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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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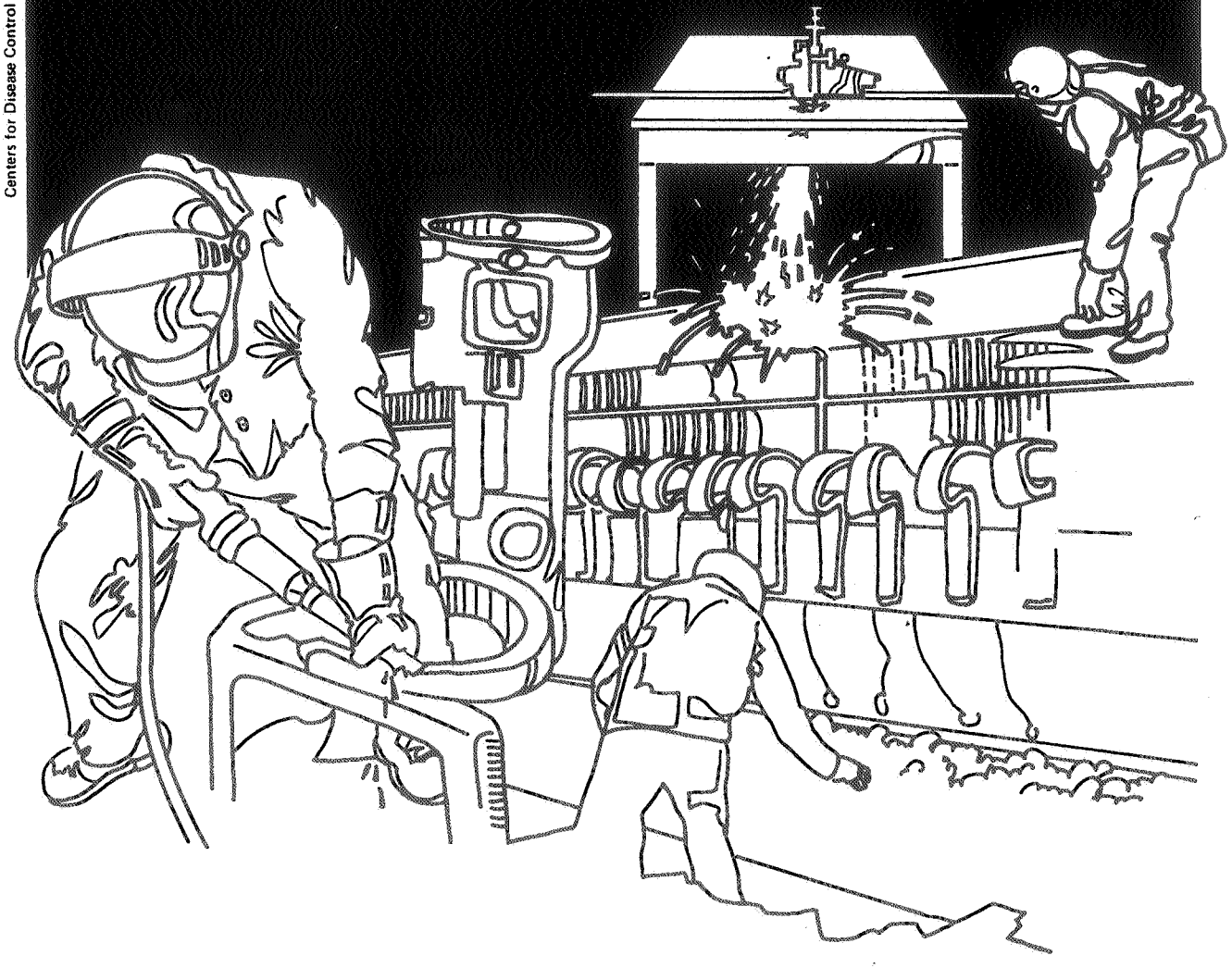
NIOSH



Health Hazard Evaluation Report

HETA 82-293-1482, 83-279-1482
UNITED ASSOCIATION OF THE PLUMBING AND PIPEFITTING INDUSTRY
CALIFORNIA DEPARTMENT OF HOUSING
CALIFORNIA AREA

PREFACE

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

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

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

HETA 82-293-1482, 83-279-1482
JULY 1984
UNITED ASSOCIATION OF THE PLUMBING
AND PIPEFITTING INDUSTRY
CALIFORNIA DEPARTMENT OF HOUSING
CALIFORNIA AREA

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I. SUMMARY

In June 1982, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate possible hazards to plumbers and pipefitters resulting from exposures during the installation of plastic pipe. In May 1983, a similar request was received from the California Department of Housing and Community Development. The goal of this study was to identify and quantitate those exposures related to the installation of plastic pipe.

The four major phases of plastic pipe installation were evaluated. These are pre-fabrication, rough-in (including ditch work), top off and finish work. The adhesives used to install the plastic pipe were analyzed, air samples were obtained for particulates during pre-fabrication (cutting) activities and organic vapors during each of the situations evaluated. Fifty-nine local unions throughout the United States were surveyed by questionnaire to obtain general information on the extent of health complaints. Each plumber or pipefitter who participated in the monitoring phase of this study was interviewed using a standardized questionnaire for information on health effects possibly related to plastic pipe installation and pre- and post-shift urine samples were analyzed for methylformamide (a metabolite of dimethyformamide which is used in PVC adhesives and readily absorbed through the skin).

The adhesives were found to contain one or more of the following solvents: methyl ethyl ketone (MEK), tetrahydrofuran (THF), dimethylformamide (DMF) and cyclohexanone (CYCLO). Trace amounts of other solvents such as toluene and xylene were also found, but benzene or carbon tetrachloride were not detected. Solvents identified on the label seldom agreed with NIOSH analysis. Multiple solvent systems were detected in primers/cleaners and ABS adhesives which were reported to require a single solvent such as MEK or THF.

Particulate exposures during the ABS and PVC cutting operations in a pre-fabrication setting range from 0.3-0.4 mg/m^3. Approximately half (0.1-0.2 mg/m^3) were of respirable size.

Long term, full shift sampling for the 4 major solvents resulted in the following exposure ranges and means ($\bar{X}$): MEK - N.D. to 40.0 ppm ($\bar{X}$ = 9.3 ppm); THF - N.D. to 29.4 ppm ($\bar{X}$ = 17.1 ppm); DMF - N.D. to 1.1 ppm ($\bar{X}$ = 0.3 ppm); CYCLO - N.D. to 0.2 ppm ($\bar{X}$ = 0.01 ppm). All exposures were 20% or less of the OSHA and/or other applicable exposure criteria (MEK - 200 ppm, THF - 200 ppm, DMF - 10 ppm, CYCLO - 25 ppm).

