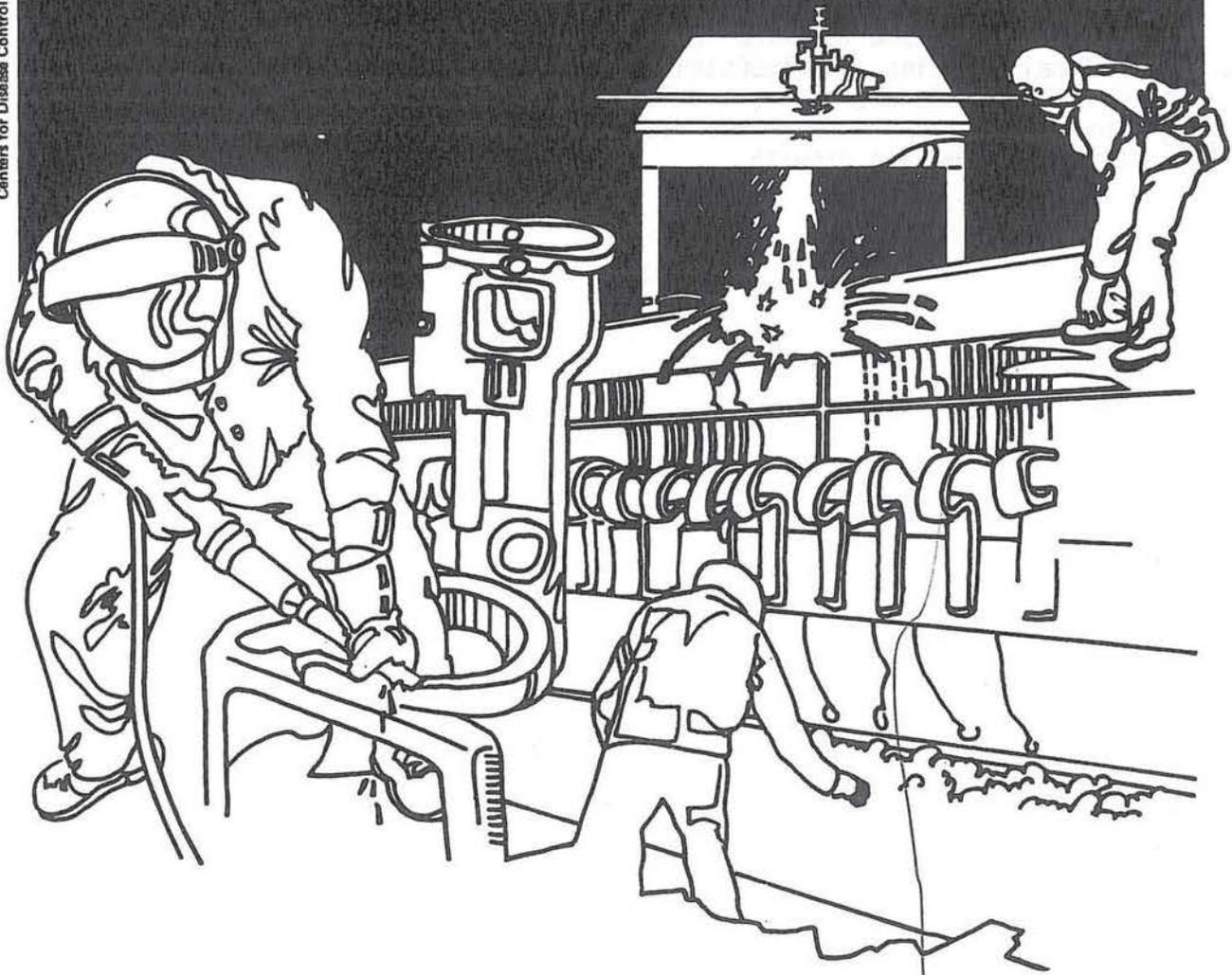


# NIOSH



## Health Hazard Evaluation Report

HETA 81-032-1174  
TAHOE DESIGNS  
TAHOE CITY, CALIFORNIA

## PREFACE

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

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

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

I. SUMMARY

In October 1980 the National Institute for Occupational Safety and Health (NIOSH) received a request from Tahoe Designs, Tahoe City, California, formerly Pitkin County T-Shirts of Aspen, Colorado. The request asked that NIOSH evaluate the potential hazardous exposures to vinyl chloride, hydrogen chloride, formaldehyde, phthalates, benzene, hexane, styrene, and other chemicals which may be generated where rubber ink labels are heat transferred onto garments. This operation is normally performed by one to three employees. Health complaints included cough, chest tightness, sore throat, eye and nose irritation, and headaches which would last for days.

Qualitative analysis of heated raw materials used in the transfer process indicated the presence of the above compounds and other chloroalkanes.

Quantitative analysis of personal breathing zone and area air samples yielded concentrations below the detectable limits for vinyl chloride, hydrogen chloride, phthalates, hexane, styrene and formaldehyde. Benzene concentrations, however, were detected in four samples ranging from 0.13 to 0.71 mg/M<sup>3</sup>; NIOSH recommends exposures for suspect human carcinogens be reduced to the lowest feasible limit.

It was also determined that the existing ventilation system is adequate for the operation performed in the new location. The results of the medical questionnaire showed that all of the employees interviewed experienced some adverse health effects during busy periods in the old Aspen, Colorado, location, e.g. eye, nose, throat irritation, chest tightness, and headaches. However, the employees stated that in the new location these symptoms appear to have subsided.

On the basis of the data obtained in this evaluation, NIOSH determined that exposure to the employees at the new work location were below the limits recommended for all the chemicals evaluated except benzene. Recommendations are included in Section VIII of this report to reduce and/or eliminate problems which may occur if the rate of production at the present location should increase or problems similar to that which existed at the previous location should arise.

KEYWORDS: SIC 2751 (Commerical Printing, Letterpress, and Screen), heat transfers, thermal degradation, printers, vinyl inks, vinyl chloride, hydrogen chloride, phthalates, benzene, hexane, styrene, formaldehyde.

