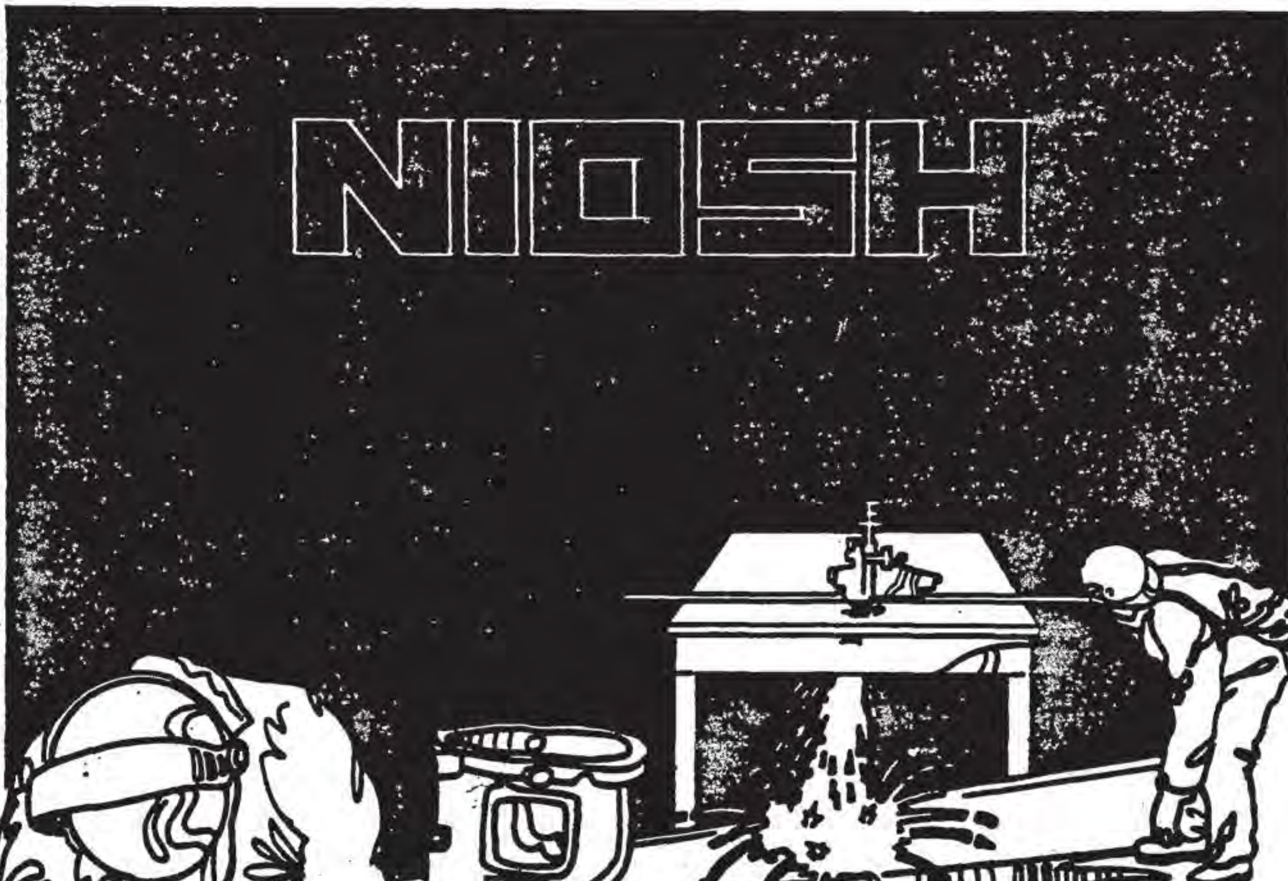
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 84-528-1764
TROCAL ROOFING SITES
CHICAGO, ILLINOIS

PREFACE

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

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

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TROCAL ROOFING SITES
CHICAGO, ILLINOIS

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I. SUMMARY

In September 1984 the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Union of Roofers, Waterproofers, and Allied Workers to assess occupational exposures during the application of Trocal single-ply roofing systems.

NIOSH investigators conducted environmental evaluations on September 26-29, 1984 and on August 29, 1985. Medical evaluations were conducted on September 27 and 29, 1984 and on November 6, 1985.

