampling during the survey with five charcoal tubes showed a range of 1 to 8 ppm with a mean of 2.6 ppm toluene. Three samples taken with the Century Organic Vapor Analyzer showed 11 to 35 ppm with a mean of 18 ppm toluene. Draeger tube samples were from a trace to 10 ppm toluene. Total hydrocarbon ranged from 28 to over 400 ppm.

Plant J manufactures toluene-based adhesives by two basic processes: the first, by polymerization and the second, by addition of solvents to mixing kettles and the solution of rubbers in these mixes. In the production of solvent-based adhesives through polymerization, the solvents used include toluene, vinyl acetate, MEK, and ethyl acetate. In addition, acrylic acid, acrylic monomers, and maleic anhydride are used. In the production of rubber-based solution polyers, the raw materials are natural and synthetic rubber, toluene, methylene chloride, MEK, hexane, and acetone. Toluene is often used in both departments for cleaning of kettles or tanks.

Area sampling in the past with charcoal tubes indicated that toluene exposures were less than 1 ppm. "Century" samples showed a range from barely detectable to 12 ppm with a mean of 7.3 ppm.

Adhesive Users

Adhesive users (see Table 3) visited included Plant K where shoes are manufactured using water and solvent based adhesives. The general manufacturing process is presented in Figure 3. Cut material of leather stock are assembled and sent to subassembly benches for sewing, trimming, decorating, and upper finishing cleaners, cements, and adhesives of different types (solvent-base, water-base or hot-melt) are used in several of these processes. Cements are used to fit the shoes' upper assemblies to lasts (dummy feet). The bottom of the shoe is trimmed, finished, "shanked" (metal arched), and fitted smooth with a mix of saw-dust and cement to form a mating surface for the sole. Soles and uppers are cemented together, cure-dried and finished. Toluene is one of the main components of the adhesives used, but other organic solvents are used in the formulations including hexane, hexol, and ethyl acetate. Exposure data in 1977 showed toluene exposures at 15 and 20 ppm. During the survey, charcoal tube samples ranged from 0.9 to 19 ppm with a mean of 11.9 ppm and Draeger detector tubes ranged from none detectable to 22 ppm. Hexane levels were 2.6 to 4.5 ppm and ethyl acetate was 0.09 to 45 ppm. These low levels may be credited to an extensive ventilation system recently installed in the facility. Another adhesive user facility, Plant L, makes pressure sensitive labels from toluene-based adhesives. Use of toluene-based adhesives began in 1948. Most of the products over the years have used 50% lactol spirits which is 5% toluene. An OSHA inspection in 1974 showed them to be in compliance. Charcoal tube samples showed a range of 1 to 31 ppm with an average of 15.6 ppm. Draeger detector tubes showed a range of none detectable to 170 ppm during laminating operations. The exposures to toluene during use of toluene-based adhesives is in the preparation of the label stock.

Table 3. Adhesive users.*

| PLANT | NO. PEOPLE EXPOSED | NO. PEOPLE EXPOSED | PRODUCTS/ PROCESS | EXPOSURES (OTHER THAN TOLUENE) | PAST EXPOSURES PPM TOLUENE | REPRESENTATIVE JOB TITLES | TOLUENE CONCENTRATIONS RANGE (PPM) | TOLUENE CONCENTRATIONS MEAN PPM (GEOMETRIC) |
|---|---|---|---|---|---|---|---|---|
| Company K | 303 | 298 | shoe manufacturing using water- and solvent-based adhesives | hexane, hexol, ethylacetate | 15.06 - 19.96 | bottom cementer | .9-19[b]<br>ND-20[c] | 11.9[b] |
| Company L | 55 | 55 | label manufacturing using solvent-based adhesives | lactol spirits, MEK, hexane, textile spirits | + | slitter operator, tape machine operator, slitter helper | ND-170[c]<br>1-31[b] | 15.6[b] |

* Three other facilities were also walk-through surveyed. They are the subject of the in-depth surveys (Plants A, B, C) and are not tabulated here.

LEGEND:

a Century Organic Vapor Analyzer samples

b Area charcoal tube samples

c Draeger detector tubes

\+ OSHA survey found levels in compliance

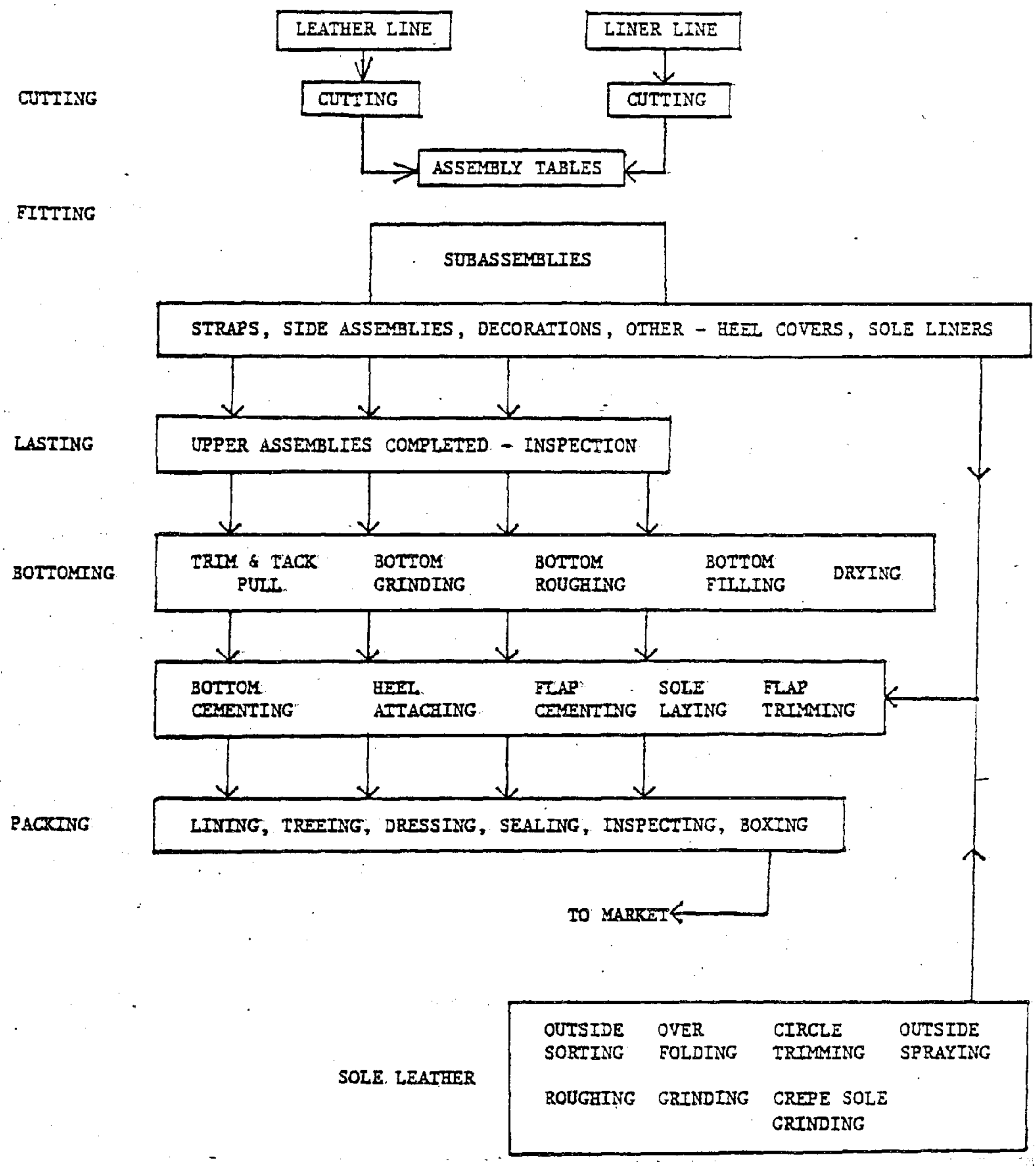



Figure 3. General Shoe Manufacturing Process

In summary, the walk-through surveys of toluene-based adhesive manufacturers and users indicate low-level exposures to toluene. There are also few areas where there is "pure" exposure to toluene, as other organic solvents are generally present.

SPECIFIC STUDIES IN SELECTED PLANTS: A, B, C,

Three facilities at which various types and styles of men's and womens's shoes are manufactured are included as the subjects for this report. Attempts have been made to provide as much of an exposure cross section as possible. The plants were selected on the basis of such criteria as the number of persons potentially exposed to toluene, the number of years of toluene use as an adhesive vehicle, the level of toluene concentrations as determined by preliminary area sampling, routine or continous operations and therefore relative continuity of exposure levels, exposure situations where the compounding effects of other chemicals would be minimized or clearly identified, and processes representative of a significant use of the substance. Based on initial investigation, toluene cannot be placed in a high-use category within the shoe industry, but its use is higher than all other industries investigated where extreme interfering factors could be held to a minimum.

The facilities are designated as Plant A, B, and C in this report. The plants are briefly described below, followed by a description of the shoe manufacturing processes, personnel and jobs in which potential exposure to toluene occurs, and control programs, if any, that have been established.

OVERVIEW OF PLANTS: A, B, C

Plant A

Plant A is located in an industrial park in a moderately industrialized area of the south-central United States. Until 1950, Plant A was located in the East. Following its geographical relocation in the South, the plant operated from approximately 12 years (1950-1962) in an inner-city setting. The present facility, constructed in 1962, is located in an industrial complex at the edge of the city where the parent company is also located. Toluene-based adhesives have been utilized by Plant A throughout its lifetime. Some shifts from neoprene to urethane adhesives have changed patterns of exposure but, in general, toluene-based adhesive usage has remained consistent within all departments.

Plant B

Plant B is located in a rural area in the Southeast. The plant was built in 1970 with a warehouse added in 1972. Prior to 1970 the plant was located in an eastern city. Operations began in 1946 and continued at that location until the facilities were moved to their current location. Toluene-based adhesives have been used in the present plant since the start-up of production in 1970. Before that, toluene-based adhesives were used in the eastern plant at least as far back as 1962. Approximately 4 years ago (1975) urethanes were introduced into the process. Currently, 65% of the cements used are neoprene, containing toluene as the solvent vehicle, and 35% are urethane, utilizing methyl ethyl ketone as the solvent base.

Plant C

Plant C is located in a small city in the East and has been in operation under the present ownership since 1924. The present plant was built in 1958, undergoing periodic enlargement through 1977. Toluene usage has been consistent at least since

1958 with little history prior to that date. Urethane adhesives have been introduced into the plant since that time, adding an additional solvent (MEK) to the airborne inventory but doing little to change the character or extent of exposure to toluene.

## PROCESS AND CONTROL OPERATIONS

### GENERAL DESCRIPTION OF SHOE MANUFACTURING PROCESS

#### Receiving--

This area of the building is where domestic and imported leather and other shoe raw materials are separated, graded, and stored. No adhesives or solvents are used in this limited-access area which is usually separated from the main manufacturing bay by means of an enclosure.

#### Cutting Area--

In this area, leather from Receiving is cut with various sized dyes to the forms needed for manufacture of different shoe styles. Cutters and trimmers are employed in this department, most of whom are highly skilled because as many pieces as possible must be cut from each skin to minimize waste. No adhesives, solvents, dyes, or finishes are used in this department.

#### Fitting Department--

This department is the first stage of shoe assembly involving the majority of the work force. There are a number of subassembly areas or benches depending on the shoe design under manufacture. These may include side assemblies, straps, decorations, linings, heel covers, etc. For example, in the Doubling Area, leather linings are glued to outer leather components, and at the VAMP Benches, the vamp glove (shoe lining) is cemented to the vamp. At the Decorative Benches, decorative fixtures such as bows, piping, inlays or other accents are assembled. The remainder of the Fitting Department consists of benches for cutting, fitting, and sewing operations.

Insole Department--

This department is engaged in cementing insoles, outsoles and heels, as well as, preparing the inner soles for the lasting operations that follow. The operation known as "insert box toe" is also done in the insole department in which the preglued box toe is assembled and subjected to heat and pressure to harden the box toe and give the shoe its firmness.

Lasting Department--

In this department, the upper part of the shoe is fitted over the "last" (a dummy foot) and shaping and additional fitting continued. Indentifiable operations include antiquing where antiquing dyes are used, side and heel lasting, toe lasting, toe fastening, bottom sanding, cobbling, back part molding, crowning, and covering.

Welting and Bottoming Department--

Some plants make welt shoes in which the soles are fully sewn as well as glued to the shoe. This is an additional process but renders the shoes more durable and form-retentive. To cement the bottoms, cement is dispersed through nozzles of the cementing machines and is laid onto the grooved periphery of ~~the~~ innersole. This operation is called "cement bottoms". In another operation called "lay soles", cement is spread over the shoe soles before they are applied to the bottom of the shoes. This process involves running the sole through an adhesive roller and stacking them in wire racks to dry. "Bottom filling" is also done, in which cork bottom filler material mixed with a toluene-based adhesive is pressed into place in the depression in the sole that is created by the surrounding welt. The cork bottom filler provides additional cushioning for the foot following application of the sole that seals the material into place. An additional operation is "shanking" where a metal arch is integrated into the shoe bottom, fitted with adhesive and a filler (cork or sawdust) to make a mating surface for the sole.

