# An INDUSTRIAL HYGIENE STUDY of POLYURETHANE FOAM INSULATION APPLICATION ACTIVITIES at THERMAL ACOUSTIC FOAM INSULATION, INC.

OFFICE LOCATION:

Columbia, Maryland

SURVEY DATES:

19-20 November 1979

SURVEY CONDUCTED BY:

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## DISCLAIMER



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# ABSTRACT

This industrial hygiene study is part of an industrywide industrial hygiene characterization of thermal insulation manufacturing and application activities. This survey was conducted at an application site where a two-component polyurethane foam system was applied. Personal sampling was conducted to determine worker exposure to MDI, fluorotrichloromethane, *alpha*-methyl styrene, dimethylethanolamine, dimethylcyclohexylamine, and dimethyltin dicarboxylate; measurements were also made for carbon monoxide and noise. The chemical agents MDI, fluorotrichloromethane, dimethylcyclohexylamine, and carbon monoxide were detected in the workplace; however, the NIOSH and ACGIH limits and the OSHA standard were not exceeded during the survey. The results of noise measurements indicated that the NIOSH and ACGIH limits were exceeded on one of the days of the survey.

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# I. INTRODUCTION

## AUTHORITY

The Williams-Steiger "Occupational Safety and Health Act of 1970) was passed into law "to assure safe and healthful working conditions for working men and women...." This Act established the National Institute for Occupational Safety and Health (NIOSH) in the Department of Health, Education, and Welfare and the Occupational Safety and Health Administration (OSHA) in the Department of Labor. The Act provides for research, informational programs, education, and training in the field of occupational safety and health and authorizes the enforcement of standards.

NIOSH has been given the authority and responsibility under the Act to conduct field research studies in industry, evaluate findings, and report on those findings. Section 20(a)(1) of the Act mandates NIOSH to "conduct (directly or by grants or contracts) research, experiments, and demonstrations relating to occupational safety and health...." Section 20(c) provides the authority to enter into contracts, agreements, or other arrangements with appropriate public agencies or private organizations for the purpose of conducting studies relating to responsibilities under the Act. For this purpose, NIOSH has established a contractual agreement with Enviro Control, Inc. (Enviro) to study worker exposures at Thermal Acoustic Foam Insulation, Inc.

## PURPOSE AND NEED FOR STUDY

Members of the insulation trade have long been noted to experience excess mortality due to malignant and nonmalignant respiratory diseases (Fleisher 1946, Marr 1964, Selikoff et al 1964, Keane et al 1966). Much of this observed disease has been attributed to exposures to asbestos fiber. However, the hazards associated with many of the other thermal insulation materials used remain unknown. With the great increase in the use of thermal insulation and the proliferation of insulation materials, there is need for a study to identify hazards associated with these materials.

The purpose of this study is to determine the types and quantities of thermal insualtion materials commonly used in the United States, the end use categories of these materials, and information regarding past worker exposure data. Current occupational exposure levels of workers to two commonly used thermal insulation materials have been determined by industrial hygiene surveys.

## MATERIAL SELECTION

To select the thermal insulation materials most appropriate for study within the resources available for this contract, the following selection criteria were applied to the more than two dozen materials currently being commonly used:

- Number of potentially exposed workers
- Present extent of use
- Projections of future extent of use
- Toxicity
- Purity of material in use
- Length of time material has been used
- Availability of worker exposure data

Since worker exposures to asbestos, glass fiber and mineral wool have been extensively studied, materials on which less information was available and which contained substantial toxic components were further considered for study. Applying the selection criteria with this emphasis led to the selection of plastic foam systems. Those materials foamed in place were considered to present a greater potential for worker exposure than preformed foam products. Therefore, considering past growth and potential future growth as well as the toxic components contained in urea formaldehyde and polyurethane foam systems for thermal insulation, these two foam systems were selected by NIOSH for detailed study.

