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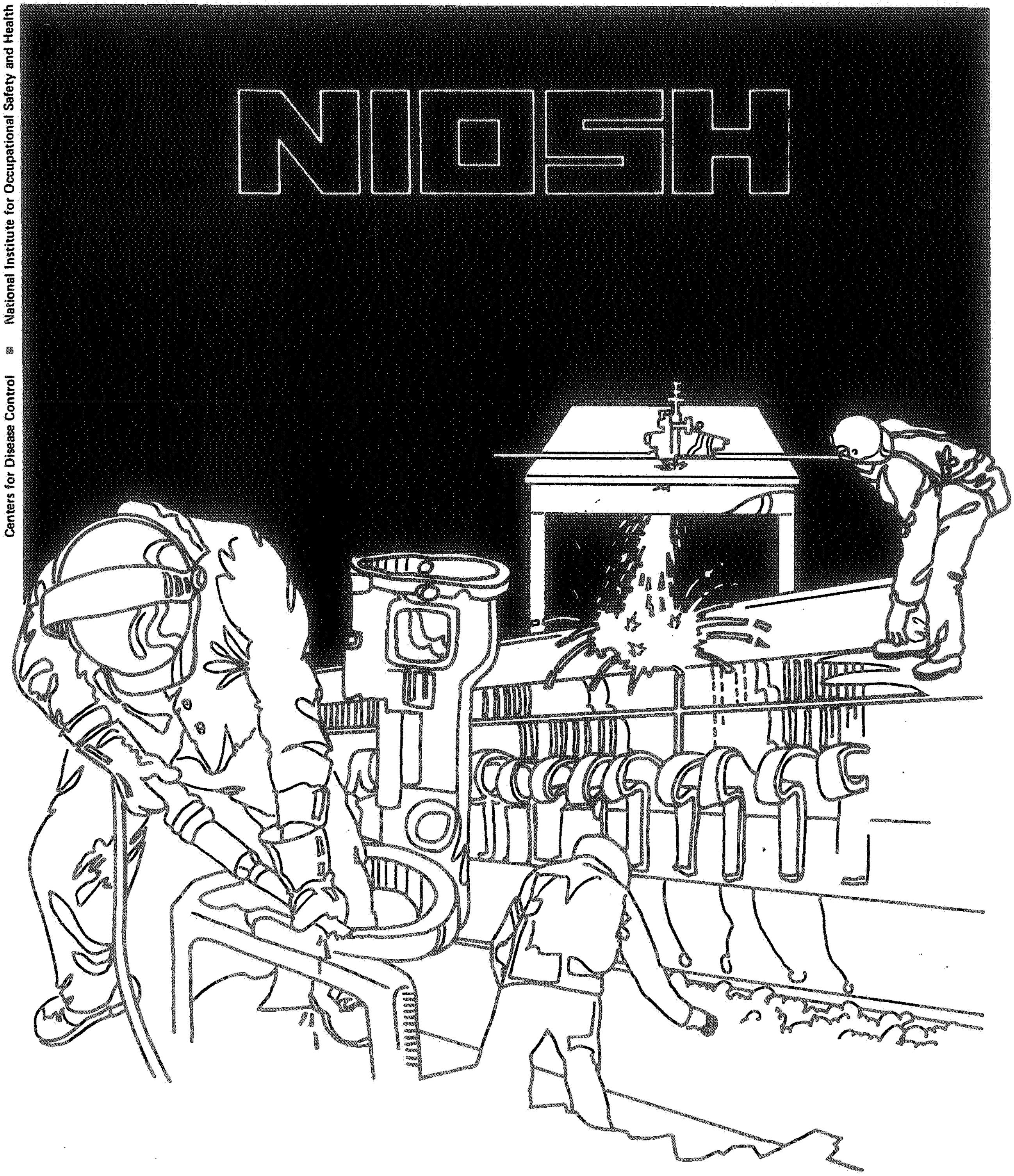

Health Hazard Evaluation Report

HETA 81-370-1050
SYNTREX CORPORATION
EATONTOWN, NEW JERSEY

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FEBRUARY 1982
SYNTREX CORPORATION
EATONTOWN, NEW JERSEY

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I. SUMMARY

On June 22, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a Health Hazard Evaluation at Syntrex Corporation, Eatontown, New Jersey. The requestors were concerned about workers' exposures to a solvent degreaser used to remove excess solder from electronic circuit boards manufactured by the company.

