IN-DEPTH SURVEY REPORT

CONTROL OF METHYLENE CHLORIDE IN FURNITURE STRIPPING

AT

Tri-County Furniture Stripping and Refinishing
Cincinnati, Ohio

REPORT WRITTEN BY
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Centers for Disease Control
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PLANT SURVEYED	Tri-County Furniture Stripping and Refinishing 1101 Springfield Pike Cincinnati, Ohio 45246
SIC CODE	7641
SURVEY DATE	September 11-13, 1991
SURVEY CONDUCTED BY	Ronald M Hall Kenneth F Martinez Paul A Jensen, P E
EMPLOYER REPRESENTATIVES CONTACTED	Jerry Ashe, Co-owner
EMPLOYEE REPRESENTATIVES CONTACTED	None (non-union)
VENTILATION SYSTEM FABRICATED BY	Daniel S Watkins

DISCLAIMER

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

INTRODUCTION

Under the authority of the Occupational Safety and Health Act of 1970 (Public Law 91-596), the National Institute for Occupational Safety and Health (NIOSH), located in the Department of Health and Human Services (formerly DHEW), conducts research to prevent occupational safety and health problems 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) in the Department of Labor An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control

Since 1976, ECTB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques Examples of these completed studies include the foundry industry, various chemical manufacturing or processing operations, spray painting, biotechnology processes, and the recirculation of exhaust air 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 for 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 particular research effort (the subject of this in-depth survey) was prompted by the growing concern of the hazards of methylene chloride and the need for technical advice to furniture strippers For years, methylene chloride and methanol have been the primary constituents in paint stripping solutions Methylene chloride provides the furniture stripper with an effective and efficient paint remover This project will evaluate the technology available for the control of hazardous substances in furniture stripping applications, particularly methylene chloride vapors

Tri-County Furniture Stripping and Refinishing was selected as a site to conduct an in-depth survey because of the methylene chloride based paint stripper used in their dip tank and the ventilation system that was installed at the facility The ventilation system was designed for this facility because of the need to further reduce exposures to methylene chloride in the facility

This report contains results of the in-depth survey, conclusions, and recommendations relevant to the operations at Tri-County Furniture Stripping and Refinishing The recommendations, if followed, can help lower worker exposure to methylene chloride vapors

PLANT AND PROCESS DESCRIPTION

PLANT DESCRIPTION

Tri-County Furniture Stripping and Refinishing was founded in 1978 This facility currently employs six full-time men, inclusive of the co-owners Two persons regularly strip furniture on a daily basis and the other four perform refinishing operations The furniture stripping area occupies 300 square feet of the 1,500 square foot work area

PROCESS DESCRIPTION

This workplace is divided into three areas furniture stripping, spray painting, and the workshop area Paint stripping is performed on pieces of furniture to be refinished as well as unfinished This facility strips and refinishes furniture on a continuous basis throughout the workday Furniture stripping does generate considerable paint sludge which is collected by the owners who pay for its pickup and disposal through a contractor Several 55 gallon drums of solvents are stored outside the garage door to the stripping area

Many furniture stripping solutions are pre-formulated solutions that are transferred to their process equipment by pouring or pumping In some instances, raw materials are purchased in bulk quantities and subsequently mixed on site both for use at this facility and for consumer and franchise sales

Paint from furniture is stripped by dipping the object in an open tank containing the appropriate stripping solution, by spraying or brushing recycled stripper on the surface of the furniture in a large open tank (Flow-Over, System), by a combination of these two methods, or by manual application of the stripper to the furniture There is little standardization in the industry due to the diversity in size, construction, and finish of items to be stripped and type of stripping solution used

Tri-County Furniture Stripping and Refinishing mixes their own stripping solutions They generally follow the "Old DuPont" formulation which includes methylene chloride, methanol, acetone, xylene, toluene, and sodium hydroxide Recently the facility started using liquid C with ingredients of methylene chloride, perchloroethylene, 1,1,1-trichloroethane, and toluene Liquid C makes up 5 to 10 percent of the stripping solution in the dip tank and is added as a temporary filler when the solution in the tank is low Paint is stripped from furniture by depositing the object into a dip tank In some instances a heated caustic soda solution dip tank is used on finishes for which methylene chloride is marginally effective Enamel painted doors, windows, and shutters are normally stripped in this tank

POTENTIAL HAZARDS

Potential chemical hazards in the furniture stripping industry are found primarily during the actual handling and stripping of the furniture Other exposure sources may include the rinsing of the furniture after stripping, the mixing or transferring of stripping solution, the evaporation of solution, or the evaporation of solution off furniture after stripping The major routes of entry of methylene chloride and other solvents into the body include inhalation of vapors and absorption of the liquid through the skin The severity of the hazard depends on the formulation of the stripping solution, type of operation (i e , dip tank, flow-over system, hand stripping), work practices, duration of exposure, temperature, ventilation (i e , type of system, location relative to worker, air patterns, and flow rates), and general workstation design

Health effects studies of methylene chloride exposure have been focused on three primary areas effects on the central nervous system, effects on cardiovascular morbidity and mortality, and induction of cancer in exposed workers [1] Most recently, research has shown methylene chloride as a possible reproductive toxicant [2] In addition, solvents are known to affect liver function, some studies suggest that this effect occurs secondary to methylene chloride exposure Repeated skin contact with methylene chloride may cause dry, scaly, and cracked skin At high airborne concentrations (greater than 500 ppm), vapors are irritating to the eyes and upper respiratory tract Direct contact with the liquid can cause skin burns Methylene chloride is a mild narcotic Effects from intoxication include headache, giddiness, stupor, irritability, numbness, and tingling in the arms and legs The reports of odor threshold range from 25-350 ppm [1]

Methanol has very similar central nervous system effects to methylene chloride Breathing very high concentrations may produce headache, weakness, drowsiness, light-headedness, nausea, vomiting, drunkenness, irritation of the eyes, blurred vision, blindness, and even death Methanol may also cause liver and kidney damage [1]

Perchloroethylene, toluene, and 1,1,1-trichloroethane were ingredients in the temporary filler liquid C which makes up 5 to 10 percent of the stripping solution Breathing high concentrations of perchloroethylene may produce headache, nausea, drowsiness, dizziness, incoordination, and unconsciousness It may also cause irritation of the eyes, nose, and throat, and flushing of the face and neck Long-term exposure effects may include damage to the liver and kidneys [3]

Breathing high concentrations of toluene may include short-term effects of irritation of the eyes, respiratory tract, and skin Other short-term effects may include fatigue, weakness, confusion, headache, dizziness, and drowsiness Very high concentrations of toluene may cause unconsciousness and death [3]

The short-term effects from high concentrations of 1,1,1-trichloroethane may include headache, dizziness, drowsiness, unconsciousness, irregular heart beat, and death Prolonged or repeated contact may cause irritation of the skin Also reproductive abnormalities have been noted in studies of animals exposed to high concentrations [3]

ENVIRONMENTAL 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, 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 criteria 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 in the United States, that can be used for the workplace, are NIOSH Recommended Exposure Limits (REL) and the U S Department of Labor (OSHA) Permissible Exposure Limits (PEL) The OSHA PELs are required to consider 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 the prevention of occupational disease It should be noted that industry is legally required to meet only those levels specified by an OSHA PEL

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

The current OSHA PEL for methylene chloride (29 CFR 1910 1000 Table Z-2) is an 8-hour TWA concentration of 500 parts per million (ppm), with a ceiling concentration of 1000 ppm, and a maximum peak concentration of 2000 ppm for no more than five minutes within any two hours This PEL was derived from a standard recommended by the American National Standards Institute (ANSI) and adopted in 1971 without rulemaking [4] The Federal Register dated Thursday, November 7, 1991, published OSHA's Proposed Rule of 25 ppm with a action level of 12 5 ppm and a short-term exposure limit (STEL) of 125 ppm for the occupational exposure to methylene chloride [5]

In 1976, the NIOSH REL for methylene chloride was 75 ppm, as a TWA for up to 10 hours per day, 40 hours per week, with a 500 ppm peak exposure as determined over any 15-minute sampling period during the workday This REL was based on the need to prevent significant reduction in the oxygen carrying capacity of the blood which affects the central nervous system [6] Then 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 [7] This new recommendation was based on the observation of cancers and tumors in both rats and mice exposed to methylene chloride in air [8] Table 1 summarizes the exposure criteria for chemical agents which were encountered at this facility

Table 1 Exposure Criteria		
	OSHA PEL 29 CFR 1910 1000 TABLE Z-1	NIOSH REL[7]
METHANOL	TWA 200 ppm	TWA 200 ppm with a STEL of 250 ppm and a skin notation
PERCHLOROETHYLENE	TWA 25 ppm	Lowest feasible limit
TOLUENE	TWA 100 ppm with a STEL of 150 ppm	TWA 100 ppm with a STEL of 150 ppm
1,1,1-TRICHLOROETHANE	TWA 350 ppm with a STEL of 450 ppm	Ceiling limit of 350 ppm
METHYLENE CHLORIDE	TWA 500 ppm with a ceiling limit of 1000 ppm and no more than 5 min at 2000 ppm within any 2 hours	Lowest feasible limit

CONTROLS

PRINCIPLES OF CONTROL

Occupational exposure can be controlled by the application of a number of well-known principles, including engineering measures, work practices, personal protection, and monitoring These principles may be applied at or near the hazard source, to the general workplace environment, or at the point of occupational exposure to individuals Controls applied at the source of the hazard, including material substitution, process or equipment modification, isolation or automation, local ventilation, and work practices are generally the preferred and most effective in terms of both occupational and environmental concerns Controls which may be applied to hazards that have escaped into the workplace environment include dilution ventilation, dust suppression, and housekeeping Control measures may also be applied near individual workers, including the use of ventilated control rooms, isolation booths, supplied-air cabs, work practices, and personal protective equipment

In general, a system comprised of the above control measures is required to provide worker protection under normal operating conditions as well as under conditions of process upset, failure, and/or maintenance Process and workplace monitoring devices, personal exposure monitoring, and medical monitoring are important mechanisms for providing feedback concerning effectiveness of the controls in use Ongoing monitoring and maintenance of controls to insure proper use and operating conditions, and the education and commitment of both workers and management to occupational health are also important ingredients of a complete, effective, and durable control system

These principles of control apply to all situations, but their optimum application varies from case to case The application of these principles is discussed below

ENGINEERING CONTROLS

After a survey conducted by the Industry Wide Studies Branch (IWSB) of the Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS) of NIOSH, the owners of this facility installed a single slot hood at each end of the dip tank [9] The air velocity at the slot averaged approximately 500 fpm and the flow through each slot averaged approximately 700 cfm, as determined using a TSI Model 1650 Air Velocity Meter (TSI, Inc , St Paul, MN) The wall fan between the dip tank and the rinse area exhausted at a rate of approximately 3000 cfm IWSB researchers returned to Tri-County to test the new local ventilation and noted a reduction in methylene chloride exposure from 2160 ppm to 230 ppm (90 minute samples)

Because methylene chloride is a suspect human carcinogen and OSHA has a proposed rule of 25 ppm, a new ventilation system was designed The ventilation system was designed for furniture stripping dip tanks in order to control methylene chloride exposures to a lower level than those observed during the IWSB study and the initial walk-through survey NIOSH researchers from the Engineering Control Technology Branch (ECTB) recommended, constructed, and installed the newly designed local exhaust ventilation system at this facility The ventilation system was constructed of galvanized sheet metal (22 gauge) with reinforcement steel used on stress points in order to maintain the system's physical integrity A plenum was attached to the front end of the tank and to the slot hoods on each side of the tank in order to obtain even airflow distribution throughout the system A 12" diameter duct ran from the center of the front plenum, through the wall of the building, into a fan located outside For this evaluation, a portable, gasoline powered fan (Coppus model number TE-6) rated at 4100 cfm in free air was used Figure 1 shows a diagram of this newly designed local exhaust ventilation system

The average slot velocity during the three day sampling period was 3200 feet per minute (fpm) and the average exhaust flow was 2900 cubic feet per minute (cfm) at 4" static pressure The exhaust flow was evaluated each day using a standard pitot tube with an incline manometer (Dwyer model 400) on the exhaust duct of the system located 6' above the fan With the exception of an open overhead door at the entrance of the shop, other dilution ventilation was

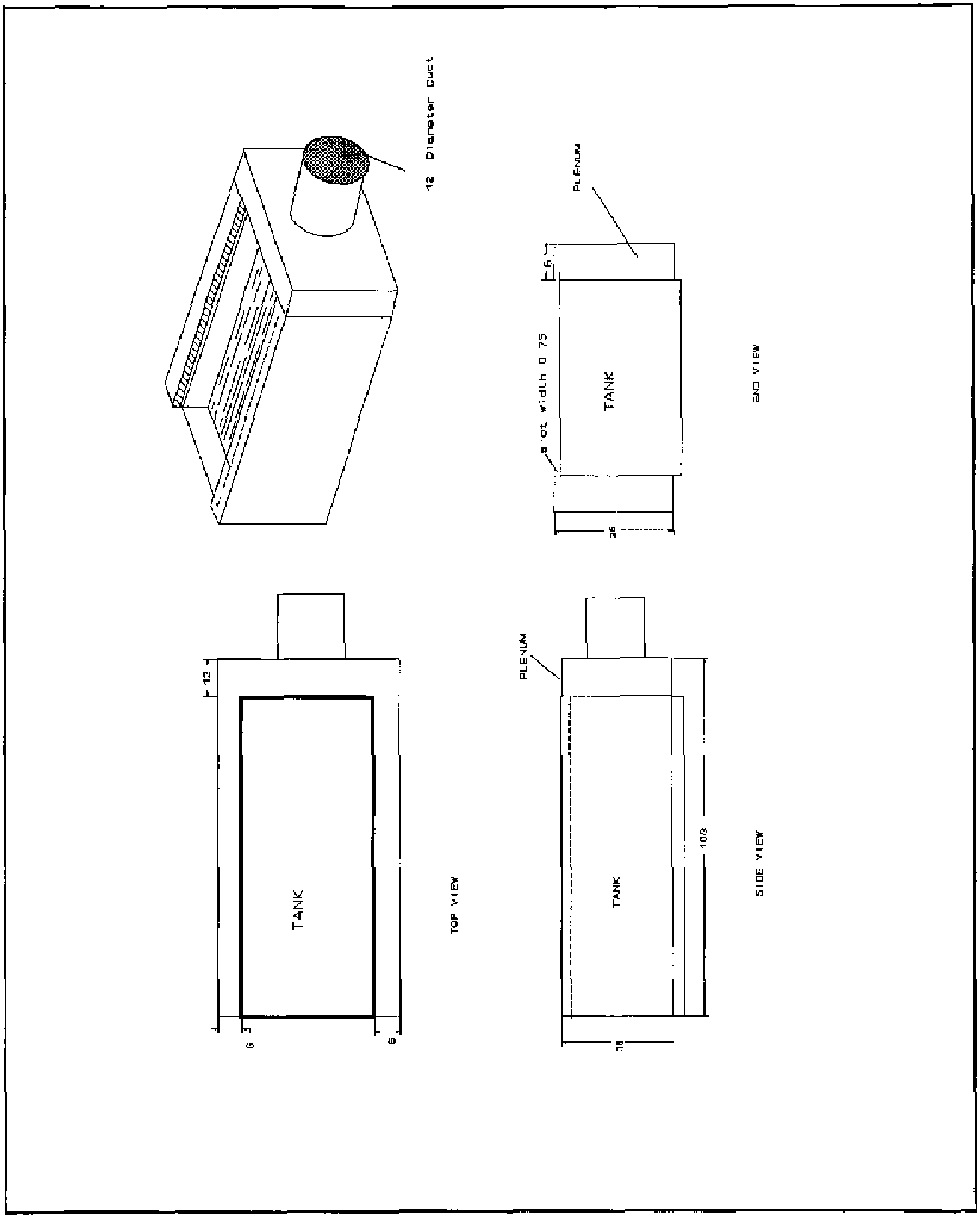

Figure 1   Exhaust Hood Attached to Furniture Stripping Dip Tank

provided by a wall fan in the paint booth located in the finishing area and two small wall fans located in the stripping/rinsing area of the building

Local exhaust ventilation at the source of methylene chloride is the best primary control of vapors short of using a nonmethylene chloride product General room ventilation must also be considered as a necessary secondary control method On September 12, 1991, samples were collected in the morning before the shop opened for business and analyzed by a SCENTOGRAPH (Sentex Sensing Technology, Ridgefield, NJ), a portable, computer operated gas chromatograph (GC) with an Argon Ionization Detector (AID) At this time, methylene chloride had a concentration of 1000 ppm, and methanol was 200 ppm Vapors in the building will build up if there is not sufficient air movement or exchange It is recommended that the local exhaust ventilation system be started and run prior to entering the building Figure 2 depicts principles of dilution ventilation and shows the importance of fan location [10]

ENVIRONMENTAL MONITORING

During this survey, quantitative air sampling was conducted for methylene chloride, methanol, toluene, perchloroethylene, and 1,1,1-trichloroethane Several pieces of furniture were stripped during the three days of our in-depth survey Personal air samples were collected side-by-side in the breathing zone of the worker for the duration of the stripping Samples for methylene chloride, perchloroethylene, toluene, and 1,1,1-trichloroethane were collected on two 50/100 mg charcoal sorbent sample tubes (SKC 226-01, SKC, Inc , Eighty-four, PA) in series, and samples for methanol were collected on 75/150 silica gel sorbent sample tubes (SKC 226-10, SKC, Inc , Eighty-four, PA) Sampling was conducted at a nominal flow rate of 0 02 liters per minute (lpm) using a personal sampling pump (P200A, E I DuPont DeNemours & Co , Inc , Wilmington, DE)