Short term exposures were as follows: MEK - 1.6 to 121.2 ppm ($\bar{X}$ = 32 ppm); THF - N.D. to 272 ppm ($\bar{X}$ = 81.2 ppm); DMF - 1.7 to 2.2 ppm ($\bar{X}$ = 2.0 ppm); CYCLO - N.D. to 2.8 ppm ($\bar{X}$ = 1.4 ppm). Except for one, all short term exposures were less than 30% of the OSHA and/or other applicable exposure criteria (MEK - 300 ppm, THF-250 ppm, DMF - 100 ppm, CYCLO - 20 ppm). One plumber was exposed to 272 ppm of THF measured over a 5 minute sample taken during a commerical PVC installation.

Benzene, carbon tetrachloride, acrylonitrite, styrene and vinyl chloride monomer were not detected. Plasticizers such as the phthalates types were not detected (plastic pipe is reportedly not plasticized).

Twenty-nine (49%) of the local union surveyed responded. Of those that responded, 14 (48%) reported no health complaints using plastic pipe, 6 (21%) reported occasional complaints, 4 (14%) reported frequent complaints, 3 (10%) reported complaints but did not indicate a frequency, 2 (7%) reported not using plastic pipe.

The most common symptoms during the interviews with the plumbers who participated in the monitoring phase of this study were occasional headaches and lightheadedness. Eye, nose, throat and skin irritation were also reported by the local unions surveyed. These symptoms were most often associated with installing plastic pipe in confined spaces. Symptoms subsided quickly with a few breaths of fresh air.

Pre- and post-shift urine samples were obtained from six plumbers installing PVC pipe and analyzed for methylformamide (a DMF metabolite). Spot urine samples from 7 controls (NIOSH office staff) were also analyzed. Only one plumber had a detectable level of methylformamide. The pre- and post-shift urine sample contained 6.7 and 15.0 mg/gr (creatinine) respectively. His airborne exposure to DMF was 0.4 ppm (5 hour, TWA) with short term exposures up to 2.2 ppm during the day. Other plumbers had similar airborne exposures but this plumber was the only one working in shorts with no shirt. He was also crouched down in a 2 foot deep ditch installing 4" to 8" PVC pipe. Skin absorption may have been an important issue in this case since DMF is readily absorbed via the skin.

Air sampling did not document exposures in excess of current criteria except for 1 case. However, the acute health affects reported by the majority of the plumbers sampled and the uncertainty as to the potential toxic effects of exposure to multiple solvents warrant measures to minimize exposure. Recommendations on adhesive content, precautions to minimize skin contact and inhalation, and plumber education on these points are included.

KEYWORDS: SIC 1711 (Plumbing, Heating, and Air Conditioning), PVC, ABS, Methyl Ethyl Ketone, Tetrahydrofuran, Dimethylformamide, Cyclohexanone, Plastic Pipe

II. INTRODUCTION

In June, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada to evaluate the exposures of plumbers and pipefitters during the installation of plastic pipe. A previous, similar request (HETA 81-113) was received in August, 1980. Although some preliminary data were gathered under the previous request, the project was closed out in December, 1981, due to the lack of an available site to conduct air sampling. The project was re-opened under the new HETA No. 82-293 in June, 1982, when arrangements were made to conduct field sampling in the San Francisco area of California.

In May 1983, the California Department of Housing and Community Development also requested NIOSH to evaluate plumbers and pipefitters exposures during plastic pipe installation and assisted, through union and industry representatives, in locating field sites for investigation. A field trip was accomplished in the Los Angeles and San Jose area of California in August 1983. This effort was assigned HETA Project No. 83-279.

The goal of both projects was to identify and quantitate those substances to which plumbers and pipefitters are potentially exposed during the routine installation of plastic pipe. Exposure data was reported via Interim Report #1 (HETA 82-293) in March 1983, and by letter (HETA 83-279) in October 1983. Interim Report #1 also presented recommendations on how to reduce exposures.

III. BACKGROUND

A. Materials

Five types of plastic are used: acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), polybutylene (PB), polyethylene (PE), and chlorinated polyvinyl chloride (CPVC). The first two, ABS and PVC, are approved for many drain-waste-vent (DWV) applications and are used more extensively. These two were the only types evaluated in this study.

1. ABS

ABS is a terpolymer of acrylonitrile, butadiene and styrene. The relative amounts of materials are variable, but typically about half by weight is styrene, with each of the others at about 25%. The additives for ABS are antioxidants, lubricants, pigments and fillers. Carbon black is the typical pigment used therefore ABS pipe is black.

Solvent-based adhesives are used to join pipe components. The most commonly used solvent for ABS pipe is methyl ethyl ketone (MEK). Other adhesive components include ABS resin and carbon black.

2. PVC

Polyvinyl chloride is produced by end-to-end polymerization of vinyl chloride in a water suspension of an oil-soluble catalyst. Components include the PVC resin, lubricant (calcium stearate type), heat stabilizer, pigment and filler. Plasticizers are reportedly not used due to the need for the pipe to be resistant to sagging.

PVC pipe components are joined using solvent-based adhesives, frequently preceded by a primer that cleans and presoftens the polymer. PVC adhesive usually contains a mixture of solvents to properly soften the pipe and allow for adequate working time. The four major solvents used are MEK, tetrahydrofuran (THF), N,N-dimethylformamide (DMF) and cyclohexanone (CYCLO). PVC resin and pigments such as titanium dioxide are also part of the adhesive. The primer is usually a pure solvent system and most often includes MEK or a mixture of MEK and one or more of the other 3 solvents listed above.

B. Installation

Cutting PVC or ABS pipe is done using either a power cut-off saw, handsaw, or tubing cutter. The cut-off saw technique generates airborne particulates and there is some concern that components of the pipe such as acrylonitrile, styrene and vinyl chloride monomer may evolve due to the heat generated as the saw cuts the pipe.

The PVC or ABS pipe and the fitting to which it is to be joined are "painted" with the appropriate adhesive in the area of the joining surfaces. They are then twisted together into the proper position and held for a few seconds until the cement "sets". Inhalation of vapors from the solvent(s) contained in the adhesives represent the most obvious source of exposure; however, appreciable skin contact with the adhesive offers a potential for absorption of the solvents through the skin and dermatitis.

There are several phases possible in the installation of plastic pipe. They include:

1. Pre-fabrication

When a large number of similar installations are planned, particular segments of the plumbing system can be pre-assembled either in a shop away from the job site (plumbing contractors yard) or at the job site in a building or trailer. This is usually a one or two man operation and, since cutting and joining can be a continuous, the potential exists for significant solvent and particulate exposure especially if the shop is enclosed and not well ventilated. The opportunity for skin contact is also higher due to the greater number of joints.