# II. FIELD SURVEY

## DESCRIPTION OF OPERATIONS

Thermal Acoustic Foam Insulation, Inc., (Thermal Acoustic), located in Columbia, Maryland, is an applicator of thermal insulation materials. The company operates out of a small warehouse containing both office and storage space. Thermal Acoustic applies polyurethane foam and urea formaldehyde foam insulation, with limited application of cellulose and fiberglass insulation materials. The application of the two-component, rigid polyurethane foam insulation systems is the subject of this study.

Typical polyurethane foam applications performed by this company include roof exteriors, refrigerated warehouses, and industrial water tanks. Thermal Acoustic, which serves a nine-state area, has been in business since 1975. There are 12 employees, 3 of whom are generally involved in polyurethane application. These employees do not belong to a union.

## POLYURETHANE FOAM APPLICATION PROCESS

Polyurethane foam systems consist of an "A" and a "B" component which are contained separately in 55-gallon drums. The "A" component consists of a mixture of monomeric and polymeric forms of methylene bisphenyl isocyanate (MDI). The "B" component consists of a blend of ingredients containing polyols (polyhydroxy compounds), amine and organotin catalysts, a silicone oil foam stabilizer, fluorotrichloromethane (Freon-11® or R-11), and *alpha*-methyl styrene. The two components are mixed in the internal mixing chamber of the spray gun, atomized, and sprayed onto a substrate, where the foam mixture expands and hardens in less than 1 minute. The foaming process involves an exothermic polymerization reaction; the heat evolved helps to expand and cure the foam. A silicone-based weather coating is usually applied after the foaming is completed.

The application team, consisting of an Applicator and a Helper, arrived at the warehouse at about 8:00 a.m. and loaded the polyurethane products onto a 20-ft Ford Tiltcab truck. Since the cab of this truck is separated from the bed, exposure while in transit to and from the job site was not evaluated. The truck also contains the application equipment and a desk.

The application site during this survey was a church in Lutherville, Maryland, in which polyurethane foam insulation was applied to the flat portions of the roof. The application team had previously cleaned the roof of dirt and loose gravel.

The application equipment consists of: a gasoline-engine-powered air compressor, pneumatic transfer pumps, a Gussmer H-2 proportioning pump, hoses, and an airless spray gun. The air compressor drives the transfer pumps which supply the "A" and "B" components to the proportioning pump. The proportioning pump heats the components to 60°C, pressurizes and meters each component to the spray gun. A line heater (electrical resistance) wrapped around the hoses maintains the temperature.

The foam is applied to the roof in 4-foot-wide paths from a standing/walking position. The foam is built-up to a thickness of an inch or more by applying the foam in layers. Periodically, the Applicator cleans the spray gun by squirting "gun cleaner" (cellosolve acetate or 2-ethoxyethyl acetate) into the mixing chamber. When spraying is completed for that day, the equipment is put back onto the truck, the spray gun is cleaned with "gun cleaner", and the application team returns to the warehouse.

The application team spent about 7 hours each day at the application site; however, only about 4-4½ hours each day were spent spraying foam. Other activity at the application site included downtime due to equipment malfunction, downtime while waiting for the roof to dry, setting up and taking down application equipment, and lunch breaks.

Potential health hazards associated with the application of polyurethane foams have been reported (3). The spraying operations can generate an aerosol containing considerable quantities of respirable isocyanate-polyurethane particulates which can travel some distance from the application point. In addition, since the polymerization process is exothermic, there is a possibility that some isocyanate will volatilize and escape into the atmosphere along with other components in the system.

## MEDICAL, INDUSTRIAL HYGIENE, AND SAFETY PROGRAMS

Thermal Acoustic has no formalized medical, industrial hygiene, or safety programs. Employees are covered under the Maryland State Accident Fund and by an optional medical insurance program; however, routine medical examinations are not provided for employees. First aid supplies on the truck consist of a first aid kit. There has never been an industrial hygiene survey conducted at this company. Thermal Acoustic provides hardhats, respirators, and goggles for all employees; however, the use of safety equipment is optional.

