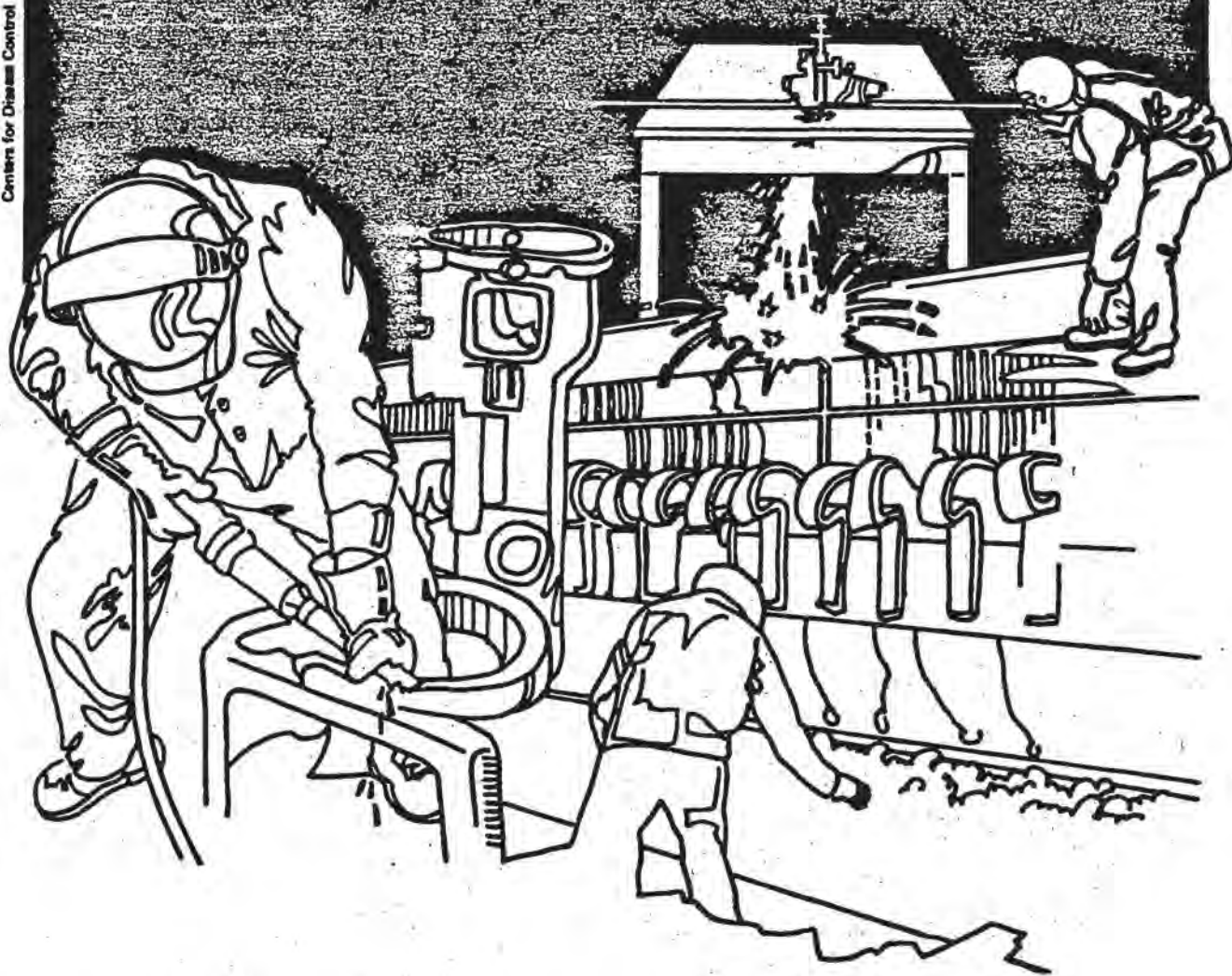


NIOSH



Health Hazard Evaluation Report

HEA 81-336-1237
PLUMBERS AND GASFITTERS LOCAL UNION 12
BOSTON, MASSACHUSETTS

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.