## II. INTRODUCTION

In October 1980 the National Institute for Occupational Safety and Health (NIOSH) received a request from a representative of Tahoe Designs, Tahoe City, California, formerly Pitkin County T-Shirts of Aspen, Colorado. The request was to determine if there was a health hazard from exposures to vinyl chloride, hydrogen chloride, formaldehyde, phthalates, benzene and hexane which are used and/or by-products found in the process of transferring rubber ink labels onto garments. Prior to the NIOSH environmental surveys in April and June 1981, Pitkin County T-Shirts moved its Colorado location in January 1981 to Tahoe City, California, under the new name of Tahoe Designs. The results and recommendations presented in this report were given to the Company and employees when they became available. The April results and recommendations were given during the June follow-up survey and June's survey information was given in October 1981 by telephone.

## III. BACKGROUND

Tahoe Designs is a retail store which sells clothing. One of the major features of this outlet is their ability to produce, by way of heat transfer machines, various design decals, letter decals, and numbering decals on garments. The store has a large variety of designs, numbers, and lettering styles and these are available in single and multiple colors. The heat transfer machines are approximately 18 inches wide by 24 inches long by 24 inches high and are operated by one person while performing the heat transfer. The heat transfer process begins once a customer has selected a design, letter, or number and the garment. At this time the employee places the garment on the open surface bottom heating plate of the transfer machine. The design is then placed on the garment and the upper heating plate is drawn down into the bottom plate. The time required to heat the vinyl decal (350° Fahrenheit) onto the garment ranges from 30 to 45 seconds depending on the complexity of the decal, color combinations, and the style of clothing. A large percentage of the garments will have a design as well as a personal name or a city and state placed on the garment, and normally over 100 heat transfers will be made each day. This operation occurs daily, seven days a week, for 10-12 hours per day, and normally there are 2-3 employees in the store during this period. The new store has approximately twice the area of the Colorado store and the transfer machines are located in the back area of the store.

The present store has general room ventilation which helps reduce and/or eliminate any buildup of gases or vapors which are generated off the heat transfer operation. As described by the employees, the old store had no ventilation and, except for opening doors and windows during favorable weather, there was very little air change occurring indoors. This became a major problem during the colder months and the employees described days of heavy smoke buildup when business was normal. During these periods and even during times that were considered slow the employee and customers would still complain of eye and nose irritation. The employees also described days and weeks where they experienced coughing, chest tightness and sore throats for extended periods. These symptoms occurred at the old location during heavy sales periods and when they were unable to adequately ventilate the store. Since the operation has been in the new location, all of the employees feel that the smoke and irritation has been reduced substantially.

#### IV. ENVIRONMENTAL DESIGN AND METHODS

A variety of sampling techniques were used to evaluate the suspected contaminants in the store. Personal and area samples were taken on each of the employees and at various locations around the heat transfer station. Bulk samples of the various types and colors of the decals were also submitted to the laboratory for analysis. The following is a description of the techniques used:

##### A. Vinyl Chloride

Six vinyl chloride air samples were collected on organic vapor charcoal tubes using vacuum pumps to draw the air through the tubes. The pumps operated at 200 centimeters (cc) per minute and the samples were analyzed by NIOSH Method No. P&CAM 178 (modified).

##### B. Hydrogen Chloride

Six hydrogen chloride air samples were collected on silica gel tubes using vacuum pumps. The pumps operated at 200 cc per minute and the samples were analyzed by NIOSH Method No. P&CAM 310.

##### C. Phthalates

Six dimethylphthalate and dioctylphthalate air samples were collected on glass fiber filters using vacuum pumps which operated at 1.5 liters per minute (lpm). The samples were analyzed by NIOSH Method S-40.

##### D. Solvents

A total of four benzene, styrene, and hexane air samples were collected on charcoal tubes using vacuum pumps which operated at 200 cc per minute. The samples were analyzed by NIOSH Method No. P&CAM 127 (modified).

##### E. Formaldehyde

Four formaldehyde air samples were collected using impingers which contained one percent sodium disulphite. The air was drawn through the solution with vacuum pumps which operated at one liter per minute (lpm) and these samples were analyzed by NIOSH Method No. P&CAM 127 (modified).

##### F. Bulk Samples

Decals of various color combinations were submitted to NIOSH laboratory for analysis. The bulk was heated to 350° Fahrenheit (177° Centigrade), equal to that temperature used when adhering the decal onto the garment with the heat transfer machine. The volatile organics released were collected on a charcoal tube and analyzed by gas chromatography and then by mass spectrogram.

As the sample was heating, the effluent was tested with pH paper and found to be very acidic (pH = 1). Hydrogen chloride was suspected; therefore, a second test was run with a portion of the bulk material which was heated again in the micro tube furnace. The effluent was sampled through an impinger containing distilled water and analyzed by ion chromatography.

#### V. EVALUATION CRITERIA AND TOXICOLOGY

In this study numerous sources of environmental exposure criteria and existing research data were used to assess the worker's exposure to the suspected chemicals evaluated in the workplace at Tahoe Designs.

The exposure limits to toxic chemicals are derived from existing human and animal data, as well as industrial experience, to which it is believed that nearly all workers may be exposed for an 8-10 hour day, 40-hour work week, over a working lifetime with no adverse effects. However, due to variations in individual susceptibility, a small percentage of workers may experience effects at levels at or below the recommended exposure limit; a smaller percentage may be more seriously affected by aggravation of a pre-existing condition or by development of an occupational illness.

Except for formaldehyde which is presented below, the environmental and medical (toxicological) evaluation criteria used for this investigation are presented in Table 1. Recommended environmental limits and/or general information concerning each substance are listed, i.e., the source of the recommended limits; the present OSHA standard, and a brief description of the primary health effects known to date.

Since aldehydes and hydrochloric acid were detected on the bulk samples analyzed and because of the recent health concerns regarding formaldehyde, especially in conjunction with hydrochloric acid the following toxicology is presented.

Formaldehyde -- The Occupational Safety and Health Administration (OSHA) standard is presently 4.5 mg/M<sup>3</sup>. However, recently NIOSH and the American Conference of Governmental Industrial Hygienists (ACGIH) declared that formaldehyde should be considered a suspect carcinogen and until further research is performed to prove the contrary there should be no safe exposure level set.

