IN-DEPTH SURVEY REPORT

THE CONTROL OF METHYLENE CHLORIDE IN FURNITURE STRIPPING

at

The J M Murray Center, Inc
Cortland, New York

REPORT WRITTEN BY
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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal organization engaged in occupational safety and health research Located in the Department of Health and Human Services (DHHS), NIOSH was established by the Occupational Safety and Health Act of 1970 This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA), which is located in the Department of Labor (DOL) An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical, biological, and physical hazards The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering (DPSE) has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control

Since 1976, the Engineering Control Technology Branch has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need or availability of an effective system of hazard control measures

These studies involve a number of steps or phases Initially, a series of walk-through surveys is conducted to select plants or processes with effective and potentially transferable control concepts or techniques Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures Ultimately, the information from these research activities builds the database of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury

This study is part of a NIOSH initiative directed toward reducing the incidence of work-related diseases among workers employed by small businesses, particularly occupational lung disease, occupational cancer, occupationally related cardiovascular diseases, diseases due to neurotoxic agents, skin disease, hearing loss, and work-related injuries Since many owners of small businesses lack basic knowledge regarding potential health effects and safe handling procedures, and at the same time are, for the most part, not subject to regular OSHA inspections, a concentrated effort on the part of NIOSH is necessary to help implement these strategies in the small business sector ECTB is in part responsible for developing recommendations for cost-effective engineering, administrative, and personal protective controls for small businesses

This particular research effort was prompted by the growing concern of the hazards of methylene chloride (CH_2Cl_2) and the need for technical advice for furniture strippers The objective of this survey was to evaluate a prototype furniture stripping tank for its ability to control exposures to methylene chloride during the stripping process

FACILITY DESCRIPTION

The J M Murray Center, Inc , is a private, nonprofit corporation that employs people with disabling conditions Furniture stripping is one of the tasks performed at this sheltered workshop Other tasks include repairing, sanding, and refinishing furniture, new furniture manufacturing, reupholstery, small bench assembly and packaging, food service, retail sales, janitorial services, and manufacturing/packaging of commodities including plastic bags, toothpaste, and toothbrushes

A prototype furniture stripping tank was designed by a private consultant as a model tank for a new stripping facility at the Murray Center The prototype tank was built to determine if the design would be practical, safe, and affordable for a new facility

The prototype tank was built in a temporary "stripping room" which is connected to the maintenance garage The room is approximately 10 by 20 feet with a ceiling which is 12 feet high The stripping room and the maintenance garage were separated by a 8 foot partition A drawing of the area where this tank is located is shown in Figure 1

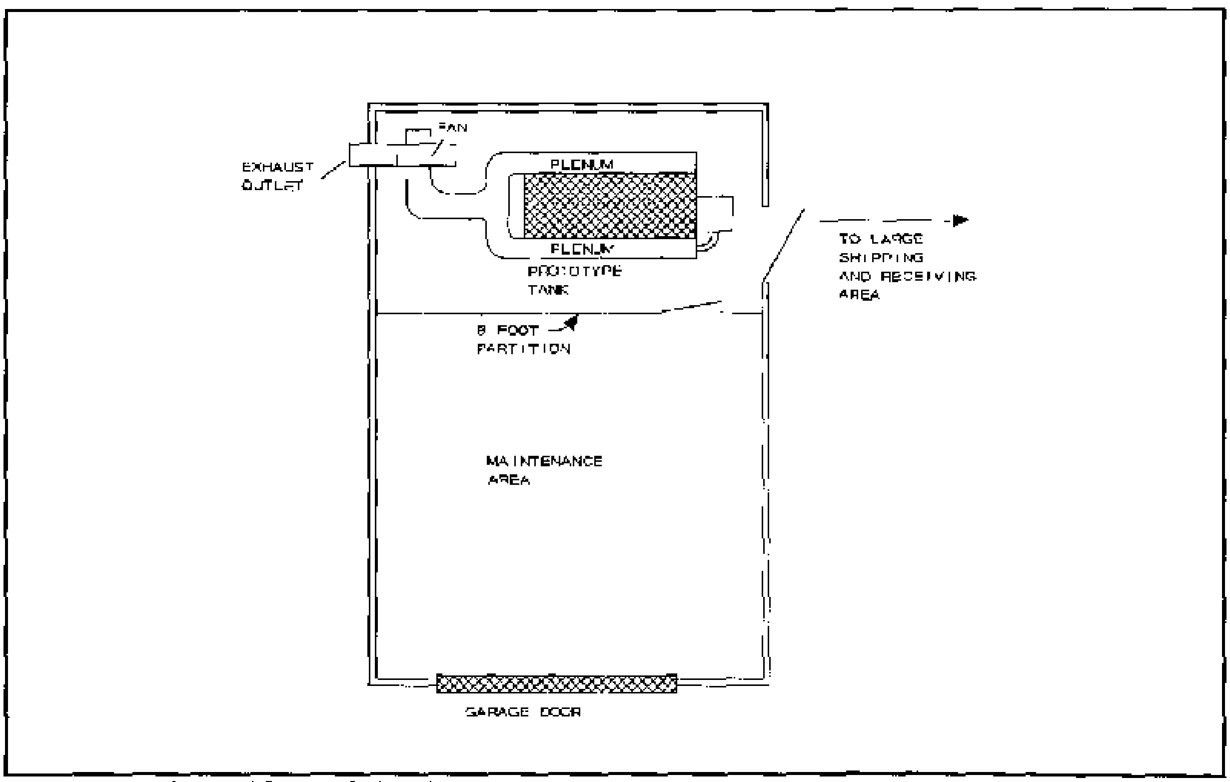

Figure 1 Floor Plan of Stripping Area

The prototype tank consisted of a solution-recycling stripping system with a downdraft ventilation system The tank was 8 feet long by 4 feet wide The top edge of the tank was 33 inches from the worker's feet A perforated plate was located 15 inches below the top edge of the tank The air for the downdraft ventilation and the stripping solution both entered the tank through the perforated plate A fan capable of 5000 cfm with 3" fan static pressure (FSP) was used for the exhaust system The volume of air that the ventilation system exhausted could be controlled by changing pulleys in the fan and adjusting a guillotine damper The workers stood on plenums, which were located along the sides of the tank, while stripping the furniture In the final design, the plenums were to be placed under the floor, however, the building construction did not allow it

The stripping solution pail, which was enclosed in a wooden box, was located at the end of the tank on the floor The wooden box was connected to the rest of the ventilation system by a small 2 inch diameter flexible duct The stripping solution will be under the floor in the final design Therefore, only designated workers will handle the stripping solution Drawings of the prototype tank are shown in Figures 2 and 3

Personal protective equipment was worn by the furniture stripper including chemical splash goggles, an apron, and shoulder length gloves The gloves were 1 3 mm thick in the hand area and 0 7 mm thick from the wrists to the shoulder

