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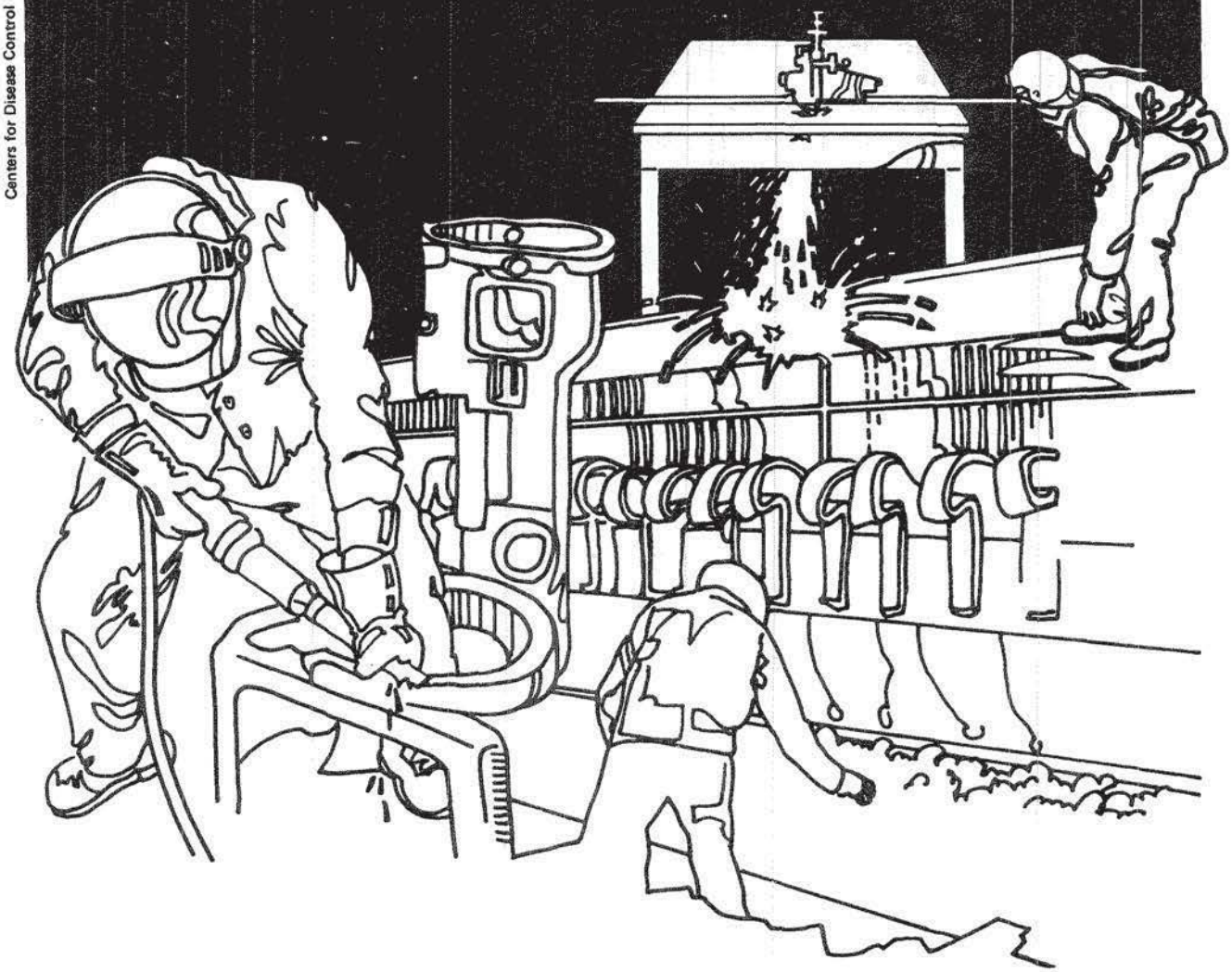

Health Hazard Evaluation Report

HETA 80-123-1268
SOLID STATE SCIENTIFIC INC.
MONTGOMERYVILLE, PENNSYLVANIA

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.