In addition, real-time exposure to total solvents present in the breathing zone of the worker was measured using a TIP II (PHOTOVAC, Inc , Thornhill, Ontario, Canada) with a 10 6 Ev ultraviolet lamp The TIP II responds to the mixture of both methylene chloride and methanol vapors The analog output signal from the TIP II was collected on a Rustrak, Ranger data logger (Gulton Industries, Inc , E Greenwich, RI) The data logger was later downloaded to a COMPAQ Portable III, (COMPAQ Computer Corp , Houston, TX) for further data analysis Grab samples of air from the exhaust of the TIP II were analyzed using a SCENTOGRAPH (Sentex Sensing Technology, Ridgefield, NJ), a portable, computer operated, gas chromatograph (GC) with an Argon Ionization Detector (AID) to give the NIOSH researchers a near real-time indication of the exposure of the workers to methylene chloride and methanol Results indicate that the ratio of methylene chloride concentration to the methanol concentration is relatively constant Thus, the TIP II should respond proportionally the same, regardless of absolute concentration Since the ratio of the two concentrations was relatively constant, back-calibration ofthe real-time TIP II exposure data was performed using the sorbent tube data Appendix A shows how the real-time exposure was estimated using the sorbent tube data

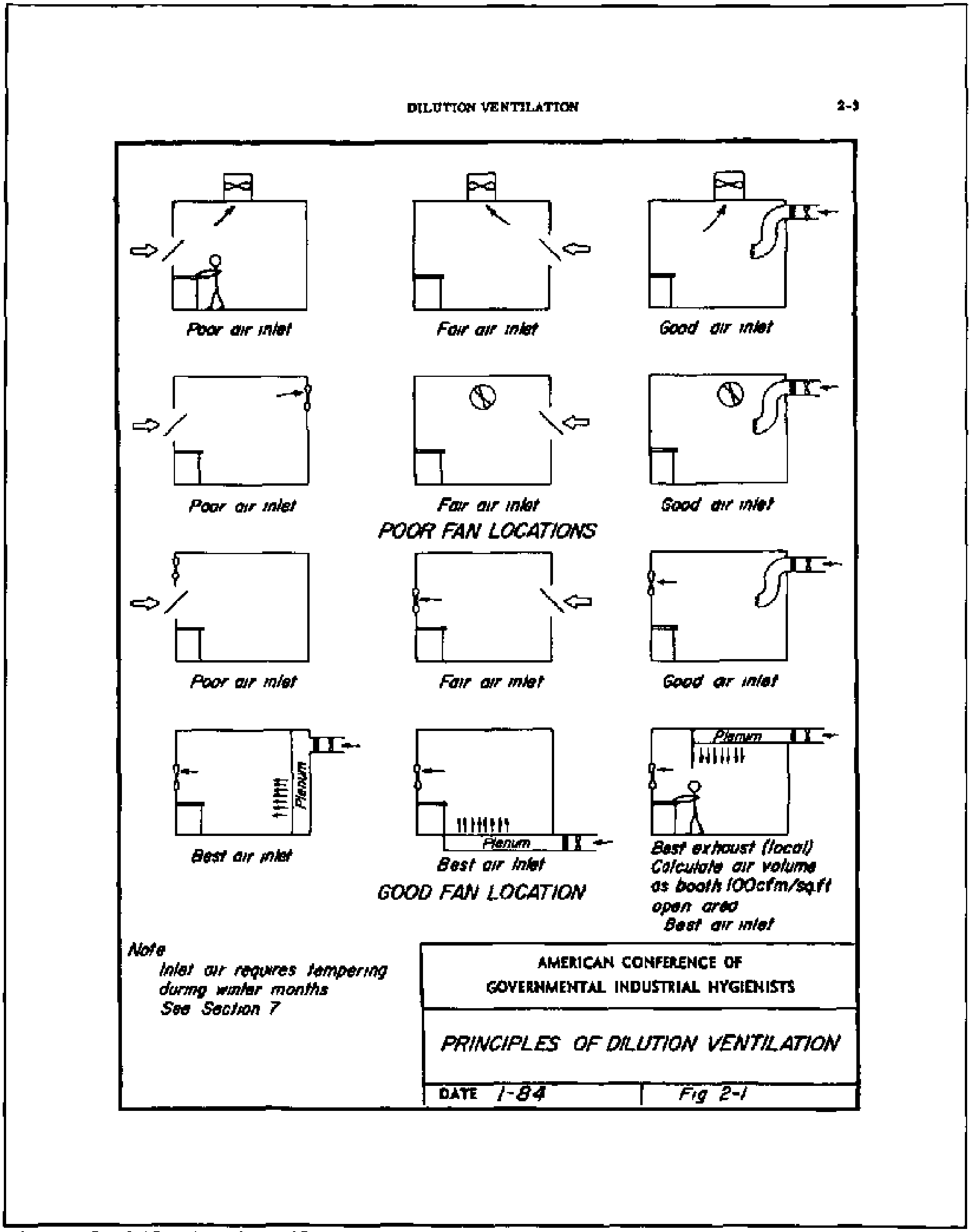

Figure 2 Dilution Ventilation

Area samples for methylene chloride, perchloroethylene, toluene, and 1,1,1-trichloroethane were collected using the same method as described above for personal samples for methylene chloride Area samples for methanol were collected using the same method described above for personal samples for methanol Six sets of area samples were collected (see Figure 3) one behind the dip tank (near the rinse area), one on a table (near the rinse area), one along the wall (in the storage area), one on the caustic tank (near the rinse area), one above the dip tank (on the plenum near the fan), and one located outside the building (near the office as a background sample)

All sorbent tubes were sent to DataChem (Salt Lake City, UT) for analysis using the appropriate method from the NIOSH Manual of Analytical Methods (NMAM) [11]

Chemical Name	NMAM No
Methylene Chloride	1005
Methanol	2000
Perchloroethylene	1003
Toluene	1500
1,1,1-Trichloroethane	1003

PERSONAL PROTECTIVE EQUIPMENT

While stripping at the dip tank, it was observed that Worker A wore a rubber apron, neoprene gloves, and safety glasses Worker B wore neoprene gloves and a rubber apron while stripping and rinsing

RESULTS AND DISCUSSION

METHYLENE CHLORIDE
- Personal Samples

The rinse area was located behind the furniture stripping dip tank (see Figure 3) During the survey, stripping and rinsing operations were generally performed at the same time Airflow patterns through the shop indicate that the air flows through the rinse area into the stripping area (see Figure 3) This would indicate that rinsing operations being performed at the same time as stripping operations could add to exposure concentrations of the operator at the stripping tank Samples for methylene chloride were collected during stripping operations with rinsing operations being performed and also during stripping only operations Although stripping only operations were not continuously conducted over an eight hour workday, stripping only operation data can be indicative of TWA exposures, since stripping operations are usually performed over the entire workday

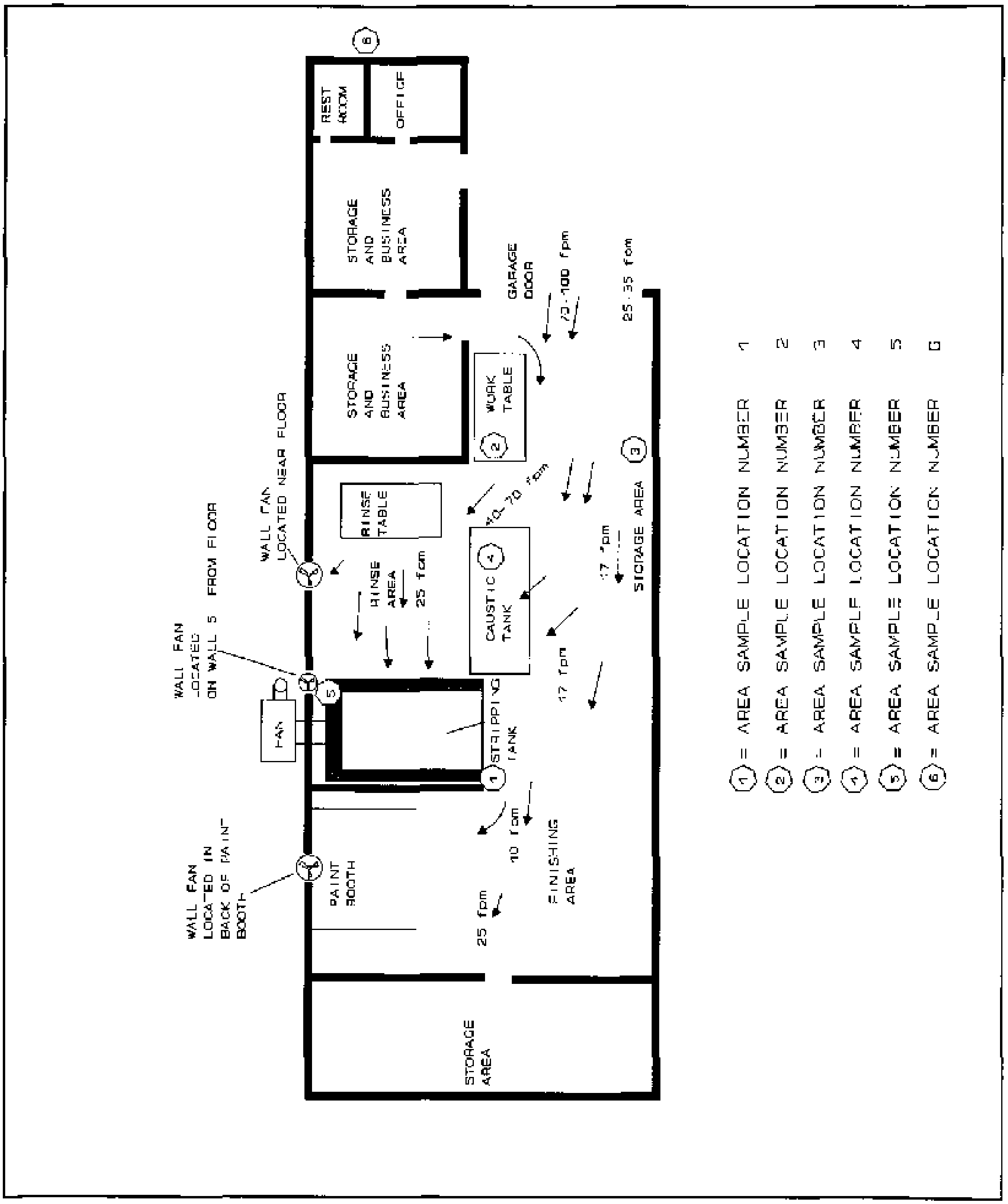

Figure 3 Tri-County Furniture Stripping and Refinishing Shop Layout With Air Currents Plotted

Figure 4 summarizes the personal air sampling data collected for methylene chloride during the survey The results of the personal air sampling data for methylene chloride are summarized in Table 2 Table 3 presents weighted personal exposures to methylene chloride in ppm by day Individual personal air sampling data for methylene chloride are listed in Appendix B All sample results were assumed to be log-normally distributed, statistical analyses were performed on the log-transformed data [12] The differences between stripping only and rinsing/stripping personal air samples were analyzed by a t-test

During rinsing/stripping sampling periods Worker A had a geometric mean of 26 ppm of methylene chloride Worker B during rinsing/stripping sampling periods had a geometric mean of 59 ppm of methylene chloride The difference in exposure of Worker B during rinsing/stripping sampling periods and Worker A was contributed to Worker A not performing rinsing operations The geometric mean for Worker A and Worker B combined during rinsing/stripping sampling periods was 41 ppm During stripping only sampling periods, Worker A had a geometric mean of 13 ppm of methylene chloride Worker B, during stripping only sampling periods, had a geometric mean of 13 ppm of methylene chloride During stripping only operations the geometric mean for Worker A and Worker B combined was 13 ppm A time weighted average (TWA) of methylene chloride exposure was calculated for each worker by day On September 11, 1991, the TWA for Worker A was 36 ppm and Worker B 70 ppm Worker A had a TWA of 14 ppm on September 12, 1991, and Worker B 46 ppm On September 13, 1991, the TWA of Worker A was 46 ppm and Worker B 48 ppm

During the survey, Worker A was in and out of the building performing other duties, therefore, Worker A was not exposed as long as Worker B who performed rinsing and stripping operations throughout the day Worker A did not perform any rinsing operations during the survey, although, he did perform stripping operations at the same time rinsing was being accomplished Therefore, because of the carry-over from the rinse area, exposures during stripping/rinsing operations were higher than stripping only operations for Worker A Data collected for Worker B during the survey did show a statistically significant difference between stripping/rinsing operations and stripping only operations The geometric mean of Worker A/B also showed a statistically significant difference between stripping/rinsing operations and stripping only operations This statistical significance indicates the contribution of the rinsing operation to the methylene chloride exposures of the worker This hypothesis is further validated by the lack of statistical significance between stripping only operations and stripping/rinsing operations for Worker A, Worker A did not perform any rinsing operations during the survey

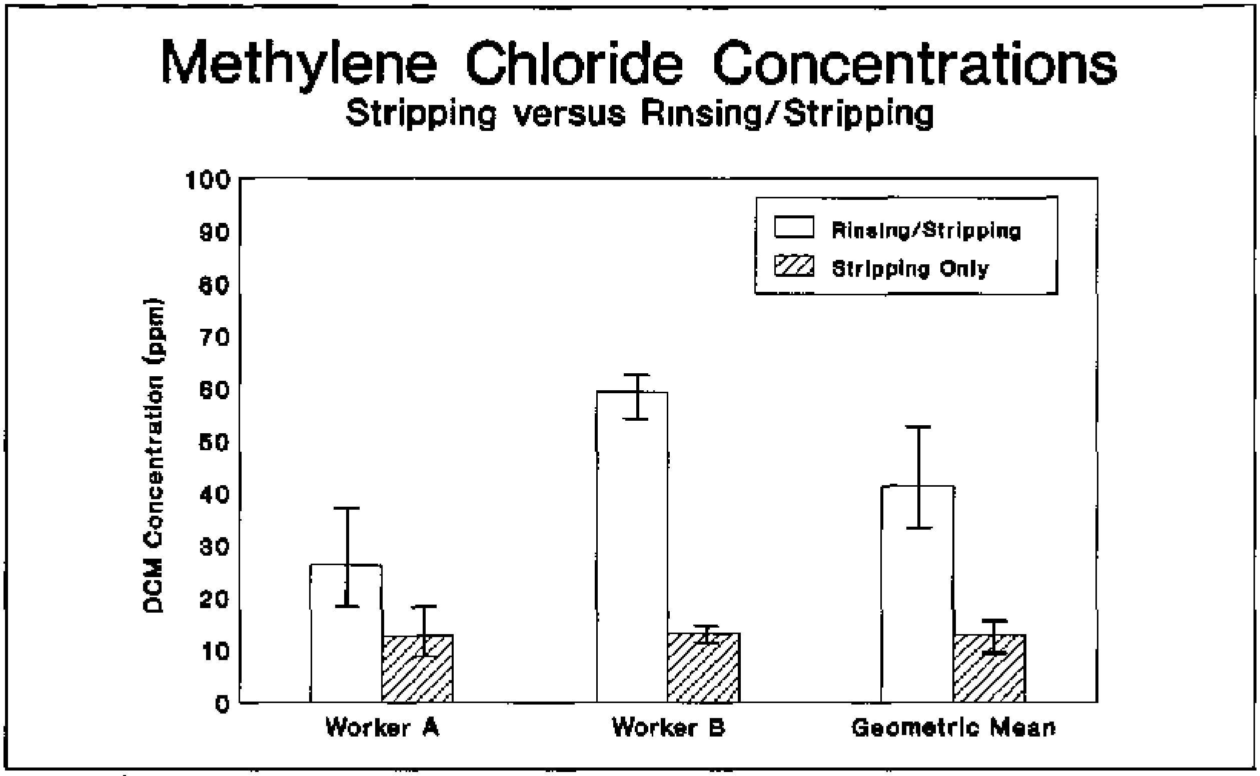

Figure 4 DCM Concentrations During Personal Air Sampling

Table 2 Personal Concentrations of DCM During Stripping/Rinsing Operations and Stripping Only Operations With 95% Confidence Levels Calculated

	GEOMETRIC MEAN	GEOMETRIC STANDARD DEVIATION	UPPER 95% CONFIDENCE LIMIT	LOWER 95% CONFIDENCE LIMIT
STRIPPING AND RINSING				
WORKER A	26	2 6	38	18
WORKER B	59	1 4	63	56
AVERAGE	41	2 2	52	33
STRIPPING ONLY				
WORKER A	13	2 0	19	9
WORKER B	13	1 4	14	12
AVERAGE	13	1 6	16	10

Table 3 Weighted Average of Methylene Chloride (ppm) of Worker by Day			
	September 11, 1991	September 12, 1991	September 13, 1991
WORKER A	36	14	6
WORKER B	70	46	48

- Area Samples

Figure 5 and Table 4 summarize area sampling data collected during the survey Individual area sampling data is listed in Appendix C Figure 3 shows the location of the area samplers

The following area sample results are reported in parts per million of methylene chloride All sample results were assumed to be log-normally distributed, statistical analyses were performed on log transformed data [12] These sample results were analyzed by an analysis of variance [13] There is a significant difference (0 05 significance level) in concentration between area samples 1, 2, 3, 4, and 5 versus area 6 (background) Area 1 was

