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ENSECO, INC.
ROCKY MOUNTAIN ANALYTICAL LABORATORY
ARVADA, COLORADO

NIOSH INVESTIGATOR:
Charles McCammon, Ph.D., CIH

## I. SUMMARY

On April 11, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation (HHE) of the Standards Preparation and Organic Extraction areas at the Rocky Mountain Analytical Laboratory, a division of Enseco, Inc. The requestor was concerned about multiple solvent exposure in the preparation of soil and water samples. On July 5, 1989, an initial walkthrough survey was conducted at the laboratory. On August 29 and 30, 1989, an environmental survey was conducted at the lab which consisted of the collection of twenty-three personal breathing zone and two area samples for multiple solvents, air flow measurements of the hoods, and short-term solvent level determination using a Miran direct-reading instrument, all in the Organic Preparations area. Limited noise level measurements were also conducted in the gas chromatography/mass spectrometry area of the lab. On December 8, 1989, a final visit was made to the lab to determine exposure to diazomethane during an occasional esterification operation that was not being conducted during the August visit.

The time-weighted average personal breathing zone samples for methylene chloride ranged from 0.8 to 8.5 ppm. The two area samples were 3.1 and 4.9 ppm. Two short-term personal samples averaged 33 ppm for a ten minute task to 286 ppm for a 24 minute job. Direct-reading instrument readings for methylene chloride found ambient levels of 1 to 3.5 ppm in the general Organic Prep Lab area and peak concentrations of 25 to 250 ppm around sample containers, 100 to 300 ppm in a sink while rinsing methylene chloride contaminated glassware, and levels in excess of 4000 ppm inside sample storage refrigerators.

Personal and area samples for hexane, ethyl ether, acetone and diazomethane were all at or below the limit of quantitation (0.03 mg/sample). Air flow measurements indicated that all the lab hoods were operating within guidelines when the sashes were kept closed to the half-way level. The exhaust vent on the flammable solvent cabinet was found to be totally plugged by accummulated lint and dust. No noise levels were found in excess of 80 dBA and general levels were below 75 dBA.

The NIOSH sampling results indicated three main problem areas which resulted in high short-term exposure to methylene chloride. This included poor ventilation over a sink where glassware containing residual methylene chloride was rinsed, the storage and handling of sample beakers containing methylene chloride and sealed only with aluminum foil, and the storage and transfer of waste solvent. NIOSH recommends that occupational exposure to methylene chloride be controlled to the lowest feasible level. If detectable levels of methylene chloride are found, further evaluation of the work environment is warranted and recommendations to reduce exposure to methylene chloride need to be implemented.

On the basis of the data collected, a potential health hazard existed from employee exposure to methylene chloride in excess of 1.0 ppm in the Organic Prepartion Laboratory at Rocky Mountain Analytical Laboratory. Recommendations are made to help management representatives minimize potential occupational health risks to methylene chloride.

KEYWORDS: SIC 7391 (Chemical Laboratories), acetone, diazomethane, ethyl ether, hexane, laboratories, methylene chloride

## II. INTRODUCTION

On April 11, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from the management of Enseco, Inc., to conduct a health hazard evaluation (HHE) of the Standards Preparation and Organic Extraction areas at the Rocky Mountain Analytical Laboratory, a division of Enseco, Inc. The requestor was concerned about multiple solvent exposure, including methylene chloride, hexane, ethyl ether, acetone, and diazomethane, in the preparation of soil and water samples. On July 5, 1989, an initial survey was conducted at the laboratory. This initial survey consisted of an opening conference with the laboratory personnel, a walkthrough of the entire laboratory, interviews with the employees in the Organic Preparation area, and a review of the chemical inventory for this area. On August 29 and 30, 1989, an environmental survey was conducted at the lab which consisted of the collection of personal breathing zone and area samples for multiple solvents, air flow measurements of the hoods, and short-term solvent level determination using a Miran direct-reading instrument, all in the Organic Preparations area. Limited noise level measurements were also conducted in the gas chromatography/mass spectrometry area of the lab. On December 8, 1989, a final visit was made to the lab to determine exposure to diazomethane during an occasional esterification operation that was not being conducted during the August visit.