On August 5 and 26, 1981, a physician and industrial hygienist from the Occupational Health Program, New Jersey Department of Health, visited the plant to conduct an environmental and medical evaluation.

Five personal air samples were collected for measurement of isopropanol, trichlorotrifluoroethane, and trichloroethane. Isopropanol levels ranged from 2.43 to 9.37 ppm (NIOSH recommended criterion - 400 ppm); trichlorotrifluoroethane levels ranged from 7.2 to 26.1 ppm (NIOSH recommended criterion - 1000 ppm); and trichloroethane levels ranged from 14.4 to 57.2 ppm (NIOSH recommended criteria - 350 ppm). Calculation of a criteria based on the additive effects of exposure revealed that combined levels were well below the criteria of 1.0 (maximum = 0.21).

Four of five degreaser operators reported neurological and irritative symptoms (e.g., headaches, upset stomach, burning eyes, light-headedness.) Similar symptoms were also experienced by employees who worked near the degreaser. These symptoms were temporally related to the use of the degreaser and are consistent with the known effects of occupational exposure to these degreasing agents.

On the basis of the data obtained in this investigation, NIOSH determined that although the levels of exposure on the day of the evaluation were below evaluation criteria, the employees were occasionally experiencing neurological and irritative symptoms consistent with the known effects of degreasing chemicals used at the plant. Recommendations to help alleviate this problem are found in Section VIII of this report.

KEYWORDS: SIC 3679, trichloroethane, trichlorotriflurorethane, isopropanol, degreasing operations, irritative symptoms, neurological symptoms.

II. INTRODUCTION

On June 22, 1981, NIOSH received a request for a health hazard evaluation from employees at Syntrex Corporation, Eatontown, New Jersey. This request was assigned to the New Jersey Department of Health under a Cooperative Agreement with NIOSH. The purpose of this study was to investigate complaints of neurologic and irritative symptoms associated with a vapor degreaser solvent. The investigation was conducted on August 5 and 26, 1981.

III. BACKGROUND

Syntrex Corporation manufactures printed circuit boards and uses them to assemble VDT (video display terminals) for word processors. Since the company began operations a year ago, they have steadily increased their production. In August 1981, they were assembling 500 VDT's a month. By early 1982, they expect their monthly production to be over 1000 units (each word processing unit includes several circuit boards).

Hogan 900 is the solvent currently used with a Bronson vapor degreaser (Model 1216) at the plant. It contains 1,1,1-trichloroethane (57%), trichlorotrifluoroethane (25%), and isopropanol (18%). At the time the HHE request was submitted, a different solvent from the same manufacturer was being used: Blaco-Tron DTA. It included all the components of Hogan 900, as well as methylene chloride. Specifications for the Model PLD-1216W Bronson Vapor Degreaser are: length - 44-1/2 inches, width - 26-1/2 inches, and height - 44 inches. It can hold up to 22 gallons of solvent and is operated at 93.5^{o} Fahrenheit, the boiling point of Hogan 900.

The degreasing process occurs after the circuit boards leave the automated solder machine. At this time, the boards are checked for defects and placed in wire baskets. The basket of electronic parts is slowly lowered by hand into the vapor level on the dirty side of the degreaser and then lowered into the vapor level of the clean side. The basket is lifted out of the degreaser and placed on a 45 degree angle in the free board area and held there until condensation ceases. When the vapors condense, the liquid solvents drip off the circuit boards and return to the degreaser to be reused. The operator wears a heavy rubber glove on his right hand as he lowers and raises the basket. The degreaser cover is replaced at the end of the operation period. At the present time, there are 4 air exchanges per hour in the building according to the maintenance engineer.