The environmental evaluations consisted of collecting personal and general area air samples for tetrahydrofuran (THF), hydrogen chloride (HCl), carbon monoxide (CO), and chlorine (Cl_2). Additionally, bulk material samples were collected and analyzed to determine their principal components. Airborne concentrations of THF ranged from non-detectable (ND) concentrations [<1.08 parts per million (ppm)] to 189 ppm during the 1984 survey and from 1.17 to 10.5 ppm during the 1985 survey. Instantaneous samples collected with an H-Nu photoionization analyzer ranged from ND to 108 ppm. Corresponding exposure criteria are 250 ppm (ACGIH) for a 15-minute sample and 200 ppm (OSHA, ACGIH) as an 8-hour time weighted average. Airborne concentrations of HCl ranged from ND to 3.7 ppm during the 1984 survey and from ND to 0.68 ppm during the 1985 survey. The corresponding exposure criterion is 5 ppm (OSHA and ACGIH) as a ceiling value.

Medical questionnaires were administered to 12 roofers on two work crews. When welding seams on hot days, 50% reported they experienced eye irritation, 40% reported headaches, 33% unusual tiredness, and 25% sinus congestion. Over 40% of the workers reported occasional wheezing apart from periods of upper respiratory infections. Before and after shift neurobehavioral testing was performed on 3 male roofers potentially exposed to THF. Computerized Continuous Performance, Symbol-Digit, and Finger Tapping tests were completed. No discernible differences were noted in the performance of these three workers over the 8-hour shift.

Based on these results the NIOSH investigators believe that a health hazard did not exist for employees exposed to THF and HCl during the time of these surveys. However, the investigators note the potential for higher personal exposures under certain conditions including: low wind, warm ambient temperatures, and enclosed roofing structures. Medical questionnaires revealed that employees had experienced health problems while seam welding on hot days. Recommendations are included in Section VIII for better training of roofing employees as to potential hazards from the materials with which they work.

KEYWORDS: SIC 1761 (Roofing and Sheet Metal Work); tetrahydrofuran, hydrogen chloride, eye irritation, headache, tiredness, sinus congestion.

II. INTRODUCTION

On September 18, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Union of Roofers, Waterproofers, and Allied Workers to assess employee exposures during the application of Trocal single-ply roofing systems.

NIOSH investigators conducted environmental and medical investigations on September 26-29, 1984, August 29, 1985, and November 6, 1985, at different locations in and around Chicago, Illinois.

Preliminary results and/or recommendations were distributed via letters to management and union representatives on October 17, November 14, and December 27, 1984. Results were also distributed via telephone in March 1986.

III. BACKGROUND

Roofing operations have slowly evolved from almost total utilization of hot buildup systems such as asphalt and coal tar pitch to more recent innovations of single-ply roofing systems. The newer type systems utilize a variety of materials and application techniques.

Conventional buildup systems utilize multiple layers of insulation and tar or asphalt. Conversely, single-ply systems have a layer of insulation covered by a single membrane layer and an optional layer of ballast (rocks) depending on the specifications of the building engineer. A variety of techniques are used to combine the sheets of membrane. Some are attached using adhesive on the entire undersurface of the membrane.

The roof system being installed during this investigation was a single-ply system called TROCAL. This system utilizes a PVC membrane over a layer of insulation. The edges of each membrane sheet are melted together using a solvent which contains over 90% tetrahydrofuran. This process is called solvent welding. The solvent is applied using a small wheeled applicator called a "jet machine", or paint brushes for short sections. A weight is then applied to the membrane edges to enhance the welding process. Hot air guns are used to heat weld a thicker PVC membrane to the base of the roof structures. The hot air guns, operating at about 500° to 600°F, are used to repair faulty seams detected during seam checks. A sealant material is then applied to all seams. After the membrane is secure, a top layer of ballast is normally applied although it may be left off if there is concern about the structural integrity of the roof.

Three sites were evaluated during this investigation. During the September 1984 survey, roofing sites included Building H of the Oak Forrest Hospital, and a rehab site at 400 West Superior in Chicago. During the August 1985 survey, the roofing site was a warehouse facility at 1333 Melrose Avenue. The first two sites had walls on each side of the roof. The hospital site also had structures under which employees worked. The 1985 site was open with no walls and the employees did not work under any structures.