2. Roughing-in (ditch-work)

The roughing-in phase consists of the installation of the pipes leading from and to the main city sewer lines, throughout the crawl space or basement of the building or under the concrete slab for slab-on-grade construction. This work is usually accomplished by 2 man crews and although outdoors, the ditch work offers an opportunity for higher solvent exposure due to poor ventilation in the bottom of the ditches. The depth of the ditches varies considerably from a minimum of 18-24 inches to six feet or more.

3. Topping-Off

Once the shell of the building is completed, but prior to application of interior or exterior or exterior wall surfaces, the plumbing is topped-off. That is, plastic pipe is installed from the point where the roughing-in ended up through the open studs and ceilings of the structure to the point where the plumbing fixtures will be installed. This phase probably offers the least opportunity for solvent exposure since it occurs above ground and not in enclosed spaces. Usually one or two plumbers handle this phase.

4. Finishing

The finishing phase involves the connection of the plumbing after the fixtures and cabinets, vanities and wet bars have been installed. A portion of this phase is conducted inside cabinets offering a greater opportunity for solvent exposure. "Setting finish" is usually done by one plumber on a residential job site.

IV. METHODS

The objective of this study was to evaluate plumbers exposures during the routine installation of ABS and PVC plastic pipe. Methods included; evaluation of the contents of the adhesives, air sampling for contaminants generated during pipe joining and cutting tasks, a survey of 59 local plumbing and pipefitter unions with regard to their use of adhesives, interviews with each plumber whose exposures were evaluated and urine analysis for a metabolite of DMF (one of the solvents used in PVC adhesives).

A. Adhesive Content

1. US Manufacturers were contacted by letter for ingredient information.

2. Bulk samples of adhesives (27 samples representing six manufacturers) were obtained from supply shelves, distilled and analyzed using a gas chromatography/mass spectrometry technique (GC/MS). Eight additional bulk samples of the adhesives used during the August 83 field trip. These samples were extracted with carbon disulfide and screen by GC/MS techniques.

B. Air Sampling

During the installation of plastic pipe, potential solvent vapor exposures include MEK, THF, DMF, cyclohexanone, and possibly others such as toluene and xylene. The sampling method typically used for these in past efforts to evaluate plumbers exposure has been the standard charcoal tube method (NIOSH method P&CAM #127). Recent NIOSH data indicates that charcoal is not the best sorbent for MEK and that there is evidence that it degrades on the charcoal tube to at least one other chemical that has been identified as acetoin. Ambersorb® XE347 tubes, currently purchased from SKC, appear to be more suitable. This new method will appear in the next volume of the NIOSH Manual of Analytical Methods which will be available in the fall of 1984. Side-by-side air samples (a charcoal and Ambersorb tube) obtained during the course of a previous NIOSH study[1] indicated that as much as 25% of the MEK may be lost on the charcoal tubes. Also charcoal is not the best solvent for DMF. Silica gel tubes are the preferred collection media. (NIOSH Method S255-1).

In an effort to avoid this complication, all three sorbents were used. An Ambersorb and a charcoal tube were placed in a dual sampler and each run at 50 cc/min. The silica gel was used in a separate sampling train also at 50 cc/min.

The analysis scheme used was as follows:

Ambersorb Tubes:	THF MEK Cyclohexanone
Silical Gel Tubes:	DMF
Charcoal Tube:	Toluene Xylene GC/MS for other organics

During pre-fabrication operations, which included cutting PVC and ABS as well as joining these pipe components using the appropriate primers and adhesives, additional sampling methods incorporated the use of 37 mm PVC filters for evaluation of total and respirable airborne particulate generated during the cutting operations. The presence of acrylonitrile, styrene, and vinyl chloride monomer was also evaluated. Acrylonitrile and styrene were collected on the standard charcoal tube (NIOSH Method P&CAM 127) and the vinyl chloride was evaluated using two charcoal tubes in series (NIOSH Method P&CAM 178). The sorbent tubes were kept refrigerated until analyzed. Glass fiber filter sampling trains operating at 1 lpm were used to screen for plasticizers (phthalates).

C. Survey of Local Unions

Fifty-nine local unions throughout the United States were surveyed with the assistance of the United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry to gain information as to their experiences related to the installation of plastic pipe. The survey was in the form of a questionnaire (see Appendix B). The unions contacted are also listed in Appendix B. They were selected to provide a geographical representation.

D. Worker Questionnaire

Each worker monitored was interviewed by the industrial hygienist using a standardized questionnaire to obtain information on symptoms possibly related to the installation of plastic pipe.

E. Urine Sampling for N-methylformamide (NMF)

DMF is not very volatile but is absorbed readily through the skin. The compound is metabolized in man by sequential N-dimethylation to methylformamide and formamide which are largely eliminated in the

urine. In order to evaluate total dose (air and skin routes of entry), pre- and post-shift urine samples were collected from those plumbers who were installing or prefabbing PVC pipe.

Six workers provided pre- and post-shift urine samples and one additional worker provided 1 post-shift sample. The methylformamide in the urine samples was separated by solid phase extraction using acetone and quantitated by gas chromatography.[2,3] Post-shift samples were analyzed first. Pre-shift samples were to be analyzed only if significant levels of NMF were detected in the post-shift samples.

V. EVALUATION CRITERIA

A. Environmental Criteria

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 standards, 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 only 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 or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Applicable exposure criteria for the 4 major solvents used in adhesives are presented in Table 1. Toxic effects of each solvent are discussed below.

B. Toxicity

1. Methyl Ethyl Ketone (MEK)[4]

MEK is slightly irritating to the nose and throat at concentrations of 100 ppm. Short-term exposure to 300 ppm was described as objectionable and mild headache and throat irritation occurred. In sufficiently high concentrations MEK can cause central nervous system depression and marcosis. MEK can also potentiate the neurological effects of other solvents. No studies of the effects of MEK on genes or chromosomes are reported. No carcinogenesis bioassays of MEK have been reported. In two studies conducted in pregnant rats, no statistically significant increase in major malformations was seen in offspring.

2. Tetrahydrofuran (THF)

THF is a mild irritant of the eyes, skin and mucous membranes. Repeated skin contact may cause dermatitis. No chronic toxicity in humans has been reported although nausea, dizziness

and headaches are said to occur with overexposure; however, these are readily reversible in fresh air.[5] No studies of cancer in humans population have been reported. No effects of THF on human or animal reproduction have been reported

3. Cyclohexanone[6]

Cyclohexanone is considered to be moderately toxic by dermal, oral and inhalation exposure. It has mild narcotic properties and exposure to concentrations greater than 75 ppm causes eye and respiratory tract irritation. Repeated skin contact may cause dermatitis, but absorption through the skin is not considered to be a significant exposure route. There have been no long-term effects in humans or animals reported. Cyclohexane is currently being tested in a carcinogenesis bioassay under the direction of the National Toxicology Programs. No data on the effects of cyclohexanone on reproduction have been reported.