I. SUMMARY

In June 1981, the National Institute for Occupational Safety and Health (NIOSH), received a request from the Plumbers and Gasfitters Local Union 12, Boston, Massachusetts, to evaluate health effects from working with polyvinyl chloride (PVC) pipe cements and cleaners. To evaluate the effects of these exposures we conducted: 1) a mail questionnaire survey of the local union's membership; and 2) an environmental evaluation of solvent exposures and medical evaluation of nine exposed workers at three work sites, where high solvent exposures might occur.

Of nine time-weighted average (TWA) exposure determinations for methyl ethyl ketone (MEK), tetrahydrofuran (THF), and cyclohexanone, none exceeded the survey criteria of 590 mg/M³, 590 mg/M³, and 100 mg/M³, respectively. Likewise, four "peak" exposure determinations did not exceed survey criteria of 885 mg/M³, 735 mg/M³, and 400 mg/M³. TWA exposures for: 1) MEK ranged from none detected to 170 mg/M³ (mean of 26 mg/M³); 2) THF ranged from 0.6 to 400 mg/M³ (mean of 100 mg/M³); and 3) cyclohexanone ranged from none detected to 36 mg/M³ (mean of 4 mg/M³). Dimethyl formamide was not detected on any of the air samples. A combined exposure index calculated for the vapor mixture and based on irritation and nervous system effects indicated one of the nine plumbers' exposure to be above survey criteria (1.33 vs 1.0).

Of the 740 plumbers surveyed by mail questionnaire, 353 (48%) responded. Most had worked with plastic pipe, almost half for 10 or more years, but only 78 has worked with it for more than 13 weeks in the preceeding year. Dizziness (54%), headache (41%), eye irritation (36%), irritation of the skin of the hands (36%), and tingling or numbness in the fingers (33%) were frequently reported and were attributed by the plumbers to working with PVC pipe. However, the low response rate for the survey and the tendency for responders to report more symptoms than non-responders indicates that the prevalence of reported symptoms may be overestimated.

The nine plumbers participating in the medical survey reported a prevalence of symptoms, similar to that found in the mail questionnaire survey. Physical examinations and laboratory testing showed no abnormal findings attributable to solvent exposure. As a group, the participants had no appreciable decrement over the workday in any of the neuropsychological tests.

The environmental data did not indicate excessive solvent exposures. None exceeded survey criteria or OSHA standards, and only one of nine combined solvent exposure fractions exceeded evaluation criteria. The medical study of a limited number of plumbers documented no impairment of brain function and no work-related chronic disease, but the questionnaire survey revealed a high reported prevalence of acute symptoms associated with working with PVC pipe. However, due to the nature of this study, a definite link between the solvent exposures and reported health effects was not established. Recommendations to reduce solvent exposures in plumbing are included in Section VIII of this report.

KEYWORDS: SIC 1711 (Plumbing, Heating, and Air Conditioning), PVC pipe cement, methyl ethyl ketone, tetrahydrofuran, cyclohexanone, dimethyl formamide, neurobehavioral tests, headache, dizziness, nausea, eye, nose, throat, and skin irritation.

II. INTRODUCTION

In June 1981, the business manager of the Plumbers and Gasfitters Local Union 12, Boston, Massachusetts, requested a Health Hazard Evaluation to assess exposures to PVC pipe cements and cleaners as used by the union's membership. The purpose of this evaluation was to assess the significance of symptoms of headache, dizziness, nausea, numbness of the fingers, and irritation of the eyes, throat, and skin, reported by plumbers using PVC pipe cements and cleaners and to determine the potential of these compounds to cause acute, transient changes in brain function and chronic, persistent changes in brain or nerve function.

In June 1981, walk-through tours of construction sites were conducted at the former Charlestown Naval Shipyard, the Villa Victoria housing development in Boston's South End, and the E.M. Duggan Company in Canton. In July and August, 1981, a questionnaire survey of the local union's membership was conducted. On July 27, September 9, and September 10, 1981, worksite evaluations were performed. The results of these activities were presented to the union's membership at a meeting of Local Union 12 on April 29, 1982.