Formaldehyde is a colorless, flammable gas with a strong, pungent odor. The first signs or symptoms from exposure to formaldehyde at concentrations ranging from 0.1 to 5.0 parts per million (ppm) are burning of the eyes, tearing, and general irritation of the upper respiratory passages. Exposures of 10-20 ppm produces coughing, tightening in the chest, a sense of pressure in head, and palpitation of the heart. Exposures at 50-100 ppm and above can cause pulmonary edema, pneumonitis, or death.

Dermatitis from formaldehyde exposure is a well recognized problem. After several days of exposure a worker may develop a sudden inflammatory reaction of the skin of the eyelids, face, neck, scrotum, and arms. Dermatitis may occur on fingers, back of hands, wrist, and forearms. Formaldehyde can also cause both dermal and respiratory allergic sensitization.

NIOSH recommends (Current Intelligence Bulletin 34: Formaldehyde: Evidence of Carcinogenicity, NIOSH Publication No. 81-111, April 15, 1981) that formaldehyde be handled as a potential occupational carcinogen. These recommendations are based on a Chemical Industry Institute of Toxicology (CIIT) study in which laboratory rats and mice exposed to formaldehyde vapor developed nasal cancers. This is supported by a New York University study where rats exposed to a mixture of formaldehyde and hydrochloric acid vapors developed nasal cancers. Formaldehyde has also been shown to be a mutagen in several short-term laboratory studies.

Since formaldehyde has induced a rare form of nasal cancer in both rats and mice, NIOSH recommends that it be handled in the workplace as a possible occupational carcinogen. Exposure levels should be maintained as low as possible. The OSHA standard of 3 ppm was established based on the irritant effects of formaldehyde and not on the carcinogenic potential.

## VI. RESULTS AND DISCUSSION

### A. Environmental

Employee exposures to suspected airborne concentrations of benzene, styrene, hexane, vinyl chloride, hydrogen chloride, phthalates, and formaldehyde were evaluated. The following are the results and conclusions of NIOSH's evaluation.

#### 1. Benzene, Styrene, and Hexane

The results received for benzene, styrene, and hexane are presented in Table 2. These samples were collected for the heat transfer operators and area samples adjacent to the transfer machine. Benzene levels ranged from 0.13 to 0.71 (four samples). The styrene and hexane results were all non-detectable for this sampling period.

#### 2. Vinyl Chloride, Phthalates, Hydrogen Chloride, and Formaldehyde

The results for vinyl chloride, three personal and three area type samples, were all non-detectable. This was also true for the phthalate samples taken. That is, six samples were collected for phthalate analysis, three on the operators and three area types, and each were below the analytical detection levels.

Samples were collected for hydrogen chloride and formaldehyde and these were all non-detectable. Again, below the level of analytical detection. Three personal samples were collected on the operators and three general room area type samples for hydrogen chloride. There were two personal samples and one area type sample collected for formaldehyde.

### 3. Bulk Material Analysis

When the bulk samples of the material used in this operation were analyzed a variety of compounds were generated off the material when heated at 375° Fahrenheit. The following is a description of the results of this analysis:

- a. Chloride was detected by ion chromatography in the impinger solution. A blank water solution contained a trace of chloride and the sample contained about 25 ppm chloride, possibly from hydrogen chloride.
- b. Both the generated charcoal sample and the tubing rinse from the oven were analyzed by GC/MS. Copies of the reconstructed chromatograms from these mass spectral analyses are presented in Appendix 1 and 2 with all identified peaks labelled. The rinse contained mainly bis(2-ethyl hexyl) phthalate and a small amount of another phthalate, probably a butyl benzyl phthalate. Major peaks identified in the charcoal sample were benzene, 1-chlorobutane, butyl acetate, benzyl chloride, 1-chloro-2 ethyl hexane, and numerous other chloroalkanes. Other compounds detected included toluene, benzaldehyde, styrene, a-methyl styrene, an 2-ethyl hexanol. Several compounds were not positively identified, since standards were not available.

### 4. Ventilation

The ventilation system in this store is a general room type ventilation system which is part of a shopping mall type ventilation system. The service maintenance operator of this facility stated that the overall ventilation system is designed to provide 10-12 air changes per hour depending on the location of the store in the mall. The employees also use a circular table top fan which is positioned next to the heat transfer machine. They use this fan to reduce the heat and any fumes which may emanate off the heat transfer process.

The employees stated that the ventilation system in the present store provides sufficient air circulation for personal comfort and that the air circulation in comparison to the previous location is far superior.

### B. Medical

Each of the employees gave medical histories. The results showed that each experienced some adverse health symptoms, e.g., cough, chest tightness, sore throat, eye and nose irritation, and prolonged headaches. All of the employees felt that the symptoms occurred at the old location during heavy production periods and during winter months when windows and doors were kept closed. Each felt that even though they were in the new location for only a few months the symptoms had subsided.

The medical data elicited from the employees does indicate that they had symptoms suggestive of exposure to each of the substances found in this process.

Another important medical issue which should be mentioned for this industry as a whole is the concern regarding New York University's findings on exposure to the mixture of hydrochloric acid (hydrogen chloride) and formaldehyde. Again, as the toxicology describes, the formation of nasal cancers were present in their research when animal subjects were exposed to these two chemical agents.

It was also described that formaldehyde at low levels (0.1 to 5.0 ppm or 0.12 to 6.0 mg/M<sup>3</sup>) can produce burning of the eyes and general irritation of the upper respiratory passages. Each of these symptoms, as well as coughing and those symptoms described above, can be found with hydrogen chloride exposures. These symptoms were described by the employees while working at the old location. It should, however, be emphasized that these symptoms also would be present with the other chemicals evaluated in this study.

## VII. CONCLUSIONS

1. All the air samples except those for benzene taken during the survey periods indicate that exposure levels to the by-products produced from the heat transfer process were below detectable levels.
2. Due to the move from the Colorado location to the Tahoe City location that occurred prior to NIOSH's investigation, it was impossible to determine those exposure levels that existed in the past. However, the medical symptoms described by all the employees strongly suggest that a health hazard did exist at the Colorado store.
3. If conditions at the new store should develop that were similar to those at the previous store, e.g., buildup of smoke or health problems as described, steps should be taken to reduce and/or eliminate these problems.

This would be especially necessary because of the health concerns regarding formaldehyde, hydrochloric acid, and benzene, which are by-products in this type of operation, and therefore potentially in this industry as a whole.