4. Dimethylformamide (DMF)

DMF is effectively absorbed via the lungs, skin and gastro intestinal tract. Alcohol consumption can retard metabolism of DMF. Alcohol intolerance (a reaction similar to that induced by the drug "antabuse" has been noted in some workers exposed to DMF.[7] DMF is moderately irritating to the eyes, skin and respiratory tract and can defat the skin. Exposure to high concentrations can produce dizziness and headaches.[6] It is toxic to the liver and highly irritating to the gastro intestinal tract.[8] Workers exposed to atmospheric concentrations of 20-35 ppm for 32 weeks complained of nausea, vomiting and abdominal pain and liver enlargement was detected in some cases.[6] DMF has produced liver and kidney damage and changes in cardiac function when administered to laboratory animals via inhalation, skin application, or oral intubation. Dogs, rabbits, guinea pigs, rats and mice were exposed to 23 ppm DMF for 5 1/2 hours followed by a 1/2 hour exposure to 426 ppm for 58 weekdays. Functional effects on the liver, pancreas, spleen, kidneys, adrenals and thymus glands of all animals were seen. Degenerative changes in the heart and cardiovascular function were seen in dogs.[9] Mutagenicity, carcinogenicity and chromic effects (ie., gastro intestinal and liver disorders) are currently under study by NIOSH. A National Toxicology Program (NTP) carcinogenic bioassay is in progress via inhalation in the rat and mouse species.

VI. RESULTS AND DISCUSSION

A. Adhesive Content

1. Manufacturers Data

Fifteen manufacturers who make PVC and ABS pipe adhesives were contacted by letter. Replies were received from each manufacturer. Also, some components are listed on each can of adhesive.

The adhesives are composed of a small quantity of the ABS or PVC resin, pigments such as carbon black and titanium dioxide, stabilizers and solvents. The solvent systems used are made up of one or more of the following solvents; MEK, THF, Cyclohexanone and DMF.

2. NIOSH Analysis

During the August 1982 survey, 27 bulk samples of plastic pipe adhesives were gathered from the shelves of local plumbing supply houses. Eight adhesive bulk samples were obtained during the August 1983 survey. All of the bulks were analyzed by NIOSH to determine the solvent composition.

Table 2 shows the data from the 27 bulk analyses and compares them to the ingredients listed on the cans. Twenty of the 27 bulk samples contained solvents in addition to and/or different than those listed on the can. Two cans had no ingredients listed. Toluene and xylene were found in trace amounts in 9 of 27 samples. No benzene or carbon tetrachloride were detected. Of note is that primers or cleaners were reported as usually consisting of a single solvent, however, all five of the samples in this category contain at least two solvents and two contained all 4 of the major solvents (MEK/DMF/THF/CYCLO).

The 8 adhesive bulks from the August 83 survey were analyzed and found to contain the 4 major solvents and trace quantities of the following solvents; acetone, styrene, chlorobutanol, butylated hydroxytoluene and ethyl oxirone (tentatively identified as a C_4H_8O isomer, possibly a rearrangement product of MEK or THF).

These were also discrepancies between the information received from the manufacturers and the data obtained from NIOSH analyses. These findings indicate that there is not an effort to identify the solvents on the labels or that there is not close surveillance at the adhesive production site regarding the types of solvents used in the various adhesives.

B. Air Sampling

The air sampling results, as reported in earlier Interim reports and/or letters, are presented in Appendix A. These results are summarized by construction phase for each of the 4 major solvents in Table 3.

1. Organic Vapors

Overall, the long-term or full-shift exposure concentrations for each of the 4 solvents were as follows: MEK - ranged from N.D. to 40.0 ppm (mean = 9.3 ppm); THF - ranged from N.D. to 29.4 ppm (mean = 17.1 ppm); DMF - ranged from N.D. to 1.1 ppm (mean = 0.3); cyclohexanone - ranged from N.D. to 0.2 ppm (mean = 0.01 ppm). All measured concentrations were less than 20% of applicable exposure criteria (MEK - 200 ppm, THF - 200 ppm, DMF - 10 ppm, cyclohexanone - 25 ppm). Table 1 lists specific criteria.

Short-term exposures to each of the 4 major solvents were as follows: MEK - ranged from 1.6 to 121.2 ppm (mean = 32 ppm); THF - ranged from N.D. to 272 ppm (mean = 81.2 ppm); DMF - ranged from 1.7 to 2.2 ppm (mean = 2.0 ppm); cyclohexanone - ranged from N.D. to 2.8 ppm (mean = 1.4 ppm). All short-term samples were less than 30% of applicable exposure criteria except for one THF sample taken during installation of PVC pipe at a commercial site that was 272 ppm. The short-term (15 min.) exposure criteria for the specific solvents are: MEK - 300 ppm; THF - 250 ppm; DMF - 100 ppm; cyclohexanone - 20 ppm.

Of note is the fact that the actual time spent applying the adhesive can be short for a given workday. For example, a stop watch was used to keep track of the total amount of time that adhesive was applied during a 7 hour job where the plumber was "laying-finish" in a residential housing complex. The time to apply adhesive while performing the individual plumbing tasks for "laying-finish in a 2 story house was as follows:

Setting closet ring	0.9 minutes
Continuous waste, double bowl sink trap assembly	3.0 minutes
Bar trap assembly	1.3 minutes
1/2 bath trap assembly	1.2 minutes
Full bath trap assembly	2.0 minutes
Master bath, wide spread trap assembly	4.7 minutes
TOTAL FOR SHIFT	13.1 minutes

Only one pre-fab plumber was observed to be using a barrier cream. No one wore protective gloves.

Two solvents not previously identified in the adhesives were identified in air samples taken during a commericial PVC installation. These were methyl-para-ketone and methyl-amyl-ketone which were detected at concentrations of 6.8 to 200 and 1.9 ppm respectively. They may have been generated due to a nearby painting operation. This illustrates the fact that construction workers need to be aware of the chemicals being used by other trades at the worksite.

Acrylonitrile, styrene, benzene, carbon tetrachloride, and vinyl chloride monomer were not detected in any air samples.

2. Particulate

The particulates generated during the cutting operation included 1) large particles (approximately 1/8 inch) which quickly deposited on any horizontal surface, 2) small particles that lingered in the air long enough to be captured in the sampling apparatus which are small enough to be inhaled but too large to be considered respirable (taken into lungs), and 3.) respirable sized particles. The total airborne particulates concentrations ranged from 0.27 to 0.43 mg/m^3. Of this total, approximately half (range 0.14 - 0.24 mg/m^3) were of respirable size as determined by using a 10 mm cyclone sampling method.