IV. METHODS

A. Environmental

The environmental investigation concentrated on characterizing exposures while roofing activities were ongoing. This consisted of collecting both grab and longer term air samples to measure tetrahydrofuran (THF) exposures during solvent welding activities. Potential membrane decomposition products inclulding hydrogen chloride (HCl), carbon monoxide (CO), and chlorine (Cl_2) were also evaluated during heat welding activities. The collection media was attached via flexible tubing to a battery operated pump calibrated at a known flow rate. All samples were cooled after collection and then forwarded with field blanks to NIOSH analytical laboratories. Potential exposures were also evaluated through analysis of the main liquid bulk samples of the Trocal system.

Grab samples were collected using colorimetric indicator tubes for CO, and Cl_2. Additionally, tetrahydrofuran samples were collected with an H-Nu photoionization analyzer, model no. PL 101. The instrument was precalibrated using isobutyl ether span gas. Readings obtained during the field visit were then multiplied by a factor of 0.6, per manufacturers instructions, to obtain the tetrahydrofuran concentration.

Additional information on sampling and analytical techniques is presented in Table 1.

B. Medical

The medical assessment consisted of symptom questionnaires, administered in September of 1984, and computerized neurobehavioral testing conducted on site in November of 1985. The questionnaires, in a uniform manner, elicited demographic information, medical histories, as well as respiratory and dermatologic symptomatology. These were administered on site by the NIOSH Medical Officer.

The neurobehavioral testing was conducted by the NIOSH Medical Officer and was designed to detect acute central nervous system dysfunction amongst the most exposed employees at a single site. The tests have been adapted for computer-assisted administration using an IBM compatible COMPAQ portable computer.[1] The following tests were administered to each subject before and after a shift:

1. Continuous Performance Test: This test measures sustained visual attention and reaction time by having the subject press a button upon seeing a large letter "S" when it is projected onto the video display.[2] Various letters, including "S", flash briefly (about 50 msec) on the screen at a rate of one per second for five minutes. The response latency for each critical stimulus, as well as the number of errors of omission and commission are recorded.

2. Symbol-Digit Substitution Task: This modification of the Digit-Symbol Substitution test of the Wechsler Adult Intelligence Scale (WAIS) presents nine symbols and nine digits paired at the top of the screen.[3] The subject has to press the digit keys corresponding to a test set of the nine symbols scrambled. The time required to complete each of five sets of symbols and the number of digits matched incorrectly with the test symbols are recorded.

3. Finger Tapping Task: This is a test of motor quickness and accuracy. The subject is asked to press a button as many times as possible within a 10-second interval. Finger tapping has been shown to be sensitive to acute and sub-acute effects of toxins[4,5]

V. EVALUATION CRITERIA

A. General

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Specific Compounds

1. Tetrahydrofuran

Tetrahydrofuran (C_4H_8O) is an anesthetic agent and a mild upper respiratory tract irritant. Animals exposed to 3000 parts per million (ppm) for 8 hours daily for 20 days exhibited irritation of the upper respiratory tract. Injury to the liver and kidneys was observed but thought to be due to impurities. Dogs exposed at 200 ppm for 6 hour daily exposures, up to 9 weeks exhibited a slight increase in pulse pressure but no other symptoms. Tetrahydrofuran has been shown to be a skin irritant to animals but has not been reported as such in the industrial setting. Nausea, dizziness and headaches are reported to occur following overexposure but no chronic systemic effects have been reported.[6]

The ACGIH TLV and the OSHA permissible exposure limit (PEL) are both 200 ppm as an 8-hour time weighted average (TWA).[7-9]

2. Hydrogen Chloride

Hydrogen chloride (HCl) is a colorless, nonflammable gas with an irritating pungent odor, which is soluble in water. The aqueous solution is called hydrochloric acid and may contain up to 38% HCl.[10]

