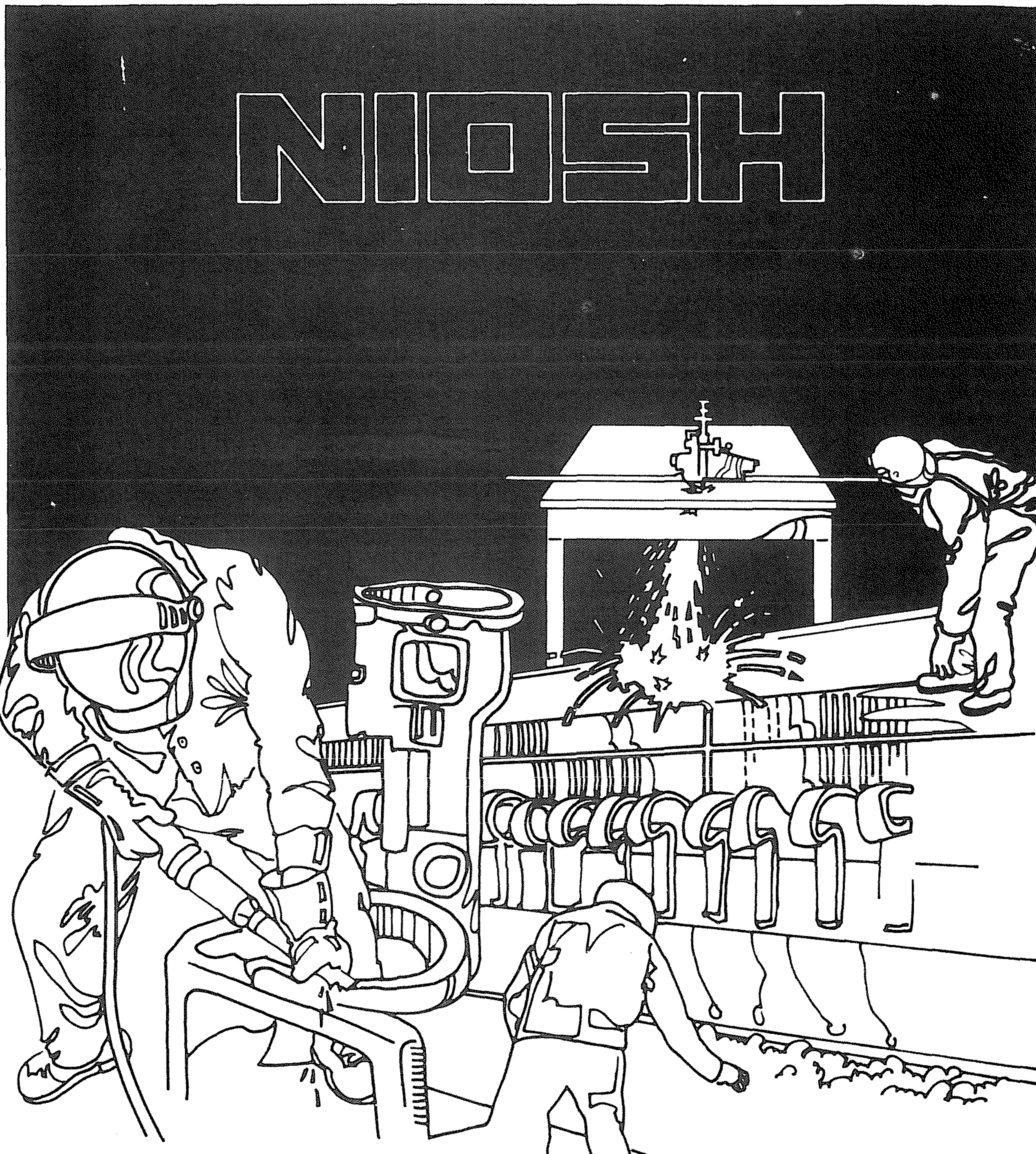
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 81-382-1439
ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS

PREFACE

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

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

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ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS

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I. SUMMARY

In July 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation at the Energy Resources Co., Inc., Cambridge, Massachusetts. The request sought an industrial hygiene evaluation of several analytical chemistry laboratories. Acting under a cooperative agreement with NIOSH the Harvard School of Public Health, Occupational Health Program, conducted environmental and medical evaluations at the laboratories during January to April 1982.

Time-weighted average (TWA) exposures to methylene chloride and hexane for a 7 to 8-hour day were determined for 20 employees, using both passive dosimeter badges (charcoal) and the NIOSH validated charcoal tube method. For hexane, the badge results compared favorably with the charcoal tube results. For methylene chloride, the badge results were significantly higher than the charcoal tube results. All TWA exposures were below Occupational Safety and Health Administration (OSHA) standards. For methylene chloride, the exposures ranged from non-detectable to 118 ppm with one sample exceeding the NIOSH recommendation of 75 ppm. For hexane, the exposures ranged from non-detectable to 45 ppm (NIOSH recommends 100 ppm). Combining the charcoal tube exposure levels for the vapor mixture, based on the central nervous system effects of methylene chloride and hexane, showed one sample to be above survey criteria.

Measurement of face velocities in laboratory hoods revealed two hoods with unacceptably low airflows. Airflow balance studies showed inadequate makeup air for both the Marine Organics and General Organics Laboratories.

Eleven of 14 workers reported acute symptoms, (e.g. headache, anxiety, fatigue, irritability, dizziness) consistent with the effects of solvent exposure. The frequency of symptoms seemed to correlate in a limited way with solvent use patterns. A slight, but not statistically significant, slowing in response time was seen in workers chronically exposed to solvents when compared with an unexposed control group.