## JOB DESCRIPTIONS

The application team consisted of an Applicator and a Helper. The responsibilities associated with each job category are as follows:

### Applicator

The Applicator, who is also the vice president of Thermal Acoustic, has the responsibility for applying the polyurethane insulation. His duties include: maintenance, cleaning and assembly of the application equipment; assuring foam quality; foam application; and general cleanup. On days when foam is not applied, he may be involved in preparation and cleaning of the surface/area to be foamed, applying a weatherproof sealant to a foamed surface, or applying another type of thermal insulation material.

The applicator spends about 1 hour inside the truck each day cleaning, assembling, and performing maintenance on the application equipment. The actual time spent performing maintenance may vary; during the survey, there were delays due to equipment malfunction. End-of-day cleanup generally takes less than 1 hour.

### Helper

The Helper's duties include: setting up equipment, moving the hoses from the path as the Applicator sprays the foam; making adjustments to the proportioning pump; changing over the MDI and resin drums when empty; and general cleanup. Occasionally the Helper may spray foam. The Helper spent less than half of his time on the roof helping the Applicator during the survey.

## EXISTING CONTROLS

Personal protective equipment consisted of respirators and gloves. The respirators (Norton half-mask respirator, NIOSH Approval No. TC-23C-74, approved for pesticides) were used when foam was applied under the overhang of the steeple. Rubber gloves were used by the Applicator while spraying foam. There is no mechanical ventilation used with the polyurethan foam application process. The foam is applied outdoors; the operator generally stands upwind of the spray taking advantage of natural ventilation.

## SURVEY LIMITATIONS AND PROCEDURES

This industrial hygiene survey represents an evaluation of conditions present on November 19-20, 1979. All apparent chemical and physical hazards were evaluated. Sampling was limited to those agents capable of causing significant exposures under existing conditions. Generally, conditions monitored during the survey were considered to be representative of typical outdoor polyurethane foam application conditions.

The polyurethane products used during this survey were manufactured by the CPR-Upjohn Company. The "A" component consisted of PAPI® (trade name for MDI). The "B" component is a blend containing polyols (polyhydroxyl compounds), silicone oil copolymer, dimethylcyclohexylamine, dimethylethanolamine, dimethyltin dicarboxylate, trichlorofluoromethane (Freon 11®, R-11), and *alpha*-methyl styrene. MDI is the common "A" component in polyurethane thermal insulation systems. The "B" component, or polyol, may vary slightly depending upon the manufacturer and the specific application.

Potential exposure to the polyurethane products can occur in the vicinity of the spraying operation where an overspray mist is usually visible and inside the truck where open drums of raw materials are located.

Both members of the application team were monitored for selected chemical air contaminants associated with the polyurethane foam application process. Grab sampling for carbon monoxide using Draeger Carbon Monoxide 5/C sampling tubes (NIOSH Certification No. TC-84-012) was conducted inside the truck while the gasoline-engine-powered air compressor was operating. An MSA, Type 2, sound level meter (Model No. 6950-90) was used to determine noise levels associated with the foam application process.

SAMPLING AND ANALYTICAL METHODS

Personal samples were collected in the breathing zone of individual employees. These were obtained by attaching the sampling device (sampling tube or impinger) to the shirt collar or lapel of the employee. Plastic tubing was used to connect the sampling device to the personal sampling pump located on the employee's belt. The flow rates through these sampling trains were determined both before and after sampling by use of a buret (soapbubble meter).

The following chemical air contaminants, identified as being potential air contaminants associated with the application of polyurethane foam insulation, were monitored at the application site: MDI, dimethylethanolamine, dimethylcyclohexylamine, fluorotrichloromethane, *alpha*-methyl styrene, and dimethyltin dicarboxylate.

## MDI

Sampling and analysis for MDI was conducted according to NIOSH Method No. P&CAM 142 (4). A known volume of air was drawn through a Bendix midget impinger (Model #7202) containing 15 mℓ of absorbing solution (hydrochloric acid and glacial acetic acid in distilled water). The sampling rate was 1 liter per minute. MSA Model G sampling pumps were used. After each sampling period, the impinger contents were transferred to glass vials having Teflon-lined caps.