HETA 80-123-1268
FEBRUARY 1983
SOLID STATE SCIENTIFIC INC.
MONTGOMERYVILLE, PENNSYLVANIA

NIOSH INVESTIGATORS:
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I. SUMMARY

In May 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from several employees for a health hazard evaluation at Solid State Scientific, Montgomeryville, Pennsylvania. Workers were concerned about: (1) occupational exposure to chemical fumes and vapors in the Wafer Fabrication and Diffusion areas; (2) lack of information provided to pregnant workers about potential toxic damage to their health and that of the fetus; and (3) radiation leakage in the Branding Room area.

In September 1980, environmental air samples for measurement of exposure to chloride, isopropyl alcohol, xylene and 1,1,1 trichloroethane were collected, and for diborane in February 1981. Medical interviews were administered by a NIOSH physician in September 1980.

Air samples for hydrogen chloride gas were found at concentration from 0.14 ppm; isopropyl alcohol ranged from none-detected to 0.7 ppm; 1,1,1 trichloroethane was not detected; xylene concentration ranged from none-detected to 0.9 ppm, and diborane concentrations ranged from 0.02 ppm to 0.06 ppm. All levels measured were well within the recommended environmental criteria/standard used in this report; for diborane, useful baseline data was gathered for the future. A review of the company's radiation badge results did not reveal any exposures to radiation.

Thirteen women were interviewed by the NIOSH Industrial Hygienist and Medical Investigators (Branding Room 3; Wafer Fabrication Area 4; Wafer Diffusion Area 6). There was no evidence of overexposure to radiation or toxic chemicals in the areas studies. However, workers were not well informed about the potential hazards of these exposures.

Based on environmental and medical studies, NIOSH has determined that no occupational health hazard exists in the Wafer Fabricaton and Diffusion areas at Solid State Scientific Inc. However, several recommendations have been made toward improving worker education and counseling and the communication of sampling and radiation measurement results.

KEYWORDS: SIC 3674 (Electronic Devices, Solid State), Hydrogen Chloride, Isopropyl Alcohol, 1,1,1 Trichloroethane, Xylene, Diborane.

II Introduction

On May 5, 1980, NIOSH received a confidential request from several employees at Solid State Scientific, Montgomeryville, Pennsylvania to investigate employee exposure to gases, and vapors on the Wafer Fabrication and Diffusion areas and vapors and radiation in the Branding Room area.
When notified of the request, the company informed the Regional Office that NIOSH would be refused entry to their facilities based on lack of probable cause for inspection of its property.

On August 1, 1980, a NIOSH Industrial Hygienist and physician obtained entry under a warrant and were finally able to conduct the evaluation. A walk-through of the areas in question and interviews with employees were conducted on this date.

The NIOSH Industrial Hygienist returned on September 19, 1980 to conduct air sampling for xylene, isopropyl alcohol, hydrogen chloride and 1,1,1 trichloroethane; and again on February 2, 1981 to sample for diborane gas - this sampling had been delayed in order for NIOSH to develop a reliable sampling technique for diborane gas at low concentrations.

III Background

Plant Process/Condition of Use

1. In the Wafer Fabrication Area (Photo-Resist Area - Building #2) there are 23 operators per shift working on three shifts. The process involves construction of solid state electronic microcircuits on silicon wafers that have been subjected to a photo-resist process. A silicon wafer with an oxide layer is coated with an ultraviolet sensitive material and a circuit mask is then projected onto or contacted using ultraviolet light. Layers of circuitry can be built up as a sandwich of oxide on silicon "etched" areas.

Air in this area is 60-70% recirculated at constant temperature as laminar flow through high efficiency filters. This avoids any contamination of the device through contact with particulate matter. Developers and cleaning solvents are contained through the use of downdraft local exhausts which go to an alkaline scrubber on the roof-top.