The technique used to cut the pipe influenced the size and amount of particulate generated. For example, a cut-off saw produced less particulate emission if a fast cut (2 second) was made than if a slow cut (15 second) was made.

3. Plasticizer

Plastic pipe is reportedly not plasticized. Nevertheless, several samples were taken during a prefab cutting operation (ABS and PVC) and analyzed for phthlate-type plasticizers. None were detected using a glass fiber filter as a collection medium. The analytical detection limit was 10 ug/sample approximately 0.1 mg/m^3). The filters were desorbed with 2 ml ethyl acetate and screened by GC/FID using a 30 meter, DB-1, bonded-phase, fused, silica capillary column (splitless mode). Dibutyl phthalate and dioctyl phthalate were used as standards to establish a detection limit.

4. Combined Effects

A calculation for mixtures is relevant when two or more potentially hazardous substances, which may result in similar health effects, are present in the same environment. The calculation is performed according to the method published by the American Conference of Governmental Industrial Hygienists. If the sum of the following fractions,

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \frac{C_T}{T_T} \quad .....$$

exceeds unity (1.0) then the recommended environmental limit for the mixture is considered as being exceeded. C_1 is the observed air level and T_1 is the corresponding environmental exposure limit. None of the calculated vapor mixture fractions exceeded the survey criteria of 1.0 for full-shift samples. The highest fraction calculated was 0.4.

C. Survey of Local Unions

The questionnaire (Appendix B) was sent to the following 59 local unions:

91	234	25*	12	131	333
52	519*	440*	190*	14*	27
375*	229	33	98	1*	690*
469*	624	165*	417	128*	28
155*	72*	171*	568*	640	391
78	188	107	8	338*	100*
444*	675*	198	35*	59	572
3*	648	60*	41	55*	68
173*	130*	217	16	344	231
26*	63*	48	350*	51*	

Twenty-nine (49%) responded (identified by an asterics). In general, the purpose of the questionnaire was to determine the experiences of the local unions across the United States with regard to the association of health complaints to the installation of plastic pipe. The following summarizes the comments of those that responded.

# of local unions that don't install plastic	2
# of local unions with no complaints	14
# of local unions with frquent complaints	4
# of local unions with occasional complaints	6
# of local unions with complaints but did not specify a frequency	3
Total	29

Of the 12 local unions that reported receiving health complaints their members relate to plastic pipe installation, the specific complaints included:

Dizziness	6/12 (50%)
Eye, nose, throat irritation	9/12 (75%)
Skin irritation	4/12 (33%)
Headache	4/12 (33%)
Skin rash	1/12 (8%)

Health complaints were most often associated with working in confined spaces. Those unions that registered complaints were not confined to any particular geographical area but were widely scattered throughout the United States.

Only two manufacturers not listed on the questionnaire were identified. These were Northern Pipe Products and Universal Fas-n-tite. Neither are listed with the National Sanitation Foundation.

D. Worker Questionnaire

1. NIOSH Survey August 1982

Six plumbers were interviewed via a standardized questionnaire. It was interesting to note that when each of the six workers evaluated was asked if they had any health problems that they felt may be releated to the installation of plastic pipe, each said no with the exception of one incident explained below. However, when the attached health symptom questionnaire was administered, all six reported that dizziness, vertigo, and a sense of being "high" were common symptoms experienced during the use of the plastic pipe adhesives.

All six were males. Age ranged from 33 to 56. Plastic pipe usage ranged from 2 to 24 years, with a mean of 12 years. When using plastic, daily usage was generally 4-6 hours each day. Four used mostly ABS and two used predominately PVC. All six reported that while dizziness, vertigo, and a sense of "high" were common symptoms during a routine plastic pipe installation, these symptoms generally subside quickly and totally with a few breaths of fresh air.

One worker, a 35 year old male in good health reported, that he almost passed out on the way home from work in May, 1982. He had been installing PVC pipe in an enclosed area throughout the day using Weldon 711 adhesive and P70 primer. He had occasionally felt light-headed during that day. He quit working with the adhesive at 4:00 p.m., and at 6:00 p.m., while driving home, had to pull off to the side of the road because he felt like he was going to pass out. He recovered in five minutes and proceeded home. He did not seek medical attention and reported to work the next day feeling fine. He stated he did not consume any alcohol that day and was not on any medication or drugs. This had never happened to him before and had not happened since (interview was on September 1, 1982). He smoked 1/2 - 1 pack of cigarettes per day for the last five years. This worker, on reflection, felt that this incident may have been related to his job.

None of the six workers uses gloves or barrier-creams and had never used respirators. Except for one worker who had not been involved in plastic pipe installation for a while, the hands of each one were dry and, in one case, scaly looking.

2. NIOSH Survey August 1983

Nine plumbers were interviewed. The questionnaires were lost during travel. Therefore, information such as age distribution and time worked with plastic pipe cannot be presented. However, health complaints were recorded on the air sample data sheets. Two of the eight plumbers had no health complaints that they related to installation of plastic pipe. The other six reported occasional headaches, dizziness, and eye/nose/throat irritation when working in enclosed areas having poor to no ventilation. One of the nine plumbers complained of occasional nausea when working in enclosed spaces. All reported the symptoms subsided with a few breaths of fresh air.

E. Urine Sampling

Pre- and post-shift urine samples were obtained from six plumbers to be analyzed for methylformamide. The detection limit was reported as 0.01 mg/ml on a creatinine basis. Seven urine samples were obtained from NIOSH office staff to use as controls. The post-shift samples were analyzed first. The pre-shift were to be analyzed only if significant concentrations of methylformamide were found in the post-shift urine samples.

Except for one plumber, no detectable quantities of methylformamide were found in any of the urine samples. The positive results occurred in a plumber who was installing PVC pipe in open ditches. His pre- and post-shift methylformamide-urine concentrations were 6.7 and 15.0 mg/gr of creatinine respectively. This workers' airborne DMF exposure for the day was determined to be 0.4 ppm for a 5 hour sample with a short-term 15 minute and a short- 5 minute exposure of 2.2 ppm and 1.7 ppm respectively. A six pack of beer was consumed the night before the urine samples were obtained. Methylformamide urine concentrations above 50 mg/24 hours urine specimen has been reported to indicate an exposure exceeding 20 ppm.[2] However, the urine samples taken in this study were spot samples and not 24 hour samples, therefore, the results cannot be compared.