III. BACKGROUND

During the past ten years in the Boston area, plumbing contractors have increasingly used plastic pipe in preference to the traditional metal pipe for waste and vent systems. The labor-intensive lead soldering of metal pipe joints is being replaced by the rapid "gluing" of plastic pipe with solvent-based compounds. The most commonly used system in Boston utilizes PVC pipe, a "cleaner" composed of methyl ethyl ketone (MEK) and tetrahydrofuran (THF), and a "cement" containing various combinations of MEK, THF, cyclohexanone, and dimethyl formamide (DMF). To join two pieces of pipe, a plumber applies a generous coat of cleaner to the appropriate surfaces and after less than a minute, applies the cement over the same area. The two pieces of pipe are manually held together for less than a minute and the joint is completed. Much of the pipe gluing is done at prefabrication shops. Subsequently, at building sites, connections are made to mains and fixtures under well to poorly-ventilated working conditions. The cleaners and cements are applied with rag or brushes. Exhaust fans and personal protective equipment such as gloves and respirators are rarely used. Dried glue is removed from the hands by peeling or by washing with PVC pipe cleaner.

IV. METHODS

Three sites were surveyed: E.M. Duggan Company in Canton (prefabrication shop - 1 plumber); Villa Victoria housing development in Boston's South End (confined space work - 1 plumber); and the D Street housing project in South Boston (basement renovation work - 7 plumbers). This selection was intended to identify high exposure locations. All plumbers working with plastic pipe at these sites were monitored for exposure to solvents and underwent medical tests.

A. Environmental

Personal air sampling with charcoal tubes was performed on plumbers throughout the workday to determine time weighted average (TWA) exposures to tetrahydrofuran, methyl ethyl ketone, and cyclohexanone. The air sampling pumps were shut off during lunch and coffee breaks. This time was subtracted from the total.

Assuming that the plumbers work an eight-hour day at their measured TWA air concentrations (some of the samples were not full shift) the results of each air sample were expressed as a calculated solvent vapor mixture fraction. (See Section V. EVALUATION CRITERIA).

Additionally, short duration charcoal tube sampling was conducted during the time when PVC pipe joints were being glued in order to estimate peak exposure levels. Draeger detector tube sampling for DMF was performed at the top of an open can of PVC pipe cement to determine if it contained any DMF. The negative results were later confirmed by gas chromatography.

B. Medical

1. Mail Questionnaire

A one-page questionnaire was mailed to the 740 active plumbers in Local Union 12. Information was requested on age, amount of plastic pipe work done, and whether any of 16 listed symptoms had ever been experienced while working with plastic pipe. A telephone survey, using the same questionnaire and introductory information, of 70 randomly chosen non-respondents was carried out to evaluate response bias. Up to three attempts were made to reach each of the 70 non-respondents. Differences in symptom and exposure frequencies between those completing the mailed questionnaire and those interviewed by telephone were tabulated and evaluated by the chi-square test.

2. Medical Evaluation

Before beginning work on the test days, the nine plumbers at the three survey sites completed detailed health and occupational history questionnaires, received neurologically oriented physical examinations by a physician, had blood samples drawn to assess liver function, and were evaluated by a standard battery of ten neurobehavioral tests (1). The neuropsychological test battery allowed an assessment of verbal and visual memory, reaction time, hand-eye coordination, and mood. Where possible, the pre-workday test scores were compared to those predicted as a function of age, sex, and educational level.

The prediction equations for the neuropsychological test battery were generated from a group of 65 healthy industrial workers without occupational exposure to neurotoxins (1). At the end of the workday, the neuropsychological test battery was repeated. Pre-workday and post-workday test scores were compared to evaluate acute changes in brain function that could be related to that workday's solvent exposures. Statistical analysis was not conducted due to the small sample size.

V. EVALUATION CRITERIA

A. Environmental

The environmental evaluation criteria used for this study are presented in Table 1. Listed in Table 1, for each substance, are the recommended environmental limit, the source of the recommended limit, the principal or primary health effects underlying each recommended limit, and the current OSHA legal standard. The NIOSH and American Conference of Governmental Industrial Hygienists (ACGIH) recommendations are often lower than the legal standards because they incorporate newer information and are mainly based on health considerations.

A calculation for mixtures is relevant when two or more 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,

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \dots$$

exceeds unity, 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 limit. Calculations of solvent vapor mixture fractions were performed for each sample of this study according to the irritative and nervous system effects of MEK, THF, and cyclohexanone.