## III. BACKGROUND

The Rocky Mountain Analytical Laboratory is a one-story building consisting of approximately 40,000 square feet of laboratory and office space. The Organic Preparation Lab is 6,500 square feet in size and consists of various areas including soils, water, sample storage, standards preparation and extract handling (see Figure 1). The primary operation in the Organics Lab involves the extraction and preparation of soil and water samples for chemical analysis. Soil samples are typically finely ground, acidified with various acids, extracted with solvents such as acetone, methylene chloride, and ethyl ether, dried and concentrated. There may be as many as 10-20 different steps involved in this process. Water samples are handled in a similar manner except the steps involve more pH adjustment and separation of aqueous layers from solvent layers. Extracted samples are generally stored in 500-ml, open-mouthed beakers covered with aluminum foil. Continuous liquid-liquid extractors (CLLEs) are commonly used to extract samples using methylene chloride (MeCl). Large banks of these CLLEs line the walls in two different locations within the Organic Prep Lab, numbering in the dozens. Each extractor contains about 550 ml of MeCl. Ventilation of these CLLEs has presented a problem and a number of different approaches have been tried including slot exhausts and canopy hoods.

Other operations in the Organic Prep Lab include the preparation of organic standards for gas chromatography, mass spectroscopy, etc.; the storage of the previously extracted samples in solvents in any of the 15 or so refrigerators; and glassware cleaning.

One of the employees reported a case of "over exposure" to chemicals shortly before Enseco filled out the request for an HHE. The employee became dizzy and nearly fainted while working in the Organic Prep Lab using MeCl for solvent extraction. The employee was taken to a nearby hospital and soon recovered. A check of the employee's carboxyhemoglobin level did not show an elevated level which would be indicative of MeCl exposure. This individual was transferred out of the area after reporting continued problems working with the solvents. No other employees have reported any health problems associated with solvent exposure. Some of the employees reported being concerned about the solvent levels particularly during sonification of samples with MeCl. In addition, ethyl ether odors were commonly noted as an area of employee concern.

## IV. EVALUATION DESIGN

The NIOSH evaluation consisted of: (1) a walkthrough evaluation of chemical handling and storage procedures throughout the lab, (2) personal breathing zone samples for multiple solvent exposures in the Organic Prep Lab, (3) air flow measurements of the laboratory hoods in the Organic Prep Lab, (4) interviews with representatives from management and laboratory employees, (5) and limited sound level determinations in two areas of the laboratory. The specific measurements and types of samples collected in the environmental survey are detailed below.

A. Personal breathing zone (PBZ) and area air monitoring was conducted for methylene chloride, ethyl ether, acetone, and hexane by collection on 150-mg charcoal tubes using personal sampling pumps at 50 to 200 cubic centimeters per minute (cc/min). For MeCl, two 150-mg charcoal tubes connected in series were used for collection. The samples were analyzed by gas chromatography (GC) equipped with a flame ionization detector (FID) according to the respective NIOSH methods with modifications:[1] acetone (#1500), ethyl ether (#1610), hexane (#1400), and methylene chloride (#1005).

B. PBZ and area air monitoring was conducted for diazomethane by collection on octanoic acid coated XAD resin tubes using personal sampling pumps at 50 cc/min. The samples were analyzed by GC/FID according to NIOSH Method #2515 with modification.[1]

C. Instantaneous measurements of MeCl concentrations were made throughout the Organic Prep Lab using a Foxboro Miran IB infrared analyzer. The instrument was calibrated several times using the internal library calibration.

D. Air flow measurements were taken at the laboratory hoods and other locations using a Kurz Series 490 mini anemometer on the 0-600 feet per minute (fpm) scale.

E. Sound level measurements were made using a Quest Model 215 sound level meter set on the A-weighted scale, slow response. It was calibrated using a General Radio Type 1562-A Permissible Sound Level Calibrator.

## V. EVALUATION CRITERIA

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

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

The primary sources of air contamination evaluation criteria for the workplace are: (1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs)[2]; (2) the American Conference of Governmental Industrial Hygienist's (ACGIH) Threshold Limit Values (TLVs)[3]; and (3) the U.S. Department of Labor (OSHA) permissible exposure limits (PELs)[4]. These sources provide environmental limits based on airborne concentrations of substances to which workers may be occupationally exposed in the workplace environment for 8 to 10 hours per day, 40 hours per week for a working lifetime without adverse health effects. Often, the NIOSH RELs and the ACGIH TLVs are lower than the corresponding OSHA PEL standards. Both NIOSH RELs and ACGIH TLVs usually are based on more recent information than are the OSHA PELs. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELs, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

The industrial criteria for the substances evaluated in this survey are presented in Table 1. 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 (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures. A discussion of the substances evaluated in this survey is presented below.