There are 12 to 15 people in addition to the operator who work near the vapor degreaser (Figure 1). These workers take circuit boards, which are not completely soldered by the wave solder machine, and hand solder the remaining terminals. They might use the degreaser to clean their boards, usually operating the machine themselves, rather than waiting for the operator. For small soldering jobs, many of the workers keep a bottle of solvent at their work area and use a cotton swab to remove the excess solder. There are an additional 5 to 10 people who work or have worked periodically in the area as production necessitates.

This process presently takes place for 4 to 5 hours, 2 to 3 times a week. The degreaser will be used more frequently and for more extended time periods as production of word processing units and additional circuit boards increases. The manual vapor degreaser is a major rate-limiting step in the production process, particularly when combined with the automated solder machine. Therefore, the company plans to install an in-line closed process degreaser in the next 6 to 12 months. However, they expect to keep the manual degreaser for smaller jobs so possible exposure will continue to be a problem.

IV. METHODS

A. Environmental

To quantify the exposure of employees to the components of the degreasing solvent (Hogan 900), personal air monitoring was performed during a second visit (August 26, 1981). Five employees who work in the area of the degreaser (see Figure 1) were monitored for 3 hours. These employees wore precalibrated MSA C-200 and Dupont P-4000 pumps with 150 mg charcoal tubes. The New Jersey Department of Health Laboratory performed the analysis for the solvent components (isopropanol, trichlorotrifluoroethane, and 1,1,1-trichloroethane) by gas chromotography using the NIOSH recommended method (4). Because the solvent being used did not contain methylene chloride, no sampling or analysis for this solvent was performed. During the 3-hour monitoring period, the degreaser was operated for 3 hours.

B. Medical

On the initial visit (August 5, 1981) to Syntrex Corporation, the NIOSH representatives met with management and employee representatives and went on a walk through of the process. Over the course of the 2 visits, 9 employees were interviewed including the current and previous operators. An additional four employees discussed their symptoms, but were not formally interviewed. The two physicians who examined the most symptomatic operator were interviewed by telephone.

V. EVALUATION CRITERIA: HEALTH EFFECTS AND INDUSTRIAL HYGIENE

When TLV's (Threshold Limit Values) or environmental criteria are mentioned, they refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed, 8 hours a day, without adverse effects. TLV refer to time-weighted average concentrations for an 8-hour workday and 40-hour workweek. The American Conference of Governmental Industrial Hygienists (ACGIH) emphasizes that TLV's should be used only as a guide in the control of health hazards and not to establish the line between safe and dangerous concentrations (1).

There are three major sources for environmental criteria: 1) NIOSH recommended evaluation criteria, which are usually published as Criteria Documents; 2) ACGIH Threshold Limit Values; and 3) OSHA standards.

The additive effects of exposure to substances with similar effects must also be considered. Since these exposures have similar irritative and neurological effects, an evaluation of this additive effect may be calculated by expressing each exposure as a fraction of the relevant evaluation criteria and then adding these fractions. If the result is greater than one, the mixed exposure is judged to exceed this criteria.

1,1,1-trichloroethane (also known as methyl chloroform) has an odor threshold ranging from 16 to 400 ppm (6). At exposure levels of 900 to 1000 ppm for 20 minutes, human subjects experienced eye irritation and incoordination. Pronounced disturbance of equilibrium was seen at exposures over 1700 ppm (1). The ACGIH TLV and NIOSH recommended criteria were set at 350 ppm to protect from both irritative and depressant effects (1). The current OSHA standard is also 350 ppm.

Isopropanol has an odor threshold of 40 to 200 ppm. Exposures to levels of 400 to 500 ppm may produce irritation of eyes, nose, and throat. Ingestion or inhalation of higher levels may cause vomiting, headaches, giddiness, and coma. The ACGIH TLV and NIOSH recommended criteria were set at 400 ppm to protect from mucosal irritation (1). The current OSHA standard is also 400 ppm.