It is difficult to draw any conclusions from only one positive sample set. Three other workers from which urine samples were obtained had airborne exposures ranging from 0.4 to 0.6 ppm. All four plumbers had noticable adhesive contamination on their hands; however, only the plumber with the positive results worked in shorts and no shirt which, presumably, could have allowed for more skin adsorption of DMF vapor. Skin absorption is thought to be more significant route of exposure than inhalation.(3)

F. Additonal Comments

Consistent with the experience of previous investigators, NIOSH investigators experienced difficulty in finding situations to evaluate. One field survey was arranged by the union. Another survey was arranged in response to the request received from the California Department of Housing and Community Developement and coordinated by a representative of the plastic pipe and adhesive manufacturers. Although more data would have been useful, exposures in each of the 4 major phases of plastic pipe installation were evaluated as part of this study. These included: pre-fabrication (both shop and field), rough-in (included ditch work), top-off and finish work.

The data was collected in California where outdoor temperatures ranged from 80-95°F during the surveys. Several of the tasks evaluated were in enclosed spaces. It should be noted that the results apply to the situations evaluated and other situations and environmental conditions may result in different exposure levels. However, the combination of high temperatures, which promotes solvent vaporization, and confined spaces are believed to represent "worst-case" situations.

VII. CONCLUSIONS

The adhesives evaluated were found to contain one or more of the following solvents; MEK, THF, DMF, and Cyclohexanone. There was a wide discrepancy between the ingredients (solvent content) listed on the labels and those identified via laboratory analysis of the adhesives and primers/cleaners. Even through PVC primers/cleaners and ABS adhesives were reported to require the use of a single solvent, multiple solvent systems were found upon analysis. No benzene or carbon tetrochloride were detected in any of the adhesives analyzed.

Full shift, 8 hr TWA exposures for the individual solvent vapors detected were all 20% or less of the applicable exposure criteria. This is consistent with the findings of another NIOSH health hazard evaluation[10] which evaluated plumbers exposures in the Boston area in July 1981 and a survey by California, OSHA in July 1980[11] which evaluated plumbers exposures in southern and central California.

Only one short-term sample exceeded applicable exposure criteria (THF, measured at 272 ppm compared to criteria of 250 ppm at a commercial PVC installation). As in the painting trades, there is a potential for toxicologically significant exposures in confined spaces if these areas are not adequately ventilated or if appropriate respirator protection is not utilized (see recommendation #B2).

No acrylonitrile, styrene, vinyl chloride monomer, benzene or carbon tetrochloride were found in any bulk sample or any air sample.

Health effects reported were typically related to work in confined spaces and included: headache, dizziness, eye/nose/throat irritation and skin irritation. There was no numbness or tingling sensations reported in this survey. In a questionnaire survey of 740 plumbers[10] of the 353 (48%) who responded, 33% complained of numbness and tingling in the fingers; however, as part of that same study, there was no appreciable decrement over the workday in six plumbers administered tests for intelligence, memory and psychomotor function.

Only one of six plumbers who were installing PVC pipe using an adhesive containing DMF had detectable concentrations of methylformamide in his pre- and post-shift urine sample. Other plumbers exposed to similar air concentrations (0.5 - 2.0 ppm) had no detectable methylformamide levels in their urine. The fact that the one plumber who had the positive levels (6.7 mg/gr of creatinine pre-shift and 15.0 mg/gr post-shift) was the only one working in shorts and no shirt may provide an explanation since DMF is readily absorbed through the skin.

Only two plumbers (both pre-fabricators at plumbing shops) used hand protection (barrier-creams). No gloves or respiratory protection was observed being worn during any of the surveys.. Adhesive residue was observed on the hands of plumbers. The amount varied considerably and seemed to be related to how careful the plumber was in trying to avoid getting the adhesive on their hands.

VIII. RECOMMENDATIONS

The plumbers' exposures depended on 1) the content of the adhesives, 2) the methods he uses to install the plastic pipe, and 3) the environmental conditions during the installation. In view of the known acute health effects and the lack of data on potential chronic health effects, the following recommendations are made to minimize exposure and therefore health risks.

A. Adhesive Content

1. ABS Adhesives

The solvent system should be limited to a single solvent such as MEK. Some adhesive manufacturers only use MEK, while NIOSH testing of others documented that multiple solvents are also used.

2. PVC Adhesives

Limit the number of solvents used and select the least toxic solvents.

3. The solvent content should be accurately identified on the label of the adhesive.

B. Plumbers Awareness and Technique

1. Apprenticeships should include a block of instruction on the potential health hazards associated with plastic pipe as well as other types of pipe installation.

2. Reduce the potential for exposure to the vapors of the adhesive solvents by insuring that installation takes place under conditions of adequate ventilation or, if ventilation is not adequate, that the appropriate respirator protection be utilized. Half-mask, organic vapor respirators may be worn under some conditions; however, in very confined spaces, the use of fresh air-supplied respirators will be necessary.

3. Minimize skin contact with the adhesives to prevent dermatitis and skin absorption of solvents by wearing gloves. Polyvinyl alcohol gloves may be the most suitable for this purpose. Barrier creams may also be helpful. Use waterless abrasive hand cleaners rather than solvents or primers for cleaning the hands.

4. Cutting of plastic pipe using a power saw should be accomplished using a stiff, carbide-tipped blade and a 1 to 2 second stroke to minimize emissions.

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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. United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry, Requestor, HETA No. 82-293
2. California Department of Housing and Community Developement, Requestor, HE 83-279.
3. California Pipe Trades Council
4. NIOSH, Region IX
5. OSHA, Region IX

For the purpose of informing affected employees, copies of this report should be distributed to local unions to be posted in a prominent place accessible to the plumbers and pipefitters for a period of 30 calendar days.

TABLE I

Evaluation Criteria and OSHA Standards

Plumbers and Pipefitters Survey
California Area
HETA 82-293, 83-279

Substance	Environmental Criteria (ppm)	Source	Primary Health Effects	OSHA Standard (ppm)
Methyl Ethyl Ketone	200 300 (15 min.)	NIOSH ACGIH*	Irritation; Liver, kidney, nervous system effects	200
Tetrahydrofuran	200 250 (15 min.)	NIOSH ACGIH	Irritation; Headaches, nervous system effects	200
Cyclohexanone	25 100 (15 min.)	NIOSH ACGIH	Irritation; Liver, kidney, nervous system effects	50
Dimethyl Formamide	10 20 (15 min.)	ACGIH ACGIH	Irritation; Liver toxicity	10

Air concentrations are time-weighted average (TWA) exposures for a normal (8 to 10 hours) workday of a 40-hour workweek unless otherwise designated.

* Threshold Limit Values (TLV's) for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1983-1984.