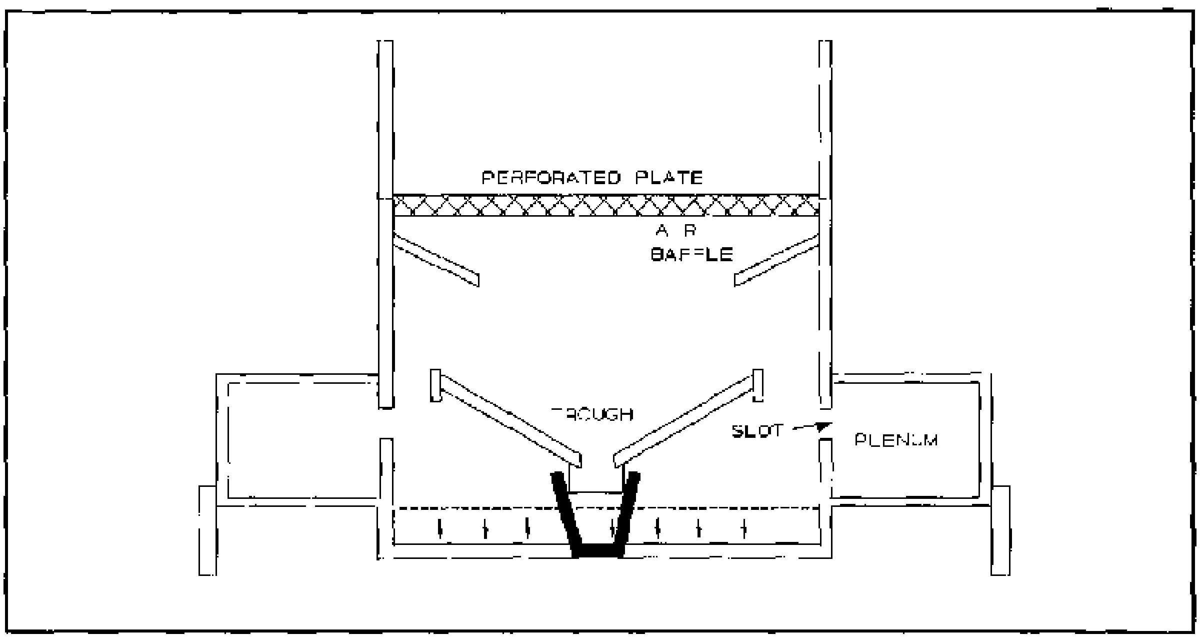

Figure 2 End View of Prototype Stripping Tank

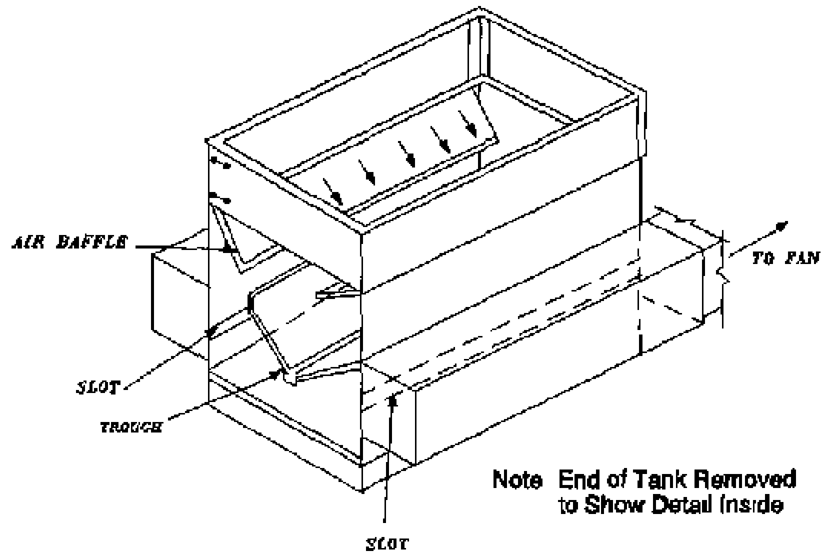

Figure 3 Isometric View of Prototype Stripping Tank

PROCESS DESCRIPTION

Furniture stripping facilities remove the existing finish and leave a bare wood (or metal) substrate for refinishing Furniture must be stripped carefully so that the finish is removed from cracks, and the wood is not damaged The furniture may be brought into the facility from institutions, businesses, or individuals, and may vary from antique to modern The finish may consist of a variety of paint coverings, stains, or varnishes Size and shape may range from large cabinets or church pews to small door knobs and other fixtures Furniture stripping must, therefore, be flexible to accommodate these different sizes, shapes, types, qualities, and finishes of furniture while still protecting the wood substrate

In order to accommodate the variety of furniture to be stripped, this facility used a prototype solution-recycling stripping tank which included a downdraft ventilation system (see description in the Facility Description Section) Solution-recycling is the most commonly used method for removing finish from furniture The furniture was initially set in the tank and covered with stripping solution Once the piece was covered, the operator waited (time depends on the finish and substrate) for the solution to begin penetrating the finish The operator alternated between brushing the piece to remove the finish and recoating the piece with the solution until the finish was completely removed This process took anywhere from a few minutes to an hour or more depending on the finish and substrate After the finish was removed, the furniture was carried into another part of the facility to be rinsed with water After rinsing, the piece was moved to an open area to dry and later to be sanded and refinished Only the stripping part of the process was investigated during this survey

The solution-recycling system included a 5-gallon pail, a pump, and a brush with plastic tubing connecting the three The pump is used to move the solution from the pail to the brush The solution is applied to the furniture with the brush The solution which runs off the furniture is collected in a trough inside the tank The trough drains back into the pail to complete the cycle Solution is typically recycled until it has lost its stripping ability, or diminishes through evaporation

The stripping solution used at this facility was Paint and Varnish Remover (Stripping Products, Inc , Bethel, Connecticut) The solvents in the stripping solution were methylene chloride, methanol, and toluene Wax or paraffin also was added as an evaporation retarder When the solution is spread over the furniture, the wax migrates to the surface to form a film barrier to reduce the evaporation rate of the stripping solvents Stripping Products, Inc , which manufactured this solution, recommended the solution's temperature be approximately 70°F while in use

POTENTIAL HAZARDS

Exposures to stripping solvents in the furniture stripping industry are found primarily during the actual handling and stripping of the furniture Other exposure sources may include the mixing or transferring of stripping solution, and vapor buildup in the room air The solvent may enter the worker's body through inhalation or dermal absorption The solution used at this facility contained a mixture of methylene chloride, methanol, and toluene (72, 20, and 2 percent by weight, respectively) [1] Of these three components, methylene chloride may cause the greatest potential hazard to the worker, because of its greater concentration in the liquid and chronic health effects discussed in the subsequent text