High concentrations of the gas are corrosive to the eyes, skin and mucous membranes. Vapors can produce severe irritation of the upper respiratory tract, resulting in cough, burning of the throat and a choking sensation. If inhaled deeply, pulmonary edema may occur. Dental discoloration and erosion may occur on prolonged exposure to low concentrations. Solutions of HCl may cause severe burns and permanent damage unless the area affected is flushed with water immediately.[9-10]

The current OSHA PEL and ACGIH TLV are 5 ppm as a ceiling value, not to be exceeded.[7-9]

VI. RESULTS

A. Environmental Air Sampling

1. 1984 Survey

Table 2 presents the results of personal samples collected for tetrahydrofuran. Airborne concentrations ranged from less than 1.08 to 189 parts per million (ppm) for 12 personal samples. Since solvent welding was conducted for only a few hours at most, all samples in were collected for 3 hours or less. All values were below the OSHA PEL and the ACGIH TLV of 200 ppm as an 8-hour TWA. All sample values are also well below the ACGIH STEL of 250 ppm. The airborne concentrations were much higher at site 1 where employees worked in a more confined space. Site 2 was much larger and had no physical structures under which employees might work.

Table 3 lists tetrahydrofuran air concentrations collected with an H-Nu photoionization analyzer. Concentrations ranged from non-detected to 108 ppm. The highest readings were obtained when employees solvent-welded by hand under building ventilation equipment. All readings are well below the current ACGIH STEL 250 ppm.[3-4]

Spot samples collected with direct reading gas detector tubes indicated minimal exposure to chlorine and carbon monoxide during heat welding of the PVC membrane. Neither material was detected on breathing zone samples and only trace amounts (below the limit of quantitation) were detected when samples were collected within a few inches of the heat gun nozzle.

Results of nine personal samples for airborne HCl are presented in Table 4. HCl was measured above the laboratory limit of detection (10 ug/sample) on only one sample (3.7 ppm), collected at Site 1. This value is approximately 74% of the OSHA PEL of 5 ppm as a ceiling value not to be exceeded.[2] As this sample was collected for 1.5 hours and the OSHA PEL is a ceiling concentration, it is possible that the PEL was exceeded at some point during the sample period. NIOSH has no recommended standard for HCl.

Airborne concentrations of organic vapors were below the laboratory limit of detection (0.01 milligram per sample) on two area screening samples.

2. <u>1985 Survey</u>

Airborne concentrations for personal exposures to tetrahydrofuran are presented in Table 5. Airborne concentrations ranged from 1.17 to 10.5 ppm on five samples. All samples are less than the current ACGIH STEL of 250 ppm and the OSHA PEL and ACGIH TLV of 200 ppm measured as an 8-hour TWA.[2-4]

HCl was detected on one of seven personal air samples at 0.68 ppm. All other samples were below the laboratory limit of detection (4 ug/m^3). The current ACGIH STEL is 5 ppm.[3-4]

Detector tube samples for CO and Cl_2 collected during heat welding showed a trace quantities of carbon monoxide (<5 ppm). Chlorine was not detected.

B. Analysis of Bulk Samples

Seven bulk material samples were analyzed to determine the principal organic components (Table 6). All materials were solvents or glues used in the application of the principal Trocal system or one of the modified systems. All of the samples contained one or two main components such as tetrahydrofuran or toluene. Methylene chloride was found to be a principal component of one of the bulk material samples (Bostic). Subsequent to the subject surveys NIOSH published (April 1986) current Intelligence Bulletin No. 46 discussing methylene chloride's carcinogenic capability. Bostic is used by employees to prepare leads, which are thin metal sheets approximately 2 ft. x 2 ft. The bostic is applied to the metal. Leads are prepared intermittently at the company's office building. None were prepared during either NIOSH visit.

C. General

Weather conditions during the 1984 survey included ambient temperatures of 41° to 48°F, rain on some days, and wind speeds of 1-11 miles per hour (MPH). During the 1-day 1985 survey temperatures ranged from 69° to 83°F with wind speeds of 1-9 miles per hour.

A respirator inspected at one of the work sites was not clean and stored unprotected with working equipment.

Ladders used to gain access to roof sites were not adequately secured. In addition to the potential for falls if the ladder slides, falls may also occur at the edge of the roof. This was a problem at one of the three sites which had no retaining wall at the roof edge. The other two sites had walls.