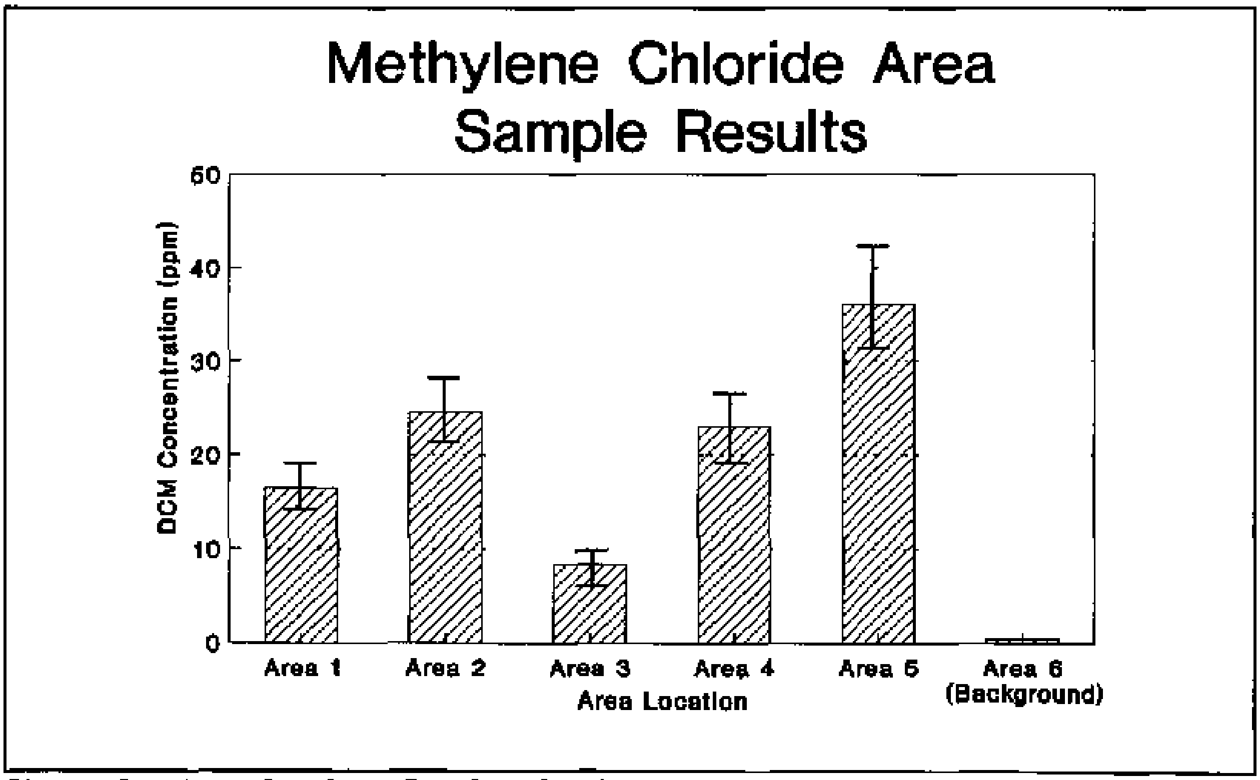

Figure 5 Area Sampling Results for DCM

Table 4 Area Sample Concentrations of DCM (ppm)				
	GEOMETRIC MEAN	GEOMETRIC STANDARD DEVIATION	UPPER 95% CONFIDENCE LIMIT	LOWER 95% CONFIDENCE LIMIT
AREA 1	17	2 04	19	14
AREA 2	24	1 77	29	21
AREA 3	8	1 61	10	7
AREA 4	23	1 95	27	20
AREA 5	36	1 49	42	31
AREA 6	0 49	1 25	0 57	0 42

significantly different (0 05 significance level) in concentration versus areas 2, 4, and 5 Area 1 was not located near the rinse area, therefore, it was not influenced as much by rinsing operations as are areas 2, 4, and 5 According to the air currents plotted on September 13, 1991, (see Figure 3) the air flowed through the rinse area into the stripping area then exhausted out through the ventilation system on the tank and the wall fan located above the tank Area 5 was located on the plenum of the ventilation system with the sorbent tubes located in front of the wall fan Area 2 (located on table near rinse area), area 4 (located on caustic tank near rinse area), and area 5 were influenced more by the rinsing operations than area 1 (located on the back side of the stripping tank) and area 3 (located on the wall in the storage area) There is no significant difference (0 05 significance level) in concentrations between areas 2, 4, and 5 Area 3 (located on the wall in the storage area) was significantly (0 05 significance level) different than areas 2, 4, and 5

METHANOL

Results of the methanol samples are listed in Appendix D The methanol weighted average exposure on September 11, 1991, for Worker A was 27 ppm and for Worker B 40 ppm On September 12, 1991, the weighted average exposure for Worker A was 11 ppm and Worker B was 22 ppm On September 13, 1991, the weighted average exposure for Worker A was 25 ppm and Worker B was 14 ppm Area sample results for methanol during the three days of evaluation are as follows area sample 1 average 13 ppm, area sample 2 averaged 16 ppm, area sample 3 averaged 6 ppm, area sample 4 averaged 20 ppm, area sample 5 averaged 24 ppm, and the background sample (area 6) averaged 1 ppm These values are all below the OSHA PEL and NIOSH REL of 200 ppm for methanol When sampling for methanol, using 75/150 silica gel sorbent sampling tubes, water vapor can interfere with the collection efficiency resulting in a decrease in the capacity of the sampling tube During the three days of this survey, relative humidity ranged from 60 to 100 percent, possibly affecting the efficiency of the 75/150 silica gel tube This affects the methanol results by the water vapor attaching to the silica gel and saturating the silica gel sorbent tube, potentially allowing methanol to flow through This is evidenced by the fact that most of the detected methanol samples contained more than 30 percent of the total methanol in the back section of the silica gel sorbent tube However, the methanol silica gel tube results did seem to correspond to the near real-time GC short-term sampling results

TOLUENE

Personal and area samples were analyzed for toluene The arithmetic mean during stripping only operations was 3 ppm, and during stripping/rinsing operations the arithmetic mean was 4 ppm The area samples had an arithmetic mean of 4 ppm These results are well below the OSHA PEL and the NIOSH REL of 100 ppm

1,1,1-TRICHLOROETHANE

The samples analyzed for 1,1,1-trichloroethane had 65 percent non-detected The detectable samples for 1,1,1-trichloroethane had a mean of 4 ppm with the highest reportable concentration of 5 ppm These values are well below the OSHA TWA PEL of 350 ppm and the NIOSH REL ceiling limit of 350 ppm

PERCHLOROETHYLENE

The limit of detection for perchloroethylene was 0 01 mg/sample No detectable levels of perchloroethylene were found

REAL-TIME DATA

The real-time exposure data estimated using the personal sorbent tube data, real-time TIP II data, and near real-time GC data are shown graphically in Appendix E The y-axis scale for the graphs in Appendix E is the concentration of methylene chloride and methanol in ppm The x-axis is the time of day, using a 24-hour clock

The following data is discussed in response to the proposed 125 ppm short-term exposure limit (STEL) [5] Results of 15-minute averages calculated over the work-shift at the dip tank are shown graphically in Figures 1-6 in Appendix E Analysis of the real-time data allows a 15-minute average to be calculated for any point in the work-shift

A separate 15-minute average was calculated using each 15-second increment To do this, an average was calculated for the time period extending 7 5 minutes before and 7 5 minutes after each 15-second increment Thus, for an 8-hour time period, it would be possible to calculate 1,860 possible 15-minute averages, each one centered on a different 15-second increment Using this approach, the values of 15-minute averages, calculated every 15-seconds are shown in Appendix E Between 87 and 100 percent of these averages were below 125 ppm of methylene chloride The NIOSH researchers judged that, in cases where the peak exposures were above 125 ppm, the cause was largely due to the rinsing operation, which was not as well controlled as the stripping operation As shown in Figures 1-6 in Appendix E, at no time during the three days of sampling did the methylene chloride exposure exceed the 2000 ppm maximum acceptable peak set forth in OSHA Regulations [4]

Temperature and humidity were monitored continuously during the three-day survey using a Rustrak Ranger data logger with a special probe (POD 29/03) The data logger was later downloaded as previously mentioned The temperature ranged from 19 to 33°C and the relative humidity ranged from 60 to 100 percent The temperature and relative humidity are shown graphically in Appendix E

CONCLUSIONS AND RECOMMENDATIONS

The personal air sampling results indicate that the engineering control on the furniture stripping dip tank effectively controlled personal exposures to methylene chloride to 13 ppm when stripping only operations were being performed When rinsing was being performed at the same time, there was an added effect on exposures to the worker conducting stripping and/or rinsing Exposure while rinsing was greater than while stripping or performing any other task, mainly due to the rinse area not having engineering controls

RINSE AREA

It is recommended that the owners apply an effective control to the rinse area in order to reduce methylene chloride concentrations For example, a simple design enclosure could be placed around the rinse area with a wall fan located in the back of the enclosure (see Figure 6 for an example of a ventilation

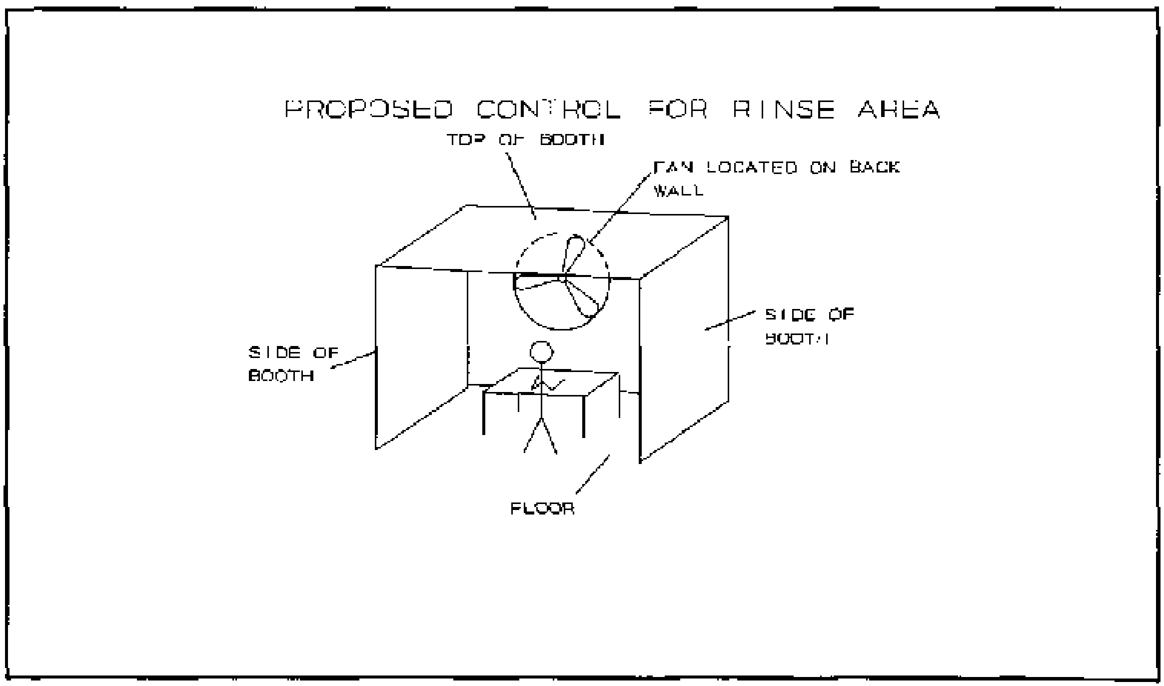

Figure 6 Proposed Control for Rinse Area

system for the rinse area) This system would be similar to the paint booth located in the finishing area There should be a velocity of 100 feet per minute (fpm) at the face of the booth For example with an opening of 6' wide and 7' high at the face of the booth the face area would be 42 square feet The area of the face of the booth (42 square feet) times 100 (in order to have 100 fpm at the face of the booth) would be 4200 cubic feet per minute (cfm) Four thousand two hundred cfm would be needed in order to operate this system, therefore, the fan selected should have the capacity to pull 4200 cfm When rinsing with this type of system, the operator should always keep the furniture between himself and the wall fan so the airflow is directed out the fan and not across the operator's breathing zone This type of system also could be designed with fire proof curtains that could be movable in order to rinse large pieces of furniture

Figure 7 shows the personal exposure reduction of methylene chloride concentrations in the Tri-County Furniture Stripping and Refinishing shop Personal sampling concentrations in the shop with no control were 2160 ppm, with the old control installed by the shop 230 ppm, with the new control during rinsing and stripping operations 41 ppm, and the new control during stripping only operations 13 ppm [9]

PERSONAL PROTECTIVE EQUIPMENT RECOMMENDATIONS

In operations where splashing, spilling, spraying, or skin and eye contact with methylene chloride may occur, employees should wear protective solvent-impermeable gloves (long enough to cover the forearms), aprons, shoe coverings, and chemical splash goggles Unfortunately, <u>no</u> elastomer provides good protection from liquid contact Neoprene (currently used), butyl rubber, nitrile rubber, or polyvinyl chloride (PVC) provide limited protection against methylene chloride and should be used with caution for short-term contact with this solvent Whenever swelling or softening of the gloves or seepage of methylene chloride into the glove is observed, dispose of the gloves immediately and replace with new ones [14]

RESPIRATOR SELECTION

A study conducted by NIOSH researchers demonstrated that chemical cartridge respirators are not adequate for removing methylene chloride, since cartridge breakthrough time is approximately 40 minutes for a methylene chloride challenge of 15 parts per million [15] Because the odor threshold of methylene chloride is near the PEL, the worker will not smell methylene chloride until significant breakthrough has already occurred Because NIOSH has identified methylene chloride as a potential human carcinogen in the workplace, two types of respirators are recommended a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure demand or other positive pressure mode, or a supplied air respirator (SAR) with a full facepiece operated in pressure demand or other positive pressure mode in combination with an auxiliary SCBA operated in pressure demand or other positive pressure mode The auxiliary SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted

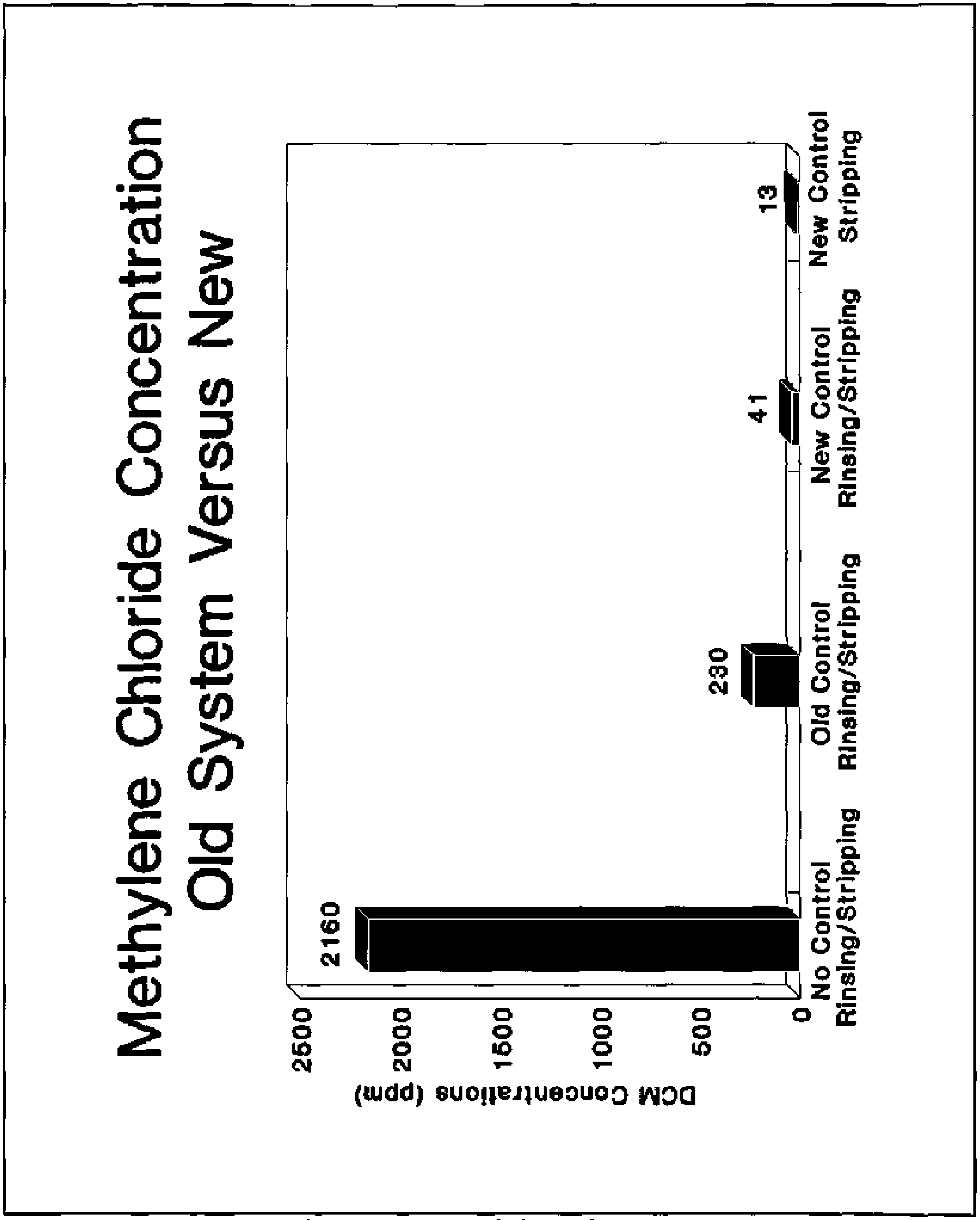

Figure 7 Personal Sampling Data Recorded in Shop

Where employees must wear respirators, an appropriate respiratory protection program in accordance with 29 CFR 1910 134 must be instituted [14] A copy of 29 CFR 1910 134 can be obtained from the local area OSHA office