HEALTH EFFECTS - METHYLENE CHLORIDE

Methylene chloride has a narcotic effect on the central nervous system, as well as the cardiovascular and respiratory systems Historically, it was used as an anesthetic Exposure may result in symptoms of dizziness, headache, tingling or numbness of the extremities, and impairment of mental alertness and physical coordination The intentional or accidental inhalation of volatile organic solvent vapors in high concentrations is a well recognized cause of morbidity and mortality [2]

Inhalation of methylene chloride causes the endogenous formation of carbon monoxide (CO) which attaches to the hemoglobin, which changes to carboxyhemoglobin The CO has an affinity to hemoglobin 200 times that of oxygen, therefore limiting the oxygen transporting capability of the body causing oxygen deprivation This can lead to heart, brain, and other tissue damage Cardiovascular stress can cause myocardial infarction in susceptible individuals This could also occur in a fetus, methylene chloride has the ability to cross the placental barrier

The National Toxicology Program (NTP) performed a 2-year methylene chloride inhalation study on rats and mice F344/N rats were grouped with methylene chloride exposures of 0, 1000, 2000, or 4000 ppm $B6C3F_1$ mice were grouped with methylene chloride exposures of 0, 2000, or 4000 ppm Increased incidence of testicular atrophy in the male rats and mice were detected Increased ovarian and uterine atrophy were present in female mice exposed to methylene chloride All groups of male rats and the mid- and high-dose female rats experienced unusually high incidence of mononuclear cell leukemia Body weights of the exposed rats were comparable to those rats receiving no exposure to the methylene chloride (the control group) High incidence of liver and lung neoplasia reduced the survival rate of dosed mice Final body weights of the dosed mice were lower than those of the control group Incidence of mammary gland tumors were increased in the dosed rats

The researchers of the NTP concluded that the benign neoplasms occurring in the female rat showed clear evidence of carcinogenicity in animals, whereas the occurrence in male rats gave some evidence of carcinogenicity In all mice, increased incidence of alveolar/bronchiolar neoplasms produce clear evidence of carcinogenicity [3]

Although epidemiologic data derived from workers exposed to methylene chloride are inconclusive about its carcinogenicity, animal inhalation studies reveal the occurrence of tumors and cancers in rodents exposed to methylene chloride These results meet the criteria established by the Occupational Safety and Health Administration (OSHA) cancer policy to consider methylene chloride a potential occupational carcinogen Based upon these data, NIOSH regards methylene chloride as a potential occupational carcinogen, and recommends that workers exposure to methylene chloride be controlled to the lowest feasible limit [4] In addition, the U S Environmental Protection Agency (EPA) regards methylene chloride as a Probable Human Carcinogen (Group B2) based on sufficient animal testing The Group B2 designation is for agents which there is sufficient evidence of carcinogenicity from animal studies but insufficient evidence from human studies [5]

HEALTH EFFECTS - OTHER SOLVENTS

Methanol has very similar central nervous system effects to methylene chloride Breathing very high concentrations may produce headache, weakness, drowsiness, lightheadedness, nausea, vomiting, drunkenness, irritation of the eyes, blurred vision, blindness, and even death Methanol also may cause liver and kidney damage [6]

Exposures to toluene of 200 ppm or greater have been found to cause changes in muscular coordination, reaction time, and production of mental confusion and irritation of mucous membranes These adverse effects have not been reported for toluene exposures of 100 ppm or less in industrial workers or experimental subjects [7]

ENVIRONMENTAL EVALUATION CRITERIA

As a guide to the evaluation of the hazards resulting in 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, preexisting medical conditions, and/or hypersensitivity (allergy) In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medication or personal habits of the workers to produce adverse 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 these multiple routes of entry potentially increase the overall dose

The primary sources of environmental evaluation criteria for the workplace are (1) NIOSH recommended exposure limits (RELs), (2) the U S Department of Labor (OSHA) permissible exposure limits (PELs), and (3) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs®) Often, the NIOSH RELs and ACGIH TLVs are lower than the corresponding OSHA PELs Both NIOSH RELs and ACGIH TLVs usually are based on more recent information than are the OSHA PELs because they are easier to update The OSHA PELs are required to take into account the feasibility of controlling exposures in various industries where the agents are used, the NIOSH RELs, by contrast, are based primarily on concerns relating to preventing any occupational health effects In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is <u>legally</u> required to meet the levels that are specified by the OSHA PELs

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

In 1986, NIOSH recommended that methylene chloride be regarded as a "potential occupational carcinogen " NIOSH further recommended that occupational exposure to methylene chloride be controlled to the lowest feasible limit This recommendation was based on the observation of cancers and tumors in both rats and mice exposed to methylene chloride in air [4]

The current OSHA PEL for methylene chloride is an 8-hour TWA concentration of 500 parts per million (ppm), with a ceiling concentration of 1000 ppm, and maximum peak concentration of 2000 ppm for no more than 5 minutes within any 2 hours This PEL was derived from a standard recommended by the American Standards Institute (ANSI) and adopted in 1971 without rulemaking [8] In 1986, OSHA published an Advanced Notice of Proposed Rulemaking for methylene chloride OSHA is considering revising the present occupational health standard because of scientific studies (discussed previously) which have reported that inhalation of methylene chloride has caused cancer in two animal species [9]

The 8-hour TLV established by the ACGIH is 50 ppm, and ACGIH has classified methylene chloride as a suspected human carcinogen This TLV was lowered from 100 ppm in order to provide a wider margin of safety in preventing liver injury This level is recommended only in the absence of occupational exposure to carbon monoxide The previous TLV of 100 ppm was based on experimental data obtained from male, nonsmoking subjects at rest The ACGIH stated that the blood of workers who were exposed at 100 ppm of methylene chloride would have carboxyhemoglobin levels below 5 percent in their blood Normal carboxyhemoglobin saturation ranges from 0 4 to 0 7 percent for nonsmokers and 4 to 20 percent for smokers The ACGIH further cautioned that "concurrent exposures to other sources of carbon monoxide or physical activity will require assessment of the overall exposure and adjustment for the combined effect "[10]

The NIOSH REL for methanol is 200 ppm, as a TWA for up to 10 hours per day, 40 hours per week, with a ceiling of 800 ppm averaged over a 15-minute period The current OSHA PEL for methanol is an 8-hour TWA concentration of 200 ppm [8] The 8-hour TWA-TLV established by ACGIH is 200 ppm, with a 250 ppm STEL [10]

The NIOSH REL for toluene is 100 ppm, as a TWA for up to 10 hours per day, 40 hours per week, with a ceiling of 150 ppm averaged over a 15-minute period The current OSHA PEL for toluene is an 8-hour TWA concentration of 100 ppm The 8-hour TWA-TLV established by ACGIH is 100 ppm, with a 150 ppm STEL