Although just one air sample indicated an exposure slightly above survey criteria, the acute symptomatology among laboratory workers may be related to solvent exposures. No evidence of chronic health impairment was found. Several health and safety recommendations are included in this report.

KEYWORDS: SIC 7391 (Chemical Laboratories), hexane, methylene chloride, passive dosimeters.

II. INTRODUCTION

In the summer of 1981, a worker from the Energy Resources Company, Inc. (ERCO), Cambridge, Massachusetts 02138, was seen at the Occupational Health Clinic of the Brigham and Women's Hospital. He complained of vasomotor rhinitis and generalized constitutional symptoms. As a result, the management of ERCO requested a health hazard evaluation from NIOSH in order to determine whether these symptoms were work-related and to have the laboratory "examined" for potential problems. During January to April 1982, the Occupational Health Program of the Harvard School of Public Health, acting under a cooperative agreement with NIOSH, carried out environmental and medical evaluations at ERCO. The environmental study included air monitoring to determine solvent exposures to laboratory personnel and an assessment of the laboratory ventilation systems. The medical study included health history and occupational questionnaires, neurobehavioral testing, a blood chemistry battery (SMAC 25), and a hematological profile.

III. BACKGROUND

There are about 50 people employed in this division of ERCO. Twenty work in the offices and the rest do various kinds of analytical chemistry on soil and water samples, including sample preparation, extraction with organic solvents, gas chromatography, mass spectrometry, atomic absorption, etc.

The building has two floors; all the labs and a few offices are on the first floor; the rest of the offices are on the second floor. The survey focused on two of the laboratories where the complaints originated, known informally by ERCO personnel as the "general organics lab" and the "marine organics lab." These labs are located in two rooms toward the rear of the first floor, adjacent to several other laboratories.

Ventilation is provided by six laboratory fume hoods in the general organics lab and four laboratory fume hoods in the marine organics lab. In addition, a slot hood runs the length of one of the benches in the general organics lab. The location of these hoods and the ceiling vents supplying general ventilation are indicated in Figure 1.

IV. METHODS

A. Environmental

On January 12, 1982, measurements of solvent concentrations (e.g., hexane, methylene chloride, methanol) were made with a direct-reading instrument (Miran 1A General Purpose Gas Analyzer) in order to select the appropriate passive dosimeter badge for personal sampling. The Miran 1A is a single-beam portable infrared gas analyzer that can operate at wavelengths from 2.5 to 14.5 um. Its gas cell has a variable pathlength between 0.75 to 20.25 meters. It has detection sensitivities of 0.02 ppm hexane, 0.2 ppm methylene chloride, and 0.1 ppm methanol, using the 20.25 meter pathlength. Hexane was measured at a wavelength of 3.43 um, methylene chloride at 13.3 um, and methanol at 9.6 um. Methanol shows a minor peak of absorbance at 3.4 um, but laboratory calibrations showed that air concentrations equal to or below 10 ppm would contribute less than 0.026 absorbance units at a pathlength of 20.25 um to hexane readings at 3.43 um. Air was sampled using a teflon hose plus particulate filter. The analyzer was connected to a portable chart recorder and the air concentrations were sampled for periods of 5 to 10 minutes in the various laboratories. Methylene chloride and hexane were the two solvents used in greatest quantity and were selected for personal exposure monitoring.

On February 10, 1982, 16 workers in various areas of the building were monitored for 8-hour methylene chloride and hexane exposures using Dupont Protek G-AA passive dosimeter badges. This dosimeter consists of 300 mg of activated charcoal embedded in a support medium sandwiched between two plastic diffuser grids, which in turn can be sealed by plastic covers. With the covers off, the diffuser grid allows air to reach the charcoal at the rate of approximately 50 cc/min by means of molecular diffusion. One cover of each badge was removed and the badge clipped to the collar of the individual being monitored. If the individual left the building for lunch, the badge was removed and covered. At the end of the day, the badges were covered, sealed in aluminum pouches, and stored at -10'C until analyzed.

On April 6, 1982, the 16 workers were remonitored using passive dosimeters. Additionally, 10 of these individuals were monitored concurrently with charcoal tubes. The charcoal tube sampling was done primarily to verify the dosimeter results, since only limited data on multiple solvent sampling has been published for dosimeters. A charcoal tube consists of a sealed glass tube holding two sections of charcoal (150 mg and 75 mg) separated by support material. For sampling, both ends are broken and the tube is placed into a holder which is connected to an air sampling pump whose airflow rate has been calibrated before and after sampling. The charcoal tube in its holder was clipped to an individual's collar and the pump was either clipped to a belt or placed in a lab coat pocket. A low flow rate (10 cc/min) was used and the charcoal tubes were changed after about 3 hours to prevent migration of the solvents from the front to the back section. Upon completion of sampling, the charcoal tubes were capped and stored at -10'C until analyzed. For analysis, the charcoal was removed from badges and tubes, desorbed with carbon disulfide, and analyzed for methylene chloride and hexane by gas chromatography as detailed in NIOSH Analytical Methods S329 and S90. The morning and afternoon charcoal tube results were combined by time weighting each result (by fraction of total sampling time) and summing the results.

B. Ventilation

The laboratory hoods in the General Organics and Marine Organics Laboratories were evaluated using the criteria and protocol of the Harvard University Chemical Fume Hood Program. The hood face velocity measurements were made using a thermal anemometer. Nine measurements were taken for each hood face at the centers of rectangles formed by dividing the hood face into a 3 by 3 grid. All hoods were measured in their normal operating configurations (i.e., with normal equipment in place even if this equipment obstructed slots, etc.) and at more than one sash height where possible. A limited survey of the airflow balance in the two laboratories was made by determining airflows in supply air ducts and through doorways with a rotating vane anemometer.