Trichlorotrifluoroethane is also known as Freon 113. At levels of 4500 ppm for 30 to 100 minutes, human subjects experienced significant impairment in attention and manual dexterity. Exposures of 1500 ppm producted mild throat irritation (6). The ACGIH TLV and the NIOSH recommended criteria were set at 1000 ppm to protect from mucosal irritation (1). The current OSHA standard is also 1000 ppm.

Methylene chloride is both a depressant and a mucosal irritant. In the body it is degraded into carbon monoxide. High exposures can raise the level of carboxyhemoglobin in the blood, which decreases oxygen delivery to the tissues. Exposure to 250 ppm for several days produces a 5% rise in carboxyhemoglobin. This effect is comparable to a daily exposure to carbon monoxide at the OSHA standard of 50 ppm (6). The odor threshold is reported as 50 to 200 ppm. The ACGIH TLV was set at 100 ppm to provide adequate oxygenation and to avoid neurological depression and mucosal irritation (1). The current NIOSH recommended criteria is 75 ppm. The current OSHA standard is 500 ppm.

VI. RESULTS

A. Industrial Hygiene Measurements

The air-monitoring results are presented in Tables 1 and 2. All exposures are well below the NIOSH and ACGIH criteria. The monitoring results indicate the exposure levels of trichloroethane were consistently within the reported odor threshold range. The highest levels were measured at the degreaser (E, Figure 1). The lowest levels were the people (A and B) sitting over 8 feet from the degreaser with a ceiling ventilation unit between them and the degreaser. Intermediate levels were obtained at C and D locations. These were 4 to 8 feet from the degreaser with a ventilation unit behind the tables. Between initial walk-through and air sampling, the worktables were moved further from the degreaser, which would be expected to decrease air concentrations of the Tables.

B. Medical Findings

Six of the 9 people formally interviewed had symptoms while working near the degreaser (Table 2). The more common symptoms were headaches, upset stomach, burning eyes, and lightheadedness. The operators were the most symptomatic. Four of the 5 men who operated the degreaser complained of neurologic and irritative symptoms. When they were transferred to another area away from the degreaser, their symptoms resolved. Several individuals commented that neurologic and irritative symptoms readily recurred when their exposure to solent increased.

VII. DISCUSSION AND CONCLUSIONS

We have found that the most symptomatic people worked with or near the degreaser, where the higher exposure levels were measured. The symptoms resolved as the worker has less direct exposure to the degreaser. The levels measured were below the ACGIH and NIOSH recommended criteria. At other times, the actual exposures may well be greater than those measured because of differences in work practices and work environment. The symptoms of the worker are consistent with exposure to these chemicals.

The airborne concentration of the solvents can be elevated by improper use of the degreaser. If there is still residual solvent on the circuit boards when they are removed from the degreaser, the solvent will evaporate into the air. It depends on the operator to use the recommended work rate to minimize disruption of the vapor level and maximize the condensation and recapture of solvent back into the degreaser. If the operator is inexperienced or rushed, levels of the solvent components in the area of the degreaser can be much higher than was measured. It may be difficult for some individuals to move the basket through the vapor level at 11 feet/minute as recommended by ACGIH (see Appendix A) without significant stress and fatigue. Operator positioning and limitations on basket weight are essential for the operator to be able to lift at this slow rate. It is important that the operator replaces the cover on the degreaser after use to prevent ongoing evaporation.

Air changes per hour is a poor basis for ventilation criteria where environmental control of hazards or odors is required. The required ventilation depends on the particular process, not on the size of the room in which it occurs. Four air exchangers per hour is not adequate to control the odors generated by the degreaser and the air exchanges should be increased to match the use of the degreasing unit (1a).

Skin absorption can be a significant route of exposure for someone with direct contact to the degreasing solvent. Proper protective equipment while using the degreaser is important to control exposure for the operator. In the past year, a proper glove was not always available. Some people continue to use the degreaser without wearing the neoprene glove.