A. Acetone

Acetone has been considered to be a low hazard to health, since few adverse effects have been reported, despite widespread use for many years. Awareness of mild eye irritation occurs at airborne concentrations of about 1000 ppm. Very high concentrations (12,000 ppm) depress the central nervous system, causing headache, drowsiness, weakness, and nausea. Repeated direct skin contact with the liquid may cause redness and dryness of the skin.[5] However, at least six studies have been reported in the literature which have documented possible adverse effects on humans at exposures below 1000 ppm. Furthermore, the available evidence indicates that occupational exposure to acetone may lead to its accumulation in the body. NIOSH has therefore recommended lowering the current exposure limit from 1000 ppm to 250 ppm.[2] The current OSHA permissible exposure limit is 1000 ppm.[4]

B. Diazomethane

Exposure to diazomethane vapor may cause severe irritation of eyes, nose, throat, skin, and lungs. Symptoms include headache, weakness, cough, fever, chest pains, shortness of breath, and wheezing. The onset of symptoms after exposure may be delayed. Skin and mucous membrane exposure to liquids containing diazomethane may cause burns with the loss of the skin or mucous membrane. Prolonged or repeated exposure may lead to sensitization. If sensitization occurs, asthma-like symptoms or fever may occur after exposure to diazomethane where no symptoms were experienced before sensitization. Diazomethane has been reported to cause cancer of the lungs in animals.[6]

C. Ethyl Ether

Overexposure to ethyl ether may cause irritation of the eyes, nose, and throat. It may also cause dizziness, drowsiness, unconsciousness, and death. Prolonged overexposure may cause loss of appetite, dizziness, drowsiness, headache, exhaustion, excitation, and mental disturbances. It may also increase the severity of the effects of drinking alcoholic beverages.[6]

D. Hexane

Normal hexane is a mild upper-respiratory irritant and causes central nervous system depression. In industry, mild symptoms of narcosis, such as dizziness, have been observed when concentrations exceeded 1000 ppm but not when below 500 ppm. Until recently, chronic effects from hexane and similar hydrocarbons had rarely been reported. However in 1967, 17 cases of polyneuritis were reported among workers exposed to n-hexane at concentrations between 500 - 1000 ppm. Subsequent animal studies demonstrated functional disturbances of the peripheral nerves of mice at 250 ppm but not at 100 ppm. Other studies reported n-hexane nuropathy among furniture workers and among workers exposed to n-hexane used as a solvent in plastic cements. It is postulated that 2,5-hexanedione, a metalolite of n-hexane, is the neurotoxic agent.[5]

E. Methylene Chloride

Methylene chloride, or dichloromethane, is a chlorinated organic compound that is commonly used as a solvent, paint remover, and degreaser. It may be absorbed into the body by inhalation of vapors and by absorption of liquid through the skin. If inhaled in high concentrations, methylene chloride may affect the nervous system, leading to symptoms such as mental confusion, light-headedness, nausea, vomiting, and headache. Continued exposure to very high concentrations may cause increased light-headedness, staggering, unconsciousness, and death.[6] High vapor concentrations may also cause irritation of the eyes and respiratory tract. There have also been reports of chronic (long-term) neurotoxic (nervous system) effects among workers who have been exposed to methylene chloride for several years. Symptoms reported from chronic exposure have included forgetfulness, insomnia, headaches, fatigue, and hallucinations.[7] Exposure to methylene chloride may aggravate the symptoms of angina pectoris (heart pain), which may be accompanied by feelings of suffocation and palpitations. If the liquid is held in contact with the skin, it may cause irritation or skin burns. Splashes of the liquid into the eyes may cause irritation. Rats and mice have developed tumors and cancers after exposure to methylene chloride under specific experimental conditions.[8] Therefore, NIOSH recommends that methylene chloride be regarded as a "potential occupational carcinogen", and that exposure be controlled to the lowest feasible level.[8]

## VI. RESULTS

A. Methylene Chloride

The results for all the air samples collected for MeCl are summarized in Table 2. In all cases there was no MeCl detected (LOD=0.01 mg/sample) on any of the secondary back-up charcoal tubes. In general, the levels were all in the low parts per million (ppm) range (< 10ppm). The highest sample resulted from a