C. Medical

Fourteen individuals were evaluated. Six worked primarily in the General Organics Lab, six were from the Marine Organics Lab, one was the dishwasher, and the remaining individual was borrowed from the Volatile Organics Lab to work for a few months in the General Organics Lab. Six employees were female, eight were male. The age range was 23 to 36 years (mean of 26.5 years, median of 26 years). Length of employment ranged from 2.5 months to 58 months (mean of 19.4 months, median of 13 months).

Each person was questioned concerning symptoms of solvent toxicity; history of prior exposure to neurotoxins in work, school, and home environments; past medical history; current levels of solvent exposure; and history of cigarette and alcohol use.

Long-term effects of solvent exposure were evaluated using continuous performance testing (CPT) and reaction time. Testing was performed prior to work on a Monday morning. A group of individuals working for ERCO but not exposed to solvents was used as a control group. Both groups were tested on April 12, 1982. The control group was similar to the exposed group (age range of 23 to 35 years, mean of 27.8 years, median of 27.0 years). There were three females and seven males. Jobs held by members of the control group included secretarial, word processing, administration, and general support functions.

Venous blood samples were collected, and an automated chemistry battery (SMAC 25) and a hematological profile were performed using standard techniques by a commercial laboratory.

V. EVALUATION CRITERIA

A. Environmental

As a guide to the evaluation of hazards posed by workplace exposures, occupational health professionals employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria 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. However, not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

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

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and (ACGIH) TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

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

The environmental criteria for methylene chloride, hexane, and methanol judged most appropriate for this study are:

Solvent	NIOSH Recommendation	OSHA Standard
Methylene Chloride	75 ppm, 10-hour day average 500 ppm, 15-minute ceiling	500 ppm, 8-hour day average 1000 ppm, 15-minute ceiling 2000 ppm, 5-minute ceiling in any 2-hour period
Hexane	100 ppm, 8-hour day average 510 ppm, 15-minute ceiling	500 ppm, 8-hour day average
Methanol	200 ppm, 10-hour day average 800 ppm, 15-minute ceiling	200 ppm, 8-hour day average

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

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

exceeds unity, then the recommended environmental limit for the mixture is considered as being exceeded. C_1 is the observed air level and T_1 is the corresponding environmental limit. Calculations of solvent vapor mixture fractions were performed for each charcoal tube sample of this study according to the central nervous system effects of methylene chloride and hexane.

B. Toxicology

Methylene chloride, a chlorinated hydrocarbon, is colorless and non-flammable. Routes of entry into the body are inhalation of vapors and skin absorption. Although chlorinated hydrocarbons are less toxic than other halogens (e.g., bromine, iodine), methylene chloride exposure may result in general central nervous system (CNS) effects and narcosis. Symptoms may include headache, giddiness, stupor, uncoordination, irritability, nausea, vomiting, numbness and tingling in limbs, and prolonged reaction time.

Methylene chloride liquid and vapor produce irritation of mucous membranes of the eyes, nose, and throat. Exposure to high concentrations produces pulmonary irritation which could lead to pulmonary edema. Liquid methylene chloride held in contact with the skin results in skin burns. Repeated exposure may produce contact dermatitis and infection. Methylene chloride is metabolized to carbon monoxide and has been associated with angina and myocardial infarction secondary to increased carboxyhemoglobin.

Some chlorinated hydrocarbons have been shown to be both mutagenic by Ames testing and carcinogenic in laboratory animals. Methylene chloride has been shown to produce liver and kidney damage in laboratory animals.

Hexane is a colorless, flammable, aliphatic hydrocarbon whose properties appear similar in many ways to the chlorinated hydrocarbons. Aliphatic hydrocarbons are asphyxiants, narcotics, and general CNS depressants. Route of entry is through inhalation and to a lesser degree through skin absorption. CNS symptoms of over exposure may include lightheadedness, giddiness, nausea, headache, and dizziness. Greater exposure can result in unconsciousness and death.

Hexane, like methylene chloride, is a respiratory, skin, and mucous membrane irritant affecting eyes, nose, and upper respiratory tract. Prolonged and repeated skin exposure causes defatting which can lead to dermatitis and infection as with methylene chloride. Aspiration may result in chemical pneumonitis and pulmonary edema.

Recent research into the exposure of glue sniffers and Japanese sandal makers has shown n-hexane to be associated with the development of peripheral neuropathy, which may develop from several months to a year following beginning of exposure. A delayed progression of the disorder may continue for up to 3 months following cessation of exposure. Initial symptoms often have been sensory with numbness and paresthesias of distal extremities. Sensory loss usually involves hands and feet. Generally the result is a subacute, progressive sensorimotor polyneuropathy, which in most cases is thought to be reversible.

VI. RESULTS AND DISCUSSION

A. Environmental

Air concentrations of hexane, methylene chloride, and methanol as measured with the Miran 1A are reported in Table 1. A summary of individual exposures to methylene chloride and hexane as measured by badges and charcoal tubes are presented for both days of sampling in Tables 2 and 3 using ranges and geometric means.

(Geometric means are measures of central tendency for air sampling data which typically have log normal distributions). Individual air sample results for all personnel monitored as well as reported activities during the sampling periods are detailed in Tables 4 and 5.

As determined by the direct reading instrument, air concentrations of methanol were below 14 ppm. It is concluded that any exposures to methanol would be well below the OSHA standard or evaluation criteria of 200 ppm for an 8-hour average daily exposure.