STUDY METHODS

The objectives of the survey were to evaluate the prototype furniture stripping tank for its ability to control exposures to methylene chloride and to determine the optimum exhaust volume of the local ventilation system A preliminary test was administered on the first day of the survey to determine a high, medium, and low exhaust volume of the system for further evaluation Once three exhaust volumes were chosen, a worker's exposure was monitored while stripping furniture with the ventilation system exhausting at the chosen volumes

For the preliminary test, data were collected to compare the concentration of methylene chloride among different exhaust volumes of the ventilation system This comparison was made by performing nine similar "runs" changing only the exhaust volumes from 540 to 1300 cfm During each run, the solution-recycling system ran for 15 minutes with the brush secured 1 foot above the tank The solvent concentration was measured using a direct reading instrument with an intake two feet above the tank Between runs, there was a 30 minute interval to remove residual vapors from the room and to calibrate the direct reading instrument To determine the amount evaporated during each run, the stripping solution was weighed before and after each run

The volume of air exhausted from the prototype tank was adjusted by a guillotine type damper in the duct work On the day of this testing, the damper could be moved to change the exhaust volume from 280 cfm to 1350 cfm The volume of air exhausted from the ventilation system was measured by placing an ALNOR® Balometer® (Alnor Instrument Company, Niles, Illinois) over the exhaust outlet on the outside of the building

To determine a comparable concentration of methylene chloride above the stripping tank, a Photovac Tip II (Photovac Inc , Thornhill, Ontario, Canada) recorded the total ionizable solvents present in volts (the term "ionizables" means gases which can be photoionized by a miniature lamp inside the instrument) The instrument, therefore, gives a combined reading (in volts) for the organic solvents present The output of the Photovac Tip (in volts) was transferred to a Rustrak® Ranger Data Logger (Gulton Industries, Inc , E Greenwich, Rhode Island) The data were down loaded to a computer Before each run, the Photovac Tip was zeroed with a Tedlar® (SKC, Inc , Eighty-four, PA) bag containing Argon and Spanned with a Tedlar® bag containing a concentration of methylene chloride The Photovac Tip inlet was secured two feet above the stripping tank during the sampling runs

Using the results from the preliminary test, three exhaust volumes (high-1600 cfm, medium-1250 cfm, and low-720 cfm) were chosen for further testing The object of the rest of the survey was to determine if there were any differences between worker exposures at high, medium, and low exhaust volumes A worker was monitored while stripping chairs at the three exhaust volumes for three days Rinsing of the furniture was done in a different location and not monitored Each exhaust volume was tested three times per day in random order Between each test, the damper was opened completely to clear the area of any residual solvents The chairs were from the same institution and therefore had the same finish and substrate The same person stripped the furniture during the entire study During each sampling period, the worker stripped chairs for 30 to 45 minutes Fresh air entered the stripping area from over the 8-foot partition between the stripping area and the maintenance garage because the doors to the stripping area were closed and the garage door was half open

The personal sorbent tube samples were attached to the worker's collar while he was stripping The area samples were located two feet above the prototype tank, on the back wall behind the tank, and on the back side of the tank on the duct (see Figure 4) Additionally, samples for methylene chloride and methanol were taken in the exhaust outlet of the ventilation system and converted to pounds per hour for an exhaust rate

Area and personal air samples for methylene chloride and methanol were taken side by side There were 27 personal samples taken for methylene chloride and methanol There were 27 methylene chloride and methanol samples taken in each of the area sampling locations There were 23 methylene chloride and 18 methanol samples taken in the exhaust stack outlet All sorbent tubes were sent to DataChem, Inc (Salt Lake City, Utah) for analysis using NIOSH Method 1005 (gas chromatography, FID) for methylene chloride and NIOSH Method 2000 (gas chromatography, FID) for methanol Samples for methylene chloride was