## VIII. RECOMMENDATIONS

In view of the findings of NIOSH's environmental and medical study the following recommendations are made to provide a better work environment for the concerned employees:

1. If the situations should reoccur that contributed to the smoke buildup or irritations as described, the following evaluation should be made:

- a. Determine if the heat transfer machine is working properly.
- b. Determine if the ventilation system is working adequately.
- c. Question if there has been a chemical composition change in the decals.
- d. Is there additional heat transfer machines in the workplace and/or a significant increase in production.

Each of these could significantly effect the breathing air in this environment.

2. If conditions in the future should exist which require a change in the ventilation system, that is, increased production or additional machines, the most cost efficient engineering system would be enclosure and/or local exhaust ventilation.

Enclosure is basically confining as much of the operation/machine or machines as possible in order to contain the vapors and fumes in one location. Once confined local exhaust ventilation, i.e., an exhaust system which collects the smoke and exhausts as close to the point of generation should be installed (see Figures 1, 2, and 3).

3. It may be necessary, if large orders and/or during busy periods, e.g., weekends, holidays, or summer vacations, that additional industrial type fans or air exhaust systems as described above be considered.
4. If large bulk orders are performed, these garments should be allowed to air either outside or under an exhaust system as described above in order to reduce and/or eliminate the off gassing from these large orders.

#### IX. REFERENCES

1. Industrial Hygiene and Toxicology, second edition, Frank Patty (editor), Interscience Publishers, 1967, Vol. II.
2. Industrial Toxicology, third edition, Hamilton and Hardy, Publishing Service Group, Inc., 1974.
3. "Threshold Limit Values for Chemical Substances in Workman Air", America Conference of Governmental Industrial Hygienists, 1981.
4. Encyclopedia of Occupational Health and Safety, International Labor Office, McGraw-Hill Book Company, New York.
5. Occupational Diseases, A Guide to Their Recognition, U.S. Department of Health, Education, and Welfare, Public Health Service Publication (NIOSH) No. 77-181.
6. Current Intelligence Bulletin 34: Formaldehyde: Evidence of Carcinogenicity. NIOSH Publication No. 81-111, April 15, 1981.

X. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared By: Paul Pryor, M.S.  
Industrial Hygienist  
NIOSH, Region VIII  
Denver, Colorado

Originating Office: Hazard Evaluation and Technical  
Assistance Branch (HETAB)  
Division of Surveillance, Hazard  
Evaluations, and Field Studies (DSHEFS)  
NIOSH, Cincinnati, Ohio

Report Typed By: Marilyn K. Schulenberg  
Occupational Health Technician  
NIOSH, Region VIII  
Denver, Colorado

XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. 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. Tahoe Designs.
2. U.S. Department of Labor/OSHA - Region IX.
3. NIOSH - Region IX.
4. California State Department of Health.
5. State Designated Agency.

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

TABLE 1  
EVALUATION CRITERIA AND TOXICOLOGY

Tahoe Designs  
Tahoe City, California

<u>Substance</u>	<u>Recommended Environmental Limit<sup>A</sup></u>	<u>Reference Source</u>	<u>Primary Health Effects</u>	<u>OSHA Standard</u>
Vinyl Chloride	(C) 2.5 mg/M <sup>3</sup>	NIOSH	Skin and eye irritation; central nervous system (CNS) depressant; lightheadedness; nausea, and hepatitis (liver) damage. Vinyl chloride is a human carcinogen.	2.5 mg/M <sup>3</sup>
Hydrogen Chloride	(C) 7.0 mg/M <sup>3</sup>	ACGIH <sup>B</sup>	Inflammation, ulceration of nose, throat irritation; cough and choking; eye and skin irritation, and dermatitis.	7.0 mg/M <sup>3</sup>
Phthalates	5.0 mg/M <sup>3</sup>	ACGIH	Irritation of nasal passages, upper respiratory; stomach irritation; potential sensitivity.	5.0 mg/M <sup>3</sup>
Benzene	(C) 3.0 mg/M <sup>3</sup>	NIOSH	Irritation to eyes, nose, respiratory system. giddy; headaches; nausea; blood changes, leukemia.	30.0 mg/M <sup>3</sup>
Styrene	215 mg/M <sup>3</sup>	ACGIH	Irritation of eyes and nose; drowsiness; weakness; unsteady gait; narcosis; dermatitis.	430 mg/M <sup>3</sup>
Hexane	180 mg/M <sup>3</sup>	ACGIH	Lightheadedness; narcosis, headaches; numbness; muscle weakness; irritation of eyes, nose; dermatitis; giddiness.	1800 mg/M <sup>3</sup>

<sup>A</sup> All air concentrations are expressed as time-weighted average (TWA) exposures for up to a 10 hour workday unless designated (C) for Ceiling which should not be exceeded.

<sup>B</sup> ACGIH = American Conference of Governmental Industrial Hygienists.

mg/M<sup>3</sup> = Approximate milligrams of substance per cubic meter of air.

(C) = Ceiling level which should not be exceeded.

TABLE 2  
 SUMMARY OF PERSONAL AND AREA AIR SAMPLES FOR  
 BENZENE, STYRENE, AND HEXANE

Tahoe Designs  
 Tahoe City, California

June 1981

Job/Area Description	Sampling Time (minutes)	mg/M <sup>3</sup>		
		Benzene	Styrene	Hexane
Transfer Operator	360	0.38	ND	ND
Transfer Operator	360	0.13	ND	ND
Left Side of Machine	360	0.71	ND	ND
Right Side of Machine	360	0.46	ND	ND
EVALUATION CRITERIA		(NIOSH) 3.0 (OSHA) 30.0	(ACGIH) 215 (OSHA) 430	(ACGIH) 180 (OSHA) 1800
LABORATORY LIMIT OF DETECTION		0.001 mg	0.01 mg	0.01 mg