Analysis for MDI involves the formation of a colored complex which is subsequently quantified utilizing a spectrophotometer. The analytical method cannot be used to differentiate between monomeric and polymeric forms of MDI; consequently, the sample results may reflect concentrations of both forms. The limit of detection for the MDI determinations reported in this study is 0.5 μg (equivalent to 0.005 ppm for a 20-liter air sample). Four impingers, each containing 15 mℓ of absorbing solution, were handled in the same manner as the samples, except that no air was drawn through them. These were analyzed by the laboratory as blanks.

## Dimethylethanolamine and Dimethylcyclohexylamine

Currently, NIOSH and OSHA do not have smapling and analytical methods specific for either dimethylethanolamine or dimethylcyclohexylamine. NIOSH Method No. P&CAM 270 I5) was selected for this survey based on the chemical similarity between dimethylethanolamine and other aminoethanol compounds which are covered in this method. This method was followed for both compounds with a slight variation in the sampling phase. The method recommends stabilization of the amine by adding hydrochloric acid (with a microliter syringe) to the collection tube immediately after sampling is completed. The stabilization procedure was not performed in the field; samples were stabilized by the laboratory on November 26.

Sampling was conducted by drawing a known volume of air through a silica gel tube to trap the amine compounds. MSA Model C-200 and SKC Model 222-3 personal sampling pumps, set between 50 and 100 mℓ per minute, were used. The silica gel tubes consist of glass tubes, 7 centimeters long, packed with 150 mg of silica gel in two sections; the front section contains 100 mg of silica gel, and the backup section contains 50 mg. Two silica gel tubes from the same batch as the samples were handled in the same manner as the samples, except that no air was drawn through them. These were analyzed by the laboratory as blanks.

At the laboratory, the samples were desorbed with methanol:water (4:1). An aliquot was taken and made basic (pH > 8) with 0.5 mℓ of a 0.2 N NaOH-methanol:water (4:1) solution, and then analyzed by gas chromatography. Desorption efficiency tests were also conducted by the laboratory by spiking silica gel tubes with known amounts of dimethylethanolamine and dimethylcyclohexylamine, and then analyzing in the same manner as described above. The desorption efficiencies for the two compounds are 92% and 88%, respectively.

Fluorotrichloromethane

Sampling and analysis for fluorotrichloroemthane were conducted in accordance with NIOSH Method No. S102 (6). A known volume of air was drawn through a charcoal tube to trap the vapor present. MSA Model C-200 and SKC Model 222-3 personal sampling pumps, set at 30 mℓ per minute, were used. The charcoal tubes consist of glass tubes, 10 centimeters long, packed with two sections of 20/40 mesh activated coconut charcoal. The front section contains 400 mg of charcoal, and the backup section contains 200 mg. Analysis involves desorption of the fluorotrichloromethane with carbon disulfide and subsequent analysis by gas chromatography. Two charcoal tubes from the same batch as the samples were handled in the same manner as the samples except that no air was drawn through them. These were analyzed by the laboratory as blanks.

### *alpha*-Methyl Styrene

NIOSH Method No. S26 (7) was selected for sampling of *alpha*-methyl styrene. The sampling method is compatible with the sampling method for fluorotrichloromethane; consequently, one collection tube was generally used for sampling and analysis for both compounds. The analytical method for *alpha*-methyl styrene involves desorption with carbon disulfide and injection of an aliquot into a gas chromatograph. Two charcoal tubes from the same batch as the samples were handled in the same manner as the samples except that no air was drawn through them. These were analyzed by the laboratory as blanks.

### Dimethyltin Dicarboxylate

Sampling for dimethyltin dicarboxylate was conducted according to NIOSH Method No. P&CAM 176 (8). Sampling was conducted by drawing a known volume of air through a Millipore 37-mm Type AA 0.8 µm filter, mounted in a cassette with a filter holder, to trap the tin compound. MSA Model G sampling pumps were used. The sampling rate was 1.5 liters per minute. One filter cassette from the same batch as the samples was handled in the same manner as the samples except that no air was drawn through it. This was analyzed by the laboratory as a blank.