During transfer of solvent into the jet welder, solvent spills were frequent.

D. Medical

On September 27 and 29, 1984 medical questionnaires were administered to roofers on two work crews utilizing the Trocal roofing process. One hundred percent of the workers participated and 12 questionnaires were completed. When welding seams on hot days, fifty percent reported they experienced eye irritation, 40% reported headaches, 33% unusual tiredness, and 25% sinus congestion. Forty percent noted a cough each morning and 3 of these 5 workers were non-smokers. Over 40% of the workers reported occasional wheezing apart from periods of upper respiratory infections. Of these, 3 were smokers and one had asthma as a child. Only 25% of this workforce (4 workers) smoked cigarettes.

One third of the workers responded that they suffered skin rashes since being on the job. All reported facial redness with two indicating involvement of their arms and legs as well. All reported worsening rashes in sun light and two specifically indicated that work with pitch, not tetrahydrofuran, produced the rash.

On November 6, 1985, before and after shift testing was performed on 3 male roofers. These workers spent the entire work shift welding seams as part of the Trocal roofing process, and were potentially exposed to tetrahydrofuran during this activity. A compaq portable computer was taken to the roofing site and CPT, Symbol-Digit, and Finger Tapping tests were utilized. No discernible differences were noted in the performance of these three workers over the 8-hour shift. (Table 7)

VII. DISCUSSION AND CONCLUSION

Based on these results the NIOSH investigators believe that a health hazard did not exist for employees during the time of the NIOSH surveys. The investigators believe that higher exposures are possible when employees work on roofs that have enclosed areas (i.e., high walls). This was documented during the 1984 survey as tetrahydrofuran air concentrations were much higher at site 1 which was smaller and had structures under which employees worked. High ambient temperatures would probably result in higher exposures also, if all other conditions were the same. However, during the 1985 survey, with higher ambient temperatures, we measured lower exposures. This site however, had no walls or structures under which employees had to work.

The questionnaires suggested that under certain weather conditions (hot) roofers engaged in seam welding activities may experience mucous membrane and central nervous system irritation, which resolves following removal from exposure. No acute, quantifiable central nervous system dysfunction was identified during this study, due in part to the cold weather on the day of the neurologic testing.

The prevalence of wheezing in this predominantly young non-smoking population is unusual as the literature indicates tetrahydrofuran is non-allergenic.[35] As this history of wheezing is a nonspecific and an undocumented finding which encompasses only 5 employees, no conclusions can be reached in this regard.

No dermatologic abnormalities were associated with exposures inherent in the Trocal process. Previously reported photosensitive dermatitis was noted by workers exposed to pitch.[6]

Among previous environmental/medical investigations of exposures to roofing materials are several HHEs conducted by NIOSH.[12-34] Approximately nine of these were evaluations in plants producing roofing materials. There have also been 15 evaluations of roofing/waterproofing systems.

Tetrahydrofuran and HCl have been evaluated during one of the previous HHEs[23]. Airborne concentrations of tetrahydrofuran in personal samples were equal to or less than 2 ppm and thus were much lower than the samples collected during this investigation. Airborne concentrations of HCl in personal samples ranged from nondetected to 1-4 ppm and are thus in the same range as the HCl samples collected in this study.

There are many potential safety hazards associated with roofing operations. Many of these will vary depending on the physical structure of the roof. A list of references, discussing potential hazards and preventative techniques are included as references.[35-42]

VIII. RECOMMENDATIONS

1. Employees should be provided training concerning the potential hazards of the chemicals they work with.

2. In conjunction with recommendation no. 1, roofing contractors should make every effort to obtain from the roofing system manufacturers the identity of and potential health effects of the major chemical components (i.e., components representing >5%) and/or decomposition products, of the roofing systems they use. Sources of information include material safety data sheets and technical information pamphlets.

3. Employees should have access to respirators for which they have been quantitatively fit tested. Each employee should have chemical cartridge respirators suitable for protection against organic vapors (tetrahydrofuran) and acid gases (HCl). The respirators should be cleaned after each use, placed in clean plastic bags, and stored in rigid containers to protect their shape. The NIOSH criteria document and certified equipment list, and the OSHA standard for respiratory protection (1910.134) provide guidelines/requirements for selection and use of respiratory protection.[43-45]

4. When ladders are used to gain access to a roof, the ladder should be secured at the top to safeguard against it falling.