B. Toxicology

MEK, THF, cyclohexanone and DMF are all liquids at room temperature (2). MEK and THF evaporate rapidly at room temperature, creating a vapor that is readily absorbed through the lungs. When splashed on the hands and arms, MEK (3) and cyclohexanone (4) are readily absorbed through the skin. DMF is exceptional in this regard as even its vapor is readily absorbed through the skin. In certain occupational settings, absorption of DMF through the skin exceeds that through the lungs (5). Reports are not available on THF's capacity for skin absorption.

For certain solvents excessive exposures may cause mucous membrane irritation and acute, reversible changes in brain function similar to the "high" experienced after alcohol consumption (6,7). There are no short-term legal exposure limits for the four solvents of this study but the ACGIH has recommended excursion values to control peak exposures. Recently, several studies of workers repeatedly exposed to these organic solvents, as single agents or mixtures, have shown persistent effects.

These workers (house painters, industrial spray painters, printers, car painters, and viscose rayon workers) (8-11), had been exposed to solvents for nearly eight hours per day, five days per week, at air concentrations ranging from 20-100% of the acceptable Threshold Limit Values for mixtures (12).

Damage to peripheral nerves is not believed to result from exposures to any of the four solvents used in PVC gluing systems. However, MEK is known to increase the peripheral neurotoxicity of two other solvents, methyl-n-butyl ketone (13) and n-hexane (14). Occupational exposures to DMF have resulted in acute and chronic liver injury, alcohol intolerance and abdominal pains and nausea (5). None of the compounds has been shown to cause cancer in humans or experimental animals (7). The National Cancer Institute has initiated long-term animal studies of cyclohexanone and dimethyl formamide (7).

All of these substances remove fat from the skin. Consequently, after repeated skin exposure, they are capable of causing dry skin and dermatitis.

VI. RESULTS

A. Environmental

Table 2 summarizes the results of the plumbers' breathing zone air sampling for DMF, THF, MEK, and cyclohexanone. DMF was not detected in any of the air samples, as expected from bulk sample analyses. Cyclohexanone was appreciably above the detection level for just one of the samples --- the result being 36 mg/M³ as compared to the survey criteria of 100 mg/M³. The tetrahydrofuran air samples ranged from 0.6 mg/M³ to 400 mg/M³ as compared to the environmental criteria of 590 mg/M³ for TWA samples or 735 mg/M³ for peak samples. The MEK air samples ranged from "none detected" to 170 mg/M³ as compared to the survey criteria of 590 mg/M³ for TWA samples or 885 mg/M³ for peak samples. THF concentrations contributed the most to the calculated vapor mixture fractions. Six of the plumbers had fractions of 0.10 or less; three had fractions of 0.23, 0.48, and 1.33. Therefore, one of the nine plumbers sampled had an exposure which exceeded the survey criteria of 1.0 for a calculated vapor mixture fraction. None of the individual solvent air concentrations were greater than OSHA legal standards.

B. Medical

1. Mail Questionnaire

Three hundred fifty-three (48%) of the active plumbers surveyed returned the mail questionnaires. Nearly all had worked with plastic pipe and almost half had spent ten or more years at such work (Table 3). However, three-quarters of the active plumbers had worked with plastic pipe for only 13 or less weeks in the previous year (Table 4). While working with plastic pipe, two-thirds reported experiencing headache and dizziness, while one-third or more reported experiencing fatigue, loss of appetite, nausea, and irritation of the throat, eyes, and skin (Table 5).

Telephone contact was made with 43 plumbers from the sample of 70 non-respondents. Their distribution of age and years of plastic pipe work was no different than that of those plumbers successfully surveyed by mail. However, 56% of those interviewed by phone had not worked with PVC pipe in the previous year as compared to 23% of those surveyed by mail ($p < 0.001$). Forty-one percent of the telephone survey group indicated that working with plastic pipe had at some point made them ill, as compared to 64% of the mail survey group ($p < 0.01$). Table 5 compares the symptom experience of those completing the mailed questionnaire with those interviewed by telephone. In general, there was a trend for a higher symptom prevalence among the questionnaire respondents than among the non-respondents. The difference was statistically significant at the 0.05 level for five of the 16 symptoms.