Making Department--

The operations in this department consist of shaping the shoe heels and applying them to the shoe by cementing and/or pinning. The lasts are removed from the shoes, and soles and heels are trimmed, ground, and smoothed.

Finishing, Packing, and Shipping Department--

Operations in this department involve the dyeing or inking of heels, the cleaning or spotting of shoes, and the application of a spray shine within two water-curtain spray hoods using latex-based liquid finishes. A shoe repair operation is also included to mend minor damage that may have occurred in manufacture. Additional spotting or antiquing may be involved and, after treeing and polishing, the shoes go on to be packaged for final delivery.

## Plant A Environmental Controls

Plant A makes extensive use of local exhaust ventilation for the control of particulates at abrasive operations such as grinding, sanding, roughing, and buffing machines in the welting, bottoming, making, and finishing departments. The majority of the dust collection hoods are ducted to two baghouse collectors on the exterior south side of the building that together return 102,000 cfm of air into the plant. Negative pressures within the building is offset by dampers entering at the rear of the building which open during negative pressure situations to bring in an additional 50,000 cfm of heated or cooled fresh air to the air handling system.

In addition to the baghouse collectors, there are seven Torit cyclone and fabric collectors inside the building, distributed throughout the front and rear of the plant to supplement baghouse collection. These units are designed to collect larger particulates in the cyclone component and diffuse return air through four fabric collectors to remove the fines. Each Torit collector is ducted to sets of from two to four adjacent abrasive machines such as sanders, sole roughers, heel scourers, and edge trimmers. In general, the particulates generated by all abrasive machines in the plant are of non-respirable size. Generation of respirable size dust is minimal, although some deposited dust from air returned through the Torit fabric filters was observed on undisturbed surfaces to the units.

Local exhaust ventilation for vapor-generating operations in Plant A was confined to spraying operations in the finishing department, vamp glove gluing operations in the fitting department, and insole and outsole cement operations in the insole department. Table 4 shows hood dimensions and flow rates encountered at vapor gen-

Table 4. Plant A - ventilation measurements for spray booths and vapor collection hoods.

| Location | Hood dimensions | Average face velocity (fpm) |
|---|---|---|
| Packing Department (finish spray booth - 2nd coat, south face) | 16" x 32" | 300 |
| Packing Department (finish spray booth - 2nd coat, north face) | 16" x 32" | 700 |
| Packing Department (repair hood) | 18" x 24" | 50-60 |
| Packing Department (repair hood) | 18" x 24" | 140 |
| Fitting Department - cement uppers | 3" x 12" | 800+ |
| Insole Department - cement outsoles - hood #1 | Exhaust system being installed | Not operating |
| Insole Department - cement outsoles - hood #2 | Exhaust system being installed | Not operating |

erating work stations. Hoods at the cement outsole and cement insole operations were new installations at the time of the survey, and electrical connections to the exhaust fans had not been made. Exhaust from vented spray hoods and other solvent vapor-generating consist of weather caps covering stacks of minimal height. Depending on temperature differential between the vented air and the outside air, there is potential for vapor to collect on the roof. It is possible but unlikely that vapors could be recirculated into the building through open doors and windows because the building is provided with air conditioning in the summer and it is not a usual practice to leave doors and windows open.

Plant B Environmental Controls

This plant uses Torit cyclone and fabric collectors exclusively throughout the buildings to collect dust from abrasives operations. Two units in Bottoming collect particulates from edge trimmers, toe grinders, and roughers. There are also two Torit collectors in the Sandal Department, each ducted to four or five trimmers, grinders, roughers, and scourers. In the Sole Department, three Torit units remove dust generated during sandal manufacture. Generation of fines was not observed to be excessive in any department, although some deposited dust from air return through the fabric filters was noted on undisturbed surfaces adjacent to the Torit units.

Local exhaust ventilation is applied to a variety of vapor generating operations throughout the plant including finish and spray hoods in Packing, adhesive dip operations in the Sandal Department, latex spray hoods in the Sole Department, and a glue applicator table and chlorinating unit in Bottoming Department. Table 5 shows hood dimensions and flow rates at hood faces, takeoffs, and duct entries

Table 5. Plant B - ventilation measurements.

| Location | Hood and Duct Dimensions | Flow Rate (fpm) |
|---|---|---|
| Bottoming-Edge trimmer No. ME 0545 from Torit Collector ME 0503 (Two branches, lower branch blocked.) | 4 inch duct with flared take-off | 2000+ |
| Bottoming-Toe grinder No. ME 0515 from Torit Collector ME 0503 (Two branches, left branch closed.) | 4 inch duct | right-1300 |
| Bottoming-Toe grinder No. ME 0537 from Torit Collector ME 0503 (Two branches, right branch closed.) | 4 inch duct | left-1000 |
| Bottoming-Rougher No. LE 124 from from Torit Collector ME 0513 | 4 inch duct | left-850<br>right-650-700 |
| Bottoming-Rougher No. LE 123 from Torit Collector ME 0513 | 4 inch duct | left-1700<br>right-1500 |
| Bottoming-Trimmer No. EX 020 from Torit Collector ME 0513 | 5" x 6" hood | 375 |
| Bottoming-Trimmer No. EX 019 from Torit Collector ME 0513 | 5" x 6" hood | 300 |
| Bottoming-Cement Sole Roller (NSN) (vented through roof) | 2' x 2' canopy hood | 175-180 |
| Finish - Vinyl Finish Hood No. ME 0728 (vented through roof) | 2-1/2' x 2-1/2' face | 150 |
| Finish - Spray Hood No. EX 037 (vented through roof) | 2-1/2' x 2-1/2" face | 40 |
| Finish - Spray Hood No. EX 038 (vented through roof) | 2-1/2' x 3' face | 60 |
| Finish - Spray Hood No. EX 039 (vented through roof) | 2' x 2' face | 75 |
| Finish - Spray Hood No. EX 040 (vented through roof) | 2' x 2' face | 75 |
| Finish - Wafer curtain hood No. EX 035 (vented through roof) | 2' x 2' face | 125 |
| Finish - Wafer curtain hood No. EX 034 (vented through roof) | 2' x 2' face | 125 |
| Sandal - Heel dip trough-east unit (vented through south wall) | 8'10" x 2'5" | left face, negligible; right face-30; at filter = 250 |
| Sandal - Heel dip trough-west unit | 9'10" x 2'5" | at face - 15<br>left filter - 125<br>right filter- 100 |
| Sandal - Heel rougher off Torit Collector No. ME 0599 | rear take-off | 1800 |
| Sandal - Trimmer No. ME 0591 off Torit Collector No. ME 0591 | rear take-off | 2000 |
| Sandal - Trimmer No. ME 0586 off Torit Collector No. ME 0591 | 4 branches | upper left - 150<br>upper right-800<br>hood face - 30<br>lower take-off-400 |
| Sandal - Trimmer No. EX 028 off Torit Collector No. ME 0587 | trimmer head enclosure | 200 |
| Sandal - Rougher-Trimmer No. ME 0605 off Torit Collector No 0587 | | hood face-negligible<br>upper take-off 325<br>tower take-off 950 |
| Sandal - Wheel Grinder No ME 0603 | 2 branches | left face - 175<br>right face= 100-150 |
| Sandal - Trimmer No. 0589 off Torit Collector No. ME 0587 | | lower - 1000<br>right - 300<br>left - no access |
| Sole - Contour heel No. ME 0067 off Torit Collector No. ME 0051 | | 200-300 |
| Sole - Latex Adhesive Sprayhood (vented through wall) | | Hoodface - 70 avg<br>left duct entry-70<br>right duct entry-20<br>lower duct entry-650 |
| Sole - Scourer-Rougher No. ME 0063 off Torit Collector No. ME 0061 | 2" x 4" hood | face - 375 |
| Sole - Chicago trim No. ME 0060 off Torit Collector No. ME 0061 | at work face | 200+ |
| Sole - Trimmer No. ME 0057 off Torit Collector No. ME 0061 | at work face | 550 |
| Sole - Grinder No. EX 003 off Toric Collector No. ME 0061 | grinder-head enclosure | enclosure face-50<br>upper duct entry-600<br>lower duct entry-250 |
| Sole - Router (NSN) off Torit Collector No. ME 0061 | | upper duct entry-600<br>lower duct entry--blocked |
| Sole - Vertical Grinder No. EX 002, off Torit Collector No. ME 0061 | flared hood | 550 |
| Sole - Vertical Grinder (NSN) off Torit Collector (NSN) | flared hood | 2000+ |
| Sole - Edge Trim No. ME 0066 off Torit Collector (NSN) | 2 take-offs | left - 500<br>right- 900 |
| Sole - Edge Trimmer No. ME 0550 off Torit Collector (NSN) | slot exhaust | 2000+ |
| Sole - Trimmer No. LE 037 | trim head enclosure | 250 at enclosure face<br>1300 @ duct take-off |

*NSN = No serial number.

at all ventilated operations in Plant B. Exhaust ducts from spray hoods, adhesives operations, and other solvent vapor-generating activities are either vented through the roof or are vented through the walls directly behind the hoods. Roof vent stacks consist of weather caps covering short stacks. It is possible but unlikely that vapors could be recirculated because doors are kept closed to maximize air-conditioner efficiency, and there are no windows. Spray hoods in the Sole Department and the heel dip hood in the Sandal Department are vented through the north and east walls. The vent ducts extend laterally through the walls to the exterior and there is some potential for plugging.

Plant C Environmental Controls

Plant C makes extensive use of local exhaust ventilation for the control of particulates at abrasive operations. The majority of dust collection hoods and take-offs are connected to an Amerjet baghouse with 31 fabric collectors, which recirculates air into the plant through a water scrubber on the roof. The remaining particulate-generating operations are vented to an American Air Filter (AAF) rotoclone and fabric collector. The unit is like the Torit units used in Plant A and B in that it is designed to collect larger particulates in the rotoclone separator and diffuse return air through four fabric bags to remove the fines. The AAF serves from 9 to 10 roughers and grinders in the cement room. No information was available on air volumes handled, but flow rates at the abrasives machines in operation (refer to Table 6) indicate good air velocities. Both units (Amerjet and AAF) recirculate filtered air into the plant, and makeup air does not appear to be a problem. Generation of fines within the makeup air appears to be minimal, although some dust deposits were noted adjacent to the AAF bag diffusers.

Table 6. Plant C - ventilation measurements.

| Location | Air Velocities Flow Rate (fpm) | Associated Collection Unit |
|---|---|---|
| Cement Room - Rougher #5791 | 2000 - upper hood face | AAF Rotoclone |
| Cement Room - Rougher #5797 | 2000 - uppper hood face | AAF Rotoclone |
| Cement Room - 3rd Rougher | 2000 - lower take-off<br>1000 - upper take-off | AAF Rotoclone |
| Cement Room - 4th Rougher #5838 | 2000 - lower take-off<br>7500 - upper take-off | AAF Rotoclone |
| Cement Room - Pounding Machine #8161 | right hood - 1050 (avg)<br>left hood - 375 (avg) | AAF Rotoclone |
| Cement Room - Pounding Machine #0164 | right hood - >600 (avg)<br>left hood - 700 | AAF Rotoclone |
| Cement Room - Pounding Machine #9820 | right hood - 625 (avg)<br>left hood - 200 (avg) | AAF Rotoclone |
| Cement Room - Pounding Machine North End | right hood - 800 (avg)<br>left hood - 400 (avg) | AAF Rotoclone |
| Lasting Dept. - Edge Trimmer #0656 | At cutting wheel - 350<br>At duct face - 140 | AMF Baghouse |
| Stockfitting - Lining Reducer | 1250 | AMF Baghouse |
| Stockfitting - Roughing Machine | 1700 | AMF Baghouse |
| Stockfitting - Shank Reducer | 700 | AMF Baghouse |
| Stockfitting - Sole Reducer | No access - Collection poor | AMF Baghouse |
| Stockfitting - Roughing outsoles | At hood face - 450 | AMF Baghouse |
| Stockfitting - Compo-machine (rougher) | >2000 | AMF Baghouse |
| Stockfitting - Edge reducer #C940 | 1200 | AMF Baghouse |
| Stockfitting - Sole reducer | At snorkel face - 2000<br>At tool head - 500 | AMF Baghouse |

| Location | Flow Rate (fpm) | Associated Collection Unit |
|---|---|---|
| Stockfitter - Beveller | 72000 | AMF Baghouse |
| Stockfitting - Roughing Machine #8552 | >250 | AMF Baghouse |
| Stockfitting - Brush stand #3496 | At hood face - 150<br>At plenum - >2000 | AMF Baghouse |
| Stockfitting - Insole beveller #28414 | 500 | AMF Baghouse |
| Stockfitting - Edge Rougher South unit | At cutting head >500 | AMF Baghouse |
| Stockfitting - Edge Rougher North unit | At cutting head 1100 | |
| Stockfitting - Edge Spray Hood | At hood face 450 | Through roof |
| Packing - Chlorinating hood | At hood face - 250 | Through roof |
| Packing - North Finish Spray Hood | At north hood face - 140<br>At plenum entry - 1000<br>At south hood face - 175 | Through roof |
| Packing -South Finish Spray Hood | At west hood face - 225<br>At east hood face - 225 | Through roof |

Local exhaust ventilation for vapor generating operations is limited to one spray hood in stock fitting, the chlorinating hood in the packing department, and two spray finish hoods also in the packing department. Exhaust from these hoods is vented through the roof to the atmosphere. The vent stacks consist of weather caps anchored at the roofline. As with Plants A and B, potential exists for recirculation into the building, but doors and windows are kept closed to accommodate the air conditioners.