WORK PRACTICES

Good work practices can significantly reduce worker exposure Keeping the worker's head as far as possible from the stripping solution and the furniture will lower the exposure Keep all soiled cloths, brushes, or tools in a ventilated area or in an airtight container Paint scrapings contain substantial amounts of methylene chloride and other organics and should be stored in airtight containers until properly disposed Any clothing that becomes soaked with stripping solution should be immediately removed and the exposure area thoroughly washed Soiled clothing should not be taken home and washed with other clothes Eating or smoking in the shop area also can contribute to exposures Hands should be thoroughly washed before eating or smoking Eating or smoking should not be done in the shop area Also, some of the chemicals used in the furniture stripping and refinishing industry are flammable, and therefore, there should be no smoking in the shop or near flammable storage areas

EDUCATION AND TRAINING PROGRAM

An effective employee education and training program can also reduce potential for exposure to methylene chloride and is required under OSHA's hazard communication standard (29 CFR 1910 1200) A copy of 29 CFR 1910 1200 can be obtained from the local area OSHA office The program should contain the following elements

The hazards of methylene chloride exposure and methods which can be used to prevent respiratory, skin, or eye contact

Use, care, and limitations of respirators and other personal protective equipment

Safe handling of methylene chloride and other relevant work practices

Effective housekeeping procedures

First aid and emergency procedures

Relevant personal hygiene aspects for controlling methylene chloride exposure [14]

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4 "Occupational Safety and Health Standards" Code of Federal Regulations 29 CFR 1910 1000, Rev July 1, 1990

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11 NIOSH NIOSH Manual of Analytical Methods, Third Edition DHHS (NIOSH) Publication No 84-100 Cincinnati, Ohio USDHHS, PHS, CDC, NIOSH, 1984

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APPENDICES

A   Estimation of Real-Time Worker Exposure
B   Methylene Chloride Personal Air Sampling Data
C   Methylene Chloride Area Sampling Data
D   Methanol Sampling Data
E   Graphs on Real-Time TIP II Data and Near Real-Time GC Data

APPENDIX A

ESTIMATION OF REAL-TIME WORKER EXPOSURE

The following formula was used to convert the output of the TIP II (volts) to concentration of contaminant (ppm)

$$C(t) = IR(t) * ST * (St / SIR(t))$$

where

- $C(t)$ = concentration of vapor at time t (ppm),
- $IR(t)$ = instrument response at time t (volts),
- ST = TWA concentration of contaminant as collected on sorbent tubes for the time period St (ppm),
- St = total elapsed time of sampling (seconds), and
- $SIR(t)$ = sum of the instrument response at every time interval (volts)

The major assumption in this estimation method is that dilution is instantaneous and occurs with no change in the relative vapor ratios In addition, it is assumed that there is linear variation in instrument response with respect to changes in concentration of all contaminants in the air

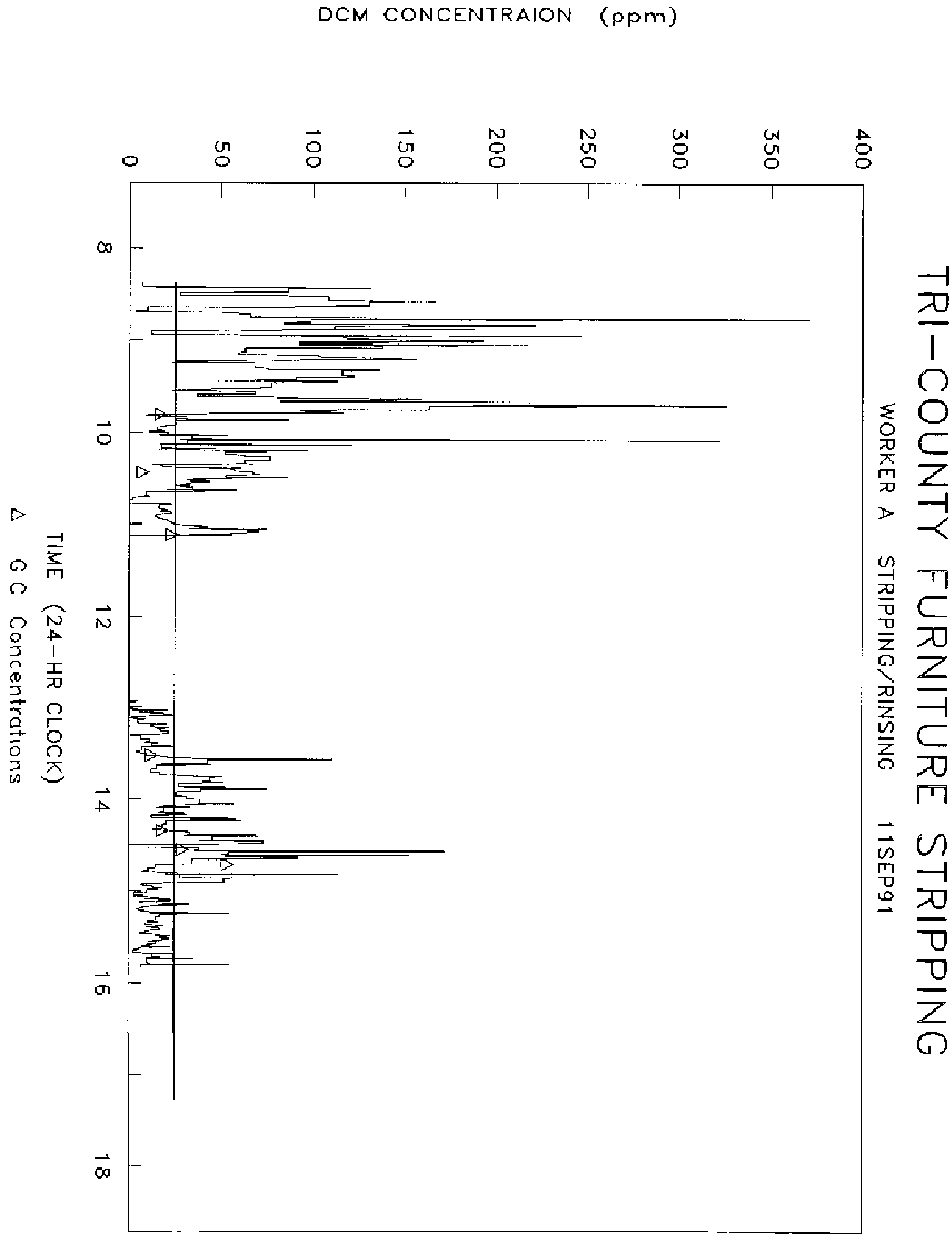
APPENDIX B

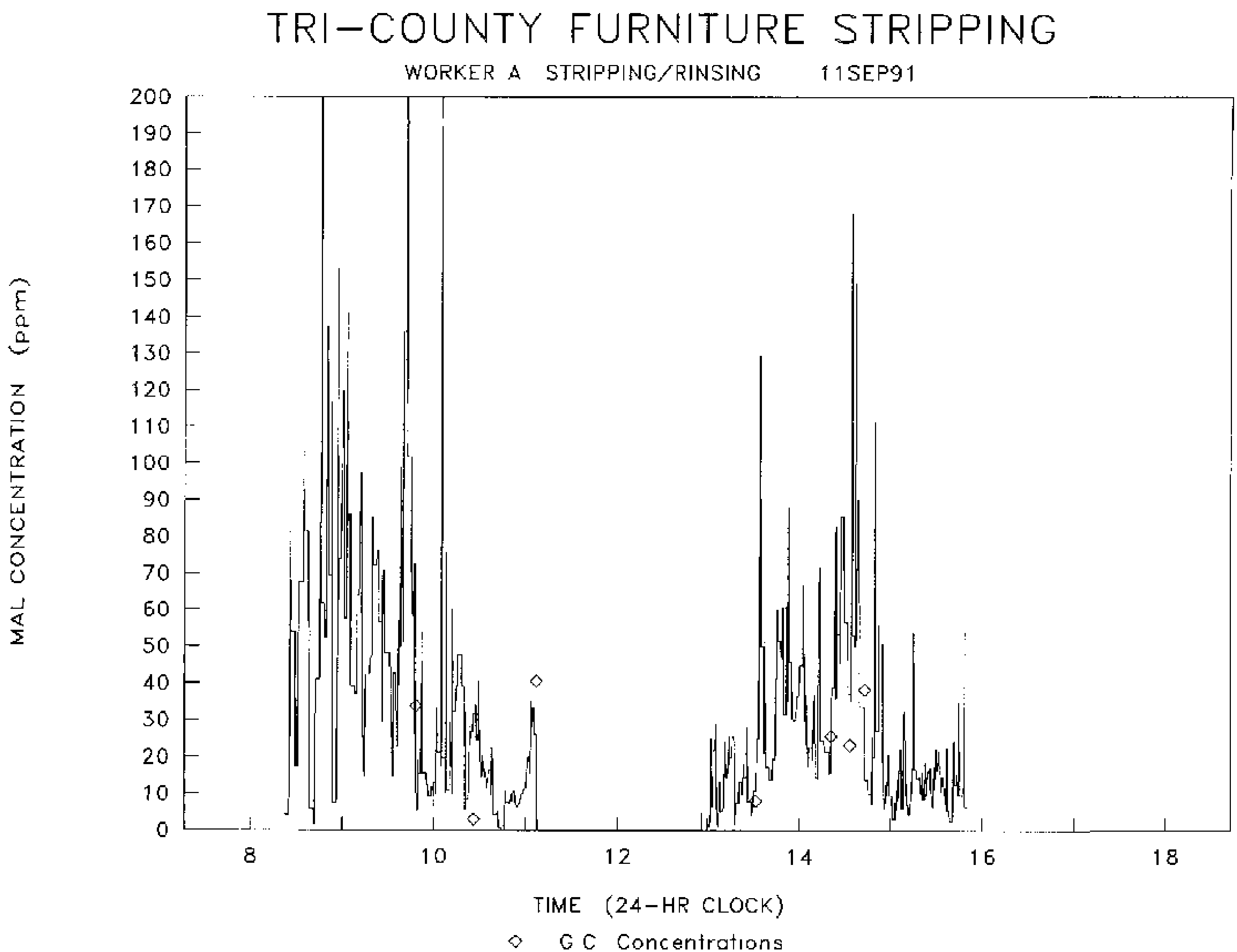
DAY	SAMPLE NUMBER	OR BACK	Time (MIN)	VOLUME LITERS	SHORT OR LONG TERM	DCM mg	DCM mg/m3	DCM ppm	DCM NATURAL LOG	PERSON OR AREA CODE
9/12/91	1135	F	32	0 6	S	0 0390	61	18	2 86	WORKER A
9/11/91	213	F	30	0 6	S	0 0200	33	10	2 26	WORKER A
9/13/91	1035	F	40	0 8	S	0 0730	91	26	3 27	WORKER A
9/12/91	291	F	50	1 0	S	0 0200	20	6	1 75	WORKER A
9/13/91	1055	F	19	0 4	S	0 0100	26	8	2 02	WORKER B
9/13/91	1107	F	48	1 0	S	0 0660	69	20	2 99	WORKER B
9/11/91	262	F	32	0 6	S	0 0300	47	13	2 60	WORKER B
9/12/91	292	F	46	0 9	S	0 0400	43	13	2 53	WORKER B
9/12/91	1089	F	62	1 2	S	0 0660	53	15	2 73	WORKER B
9/11/91	226	F	82	1 6	L	0 0980	60	17	2 84	WORKER A
9/11/91	235	F	97	1 9	L	0 1500	77	22	3 10	WORKER A
9/11/91	250	F	78	1 6	L	0 1100	71	20	3 01	WORKER A
9/13/91	1031	F	84	1 7	L	0 4000	238	69	4 23	WORKER A
9/11/91	219	F	120	2 4	L	0 6600	275	79	4 37	WORKER A
9/12/91	1123	F	52	1 0	L	0 1200	115	33	3 50	WORKER A
9/13/91	1025	F	103	2 1	L	0 2400	117	34	3 51	WORKER A
9/12/91	279	F	90	1 8	L	0 0300	17	5	1 57	WORKER A
9/11/91	223	F	103	2 1	L	0 5700	277	80	4 38	WORKER B
9/11/91	231	F	95	1 9	L	0 3800	200	58	4 05	WORKER B
9/12/91	277	F	120	2 4	L	0 3300	138	40	3 68	WORKER B
9/12/91	1136	F	110	2 2	L	0 3300	150	43	3 77	WORKER B
9/13/91	1054	F	120	2 4	L	0 4000	167	48	3 87	WORKER B
9/13/91	1038	F	100	2 0	L	0 4800	240	69	4 24	WORKER B
9/11/91	255	F	112	2 2	L	0 6000	268	77	4 35	WORKER B
9/12/91	298	F	111	2 2	L	0 7200	324	93	4 54	WORKER B
9/12/91	1082	F	100	2 0	L	0 2500	125	36	3 58	WORKER B
9/11/91	204	F	119	2 4	L	0 6600	277	80	4 38	WORKER B

ALL THE BACK TUBES WERE NON-DETECTED

DAY	SAMPLE NUMBER	OR BACK	Time (MIN)	VOLUME LITERS	SHORT OR LONG TERM	DCM mg	DCM mg/m3	DCM ppm	DCM NATURAL LOG	PERSON OR AREA CODE
9/11/91	208	F	123	2 5	L	0 34	138	40	3 68	AREA1
9/12/91	1117	F	75	1 5	L	0 1000	67	19	2 95	AREA1
9/12/91	1121	F	120	2 4	L	0 0950	40	11	2 43	AREA1
9/12/91	286	F	228	4 6	L	0 1500	33	9	2 25	AREA1
9/11/91	269	F	80	1 6	L	0 0800	50	14	2 67	AREA1
9/11/91	228	F	141	2 8	L	0 073	26	7	2 01	AREA1
9/11/91	243	F	108	2 2	L	0 085	39	11	2 43	AREA1
9/13/91	1075	F	240	4 8	L	0 9400	196	56	4 03	AREA1
9/12/91	295	F	152	3 0	L	0 2400	79	23	3 12	AREA2
9/13/91	1030	F	75	1 5	L	0 1700	113	33	3 49	AREA2
9/11/91	209	F	122	2 4	L	0 29	119	34	3 53	AREA2
9/11/91	225	F	143	2 9	L	0 23	80	23	3 14	AREA2
9/12/91	1113	F	126	2 5	L	0 1800	71	21	3 02	AREA2
9/11/91	246	F	104	2 1	L	0 3	144	42	3 73	AREA2
9/12/91	284	F	133	2 7	L	0 0550	21	6	1 78	AREA2
9/11/91	257	F	85	1 7	L	0 23	135	39	3 66	AREA2
9/13/91	1074	F	125	2 5	L	0 1800	72	21	3 03	AREA2
9/13/91	1115	F	115	2 3	L	0 4500	196	56	4 03	AREA2
9/12/91	1085	F	71	1 4	L	0 0840	59	17	2 83	AREA2
9/13/91	1040	F	48	1 0	L	0 0670	70	20	3 00	AREA2
9/12/91	1139	F	200	4 0	L	0 2200	55	16	2 76	AREA3
9/11/91	207	F	116	2 3	L	0 079	34	10	2 28	AREA3
9/11/91	248	F	108	2 2	L	0 053	25	7	1 95	AREA3
9/11/91	268	F	82	1 6	L	0 0500	30	9	2 17	AREA3
9/12/91	285	F	228	4 6	L	0 0840	18	5	1 67	AREA3
9/11/91	221	F	142	2 8	L	0 042	15	4	1 45	AREA3
9/13/91	1052	F	240	4 8	L	0 2300	48	14	2 62	AREA3
9/12/91	290	F	153	3 1	L	0 1600	52	15	2 71	AREA4
9/12/91	275	F	133	2 7	L	0 0730	27	8	2 07	AREA4
9/13/91	1029	F	51	1 0	L	0 0810	79	23	3 13	AREA4
9/13/91	1065	F	125	2 5	L	0 1200	48	14	2 63	AREA4
9/13/91	1044	F	115	2 3	L	0 4400	191	55	4 01	AREA4
9/11/91	233	F	107	2 1	L	0 56	262	75	4 32	AREA4
9/12/91	1108	F	102	2 0	L	0 1300	64	18	2 91	AREA4
9/12/91	1127	F	123	2 5	L	0 1400	57	16	2 80	AREA4
9/13/91	1122	F	72	1 4	L	0 0830	58	17	2 81	AREA4
9/11/91	234	F	140	2 8	L	0 27	96	28	3 32	AREA4
9/11/91	259	F	85	1 7	L	0 1100	65	19	2 92	AREA4
9/11/91	200	F	120	2 4	L	0 46	192	55	4 01	AREA4
9/12/91	294	F	153	3 1	L	0 3600	118	34	3 52	AREA5
9/12/91	1051	F	120	2 4	L	0 3600	150	43	3 77	AREA5
9/13/91	1060	F	125	2 5	L	0 2100	84	24	3 19	AREA5
9/12/91	287	F	133	2 7	L	0 2300	86	25	3 21	AREA5
9/11/91	254	F	80	1 6	L	0 1900	119	34	3 53	AREA5
9/13/91	1109	F	51	1 0	L	0 1100	108	31	3 44	AREA5
9/11/91	247	F	112	2 2	L	0 46	205	59	4 08	AREA5
9/11/91	214	F	120	2 4	L	0 64	267	77	4 34	AREA5
9/13/91	1111	F	72	1 4	L	0 1300	90	26	3 26	AREA5
9/12/91	1110	F	105	2 1	L	0 1800	86	25	3 21	AREA5
9/11/91	210	F	135	2 7	L	0 28	104	30	3 40	AREA5
9/13/91	1036	F	115	2 3	L	0 4800	209	60	4 10	AREA5
9/11/91	230	F	180	3 6	L	0 0071	2	1	-0 57	AREA6
9/13/91	1061	F	445	8 9	L	0 0200	2	1	-0 44	AREA6
9/12/91	1126	F	212	4 2	L	0 0071	2	0	-0 73	AREA6
9/12/91	281	F	227	4 5	L	0 0071	2	0	-0 80	AREA6
9/11/91	211	F	280	5 6	L	0 0071	1	0	-1 01	AREA6