2. In the Diffusion Area (Building #2) there are ten operators per shift on three shifts. Wafers are treated with various gases (diborane, silane phosphorous-oxychloride with hydrogen chloride as a carrier gas) while in a diffusion furnace which "bakes in" these elements. This imparts desired characteristics to the device depending on which element is diffused into the wafer. Diffusion ovens are in

exhaust hoods and fugitive gases are passed onto an alkaline scrubber located on the roof. The presence of hydrogen chloride gas had been noted by operators in the past and was thought to be due to the reentrainment of gases from the scrubber back into the ventilation intake ducts on the roof. Because of this, a larger alkaline scrubber was installed on the exhaust end and carbon filters were added to the intake end of the ventilation system. Since this augmentation (one month prior to the inspection), no further incidents have been officially noted.

3. Branding Room - Building #3 - There are six operators per shift for one shift - adjacent to the radiation testing area where workers test and label assembled electronic devices using vibration, pressure and radiation to check for defects, cracks and structural integrity.

Isopropyl alcohol, 1,1,1 trichloroethane and some acetone is used to prepare the surface of the device housing for labeling/branding. A local exhaust is available and intermittently used, although the quantity of solvent used is minute.

IV Evaluation Design and Methods

A. Environmental

In September 1980, NIOSH conducted environmental studies of the following area and operations for:

1) Hydrogen Chloride - Diffusion Area - two area samples and two personal samples on the diffusion operators.

2) Xylene and Isopropyl Alcohol - Photo-Resist Area - two personal samples on the photo-resist operators.

3) 1,1,1 Trichloroethane - Branding Room - one personal sample on the brander operator.

4) Diborane - Diffusion Area - two area samples and two personal samples on the production operators.

Hydrogen Chloride was sampled using silica gel tubes with personal air sampling pumps at a rate of 200 cc/minute.

Airborne samples collected on silica gel were analyzed for hydrogen chloride vapors by ion chromatography. NIOSH Method P&CAM 310 was used to prepare and analyze samples.

To effect separation of the chloride peak from neighboring interfering signals, pump flow rate was decreased to 25% (115 mL/hour) and an additional 3 X 250 mm anion separator column was placed in series with the 3 X 500 mm analytical column specified in the method. A retention time for chloride of 6.6 minutes was observed under these conditions.

Reported results are in the units of micrograms HCl per sample. A detection limit of 2.5 ug HCl per sorbent section is estimated; this results in an LOD of 5 ug HCl per sample.

Isopropyl Alcohol and Xylene were sampled using activated charcoal tubes and personal sampling pumps at a rate of 100 cc/ minute.

These samples were analyzed by gas chromatography according to NIOSH Method S-65 with minor modifications.

The A and B sections of each sample were separately desorbed with 1 ml of carbon disulfide containing 1 ul/ml ethylbenzene as internal standard and 1% sec-butanol to assist in desorption. The analysis was performed using a Hewlett-Packard 5731A gas chromatograph equipped with a flame ionization detector. A 12' X 1/8" stainless steel column packed with 10% TCEP on 80/100 mesh Chromosorb P AW was used under isothermal conditions at an oven temperature of 90oC.

The limit of detection: Isopropyl Alcohol 0.01 mg
Xylene 0.01 mg

1,1,1 trichloroethane was sampled using activated charcoal tubes and personal sampling pumps at a flow rate 100 cc/minute.

The charcoal tubes were separated into A and B portions and desorbed in 1 ml of carbon disulfide containing 1 ul/ml benzene as an internal standard. The samples were analyzed according to NIOSH Method S-328 (modified) using a Hewlett-Packard 5830A gas chromatograph with a flame ionization detector. A 12' X 1/8" stainless steel column packed with 10% SP-1000 on Supelcoport 80/100 was used at an oven temperature of 90oC (isothermal).

No significant unknowns were observed in the analysis.

The limit of detection: 1,1,1 trichloroethane 0.02 mg per sample tube.

Diborane was sampled using impregnated charcoal sorbent tubes (Barneby-Cheney) and personal air sampling pumps at a flow rate of 100 cc/minute.