COMPOSITE EVALUATION OF PROCESSES AND ENVIRONMENTAL CONDITIONS - PLANTS A, B, AND C

It is apparent from the foregoing that the three shoe manufacturing facilities are very similar from the standpoint of both the physical plant and the processes. Operations at all three are conducted for the most part in large, open, single-story facilities with little or no definition or separation between departments or "rooms". The single exception is Plant B where sandal manufacturing is done in a separate room at the rear of the facility. Machines and equipment used in the manufacturing processes in the three facilities are also much the same with only minor in-plant modifications. This applies to sanders, roughers, grinders, and buffers as well as pull-over machines and relatively new, hot-melt adhesive machines. We were advised during our surveys that there are no proprietary processes or equipment in the industry and this appeared to hold true as there were few meaningful variations in process flow, production techniques, or the type of equipment used. As applied to environmental controls, pronounced similarities appeared in their application. All plants had concentrated heavily on dust collection systems with relatively few vapor collection devices applied to adhesives operations. Spray shine and antiquing stations in all plants utilized water curtain hoods or dry enclosures of similar design. In addition, all three plants relied heavily on interior rotoclone and diffuser bag collectors for a variety of particulate-generating operations. The two larger plants (A and B) had also installed baghouses to accomodate their larger number of operations.

Chemicals used in these plants involve a large number of adhesives, glues, and cements, employing a variety of industrial solvents. Requests were made to ascertain the composition of these materials. Many of these requests were compiled through Material Safety Data Sheets or other forms of information. A summary of all these responses is tabulated in Appendix B.

## PERSONNEL ACTIVITIES

### COMPOSITE JOB ANALYSIS, PLANTS A, B, AND C

In general, jobs within the three plants are similar in character with minor variations associated with the production of sandals in Plant B. Most cementing, cleaning, and washing operations in all plants are done in open areas on what can be considered the open, main floor. However, heel dips, heel wash, and heel cover operations in Plant B are done in a walled room at the rear of the building and larger quantities of neoprene and urethane adhesives are used than are normally associated with traditional shoe manufacturing operations.

In addition to the personnel sampled who had direct contact with toluene, count was kept in all plants of employees with potential direct exposure to toluene. These numbers compared to total production personnel are shown in Table 7. Only those employees actually working with adhesives or other solvent containing materials are reflected in the table. Employees at noncontact operations are not included regardless of the proximity.

Table 7 Number of employees with potential direct toluene exposure.

| Plant ID | Total production work force | Number of employees potentially exposed | Percent of employees potentially exposed |
|---|---|---|---|
| Plant A | 430 | 47 | 11.0 |
| Plant B | 290 | 35 | 12.0 |
| Plant C | 306 | 44 | 14.3 |

## HEALTH AND SAFETY PROGRAMS

### HEALTH AND SAFETY PROGRAM - PLANT A

Plant A, as a subsidiary of a larger corporate structure located on the same site, has available to it safety engineering and loss control services as part of the corporate program. Safety training and development of safety awareness are an on-going part of the program in conjunction with periodic safety inspections and safety engineering of facilities and equipment.

Industrial hygiene services have in the past been available through a consultant, but industrial hygiene surveys have not been available except through the insurance carrier. Only one survey had been conducted by the carrier at Plant A. This had been done 3 years ago, but no information relating to that survey had been submitted to the plant. Aside from this one corporate survey, no other walk-throughs or sampling surveys had been made at Plant A.

Medical services are provided through a local clinic and hospital located near the plant. A licensed nurse is not employed at Plant A, but there is a nurse at the adjacent corporate facilities. First aid treatment is provided by employees with formal CPR-first aid training. Preemployment or baseline physical examinations are not given to new employees nor are periodic physical examinations provided.

Protective clothing, shoes, and respirators are not required or provided by plant management. It was observed that smocks are worn by many of the employees to protect street clothing. Safety glasses are provided for some of the trimming and all of the grinding operations. Latex gloves are provided by the employer and are worn particularly in antiquing and treeing, but consistent use is not enforced. There are no facilities for taking showers and there are no lockers. Some employees change from their street clothing into work clothing in the rest rooms, but the majority wear their work clothing home. To the best knowledge of plant management, there have been no medical abnormalities aside from occasional dermatitis that can be attributed to occupational exposure.

In regard to housekeeping, the plant is well maintained. Floors are kept clean, and litter, scattered dust, and scrap are kept to a minimum. Employees are responsible for cleaning and maintaining their own work areas throughout the day, and general plant cleaning is done at night by a contractor.

HEALTH AND SAFETY PROGRAM - PLANT B

There is no formal safety program at Plant B, but employees receive initial safety instruction from the foreman on the precautions pertaining to their jobs. There are no formalized safety inspections, no employee safety committee, or awareness training. Injury frequency and severity are low, with the frequency of lost-time accidents in 1978 reported as nine and the severity reported as two. Most of these were tripping, falling, or lifting types of accidents. The only medical abnormalities known to the plant were two cases of contact dermatitis incurred by cement operators using latex cement.

To the best knowledge of plant management, there have been no industrial hygiene surveys conducted within the facility, either through the insurance carrier or other contractual arrangement.

The plant does not retain a physician either on a full-time or part-time basis to provide medical treatment for the employees, although a full-time licensed practical nurse is available to provide first aid treatment from a dispensary. Pre-employment physicals are not conducted nor are periodic physical examinations offered to the employees. Ambulance service is available locally, and seriously ill or injured employees are transported to either of two regional hospitals, a distance of 10 or 25 miles.

Protective clothing, shoes, respirators, and safety glasses are not required or provided by the plant. Latex gloves are provided and are worn, particularly at the heel dipping operations and in treeing. Consistent use is not enforced. There are no facilities for taking showers nor are lockers available for the employees. Some employees change from street clothing into work clothing in the restrooms, but the majority wear their work clothing home. Smocks are worn over street clothing, mostly by female employees.

In regard to housekeeping, the plant is well maintained. Floors are kept clean, and litter and scrap are not allowed to accumulate. General plant cleaning is done at night by maintenance department personnel.

HEALTH AND SAFETY PROGRAM - PLANT C

There is no formal safety program at Plant C. Employees receive initial safety instructions as it applies to their assignment, but periodic safety training and awareness programs are not established. Safety inspections are informal and are not conducted on a regularly scheduled basis.

There have been no industrial hygiene surveys at Plant C except for an air sampling survey by the insurance carrier 3 years ago. Information relating to that survey was not submitted to the company. Aside from the above survey, the only other air sampling conducted in the plant has been by plant management personnel using a Bendix fixed-volume sampling pump, and indicator tubes for acetone, MEK, and toluene.

The plant does not employ the services of an occupational physician. Trained personnel, including two paramedics working in the plant, are available to administer first aid. CPR-first aid training is available at a local hospital, and personnel in the plant have taken advantage of this training. A well-equipped first aid room is available for dispensing first aid treatment. Any emergency cases would be taken to the local hospital, or for nonambulatory cases, the fire department ambulance would be summoned. Preemployment or baseline physical examinations are not given to new employees nor are periodic physical examinations provided.

Protective clothing, shoes, and respirators are not required or provided by Plant C. Smocks are worn by some female employees to protect street clothing. Safety glasses are provided for some of the trimming and grinding operations. Latex gloves and barrier creams are provided by the employer and are worn by some of the adhesive and solvent handling operators. Consistent use, however, is not enforced. There are no facilities for taking showers and there are no lockers. Some employees change from their street clothing to work clothing in the restrooms, but most employees wear their work clothing home. To the best knowledge of plant management, there have been no medical abnormalities attributable to occupational exposure other than occasional, mild contact dermatitis.

The plant is well maintained from the standpoint of housekeeping. Floors are kept clean, and litter and accumulated scraps are kept to a minimum. General plant cleaning is conducted during the day and evening by plant service personnel.

## SURVEY PROCEDURES AND METHODS

The procedures for sampling and analytical methods employed in the three surveys of exposure to toluene are described in this section.

### PRELIMINARY WALK-THROUGH SURVEYS - PLANTS A, B, AND C

The detailed surveys at each of the three plants had all been preceded by preliminary walk-through surveys, the purpose of which was to identify suitable facilities for in-depth study. The preliminary surveys were conducted throughout the months of December, 1978 and January, 1979.

Plant A—Preliminary determinations were made in manufacturing areas using the Century Organic Vapor Analyzer (OVA), MDA Accuhaler pumps with 150-mg charcoal tubes, and Draeger detector tubes. Measurements with the OVA utilized the gas chromatograph column to provide spot measurements of toluene. Area concentrations of toluene during that survey were found to range from 7 to 60 ppm with highest concentrations found near cementing operations and the box toe operation. One-hour charcoal tube sampling indicated a toluene level of 60 ppm at selected cement bottoms operations, 14 to 16 ppm in fitting where a latex cement was being used, and only 7 ppm in treeing where there is extensive use of aliphatic hydrocarbon solvents and solvent mixtures containing methyl ethyl ketone and ethyl acetate.

Plant B--Preliminary determinations in the production areas were made using the J-W TLV Sniffer, Draeger pump and length-of-strain toluene detector tubes, and charcoal tubes. Low-flow Accuhaler personal sampling pumps were used to draw air through the charcoal tubes. Sampling results showed relatively high total hydrocarbon levels ranging from 65 ppm at the east end of the cutting room to 400 to 420 ppm near the cement outsole operation in the Sole Department. Toluene levels are measured with the Draeger pump and indicater tubes ranged from 45 ppm in the Heel and Bottoming Department to 100 ppm at a Bottom Cementing operation also in the Bottoming Department. Short-term charcoal tube sampling revealed levels of 6 to 16 ppm in the Heel, Sole, and Fitting Department.

Plant C--Preliminary determinations were made using the J-W TLV Sniffer, Draeger pump and length-of-stain detector tubes, and 150-mg charcoal tubes. Low-flow Bendix pumps were used to draw air through the charcoal tubes. Area concentrations of toluene were found to range from 10 to 75 ppm with the highest levels encountered at Bottom Cementers and Treeing operations in the packing room.

## IN-DEPTH INDUSTRIAL HYGIENE SURVEY FOR TOLUENE

Both personal and area environmental air samples for the presence of toluene and other expected vapor contaminants were taken during the course of the in-depth surveys at Plants A, B, and C. Personal sampling employed low-flow MDA Accuhaler pumps which were attached to the belts of the workers with Tygon tubing leading to the breathing zone collectors. Charcoal tubes were used as the collection media. Two different sizes of charcoal tubes, 150 and 300 mg, were used during the surveys. The 300-mg charcoal tubes were used at those manufacturing locations where higher concentrations were anticipated to avoid breakthrough of the back-up section and subsequent sample loss. The sampling pumps were used to draw air through the charcoal tubes at nominal rates of 20 or 100 ml/min. Calibration of the pumps was performed before and after sampling with a bubble-meter (buret set in an inverted position) using a charcoal tube assembly in-line between the pump and buret. The fixed flow rates of the pumps equipped with 20, 50, and 100 ml/min orifices were checked by marking the time required for the soap bubble to traverse the distance from the zero to the appropriate marking on the buret.

Personal sampling was conducted on workers during their total working shift, and the time-weighted average (TWA) exposure for each job was calculated.

Out of the 116 operator and area locations subject to charcoal tube sampling in Plants A, B, and C, 60 of the operator locations were selected for side-by-side passive vapor monitor sampling. The results of the passive monitor sampling will not be discussed or compared to charcoal tube sampling results in this report. An additional study, to be published at a later date, will examine the aspects of the parallel sampling conducted in this study.

In addition to long-term charcoal tube sampling and passive vapor monitoring, readings were taken with different direct-reading instruments at several locations in three plants where pronounced concentrations of solvent vapors were noted. The "grab" samples or direct-reading tests not only gave a secondary set of field measurments but also afforded the opportunity of observing maximum or "ceiling" values where these were suspected. Tables A-1 through A-5 in Appendix A show the results of these measurements. The Draeger pump and Draeger length-of-stain detector tubes were used in Plant A and B at several hand-adhesive application operations. The length-of-stain tubes have presumed accuracy of plus or minus 25% but in the instances where the Draeger unit was used, results corresponded well to those readings obtained with other direct-reading instruments.