2. Medical Study

The nine plumbers evaluated at the work site had a mean age of 44.0 years and had, on the average, 13.1 years of schooling, 7 years of PVC pipe work, and 22.1 years of plumbing. Two were taking medication that affects the nervous system and had medical histories of neurological effects which necessitated their exclusion from the analysis.

Two other subjects were drinking up to 70 ounces of alcohol per week while the others were currently moderate drinkers or non-drinkers (5.7 ± 7.5 ounces per week). Two of the current moderate drinkers had regularly consumed 70 ounces of alcohol per week in the past. Of the four plumbers without a significant medical history and without a past history of consuming 70 ounces of alcohol per week, one was currently taking an anti-hypertensive drug that affects the central nervous system.

Six of the plumbers had experienced symptoms suggestive of acute solvent effects on brain function, and had skin and mucous membrane irritation while the remaining three had not.

The physical examinations of eight plumbers were normal except for decreased vibration sensation in two who had past histories of excessive alcohol use. One individual was not available for physical examination. Screening liver function tests revealed normal patterns. Three individuals had borderline elevations of single liver function tests that were not consistent with the other tests. Gamma-glutamyl transpeptidase (GGTP) was elevated to twice normal levels in three individuals. This blood test is an extremely sensitive indicator of liver dysfunction but it may also be elevated by drugs and alcohol that merely increase the liver's enzymes activity without injury (16). The three individuals with elevated GGTP reported consuming large amounts of alcohol or using medication known to induce elevations in GGTP.

The neuropsychological test results indicate that the pre-workday test scores were comparable to those predicted as a function of age, sex, and education (Table 6). Pre-workday mean scores and post-workday mean scores of six of the nine plumbers are compared on Table 7. Such a comparison was not appropriate for the remaining three plumbers for various reasons. There was no appreciable decrement in any of the tests of intelligence, memory, or psychomotor function over the workday.

VII. CONCLUSIONS

Most plumbers reported having experienced acute central nervous system symptoms at one time while working with PVC pipe cements and cleaners. We did not, however, detect any appreciable decrease in brain function over the course of the work day in individuals whom we tested while using these substances. Since the exposures that we measured on these work days were typically quite low, the absence of acute behavioral effects in these individuals was to be expected.

Although there was a high rate of reported symptoms among persons using PVC glues and cleaners, we were unable to identify a group of plumbers with excessive exposure to solvent vapors. NIOSH has in progress other studies which may indicate whether the levels of exposure of this study are representative of the industry. In view of the difficulties associated with implementing engineering control measures on construction sites, we have developed specific recommendations, to control exposures, which are based on general principles of personal protection.

VIII. RECOMMENDATIONS

In view of the known health effects of solvents used in PVC cements and cleaners, and symptoms reported by plumbers, this process should be treated as potentially hazardous to health and the following recommendations taken to decrease exposures.

A. Skin contact with PVC cements and cleaners can be minimized by:

1. Cleaning hands with waterless abrasive hand cleaners rather than with PVC cleaner.
2. Wearing appropriate gloves which will not deteriorate on contact with PVC cements and cleaners (gloves made from polyvinyl alcohol are the most effective in this regard).

B. Lung absorption of solvents from PVC cements and cleaners can be reduced by:

1. Reducing air concentrations of these components by increasing natural room ventilation in open spaces and by providing local exhaust ventilation in closed or semi-confined spaces.
2. Wearing a well-fitted, well-maintained respirator which is appropriate to the type of work being done and the type of exposures encountered. For the concentrations of cement and cleaner vapors observed in this study, a half-mask organic vapor respirator, certified by NIOSH, should provide a sufficient factor of protection.

C. When possible, PVC cements and cleaners should be used which do not contain DMF. Sometimes a product's composition can be determined by obtaining Material Safety Data sheets from the manufacturer.