ND = non-detectable

mg = milligrams

mg/M<sup>3</sup> = milligrams of substance per cubic meter of air

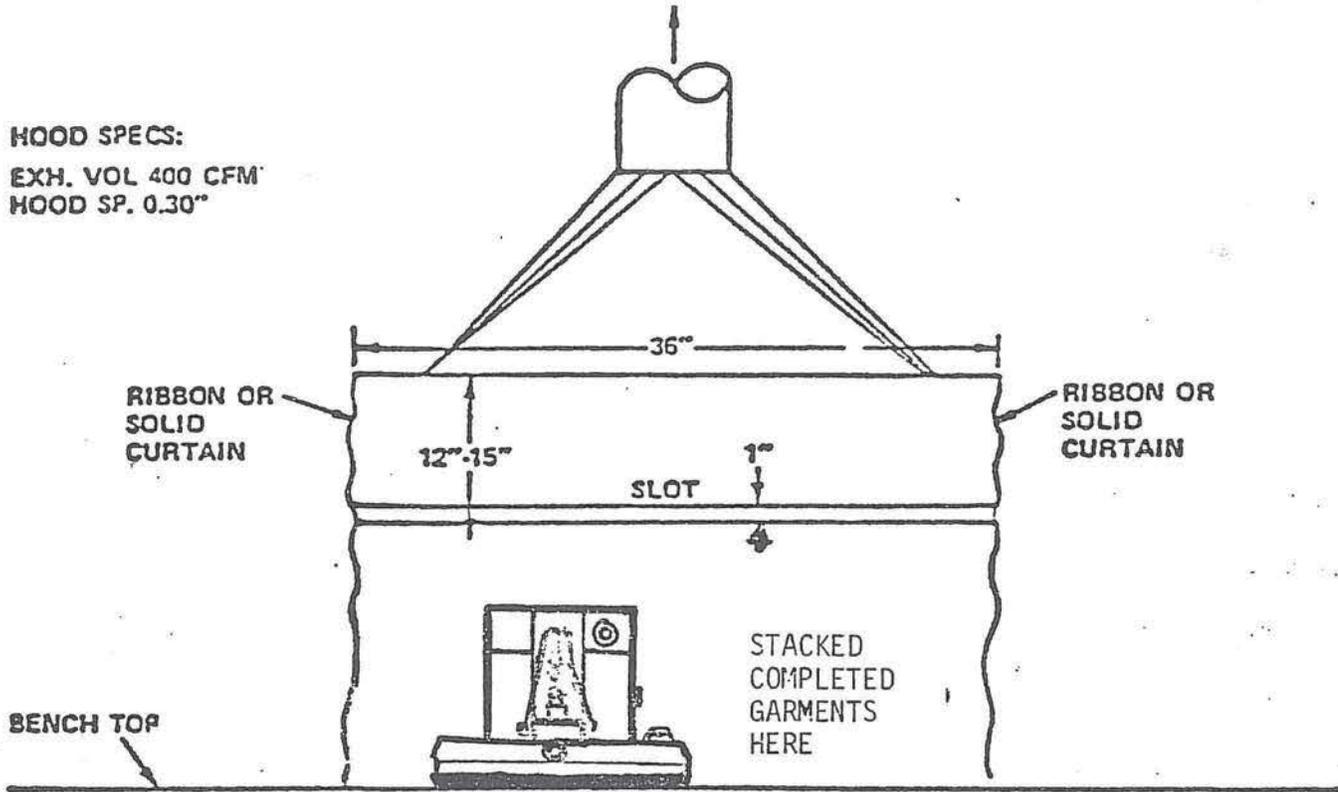
FIGURE 1

HEAT TRANSFER MACHINE EXHAUST

-PREFERRED METHOD-  
GOOD ENCLOSURE WITH SLOT EXHAUST

HOOD SPECS:

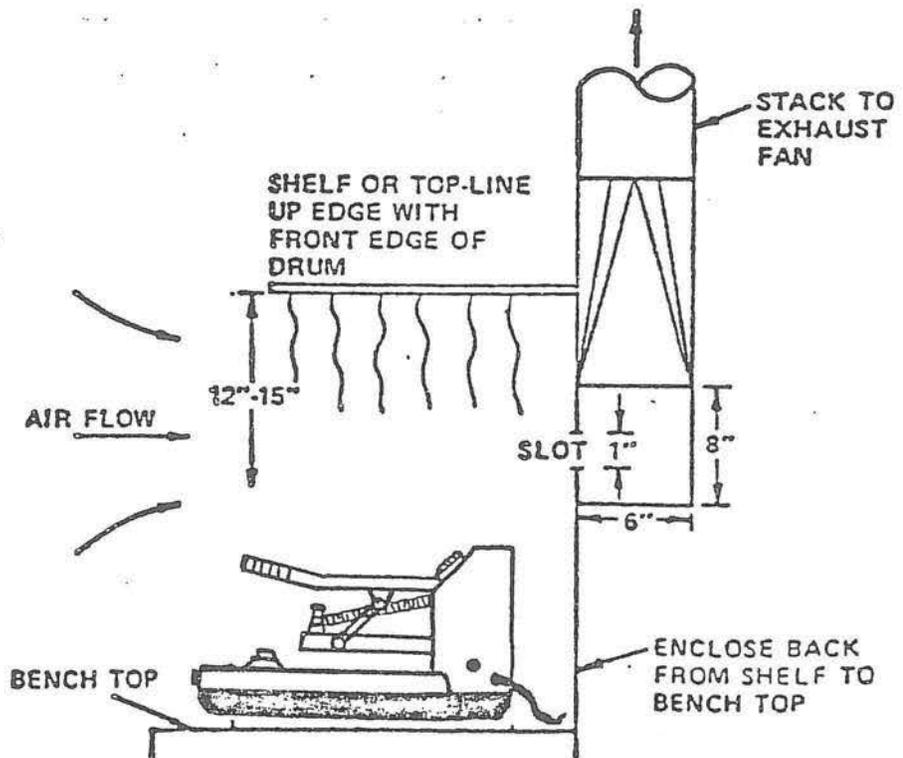
EXH. VOL 400 CFM  
HOOD SP. 0.30"



FRONT VIEW

NOTE:

- ADD HOOD SP. TO SYSTEM SP. FOR FAN SIZE EXH. TAKE OFF CAN BE DOWN
- PROVIDE FOR MAKE-UP AIR EG. VENT IN DOOR
- LOCAL CODES MAY PROHIBIT EXHAUSTING THROUGH WINDOW PANES