5. Funnels should be used when transferring tretrahydrofuran into the jet welder.

6. Employee exposures to airborne methylene chloride when preparing leads, using the Bostic material, should be evaluated.

7. As much as possible, employees should stay upwind of solvent, and heat welding activities.

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. Roofs, Inc., Chicago, Illinois
2. United Union of Roofers, Waterproofers and Allied Workers, Union Local #11, Chicago, Illinois
3. United Union of Roofers, Waterproofers and Allied Workers, Washington, D.C.
4. OSHA, Region V

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

XI. AUTHORSHIP AND ACKNOWLEDGEMENTS

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Table 1

Sampling and Analytical Techniques

Trocal Roofing Sites
Chicago, Illinois
HETAB 84-528

Contaminant	Sampling Media	Flow Rate (LPM)	Method	Analytical Technique
Tetrahydrofuran	Charcoal tubes	0.05-0.2	NIOSH Method Numbers 785 (modified) and 1609 (modified)	A and B sections of the charcoal were separated and analyzed by gas chromatography (GC). Samples were desorbed with 1 ml carbon disulfide containing 1 ul of toluene or benzene as an internal standard. The GC was a Hewlett Packard model 5711A equipped with a flame ionization detector
Hydrochloric Acid	Washed silica gel tubes	0.2	NIOSH Method Number 7903	A and B sections of the silica gel tubes were separately desorbed in 10 ml of an eluent and heated in a boiling water bath for 10 minutes. The resulting solutions were filtered through a 0.45 miron filter and an aliquot of each solution was analyzed via a Dionex ion chromatograph.

(Continued)

Table 1 (Continued)

Contaminant	Sampling Media	Flow Rate (LPM)	Method	Analytical Technique
Material Bulks	Collected in glass vial	NA	No Method Number Assigned	For free flowing liquids direct injection into gas chromatograph and analysis via GC/MS. For viscous liquids, extraction initially with carbon disulfide (CS_2) and then analysis of CS_2 extract using a gas chromatograph equipped with a flame ionization detector. 30 meter DB-1 bonded phase fused silica capillary columns were used for all analyses.
Airborne Bulks Screening Samples for Organic Solvents	Charcoal tube	0.2	NIOSH Method P&CAM 127 (modified)	A and B sections of the charcoal tubes were combined and analyzed using GC/MS. Samples were desorbed in 1 ml of carbon disulfide for 1 hour.
(Gases and vapors)	Indicator tubes	NA	Direct Reading	Indicator tube with corresponding pump.
Tetrahydrofuran	Charcoal tube	NA	Photoionization	Direct Reading using H-Nu Photoionization Analyzer, Model No. PL 101. Instrument calibrated using isobutyl ether. Meter readings obtained during field survey multiplied by 0.6 due to difference in ionization sensitivity for tetrahydrofuran (6.0) and benzene (10), which is the reference standard.

Table 2

Tetrahydrofuran Air Concentrations
Personal Samples

Trocal Roofing Sites
Chicago, Illinois
HETA 84-528

September 27-29, 1984

Location/ Description	Date	Sample Time	Volume (liters)	Roofing Site	Employee	Concentration (ppm)
Solvent welding by hand	9-27	959-1158	6.6	1	A	88.1
Solvent welding by hand	9-27	1018-1033	3.2	1	A	189
Solvent welding by hand	9-27	1033-1048	3.1	1	A	64
Solvent welding by hand	9-28	1231-1246	3.2	2	B	29.1
Solvent welding by hand	9-29	721-1021	9.1	2	A	12.4
Solvent welding by hand	9-29	1021-1149	2.6	2	A	7.93
Solvent welding with jet machine	9-29	826-841	3.4	2	A	25.8
Solvent welding with jet machine	9-29	743-758	3.1	2	C	<1.08
Solvent welding by hand	9-29	1132-1147	3.2	2	D	18
Solvent welding by hand	9-29	1108-1150	8.6	2	E	12.3
Solvent welding by hand	9-29	1053-1108	3.1	2	E	4.35
Solvent welding by hand	9-29	835-927	3	2	F	2.64