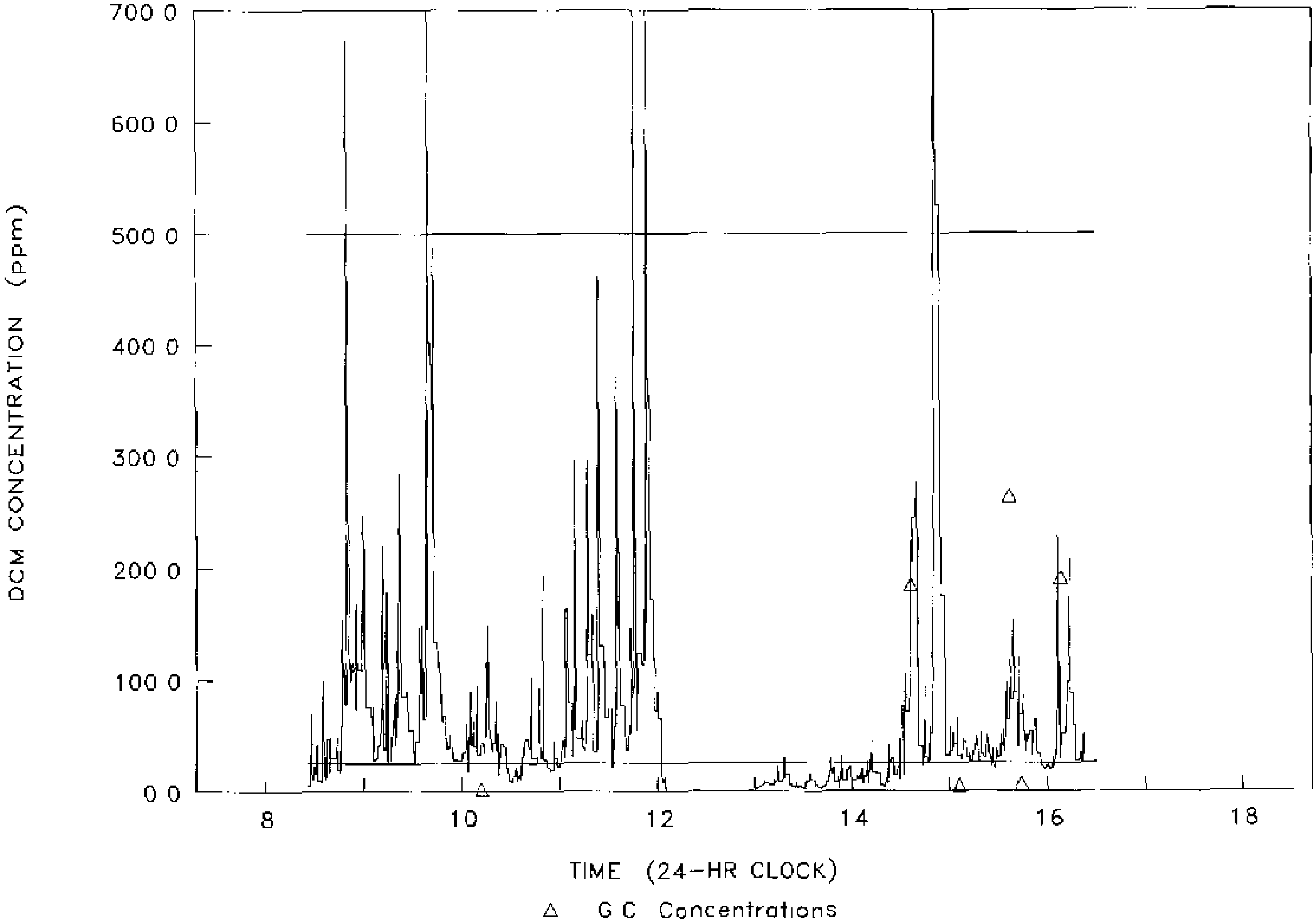
DAY	SAMPLE NUMBER	SAMPLE Time (MIN)	VOLUME LITERS	SAMPLE MEDIA	SHORT OR LONG TERM	MAL mg	MAL mg/m3	MAL ppm	PERSON OR AREA CODE
9/11/91	459	264	5 3	SG	L	0 09	17	13	AREA1
9/11/91	455	265	5 3	SG	L	0 12	23	17	AREA2
9/11/91	457	263	5 3	SG	L	0 03	6	4	AREA3
9/11/91	450	260	5 2	SG	L	0 28	54	41	AREA4
9/11/91	454	255	5 1	SG	L	0 25	49	37	AREA5
9/11/91	458	280	5 6	SG	L	0 0071	1	1	AREA6
9/11/91	415	190	3 8	SG	L	0 03	8	6	AREA3
9/11/91	418	190	3 8	SG	L	0 054	14	11	AREA1
9/11/91	412	180	3 6	SG	L	0 0071	2	1	AREA6
9/11/91	411	192	3 8	SG	L	0 15	39	30	AREA5
9/11/91	416	192	3 8	SG	L	0 16	42	32	AREA4
9/11/91	414	191	3 8	SG	L	0 15	39	30	AREA2
9/11/91	451	272	5 4	SG	L	0 32	59	45	WORKER B
9/11/91	453	202	4 0	SG	L	0 17	42	32	WORKER A
9/11/91	452	30	0 6	SG	S	0 0071	12	9	WORKER A
9/11/91	410	32	0 6	SG	S	0 0071	11	8	WORKER B
9/11/91	417	175	3 5	SG	L	0 11	31	24	WORKER A
9/11/91	413	205	4 1	SG	L	0 21	51	39	WORKER B
9/12/91	423	90	1 8	SG	L	0 02	11	8	WORKER A
9/12/91	428	233	4 7	SG	L	0 21	45	34	WORKER B
9/12/91	431	46	0 9	SG	S	0 0071	8	6	WORKER B
9/12/91	439	50	1 0	SG	S	0 0071	7	5	WORKER A
9/12/91	437	52	1 0	SG	L	0 03	29	22	WORKER A
9/12/91	433	210	4 2	SG	L	0 095	23	17	WORKER B
9/12/91	436	32	0 6	SG	S	0 0071	11	8	WORKER A
9/12/91	442	62	1 2	SG	S	0 01	8	6	WORKER B
9/12/91	420	228	4 6	SG	L	0 048	11	8	AREA1
9/12/91	422	238	4 8	SG	L	0 071	15	11	AREA2
9/12/91	429	228	4 6	SG	L	0 03	7	5	AREA3
9/12/91	424	238	4 8	SG	L	0 085	18	14	AREA4
9/12/91	421	238	4 8	SG	L	0 16	34	26	AREA5
9/12/91	425	227	4 5	SG	L	0 0071	2	1	AREA6
9/12/91	438	200	4 0	SG	L	0 076	19	14	AREA3
9/12/91	434	197	3 9	SG	L	0 074	19	14	AREA2
9/12/91	435	225	4 5	SG	L	0 089	20	15	AREA4
9/12/91	441	225	4 5	SG	L	0 13	29	22	AREA5
9/12/91	432	195	3 9	SG	L	0 12	31	23	AREA1
9/12/91	430	212	4 2	SG	L	0 0071	2	1	AREA6
9/13/91	444	220	4 4	SG	L	0 087	20	15	WORKER B
9/13/91	2019	188	3 8	SG	L	0 15	40	30	WORKER A
9/13/91	443	19	0 4	SG	S	0 0071	19	14	WORKER B
9/13/91	2008	40	0 8	SG	S	0 0071	9	7	WORKER A
9/13/91	2018	48	1 0	SG	S	0 0071	7	6	WORKER B
9/13/91	449	240	4 8	SG	L	0 067	14	11	AREA1
9/13/91	446	240	4 8	SG	L	0 07	15	11	AREA2
9/13/91	448	240	4 8	SG	L	0 02	4	3	AREA3
9/13/91	447	240	4 8	SG	L	0 077	16	12	AREA4
9/13/91	445	240	4 8	SG	L	0 054	11	9	AREA5
9/13/91	440	445	8 9	SG	L	0 0071	1	1	AREA6
9/13/91	2000	51	1 0	SG	L	0 02	20	15	AREA5
9/13/91	2002	51	1 0	SG	L	0 01	10	7	AREA4
9/13/91	2015	48	1 0	SG	L	0 01	10	8	AREA2
9/13/91	2003	24	0 5	SG	S	0 0071	15	11	WORKER B
9/13/91	2001	20	0 4	SG	S	0 0071	18	13	WORKER A
9/13/91	2006	63	1 3	SG	L	0 03	24	18	WORKER B
9/13/91	2004	75	1 5	SG	L	0 03	20	15	AREA2
9/13/91	2013	72	1 4	SG	L	0 03	21	16	AREA5
9/13/91	2009	72	1 4	SG	L	0 0071	5	4	AREA4

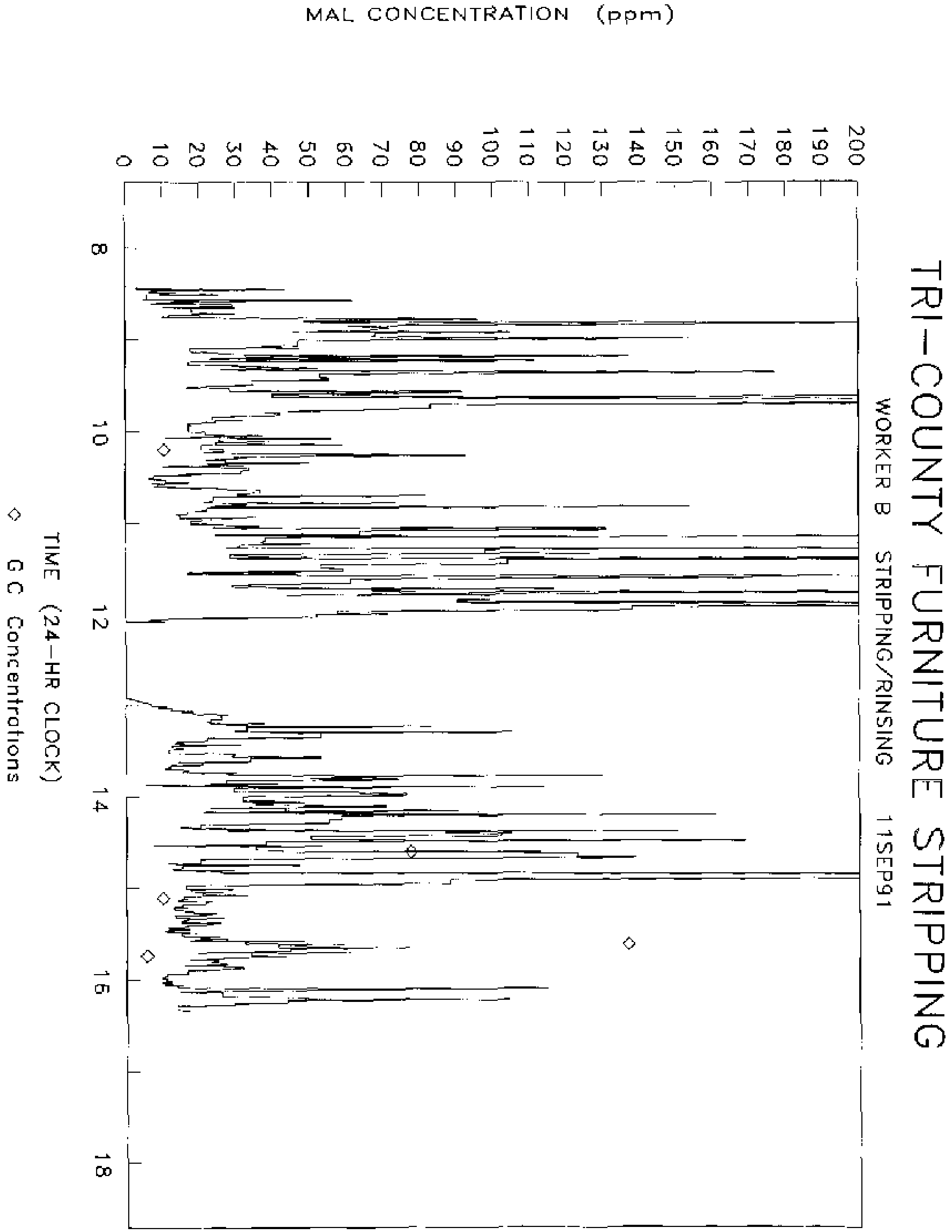

DCM CONCENTRAION (ppm)
TRI-COUNTY FURNITURE STRIPPING
WORKER A STRIPPING/RINSING 11SEP91
0
50
100
150
200
250
300
350
400
8
10
12
14
16
18
TIME (24-HR CLOCK)
△ G C Concentrations


TRI-COUNTY FURNITURE STRIPPING
WORKER A STRIPPING/RINSING 11SEP91
MAL CONCENTRATION (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
8
10
12
14
16
18
TIME (24-HR CLOCK)
◇ G C Concentrations

TRI-COUNTY FURNITURE STRIPPING

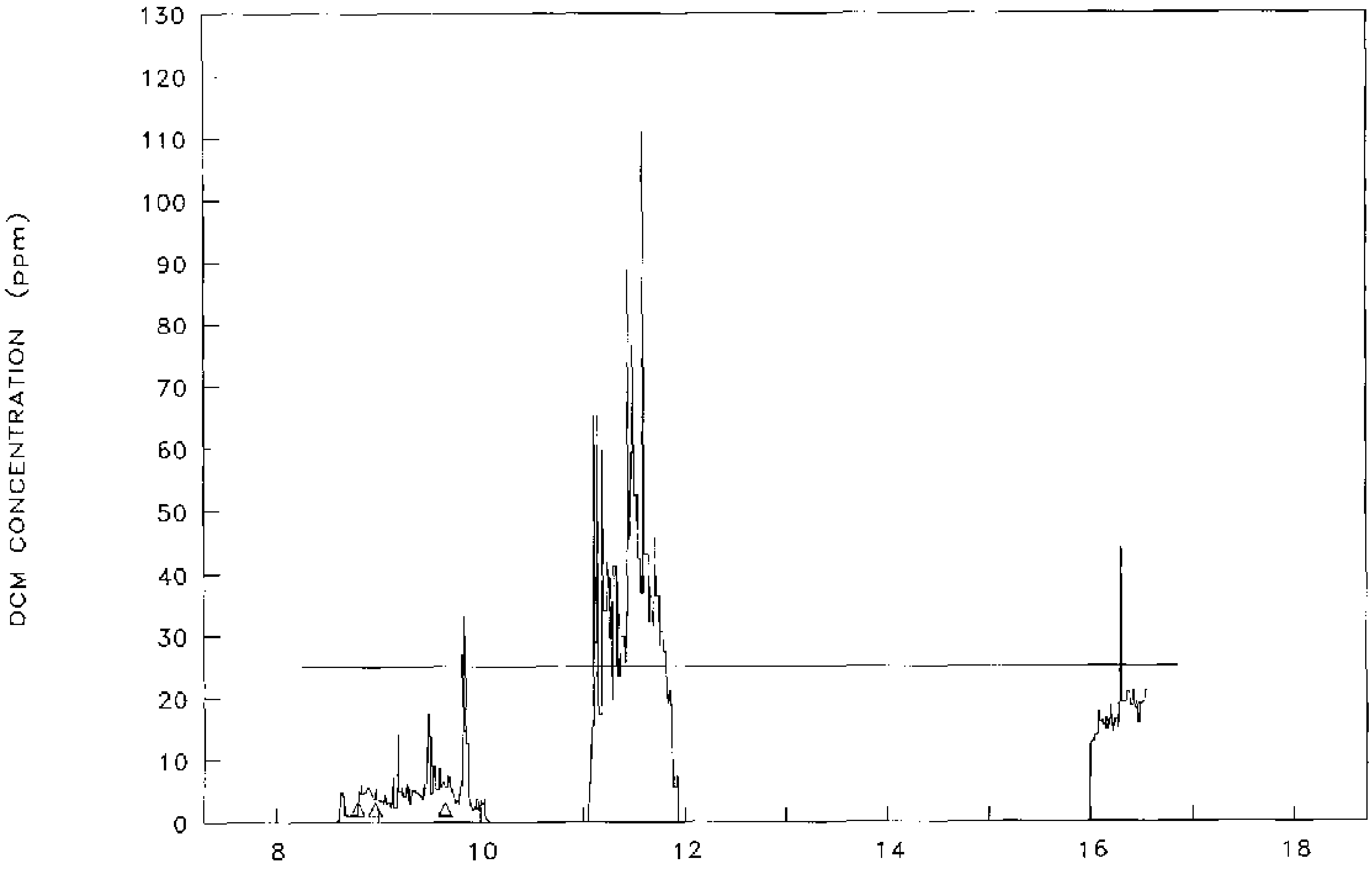
WORKER B STRIPPING/RINSING 11SEP91




TRI-COUNTY FURNITURE STRIPPING
WORKER B STRIPPING/RINSING 11SEP91
MAL CONCENTRATION (ppm)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
8 10 12 14 16 18
TIME (24-HR CLOCK)
◇ G C Concentrations