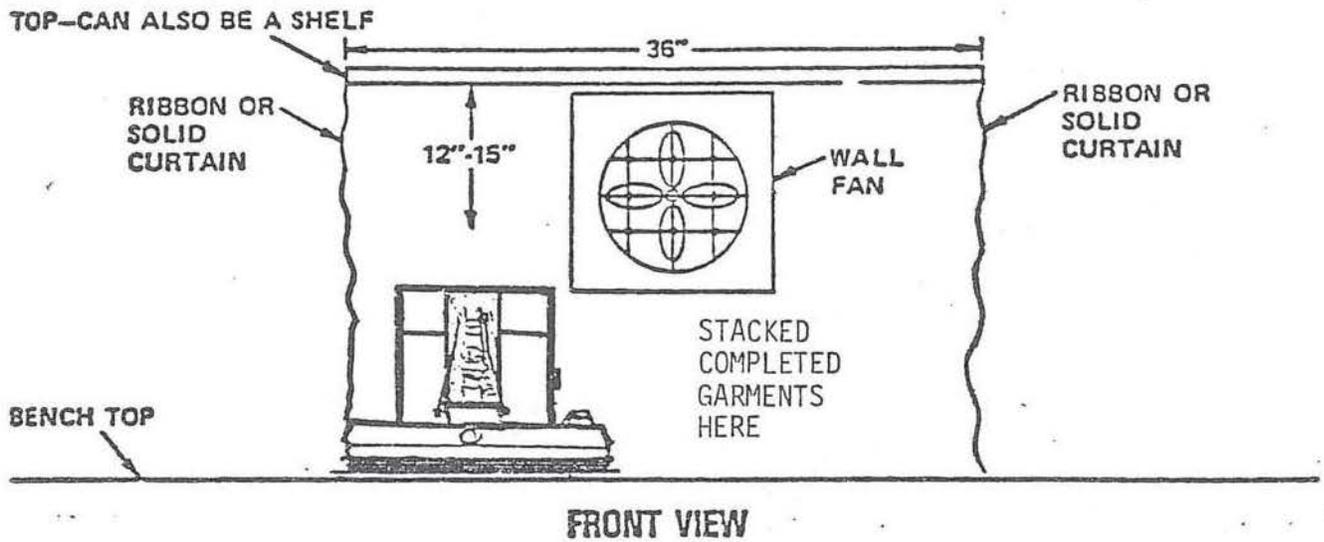


END VIEW

FIGURE 2

HEAT TRANSFER MACHINE EXHAUST

-ALTERNATE METHOD-  
WALL FAN WITH GOOD ENCLOSURE



EXH FAN:  
WALL TYPE  
WITH AUTO-  
SHUTTER  
400 CFM  
MINIMUM

NOTE:  
-LOCAL CODES MAY  
PROHIBIT WINDOW  
MOUNT  
-PROVIDE FOR MAKE-UP  
AIR EG. VENTS IN  
DOOR

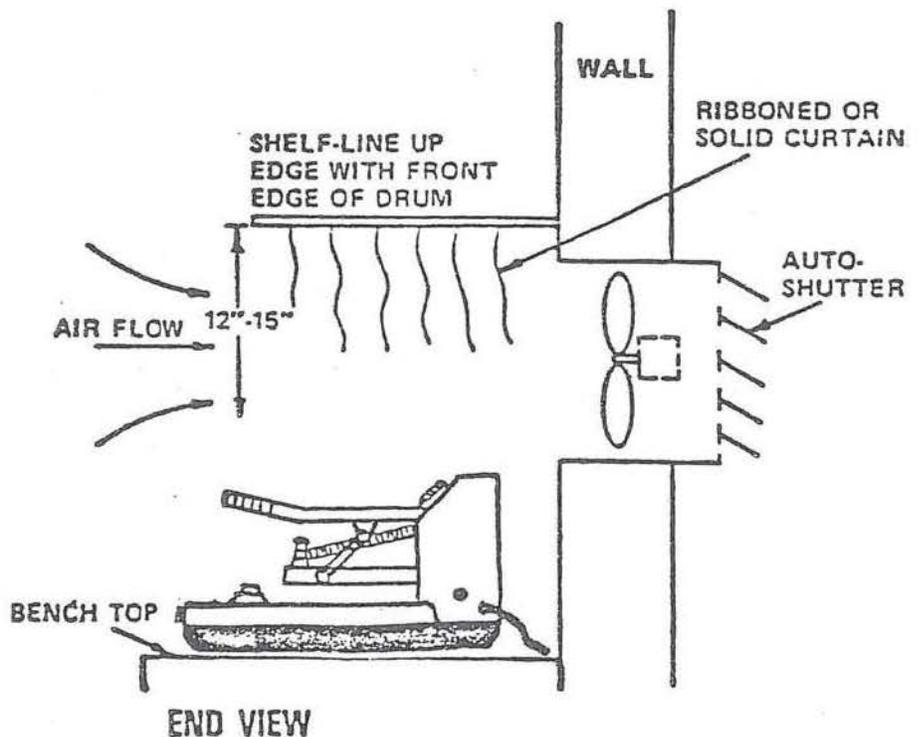
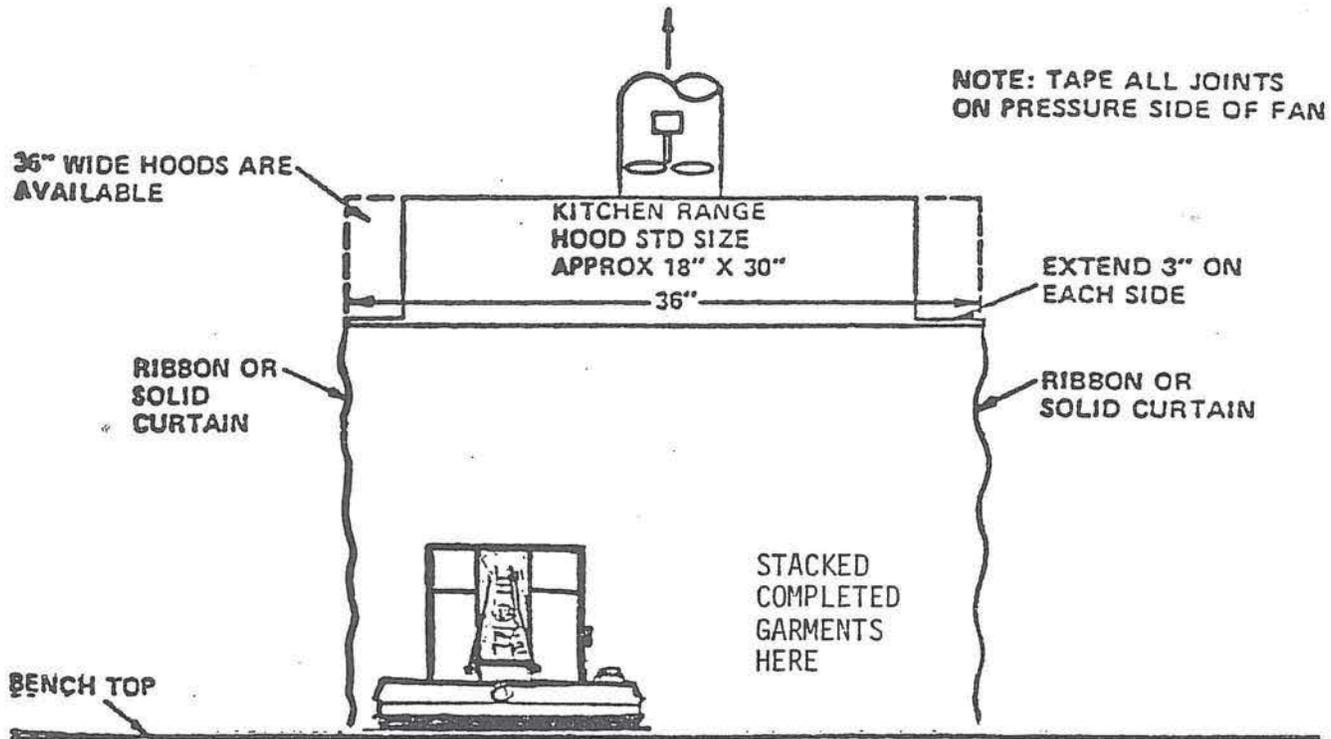