24-minute waste chemical dumping operation. This procedure was done upon special request even though the waste chemicals had been collected and dumped only days earlier. Therefore this job, which had an average exposure of 286 ppm, was probably an underestimation of the usual waste dumping task. The second highest exposure resulted from washing and rinsing separatory funnels in the sink with a canopy hood adjacent to the CLLEs in the Waters portion of the Organic Prep Lab. This was only a 10-minute job yet it averaged 33 ppm. Instantaneous readings showed levels to reach as high as 300 ppm. The remaining samples collected during routine jobs conducted in the laboratory, such as sample concentrating, column cleaning, various sample transfer operations, and sample sonification all resulted in MeCl concentrations ranging from 1 to 8 ppm.

A summary of the instantaneous MeCl reading obtained with the Miran IB are presented in Table 3. The ambient levels around the Organic Prep Lab ranged from 1 to 3.5 ppm. Several specific jobs resulted in substantial short-term exposure to MeCl, particularly dumping and rinsing the separatory funnels in the sink with a canopy and opening the refrigerators to get samples. The highest levels of MeCl were encountered around the sample storage refrigerators. Those refrigerators which contained only samples dissolved in MeCl in 500-ml beakers with aluminum foil on the top, had levels of MeCl as high as 4000 ppm inside the refrigerator (refrigerator #C, see Table 3). Refrigerators # C-H all had MeCl levels greater than 500 ppm inside them when first opened up.

B. Other Solvents

All samples for hexane, acetone, and ethyl ether were less than the limit of quantitation for the analytes which was 0.03 mg/sample. The tasks that were monitored for acetone and hexane included column cleaning, sample concentrating, sample preparation, and dishwashing which included an acetone rinse. An area sample placed on top of refrigerator #G where many samples that are dissolved in hexane and ether are stored, was also less than the limit of quantitation. The specific jobs monitored for ethyl ether included ether stripping, waste chemical collection and dumping, and the removal of ether dissolved samples from a refrigerator. All these samples were less than the limit of detection (0.01 mg/sample)

A 20-liter air sample was collected in the chemical storage cabinet in the Standards Prep area to determine what volatile chemicals were contributing to the odors noticed when the storage cabinet was opened. This sample was analyzed by gas chromatography/mass spectrometry. The reconstructed total ion chromatogram can be seen in Figure 2. The only detectable components found were traces of hexane and toluene.

C. Noise and Ventilation Measurements

Sound levels measurements taken during the sonification of samples in the Soils area of the lab ranged from 78 to 80 dBA during this short operation. The measurements were taken at head level at the hood sash. General sound level measurements were also taken around the mass spectrometer (MS) where employees had expressed concern about the noise levels from the vacuum pumps on the MS units. Noise levels were in the range of 70 to 75 dBA in this area and were highest directly under the speakers for the sound system.

Ventilation measurements were made on all 9 hoods in the Soils and Water areas. The air flows in the hoods were fairly consistent from hood to hood and averaged between 150-200 feet per minute (fpm) when the sashes were closed to the half-way mark and 50-100 fpm when the sashes were opened all the way. When fully opened, the air flows tended to be in the range of 50-75 fpm at the bottom and 75-100 at the top of the opening. At any given time, at least one-half of the hoods had the sashes fully opened regardless of whether there were samples in the hood or if any one was working at the hood.

Air flow measurements at the exhaust exit on the flammable solvent storage cabinets indicated there was no air being exhausted. Closer examination revealed that the screen at the exit was totally blocked by lint and dust.

## VII. DISCUSSION AND CONCLUSIONS

The major exposures in the lab centered around the large volume of methylene chloride used to extract and concentrate the soil and water samples. A big contributor of ambient MeCl levels was the use of aluminum foil to cover the tops of the open-mouthed beakers containing MeCl. Carts full of these samples would sit in the lab while they were processed. The aluminum foil did not seal well for such a volatile solvent as MeCl. Storage of literally hundreds of these samples in the various refrigerators also was a major source of MeCl vapors, resulting in high short-term exposures whenever the refrigerators were opened.

The ventilation on the CLLEs was not very effective in collection of MeCl vapors from distances of greater than 10 inches from the slot as determined by smoke tests. This also contributed to MeCl vapors in the lab. The sink adjacent to the CLLEs had a canopy hood which was not efficient nor appropriate. The vapors collected by the canopy would travel from the glassware in the sink, past the employees face and into the exhaust, thus exposing the employees to a greater degree. This is illustrated by the 33 ppm exposure of the employee washing separatory funnels in this sink and by the peak levels of up to 300 ppm measured with the direct-reading instrument.