All individual exposures were below the OSHA legal standard, which is a 500 ppm time-weighted average over an 8-hour day for both methylene chloride and hexane. With the exception of one exposure to methylene chloride (92 ppm, May 6, 1982, Employee No. 6, performing sample separation in poorly ventilated corner of Marine Organics Laboratory), all exposures were below NIOSH recommended limits of 75 ppm for methylene chloride and 100 ppm for hexane. Combining the charcoal tube solvent exposures as a percent of survey criteria (see Section V) also showed just the one sample to be above survey criteria. Since NIOSH recommended standards are generally designed to ensure worker health for 8 hours a day exposures for a number of years, it is unlikely that the single elevated excursion represents any harm to the employee, especially since the recommended standard is based on a reversible effect, i.e., elevated carboxyhemoglobin levels. However, in the future, the back poorly ventilated corner of the front room of the Marine Organics Laboratory should probably not be used for extensive solvent work.

One exposure to methylene chloride was unexpectedly high in that the individual worked in the office. Both badge and charcoal tube showed a high exposure. The employee reportedly had not entered the Marine or General Organic Laboratories on the day of sampling but had made several trips through the hallway in the front section of the building (in the vicinity of Volatile Organics). The employee had used the duplicating machine but had not worked with toners. The elevated methylene chloride exposure cannot be explained by reported activities, but should be investigated. The location of the intake duct for the ventilation of the office should be checked. Air outlet ducts from buildings are often improperly placed too close to air intake vents and can serve as a route of exposure.

Finally, the dosimeters and charcoal tubes agreed well on the levels of hexane exposure. However, in six of eight methylene chloride measurements with detectable results, the badges gave higher results than the charcoal tubes (by 30 to 500%). This difference was statistically significant and may be due to the sampling rate provided by the manufacturer of the dosimeters.

Passive dosimeter badges are a relatively new sampling method developed within the past 5 years for 8-hour time-weighted average vapor sampling. Passive badges have the advantages of being convenient, lightweight, unobtrusive, and they require no calibration of pumps on the part of the user. Their main disadvantage is that they have not been used or validated as extensively as the traditional charcoal tube method. In addition, the dosimeter sampling rates for many solvents have not been determined experimentally.

B. Ventilation

The Marine Organics Laboratory contained four hoods, none with supplied air. All four fume hoods had face velocities equal to or greater than 100 fpm when open to a height of 21 inches. Hoods 1, 2, and 3 also had face velocities greater than 100 fpm when open to their full height of 33 inches. Hood 4 did not, and should be restricted to operation with a sash height of not greater than 21 inches. All measurements were within the prescribed range of ±20% of the average reading (Table 6).

The airflow balance (Table 7) in the Marine Organics Laboratory was determined together with the Instrumentation Room immediately behind it. These two rooms receive supply air through four ceiling outlets. There are two additional ceiling outlets which did not supply air. The airflow in the Marine Organics Laboratory is out of balance. The hoods are drawing off more air than the existing makeup air system can supply. Air enters from the Organics Laboratory through a door that seemed to be constantly open. When the door to the hallway is open, 1320 cfm enters through the door way. When the hall door is closed, makeup air is drawn in through loose tile in the suspended ceiling.

The General Organics Laboratory has more ventilation equipment than the Marine Organics Laboratory, more variation in equipment, and more complex problems (Table 8). Hood 1 did not have an acceptable face velocity when open. Since this hood houses distillation apparatus containing a large amount of volatile solvent, it represents a hazard and should be corrected. Hood 4 also has unacceptably low face velocity. This hood could not be closed below the 28-inch mark because of the permanent installation of equipment. Adjustments should be made to this hood to bring the average face velocity up to 100 fpm or the equipment configuration should be modified so that the sash can be lowered.

In addition to fume hoods, the General Organics Laboratory had one exhaust slot mounted at the center and above the counter top on one bench. The slot face was about 18 inches from the edge of the benchtop. Air velocity at the edge of the bench varied from 0 to 50 fpm. Because the benchtop was unprotected, any movement in the aisles would be expected to disrupt the minimal capture velocity. Solvent vapor capture by this slot is low to non-existent.

Although there are several supplied air hoods in the General Organics Laboratory and more ceiling air supply vents than in the Marine Organics Laboratory, there is insufficient makeup air (Table 9). When the door to the hallway is opened, 1250 cfm enters (Table 9). As in the Marine Organics Laboratory, this room is operating under negative pressure. The necessary makeup air may be drawn in through loose tile in the suspended ceiling.

ERCO management desires the Marine Organics Laboratory and the General Organics Laboratory to be under positive pressure because of the analyses for trace amounts of materials. Since these labs are under negative pressure there is a greater possibility of sample contamination from the entering air.

C. Medical

Eleven of the 14 workers questioned had experienced one or more symptoms generally associated with acute solvent exposure (Table 10). The most frequently reported symptoms included headache, anxiety, fatigue, irritability, and dizziness. These symptoms are consistent with methylene chloride and hexane exposures.

Eleven of 14 workers reported weekly hexane use, with amounts ranging from 0.1 L to 10 L per week (mean use was 5 L, median use 4 L). Ten of 14 workers reported weekly methylene chloride use, with amounts ranging from 2 L to 16 L per week (mean of 6.6 L, median of 6.5 L). Data stratified by number of health complaints, estimated weekly solvent use, and length of time exposed yielded numbers per group which, while too small to be of general significance, nonetheless did not show evidence of a dose-response relationship (Table 11).

Both simple reaction time and continuous performance testing results showed the exposed group to be consistently slower than the control group (Tables 12 and 13). The results are not significant statistically, due to the small sample size, with the possible exception of Sound at 10 inches (see Table 12) where $p = 0.06$.