The regular need to hand solder a few terminals on many of the circuit boards increases the number of people exposed to the degreasing solvent. Bottles of degreaser at the worktable can be a source of low level but sustained exposure. Also, having several people operate the degreaser intermittently makes it more difficult to maintain satisfactory work practices. Overall exposure to the solvent would be decreased if the boards resoldered by hand were run in a batch operation by the regular degreaser operator.

One of the difficulties in determining safe exposure levels is that individuals vary in their susceptibility. We have little data to explain why individuals might have variable susceptibilities to solvent and degreaser exposures. Experiences indicate that symptoms at levels below the recommended evaluation criteria for these compounds are not uncommon. Another problem is that rather crude measures of health are used to evaluate the effects of exposure. Most studies have not used some of the more sophisticated psychomotor testing available to identify such changes as decreased concentration and impaired motor performance. Finally, it is pertinent to note that we do not know the additive effect of these combined exposures. There are several animal studies which show that isopropanol can potentiate the toxicity of carbon tetrachloride (another chlorinated hydrocarbon) (4). We do not have information on the combined effect of isopropanol and the chlorinated hydrocarbons in the degreaser solvent.

We were not able to measure levels of the solvent used at the time the HHE request was submitted. It is difficult to know how many of the symptoms reported can be attributed to this earlier solvent. The methylene chloride contained in the other solution was one of the potentially more toxic components of the solvent.

One concern is that as company production of word processing units increases there will be more use of the degreaser and greater exposure to operators and people in the immediate vicinity. It is important to recognize that adequate ventilation, proper work practices, and positioning of tables at some distance from the degreaser all contribute to controlling exposure levels. After an in-line automated degreaser is installed, use of the manual degreaser will still be necessary. Reduced and less regular use of this equipment increases the need for vigilance regarding safe practices.

VIII. RECOMMENDATIONS

The goal is to minimize inhalation and skin exposure to the degreaser solvents of the operator and employees who work in the area of the degreaser.

1. When operating a solvent degreaser, good work practices will reduce exposure to solvent.

a) Operator should wear neoprene gloves while immersing and removing baskets.

b) Operator should replace cover when the unit is not in operation.

c) Work should be placed in and removed slowly from the degreaser, at a rate no greater than 11 feet/minute to prevent sudden disturbances of the vapor level. Body mechanics and work load weight need to be taken into consideration to achieve this rate.

d) The work pace needs to be set such that vapors have time to fully condense and drain back into the tank.

2. Ensure that the workbenches are placed at least 8 to 10 feet from the degreaser with a ceiling ventilation unit between the workbench and the degreaser (see A and B on Figure 1).

3. Increase the amount of fresh air provided by the ventilation system. This will further dilute air levels of the solvent components.

4. All potential operators need training to ensure that work practices as outlined in Recommendation No. 1 are consistently upheld.

5. The production should be organized to minimize the number of people operating the degreaser. The resolder circuit boards can be collected to be run in batch by the regular degreaser operator.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Requester
2. Syntrex Corporation
3. NIOSH, Region II
4. OSHA, Region II

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 EXPOSURE, RESULTS OF AIR ANALYSIS

PERSON	ISOPROPANOL	TRICHLOROETHANE	TRICHLOROTRIFLUOROETHANE	MIXTURE
A	2.43 ppm	15.5 ppm	7.21 ppm	0.06
B	2.49 ppm	14.4 ppm	9.66 ppm	0.06
C	4.04 ppm	23.3 ppm	14.5 ppm	0.09
D	3.72 ppm	23.4 ppm	10.2 ppm	0.09
E	9.37 ppm	57.2 ppm	26.1 ppm	0.21
Odor Threshold	40-220 ppm	16-400 ppm		
OSHA Standard	400 ppm 8 hour workday	350 ppm 8 hour workday	1000 ppm 8 hour workday	
ACGIH TLV	400 ppm 8 hour workday	350 ppm 8 hour workday	1000 ppm 8 hour workday	1.0
NIOSH Recommendation	400 ppm 10 hour workday	350 ppm 8 hour workday	1000 ppm 8 hour workday	
Skin Absorption	Yes	Yes	No	