The samples were analyzed as per P&CAM S231. The charcoal tubes were broken open and the front and back-up sections emptied into plastic bottles containing 10 mL of 3% hydrogen peroxide. Samples were allowed to sit for 30 minutes. The samples were filtered through 0.45 um Millipore HA filters in a Swinex holder and stored in plastic bottles. The samples were then analyzed for boron on a Spectrametrics III DC Plasma Emission Spectrophotometer, at a wavelength of 249.7 nm. A reagent blank and two sample spikes were also analyzed. The sample spikes were prepared by spiking sample 11 and 12 with 1 ug diborane. Recovery from these solutions, which are reported on the attached MSB QA form, was about 85%. Overall recovery was determined by measuring desorption efficiency on six sorbent tubes spiked with 6 ug diborane. The desorption efficiency was about 89%.

Standards ranging from 5-40 ug/sample were analyzed along with samples and blanks. The linear regression data for the standard curve is reported on the MSB QA form. The detection limit is estimated at 0.01 ug while the limit of quantitation is about 0.04 ug. The sample results reported in Table 1 indicated small (<1 ug) but quantifiable amounts of diborane in each sample and blank tube. The samples are corrected for desorption efficiency of 90% and the blank level. The precision of replicate analysis is better than $\pm$ 10%.

B. Medical

A total of 12 workers - three in the Branding Room, three in the wafer fabrication area and six in the wafer diffusion area - were interviewed by the NIOSH physician. The workers were questioned about their occupational history, smoking history, history of work-related illness and their current perceptions of their job with regard to safety and health.

V. Evaluation Criteria - Toxicology (4,5,6)

The environmental evaluation criteria for the substances sampled are shown in Table I. The criteria are the (1) NIOSH recommended standards, (2) Threshold Limit Values (TLV) of the American Conference of Governmental Industrial Hygienists (ACGIH), and (3) Federal occupational health standards as promulgated by the Occupational Safety and Health Administration, U.S. Department of Labor (29 CFR 1910.1000).

Diborane

Local - Vapors of boron hydrides are irritating to skin and mucous membranes.

Systemic - Diborane is the least toxic of the boron hydrides. In acute poisoning the symptoms are similar to metal fume fever, i.e. tightness, heaviness and burning in chest, coughing, shortness of breath, chills, fever, pericardial pain, nausea, shivering, and drowsiness. Signs appear soon after exposure or after a latent period of up to 24 hours and may persist for 1-3 days or more. Pneumonia may develop later. Reversible liver and kidney changes have been observed in rats exposed to very high concentrations of gas. This has not been noted in man. Subacute poisoning is characterized by symptoms of pulmonary irritation. Following more prolonged exposure, CNS symptoms such as headaches, dizzines, vertigo, chills, fatigue, muscular weakness, and transient tremors may appear. Convulsions do not occur. Chronic exposure leads to wheezing, dyspnea, tightness, dry cough, and rales.

Hydrogen Chloride

Local - Hydrochloric acid and high concentration os hydrogen chloride gas are highly corrosive to eyes, skin and mucous membranes. The acid may produce burns, ulceration and scarring on skin and mucous membranes, and it may produce dermatitis on repeated exposure. High concentrations in the eye may result in reduced vision or blindness. Dental discoloration and erosion of exposed incisors occur on prolonged exposure to low concentrations. Ingestion may produce fatal effects from esophageal or gastric necrosis.

The irritant effect of vapors on the respiratory tract may produce laryngitis, glottal edema, bronchitis, pulmonary edema, and death.

Isopropyl Alcohol

Isopropyl Alcohol vapors are mildly irritating to the conjunctiva and mucous membranes of the upper respiratory tract.

Systemic - No cases of poisoning from industrial exposure have been recorded. Isopropyl Alcohol is potentially narcotic in high concentrations.