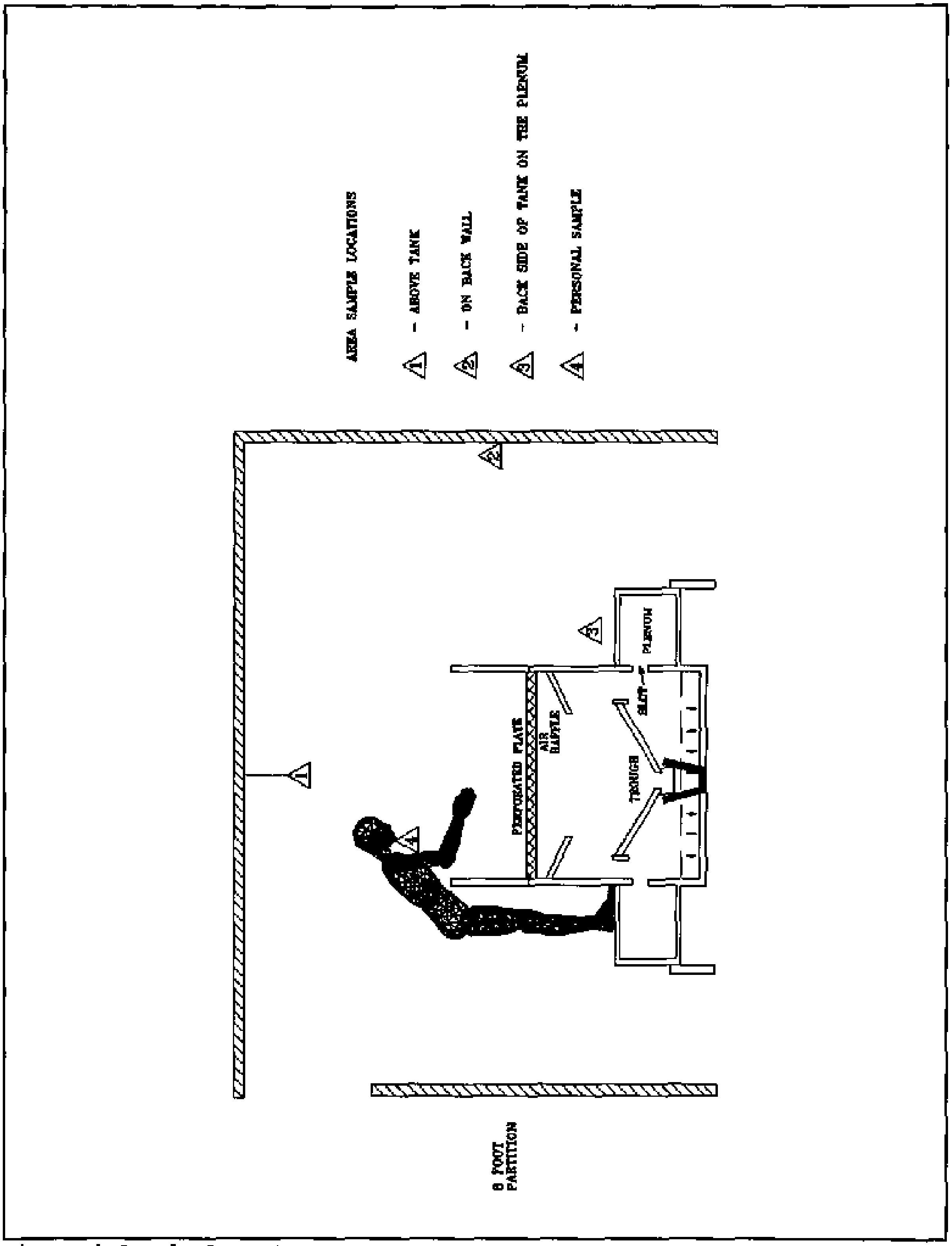

Figure 4 Sample Locations

collected on two 100/50 mg coconut charcoal sorbent sample tubes (SKC 226-01, SKC, Inc , Eighty-four, Pennsylvania) in series Samples for methanol were collected on one 150/75 mg silica gel sorbent tube (SKC 226-10, SKC, Inc , Eighty-four, Pennsylvania) Methylene chloride area and personal samples were collected at a flow rate of 60 cc/min, methanol personal and area samples were collected at a flow rate of 80 cc/min The exhaust outlet samples were collected at a flow rate of 20 cc/min All samples were taken with a personal sampling pump (P200A, E I DuPont deNemours and Co , Inc , Wilmington, Delaware)

The average temperature of the stripping solution, the ambient air temperature, and the relative humidity during each sampling period was recorded during the entire survey The gloves used by the worker during the survey were sent to NIOSH's Appalachian Laboratory in Morgantown, West Virginia to determine chemical breakthrough time The gloves were evaluated against BIX Dissolver XT Industrial Paint Remover For comparison, a 3 mm glove made of natural rubber was ordered from the Bix catalog and was tested in a similar fashion Three samples were evaluated using the American Society for Testing and Materials (ASTM) permeation test method using an AMK test cell in series with a Miran IR calibrated for methylene chloride and one calibrated for methanol [11]

RESULTS

The results from the preliminary test found that the concentration above the stripping area was relative to the exhaust volume of the ventilation system The relative concentration for the nine exhaust volumes ranged from 0 388 volts at 540 cfm to 0 010 volts at 1300 cfm as shown in Table 1 The relative breathing zone concentrations were plotted as a function of the exhaust volume A linear regression of these log-transformed data resulted in a R^2 of 0 823 (p=0 001) This result implies that the exhaust volume explains 82 percent of the variation in the relative concentration

TABLE 1
Relative Breathing Zone Concentration

Exhaust Volume (cfm)	Relative Concentration (volts)
1300	0 010
1200	0 008
1025	0 044
975	0 063
920	0 089
770	0 182
710	0 229
620	0 308
540	0 388

The weight of solution used during each run of the preliminary test varied from 8 to 15 pounds The solution weight before and after each run is shown in Table 2 for each exhaust volume tested There was no correlation between the amount of solution used and the exhaust volume of the ventilation system The ambient air temperature, the liquid solution temperature, and the relative humidity were similar during all runs The average air temperature during the preliminary test was 56°F with standard deviation of 2°F The average relative humidity was 33 percent with a standard deviation of 2 percent The solution temperature was 45°F with standard deviation of 4°F

TABLE 2
Solution Weight Before and After Each Run

Run Number*	Exhaust Volume During Run (cfm)	Solution Weight Before Run (lb)	Solution Weight After Run (lb)	Weight of Solution Used (lb)
1	1300	43 5	28 5	15 0
8	1200	42 0	33 0	9 0
2	1025	42 5	34 0	8 5
9	975	46 0	38 0	8 0
3	920	44 0	36 0	8 0
10	770	43 0	33 0	10 0
5	710	46 0	37 0	9 0
6	620	45 5	36 0	9 5
7	540	44 3	35 8	8 5

* Run Number 4 was excluded

The high, medium, and low exhaust volumes significantly affected the worker's exposures to methylene chloride and methanol while stripping furniture A comparison of the methylene chloride personal samples indicated that exposures were statistically different as a function of exhaust volume (p=0 0012) Similarly, methanol personal samples were statistically different as a function of exhaust volume (p=0 0153) The geometric means for methylene chloride and methanol are shown in Table 3 The column labeled "grouping code" shows the results of Tukey's Studentized Range Test This statistical test evaluates differences between means A Multivariate Analysis of Variance using methylene chloride and methanol as dependent variables indicated a statistically significant difference among exhaust volumes (p=0 0003 using Wilks' Lambda)

TABLE 3 Personal Sample Results							
Exhaust Volume (cfm)	Number of Samples	Methylene Chloride			Methanol		
		Range (ppm)	Geometric Mean (ppm)	Grouping Code*	Range (ppm)	Geometric Mean (ppm)	Grouping Code*
High (1600)	9	1-39	18	A	3-31	9	A
Medium (1250)	9	27-68	44	A,B	5-28	11	A
Low (720)	9	65-160	96	B	24-48	32	B

* Exhaust volumes with different grouping codes have significantly different sampling results   Exhaust volumes which contain the same grouping code are not significantly different

The area concentrations were also affected by the exhaust volume   The geometric means of the area samples were 5 ppm methylene chloride and 4 ppm methanol above the tank, 14 ppm methylene chloride and 4 ppm methanol on the back side of the tank, and 3 ppm methylene chloride on the back wall behind the tank   The area sampling results are shown by exhaust volume in Table 4

The average rate of methylene chloride and methanal exhausted from the exhaust outlet was 2 5 lb/hr and 0 8 lb/hr, respectively   The amount of methylene chloride and methanol exhausting from the exhaust system was not statistically different (95 percent confidence level) among the exhaust volumes (high, medium, and low)   Table 5 shows the exhaust rates as determined from the exhaust outlet samples

TABLE 4 Area Sample Results						
Area Sample Location	Exhaust Volume	Number of Samples	Methylene Chloride		Methanol	
			Range of Samples (ppm)	Geometric Mean (ppm)	Range of Samples (ppm)	Geometric Mean (ppm)
Above Tank	High	9	1-52	4	3-4	4
	Medium	9	1-5	2	3-8	5
	Low	9	7-17	12	3-8	4
Behind Tank	High	9	2-14	4	3-9	4
	Medium	9	3-21	9	3-5	4
	Low	9	42-189	92	4-22	10
Back Wall Behind Tank	High	9	1-37	2	N/A	N/A
	Medium	9	1-9	2	N/A	N/A
	Low	9	4-28	11	N/A	N/A
N/A - Sample not taken in this location for Methanol						