HOGAN 900 contains:

Isopropanol 18%
1,1,1-trichloroethane 57%
Trichlorotrifluoroethane 25%

Sampling Time: 3 hours for each sample

TABLE 2

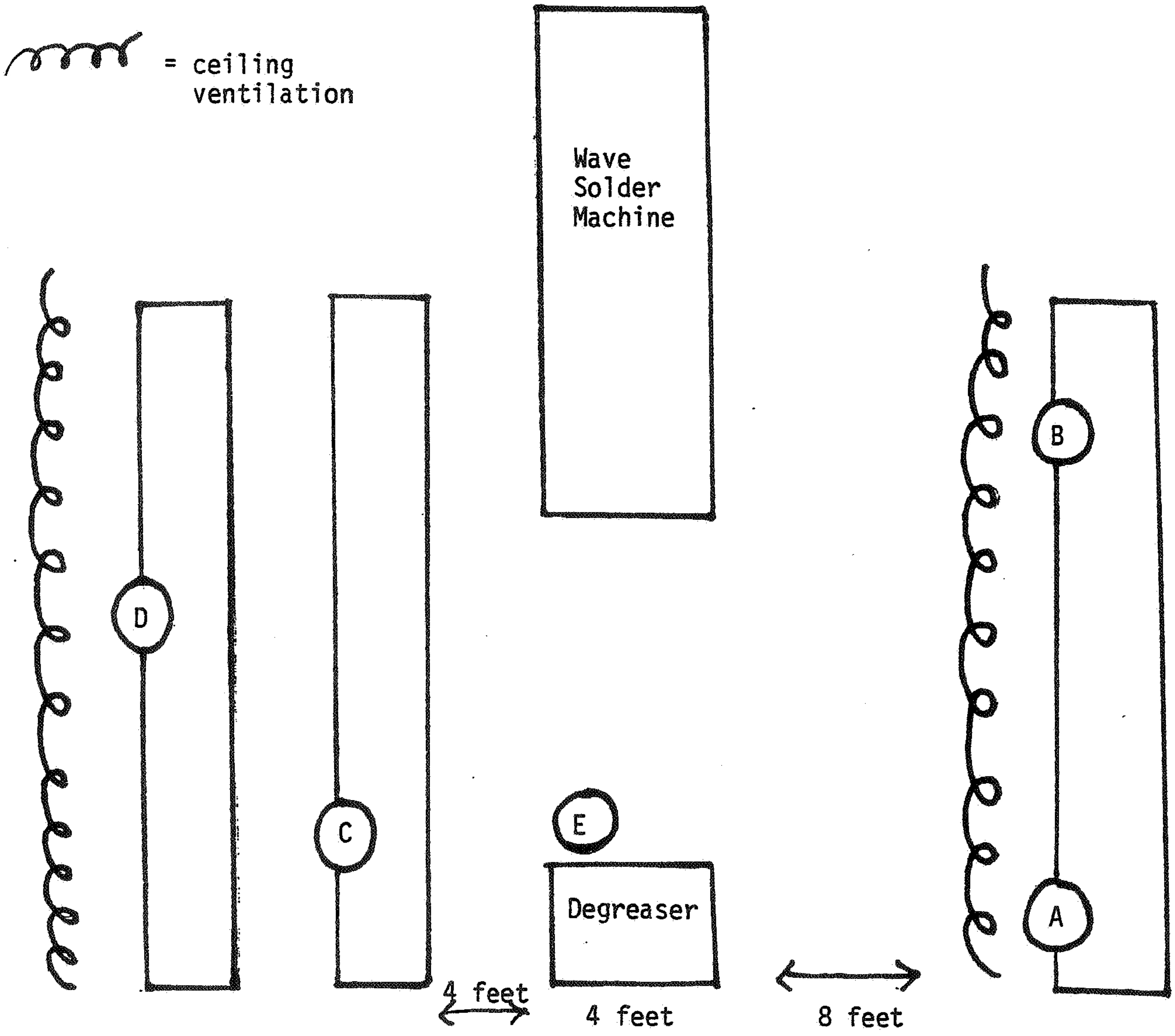
SYMPTOMS EXPERIENCED BY PEOPLE WORKING AROUND THE DEGREASER

	Location	
	General Area	Degreaser Operators
Burning Eyes	4	4
Headaches	4	2
Lightheadedness	4	3
Nausea	4	1
Sore Throat	2	2
Other*	1	1
No. of people interviewed with no symptoms	3	1
No. of people with three or more symptoms	3	2
Total Interviewed	9	5

*Confusion, irritable, ataxia, fatigue, slurred speech.

Placement of Air Sampling Equipment
Syntrex (August 26, 1981)
Eatontown, N.J.

Figure 1



People at Stations A, B, C, and D are repairing plastic circuit boards that were not soldered properly. This involves using soldering guns and a small amount of solvent. Improperly placed solder is removed and new solder is applied manually.

Person E is responsible for degreasing all the plates that pass through the wave solder machine.

INDUSTRIAL VENTILATION
APPENDIX A

Solvent vapor degreasing refers to boiling liquid cleaning systems utilizing trichloroethylene, perchloroethylene, methylene chloride, freons (R) or other halogenated hydrocarbons. Cleaning action is accomplished by the condensation of the solvent vapors in contact with the work surface producing a continuous liquid rinsing action. Cleaning ceases when the temperature of the work reaches the temperature of the surrounding solvent vapors. Since halogenated hydrocarbons are somewhat similar in their physical, chemical and toxic characteristics, the following safeguards should be provided to prevent the creation of a health or life hazard:

1. Vapor degreasing tanks should be equipped with a condenser or vapor level thermostat to keep the vapor level below the top edge of the tank by a distance equal to one-half the tank width or 36 inches, whichever is shorter.

2. Where water type condensers are used, inlet tempertures should not be less than 80° F (27° C) and the outlet temperature should not exceed 110° F (43° C).