The Century Organic Analyzer with gas chromatograph system option was used in Plant A to check the range of airborne hydrocarbon levels. This unit utilizes sample ionization by a hydrogen flame. The total number of ions produced is directly proportional to the concentration of organic materials in the flame. An electric field in the chamber drives the ions to the collecting electrode which causes the current to flow into a pre-amplifier. The rate of ion generation is a function of the quantity and structure of the carbon compound in the sample. Prior to use, the gas chromatograph system option was calibrated against known toluene concentrations.

Because of its rapid response and observed reliability, the "h-nu" photoionization analyzer, Model PI 101 was used to detect toluene concentrations at Plants A and C. The h-nu employs the principle of photoionization. The pump samples at approximately 150 to 200 cc/minute and the readout meter is linear, reading directly in parts per million. The h-nu was calibrated to known toluene concentrations prior to use. Concentrations at Plant A ranged from 20 ppm to 400 ppm and 10 ppm to 250 ppm at Plant C.

Survey Methodology - Plant A

The two members of the survey team sampled every employee at Plant A who showed any significant potential for toluene exposure. Long-term samples were also collected from adjacent nonadhesives operations to check on dispersion and migration of the solvent vapors. In total, over 290 man-hours of exposure time were sampled at Plant A. Individual breathing zone samples were taken for 6 to 7 hours from all employees with the exception of short-term or interrupted samples at a few operations.

Charcoal tube monitoring was used as the primary sampling system to quantitate area and personal exposure levels to toluene and other potentially hazardous substances. Although passive monitors were also deployed, charcoal tube sampling is presently considered the most reliable and effective sampling procedure for determining airborne levels of the chemical agents present. Consequentially, all conclusions in this report are derived from the charcoal tube sampling results.

As indicated, spot area monitoring was performed using Century Organic Vapor Analyzer, the h-nu photoionization analyzer, and Draeger length-of-stain tubes. Although not directly translated into exposure concentrations, the direct-reading instruments indicated those areas within the facility where potential for exposure was highest and also those aspects of any one particular operation that generated higher concentrations.

Survey Methodology - Plant B

To obtain the most information possible, the two members of the survey team sampled all personnel at Plant B who showed any significant potential for toluene exposure. As at Plant A, long-term samples were collected from adjacent nonadhesives operations in most departments to check a dispersion and migration of the solvent vapors. In total, over 213 man-hours of exposure time were sampled at Plant B. Individual breathing zone samples were taken for 5 to 7 hours from all employees with the exception of short-term or interrupted samples at a few operations. Primary sampling was accomplished through use of charcoal tubes and all conclusions in this report are derived from the charcoal tube sampling results. Area monitoring was performed to a limited extent using Draeger pump and toluene detector tubes. The results of that sampling, as set forth in Table A-4 in Appendix A, showed no excursions of note.

Survey Methodology - Plant C

The two-member survey team followed the same procedures as outlined above for Plants A and B. In total, over 180 man-hours of exposure time were sampled at Plant C. Individual breathing zone samples were taken for 6 to 7 hours from all employees with the exception of shorter-term area samples. Charcoal tube monitoring was accomplished through use of charcoal tubes and personal exposure levels to toluene and other potentially hazardous substances. Area monitoring was performed using the h-nu photoionization analyzer. The results of that sampling are set forth in Table A-5 in Appendix A.

## RESULTS AND OBSERVATIONS: PLANTS A, B, AND C

Results of the in-depth surveys carried out at Plant A, B, and C are presented in separate parts together with interpretive discussion of the data, summaries, and recommendations.

### RESULTS OF SURVEY - PLANT A

Full-shift, time-weighted average exposures, and short-term exposures of personnel at Plant A are presented in Table 12, together with results of area sampling. All charcoal tube sampling results for toluene, the main contaminant of interest in this study, were well below the current OSHA time-weighted average standard of 200 parts per million. A maximum of 124 ppm was observed during a short-term (78 min) sampling of cementing outsoles in the Insole Department.

Table 13 shows the range of exposures and the geometric mean for all major charcoal sample analysis. These means were found to be extremely low denoting the high proportion of low values encountered for all contaminants. Short-term or interrupted sample values are not included in the ranges or geometric means process.

The last column of Table 12 is the cumulative exposure computed for the entire mix of solvents (as determined from charcoal tubes) in terms of fractions of the permissible daily exposure. Cumulative exposure is calculated from the following formula where C indicates the observed atmospheric concentration and T the corresponding threshold limit.

$$\frac{C1}{T1} + \frac{C2}{T2} + \ldots \frac{Cn}{Tn}$$

If the sum of the above fraction exceeds unity, then the threshold limit of the vapor mixture is considered as being exceeded.

Local exhaust ventilation has only recently been applied to some of the adhesive building operations. In the past, only spraying and grinding operations were equipped with exhaust hoods. The majority of all abrasive operations are provided with hoods, and particulate generation is not a significant problem from an industrial hygiene standpoint. There are wide fluctuations in transient toluene levels, which are effectively moderated by efficient air exchange within the plant.

Although conditions may vary somewhat according to meteorological conditions, it appears that Plant A provides a workplace with moderate toluene concentrations. The scope of exposure to other chemical and physical agents is well defined and does not include materials of overwhelmingly confounding character. The potential for other exposures does exist however, and must be recognized as factors in the future epidemiological study.

RESULTS OF SURVEY - PLANT B

The results of all personal and area samples collected in Plant B are shown in Table 14. Samples #101 through #130 are personal samples and samples #131 through #138 are area samples. As indicated, all charcoal tube sampling results for toluene were well below the OSHA TWA permissible exposure limit of 200 ppm. None of the toluene samples exceeded the level of 55.8 ppm encountered at the heel-covering operation (Sample #112) in the Sandal Department. The range of long-term exposure to toluene extended from 7.2 ppm at an assembler operator location in the Sandal Department where no adhesives or solvents were being used to the aforementioned level of 55.8 ppm at a heel covering operation in the same department where extensive amounts of neoprene adhesives and solvents were in use.

Aside from trace or minimal detectable levels, benzene concentrations ranging from 1.3 to 5 ppm were encountered at a cement lining operation in Fitting and four working, treeing, and vinyl spraying operations in the Sandal and Packing Departments. As with plants A and C, there is no ready explanation for the presence of these benzene levels. While solvent stocks, presumably used at all five operations, may be expected to contain small traces of benzene, the atmospheric concentrations under such circumstances would be expected to remain well below the levels found.

Table 8. Personal and area 8-hour (200 ml/min) time weighted average concentrations (ppm) at Plant A, 11/28-11/30/79.

| SAMPLE NUMBER | LOCATION AND/OR JOB TITLE | CONTAMINANT CONCENTRATION, PPM | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | TOLUENE | BENZENE | MEK | ACETONE | ETHYL ACETATE | XYLENE | HEXANE | HEPTANE | CUMULATIVE EXPOSURES a |
| | Fitting Dept. | | | | | | | | | |
| 25 | Cement Uppers | 52.0 | ND | ND | 4.2 | 3.6 | ND | 43.0 | 15.0 | 0.39 |
| 37 | Cement Uppers | 4.0 | ND | ND | 13.5 | 5.2 | 0.2 | ND | ND | 0.05 |
| | Insole Dept. | | | | | | | | | |
| 17 | Cement Insoles | 2.4 | 0.06 | ND | 0.4 | 1.0 | ND | 2.4 | 1.1 | 0.02 |
| 41 | Area samples (adjacent to cement insole operation) | 0.02 | 0.19 | ND | ND | 2.6 | 0.4 | ND | ND | 0.03 |
| 23 | Cement Heels & Insoles | 10.9 | 0.11 | ND | 13.0 | 6.9 | 1.7 | ND | ND | 0.11 |
| 46 | Outside Cementing | ND | ND | ND | 16.0 | 14.0 | 0.5 | ND | ND | 0.06 |
| 47 | Roughing | 5.8 | 0.22 | ND | 6.9 | 2.0 | ND | ND | 2.0 | 0.07 |
| | Lasting Dept. | | | | | | | | | |
| 1 | Antiquing | 14.0 | 1.05 | ND | 9.0 | 13.1 | 0.6 | 13.1 | 9.8 | 0.21 |
| 7 | Co-Laster (Scholl pull-over) | 30.0 | ND | ND | 9.5 | 10.2 | 0.2 | 41.0 | 18.1 | 0.30 |
| 12 | Toefast Machine | 0.03 | 0.27 | ND | 20.0 | 10.0 | 0.1 | ND | ND | 0.07 |
| 14 | Sand Bottoms (Machine #38985) | 2.3 | 0.13 | 0.2 | ND | .16 | ND | .18 | 1.1 | 0.03 |
| 15 | Cobbling | 16.8 | ND | ND | 27.2 | 15.5 | 3 | ND | ND | 0.18 |
| 16 | Crowner | 17.6 | 1.0 | ND | 22.0 | 6.1 | ND | 13 | 9.15 | 0.18 |
| 42 | Area sample (at pull-over machine) | 0.03 | 0.096 | ND | ND | 2.1 | 0.6 | ND | ND | 0.02 |
| 21 | Backpart mold and Cobbling | 9.1 | 0.033 | ND | 12.0 | 0.5 | 0.2 | 6.6 | 5.0 | 0.05 |
| 28 | Side and Heel Laster | 19.0 | ND | ND | 18.0 | 10.0 | 0.3 | 14.0 | 10.0 | 0.17 |
| 49 | Covering Machine and Trim Edges | 10.4 | 0.1 | 0.2 | 15.0 | 5.1 | 0.4 | 45.0 | 5.3 | 0.15 |

Table 8. Personal and area 8-hour (200 ml/min) time weighted average concentrations (ppm) at Plant A, 11/28-11/30/79.

| SAMPLE NUMBER | LOCATION AND/OR JOB TITLE | CONTAMINANT CONCENTRATION, PPM | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | TOLUENE | BENZENE | MEK | ACETONE | ETHYL ACETATE | XYLENE | HEXANE | HEPTANE | CUMULATIVE EXPOSURES a |
| | **Welting Dept.** | | | | | | | | | |
| 3 | Shanking | 26.5 | ND | 3.8 | ND | 0.5 | ND | 47.4 | 10.5 | 0.27 |
| 4 | Bottom Filler | 31.0 | ND | 3.7 | 164.0 | 0.6 | ND | 51.7 | 55.0 | 0.55 |
| 5 | Sole giving, Perforating Bevelling | 62.0 | 0.24 | 29.0 | 20.2 | 7.35 | ND | 65.0 | 46.2 | 0.74 |
| 8 | Welt Butt | 19.6 | ND | ND | 32.0 | 5.0 | ND | 25.6 | 17.2 | 0.23 |
| 9 | Cement Rans and Bottoms and lay sole machine operation | 12.0 | ND | 0.52 | 19 | 6.2 | ND | 33.0 | 18.2 | 0.20 |
| 10 | Cement Bottoms (machine # 41977) | 1.51 | 0.13 | ND | ND | ND | ND | 3.0 | 0.8 | 0.03 |
| 11 | Sole Layer | 0.056 | 0.066 | ND | ND | 3.05 | 0.6 | ND | ND | 0.02 |
| 43 | Area Sample (near cement bottom station) | ND | 0.062 | ND | ND | ND | 0.05 | ND | ND | 0.01 |
| 51 | Shank Cementing | 11.6 | 0.09 | 14.0 | 16.6 | 9.0 | 2.1 | ND | ND | 0.18 |
| 52 | Outsole gluing, sole trimming & roughing | 36.1 | ND | 21.4 | 3.7 | 18 | 0.4 | 39.0 | 16.0 | 0.45 |
| | **Bottoming Dept.** | | | | | | | | | |
| 13&44b | Cement Bottoms | 12.8 | 0.47 | ND | 6.5 | 3.6 | 0.16 | ND | ND | 0.13 |
| | **Making Dept.** | | | | | | | | | |
| 26 | Cement Heels | 30.5 | ND | 15.0 | 33.0 | 30.0 | ND | 51.0 | 22.0 | 0.48 |
| 27 | Cement Heels | 4.0 | 0.112 | 3.4 | 13.6 | 3.0 | ND | 0.5 | 0.2 | 0.75 |
| 32 | Slugger | ND | 0.04 | 8.7 | 18.6 | 13.3 | 0.53 | ND | ND | 0.10 |
| 35 | Edge Trimming, Heel roughing | 16.5 | 0.18 | ND | 11.4 | 4.4 | 0.2 | 13.0 | 8.5 | 0.17 |
| 36 | Repairing-Packing | 0.12 | 0.3 | ND | ND | ND | ND | 0.7 | 0.2 | 0.03 |
| 38 | Area sample, heel cement area | 0.01 | 0.05 | ND | 10.3 | 13.4 | 0.4 | ND | ND | 0.01 |
| 40 | Area sample, Heel inking | 4.33 | 0.03 | 8.4 | 8.6 | 0.2 | 0.2 | ND | ND | 0.06 |