TABLE 5 Exhaust Stack Outlet Sample Results						
Exhaust Volume	Methylene Chloride			Methanol		
	Number of Samples	Range of Samples (lb/hr)	Mean (lb/hr)	Number of Samples	Range of Samples (lb/hr)	Mean (lb/hr)
High	8	0 5-4 4	2 5	6	0 6-1 2	0 8
Medium	7	0 3-4 8	2 6	6	0 5-1 0	0 7
Low	8	0 4-4 4	2 3	6	0 5-1 6	0 9

The palm of the gloves used at this facility which were 1 3 mm thick had a breakthrough time of 7 minutes with a 12 percent Coefficient of Variance The gauntlet of the gloves which were 0 7 mm thick had a breakthrough time of 2 minutes with 0 percent Coefficient of Variance The 3 mm gloves bought through the Bix catalog had a breakthrough time of 79 minutes with 17 percent Coefficient of Variance

The air temperatures, relative humidities, and liquid solution temperatures were statistically different among the days of the survey ($p=0\ 0001$ for air temperature, $p=0\ 0001$ for relative humidity, and $p=0\ 0023$ for solution temperature) However, there were no statistically significant differences among the exhaust volumes for temperature and humidity (95 percent confidence level) The average temperature and humidity for each day of the survey are shown in Table 6

TABLE 6
Temperature and Humidity Comparison for Survey Days

Day	Average Ambient Air Temperature (°F)	Average Relative Humidity (%)	Average Solution Temperature (°F)
1	57	25	45
2	63	23	63
3	66	31	55

DISCUSSION

As shown in the results, there was a good correlation between exhaust volume and the log-transformed relative concentration ($R^2=0\ 823$) in the range which was tested The authors believed that a higher volume was necessary to find the point that the exhaust volume was not a significant factor in determining a worker's exposure Therefore, the authors chose an exhaust volume which was greater than those tested in the preliminary test The exhaust volumes chosen for further testing were 1600 cfm (high), 1250 cfm (medium), and 720 cfm (low)

When comparing exhaust volumes, one should consider the other costs which may be associated with adding ventilation A comparison of the amount of methylene chloride and methanol exhausted per hour showed that the high volume did not remove a statistically significantly different amount than the medium or low volumes, under the low temperature conditions of the test runs Therefore, additional ventilation does not appear to cause more stripping solution to evaporate Conversely, there will be more air exhausting which will increase the cost to heat the make-up air The facility indicated that in Central New York this added cost was between $1,000 and $,2000 per month during the winter

Stripping furniture, as opposed to rinsing or refinishing, is typically the greatest source of exposure during the stripping process [12 13 14] Therefore, personal samples during this study were taken only while the worker was stripping the furniture Because the exposures while stripping were fairly low using the prototype tank, the exposure while rinsing may be the new highest source of exposure during the stripping process Therefore, in addition to the ventilation associated with the prototype tank, a local exhaust system for the rinse area will be needed

Some of the design techniques of the prototype tank are particularly useful for reducing exposures to methylene chloride Exposures are reduced because of the location of the local exhaust system with respect to the source of exposure and the location of the worker's breathing zone The downdraft ventilation system removed the methylene chloride vapors at the same location that the solution was removed The pail where the stripping solution was kept was enclosed and ventilated so that the solution did not evaporate into the room Because the downdraft ventilation system was designed as an integral part of the tank, good ventilation techniques were optimized Good ventilation techniques included minimizing the exhaust system pressure loss and distributing the capture potential evenly over the tank, and a downdraft design which moved the stripping solution and vapors away from the worker's breathing zone In addition, the prototype tank was reasonably versatile and practical for the needs of most stripping processes

CONCLUSIONS

The exhaust volume of the ventilation system was a dependent factor in determining the worker's exposures to methylene chloride and methanol The geometric mean of the worker's exposure to methylene chloride and methanol using a high (1600 cfm) exhaust volume was 18 ppm and 9 ppm, respectively The high exhaust volume emitted the same amount of methylene chloride and methanol from the exhaust stack outlet as the medium (1250 cfm) and low (720 cfm) exhaust volumes Therefore, the prototype tank used at high volume controls personal exposures to a fairly low level and did not cause increased evaporation of the stripping solution In general, effective engineering measures, good work practices, and appropriate personal protection should be implemented <u>and</u> maintained in order to control methylene chloride to the lowest feasible levels

The prototype tank was a sound design for a furniture stripping tank because the downdraft ventilation system was an intregal part of the design Removing this significant source of exposure necessitates evaluating the second major source, the rinse area The facility also designed a downdraft ventilated rinse booth to be used in conjunction with the stripping tank which should minimize this other exposure source

The personal exposures to methylene chloride using the prototype tank regardless of exhaust volume (high, medium, and low) was in compliance with the current OSHA PEL of 500 ppm OSHA has proposed to lower this standard in the near future, probably in the range of 25 ppm The levels seen in the present study seem to indicate that control can be achieved in the range of 25 to 50 ppm on an 8-hour time-weighted average basis

The facility indicated that their cost to achieve this exposure level involved a capital investment in the $5 to $10 thousand range for a set of boothes (strip and rinse), about $30,000 for the ventilation and make-up air heating units, and in cold weather, a gas bill in the range of $1,000 to $2,000 per month

RECOMMENDATIONS

It is recommended that this facility use the prototype stripping tank with the high exhaust volume (1600 cfm) because the high exhaust volume accounted for the lowest exposures to methylene chloride and methanol and did not effect the evaporation rate of the stripping solution If a new stripping facility is built using the prototype tank as a model, the new tank should also exhaust approximately 1600 cfm The ventilated rinse booth for the new facility should also be used Other tasks in which the worker is directly handling the stripping solution should be kept to a minimum and done in a well-ventilated area

This facility should continue providing personal protective equipment to the furniture stripper including a face shield which prevents chemical splash or spray onto the worker's face Shoulder length gloves, as used at this facility, are much better than elbow length gloves because they protect the upper arm Gloves should be made of natural rubber which is 3 mm thick in order to increase the breakthrough times The following are recommendations for care and use of furniture stripping gloves replace (or change) the glove before chemical breakthrough occurs, rinse and dry gloves in a warm, well ventilated area, and inspect the gloves prior to use for pin holes, cracks, thin spots, stiffer than normal or sticky surfaces, and other abnormalities Electrical linesman (natural rubber) gloves can be reused with the proper decontamination and inspection There should be a rotation program which incudes many pairs of gloves, rotating the gloves before breakthrough times are reached [11]

Use of these recommendations should help this facility toward the goal of maintaining levels of methylene chloride as low as feasible

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APPENDIX A

Table A-1
J M Murray Center
Methylene Chloride Sorbent Tube Sample Results
April 18-20, 1990