The exposed and control groups were similar in that no individuals reported abnormal lack of sleep the night prior to testing. Most had drunk coffee within the 1 to 2 hours immediately prior to the tests, and most had reported no alcohol consumption for 24 hours before the tests. There were three females and seven males in the control group with a mean age of 27.8 years and four females and six males in the exposed group with a mean age of 26.5 years. Since age and sex are factors affecting level of performance, Table 14 shows the results of individuals matched by age and sex. These results are consistent with the group findings, showing the exposed individuals slower than the control individuals.

There were no significant abnormalities noted on the blood chemistry or hematologic profiles.

VII. RECOMMENDATIONS

1. Restrict work with volatile solvents to hoods, where possible. Especially, discontinue use of poorly ventilated back corner in the front section of the Marine Organics Laboratory for solvent work.

2. Determine the source of solvent exposures for employees in the front secretarial office.

3. Determine employee solvent exposures during periods of peak activity and during summer months. Given the analytical facilities available, ERCO's Safety Committee should be able to easily reassess employee exposures.

4. Increase face velocities in Hoods 1 and 4 in the Organics Laboratory to a minimum of 100 fpm.

5. Restrict work with volatile solvents to the hoods, since the capture velocity at the benchtop from the "slot" fluctuates and is inadequate to capture fumes.

6. Supply additional makeup air to the laboratories if "positive pressure" conditions are required.

7. Complete the survey of the exhaust and supply air systems to determine the source and purity of supply air, since personnel complain of diesel "fumes".

8. In the "Fish Laboratory", the serial dilution unit used for testing appears to have plug-in wiring as opposed to being "hard wired". This should be inspected by someone versed in the National Electrical Code.

9. In the General Chemicals Laboratory, the "Biohazard Hood" which is used with cyanide in the preparation of specimens has no measurable air movement. This hood should be inspected and modified to achieve a minimum average face velocity of 100 fpm.

10. Encourage the use of barrier creams to prevent hands from becoming red, dry, and fissured, following solvent exposure.

11. Determine the need for personal protective equipment including gloves, safety glasses with side shields or chemical goggles, arm guards, aprons, and respiratory protection.

12. Contact the State Department of Health concerning immunization programs for workers handling raw sewage.

VIII. REFERENCES

1. Proctor NH, Hughes JP. Chemical Hazards of the Workplace. JB Lippincott Co., Philadelphia, 1978.

2. Occupational Diseases: A Guide to Their Recognition. Rev. ed. 1977. U.S. Department of Health, Education, and Welfare, Centers for Disease Control, National Institute for Occupational Safety and Health.

IX. ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. Energy Resources Company
2. Massachusetts Department of Labor and Industries
3. NIOSH, Region I
4. OSHA, Region I

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
SOLVENT AIR CONCENTRATION RANGES BY DIRECT READING INSTRUMENT*

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

JANUARY 1981

DEPARTMENT	ACTIVITY	HEXANE (ppm)	METHYLENE CHLORIDE (ppm)	METHANOL (ppm)
Marine Organics	Column Chromatography	8 to 30	6 to 22	5 to 14
Marine Organics	Rotoevaporation	---	12 to 38	8
General Organics	Sample Separation	---	26 to 154	---
Inorganic Lab	Sample Transfer and Jar Rinsing	---	42 to 438	---
Survey Criteria		100	75	200

*Air concentrations were determined using a portable infrared gas analyzer. See text for additional details.

TABLE 2
SUMMARY OF TIME WEIGHTED AVERAGE METHYLENE CHLORIDE EXPOSURES

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

LOCATION	PASSIVE DOSIMETER (2/10/82) NO. SAMPLES	AIR CONCENTRATIONS* MEAN*	AIR CONCENTRATIONS* RANGE	PASSIVE DOSIMETER (5/6/82) NO. SAMPLES	AIR CONCENTRATIONS* MEAN	AIR CONCENTRATIONS* RANGE	CHARCOAL TUBE (5/6/82) NO. SAMPLES	AIR CONCENTRATIONS* MEAN	AIR CONCENTRATIONS* RANGE
Marine and General Organics	11	9	nd* to 34	13	20	nd to 119	7	15	nd to 92
Volatile Organics	3	8	4 to 13	2	5	nd to 16	2	5	nd to 16
First Floor-Front Office	1	88	---	1	38	---	1	44	---
Second Floor-Front Office	1	1.3	---	---	---	---	---	---	---

The survey criteria for methylene chloride is 75 ppm for up to a 10-hour average daily exposure of a 40 hour work week.

*Notes:
1. All air concentrations are in parts per million by volume.
2. The geometric mean was used for the results of this table.
3. "nd" means none detected at laboratory limit of quantitation.

TABLE 3
SUMMARY OF TIME WEIGHTED AVERAGE HEXANE EXPOSURES

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

	PASSIVE DOSIMETER (2/10/82)			PASSIVE DOSIMETER (5/6/82)			CHARCOAL TUBE (5/6/82)		
		AIR CONCENTRATIONS*			AIR CONCENTRATIONS*			AIR CONCENTRATIONS*	
LOCATION	NO. SAMPLES	MEAN*	RANGE	NO. SAMPLES	MEAN	RANGE	NO. SAMPLES	MEAN	RANGE
Marine and General Organics	11	4	nd* to 45	13	3	nd to 16	7	4	0.4 to 20
Volatile Organics	3	7	2 to 35	2	0.1	nd to 0.4	2	0.5	0.2 to 1.5
First Floor-Front Office	1	15	---	1	0.4	---	1	0.5	---
Second Floor-Front Office	1	nd	---	---	---	---	---	---	---

The survey criteria for hexane is 100 ppm for up to a 8-hour average daily exposure of a 40-hour work week.