Table 8. Personal and area 8-hour (200 ml/min) time weighted average concentrations (ppm) at Plant A, 11/28-11/30/79

| | | CONTAMINANT CONCENTRATION, PPM | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE NUMBER | LOCATION AND/OR JOB TITLE | TOLUENE | BENZENE | MEK | ACETONE | ETHYL ACETATE | XYLENE | HEXANE | HEPTANE | CUMULATIVE EXPOSURES a |
| | Finishing Dept. | | | | | | | | | |
| 29 | Ink Heels | 5.3 | 0.046 | 0.35 | 3.4 | 2.0 | 1.06 | ND | ND | 0.04 |
| | Packing Dept. | | | | | | | | | |
| 24 | Finish, spraying (second coat) | 2.8 | 0.081 | 0.1 | 0.2 | 0.4 | 0.6 | 3.2 | 2.2 | 0.03 |
| 30 | Packing-Repair Hood | 0.41 | 0.075 | 0.3 | 0.6 | ND | ND | 0.8 | 0.2 | 0.04 |
| 31 | Treeing | 6.0 | 0.09 | 5.7 | 6.2 | 2.5 | 0.4 | ND | ND | 0.08 |
| 33 | Treeing | 12.0 | 2.29 | 6.0 | 11.4 | 0.05 | 0.15 | 16 | 10.6 | 0.30 |
| 34 | Treeing | 13.0 | 0.525 | 6.9 | 7.2 | 4.3 | 0.6 | ND | ND | |
| 39 | Area sample, repair area | 2.2 | 0.5 | 0.65 | 2.0 | 1.4 | 0.14 | ND | ND | 0.07 |
| 48 | Solvent Spray | 3.7 | ND | 15.0 | ND | ND | ND | 2.6 | 4.93 | 0.10 |
| | OSHA Standard (PEL) | 200 | 10 | 200 | 1000 | 400 | 100 | 500 | 500 | 1.000 |

LEGEND:

a Cumulative Exposure = Fraction of Permissible Exposure
ND - not detectable within limits of sampling and analytical methods used

b TWA for charcoal tube samples 13 and 44 $\frac{C_{13} T_{13} + C_{44} T_{44}}{8}$ levels reported in table

Table 9 . Range of 8 hr TWA Exposures at Plant A for the 45 samples reported in Table 12.

| Contaminant | Range (ppm) | Geometric Mean (ppm) |
|---|---|---|
| Toluene | 0.01-62.0 | 3.11 |
| Benzene | 0.03-2.29 | 0.164 |
| Methyl Ethyl Ketone | ND-29 | 1.56 |
| Acetone | ND-164 | 6.32 |
| Ethyl Acetate | ND-30 | 3.14 |
| Xylene | ND-3 | 1.48 |
| Hexane | ND-65.0 | 2.8 |
| Heptane | ND-46.2 | 3.3 |

Table 10 Personal and area 8-hour time weighted average concentrations (ppm) at Plant B, December 10-13, 1979.

| SAMPLE NUMBER | LOCATION AND/OR JOB TITLE | CONTAMINANT CONCENTRATION, PPM TOLUENE | BENZENE | MEK | ACETONE | ETHYL ACETATE | XYLENE | HEXANE | HEPTANE | CUMULATIVE EXPOSURES b |
|---|---|---|---|---|---|---|---|---|---|---|
| | FITTING DEPT. | | | | | | | | | |
| 105 | Cement Linings | 22.9 | 1.9 | 11.6 | 56.8 | ND | 0.6 | ND | ND | 0.43 |
| 106 | Seal box toes and cradle vamps | 15.0 | ND | 24.8 | 48.6 | 9.3 | 1.0 | ND | ND | 0.28 |
| 107 | Cement linings and counter pockers | 19.6 | ND | 53.6 | 2.1 | 0.1 | ND | 30.0 | 20.4 | 0.46 |
| 131 | Area Sample-Central area | 11.9 | 0.1 | 16.0 | 32.9 | 10.3 | 1.4 | ND | ND | 0.22 |
| | SOLE DEPT. | | | | | | | | | |
| 109 | Cement Soles | 28.2 | ND | ND | 17.6 | 0.1 | ND | 38.0 | 12.1 | 0.26 |
| 132 | Area Sample-West side of ME0054 Torit | 11.7 | ND | 14.0 | 26.4 | 9.3 | 2.0 | ND | ND | 0.20 |
| | LASTING DEPT. | | | | | | | | | |
| 129 | Hand Lasting and Hand Cement Uppers | 15.1 | ND | 20.5 | 42.8 | 7.3 | 0.4 | ND | 21.9 | 0.28 |
| 130 | Heel Lasting (back part molding) | 16.7 | ND | 13.8 | 41.6 | 8.3 | 0.6 | ND | 26.8 | 0.27 |
| 133 | Area Sample-between roller conveyors and adjacent to router | 10.7 | ND | 12.7 | 25.0 | 8.0 | 1.0 | ND | ND | 0.17 |
| 134 | Area sample-center area adjacent to floor conveyor | 11.8 | ND | 18.1 | 31.8 | 10.2 | 1.2 | ND | ND | 0.22 |
| | HEEL DEPT. | | | | | | | | | |
| 110 | Heel dipper - sandal | 17.6 | ND | 7.4 | 9.8 | 0.1 | 7.9 | ND | ND | 0.21 |

Table 10 Personal and area 8-hour time weighted average concentrations (ppm) at Plant B, December 10 13, 1979.

| SAMPLE NUMBER | LOCATION AND/OR JOB TITLE | CONTAMINANT CONCENTRATION, PPM TOLUENE | BENZENE | MEK | ACETONE | ETHYL ACETATE | XYLENE | HEXANE | HEPTANE | CUMULATIVE EXPOSURES b |
|---|---|---|---|---|---|---|---|---|---|---|
| | BOTTOMING DEPT. | | | | | | | | | |
| 101 | Bottom cementing | 15.7 | ND | 31.9 | 34.7 | 8.4 | 1.9 | ND | ND | 0.31 |
| 102 | Bottom cementing | 23.8 | ND | 54.5 | 69.7 | 8.1 | 0.7 | ND | 26.1 | 0.54 |
| 103 | Bottom cementing | 28.5 | ND | 31.1 | 71.3 | 6.8 | 0.2 | ND | 36.1 | 0.46 |
| 104 | Cement wedges and heels | 30.0 | ND | 77.8 | 104.7 | 11.2 | ND | ND | 5.0 | 0.68 |
| 130 | Blank | ND | ND | ND | ND | ND | ND | ND | ND | |
| | BOTTOMING DEPT. CONT. | | | | | | | | | |
| 121 | Shanking | 24.3 | ND | 9.6 | 38.3 | ND | 0.3 | 66.4 | 32.4 | 0.41 |
| 128 | Cement Outsoles | 19.1 | ND | ND | 69.8 | 74.4 | 1.3 | ND | ND | 0.36 |
| 135 | Area Sample-Adjacent to west side of conveyor dryer | 11.5 | ND | 16.4 | 29.0 | 9.5 | 1.1 | ND | ND | 0.22 |
| 136 | Area sample-at cement outsoles on east side of conveyor(cement machine #LE136) | 14.6 | ND | 11.0 | 24.4 | 14.6 | 0.9 | ND | ND | 0.22 |
| | SANDAL DEPT. | | | | | | | | | |
| 111 | Cement heel covers | 0.1 | lost | 0.2 | ND | ND | lost | ND | ND | |
| 112 | Covering heels | 55.8 | ND | 27.2 | 16.2 | 0.2 | 13.7 | 123.3 | 89.4 | 0.99 |
| 113 | Rough heels | 24.4 | ND | 2.6 | 7.4 | 3.7 | 1.3 | 70.9 | 22.1 | 0.35 |
| 114 | Cement insole and outsole, shanking spot press | 35.6 | ND | ND | 0.3 | 21.4 | .7 | ND | 40.9 | 0.34 |
| 115 | Blank | ND | ND | ND | ND | ND | ND | ND | ND | |
| 116 | Assembler | 7.2 | ND | 1.25 | 2.98 | 1.4 | 1.5 | 19.9 | 65.9 | 0.28 |
| 117 | Assembler & Heel cover | 8.1 | ND | ND | 2.0 | ND | 1.5 | 21.1 | 5.2 | 0.11 |
| 118 | Wash heels | 20.4 | 5.0 | 5.3 | 41.0 | 23.5 | 4.9 | ND | ND | 0.78 |
| 119 | Heel cover and wash heels | 39.8 | 1.6 | 10.7 | 48.3 | 18.6 | 3.2 | ND | 66 | 0.67 |

Table 10 Personal and area 8-hour time weighted average concentrations (ppm) at Plant B, December 10-13, 1979

| | | CONTAMINANT CONCENTRATION, PPM | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE NUMBER | LOCATION AND/OR JOB TITLE | TOLUENE | BENZENE | MEK | ACETONE | ETHYL ACETATE | XYLENE | HEXANE | HEPTANE | CUMULATIVE EXPOSURES[b] |
| 138 | Area sample-on roller conveyor in wash and heel cover area | 12.5 | 0.1 | 2.6 | 9.1 | 4.2 | 4.7 | ND | ND | 0.15 |
| 139 | Blank | ND | ND | ND | ND | ND | ND | ND | ND | |
| | PACKING DEPT. | | | | | | | | | |
| 122 | Spray repair | 14.6 | ND | 3.6 | 10.4 | 5.5 | 0.1 | ND | 18.1 | 0.16 |
| 123 | Spot repair and cementing | 20.5 | ND | 5.5 | 17.7 | 5.7 | 0.2 | ND | 32.1 | 0.22 |
| 124 | Vinyl spray | 14.5 | .7 | 2.5 | 18.9 | 5.8 | 0.3 | ND | ND | 0.19 |
| 125 | Treeing | 14.3 | ND | 4.2 | 17.0 | 5.3 | 0.4 | ND | 29.3 | 0.18 |
| 126 | Treeing | 30.9 | ND | 1.4 | 46.9 | 4.7 | 0.3 | ND | ND | 0.22 |
| 127 | Treeing | 14.0 | 1.3 | 10.2 | 32.8 | 10.9 | 0.6 | ND | ND | 0.31 |
| 137 | Area sample-adjacent to boxing line and treeing operators | 8.0 | ND | 7.4 | 20.0 | 8.7 | 0.4 | ND | ND | 0.12 |
| | OSHA | 200 | 10 | 200 | 1000 | 400 | 100 | 500 | 500 | 1.000 |

LEGEND:

b Cumulative Exposure = Fraction of permissible exposure
ND Not detectable

Stocks may be on hand that contain benzene as a higher fraction, but this was not apparent at the time of the survey.

Table 15 lists the ranges of exposure to the solvents discussed here and the geometric mean of the levels encountered.

The last column of Table 14 is the cumulative exposure computed for the mixture of solvents determined from the charcoal tubes in terms of fraction of the permissible daily exposure.

Local exhaust ventilation is applied to the majority of abrasives operations at Plant B, but several manual adhesives application operations are not vented. There are fluctuations in transient vapor levels as shown by instrument survey readings, but lingering elevated concentrations are moderated by good air exchange within the building. From a subjective standpoint, particulate generation from the wide variety of abrasives operations did not appear to be a problem. This was borne out by limited sampling at Plant C where "worst conditions" typical of all the plants were monitored for total dust. Projection back to Plant B indicates that particulate generation is minimal.

Although conditions may vary somewhat according to meteorological behavior, it appears that Plant B has a workplace that generates light to moderate concentrations of toluene. The scope of exposure to other chemical and physical agents was defined as best as could be done in this study and may not include materials of significantly confounding character.

Table 11. Range of exposure at Plant B for 35 samples

| Contaminant | Range (ppm) | Geometric Mean (ppm) |
|---|---|---|
| TOLUENE | 0.1-55.8 | 14.2 |
| BENZENE | ND-5 | 0.201 |
| METHYL ETHYL KETONE | ND-77.8 | 5.64 |
| ACETONE | ND-104.7 | 18.2 |
| ETHYLACETATE | ND-74.4 | 3.2 |
| XYLENE | ND-13.7 | 0.791 |
| HEXANE | ND-123.3 | 0.38 |
| HEPTANE | ND-89.4 | 1.5 |

## RESULTS OF SURVEY - PLANT C

Full-shift, time weighted average exposure levels and short-term exposure levels to personnel at Plant C are presented in Table 16, together with results of area sampling. Charcoal tube sampling results for toluene, the main contaiminant of interest, were well below the OSHA TWA permissible exposure limit of 200 ppm, and in fact none exceeded the level of 136 ppm encountered during sampling at a bottom filler operation in the cement room (Bottoming). As indicated in the table, two samples were collected on the same date at two bottom filler operations in the same area of the plant. Although the one bottom filling operation showed a TWA of 136 ppm during 5 hours and 16 minutes of sampling, sample No. 205 revealed only 6.8 ppm toluene during more than 6-1/2 hours of sampling. The reason for the wide variation in exposure levels cannot be clearly established, but there were differences in the types of shoes being filled, the amount of filler being applied, and the extent of exposed filler on completed shoes in adjacent drying racks. A technique to reduce solvent vapor levels at a variety of the operations in Plant C would be to move filled racks of drying shoes or pieces promptly to a ventilated area away from the fill area.