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X. AUTHORSHIP AND ACKNOWLEDGEMENTS

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 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 the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. E. M. Duggan Co.
2. Boston Housing Authority
3. IBA (Inquilinos Boricuas en Accion)
4. Plumbers and Gasfitters Local Union 12
5. OSHA, Region I
6. NIOSH, Region I
7. Massachusetts Department of Labor and Industries

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

TABLE 1
EVALUATION CRITERIA AND OSHA STANDARDS
PLUMBER AND GASFITTERS LOCAL UNION 12
BOSTON, MASSACHUSETTS

Substance	Environmental Criteria (mg/M ³)	Source	Primary Health Effects	OSHA Standard (mg/M ³)
Methyl Ethyl Ketone	590 885 (15 min.)	NIOSH ACGIH*	Irritation; Liver, kidney, nervous system effects	590
Tetrahydrofuran	590 735 (15 min.)	NIOSH ACGIH	Irritation; Headaches, nervous system effects	590
Cyclohexanone	100 400 (15 min.)	NIOSH ACGIH	Irritation; Liver, kidney, nervous system effects	200
Dimethyl Formamide	30 60 (15 min.)	ACGIH ACGIH	Irritation; Liver toxicity	30

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 1981.

TABLE 2
PERSONAL AIR SAMPLE RESULTS (mg/M³)
PLUMBERS AND GASFITTERS LOCAL UNION 12
BOSTON, MASSACHUSETTS

Plumber #	Sample Type	Tetrahydrofuran*	Methyl Ethyl Ketone*	Cyclohexanone*	Calculated Vapor Mixture Fraction
<u>E. M. Duggan Fabrication Shop</u>					
1	TWA (am)	15	9.5	<1	0.04
1	Peak (am)	7.8	12	nd	0.03
1	TWA (pm)	6.0	11	nd	0.03
1	Peak (pm)	8.7	27	1.4	0.05
<u>Villa Victoria Development</u>					
2	TWA (day)	120	15	nd	0.23
2	Peak (day)	280	nd	nd	0.38
<u>D Street Housing Project</u>					
3	TWA (day)	400	170	36	1.33
4	TWA (day)	6.8	nd	nd	0.01
5	TWA (day)	40	1.7	nd	0.07
6	TWA (day)	51	5.1	nd	0.10
6	Peak (day)	120	nd	nd	0.16
7	TWA (day)	11	7.4	<1	0.03
8	TWA (day)	0.6	nd	nd	0.001
9	TWA (day)	260	21	nd	0.48
<hr/>					
Survey Criteria	TWA	590	590	100	1.0
	Peak	735	885	400	1.0
OSHA STANDARD	TWA	590	590	200	

Notes: 1. All air concentrations are in milligrams per cubic meter of air (mg/M³)
2. "nd" means not detected at laboratory limit of quantitation.

TABLE 3

DISTRIBUTION OF PLUMBERS RESPONDING TO QUESTIONNAIRE
BY YEARS OF WORK
WITH PLASTIC WASTE AND VENT SYSTEMS

PLUMBERS AND GASFITTERS LOCAL UNION 12
BOSTON, MASSACHUSETTS

<u>Number of Years</u>	<u>Number of Plumbers</u>	<u>Percent of Plumbers</u>
0	26	8
1-3	52	16
4-6	48	15
7-9	57	18
10+	<u>137</u> :	<u>43</u>
	320	100
Insufficient Data	33	
	—	
Total	353	

TABLE 4
 DISTRIBUTION OF PLUMBERS RESPONDING TO QUESTIONNAIRE
 BY WEEKS DURING PAST YEAR
 INSTALLING OR FABRICATING PLASTIC PIPE
 PLUMBERS AND GASFITTERS LOCAL UNION 12
 BOSTON, MASSACHUSETTS

<u>Number of Weeks</u>	<u>Number of Plumbers</u>	<u>Percent of Plumbers</u>
0	77	23
1-13	180	54
14-26	34	10
27-39	29	9
40-52	<u>15</u>	<u>4</u>
	335	100
Insufficient Data	<u>18</u>	
Total	353	

Table 5
Comparison of Symptoms Between
Questionnaire Responders and Non-Responders