3. Degreasers should be equipped with a boiling liquid thermostat to regulate the rate of vapor generation, and with a safety control at an appropriate height above the vapor line to prevent the escape of solvent in case of a malfunction.

4. Tanks or machines of more than 4 square feet of vapor area should be equipped with suitable gasketed cleanout or sludge doors, located near the bottom, to faciliate cleaning.

5. Work should be placed in and removed slowly from the degreaser, at a rate no greater than 11 feet/minute (0.055 m/s), to prevent sudden disturbances of the vapor level.

6. CARE MUST BE TAKEN TO PREVENT DIRECT SOLVENT CARRYOUT DUE TO THE SHAPE OF THE PART. Maximum rated workloads as determined by the rate of heat transfer (surface area and specific heat) should not be exceeded.

7. Special precautions should be taken where natural gas or other open flames are used to heat the solvent to prevent vapors* from entering the combustion air supply.

8. Heating elements should be designed and maintained so that their surface temperature will not cause the solvent or mixture to breakdown* or produce excessive vapors.

9. Degreaser should be located in such a manner that vapors* will not reach or be drawn into a atmosphere used for gas or electric arc welding, high temperature heat treating, combustion air or open electric motors.

10. Whenever spray or other mechanical means are used to disperse solvent liquids, sufficient enclosure or baffling should be provided to prevent direct release of airbourne vapor above the top of the tank.

11. An emergency quick-drenching facility should be located in near proximity to the degreaser for use in the event of accidental eye contact with the degreasing liquid.

*Electric arcs, open flames and hot surfaces will thermally decompose halogenated hydrocarbons to toxic and corrosive substances (such as hydrochloric and/or hydrofluoric acid). Under some circumstances phosgene may be formed.

(from reference 1a.)

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