When compared to the photoionization instrument readings in Table A-5, TWA exposure levels derived from charcoal tube monitoring are relatively low. This difference is primarily due to the relative nonspecificity of the photoionization analyzer, but is also due in part to the wide excursions in vapor concentrations that can occur during various phases of the operations.

As was observed at Plant A and B, unexpected high benzene levels were seen at one operation in Plant C. The level encountered was 4.5 ppm at a bottom-wash soles operation in the packing room. As with the other plants, there is no ready explanation for the presence of this high benzene level. Toluene stocks may be expected to contain small traces of benzene, but the resulting atmospheric concentrations should remain well below the standard of 10.0 ppm.

Varying levels of methyl ethyl ketone were found at all sampled locations throughout Plant C due to the widespread use of urethane adhesives containing the compound as a solvent vehicle. Concentrations ranged from 1.1 ppm to 161 ppm. The highest level was found at an inspection and washing station in the Making Department where solvent is used routinely to wash shoes. One confounding aspect applied to the production operator wearing the pump. This person spent several hours in different parts of the plant and was at the washing station less than half the time.

Due to the low levels observed at Plants A and B (as related to the respective permissible exposure limits) and for reasons of costs, the charcoal tubes collected at Plant C were not analyzed for acetone, ethyl acetate, xylene, hexane, and heptane.

Table 13 shows the ranges of exposure to toluene, benzene, and methyl ethyl ketone, and the geometric mean.

To verify the impression formed during the surveys at Plants A and B that airborne dust levels were not of significance, two total dust samples were taken in two major abrasive areas (refer to Table 18). Sample No. 233 was a personal sample collected at an edge roughing operation in Stock-Fitting. Total dust was minimal at 0.35 $mg/m^3$. The second total dust sample was collected in the Cement Room adjacent to four roughing and pounding machines. The level encountered was 0.11 $mg/m^3$. The dust generated in this area was mostly non-respirable dust of natural or synthetic leather sole material with untreated minimal health hazard protection.

The last column of Table 16 is the cumulative exposure computed for the mixture of solvents as determined from charcoal tubes in terms of the fraction of the permissible daily exposure.

Local exhaust ventilation at Plant C is applied exclusively to spray hoods, finish hoods, and the intermittently used chlorinating hood in the Packing Department. Exhaust ventilation is applied to none of the bottom filler, bottom cementing, sole cementing, and cement lining operations.

There are wide fluctuations in transient toluene levels which are generally moderated by good air exchange within the plant.

The majority of all abrasives operations are provided with hoods, and as a result, particulate generation is not a significant industrial hygiene problem.

As with Plant A and B, conditions relating to vapor exposure levels may tend to vary according to the weather, but it is apparent that the work force is exposed to light toluene concentrations at most adhesives and cleaning operations. Plant C is typical of other shoe manufacturing facilities, and the scope of exposure to chemical and physical agents is well defined. No materials of significantly confounding character were present in the work environment.

## GENERAL RESULTS AND RECOMMENDATIONS

### GENERAL RESULTS

A summary of sampling results for toluene, benzene, and methyl ethyl ketone are presented in Table 19. The upper and lower levels of TWA personal exposure to tolu-

Table 16. Personal and Area Time Weighted Average Concentrations (ppm) at Plant C, January 15-18, 1980.

| SAMPLE NUMBER | LOCATION AND/OR JOB TITLE | CONTAMINANT CONCENTRATION, PPM TOLUENE | BENZENE | MEK ACETONE | CUMULATIVE EXPOSURE |
|---|---|---|---|---|---|
| | CUTTING | | | | |
| 229 | Area Sample - center location | 6.1 | ND | 11.6 | .089 |
| | Pre-Fit | | | | |
| 230 | Area sample - center location | 5.6 | ND | 10.6 | .081 |
| | FITTING | | | | |
| 231 | Area sample - center location on ceiling suspended blackboard | 6.13 | ND | 1.96 | .040 |
| | STOCK - FITTING | | | | |
| 207 | Sole cementer | 0.09 | ND | 4.5 | 0.23 |
| 208 | Sole cementer | 22.0 | ND | 65.0 | .435 |
| 209 | Cementing half forms | 21.6 | ND | 15.0 | .183 |
| 210 | Cementing half forms | 30.7 | ND | 11.4 | .211 |
| 211 | Edge Spray at Hood | 13.0 | ND | 8.0 | .105 |
| 221 | Edge Binder | 15.7 | ND | 4.3 | .100 |
| 222 | Cement heels | 7.0 | ND | 20.0 | .135 |
| 223 | Cement heels | 16.2 | ND | 41.0 | .286 |
| 224 | Outsole printing | ND | ND | 12.0 | .060 |
| 225 | Heel Spotter | 9.8 | ND | 8.0 | .089 |
| | LASTING | | | | |
| 227 | Cement Soles | 27.0 | ND | 12.0 | .195 |
| 228 | Area Sample Adjacent to side laster (Machine #11395) | 5.7 | ND | 4.6 | .052 |

TABLE 16 (Continued)

| SAMPLE NUMBER | LOCATION AND/OR JOB TITLE | TOLUENE | BENZENE | MEK ACETONE | CUMULATIVE EXPOSURE |
|---|---|---|---|---|---|
| | <u>CEMENT BOTTOMING</u> | | | | |
| 201 | Bottom Cementer | 5.2 | ND | 13.2 | .092 |
| 202 | Bottom Cementer | 13.7 | ND | 43.3 | .285 |
| 203 | Bottom Cementer | 11.9 | ND | 33.0 | .225 |
| 204 | Shanker | 6.8 | ND | 14.3 | .1055 |
| 205 | Bottom Filler | 6.8 | ND | 13 | .099 |
| 206 | Bottom Filler | 136 | ND | 36.5 | .843 |
| | <u>MAKING</u> | | | | |
| 216 | Finish spray at hood using lacquer and latex | 10 | ND | 23 | .165 |
| 217 | Waxing joints, inking edging | 7.8 | ND | 18.8 | .133 |
| 218 | Production operator, inspecting and washing | 94 | ND | 161 | 1.275 |
| 226 | Stock Lining | 2.3 | ND | 1.1 | .017 |
| | <u>PACKING AND FINISHING</u> | | | | |
| 212 | Bottom wash (wash soles) | 16.54 | ND | 27.5 | .220 |
| 213 | Bottom wash (wash soles) | 32.7 | 4.5 | 36 | 0.793 |
| 214 | Bottom wash | 57.1 | ND | 55.5 | .563 |
| 215 | Treeing | 0.06 | ND | 67 | .335 |
| 219 | Treeing | 38 | ND | 66 | .520 |
| 220 | Treeing | 26.5 | ND | 17.4 | .220 |
| | <u>ANALYTICAL CONTROL</u> | | | | |
| 232 | Blank | ND | ND | ND | |

LEGEND: Cumulative Exposure = Fraction of permissible daily exposure

ND = Not detectable

Table 13. Range of Exposure at Plant C
For 32 Charcoal Tube Samples

| Contaminant | Range (ppm) | Mean ($\bar{X}_g$) |
|---|---|---|
| Toluene | ND-136 | 9.42 |
| Benzene | ND-4.5 | |
| Methyl ethyl ketone | 1.1-161 | 11.5 |

Table 14. Air Sampling Results for Airborne Dust - Plant C - January 18, 1980

| Sample Number | Job title - location | Date | Sampling time (minutes) | Air volume (liters) | Total dust ($mg/m^3$) |
|---|---|---|---|---|---|
| 233 | Edge rougher in Stock-fitting Department - Personal Sample | 1/18/80 | 294 | 588 | 0.35 |
| 234 | Area Sample in Cement Room adjacent to roughing and edging operations | 1/18/80 | 295 | 501.5 | 0.11 |

Table 15. Exposure range and mean at similar operations in Plants A, B, and C.

| Contaminant process or work area | Range (ppm) | Mean (ppm) |
|---|---|---|
| Toluene | | |
| Fitting, Prefit | 4-52 | 12.45 |
| Sole, Insole, Stockfitting | ND-124.0 | 3.73 |
| Lasting | 0.03-32.0 | 6.58 |
| Welt, Bottoming, Cement | 0.056-136.0 | 8.716 |
| Making, Finishing, Packing | 0.01-94.0 | 4.97 |
| Sandal, Heel | 0.1-55.8 | 11.8 |
| Benzene | | |
| Fitting, Prefit | ND-1.9 | 0.26 |
| Sole, Insole, Stockfitting | ND-7.3 | 0.45 |
| Lasting | ND-2.1 | 1.93 |
| Welt, Bottoming, Cement | ND-4.34 | 0.302 |
| Making, Finishing, Packing | ND-4.5 | 0.379 |
| Sandal, Heel | 0.1-5.0 | 0.338 |
| Methyl Ethyl Ketone | | |
| Fitting, Prefit | ND-53.6 | 5.01 |
| Sole, Insole, Stockfitting | ND-65 | 2.16 |
| Lasting | ND-20.5 | 2.01 |
| Welt, Bottoming, Cement | ND-77.8 | 7.89 |
| Making, Finishing, Packing | ND-161 | 5.2 |
| Sandal, Heel | 0.1-27.2 | 1.89 |

ND - non detected by sampling and analytical method ene in Plants A, B, and C are reflected within the range of those encountered in Plant C (none detected to 136 ppm) with the levels in Plants A and B lying between these values. None of the chemicals sampled on the charcoal tubes approached the permissible exposure limits established for these compounds.

## SUMMARY AND RECOMMENDATIONS

In-depth surveys at the three shoe manufacturing plants revealed similarities in operations processes, building design, and types of local exhaust hoods and collection devices utilized. Variations were apparent in work flow configurations and the names of similar departments or "rooms", but in general, production followed identifiable patterns from cutting to packaging. Of more importance, jobs and piecework tasks in the three facilities also displayed similarities that in conjunction with good air exchange, tended to exert a leveling effect on patterns and magnitudes of personal exposure to solvent vapors.

None of the major contaminants sampled in the three facilities displayed individual airborne levels equivalent to or in excess of established permissible exposure limits. In fact, only one long-term personal sample, No. 206 - Plant C at 136 ppm, reached an order of magnitude that placed it at the "action level" for toluene.

In regard to benzene exposure levels, all samples were below the existing standard of 10 ppm and 10 samples exceeded the controversial resended OSHA exposure limit of 1 ppm. This was an unanticipated finding because present day aromatic solvents are assumed to contain only traces of residual benzene that would be expected to maintain atmospheric concentrations below 1 ppm. As previously indicated, a majority of the elevated benzene concentrations were encountered at washing, cleaning, and antiquing activities in various finishing areas. This thesis tends to show that benzene as a component of solvent-based cleaners, washes, or tinting solutions, may be present in sufficient quantities to result in air contamination. A smaller number of adhesive application operations also showed higher benzene levels. Both were manual operations where aside from the solvents in the adhesives, solvent mixtures were used for cleaning and wiping. These locations, consisting of the Insole Department in Plant A and the Fitting Department in Plant B, should be checked to determine if solvents peculiar to finishing operations are used at these work stations. A critical study of the substances used in the aforementioned categories appears to be the most logical approach to the verification of their unexpected potential hazard.

Particulate levels were monitored by the collection of total dust samples at representative locations in Plant C to verify the contention that dust exposures in all plants were not of industrial hygiene significance. Levels of 0.35 $mg/m^3$ and 0.11 $mg/m^3$ were found at roughing and edging operations which are well below the permissible exposure limit for nuisance dust of 10 $mg/m^3$.

## RECOMMENDATIONS FOR FURTHER STUDY

Plants A, B, and C can be considered highly representative of the shoe manufacturing industry in the United States with operations and equiptment that are common to and typical of other facilities. Although the subject plants have shown a tendency toward relocation through the years, Plants A and C have been in their present geographical locations for 18 and 22 years, respectively, with plant B at its present site for only 10 years. Worker populations have remained fairly stable during these years of existence, with general trend toward increased personnel as production levels have increased.

Although the three plants do not represent "pure" exposures to toluene or even exclusive exposure to commerical grade or "impure" toluene, the scope and extent of exposure to other chemical and physical agents are well defined and except for benzene as a contaminant, does not include materials present at higher levels or which are of a significantly confounding character. Toluene-exposed populations cannot be considered high in any single plant, but considering the numbers of similar facilities in the country, the potential exists for an adequate epidemiological cohort.

Records retention was found to be a problem only in Plant C where it was reported that records of terminated employees are kept only for a period of 5 years. Records at Plant A date back to 1932, and at Plant B records dating back to 1946 are maintained in a small storage warehouse on site.