FIGURE 3

HEAT TRANSFER MACHINE EXHAUST

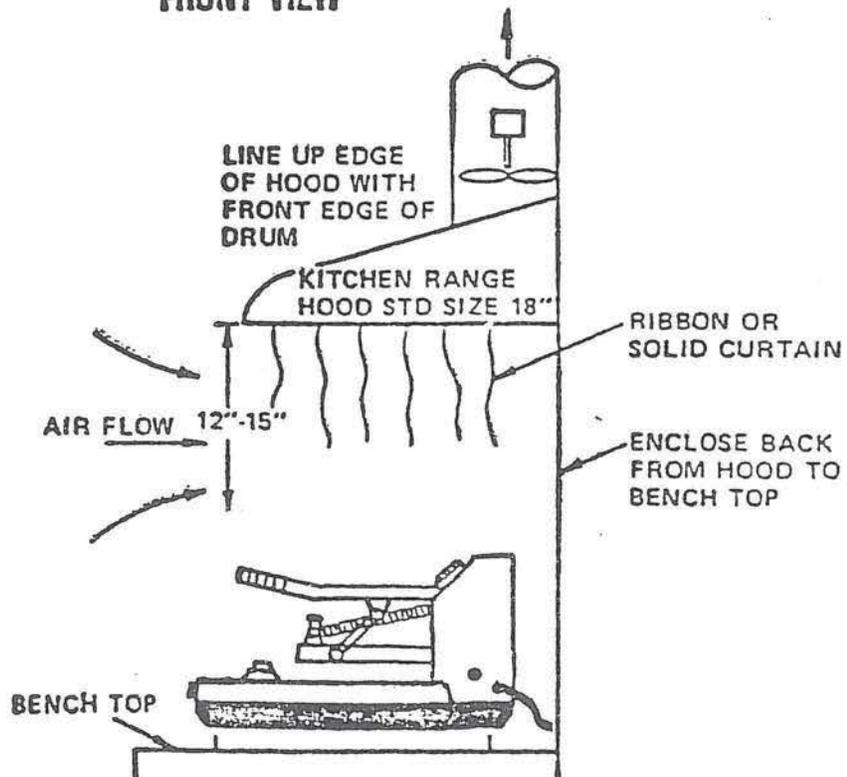
←ALTERNATE METHOD→  
KITCHEN RANGE TYPE HOOD  
WITH GOOD ENCLOSURE



FRONT VIEW

EXH. VOL  
400 CFM  
MINIMUM

NOTES:  
-PROVIDE FOR MAKE-UP AIR EG. VENTS IN DOOR  
-LOCAL CODES MAY PROHIBIT EXHAUSTING THROUGH WINDOW PANES



END VIEW

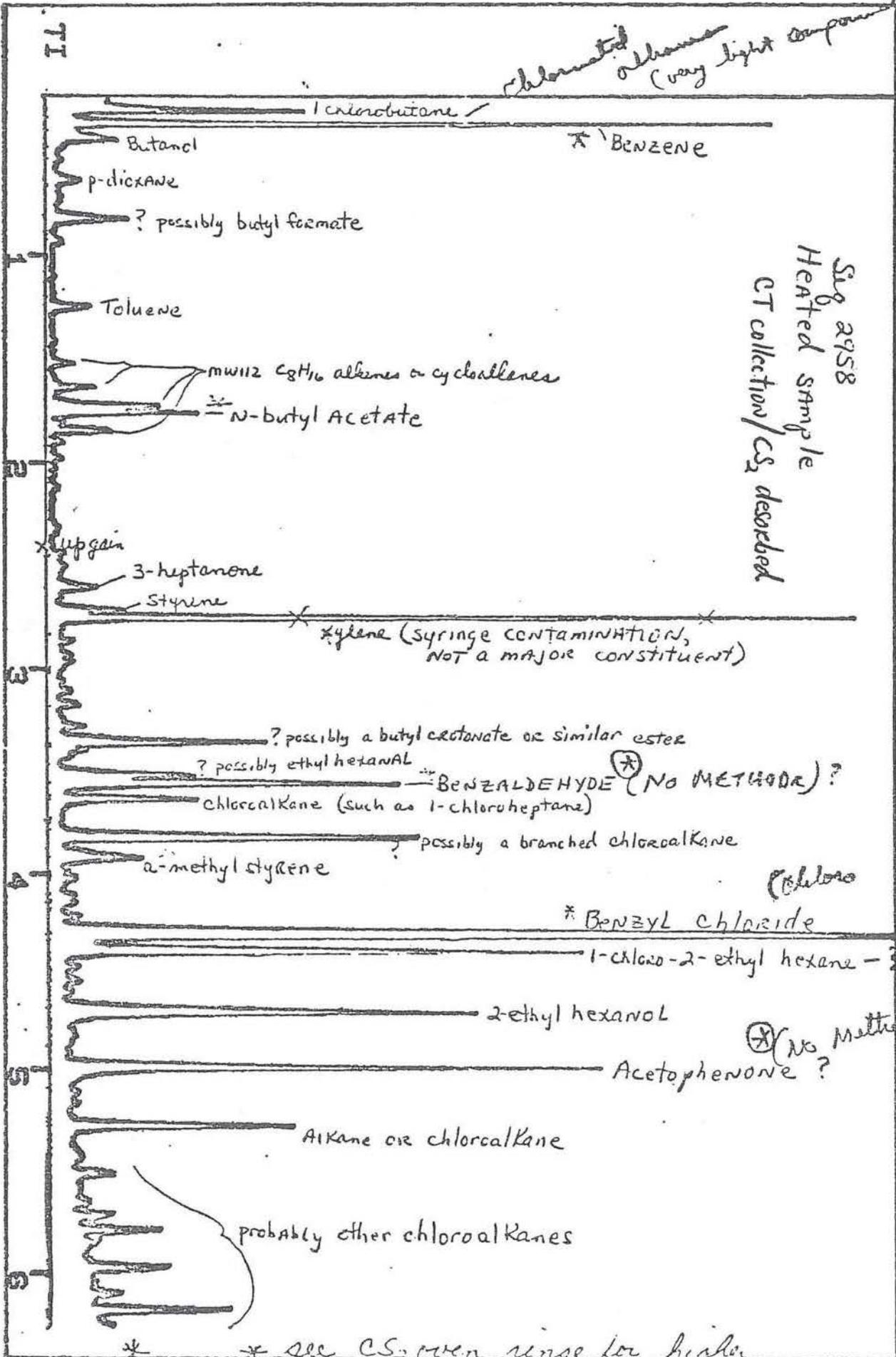
SE03558 P.PYROR DECAL CT/052 S030-300  
 25MSP2100 SPLITLESS 5-19-81

\*\* SPECTRUM DISPLAY/EDIT \*\*

FRN 6000  
 1ST SC/PG: 10  
 X- .50 V- 2.00

Sig 2958  