Samples were analyzed according to a method developed by the analytical laboratory and based on published methods (9,10). Analysis involves refluxing with nitric acid to dissolve the filter matrix, treating with concentrated hydrochloric acid, and analyzing on an atomic absorption spectrophotometer with an air-acetylene flame. Results are reported as elemental tin.

At the end of the survey, all samples were shipped by air to Clayton Environmental Consultants, Inc., in Southfield, Michigan. All analyses were performed by Clayton, which is accredited under the Laboratory Accreditation Program of the American Industrial Hygiene Association. Sampling media, including the MDI absorbing solution, were provided by Clayton.

## EVALUATION CRITERIA

### MDI

In 1965, the American Conference of Governmental Industrial Hygienists (ACGIH) adopted a threshold limit value (TLV) for MDI of 0.02 ppm expressed as a ceiling value, which should not be exceeded even instantaneously. The current ACGIH-TLV for MDI remains at 0.02 ppm (11).

In 1973, NIOSH published criteria for a recommended standard for occupational exposure to toluene diisocyanate (TDI) recommending a time-weighted-average (TWA) limit of 0.005 ppm and a ceiling limit of 0.02 ppm. In 1978, this recommendation for a standard was extended to include all diisocyanates including MDI. Exposure to diisocyanates should be controlled so that no employee is exposed at concentrations in excess of 5 ppb as a TWA for a 10-hour work shift, 40-hour workweek, and a ceiling limit of 20 ppb for a 10-minute sampling period (12).

The current OSHA standard (29 CFR 1910.1000) for occupational exposure to MDI is a ceiling limit of 0.02 ppm.

### Fluorotrichloromethane

The current ACGIH-TLV for fluorotrichloromethane is 1,000 ppm (11). Fluorotrichloromethane is a central nervous system depressant in animals; however, there are no reported effects in humans. The current OSHA standard for fluorotrichloromethane is 1,000 ppm. There is no NIOSH-recommended limit for occupational exposure to this compound.

### *alpha*-Methyl Styrene

The current ACGIH-TLV for *alpha*-methyl styrene is 100 ppm (11) expressed as a ceiling concentration. This TLV was set to prevent eye irritation (13). The present OSHA standard for *alpha*-methyl styrene is 100 ppm, expressed as a ceiling concentration. There is no NIOSH-recommended limit for occupational exposure to this compound.

Dimethylethanolamine and Dimethylcyclohexylamine

There is currently no standard or recommended limit for occupational exposure to dimethylethanolamine or dimethylcyclohexylamine.

Dimethyltin Dicarboxylate

The current OSHA standard for organotin compounds (including dimethyltin dicarboxylate) is 0.1 mg/m$^3$, as tin. NIOSH (14) recommends that the current OSHA standard be retained until more definitive information can be obtained. The current ACGIH-TLV for organotin compounds is also 0.1 mg/m$^3$, as tin (11).

Carbon Monoxide

The current OSHA standard for carbon monoxide is 50 ppm as a TWA limit. The NIOSH-recommended limit (15) for exposure to carbon monoxide is 35 ppm as a TWA limit for a 10-hour work shift. The ACGIH-TLV (11) for carbon monoxide is an 8-hour TWA limit of 50 ppm.

Continous Noise

Currently, the OSHA standard allows employees to be exposed to an average of 90 dBA, as measured on the A-scale of a standard sound level meter at slow response, for an 8-hour period. For every 5-dBA increase in the average exposure, the allowable exposure time period is reduced by a factor of 0.5. Exposures to levels in excess of 115 dBA are not permitted (11). The ACGIH recommends that sound levels not exceed an average of 80 dBA for a 16-hour workday. For every 5-dBA increase in the average exposure, the allowable exposure time period is reduced by a factor of 0.5. Exposures to levels in excess of 115 dBA are not recommended (11).

The NIOSH-recommended permissible sound level exposures (16) are identical to the ACGIH levels. The criteria document recommends that these sound levels become effective for existing places of employment after an extensive feasibility study.