LOCATION	VENT FLOW RATE	SET NUMBER	DAY	SAMPLE NUMBER	RUN TIME (min)	SAMPLE VOLUME (liters)	DCM CONC (ppm)
abvstrp	h	1	1	572	36	2 2	52
abvstrp	h	1	3	884	33	2 0	12
abvstrp	h	2	2	797	38	2 3	2 5
abvstrp	h	4	2	802	40	2 4	1 2
abvstrp	h	5	1	711	48	2 9	2
abvstrp	h	5	3	932	31	1 9	23
abvstrp	h	9	1	761	33	2 0	2 9
abvstrp	h	9	2	878	28	2 3	2 5
abvstrp	h	9	3	989	35	2 1	<1 3
abvstrp	l	1	2	782	37	2 2	13
abvstrp	h	1	3	895	30	1 8	11
abvstrp	l	3	1	587	34	2 0	14
abvstrp	l	4	1	593	43	2 6	17
abvstrp	l	6	2	832	35	2 1	9 6
abvstrp	l	6	3	960	35	2 1	9 6
abvstrp	l	7	3	970	40	2 4	7 2
abvstrp	l	8	1	753	34	2 0	14
abvstrp	l	8	2	860	39	2 3	12
abvstrp	m	2	1	589	43	2 6	4 5
abvstrp	m	3	2	804	33	2 0	2 9
abvstrp	m	3	3	915	31	1.9	3 1
abvstrp	m	4	3	924	36	2 2	2 7
abvstrp	m	5	2	828	32	1 9	1 5
abvstrp	m	6	1	729	34	2 0	<1 4
abvstrp	m	7	1	745	33	2 0	4 4
abvstrp	m	7	2	853	37	2 2	2 6
abvstrp	m	8	3	973	30	1 8	<1 6
backflr	h	1	1	407	32	2 6	4 5
backflr	h	1	3	892	34	2 0	14
backflr	h	2	2	794	38	2 3	2 5
backflr	h	4	2	813	43	2 6	2 2
backflr	h	5	1	714	44	2 6	6 6
backflr	h	5	3	942	32	1 9	1 5
backflr	h	9	1	762	34	2 0	7 1
backflr	h	9	2	880	35	2 1	8 2
backflr	h	9	3	959	35	2 1	<1 4
backflr	l	1	2	776	38	2 3	42
backflr	h	1	3	910	30	1 8	82
backflr	l	3	1	582	34	2 0	65
backflr	l	4	1	600	45	2 7	89

Table A-1
J M Murray Center
Methylene Chloride Sorbent Tube Sample Results
April 18–20, 1990

LOCATION	VENT FLOW RATE	SET NUMBER	DAY	SAMPLE NUMBER	RUN TIME *(min)*	SAMPLE VOLUME *(liters)*	DCM CONC *(ppm)*
backflr	l	6	2	839	35	2 1	170
backflr	l	6	3	946	35	2 1	44
backflr	l	7	3	966	33	2 0	190
backflr	l	8	1	751	33	2 0	130
backflr	l	8	2	870	37	2 2	140
backflr	m	2	1	578	44	2 6	5 5
backflr	m	3	2	806	33	2 0	2 9
backflr	m	3	3	920	31	1 9	11
backflr	m	4	3	921	36	2 2	2 7
backflr	m	5	2	830	32	1 9	3
backflr	m	6	1	725	34	2 0	21
backflr	m	7	1	733	36	2 2	49
backflr	m	7	2	848	40	2 4	9 6
backflr	m	8	3	978	35	2 1	19
backwall	h	1	1	561	32	1 9	<1 5
backwall	h	1	3	886	34	2 0	37
backwall	h	2	2	793	38	2 3	<1 3
backwall	h	4	2	818	43	2 6	<1 2
backwall	h	5	1	709	43	2 6	3 4
backwall	h	5	3	941	32	1 9	<1 5
backwall	h	9	1	756	34	2 0	1 4
backwall	h	9	2	874	35	2 1	1 4
backwall	h	9	3	984	35	2 1	<1 4
backwall	l	1	2	780	38	2 3	11
backwall	l	2	3	891	30	1 8	9 6
backwall	l	3	1	592	34	2 0	17
backwall	l	4	1	704	44	2 6	28
backwall	l	6	2	831	35	2 1	8 2
backwall	l	6	3	934	35	2 1	4 1
backwall	l	7	3	963	33	2 0	8 7
backwall	l	8	1	743	34	2 0	18
backwall	l	8	2	866	37	2 2	9 1
backwall	m	2	1	581	45	2 7	5 3
backwall	m	3	2	789	33	2 0	<1 5
backwall	m	3	3	904	31	1 9	3 1
backwall	m	4	3	929	36	2 2	<1 3
backwall	m	5	2	823	32	1 9	<1 5
backwall	m	6	1	730	35	2 1	4,1
backwall	m	7	1	734	37	2 2	9 1
backwall	m	7	2	850	40	2 4	3 6

Table A–1
J M. Murray Center
Methylene Chloride Sorbent Tube Sample Results
April 18–20, 1990

LOCATION	VENT FLOW RATE	SET NUMBER	DAY	SAMPLE NUMBER	RUN TIME (min)	SAMPLE VOLUME (liters)	DCM CONC (ppm)
backwall	m	8	3	954	35	2 1	<1 4
personal	h	1	1	568	32	1 9	21
personal	h	1	3	889	36	2 2	20
personal	h	2	2	791	39	2 3	26
personal	h	4	2	819	43	2 6	39
personal	h	5	1	719	43	2 6	25
personal	h	5	3	940	31	1 9	36
personal	h	9	1	766	33	2 0	33
personal	h	9	2	872	37	2 2	<1 3
personal	h	9	3	987	35	2 1	25
personal	l	1	2	778	40	2 4	83
personal	l	2	3	906	30	1 8	80
personal	l	3	1	590	33	2 0	160
personal	l	4	1	708	42	1 1	140
personal	l	6	2	838	35	2 1	89
personal	l	6	3	952	36	2 2	68
personal	l	7	3	964	32	1 9	65
personal	l	8	1	754	35	2 1	91
personal	l	8	2	863	37	2 2	130
personal	m	2	1	573	44	2 6	46
personal	m	3	2	785	30	1 8	54
personal	m	3	3	896	29	1 7	53
personal	m	4	3	926	36	2 2	57
personal	m	5	2	829	30	1 8	37
personal	m	6	1	726	34	2 0	32
personal	m	7	1	735	27	1 6	34
personal	m	7	2	857	38	2 3	68
personal	m	8	3	980	35	2 1	27
plenum	h	1	3	890	35	2 1	45
plenum	h	2	2	795	39	2 3	160
plenum	h	4	2	811	50	3 0	160
plenum	h	5	1	713	49	2 9	160
plenum	h	5	3	931	35	2 1	25
plenum	h	9	1	763	36	2 2	210
plenum	h	9	2	876	31	1 9	190
plenum	h	9	3	985	35	2 1	30
plenum	l	1	2	779	41	2 5	410
plenum	l	2	3	902	32	1 9	78
plenum	l	6	2	844	37	2 2	470
plenum	l	6	3	937	34	2 0	61