Another area of concern was the waste chemical handling and storage. The person conducting this operation would wear heavy rubber gloves, an apron, and a full-face organic cartridge respirator. The bungs of the 55-gallon storage drums for the waste chemicals had all been left loose so that the employee doing the waste chemical job could easily remove the bungs with the bulky rubber gloves. These loose bungs resulted in solvent vapor accumulation in the waste chemical storeroom since it was not well vented. Additionally, there was no local exhaust ventilation on the drums so when waste solvent was poured into the drum, the saturated vapor was displaced directly into the employees breathing zone. This situation was the cause for the high (286 ppm) MeCl exposure during an abbreviated waste chemical collection and dumping operation.

Exposures to other solvents including acetone, hexane, and ethyl ether were all quite low. No problems were identified with the handling of these chemicals. Also, no diazomethane was detected during the esterification procedure. The procedures and precautions developed for handling diazomethane appeared to be sufficient.

No noise levels were found above 80 dBA and those measured between 75 and 80 dBA were for only short periods of time. Those areas checked included around the sample sonification in the Organic Prep Lab and in the general GC/MS area.

## VIII. RECOMMENDATIONS

1. Air-tight containers should be used for samples instead of foil covered open-mouthed beakers. This would help contain the volatile solvent vapors from methylene chloride, ethyl ether, and hexane.

2. As a part of the periodic maintenance program in the lab, the screens on the exhaust port in the flammable solvent cabinets should be routinely cleaned.

3. Although the laboratory hoods operate well when the sashes are kept closed to the half-way level, there was no consistency in insuring that hood sashes were properly placed. Employees should be constantly reminded, through training, of the importance of keeping the sashes at the proper position. The first-line supervisor should have the responsibility to insure that this is done.

4. New ventilation designs should be sought for control of vapors around the CLLEs. The old slot ventilation was not effective beyond about 10 inches from the slot. The new canopy slot design was was not very effective due to the turbulence cause by the high exhaust rate of the air and proximity to the air supply ducts on the ceiling. This system is also wasteful of energy in that large volumes of air are being exhausted in an inefficient system. More thought should be given to enclosure (full or partial) of the CLLEs and trying to ventilate a smaller area more efficiently.

5. The local exhaust ventilation on the sink next to the CLLEs needs to be redesigned. The canopy hood design is not effective and actually increases worker exposure. A possible approach would be to enclose the sink on the sides and top and providing exhaust ventilation using a slot at the back of the sink.

6. Employees should be instructed to keep the bungs tight on all the waste chemical storage drums. Ventilation of the waste storage area should also be implemented. Local exhaust ventilation should be installed on the waste storage drums to reduced the displaced solvent vapor during waste solvent pouring. NIOSH does not recommend air-purifying respirators for use with methylene chloride, only air supplied respirators should be used.

7. NIOSH considers methylene chloride to be a potential human carcinogen. As such, efforts should be made to control exposures to the lowest feasible concentration.

## IX. REFERENCES

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6. Occupational Health Guidelines for Chemical Hazards. DHHS (NIOSH) Publication No. 81-123, January 1981.

7. Criteria for a recommended standard: Occupational exposure to methylene chloride. National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1976. DHEW publication No. (NIOSH) 76-138.

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## X. AUTHORSHIP AND ACKNOWLEDGEMENTS

| | |
|---|---|
| Report Prepared by: | Charles S. McCammon<br>Regional Consultant for<br>Occupational Health<br>Denver Regional Office |
| Field Assistance: | William J. Daniels<br>Regional Industrial Hygienist<br>Denver Regional Office |
| Report Typed by: | Marile DiGiacomo<br>Secretary<br>Denver Regional Office |

## XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. Enseco, Inc., Arvada, Colorado
2. OSHA Region VIII
3. NIOSH Cincinnati Region