TRI-COUNTY FURNITURE STRIPPING

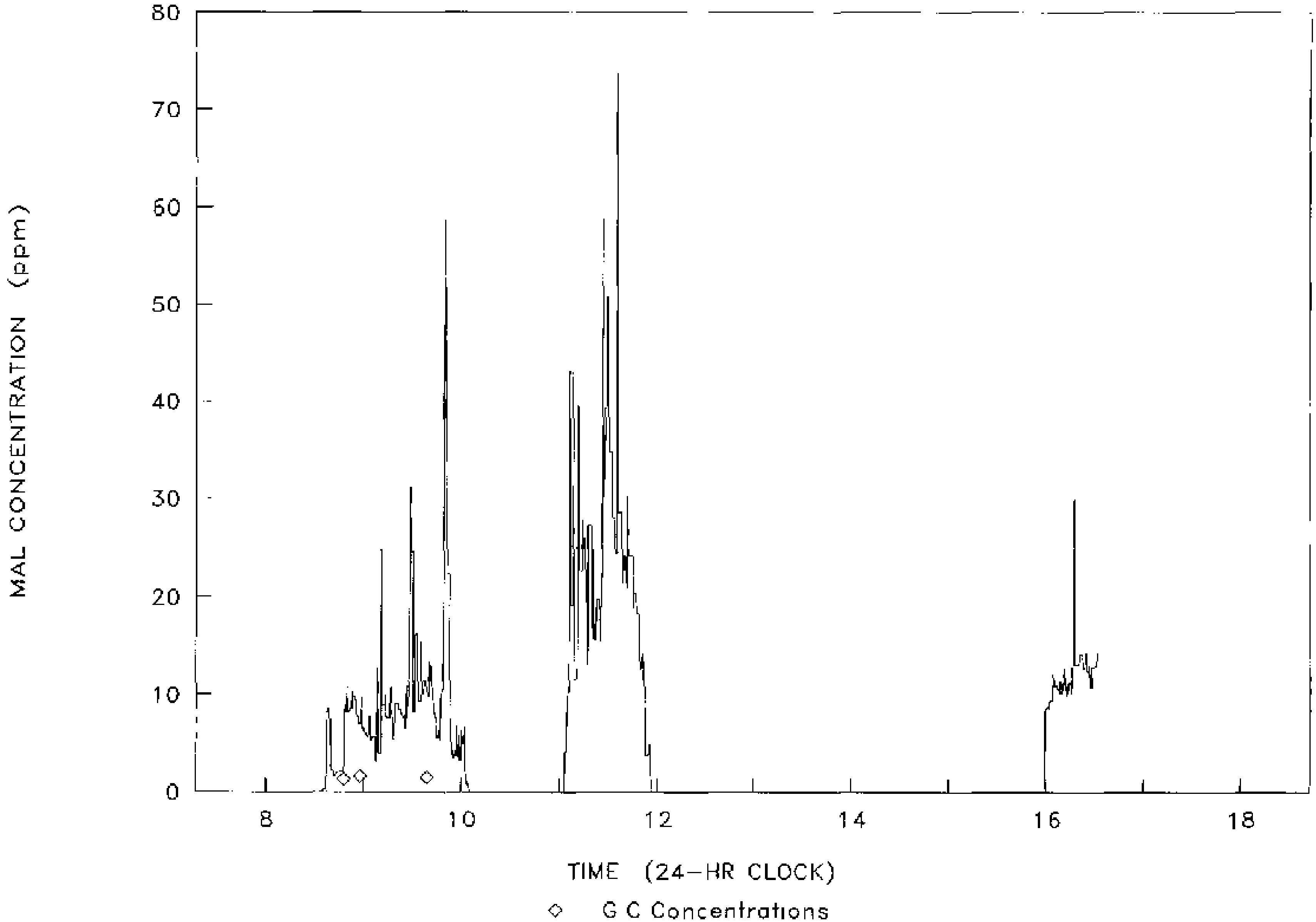
WORKER A STRIPPING/RINSING 12SEP91

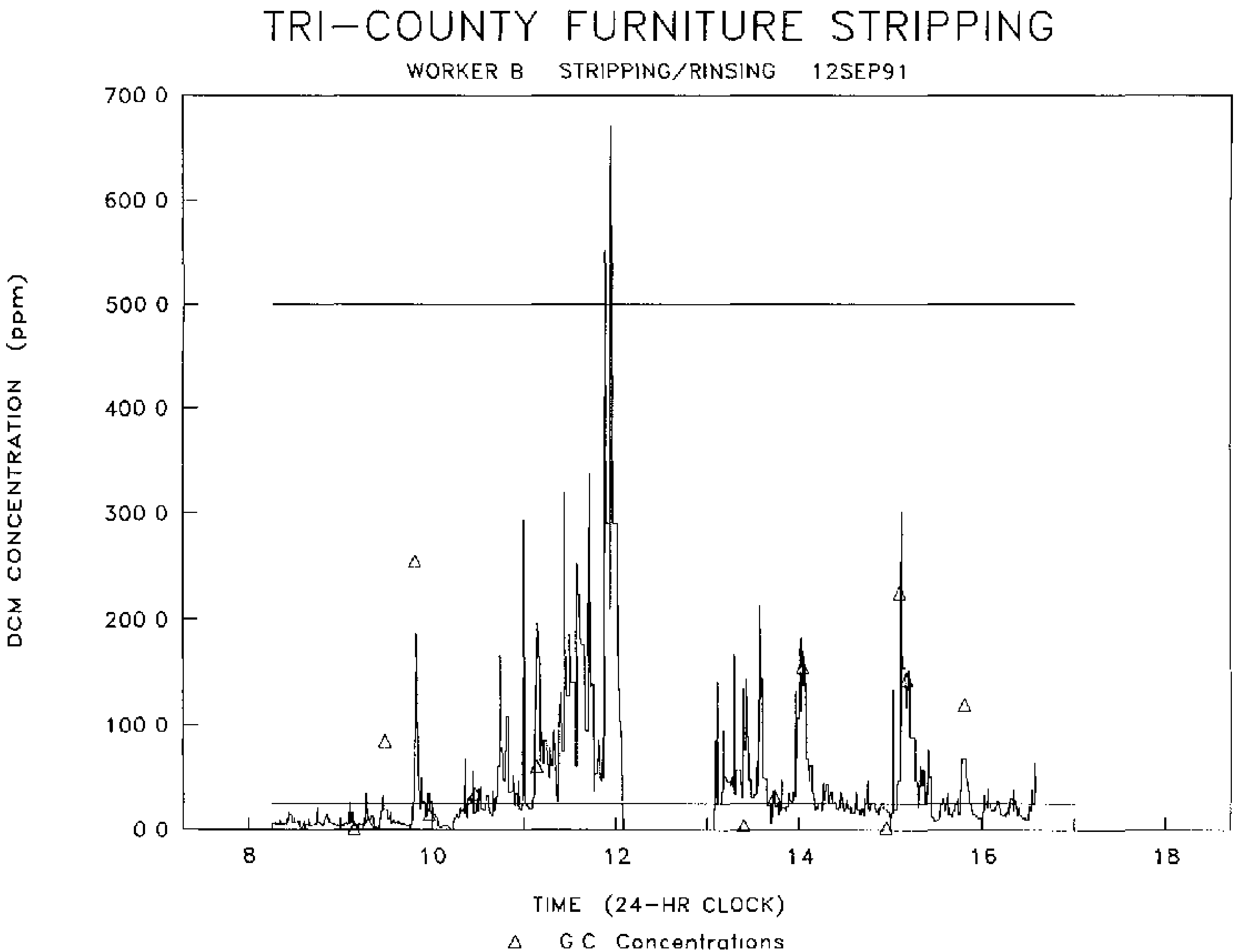


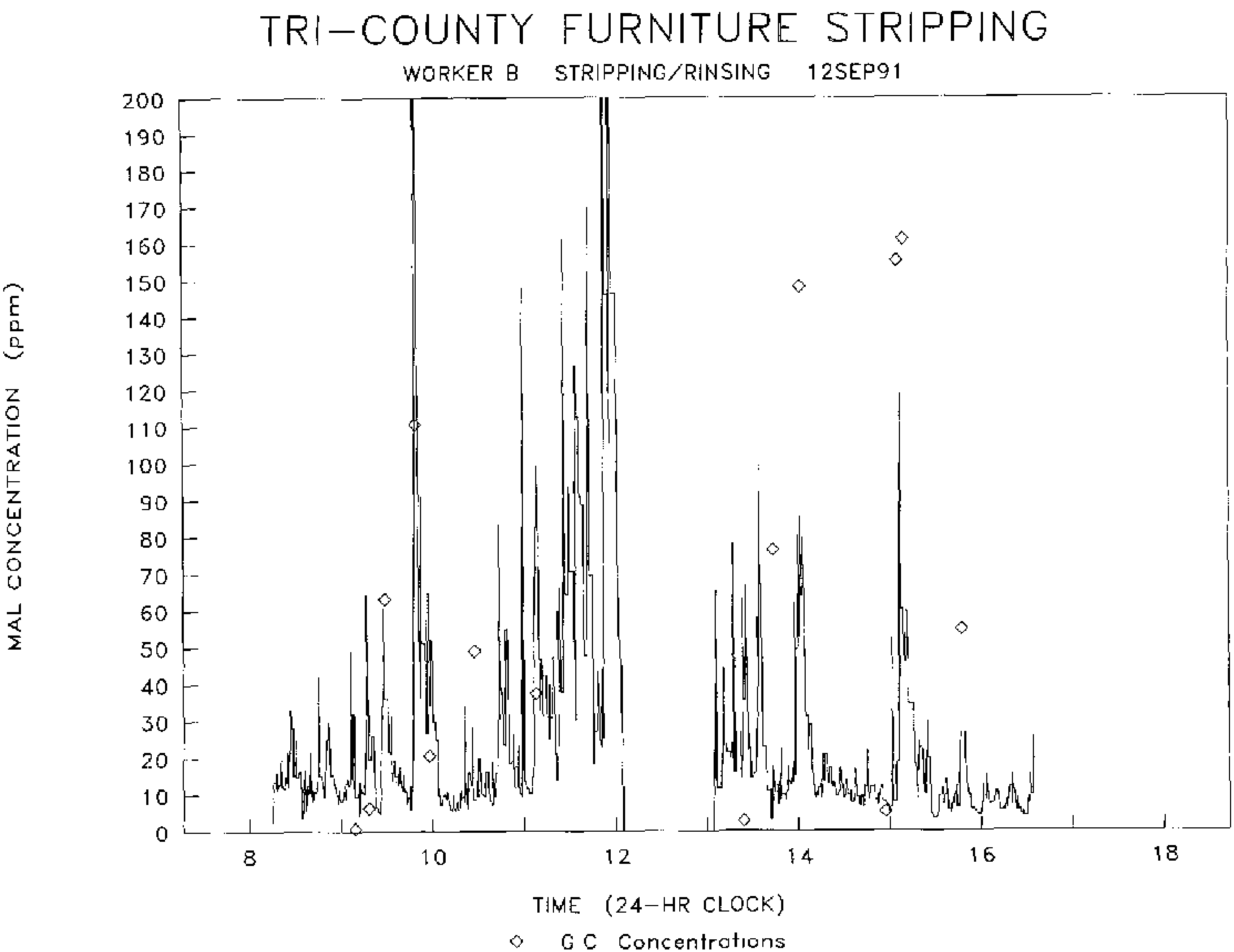
△ G C Concentrations

TRI-COUNTY FURNITURE STRIPPING

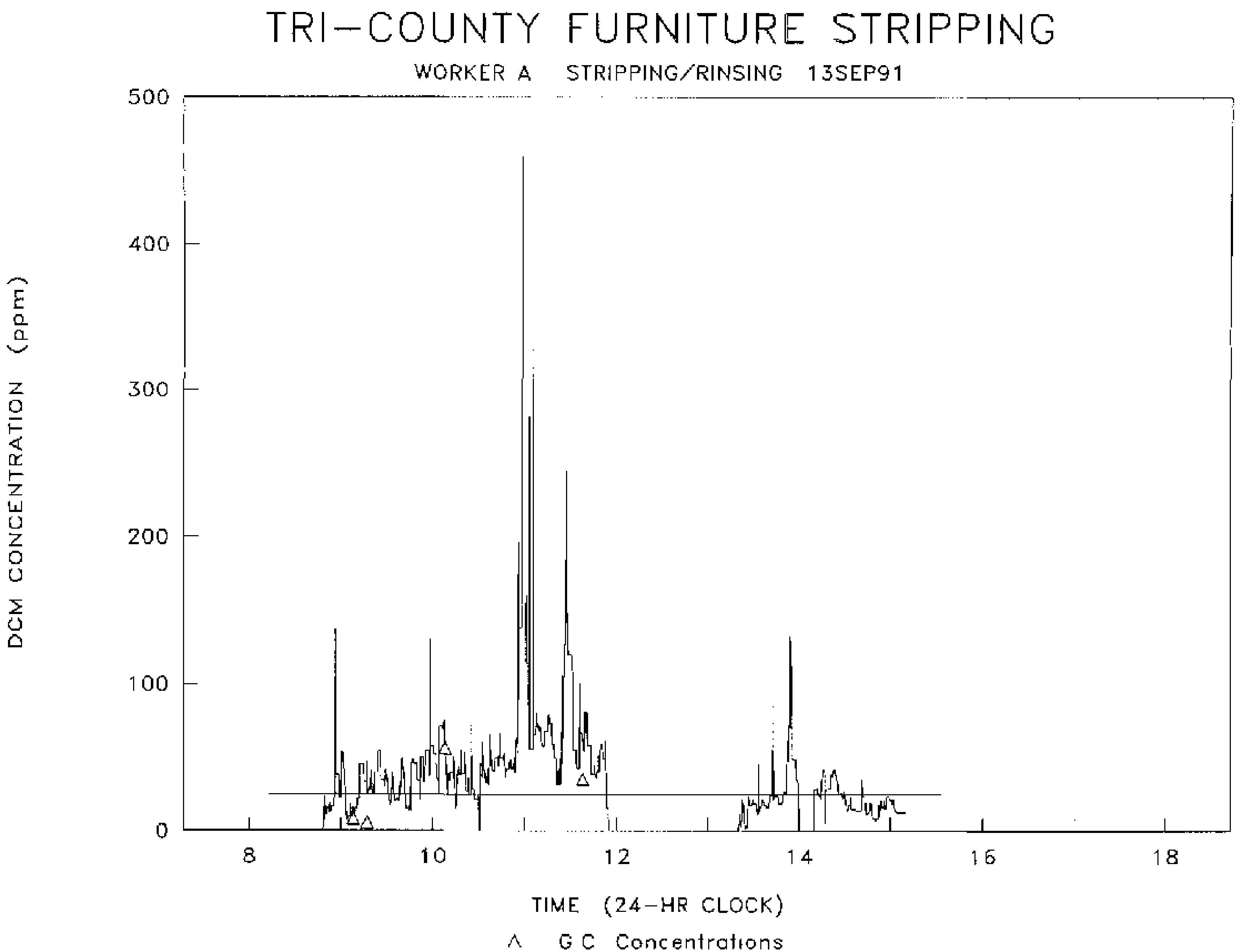
WORKER A   STRIPPING/RINSING   12SEP91

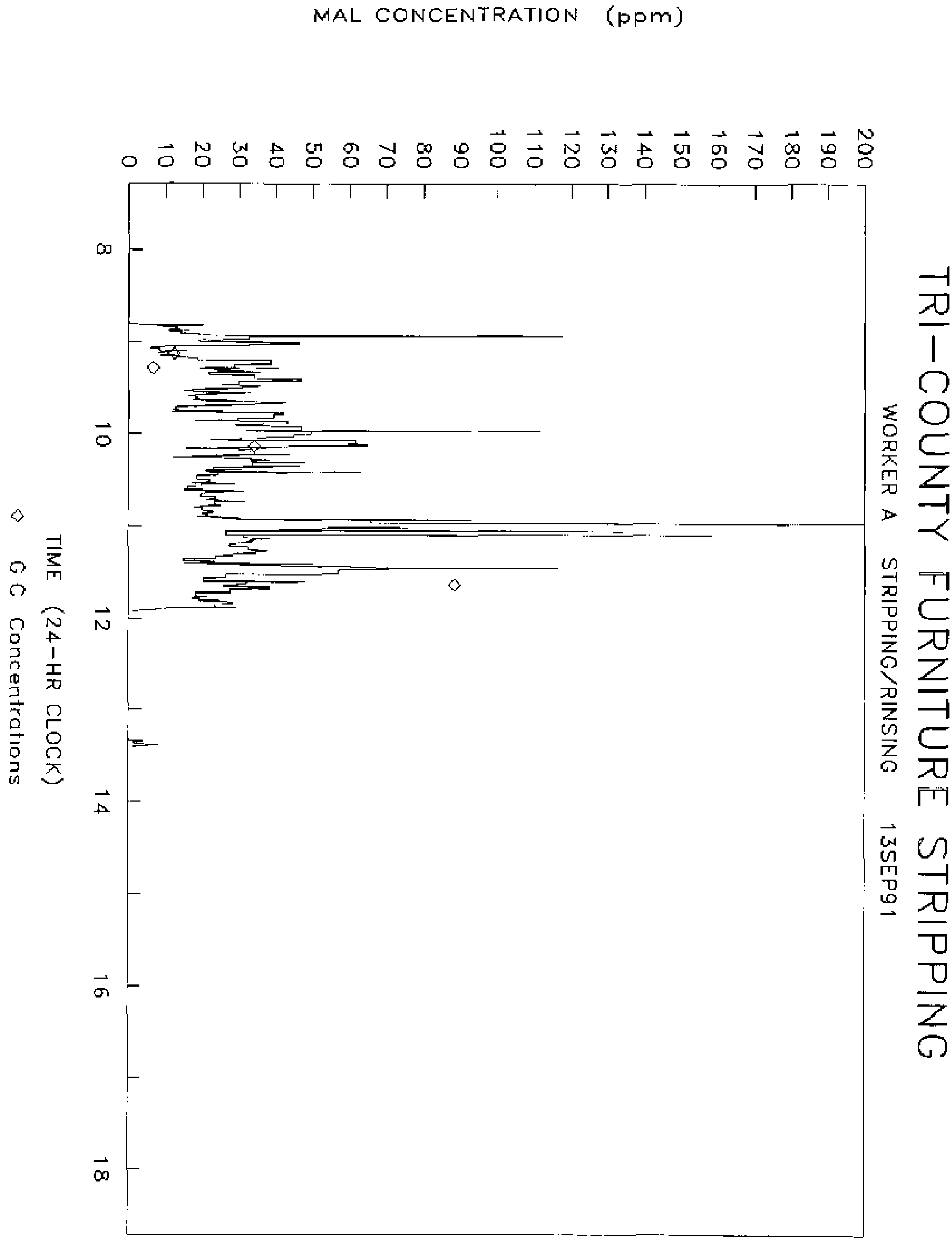


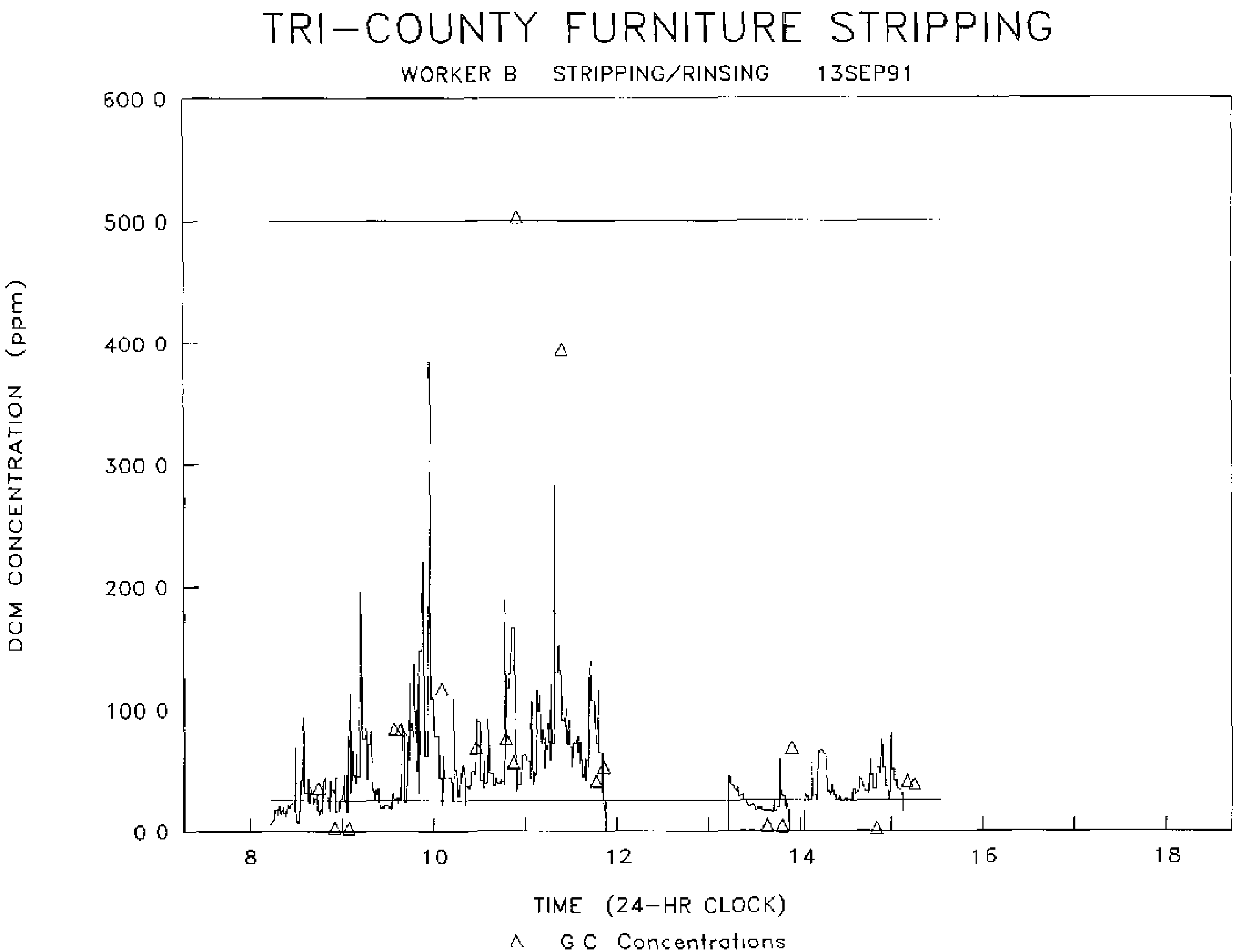

TRI-COUNTY FURNITURE STRIPPING
WORKER B STRIPPING/RINSING 12SEP91
DCM CONCENTRATION (ppm)
700 0
600 0
500 0
400 0
300 0
200 0
100 0
0 0
8
10
12
14
16
18
TIME (24-HR CLOCK)
△ G C Concentrations



TRI-COUNTY FURNITURE STRIPPING
WORKER B STRIPPING/RINSING 12SEP91
MAL CONCENTRATION (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
8
10
12
14
16
18
TIME (24-HR CLOCK)
◇ G C Concentrations


TRI–COUNTY FURNITURE STRIPPING