Table 2
Adhesive Content Data
Plumbers and Pipefitters Survey
August, 1982
HETA 82-293

Manufacturer	Use	Ingredients on Can	NIOSH Analysis	Significant Difference
Oaty	ABS Cement	MEK	THF/MEK	YES
"	ABS Special Cement	MEK	THF/MEK/DMF/Toluene(T) Xylene(T)[1]	YES
"	CPVC/PVC Purple Cleaner	MEK	THF/MEK	YES

Table 2 continued

Manufacturer	Use	Ingredients on Can	NIOSH Analysis	Significant Difference
PIP	ABS Cement	NONE	THF/MEK/Toluene/Xylene/DMF/CYCLO	YES
"	PVC Cement Clear	NONE	THF/MEK/DMF/Toluene(T)/Xylene(T)	YES
"	PVC Primer	THF and Ketones	THF/MEK/DMF	YES
Fuse	PVC Cement	THF/CYCLO	THF/MEK/DMF/Toluene (T)	YES
"	ABS Cement	MEK	THF/MEK/DMF	YES
UNI	PVC Cement	THF/MEK	THF/MEK	NO
"	ABS Cement	MEK	THF/MEK	YES
Christy's	PVC Red Hot Blue Glue	THF/MEK/DMF/CYCLO	THF/MEK/DMF/CYCLO	NO

(1) (T) = Trace

Table 3
Summary
Solvent Exposures
Plumbers and Pipefitters Survey
HETA 82-293, 83-279

Construction Phase	Solvent	Long Term Exposures(ppm)[1] # Samples	Range	Mean($\bar{X}$)	Short Term Exposures(ppm)[1] # Samples	Range	Mean($\bar{X}$)
Pre-Fabrication	MEK	8	N.D.[(2)]-40.0	16.3	5	5.9-33.4	15.5
	THF	8	2.3-29.4	15.8	5	N.D.-34.0	17.0
	DMF	8	N.D.- 1.7	0.9	5	N.D.- 1.7	0.9
	CYCLO	8	N.D.	-	5	N.D.	-
Ditch-Work	MEK	2	4.3- 5.7	5.0	2	7.4-22.0	15.2
	THF	2	13.7-16.6	15.2	2	16.3-59.0	37.7
	DMF	2	0.4- 0.6	0.5	2	1.7-2.2	2.0
	CYCLO	2	N.D.	-	2	N.D.	-
Rough-In	MEK	5	0.9-12.3	5.3	4	1.6-121.2	41.5
	THF	5	11.8-26.8	20.3	4	20.2-272.0	118.9
	DMF	5	0.4- 1.1	0.8	4	N.D.	-
	CYCLO	5	N.D.	-	4	N.D.	-
Top-Off	MEK	3	N.D.-3.1	1.3	None Taken		
	THF	3	N.D.	-			
	DMF	3	N.D.	-			
	CYCLO	3	N.D.	-			
Finish	MEK	2	6.7- 7.1	6.9	2	59.9- 80.2	70.0
	THF	2	N.D.-10.9	5.5	2	N.D.-122.8	61.4
	DMF	2	N.D.	-	2	-	-
	CYCLO	2	N.D.	-	2	N.D. - 2.8	1.4
Exposure Criteria	MEK		200		300 (15 min.)		
	THF		200		250 (15 min.)		
	DMF		25		100 (15 min.)		
	CYCLO		10		20 (15 min.)		

(1) Long Term refers to full shift (usually 6 to 8 hours); Short Term refers to 15 minute sample but also in some cases to an accumulative exposure while using glue. Refer to Tables 3 and 4 for specific information.

(2) N.D. is not detected. Analytical detection limit 0.01 mg/sample. Overall detection limit varies with solvent and sample volume but was usually less than 1 ppm.

APPENDIX A

Appendix A

Plumbers and Pipefitters Survey
San Francisco, California Area
HETA 82-253

August 26 - September 2, 1982

Operation/Date	Task Evaluated	Adhesive Used	Sample Type	Sampling Time	Airborne Concentrations: Particulates(mg/m³) Total	Particulates(mg/m³) Respirable	Solvents[1](ppm) MEK	THF	DMF	Other	Comments
Prefab, ABS, 2 workers, 8/26/82, large shop, general ventilation	Assembly of 3 ABS trees, approximately 60 joints	Weldon 773	Breathing Zone, Worker A	1428-1450	-[2]	-	40.3	ND[3]	ND	None	No gloves or barrier creams used
			Breathing Zone, Worker B	1428-1450	-	-	17.2	ND	ND	None	
Commercial PVC Installation, 2 workers, Sewage Plant, basement of Solids building, 9/1/82	80 Sch PVC pipe (gray color), 50 joints connected	Weldon P-70 primer P-711 Adhesive	Breathing Zone, Workers #1	0845-1155	-	-	6.9	19.1	0.7	MPK[1] @0.7ppm	Painting in the area may have generated some solvent vapors.
			Breathing Zone, Workers #1, 15 minute sample, gluing on floor	1453-1508	-	-	25.7	44.2	ND	MPK @20ppm	
			Breathing Zone, Worker #2	0843-1535	-	-	12.3	23.4	1.12	MPK @6.8ppm Toluene @1.7ppm MAK[1]@1.9ppm	
Residential Top-off, ABS, 1 worker, custom built house on crawl space, 9/2/82	SCH40, ABS installation, open stud and crawl space	Weldon 773	Breathing Zone	1008-1400	-	-	3.7	ND	ND	None	
			Breathing Zone, while in 24" crawl space	0912-0950	-	-	121.7	ND	ND	None	
Prefab (Simulation) 1 worker, 20'x40' garage-like structure, openings on 3 sides, general ventilation, 8/30-31/82	Cutting ABS[4] using Sears™ cutoff saw	-	Area sample 18" above saw table 12" from breathing zone	0925-1130	0.28	0.14	-	-	-	None	Detectable odor was present
			Area sample 18" above, 5' downwind of saw	0925-1130	0.28	0.14	-	-	-	None	
	Gluing ABS, 8 trees, 28 joints per tree, used 1 and 3/4 Qt. of adhesive	Weldon 773	Breathing Zone	1325-1540	-	-	38.4	ND	ND	None	Very noticeable MEK odor, occasional slight light headedness reported by worker
			Breathing Zone 15 minute sample	1545-1600	-	-	33.4	ND	ND	None	
			Area, placed above gluing area	1325-1600	-	-	10.7	ND	ND	None	

(continued)

APPENDIX A

Appendix A (continued)