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

Table 1
ENVIRONMENTAL CRITERIA FOR SELECTED SUBSTANCES

| SUBSTANCE | OSHA PEL | NIOSH REL | ACGIH TLV |
|---|---|---|---|
| Acetone | 750 ppm<br>8-hr TWA<br>1,000 ppm<br>STEL | NA | 750 ppm<br>8-hr TWA<br>1,000 ppm<br>STEL |
| Diazomethane | 0.2 ppm<br>8-hr TWA | NA | 0.2 ppm<br>8-hr TWA |
| Ethyl ether | 400 ppm<br>8-hr TWA<br>500 ppm<br>STEL | NA | 400 ppm<br>8-hr TWA<br>500 ppm<br>STEL |
| Hexane | 50 ppm<br>8-hr TWA | NA | 50 ppm<br>8-hr TWA |
| Methylene chloride | 500 ppm<br>8- TWA<br>1000 ppm<br>STEL | Ca-LFC* | 50 ppm<br>8-hr TWA |

Abbreviations and Key

TWA - Time-weighted average concentration
STEL - Short-term exposure limit; 15-minute TWA exposure
ppm - Parts of contaminant per million parts of air
NA -not applicable, NIOSH has no recommended exposure limit
*Ca-LFC - potential human carcinogen, reduce exposures to the lowest feasible concentration

TABLE 2
SUMMARY OF PERSONAL AND AREA AIR SAMPLES FOR METHYLENE
CHLORIDE, ORGANIC PREPARATION LAB
ROCKY MOUNTAIN NATIONAL LABORATORY
*DIVISION OF ENSECO, INC.*
AUGUST 29-30,1989

| Sample # | Area (A) or Personal(P) | Date | Sample Duration (min) | Concentration mg/m3 | ppm | Description of Activities or Location |
|---|---|---|---|---|---|---|
| 101 | P | 8-29-89 | 241 | 7.0 | 2.0 | Sample prep, transfer of MeCl from separatory funnels |
| 102 | P | 8-29-89 | 293 | 5.4 | 1.6 | Transferring sample from 250-ml beakers, load on steam bath |
| 103 | P | 8-29-90 | 233 | 2.7 | 0.8 | Sample concentrating |
| 104 | P | 8-29-90 | 218 | 3.9 | 1.1 | Sample sonification |
| 105 | P | 8-29-90 | 218 | 4.5 | 1.3 | Sample sonification |
| 106 | P | 8-29-90 | 318 | 4.2 | 1.2 | Sample concentrating |
| 111 | A | 8-29-90 | 142 | 17.0 | 4.9 | Above refrigerator #G in organic lab storage |
| 113 | P | 8-29-90 | 10 | 113 | 33 | Washing separtory funnels in sink near CLLE |
| 114 | P | 8-30-90 | 200 | 10 | 2.9 | Column cleaning |
| 119 | P | 8-30-90 | 210 | 30 | 8.5 | Sample concentrating |
| 121 | P | 8-30-90 | 234 | 4.2 | 1.2 | Sample concentrating |
| 127 | P | 8-30-90 | 198 | 6.8 | 2.0 | Sample concentrating |
| 132 | P | 8-30-90 | 115 | 9.8 | 2.8 | Transferring 100 ml MeCl into soil samples |
| 134 | A | 8-30-90 | 199 | 11 | 3.1 | On top of refrigerator #F in organics lab storage |
| 135 | P | 8-30-90 | 24 | 995 | 286 | Collecting waste chemicals & dumping into waste chemical storage |