# III. RESULTS AND DISCUSSION

Results of personal monitoring for ceiling and TWA concentration determinations obtained during the 19-20 November 1979 survey of the Thermal Acoustic application team are presented in Tables 1 through 7. The sampling periods do not include lunch breaks or transit time to the application site. Unscheduled breaks are included. The results of blank sample analyses were less than the detectable limits for all compounds sampled.

## MDI

MDI monitoring results obtained and activities performed during the sampling periods are presented in Tables 1 and 2. The NIOSH and ACGIH recommended limits and the OSHA standard were not exceeded during the survey.

The employees' sampling period time-weighted average (TWA) exposure to MDI is also presented in Tables 1 and 2. The series of short-term samples does not encompass all of the time spent each day at the application site; however, the samples are representative of daily MDI exposure in that they encompass all of the routinely performed activities associated with the foam application process. Many of the values used in the calculation of the TWAs reflect concentrations at or below the limit of detection. Therefore, the sampling period TWAs represent a reasonable approximation of maximum daily TWAs for workers engaged in outdoor application of polyurethane foam.

An MSA model G pump was used in each MDI collection sampling train. Six pumps were used. The coefficient of variation based on multiple calibration at a fixed rotameter setting was calculated for each pump. The average coefficient of variation for all of the pumps was 0.05. The laboratory reported an analytical coefficient of variation of 0.05 or less. The total coefficient of variation ($C_T$) is equal to the square root of the sum of the squares of the pump and analytical coefficients of variation. Assuming an analytical coefficient of variation of 0.05, the $C_T$ is 0.07.

MDI was detected in six of the 16 personal samples of the Applicator (see Table 1). Two of the sample results were greater than the NIOSH-recommended 10-hour TWA of 0.005; however, the estimated employee TWA, based on sample results, would be less than 0.005 ppm. The series of samples encompasses approximately 90% of the time spent spraying foam and also included other activities associated with the application process.

MDI was detected in two of the 11 personal samples of the Helper (see Table 2). One of the detected concentrations (sample #7) occurred while the Helper was inside the truck monitoring the proportioning pump; the other occurred while the Helper was on the roof assisting the Applicator and applying foam.

A recent study (16) has shown that a major portion of MDI is present as an aerosol in polyurethane foam spraying environments. The study indicated that the standard method for collecting MDI, NIOSH P&CAM 142 (1), using a 1.0 liter per minute flow rate through an impinger may not collect 100% of the MDI in the air. Consequently, the sampling method used in this survey may underestimate the actual concentration of MDI.

FLUOROTRICHLOROMETHANE AND *alpha*-METHYL STYRENE

Results of personal samples for fluorotrichloromethane and *alpha*-methyl styrene are presented in Table 3. The sample periods include more than 90% of the time spent at the application site and include all activities which could contribute to workers' overall exposure to either of these compounds.

## TABLE 1. Exposure to MDI -- Applicator

| Sample # | Date | Sampling Period (On-Off) | Sampling Period (min) | Activity | Concentration (ppm) | Sampling Period TWA (ppm) |
|---|---|---|---|---|---|---|
| 1 | 11/19/79 | 0952-1103 | 65 | Cleaning/assembling spray gun and spraying foam | 0.0010 | |
| 2 | 11/19/79 | 1103-1124 | 21 | Spraying foam | 0.0090 | |
| 3 | 11/19/79 | 1124-1210 | 46 | Spraying foam | 0.0015 | |
| 4 | 11/19/79 | 1329-1501 | 92 | Spraying foam (includes 50-min downtime) | 0.0010 | |
| 5 | 11/19/79 | 1501-1521 | 20 | Spraying foam under gutter | <0.0025 | |
| 6 | 11/19/79 | 1606-1617 | 11 | Spraying foam under gutter | <0.0045 | 0.0020 |
| 7 | 11/20/79 | 1100-1129 | 29 | Cleaning/assembling spray gun and waiting for roof to dry--no spraying | <0.0017 | |
| 8 | 11/20/79 | 1155-1230 | 35 | Spraying foam | <0.0013 | |
| 9 | 11/20/79 | 1324-1354 | 30 | Spraying foam | <0.0017 | |
| 10 | 11/20/79 | 1354-1420 | 26 | Spraying foam | 0.0022 | |
| 11 | 11/20/79 | 1420-1430 | 10 | Spraying foam | <0.0050 | |
| 12 | 11/20/79 | 1430-1441 | 11 | Spraying foam | <0.0045 | |
| 13 | 11/20/79 | 1441-1452 | 11 | Spraying foam | <0.0045 | |
| 14 | 11/20/79 | 1452-1502 | 10 | Spraying foam | <0.0050 | |
| 15 | 11/20/79 | 1502-1513 | 11 | Spraying foam | <0.0045 | |
| 16 | 11/20/79 | 1532-1618 | 46 | Spraying foam (includes cleanup) | 0.0053 | 0.0031 |