Table A-1
J M Murray Center
Methylene Chloride Sorbent Tube Sample Results
April 18-20, 1990

LOCATION	VENT FLOW RATE	SET NUMBER	DAY	SAMPLE NUMBER	RUN TIME (min)	SAMPLE VOLUME (liters)	DCM CONC (ppm)
plenum	l	7	3	961	32	1 9	45
plenum	l	8	1	747	35	2 1	370
plenum	l	8	2	862	37	2 2	310
plenum	m	3	2	808	31	1 9	250
plenum	m	3	3	909	31	1 9	53
plenum	m	4	3	925	34	2 0	50
plenum	m	5	2	821	30	1 8	240
plenum	m	6	1	722	35	2 1	180
plenum	m	7	1	744	34	2 0	300
plenum	m	7	2	856	44	2 6	190
plenum	m	8	3	974	40	2 4	19

KEY

abvstrp –	area sample above stripping tank
backflr –	area sample behind stripping tank on the floor
backwall –	area sample behind stripping tank on wall
personal –	worker's personal breathing zone sample
plenum –	sample in the exhaust system
h –	high
m –	medium
l –	low

Table A-2
J.M Murray Center
Methanol Sorbent Tube Sample Results
April 18-20, 1990

LOCATION	VENT FLOW RATE	SET NUMBER	DAY	SAMPLE NUMBER	RUN TIME (min)	SAMPLE VOLUME (liters)	MAL CONC. (ppm)
abvstrp	h	1	1	406	36	2 9	<7 9
abvstrp	h	2	2	368	39	3 1	<7 3
abvstrp	h	4	2	376	40	3 2	<7 2
abvstrp	h	5	1	426	48	3 8	<5 9
abvstrp	h	9	1	394	33	2 6	<8 7
abvstrp	h	9	2	440	28	2 2	<10
abvstrp	h	9	3	14	35	2 8	<8 2
abvstrp	l	1	2	446	37	3 0	7 7
abvstrp	l	3	1	405	34	2 7	<8 4
abvstrp	l	4	1	411	43	3.4	<6 7
abvstrp	l	6	2	389	35	2 8	<8 2
abvstrp	l	7	3	4	40	3 2	<7 2
abvstrp	l	8	1	434	34	2 7	<8 4
abvstrp	l	8	2	400	39	3 1	<7 3
abvstrp	m	2	1	408	43	3 4	<6 7
abvstrp	m	3	2	367	33	2 6	<8 7
abvstrp	m	5	2	373	32	2 6	<8 9
abvstrp	m	6	1	423	34	2 7	<8 4
abvstrp	m	7	1	430	33	2 6	<8 7
abvstrp	m	7	2	382	37	3 0	<7 7
abvstrp	m	8	3	10	30	2 4	<9 5
backflr	h	1	1	407	32	2 6	<8 9
backflr	h	2	2	365	38	3 0	<7 5
backflr	h	4	2	377	43	3 4	<6 7
backflr	h	5	1	417	44	3 5	<6 5
backflr	h	9	1	447	34	2 7	<8 4
backflr	h	9	2	392	35	2 8	<8 2
backflr	h	9	3	12	35	2 8	<8 2
backflr	l	1	2	449	38	3 0	<7 5
backflr	l	3	1	420	31	2 5	<9 2
backflr	l	4	1	415	45	3 6	11
backflr	l	6	2	388	35	2 8	22
backflr	l	7	3	3	33	2 6	43
backflr	l	8	1	435	33	2 6	<8 7
backflr	l	8	2	391	37	3 0	15
backflr	m	2	1	410	44	3 5	<6 5
backflr	m	3	2	364	33	2 6	<8 7
backflr	m	5	2	374	32	2 6	<8 9
backflr	m	6	1	425	34	2 7	<8 4
backflr	m	7	1	383	36	2 9	<7 9
backflr	m	7	2	437	40	3 2	<7 2
backflr	m	8	3	8	35	2 8	<8 2
personal	h	1	1	401	32	2 6	<8 9
personal	h	2	2	363	39	3 1	7 3
personal	h	4	2	375	43	3 4	8 9
personal	h	5	1	429	43	3 4	<6 7

Table A-2
J.M Murray Center
Methanol Sorbent Tube Sample Results
April 18-20, 1990

LOCATION	VENT FLOW RATE	SET NUMBER	DAY	SAMPLE NUMBER	RUN TIME (min)	SAMPLE VOLUME (liters)	MAL CONC. (ppm)
personal	h	9	1	445	34	2 7	<8 4
personal	h	9	2	398	37	3 0	31
personal	h	9	3	13	35	2 8	27
personal	l	1	2	441	40	3 2	26
personal	l	3	1	418	33	2 6	48
personal	l	4	1	414	42	3 4	33
personal	l	6	2	386	35	2 8	25
personal	l	7	3	5	32	2 6	36
personal	l	8	1	432	36	2 9	24
personal	l	8	2	393	37	3 0	39
personal	m	2	1	404	43	3 4	8 9
personal	m	3	2	361	30	2 4	25
personal	m	5	2	390	30	2 4	<9 5
personal	m	6	1	427	34	2 7	11
personal	m	7	1	433	27	2 2	<10 6
personal	m	7	2	387	37	3 0	28
personal	m	8	3	7	35	2 8	14
plenum	h	2	2	370	39	3 1	29
plenum	h	4	2	371	50	4 0	53
plenum	h	5	1	421	49	3 9	19
plenum	h	9	1	442	36	2 9	34
plenum	h	9	2	396	31	2 5	43
plenum	h	9	3	15	35	2 8	60
plenum	l	1	2	448	41	3 3	63
plenum	l	6	2	385	37	3 0	130
plenum	l	7	3	2	32	2 6	180
plenum	l	8	1	436	35	2 8	55
plenum	l	8	2	397	37	3 0	59
plenum	m	3	2	362	31	2 5	40
plenum	m	5	2	378	30	2 4	60
plenum	m	6	1	422	35	2 8	33
plenum	m	7	1	439	34	2 7	40
plenum	m	7	2	395	44	3 5	35
plenum	m	8	3	9	40	3 2	36

KEY

abvstrp – area sample above stripping tank
backflr – area sample behind stripping tank on the floor
backwall – area sample behind stripping tank on wall
personal – worker's personal breathing zone sample
plenum – sample in the exhaust system
h – high
m – medium
l – low