*Notes:
1. All air concentrations are in parts per million by volume.
2. The geometric mean was used for the results of this table.
3. "nd" means none detected at laboratory limit of quantitation.

TABLE 4
EXPOSURE OF PERSONNEL TO METHYLENE CHLORIDE (CH_2Cl_2)

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

EMPLOYEE	LAB	REPORTED ACTIVITY 2/10/82	DOSIMETER METHYLENE CHLORIDE (ppm)	REPORTED ACTIVITY 5/6/82	DOSIMETER METHYLENE CHLORIDE (ppm)	CHARCOAL TUBE METHYLENE CHLORIDE (ppm)
1	G.O.	Sample dilutions, moderate amounts of CH_2Cl_2 & hexane	8.5	am: in & out of lab pm: sample extractions, moderate amts of CH_2Cl_2	34	
2	G.O.	Column chromatography; large amts of hexane	5.2	am: small amts of hexane and CH_2Cl_2 pm: large amt of hexane; moderate amt of CH_2Cl_2	32	12
3	G.O.	Rotoevaporation; column chromatography	nd	am: large amts of hexane; moderate amt of CH_2Cl_2 pm: rotoevaporation large amt of hexane	53	9
4	G.O.	Dishwashing in G.O. lab; large amt of methanol	11	am & pm: dishwashing	1.8	nd
5	G.O.	Sample extraction & dilution; moderate amts of CH_2Cl_2 and hexane	1.6	am & pm: sample extractions; moderate amounts of CH_2Cl_2	48	24
6	G.O.	Moderate amts of CH_2Cl_2 & hexane; office for large part of day	14	am: in & out of lab pm: sample separation; large amts of CH_2cl_2 (dead corner of M.O.)	120	92
7	G.O.	Extractions; column chromatography; large amounts of CH_2Cl_2 & hexane	27	am: in & out of lab pm: GC work; trace amounts of solvents	nd	nd
8	G.O.	Exposure to mod. amts of hexane; trace amt of CH_2Cl_2	13	am & pm: in & out of lab; mostly office	23	
9	G.O.	Small amts of CH_2Cl_2, hex. & MeOH: worked in loading dock area	11	am & pm: 2nd floor office	nd	

TABLE 4 - Exposure to Methylene Chloride (Continued)

EMPLOYEE	LAB	REPORTED ACTIVITY 2/10/82	DOSIMETER METHYLENE CHLORIDE (ppm)	REPORTED ACTIVITY 5/6/82	DOSIMETER METHYLENE CHLORIDE (ppm)	CHARCOAL TUBE METHYLENE CHLORIDE (ppm)
10	C.O.	Sample extraction; mod. amts of CH_2Cl_2	34			
11	M.O.	GC work; trace amts of CH_2Cl_2, hexane, & MeOH	5.6			
12	M.O.			am: column chromatography; mod. amts of CH_2Cl_2 pm: column chromatography; mod. amts of CH_2Cl_2 and hexane	52	37
13	M.O.			small amounts of hexane, CH_2Cl_2 & MeOH	9.2	
14	M.O.			am & pm: in & out of lab; small amts of CH_2Cl_2 & MeOH	11	
15	M.O.			am & pm: in & out of lab; mostly desk work	9.1	
16	V.O.	GC lab; trace quantities of CH_2Cl_2 & MeOH	4.2	am & pm: GC work; trace amts of CH_2Cl_2 & MeOH	16	16
17	V.O.	GC lab; trace quantities of CH_2Cl_2 & MeOH	9.5			
18	V.O.	GC lab; small amts of MeOH	13	am & pm: GC work; small amounts of MeOH	nd	nd
19		Second floor office	1.3			
20		Front first floor office	88	am & pm: front 1st floor office; used Xerox machine occasionally; infrequently enters labs	38	44
Survey Criteria			75		75	75

Notes: 1. "nd" means none detected at laboratory limit of quantitation
2. CH_2Cl_2 means methylene chloride
3. MeOH means methyl alcohol (methanol)

TABLE 5
EXPOSURE OF PERSONNEL TO HEXANE

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

EMPLOYEE	LAB	REPORTED ACTIVITY 2/10/82	DOSIMETER HEXANE (ppm)	REPORTED ACTIVITY 5/6/82	DOSIMETER HEXANE (ppm)	CHARCOAL TUBE HEXANE (ppm)
1	G.O.	Sample dilutions, moderate amounts of CH_2Cl_2 & hexane	4.5	am: in & out of lab pm: sample extractions, moderate amts of CH_2Cl_2	1.0	
2	G.O.	Column chromatography; large amts of hexane	45	am: small amts of hexane and CH_2Cl_2 pm: large amt of hexane; moderate amt of CH_2Cl_2	7.3	7.9
3	G.O.	Rotoevaporation; column chromatography	nd	am: large amts of hexane; moderate amt of CH_2Cl_2 pm: rotoevaporation large amt of hexane	11	3.6
4	G.O.	Dishwashing in G.O. lab; large amt of methanol	4.2	am & pm: dishwashing	1.0	3.8
5	G.O.	Sample extraction & dilution; moderate amts of CH_2Cl_2 and hexane	4.2	am & pm: sample extractions; moderate amounts of CH_2Cl_2	2.6	2.7
6	G.O.	Moderate amts of CH_2Cl_2 & hexane; office for large part of day	1.0	am: in & out of lab pm: sample separation; large amts of CH_2cl_2 (dead corner of M.O.)	3.0	3.1
7	G.O.	Extractions; column chromatography; large amounts of CH_2Cl_2 & hexane	3.9	am: in & out of lab pm: GC work; trace amounts of solvents	0.4	0.4
8	G.O.	Exposure to mod. amts of hexane; trace amt of CH_2Cl_2	4.1	am & pm: in & out of lab; mostly office	0.7	
9	G.O.	Small amts of CH_2Cl_2, hex. & MeOH: worked in loading dock area	4.6	am & pm: 2nd floor office	nd	