WORKER A STRIPPING/RINSING 13SEP91
DCM CONCENTRATION (ppm)
500
400
300
200
100
0
8
10
12
14
16
18
TIME (24–HR CLOCK)
Δ G C Concentrations


TRI-COUNTY FURNITURE STRIPPING
WORKER A STRIPPING/RINSING 13SEP91
MAL CONCENTRATION (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
8
10
12
14
16
18
TIME (24-HR CLOCK)
◇ G C Concentrations



TRI-COUNTY FURNITURE STRIPPING
WORKER B STRIPPING/RINSING 13SEP91
DCM CONCENTRATION (ppm)
600 0
500 0
400 0
300 0
200 0
100 0
0 0
8
10
12
14
16
18
TIME (24-HR CLOCK)
Δ G C Concentrations

TRI-COUNTY FURNITURE STRIPPING

WORKER B STRIPPING/RINSING 13SEP91

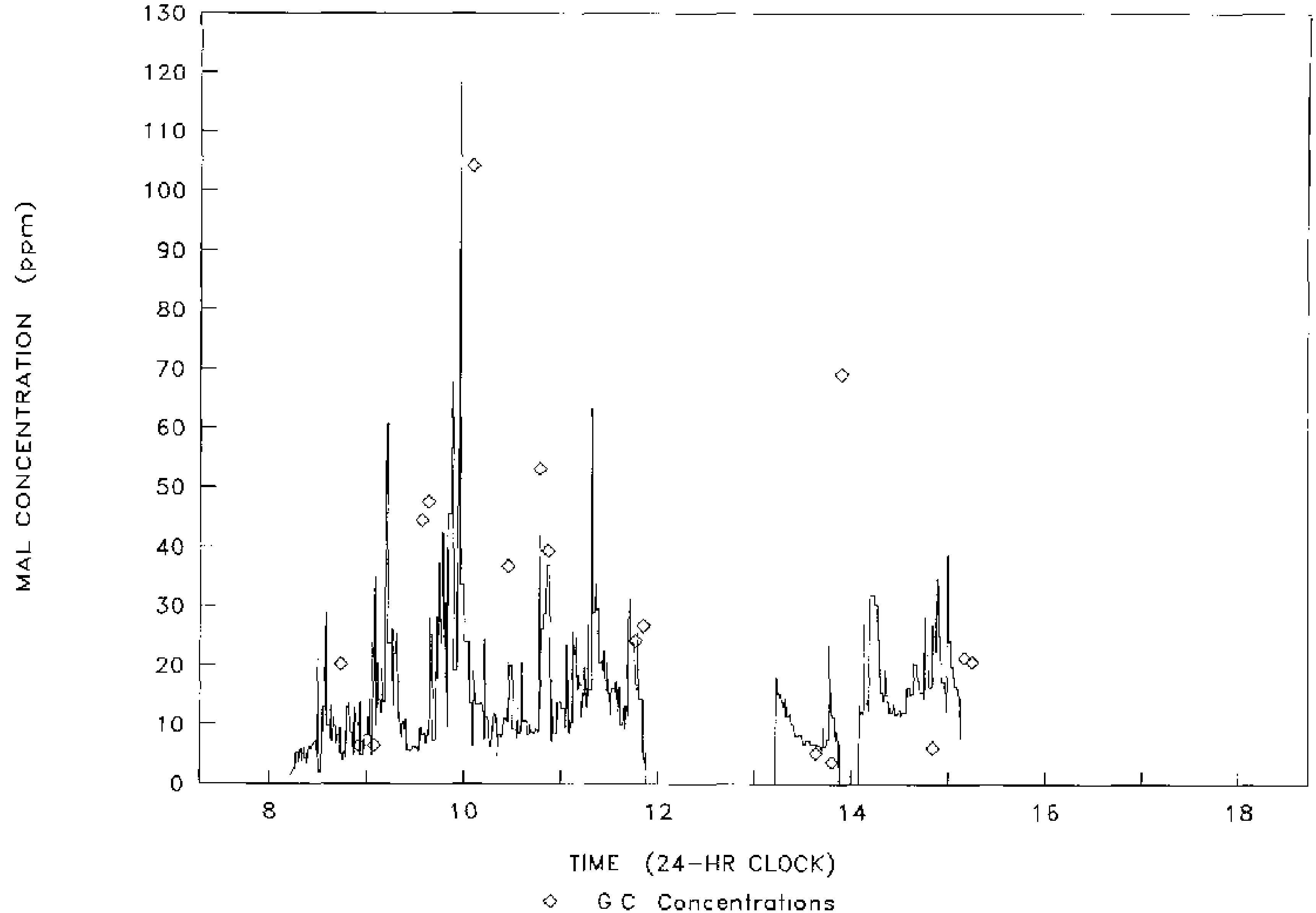


Figure 1

15-MIN MeCl AVG FOR DIP TANK STRIPPING

WORKER A STRIPPING/RINSING 11SEP91

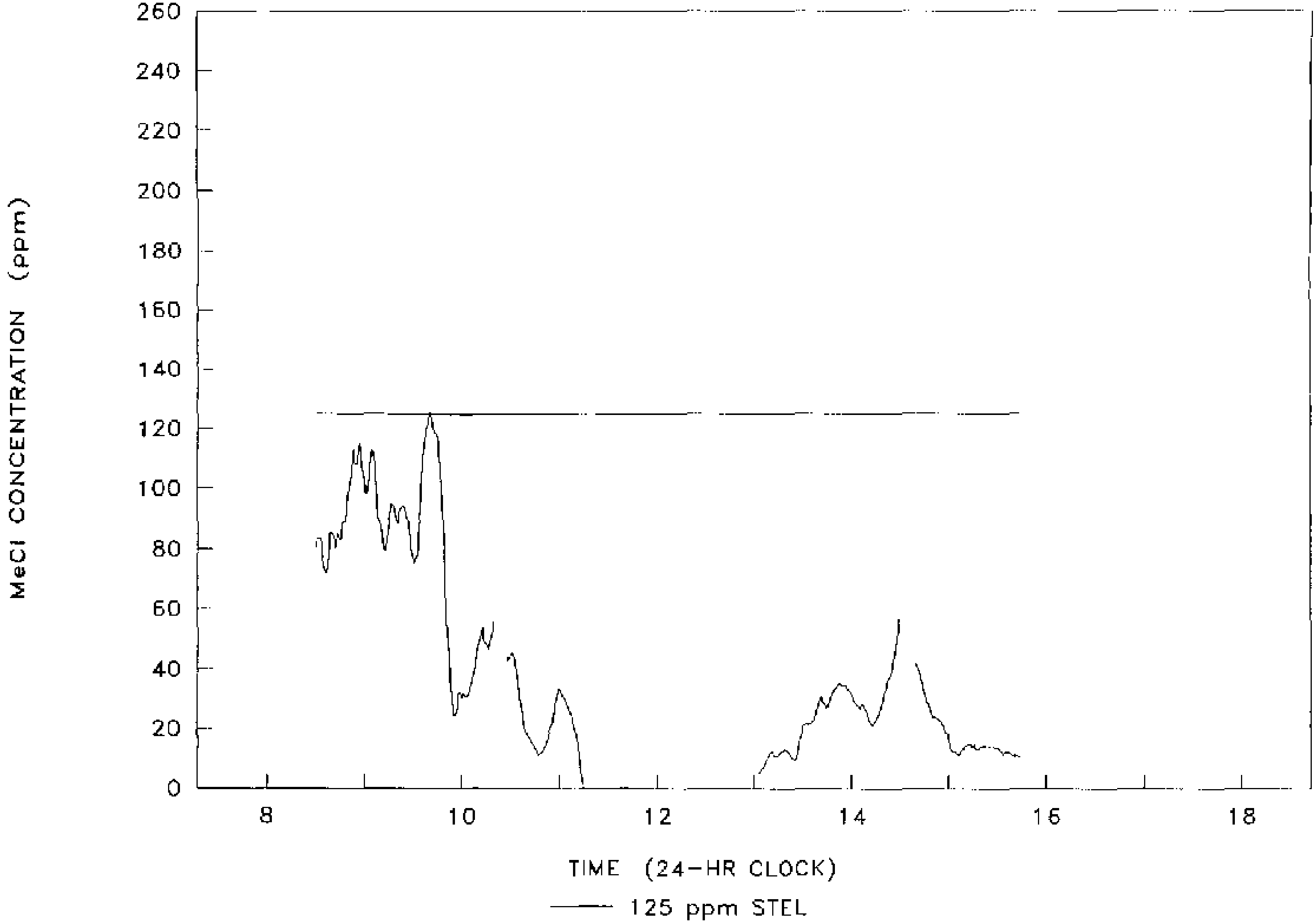
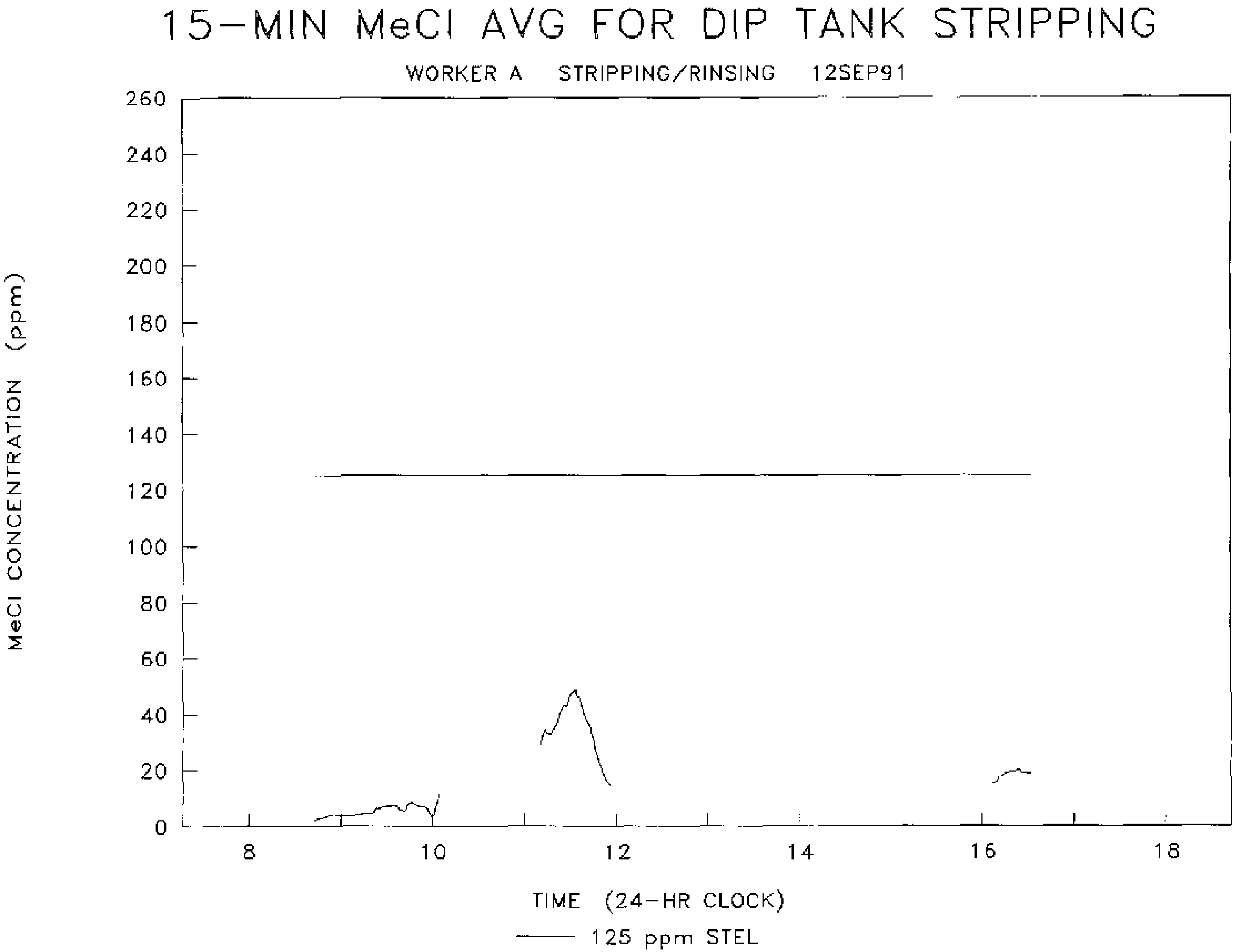