Plumbers and Gasfitters Local Union 12
Boston, Massachusetts

Symptom	Percent with Symptom	
	Mailout Questionnaire (Responders, N=253)	Telephone Questionnaire (Non-Responders, N=43)
Dizziness	64	54*
Headache	65	41**
Unusual Tiredness	39	10***
Difficulty Concentrating While Driving Home	18	8
Difficulty Concentrating in General	20	13
Clumsiness When Walking	20	10
Four or More of the Above Symptoms	20	10
Loss of Appetite	32	18
Nausea	38	20
Increased Effect From Alcohol	13	3
Tingling or Numbness in the Fingers	22	33
Tingling or Numbness in the Toes	12	13
Decreased Muscle Strength in Arms or Hands	19	10
Throat Irritation	40	23
Eye Irritation	51	36
Bloody Nose	6	5
Skin Irritation of the Hands	44	36
Seven or More of All of the Above Symptoms	31	18
No Symptoms	14	28

* Significant at $p < 0.05$ level

** Significant at $p < 0.01$ level

*** Significant at $p < 0.001$ level

TABLE 6

NEUROPSYCHOLOGICAL TEST RESULTS:
COMPARISON OF BASELINE (PRE-WORKDAY) SCORES WITH
AGE-SEX-EDUCATION PREDICTED SCORES

PLUMBERS AND GASFITTERS LOCAL UNION 12
BOSTON, MASSACHUSETTS

TEST	PLUMBERS' MEAN SCORE (N=9)	MEAN PREDICTED SCORE* (N=9)
Intelligence		
Visual Block Design	12.8 \pm 0.9	
Memory		
Attention/Concentration		
Digit Span Total	11.8 \pm 1.3	11.5 \pm 0.5
Digit Symbol Total	44.4 \pm 10.3	49.3 \pm 5.2
Short-Term Memory		
Visual Reproduction	10.1 \pm 2.7	11.1 \pm 0.8
Psychomotor Function		
Santa Ana Dexterity		
Preferred Hand	21.3 \pm 4.1	
Non-Preferred Hand	21.7 \pm 4.3	
Mood State		
POMS		
Tension	6.8 \pm 5.0	12.5 \pm 6.2
Depression	5.1 \pm 5.3	5.1 \pm 1.8
Anger	5.3 \pm 5.3	8.3 \pm 0.8
Vigor	16.9 \pm 4.9	19.6 \pm 1.1
Fatigue	5.9 \pm 6.2	6.2 \pm 0.6
Confusion	4.9 \pm 2.5	4.5 \pm 1.1

* Prediction equations were derived from a group of 65 healthy industrial workers without exposure to neurotoxins.

TABLE 7
NEUROPSYCHOLOGICAL TEST RESULTS:
COMPARISON OF PRE-WORKDAY SCORES WITH POST-WORKDAY SCORES
PLUMBERS AND GASFITTERS LOCAL UNION 12
BOSTON, MASSACHUSETTS

TEST	PRE-WORKDAY MEAN SCORE (+ S.D.) N=6	POST-WORKDAY MEAN SCORE (+ S.D.) N=6
Intelligence		
Verbal		
Vocabulary	36.5 + 13.2	38.0 + 11.8
Memory		
Attention/Concentration		
Digit Span Total	11.5 + 1.6	11.0 + 3.0
Digit Symbol Total	47.7 + 8.9	41.7 + 11.0
CPT	64.0 + 5.1	60.0 + 3.7
Short-Term Verbal Memory		
Associate Learning	2.0 + 0.7	1.6 + 0.6
Short-Term Visual Memory		
Visual Reproduction	9.8 + 3.6	12.5 + 2.5
Psychomotor Function		
Santa Ana Dexterity		
Preferred Hand	22.2 + 3.6	24.5 + 3.8
Non-Preferred Hand	22.3 + 4.1	23.5 + 4.2
Reaction Time (best 5/6 trials)		
Sound: Preferred Hand	217.7 + 60.5	236.7 + 60.1
Sound: Non-Pref. Hand	209.9 + 51.1	214.6 + 65.8
Light: Preferred Hand	260.5 + 33.1	253.1 + 36.1
Light: Non-Pref. Hand	259.5 + 47.7	247.6 + 29.8
Mood States		
POMS		
Tension	7.3 + 5.2	6.0 + 2.7
Depression	5.8 + 5.4	2.2 + 1.6
Anger	5.2 + 5.9	0.8 + 1.6
Vigor	19.5 + 5.6	18.0 + 3.8
Fatigue	6.0 + 6.7	6.7 + 2.2
Confusion	4.7 + 2.6	3.2 + 1.5

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