TABLE 5 Exposure to Hexane (Continued)

EMPLOYEE	LAB	REPORTED ACTIVITY 2/10/82	DOSIMETER HEXANE (ppm)	REPORTED ACTIVITY 5/6/82	DOSIMETER HEXANE (ppm)	CHARCOAL TUBE HEXANE (ppm)
10	G.O.	Sample extraction; mod. amts of CH_2Cl_2	5.2			
11	M.O.	GC work; trace amts of CH_2Cl_2, hexane, & MeOH	2.2			
12	M.O.			am: column chromatography; mod. amts of CH_2Cl_2 pm: column chromatography; mod. amts of CH_2Cl_2 and hexane	16	20
13	M.O.			small amounts of hexane, CH_2Cl_2 & MeOH	11	
14	M.O.			am & pm: in & out of lab; small amts of CH_2Cl_2 & MeOH	0.4	
15	M.O.			am & pm: in & out of lab; mostly desk work	1.3	
16	V.O.	GC lab; trace quantities of CH_2Cl_2 & MeOH	2.2	am & pm: GC work; trace amts of CH_2Cl_2 & MeOH	0.4	1.5
17	V.O.	GC lab; trace quantities of CH_2Cl_2 & MeOH	1.2			
18	V.O.	GC lab; small amts of MeOH	35	am & pm: GC work; small amounts of MeOH	nd	0.2
19		Second floor office	nd			
20		Front first floor office	15	am & pm: front 1st floor office; used xerox machine occasionally; infrequently enters labs	0.4	0.5
Survey Criteria			100		100	100

Notes: 1. "nd" means none detected at laboratory limit of quantitation
2. CH_2Cl_2 means methylene chloride
3. MeOH means methyl alcohol (methanol)

TABLE 6
MARINE ORGANICS LAB - LABORATORY HOOD EVALUATIONS

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

HOOD NUMBER	SASH HEIGHT (in.)	AVERAGE FACE VELOCITY (fpm)
1	21	160
	33	120
2	21	170
	33	110
3	21	150
	33	100
4	21	100
	33	70

TABLE 7
MARINE ORGANICS LAB - AIRFLOW BALANCE (HEATING SEASON)

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

OUTFLOW (cfm)		INFLOW (cfm)	
Hood 1	1000	Supply 1	0
Hood 2	1070	Supply 2	40
Hood 3	940	Supply 3	60
Hood 4	620	Supply 4	0
	3630	Supply 5*	430
		Supply 6*	280
		Organics Lab Doorway	810
			1620

Net outflow 2010 cfm

*Located in the Instrumentation Room

TABLE 8
GENERAL ORGANICS LAB - LABORATORY HOOD EVALUATIONS

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

HOOD	TYPE	SASH HEIGHT (in)	AVG. FACE VEL. (fpm)	OUTFLOW (cfm)
1	Floor to 6'	72	Not Measurable	400
		36	28	
		20	47	
2	Supplied Air	28	80	1000
		15	170	
3	Supplied Air	28	105	1250
		15	185	
4		28	55	660
5L	Supplied Air twin sashes	28	99	
		14	210	
5R		28	105	1740
		14	180	

TABLE 9
GENERAL ORGANICS LAB - AIRFLOW BALANCE

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

OUTFLOW (cfm)		INFLOW (cfm)	
All Hoods	5000	Hoods 2, 3, 4	880
Bench Slot	200	Supply 2	380
Door to Instrumentation Lab	810	Supply 4	720
Air Return #1	340	Supply 5	480
Air Return #2	0	Supply 6	660
	6350	Supply 7	810
		Supply 8	450
			4380

TABLE 10
SYMPTOMS REPORTS OF 14 EXPOSED EMPLOYEES

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

SYMPTOM	NUMBER WITH SYMPTOM
Headache	4
Anxiety	4
Fatigue	5
Stomach Cramps	3
Dry Skin	3
Blurred Vision	2
Shortness of Breath	1
Loss of Memory	4
Eye Irritation	3
Nosebleeds	2
Sleep Increase	2
Irritability	4
Depression	3
Dizziness	4
Difficulty Concentrating	3
Increase Effect of Alcohol	1
Throat Irritation	2
Decreased Muscle Strength - Arms/Hands	2
Numbness, Tingling - fingers	1
Loss of Balance	1
Confusion	1
Loss of Appetite	1

TABLE 11
EXPOSURE HISTORY BY LEVEL OF SYMPTOM REPORTS

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

NO. OF SYMPTOMS	NO. OF PEOPLE	AVG. WEEKLY USE (liters) HEXANE	METHYLENE	AVG. LENGTH OF TIME IN JOB (months)
0	3	8*	8*	15.5
1	2	2*	2*	31
2	1	6	10	6
3	2	6	5	18
5	2	4.2	10	14.5
7	1	8	10	10
8	2	3	5*	35
14	1	2	3	24

*Only one worker in the group reported amount of solvent exposure.