It is our premise that despite those factors relating to multiple exposures, the shoe manufacturing industry is the industry of choice for a retrospective mortality study. The chemical industry, furniture and adhesives manufacturing, printing industry, and a variety of other industries have been evaluated but all have exhibited deficiencies from the standpoint of cohort qualification, records retention, or confounding chemical factors. Because there are no meaningful populations in the country exposed solely to toluene, further study would be best served by selecting an industry with a finite number of controllable chemical factors and one that reflects similarities in processes, equipment, and work procedures.

The presence of benzene in several samples indicates the need for a systematic search for this chemical in the raw materials used by the industry and a concerted effort for its eradication.

The industry is currently taking steps for the control of airborne contaminants through the installation of exhaust ventilation systems, and air cleaners. Because most companies do not have industrial hygiene services directly available, the industry through its trade associations should take steps in improving the design of its tooling to ensure better worker protection. It should also sponsor education and information of manufacturers and workers on the potential hazards of its processes and the most practical controlling measures.

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## APPENDIX A - SHORT TERM SAMPLING DATA

Table A-1. Plant A - Air sampling results (Draeger Pump and Detector Tubes) 11/28/79.

| Measurement Number | Sample Location | Toluene Draeger Tube Reading (ppm) |
|---|---|---|
| 1 | Cement insole operations - Insole Department | 70 - 75 |
| 2 | Cement heels - Making Department | 50 |
| 3 | Cement outsoles - Insole Department | 70 - 80 |
| 4 | Insole cementing - (sock line to insole) - Insole Department | 100 |
| 5 | Cement outsoles - Insole Department | 250 |
| 6 | Between cement insole (manual and machine cementing) - Insole Department | 70 - 75 |
| 7 | Cement heels - Making Department | 50 |
| 8 | Automatic shanking machine - Welt Department | 40 |
| 9 | Hand cement uppers - Fitting Department | 25 |

Table A-2. Plant A - Air sampling results (Century Organic Vapor Analyzer) 11/28/79.

| Reading Number | Sample Location | Century Reading Total Organic Vapor (ppm) | Century Reading G. C. Shunt Toluene, (ppm) |
|---|---|---|---|
| 1 | Cement insoles - Insole Department | 25 | <10 |
| 2 | Cement bottoms - Bottoming Department | 15 | none detected |
| 3 | Cement heels - Making Department | 36 | < 2 |
| 4 | Cement outsoles - Insole Department | 22 | none detected |

Table A-3. Air sampling results (h-nu Photoionization Analyzer).

| Reading Number | Date | Sample Location | *hnu Reading Toluene, (ppm) |
|---|---|---|---|
| 1 | 11/28/79 | Cement bottoms - Bottoming Dept. | 75-150 |
| 2 | 11/28/79 | Center exit to office area (adjacent to cement bottoms) | 70 |
| 3 | 11/28/79 | Side & heel laster - Lasting Dept. | 65 |
| 4 | 11/28/79 | Cement insoles - Insole Dept. | |
| | | -no activity | 45 |
| | | -cleaning adhesive applicator | 75 |
| | | -insole cementing (full table) | 50-150 |
| 5 | 11/28/79 | Cement insoles - Insole Dept. at 10:00 a.m. | 80 |
| 6 | | Cement insoles - Insole Dept. at 2:00 p.m. | 70-90 |
| 7 | 11/28/79 | Adhesive & solvent store room | 11.5 |
| 8 | 11/29/79 | Shanking machine - Welt Dept. | 45 |
| 9 | 11/29/79 | Cement bottom machine no. 41977 Bottoming Dept. | |
| | | -at dispenser nozzle | 60-150 |
| | | -in breathing zone | 80 |
| 10 | 11/29/79 | Side and heel laster - Lasting Dept. | 60 |
| 11 | 11/29/79 | Puller-laster machine - Lasting Dept. | 60-70 |
| 12 | 11/29/79 | Antiquing - Finishing Dept. | 20 |
| 13 | 11/29/79 | Heel inking - Finishing Dept. | 20 |

(continued)

Table A-3. (Concluded)

| Reading Number | Date | Sample Location | *hnu Reading Toluene, (ppm) |
|---|---|---|---|
| 14 | 11/29/79 | Cement heels - Making Dept. | |
| | | -no activity | 50 |
| | | -cementing (average levels) | 70-80 |
| | | -cementing (peak concentration) | 100-150 |
| 15 | 11/29/79 | Cement rans & bottoms - Welting Dept. | |
| | | -in breathing zone | 50 |
| | | -adjacent to full drying rack | 70-80 |
| 16 | 11/30/79 | Cement insoles - Insole Dept. | 70-100 |
| 17 | 11/30/79 | Cement outsoles - Insole Dept. | |
| | | -in breathing zone | 75-150 |
| | | -near drying rack | 200 |

*Nonspecific-instrument responds to all vapors and gases with ionization potentials of 10eV or less, including toluene, benzene, zylene, MEK and acetone.

Table A-4. Plant B - Air sampling results - Dreager Pump and Toluene Detector Tubes.

| Measurement Number | Sample Location | Draeger Tube Reading (ppm)Toluene |
|---|---|---|
| 1 | Bottoming Dept. - Cement Heels | 25 |
| 2 | Bottoming Dept. - Cement Outsoles (during chlorinating of soles with solution of solvent and hypochlorite) | 35 |
| 3 | Sandal Dept. - Heel Dip tanks at face of neoprene hood | 50 |
| 4 | Sole Dept. - Cement Sandals | 45 |
| 5 | Fitting Dept. - Cement Linings | 25 |
| 6 | Bottoming Dept. - Shanking | 20 |
| 7 | Packing Dept. - Treeing | 15 |

Table A-5. Plant C - Air sampling results (h-nu Photoionization Analyzer) 11/17/80.

| Reading Number | Sample Location | Toluene (ppm) |
|---|---|---|
| 1 | Packing Dept. - Bottom wash | 30-40 |
| 2 | Packing Dept. - Bottom wash station adjacent to laboratory | 50 |
| 3 | Packing Dept. - Bottom wash | 110-140 |
| 4 | Stockfitting - Outside priming | 70 |
| 5 | Stockfitting - Sole cementing | at sole rack - 250<br>operator breathing zone - 80 |
| 6 | Stockfitting - Sole cement table at rear of dept. | 70 |
| 7 | Stockfitting - Spray hood during edge spraying | 50 |
| 8 | Rear of Lasting Dept. | 15 |
| 9 | Center of Lasting Dept. | 25 |
| 10 | Cementing - Center Area | 10 |
| 11 | Cementing - Bottom Cementer | 60-70 |

## Appendix B

## COMPOSITION OF MATERIALS

A partial list of materials encountered in this study are tabulated here. Where the last column indicates MSDS (Material Safety Data Sheets), these were available, where not, data reported from manufacturers or users.

TABLE B-1. Summary of solvent materials encountered in study

| Trade Name | Hazardous ingredients | Appearance/odor | B.P. | Vapor Press. | Vapor Dens. | $H_2O$ Soly. | Sp. Gr. | % Volat. | Evap. Rate | Flash | LEL | Other | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Imperial Adhesives & Chemicals, Inc. - Cincinnatti, OH | | | | | | | | | | | | | |
| 310 Neoweld | Naphtha 5%<br>Methylene Chloride 5%<br>Ammonia 0.5% | White liq.<br>Solv. odor | 215 | - | >1 | ∞ | 1.06 | 58 | <1 | 85 | 1.1 | | MSDS |
| 527 Permagrip | Acetone 25%<br>Textile Spirits 34% | Amber liq.<br>Ketone od. | 140 | - | >1 | Sol. | .845 | 68 | >1 | <-10 | 1.2 | | MSDS |
| 608 Cleaner | Textile Spirits 96% | Clear liq.<br>Solvent od. | 148 | - | >1 | Negl. | .675 | 100 | >1 | <-10 | 1.2 | | MSDS |
| 683 Thinner | Toluol 57%<br>Xylol 16%<br>4-methyl 2-Pentanone 15% | Clear liq.<br>Ketone odor | 190 | - | >1 | Sol. | .85 | 100 | <1 | 38 | 1.2 | | MSDS |
| 904 Leather Softener | Isopropanol 13% | Clear liq.<br>Sweet odor | 212 | - | >1 | ∞ | .932 | 95 | <1 | 76 | 2.0 | | MSDS |
| 9410 Medium Bright Spray | Mineral Spirits <2%<br>Isopropanol <5%<br>M-Pyrot <3%<br>Ammonia <3%<br>Formaldehyde <1% | Off white liq.-<br>Amm. odor | 210 | - | >1 | ∞ | 1.005 | 80 | <1 | 98 | - | | MSDS |
| 9505 Suede Spray | Toluol 44%<br>Textile Spirits 34% | Pale Yell. liq.<br>Solv. odor | 148 | - | >1 | Negl. | .810 | 86 | >1 | <10 | 1.2 | | MSDS |
| 9529 Urethane Spray | Toluol 29%<br>Isopropanol 26%<br>Diacetone alcohol <15%<br>Ethylene glycol mono ethyl ether acetate <15% | Clear liq.,<br>Solv. odor | 179 | - | >1 | Sol. | .86 | 96 | <1 | 40 | 1.2 | | MSDS |
| 9531 | 2-Butanone 96% | Brown liq.,<br>Ketone od. | 174 | - | >1 | V. sol. | .81 | 99 | >1 | -10 | 1.8 | | MSDS |

| Trade Name | Hazardous ingredients | | Appearance/odor | B.P. | Vapor Press. | Vapor Dens. | $H_2O$ Soly. | Sp. Gr. | % Volat. | Evap. Rate | Flash | LEL | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 131 Unitak | Toluol<br>Ammonia<br>Potassium hydroxide | 8%<br><.5%<br><.5% | White liq.<br>Amm. odor | 220 | - | >1 | ∞ | .995 | 52 | <1 | 97 | 1.2 | MSDS |
| Quinn Inc., Malden, MA | | | | | | | | | | | | | |
| Swadsticks | Pigment + binder | | | | | | | | | | | | Condidered hazardous |
| Crayons | Wax + pigment | | | | | | | | | | | | Considered hazardous |
| Wax Cakes | Wax + pigment | | | | | | | | | | | | Considered hazardous |
| Super Cera | Wax + pigment | | | | | | | | | | | | Considered hazardous |
| SS-1148 | Brazilian Paste | | | | | | | | | | | | Not considered hazardous |
| SS-1182 | Brazilian Paste | | | | | | | | | | | | Not considered hazardous |
| SS-1147 | Brazilian Paste | | | | | | | | | | | | Not considered hazardous |
| SS-1150 | Brazilian Paste | | | | | | | | | | | | Not considered hazardous |
| SS-1140 | Brazilian Paste | | | | | | | | | | | | Not considered hazardous |
| SS-1154 | Brazilian Paste | | | | | | | | | | | | Not considered hazardous |
| SW-1483 | Paste Cleaner | | | | | | | | | | | | Not considered hazardous |
| TR-13 Conditioner | Aromatic hydrocarb<br>Ammonia<br>Water | 12% | | | | | | | | | 48 | | |
| A-Ceranize series | Aromatic hydrocarbons<br>Aliphatics<br>Water<br>Dyes & Waxes | 20% | Semi-pastes<br>Emulsions | | | | | | | | | | |
| D-4869 Antique | Aromatic hydrocarbons<br>Aliphatics<br>Water<br>Dyes & Waxes | 20% | Semi-paste<br>Emulsions | | | | | | | | | | |

| Trade Name | Hazardous ingredients | Appearance/odor | B.P. | Vapor Press. | Vapor Dens. | $H_2O$ Soly. | Sp. Gr. | % Volat. | Evap. Rate | Flash | LEL | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Quinn, Continued):<br>D-151 Antique | Aromatic hydrocarbons 20%<br>Aliphatics<br>Water<br>Dyes & Waxes | Paste emulsion | | | | | | | | | | |
| D-8199 Antique | Aromatic hydrocarbons 20%<br>Aliphatics<br>Water<br>Dyes & Waxes | Paste emulsion | | | | | | | | | | |
| SS-1135 Brush Teak | Aliphatic/Aromatics 30%<br>Alcohols, Esters<br>Ketones<br>Plasticized nitrocellulose<br>Dyes | | | | | | | | | 15 | | |
| QS-215 Thinner | Aliphatic/Aromatic hydrocarbon solvents 60% | | | | | | | | | <-14 | | |
| 1291 X Cleaner | Ether & Aliphatic Solvents | | | | | | | | | <-40 | | |
| Q-4419 Cleaner | Aliphatic hydrocarbons | Water emulsion gel | | | | | | | | <-14 | | |
| A-3902 Thinner | Ketone | | | | | | | | | 61 | | |
| LL-20 Spray | Plasticized Nitrocellulose<br>Ester, Aliphatic hydrocarb.<br>Aromatic hydrocarbons<br>Alcohols | 2% | | | | | | | | <-30 | | |
| SA-7569 Polish | Silicone, ketones, aliphatics<br>Aromatic hydrocarbons | 15% | | | | | | | | <-14 | | |
| SA-6968 Cleaner | Ketones & aliphatics<br>Aromatic hydrocarbons | 15% | | | | | | | | <-14 | | |