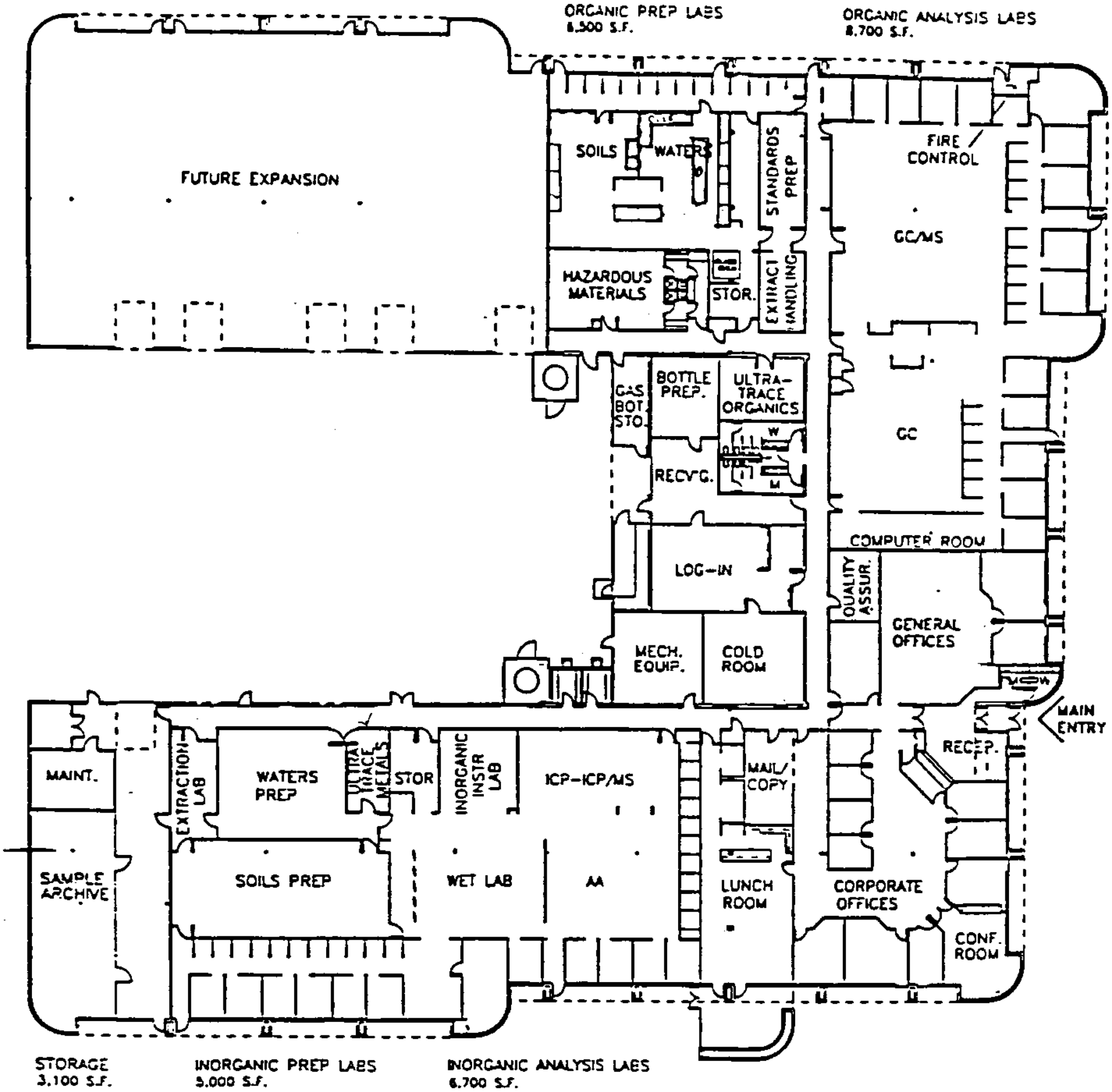
Table 3
SUMMARY OF INSTANTANEOUS METHYLENE CHLORIDE
CONCENTRATIONS MEASURED BY MIRAN IB INFRARED ANALYZER
ROCKY MOUNTAIN ANALYTICAL LABORATORY
AUGUST 29-39, 1989

| Location | Concentration (ppm) |
|---|---|
| Throughout Organic Prep Lab - ambient | 1-3.5 |
| Near base of CLLEs, adjacent to sink | 6-10 |
| Two-inches above 500-ml beakers (with MeCl) on metal cart | 25-250 |
| Waste storage room, ambient | 20-25 |
| Emptying and rinsing separatory funnels in sink | 100-300 |
| Opening refrigerator #G, breathing zone level, 5-min average | 100-125 |
| Standard Prep area, ambient | 2.5 |
| Refrigerator Measurements* | |
| Refrigerator # | |
| 18 | 4.0 |
| L | 17 |
| M | 8.7 |
| Q | 2.7 |
| P | 5.9 |
| O | 1.1 |
| L | 7.7 |
| K | 1.9 |
| J | 9.8 |
| E | 710 |
| F | 780 |
| G | 3390 |
| H | 3760 |
| B | 31 |
| C | 4180 |
| D | 1740 |

*Samples were collected by opening refrigerator and inserting Miran IB probe in the middle of the space above the lowest shelf.

Figure 1

Floorplan for Rocky Mountain Analytical Laboratory




Rocky Mountain Analytical Laboratory

A Division of ENSECO, Incorporated

Figure 2

Reconstructed Chromogram of GC/MS Analysis of
Air Sample from Chemical Storage Cabinet