TABLE 12
SIMPLE REACTION TIME RESULTS FOR EXPOSED AND CONTROL WORKERS

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

		RESPONSE LATENCY (msec)		
		EXPOSED (N = 10)	CONTROL (N = 10)	
STIMULUS	DELAY	MEAN (+SD)	MEAN (+SD)	p
Sound	3"	226.9 (17.9)	214.1 (29.0)	0.25
Sound	10"	229.2 (21.4)	207.3 (27.0)	0.06
Light	3"	275.9 (37.1)	269.2 (29.4)	0.66
Light	10"	293.9 (30.5)	277.1 (35.4)	0.27

TABLE 13
CONTINUOUS PERFORMANCE TESTING RESULTS

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

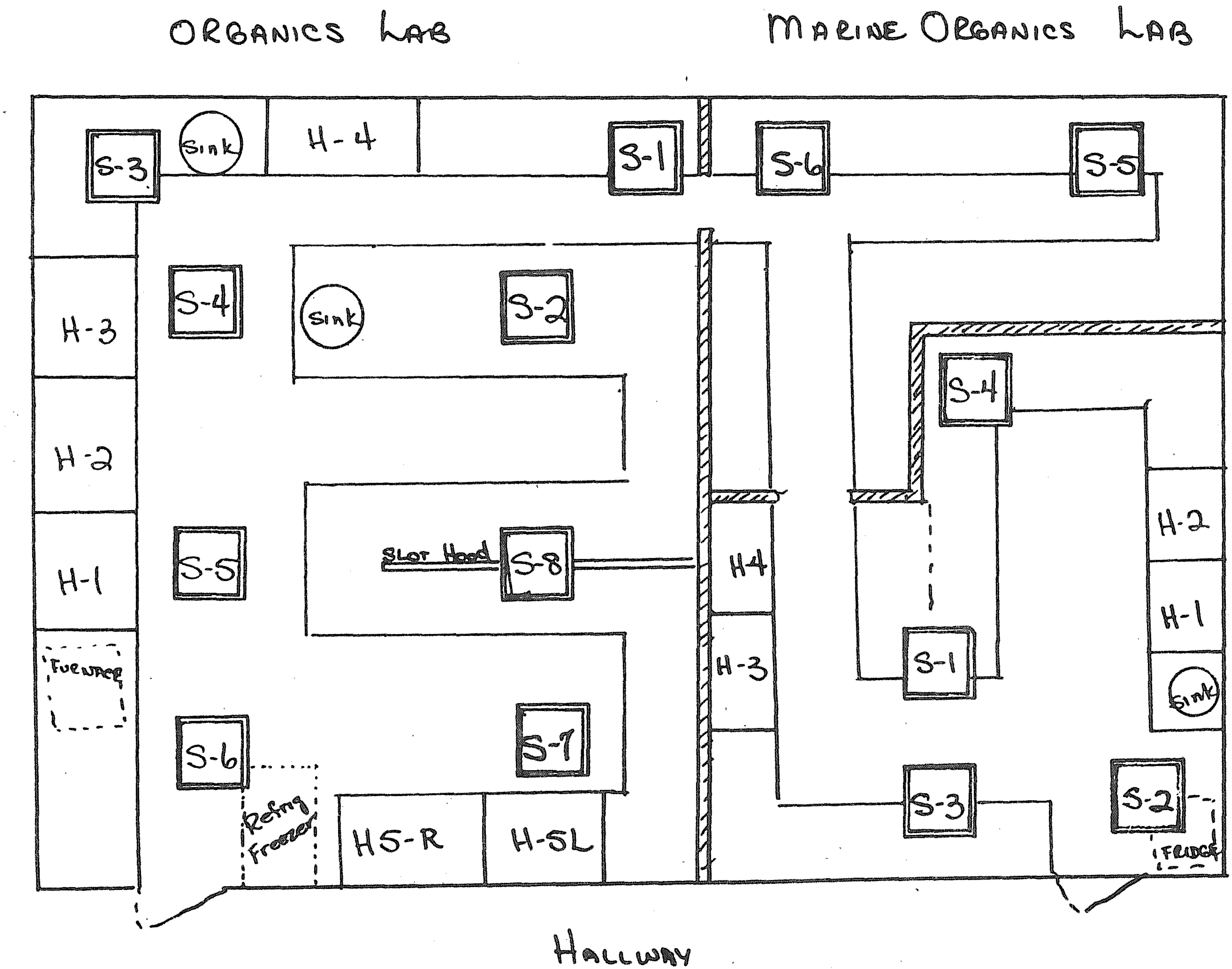
	EXPOSED (N = 10)	CONTROL (N = 10)	p
Number Late Mean (SD)	14.4 (6.9)	9.6 (8.4)	0.66
Response Time Mean (SD)	59.2 (3.2)	57.9 (9.5)	0.69

TABLE 14

ENERGY RESOURCES CO., INC.
CAMBRIDGE, MASSACHUSETTS
HETA 81-382

SEX	SIMPLE REACTION TIME 3" SOUND		CONTINUOUS PERFORMANCE TESTING MEAN TIME TO RESPOND	
	EXPOSED	CONTROL	EXPOSED	CONTROL
Male	219.2	182	0.056	0.0490
Female	263.4	247.5	0.059	0.0534
Female	236.4	228	0.059	0.0564
Male	228.6	193.6	0.056	0.0533
Male	229.8	215.4	0.062	0.0833

Figure I


ORGANICS LAB
MARINE ORGANICS LAB
S-3
Sink
H-4
S-1
S-6
S-5
H-3
S-4
Sink
S-2
H-2
H-1
S-5
Slot Hood
S-8
Furnace
S-6
S-7
Refrig Freezer
H5-R
H-5L
H4
H-3
S-4
H-2
H-1
S-1
Sink
S-3
S-2
FRIDGE
HALLWAY

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