	Short-Term	Time Weighted Average
Occupational Exposure Limits (ppm):	ACGIH - 250	OSHA - 200 ACGIH - 200

Roof Site 1 = Oak Forrest Hospital, Building H
Roof Site 2 = 400 West Superior

Table 3

Tetrahydrofuran Air Concentrations
Area Peak Samples Collected with a Direct Reading
H-Nu Photoionization Analyzer

Trocal Roofing Sites
Chicago, Illinois
HETAB 84-528

August 27 and 29, 1984

Location/ Description	Time	Date	Roofing Site	Concentration (ppm)
Employee solvent welding band aids or equip. bases	1013	9-27	1	6-60
Employee solvent welding under ventilation equipment	1020	9-27	1	up to 102
Employee solvent welding equipment under ventilation	1028	9-27	1	108
Employee solvent welding out in the open	1105	9-29	2	12
Employee using jet machine to solvent weld	847	9-29	2	ND-3
Employee solvent welding by hand	910	9-29	2	ND-30 Peak=60
Employee solvent welding by hand along wall	920	9-29	2	ND-18
Employee solvent welding by hand in corner	920	9-29	2	Peak=60
Employee solvent welding by hand	1116	9-29	2	ND-30 Peak 90

Occupational Exposure Criteria (ppm) 250 ACGIH
ND = not detected.

Roof Site 1 = Oak Forrest Hospital, Building H
Roof Site 2 = 400 West Superior

Note: H-Nu was calibrated using isobutyl ether span gas and the measurements made in the field were multiplied by a factor of 0.6 to obtain tetrahydrofuran concentration. For example, for the third entry, meter reading was 180 actual concentration = 108 ppm.

Table 4

Air Concentration for HCL Personal Samples

Trocal Roofing Sites
Chicago, Illinois
HETA 84-528
November 14, 1984

Sample Number	Location/ Description	Date	Sample Time	Volume (liters)	Roofing Site	Employee	Concentration (ppm)
ORB-1	Heat gunner heat welding band aids	9-26	1325-1430	13.2	1	A	<0.52
ORB-2	Heat gunner heat welding under ventilation equip.	9-26	1337-1352	3.19	1	A	<2.1
ORB-20	Heat gunner checking seams under ventilation equip.	9-27	1321-1336	2.99	1	A	<2.2
ORB-21	Heat gunner checking seams	9-27	1259-1438	20.1	1	A	3.7
ORB-22	Heat gunner heat welding small parts	9-27	1303-1434	18.5	1	B	<0.36
ORB-23	Heat gunner heat welding band aids	9-27	1423-1438	2.85	1	A	<2.4

(continued)

Table 4 (continued)

Sample Number	Location/ Description	Date	Sample Time	Volume (liters)	Roofing Site	Employee	Concentration (ppm)
ORB-40	Heat gunner heat welding band aids	9-29	1112-1154	8.66	2	C	<0.77
ORB-42	Heat gunner heat welding band aids	9-29	1057-1112	2.94	2	C	<2.3
ORB-43	Heat gunner checking seams and heat welding band aids	9-29	957-1049	10.1	2	A	<0.66

Laboratory Limit of Detection = 10 ug HCL/Sample

< Indicates that HCL was not detected on this sample. This also indicates that if HCL were present it was at an air concentration below the value shown.

Exposure Criteria (ppm) = 5 (OSHA, ACGIH) as a ceiling concentration not to be exceeded.

Roof Site 1 = Oak Forrest Hospital, Building H
Roof Site 2 = 400 West Superior

Table 5

Air Concentrations of Tetrahydrofuran
Personal Samples

Trocal Roofing Sites
Chicago, Illinois
HETA 84-528

August 29, 1985

Sample Number	Description/ Location	Sample Time	Volume (Liters)	Air Concentrations (ppm)
65	Solvent welding using jet welder	845-1008	4.02	5.94
68	Solvent welding using jet welder	948-958	2.87	1.17
64	Solvent welding by hand	707-1012	8.94	10.5
66	Solvent welding by hand	1056-1153	2.56	3.63
67	Solvent welding by hand	912-927	2.62	8.01