| Trade Name | Hazardous ingredients | Appearance/odor | B.P. | Vapor Press. | Vapor Dens. | $H_2O$ Soly. | Sp. Gr. | % Volat. | Evap. Rate | Flash | LEL | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Quinn, Continued):<br>SS-1397 Dye | Alcohols, glycol ethers<br>Water, dyes | | | | | | | | | 65 | | |
| BU-1026 Sole Finish | Dyes, Urethane resin in ketone solvent | | | | | | | | | 25 | | |
| BU-2221 Sole Finish | Dyes, Urethane resin in esters & ketone solvents | | | | | | | | | 25 | | |
| 3003 Sponge Cleaner | Aromatic hydrocarbon 80% | | | | | | | | | 110 | | |
| 7730 Sponge Cleaner | Alcohol, ketones<br>aromatic hydrocarbons 40% | | | | | | | | | 25 | | |
| A-1813 Spray | Plasticized nitrocellulose alcohols, esters, aliphatics aromatic hydrocarbons 5% | | | | | | | | | <-14 | | |
| A-4907 Shader | Dyes, ketone, alcohol, esters & resin binder | | | | | | | | | 25 | | |
| A-1453 Shader | Dyes, plasticized nitrocellulose, esters, alcohols, ketones, glycol ethers aromatic hydrocarbons 10% | | | | | | | | | 25 | | |
| A-5140 Shader | Dyes, plasticized nitrocellulose, alcohols, esters, glycol ethers, aromatic hydrocarbons 15% | | | | | | | | | 60 | | |
| SS-1359 Dye | Dyes, alcohol, glycol-ethers | | | | | | | | | 65 | | |
| PT-513 Pro-Teak | Dyes, alcohol, glycol-ethers | | | | | | | | | 65 | | |
| SA-7385 Heel Finish | Black dye, alcohol, esters, ketones, resin binder | | | | | | | | | 25 | | |

| Trade Name | Hazardous ingredients | | Appearance/odor | B.P. | Vapor Press. | Vapor Dens. | $H_2O$ Soly. | Sp. Gr. | % Volat. | Evap. Rate | Flash | LEL | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Compo Industries, Inc., Waltham, MA | | | | | | | | | | | | | |
| 4100 Urethane | Acetone<br>MEK<br>Toluene | 31-38%<br>26-32<br>24-30 | | | | | | | | | | | |
| 4625 Urethane | Acetone<br>MEK<br>Toluene | 28-35%<br>28-35<br>24-30 | | | | | | | | | | | |
| 4625A Urethane | Acetone<br>MEK<br>Toluene | 28-35%<br>28-35<br>24-30 | | | | | | | | | | | |
| 9650 (9650B) Urethane | Acetone<br>MEK<br>Toluene | 59-77%<br>12-15<br>6-8 | | | | | | | | | | | |
| 3174 Cleaner | Hydrocarbon mixture | 100% | | | | | | | | | | | |
| 3035 Primer | Toluene<br>Methylene chloride | 59-71%<br>25-29 | | | | | | | | | | | |
| 3914 Primer | Ethyl Acetate | 97.5-100% | | | | | | | | | | | |
| 3861 Primer | MEK<br>Toluene | 41-50%<br>41-50 | | | | | | | | | | | |
| C-186 | Toluene<br>Ethyl Acetate | 46.5-70%<br>20-30 | | | | | | | | | | | |
| C-394 | MEK<br>Tetrahydrafuran | 63-91.5%<br>6.5-8.5 | | | | | | | | | | | |

| Trade Name | Hazardous ingredients | | Appearance/odor | B.P. | Vapor Press. | Vapor Dens. | $H_2O$ Soly. | Sp. Gr. | % Volat. | Evap. Rate | Flash | LEL | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Compo Continued) 5134 M Neoprene | Ethyl Acetate | 8-10% | | | | | | | | | | | |
| | Toluene | 52-67 | | | | | | | | | | | |
| | n-Hexane | 15-20 | | | | | | | | | | | |
| | Xylene | 2-3 | | | | | | | | | | | |
| 5142 Neoprene | Toluene | 51-75% | | | | | | | | | | | |
| | n-Hexane | 17-25 | | | | | | | | | | | |
| 6600 Neoprene | Ethyl Acetate | 10-13% | | | | | | | | | | | |
| | Toluene | 37-50 | | | | | | | | | | | |
| | n-Heptane | 18-50 | | | | | | | | | | | |
| 6602 (6612) Neoprene | Ethyl Acetate | 10-13% | | | | | | | | | | | |
| | Toluene | 28-36 | | | | | | | | | | | |
| | n-Heptane | 38-51 | | | | | | | | | | | |
| 6700 Neoprene | Ethyl Acetate | 10-14% | | | | | | | | | | | |
| | Toluene | 26-35 | | | | | | | | | | | |
| | n-Hexane | 17-24 | | | | | | | | | | | |
| | n-Heptane | 19-27 | | | | | | | | | | | |
| 6708 Neoprene | Ethyl Acetate | 10-14% | | | | | | | | | | | |
| | Toluene | 26-38 | | | | | | | | | | | |
| | n-Hexane | 18-25 | | | | | | | | | | | |
| | n-Heptane | 17-23 | | | | | | | | | | | |
| 7704 Neoprene | Ethyl Acetate | 10-14% | | | | | | | | | | | |
| | Toluene | 26-36 | | | | | | | | | | | |
| | n-Hexane | 17-23 | | | | | | | | | | | |
| | n-Heptane | 20-27 | | | | | | | | | | | |
| 7780 Neoprene | Acetone | 4-5% | | | | | | | | | | | |
| | Toluene | 46-60 | | | | | | | | | | | |
| | n-Hexane | 19-25 | | | | | | | | | | | |
| | n-Heptane | 8-10 | | | | | | | | | | | |

| Trade Name | Hazardous ingredients | | Appearance/odor | B.P. | Vapor Press. | Vapor Dens. | $H_2O$ Soly. | Sp. Gr. | % Volat. | Evap. Rate | Flash | LEL | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMSCO - Div. of Union Oil, Palatine, IL | | | | | | | | | | | | | |
| Solvent 1001 | Petroleum hydrocarbon | | Clear liq.<br>Solvent odor | 115-<br>235 | 155 | 3.5 | Negl. | 0.70 | 100 | 4.9 | 0 | 1 | 230 ppm TLV<br>MSDS |
| General Adhesives & Chemical Co. Nashville, TN | | | | | | | | | | | | | |
| Formula 77-192 | Aromatics<br>Rubber resin | 76%<br>24 | Straw color<br>adhesive, Of-<br>fensive odor | 229 | 22.4 | 3.14 | Ins. | .867 | 80.6 | 2.1 | 45 | 1.3 | 200 ppm TLV<br>MSDS |
| Formula 77-193 | Vehicle<br>Aliphatics<br>Aromatics | 25%<br>27<br>48 | Yellow | 228 | | | | .875 | 81 | 1.9 | 0 | | 200 ppm TLV<br>MSDS |
| Formula 77-193LV | Aromatics<br>Aliphatics<br>Rubber Resin | 50.6%<br>31.0<br>18.4 | Straw color<br>adhesive, Of-<br>fensive odor | 110-<br>229 | 22.4 | | Ins. | | 86.4 | 2.1-<br>3.9 | > 0 | 1.3 | 200 ppm TLV<br>MSDS |
| Formula 77-1440 | Vehicle<br>Aromatics<br>Aliphatics | 20%<br>40<br>40 | | 142 | | | | .837 | 86 | 3.4 | -16 | | 200 ppm TLV<br>MSDS |
| COMPO Industries, Inc., Waltham, MA | | | | | | | | | | | | | |
| 3035 Neoprene Solution | Solvents | 94.5% | Amber liq.<br>Aromat. odor | 104 | 118 | 3.1 | 0.1% | .947 | 94.2 | 9 | 40 | 1.2 | 200 ppm TLV<br>MSDS |
| 8027 | Solvents | 89% | Clear liq.<br>Sweet odor | 133-<br>179 | 160 | 2.3 | 81% | .814 | 95 | 8.9 | 0 | 1.2 | 500 ppm TLV<br>MSDS |
| 9650 Urethane Solution | Solvents | 76.5% | | 133-<br>231 | 160 | 2.3 | 62% | .869 | 83.3 | 9.7 | 0 | 1.3 | 200 ppm TLV<br>MSDS |
| 3814 Chlorinating Primer | Solvents | 97.5% | Pale yell. liq.<br>Clorine od. | 171 | 73 | 3 | 3.3% | .900 | 98 | 4.1 | 24 | 2.5 | 400 ppm TLV<br>MSDS |

| Trade Name | Hazardous ingredients | | Appearance/odor | B.P. | Vapor Press. | Vapor Dens. | $H_2O$ Soly. | Sp. Gr. | % Volat. | Evap. Rate | Flash | LEL | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Compo Continued)<br>4100A Urethane Solution | Solvents | 80.5% | Translucent liq. Pungent | 133-231 | 125 | 2.3 | 35.5% | .864 | 86 | 6.1 | 0 | 1.3 | 200 ppm TLV<br>MSDS |
| 4100H Urethane Solution | Solvents | 80.5% | Translucent liq. Pungent | 133-231 | 125 | 2.3 | 35.4% | .872 | 86 | 6.1 | 0 | 1.3 | 200 ppm TLV<br>MSDS |
| K. J. Quinn & Co. Inc. Malden, MA | | | | | | | | | | | | | |
| RF 205 Coating Thinner | Esters<br>Alcohols<br>Toluol | 38%<br>30<br>32 | Thin Colorless liq. Butyl od. | - | - | - | Ins. | .84 | 100 | - | 43 | - | MSDS |
| RF 212 Edge Finish | Alcohol<br>Ester<br>Glycol-Ether<br>Xylol<br>Pigments & Solids | 23%<br>9<br>6<br>25<br>37 | Thin liquid Lacquer odor | - | - | - | Ins. | .89 | 63 | - | 58 | - | MSDS |
| 1291-X Cleaner | Aliphatic Hydrocarb<br>Ether | 30%<br>20 | Thin colorless liq., Ether od. | - | - | - | Ins. | .62 | 100 | - | <-14 | - | MSDS |
| SS 1847 Cleaner | Aliphatic Hydrocarb<br>Ether | 70%<br>30 | Thin colorless liq. Gasoline odor | - | - | - | Ins. | .74 | 100 | - | <-14 | - | MSDS |
| VL-1923 Spray | Esters<br>Alcohol<br>Toluol<br>Solids | 78%<br>14<br>4<br>4 | Thin colorless liq., Ester od. | - | - | - | Ins. | .87 | 96 | - | 31 | - | MSDS |
| 3205 Thinner | Ketones | 99% | Thin colorless liq., ketone od. | - | - | - | Ins. | .80 | 100 | - | 25 | - | MSDS |

| Trade Name | Hazardous ingredients | | Appearance/odor | B.P. | Vapor Press. | Vapor Dens. | $H_2O$ Soly. | Sp. Gr. | % Volat. | Evap. Rate | Flash | LEL | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Markem Corporation, Keene, NH | | | | | | | | | | | | | |
| 8855 Ink | Solvents | ≤50% | Waterwhite characteristic odor. | 475 | low | 4.8 | sl. sol. | 1.1 | 100 | <0.1 | 250 | - | MSDS |
| Slocum Chemical Co., Lynchburg, VA | | | | | | | | | | | | | |
| 207 Latex Counter Adhesive | 2.5% Natural Latex<br>Toluene<br>10% KOH Solution<br>Resin emulsions & stabilizers | 26%<br><5<br>Trace | Milky, slight ammon. od | 212 | 17.5 | NA | | .998 | 72.8 | 1 | None | None | MSDS |
| 320 Marking Ink Cleaner | Alcohol & Ester | 100% | Clear liq., Ester odor | 171 | 76 | 3.04 | 33 | .87 | 100 | 5.1 | 31 | 4.0 | 400 ppm TLV<br>MSDS |
| USM Corporation, Bostik Div., Middleton, MA | | | | | | | | | | | | | |
| Be Be Bond LR-55 | Aliphatic Blend<br>Denatured alcohol | 86%<br>2 | Straw liq.<br>Naptha odor | 120 | 149 | 3.44 | slight | .708 | 92 | 2.6 (ethr) | <-8 | 1.3 | 516 ppm TLV<br>MSDS |
| American Finish & Chemical Co., Chelsea, MA | | | | | | | | | | | | | |
| C1347 Toe Lasting Adhesive | Water<br>Ammonia | 38%<br>0.2 | Clear liq.<br>Ammon. odor | 212 | - | - | ∞ | .974 | 38 | 1 | NA | - | MSDS |