1,1,1 Trichloroethane

1,1,1 Trichloroethane in liquid or vapor phases may be irritating to the eyes on contact. This effect is usually noted first in acute exposure cases. Mild conjunctivitis may develop but recovery is usually rapid. Repeated skin contact may produce a dry, scaly, and fissured dermatitis, due to the solvent's defatting properties.

1,1,1 Trichloroethane when inhaled as a vapor acts as a narcotic and depresses the central nervous system. Acute exposure symptoms include dizziness, incoordination, drowsiness, increased reaction time, unconsciousness, and death.

Xylene

The local effects of xylene vapor include irritation of the eyes, nose, and throat. Repeated or prolonged skin contact with xylene may cause drying and defatting of the skin which may lead to dermatitis. Liquid xylene is irritating to the eyes and mucous membranes, and aspiration of few milliliters may cause chemical pneumonitis, pulmonary edema, and hemorrhage. Repeated exposure of the eyes to high concentrations of xylene vapor may cause reversible eye damage.

The systemic effects of acute exposure to xylene vapor include central nervous system depression and reversible abnormalities in liver and kidney function. In high concentrations xylene vapor may cause dizziness, staggering, drowsiness, and unconsciousness. At very high concentrations, i.e. 2500 ppm, xylene vapors may cause anorexia, nausea, vomiting, abdominal pain and pulmonary edema.

VI Results and Discussion

A. Environmental

Refer to Table II for tabulated results.

Diborane - Air samples taken in the Diffusion Area showed a range of 0.03 ppm to 0.06 ppm of diborane gas for the area and production operators.

Hydrogen Chloride - Air samples taken in the Diffusion Area showed a level of concentration at 0.14 ppm of hydrogen chloride gas for the area samples and diffusion operators samples.

Isopropyl Alcohol - Air samples taken in the Photo- Resist Area show concentrations of the vapor at 0.4 and 0.7 ppm for the photo-resist operators.

1,1,1 Trichloroethane - Air samples taken in the Branding Room shows no vapor detected (below reliable detection limit) for the brander operator.

All environmental air concentrations were well within the recommended environmental criteria/standards used in this study (Refer to Table I).

B. Medical

Three women were interviewed in the Branding Room. None complained of symptoms but they were concerned about exposure to radiation from the adjacent radiation testing area. Radiation badges are worn by the two operators who may work in the Radiation Room. A review of the company's radiation badge results did not reveal any radiation exposures. Also, the Nuclear Regulatory Commission comes into this facility once every three months to review these records and to check the Radiation Room and work procedures.

Four women were interviewed who worked in the wafer fabrication area. Three worked at microscopes under exhaust hoods and one was an inspector of the photo-resist process. They had no specific health complaints but two complained of sensitivity to solvent fumes from the photo-resist process which were occasionally "strong".

All were anxious about the possibility of exposure to chemicals from accidental spills in the area and were poorly informed about the potential hazards of handling the chemicals to which they were exposed. Each had been informed about emergency evacuation procedures.

Six women were interviewed in the adjacent diffusion area and none had specific health complaints. However, they recounted recent episodes of failure of the ventilation system that necessitated evacuation of the area. Company says that hydrogen chloride gas was smelled in the diffusion area. There was general concern about crowded working conditions that made handling of caustic chemicals hazardous. One worker who treated wafers with acid and alkali solutions was working on both sides of a general thoroughfare in the laboratory. She was concerned about the possibility of accidental spills. All workers interviewed wanted to know more about the nature of the chemicals they were handling. New employees have a pre-placement physical examination performed by a contract physician. It is a company policy that pregnant women may work after the 6th month of pregnancy if provided with a certificate to that effect by a private physician. There was no special concern or counselling about exposure during the first trimester of pregnancy.

Discussion

In this important and rapidly expanding industry, concerns about technical innovations and development may overtake those required to protect the health and safety of the workforce. As new processes are developed, there is potential for poor planning of work procedures that may result in crowding and exposure to harmful substances.