Figure 2



15-MIN MeCl AVG FOR DIP TANK STRIPPING
WORKER A STRIPPING/RINSING 12SEP91
MeCl CONCENTRATION (ppm)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
8
10
12
14
16
18
TIME (24-HR CLOCK)
125 ppm STEL

Figure 3

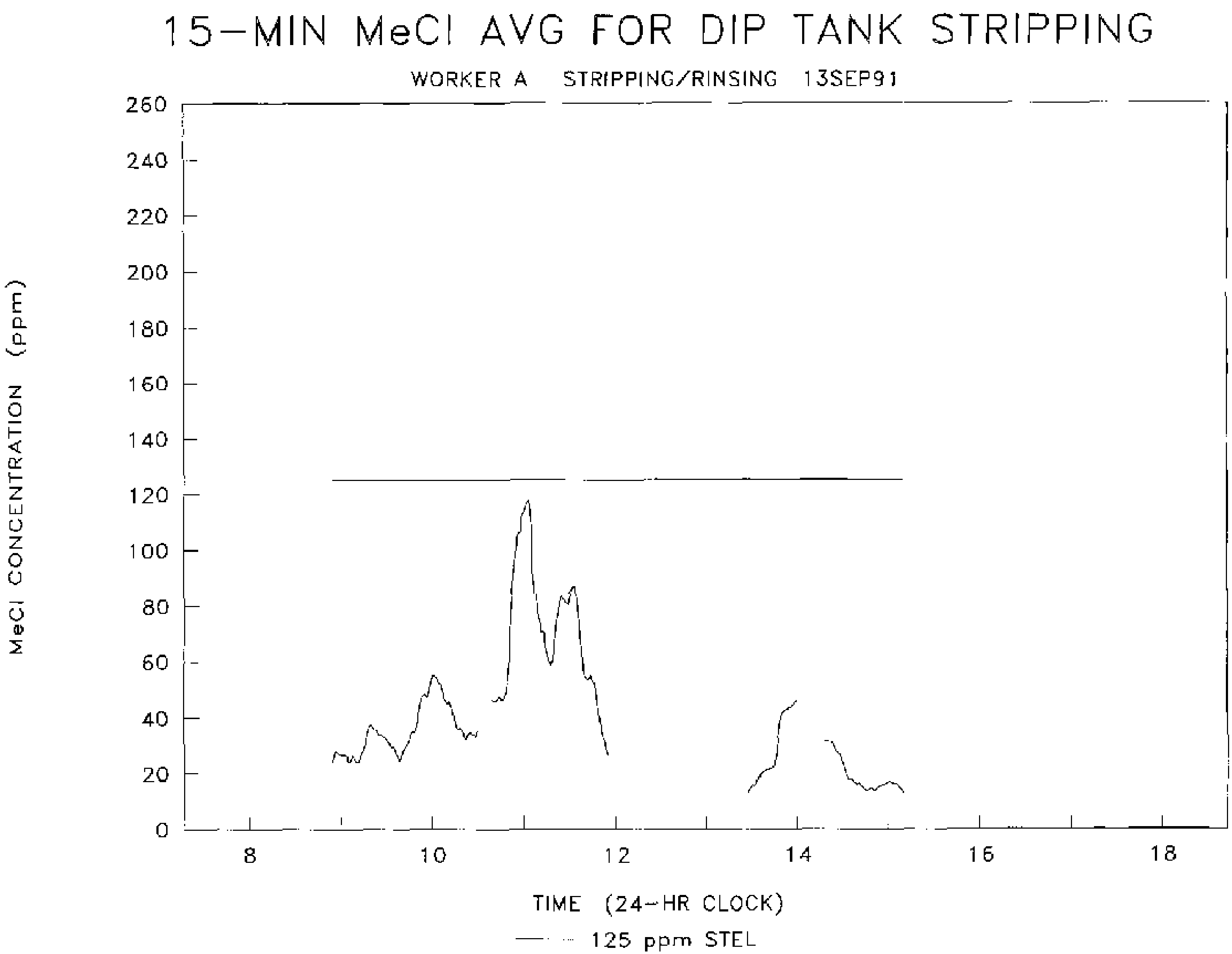

15–MIN MeCl AVG FOR DIP TANK STRIPPING
WORKER A STRIPPING/RINSING 13SEP91
MeCl CONCENTRATION (ppm)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
8
10
12
14
16
18
TIME (24–HR CLOCK)
125 ppm STEL

Figure 4

15-MIN MeCl AVG FOR DIP TANK STRIPPING

WORKER B STRIPPING/RINSING 11SEP91

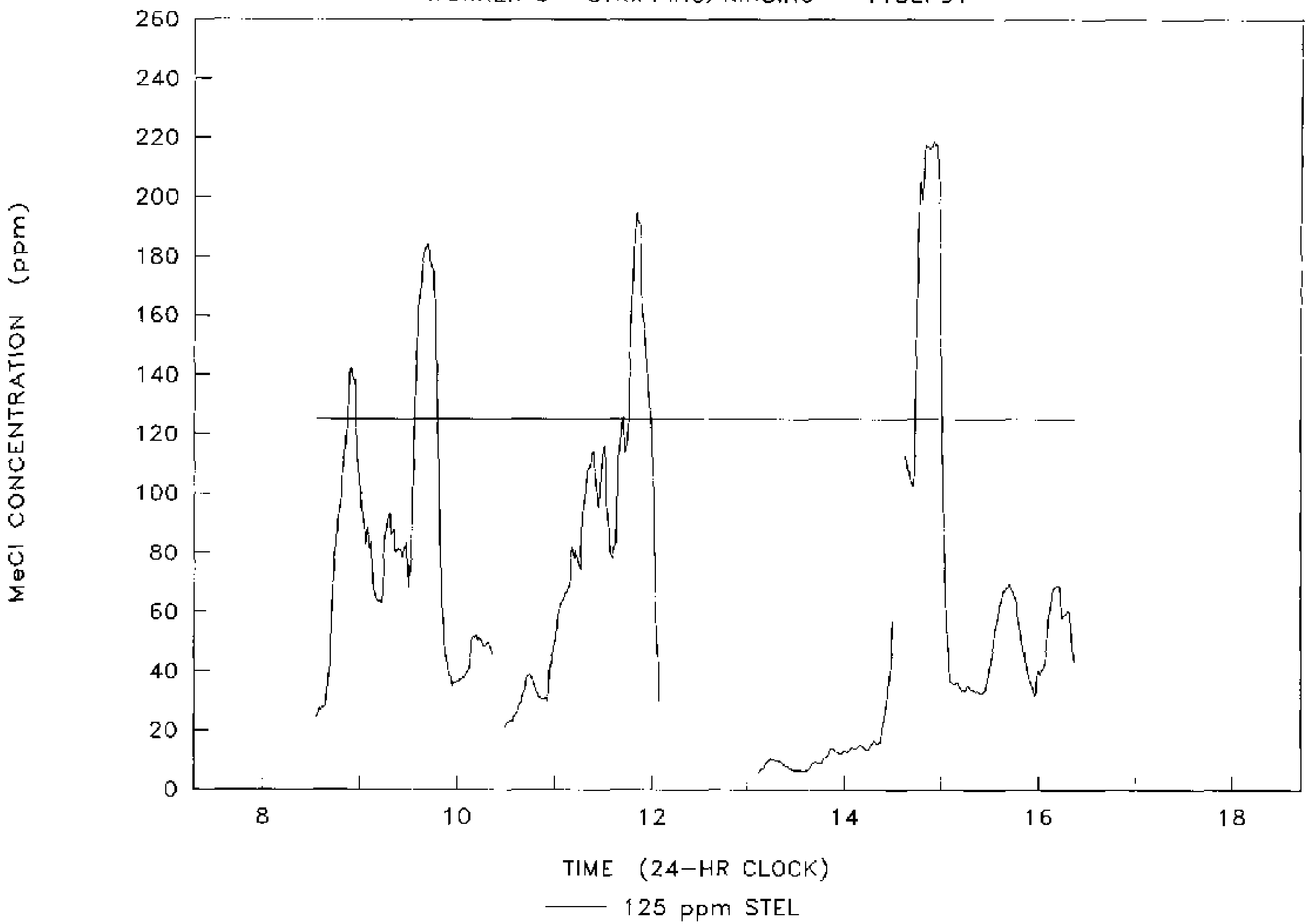


Figure 5

15–MIN MeCl AVG FOR DIP TANK STRIPPING

WORKER B STRIPPING/RINSING 12SEP91

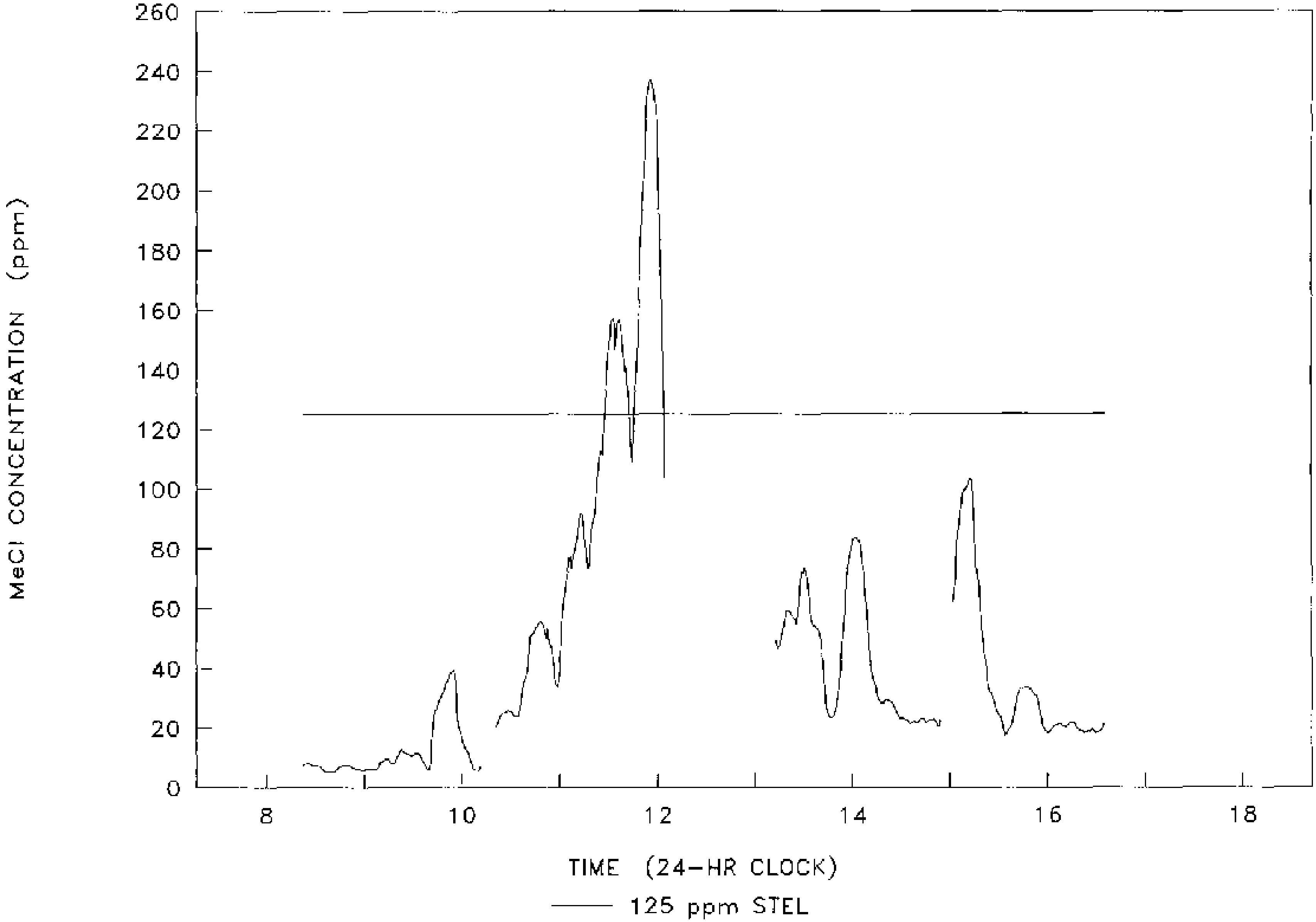
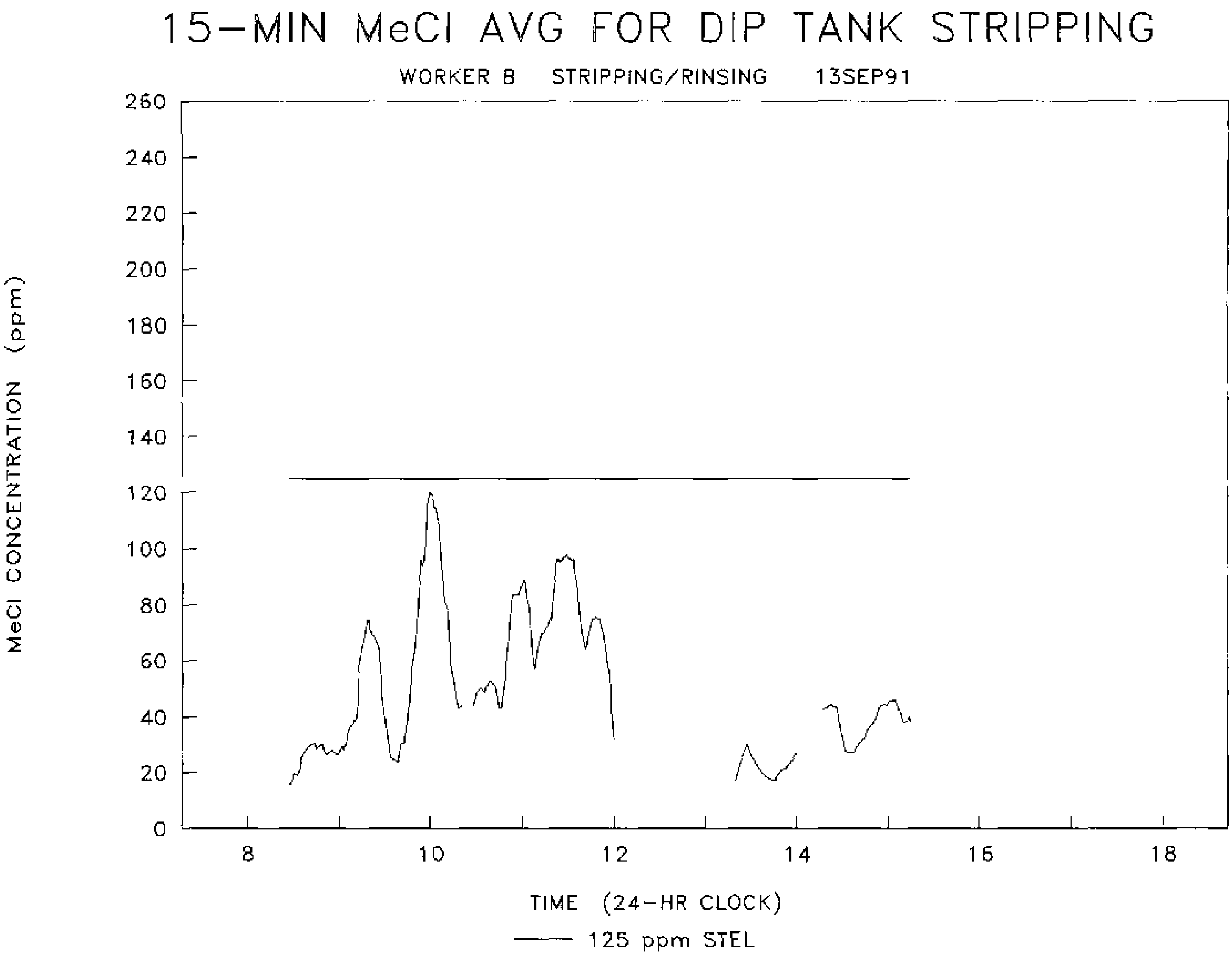


Figure 6


15-MIN MeCl AVG FOR DIP TANK STRIPPING
WORKER B STRIPPING/RINSING 13SEP91
MeCl CONCENTRATION (ppm)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
8
10
12
14
16
18
TIME (24-HR CLOCK)
125 ppm STEL

Tri-County Furniture Stripping and Refinishing Company