 Heated sample  
 CT collection/CS<sub>2</sub> described

chlorinated alkanes (very light compound)

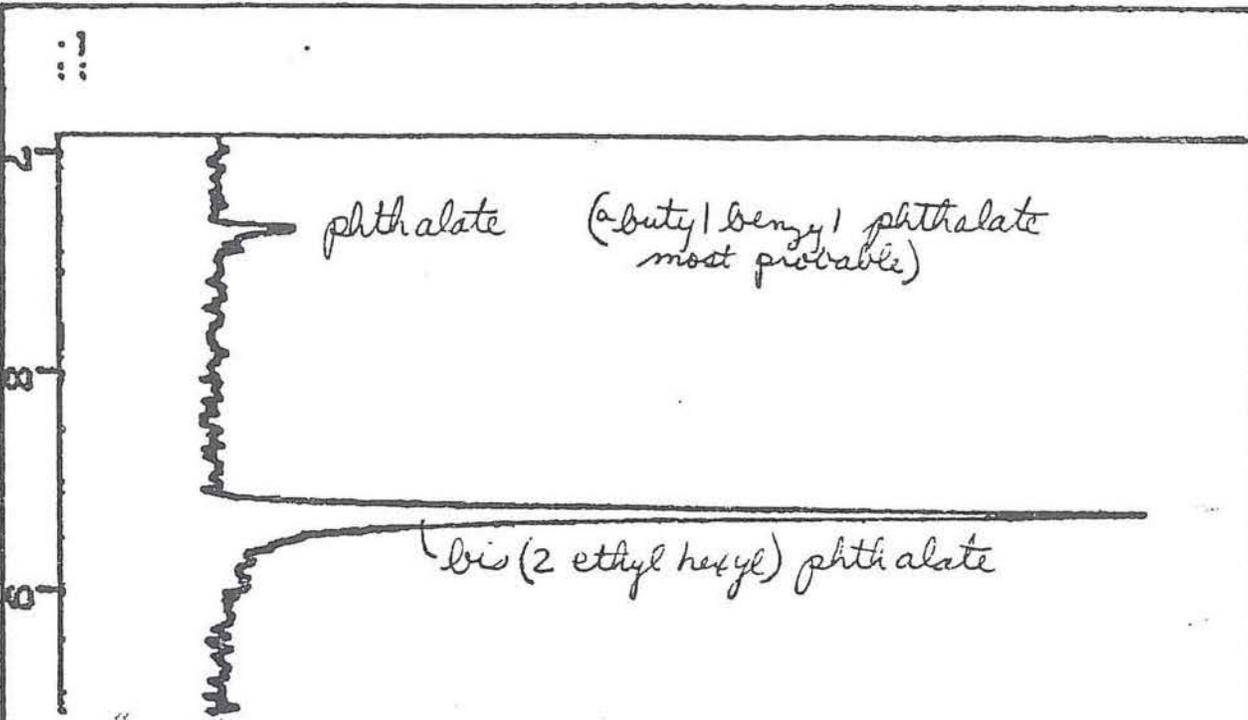


\* see CS<sub>2</sub> oven rinse for higher boiling components

SEC2558 PRYOR CS2 RINSE OF TUBING DECAL  
SCA0-400 25MSP2100 SPLITLESS 5-19-81

\*\*\* SEC2558.DJ. 11/04/81 11:27 \*\*\*

FRN 8002  
1ST 80/PG1 405  
X= .50 4.2 1.00



log 2958  
 CS<sub>2</sub>-Oven tubing rinse  
 from heated sample  
 (Compounds also found  
 in CT/CS<sub>2</sub> generated  
 sample)