## TABLE 2. Exposure to MDI -- Helper

| Sample # | Date | Sampling Period (On-Off) | Sampling Period (min) | Activity/Location | Concentration (ppm) | Sampling Period TWA (ppm) |
|---|---|---|---|---|---|---|
| 1 | 11/19/79 | 1003-1105 | 62 | Setting up hoses and helping Applicator on the roof | <0.0010 | |
| 2 | 11/19/79 | 1105-1214 | 69 | Cleaning roof (distant to spraying operation) | <0.0010 | |
| 3 | 11/19/79 | 1358-1455 | 57 | Cleaning roof and general cleanup on the ground | <0.0010 | |
| 4 | 11/19/79 | 1455-1617 | 82 | Helping Applicator on roof and applying foam | 0.0015 | 0.0011 |
| 5 | 11/20/79 | 1101-1131 | 30 | Cleaning roof (distant to spraying operation | <0.0016 | |
| 6 | 11/20/79 | 1152-1235 | 43 | Helping Applicator on roof | <0.0010 | |
| 7 | 11/20/79 | 1324-1353 | 29 | Inside truck monitoring equipment | 0.0019 | |
| 8 | 11/20/79 | 1353-1440 | 47 | Inside truck monitoring equipment | <0.0010 | |
| 9 | 11/20/79 | 1440-1450 | 10 | Inside truck monitoring equipment | <0.0050 | |
| 10 | 11/20/79 | 1450-1500 | 10 | Helping Applicator on roof | <0.0050 | |
| 11 | 11/20/79 | 1532-1617 | 45 | Helping Applicator and cleanup | <0.0011 | 0.0016 |

TABLE 3

Employee Exposure to Fluorotrichloromethane and *alpha*-Methyl Styrene

| Sample # | Employee | Date | Sampling Period (min) | Concentration (ppm) | |
|---|---|---|---|---|---|
| | | | | fluoro-trichloro-methane | *alpha*-methyl styrene |
| 1 | Applicator | 11/19/79 | 312 | 13.0 | <0.17 |
| 2 | Helper | 11/19/79 | 314 | 2.5 | <0.24 |
| 3 | Applicator | 11/20/79 | 281 | 1.6 | <0.15 |
| 4 | Helper | 11/20/79 | 283 | 5.6 | <0.49 |

Employees were not exposed to fluorotrichloromethane at concentrations in excess of either the OSHA standard or the ACGIH-recommended limit of 1,000 ppm. The highest concentration obtained was 13.0 ppm which occurred in the Applicator's sample.

*alpha*-Methyl stryene was not detected in any of the employees' samples. *alpha*-Methyl styrene is a trace constituent of the "B" component and is generally present at 0.4% (by weight) of the fluorotrichloromethane. The ACGIH-TLV and the OSHA standard for *alpha*-methyl styrene are both 100 ppm expressed as a ceiling concentration.

AMINE COMPOUNDS

Employee exposure to the amine compounds dimethylethanolamine and dimethylcyclohexylamine is presented in Table 4. Dimethylethanolamine was not detected in any of the samples. Dimethylcyclohexylamine was detected in 3 of the 4 samples. The highest detected concentration was 0.17 ppm. There are no standards or recommended limits for occupational exposure to either of these amine compounds. The sampling periods include all activities which could contribute to workers' overall exposure to these compounds.