Operation/Date	Task Evaluated	Adhesive Used	Sample Type	Sampling Time	Airborne Concentrations: Particulates (mg/m³) Total	Particulates (mg/m³) Respirable	Solvents[1] (ppm) MEK	THF	DMF	Other	Comments
	Cutting PVC[4]	-	Area, 18" above saw table	0944-1150	0.43	0.24	-	-	-	None	Detectable odor present
			Area, 18" above 24" downwind	0944-1150	0.29	0.24	-	-	-	None	
Prefab (Simulation) 1 worker, 20'x40' garage-like structure, openings on 3 sides, general ventilation, 8/30-31/82 (continued)	Gluing PVC	Weldon P-70 primer P-705 adhesive	Breathing Zone	1352-1539	-	-	5.4	9.3	ND	None	
			Breathing Zone 15 minute sample	1545-1600	-	-	5.9	10.2	ND	None	Very noticeable odor present.
			Area 2' above, 1' to right of gluing area	1352-1600	-	-	1.5	1.4	ND	None	Noticeable breeze through the building
			Area, 2' above, 1' to left of gluing area	1352-1600	-	-	1.6	2.5	ND	None	
Survey Criteria							200	200	10		

Note (1): MEK = Methyl Ethyl Ketone

Appendix A
Plumbers and Pipefitters Survey
Los Angeles & San Jose, California

August 1-12, 1983

Operation/Date	Task Evaluated	Adhesive Used	Sample Type	Sampling Time	Airborne Concentrations(ppm)[2] MEK	THF	CYCLO	DMF	Comments
Prefab, PVC, 2 workers 8/1/83, inside large barn (35'x50x25') Doors on 3 sides open	Joining, 3", 4", and 6" PVC pipe and connectors and cutting pipe with abrasive blade	Weldon P70 Primer P-711	BZ Worker A Cutting	0745-1345	ND	2.3	ND[3]	ND	
			BZ, Worker B gluing	0745-1345	10.4	29.4	0.2	1.7	
			area, 12" above cut off saw	0845-1020	0.9	5.5	ND	0.7	
			BZ, Worker B gluing	0900-0915	7.5	34.0	ND	1.7	15 minute samples
Commercial, PVC, CPVC, 2 Workers, 8/2/83	Installing pipe for plating line cut with handsaw	Weldon P70 Weldon 7-11	BZ, Worker A	0935-1445	0.9	11.8	ND	0.5	
(RM 15'x25'x9') AC system not working		Weldon P-72 Weldon 714	BZ, Worker B	0945-1445	2.9	26.8	ND	0.4	
			BZ, Worker B	0945-1000	1.6	20.2	ND	ND	15 minute sample
			BZ, Worker B	1015-1020	13.6	272.0	ND	ND	5 minute sample
Ditchwork (24"), PVC, 2 workers, 8/3/83	laying 3", 4" and 6" PVC in knee high ditch	Weldon P-70 Primer Weldon 711 Adhesive	BZ, Worker A	0700-1200	5.7	16.6	ND	0.6	
			BZ, Worker B	0700-1200	4.3	13.7	ND	0.4	
			BZ, Worker B	30 min.[4]	22.9	59.1	0.6	2.2	Pump activated only while gluing: TWA of Peak Exposure
			BZ, Worker B	15 min.[4]	7.4	16.3	ND	1.7	Pump activated only while gluing: TWA of Peak Exposure

Continued

Operation/Date	Task Evaluated	Adhesive Used	Sample Type	Sampling Time	Airborne Concentrations(ppm)(2) MEK	THF	CYCLO	DMF	Comments
Topoff, ABS, 8/4/83 1 plumber, cut with handsaw	Rough-in of ABS DWV in 1st story of 2 story, 8 unit Apartment, open stud	Weldon 773	BZ	0820-1130	ND	ND	ND	ND	only glued 12-15 joints most of time spent measuring and cutting
Finish, ABS, 8/5/83 1 plumber	set traps in 2 1/2 baths, kitchen and bar sink in residence	Weldon 793	BZ 1	0815-1445	6.7	10.9	ND	ND	Used 793 because it was clear, total glue time
			BZ 2	13 min.(4)	80.2	122.8	2.8	ND	13.0 minutes BZ 2 is TWA of Peak Exposures
Finish, ABS, 8/8/83 1 plumber(1helper)	set finish in 2, 2 story residences	Uniweld 4400	BZ 1	0900-1315	7.1	ND	ND	ND	
			BZ 2	16 min(4)	59.9	ND	ND	ND	BZ 2 is TWA of Peak exposure
Prefab, ABS, 8/10/83 outdoor shop	Assembled pipe trees, glued 556 joints	Uniweld 4400	BZ 1	0730-1530	9.9	ND	ND	ND	Used barrier Krene
			BZ 2	1300-1315	20.6	ND	ND	ND	BZ 2, 15 min sample
Topoff, ABS, 8/11/83 2 plumbers	Rough-in of ABS DWV in open stud, Apt.	Weldon 793	BZ, Worker A	0830-1500	0.9	ND	ND	ND	Most of time spent measuring and cutting
			BZ, Worker B	0830-1500	3.1	ND	ND	ND	

Note (1): BZ = Breathing zone sample

(2): MEK = Methyl Ethyl Ketone, THF = Tetrahydrofuran, CYCLO = Cyclohexane, DMF = Dimethylformamide

(3): ND = Not detected. Analytical detection limit was 0.01 mg/sample

(4): Sampling period but not continuous. Pump was activated each time glue can was opened and stopped when closed. Exposure concentration represent time-weighted-average (TWA) of peak exposure.

APPENDIX B

Tel. No. _____ Local Union No. _____

Address _____

1. Survey your local plumbing supply houses and/or plumbing contractors to identify which products are sold or stocked for use in the joining of PVC, CPVC and ABS plastic pipe. Place an (X) in front of identified manufacturers. Each can has the manufacturer's name printed on the label. Some products are more easily recognized by its trade designation (shown in parenthesis).

__Arrow	__Lake (La-co Loc)	__Radiator (T-60)
__C. Cure	__Marsh	__Rectorseal (Honest John, etc.
__Celanese	__Masco (Chem-weld)	__RG Sloane (Fuse-on)
__Genova (Nova-Weld)	__OATY	__Sureguard
__Hercules	__PCI (EZ-weld)	__United Elchem
__Hulkill	__Para chem (Parabond)	__JC Whitlam (Unyte)
__IPS (Weld-on)	__Permalite (PIP)	__Christy's

Which of those marked is most popular in your area? _____

_____

2. How many supply houses did you survey? _____ (No.)

3. How many plumbing shops did you survey? _____ (No.)

4. Did you find any joining compounds made by any companies not listed above? If so, please write the company name and location.

5. Is there any particular product used for installation of ABS, PVC or CPVC pipe that your membership complain about using? If so, please write the name of the product and put an (X) under the appropriate column to indicate the frequency of complaints.

Product	Often	Occasionally	1 or 2

6. If these complaints are from 1 or 2 people, in your estimation, would they tend to represent the feeling of your membership? ____Yes ____No

7. Briefly explain the complaints.

8. Include any additional comments related to subject of this survey on the back of this page.