Numerous potentially toxic chemicals are used and the possibilities of harmful health effects from these are well recognized by workers at Solid State Scientific. Many are young women of child bearing age concerned about reproductive effect from exposure to chemicals and radiation.

The safety and well being of the work force will be promoted by programs of counselling and education for the workers and attention to planning of work practices to reduce the risk of accident and exposure to chemicals.

There was no evidence that workers were over-exposed to radiation or toxic chemicals in the areas studied. However, workers should be better informed of the risks of such exposures especially during the first trimester of pregnancy.

VII Recommendations

1. A program of workers' education and counselling concerning chemicals and exposures in the workplace should be developed and periodically updated.

2. Results of industrial hygiene measurements and radiation dosimeter badges should be made available to workers upon request.

3. Corrosive chemicals and solvents should be used in the lab hoods with the hood sash in the minimal vertical position possible (i.e. 20-25% open); and workers should wear protective goggles and gloves in these operations.

VIII Authorship and Acknowledgements

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6. General Industry, OSHA Safety and Health Standards, 29 CFR 1910, OSHA 2206, Revised January 1976

X Distribution and Availability of Determination Report

Copies of this report are available 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 can be obtained from the NIOSH Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. Solid State Scientific Inc., Montgomeryville, Pennsylvania
2. Employee Requestors
3. NIOSH, Region III
4. OSHA, Region III

For the purpose of informing the 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 I

HE 80 123

Solid State Scientific Inc.
Montgomeryville, Pennsylvania

Environmental Exposure Limits

Substance	NIOSH	OSHA	ACGIH
Diborane	-	0.1ppm-TWA(1)	0.1ppm-TWA
Hydrogen Chloride	-	5.0ppm-ceiling(2)	5.0ppm-ceiling
Isopropyl Alcohol	400ppm-TWA	400ppm-TWA	400ppm-TWA 500ppm-STEL(3)Skin(4)
1,1,1 Trichloroethane	350ppm-15 min. ceiling	350ppm-TWA	350ppm-TWA 440ppm-STEL
Xylene	100ppm-TWA 200ppm-10 min. ceiling	100ppm-TWA	100ppm-TWA 150ppm-STEL-Skin

1. TWA = Time-weighted average based on 8-hour exposure.
2. Ceiling = value which at no time shall be exceeded unless noted.
3. STEL = Short term exposure limit maximim concentration no to be exceeded during a 15 minute excursion period.
4. Skin = Potential contribution to overall exposure by the cutaneous route to be taken into account.

TABLE II

HE 80 123

Solid State Scientific Inc.
Montgomeryville, Pennsylvania

Air Sampling Results

Substance	Location/Job Operation	Sampling Time	Concentration (8-hr.-TWA)
Diborane (2/18/81)	- Diffusion Area - Production Operator 1.	180 min.	0.06 ppm
	- Diffision Area - Production Operator 2.	180 min.	0.03 ppm
	- Diffusion Area - Area Sample - near Diborane Unit #BPSG-PW-2.	180 min.	0.03 ppm
	- Diffusion Area - Area Sample - inside of hood with this Diborane Unit.	180 min.	0.03 ppm
Hydrogen Chloride (9/19/80)	- Diffusion Area	388 min	0.14 ppm
	Diffusion Operator 1.	180 min.	0.06 ppm
	- Diffusion Area - Diffusion Operator 2.	385 min.	0.14 ppm
	- Diffusion Area - top of LPCUDI furnace.	375 min.	0.14 ppm
	- Diffusion Area - hood 34(QC) aisleway.	371 min.	0.14 ppm
Ispropyl Alchohol (9/19/80)	- Photo-Resist - Operator 1.	366 min.	0.66 ppm
	- Photo-Resist - Operator 2.	365 min.	0.40 ppm
1,1.1 Trichloroethane (9/19/80)	- Branding Room - Brander Operator	358 min.	None Detected
Xylene (9/19/80)	- Photo-Resist - Operator 1.	366 min.	0.60 ppm
	- Photo-Resist - Operator 2.	365 min.	0.90 ppm

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