Exposure Limits (ppm)	Short-term	Time Weighted Average
	OSHA-None	OSHA-200
	ACGIH-250	ACGIH 200

Roofing Site = 1333 Melrose

Table 6

Main Components of Raw Materials

Trocal Roofing Sites
Chicago, Illinois
HETA 84-528

Sample Number	Raw Material	Consistency	Identified Components
B1	THF solvent	FFL	tetrahydrofuran (THF)
B2	Trocal solvent	FFL	toluene n-hexane methypentanes methylcyclopentane cyclohexane n-heptane methylcyclohexane other C_7-C_8 alkanes
B3 compounds	Trocal Z sealant	VL	Only CS_2 extractable included toluene as major component plus various C_{6-9} alkanes
B4	Thinner	FFL	methyl ethyl ketone (MEK)
B5	Bulk of regular sealant	VL	CS_2 extractable was tetrahydrofuran
B6 compounds	Bostic-Activator	VL	CS_2 extractable were: methylene chloride* MEK, ethyl acetate, THF cyclohexane, toluene
B7	Bostic - main component	FFL	CS_2 extractables were: methylene chloride* methyl ethyl ketone ethyl acetate tetrohydrofuran cyclohexane Toluenes

*Recently determined to be carcinogenic in laboratory animals.

FFL = Free flowing liquid
VL = Viscous liquid

Table 7

Neurobehavioral Testing

Trocal Roofing Sites
Chicago, Illinois
HETA 84-528

Roofer #	Continuous Performance Time Median Reaction Time	Symbol-Digit Seconds/Digit	Finger Tapping Left-Right-Alternating
[1]Before	462 msec	2.46	55 - 67 - 52
After	462 msec	2.47	62 - 76 - 58
[2]Before	445 msec	2.43	57 - 59 - 51
After	442 msec	2.33	57 - 54 - 52
[3]Before	450 msec	2.21	64 - 76 - 56
After	448 msec	2.21	66 - 74 - 56

Table 8 (Cont.)

Reference No.	HE No.	Date of Study (month/yr)	State Conducted In	Principal* Materials Evaluated	Type Sample	No. of Samples	Air Concentration* Range in mg/m^3 (unless noted otherwise)
33	83-380-1671	8-9/83	Oh	TP	Personal	6	0.76 to 2.8
				BS	Personal	6	ND to 0.32
				PNA-T	Personal	6	ND
				HEX	Personal	13	3.8 to 72
				TOL	Personal	13	7.7 to 96
				XYL	Personal	13	0.19 to 5.3
				EB	Personal	13	ND to 1.3
34	85-416-1742	8-9/85	Il	ACE	Personal	17	ND to 12
				TOL	Personal	22	5 to 66
				XYL	Personal	14	1.7 to 145
				PNA-T	Personal	11	2.1 to 5.6 ug/m^3

State Abbreviations: Ks=Kansas, Mo=Missouri, Fl=Florida, Md=Maryland, NY=New York, Oh=Ohio, WV=West Virginia, Wi=Wisconsin, Pa=Pennsylvania

Chemical Abbreviations:

TP = total particulate
TW = total weight
RD = respirable dust
AS = acetonitrile soluble fraction
BS = benzene soluble fraction
CS = cyclohexane soluble
PPOM = particulate polycylic organic matter
PAH = polynuclear aromatic hydrocarbons
PNA = polynuclear aromatics
PNA-TND = total PNAs
BAP = benzo(a)pyrene
FLE = fluoranthene
PYR = pyrene
BAA = benzo(a) anthracene
BEP = benzo(e) pyrene
PHE = phenanthrene
CHR = chryene
AAH-CW = combined weight of aromatic and aliphatic hydrocarbons
HCL = hydrogen chloride/hydrochloric acid

MC = methylene chloride
2-B = 2-butanone
TOL = toluene
XYL = xylene
HEX = hexane
EB = ethyl benzene
THF = tetrahydrofuran
MEK = methyl ethyl ketone
DRT = direct reading detector tube
TRIG = total reactive isocyanate group
MDI = methylene diisocyanate
TDI = toluene diisocyanate
EG = Ethylene glycol

*Names of the chemicals sampled for and air concentrations listed are as reported by the authors of the referenced reports