TABLE 4

Employee Exposure to Amine Compounds

| Sample # | Employee | Date | Sampling Period (min) | Concentration (ppm) | |
|---|---|---|---|---|---|
| | | | | dimethyl-ethanolamine | dimethyl-cyclohexylamine |
| 1 | Applicator | 11/19/79 | 209 | <0.016 | 0.17 |
| 2 | Helper | 11/19/79 | 314 | <0.011 | 0.017 |
| 3 | Applicator | 11/20/79 | 281 | <0.008 | 0.025 |
| 4 | Helper | 11/20/79 | 283 | <0.025 | <0.017 |

DIMETHYLTIN DICARBOXYLATE

The Applicator's exposure to dimethyltin dicarboxylate is shown in Table 5. Dimethyltin dicarboxylate was not detected in either of the samples. Potential exposure to this compound is expected in the vicinity of the spraying operation. Because significant exposure to the Helper was not expected, this employee was not monitored for exposure to dimethyltin dicarboxylate.

TABLE 5

Applicator's Exposure to Dimethyltin Dicarboxylate[a]

| Sample # | Date | Sampling Period (min) | Concentration ($mg/m^3$) |
|---|---|---|---|
| 1 | 11/19/79 | 244 | <0.027 |
| 2 | 11/20/79 | 281 | <0.023 |

[a]Reported as tin.

NOISE

Sound level readings were taken inside the truck while the air compressor was operating; results are presented in Table 6. The compressor operates continuously throughout the day except during lunch break. The length of time that the Helper stayed inside the truck varied widely, from less than

15 minutes on the first day to approximately 2 hours on the second day. Normally the Helper enters the truck several times a day to change over the drums or to adjust the proportioning pump, and spends less than 10 minutes per day inside the truck; however, a malfunction on the second day resulted in the Helper's monitoring the pump for nearly 2 hours. The projected potential noise exposures to the Helper on the second day are 57% to 66% of the OSHA standard and 115% to 132% of the NIOSH- and ACGIH-recommended limits. These values are based on 2 hours of exposure to the minimum and maximum sound level readings (96 and 97 dBA, measured at the employee's ear).

TABLE 6

Sound Level Readings — November 20, 1979

| Time | Location | Sound Level (dBA) |
|---|---|---|
| 1230 | Inside truck at the desk | 93-94 |
| 1230 | Inside truck, approximately 2½' from the compressor | 101-102 |
| 1400 | Inside truck at the employee's ear | 96-97 |

CARBON MONOXIDE

The results of detector tube sampling inside the truck for carbon monoxide are presented in Table 7. The concentrations ranged from 30 to 50 ppm, depending upon the proximity to the gasoline-powered air compressor. Employees were not present when the measurements were made. Based on observed worker activities, exposures to carbon monoxide in excess of the federal standard or the NIOSH- and ACGIH-recommended limits would not be likely.

TABLE 7

Results of Detector Tube Sampling
for Carbon Monoxide — November 20, 1979

| Time | Location | Concentration (ppm) |
|---|---|---|
| 1215 | Inside truck at the desk | 30 |
| 1220 | Inside truck near the compressor | 50 |

## IV. CONCLUSIONS AND RECOMMENDATIONS

Employees were not exposed to chemical air contaminants in excess of the OSHA standard or the NIOSH- and ACGIH-recommended limits during this 2-day industrial hygiene survey. The compound, dimethylcyclohexylamine, which was detected in the personal samples of both members of the application team, has no standard or recommended limits for occupational exposure. Consequently, there is insufficient data available to assess the significance of the detected concentrations relative to worker health.

The NIOSH- and ACGIH-recommended limits for noise exposure were exceeded on one of the sampling days. The worker activity that resulted in the exposure is not considered to be routine: a malfunction in the proportioning pump required the Helper's presence inside the truck near the noise source (an air compressor) for an extended period of time. The compressor should be removed from the truck whenever conditions require the presence of an employee inside the truck for extended periods. Both NIOSH and ACGIH recommend that an effective hearing conservation program with audiometric testing be implemented for workers who are exposed to noise at or above the recommended limits.

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