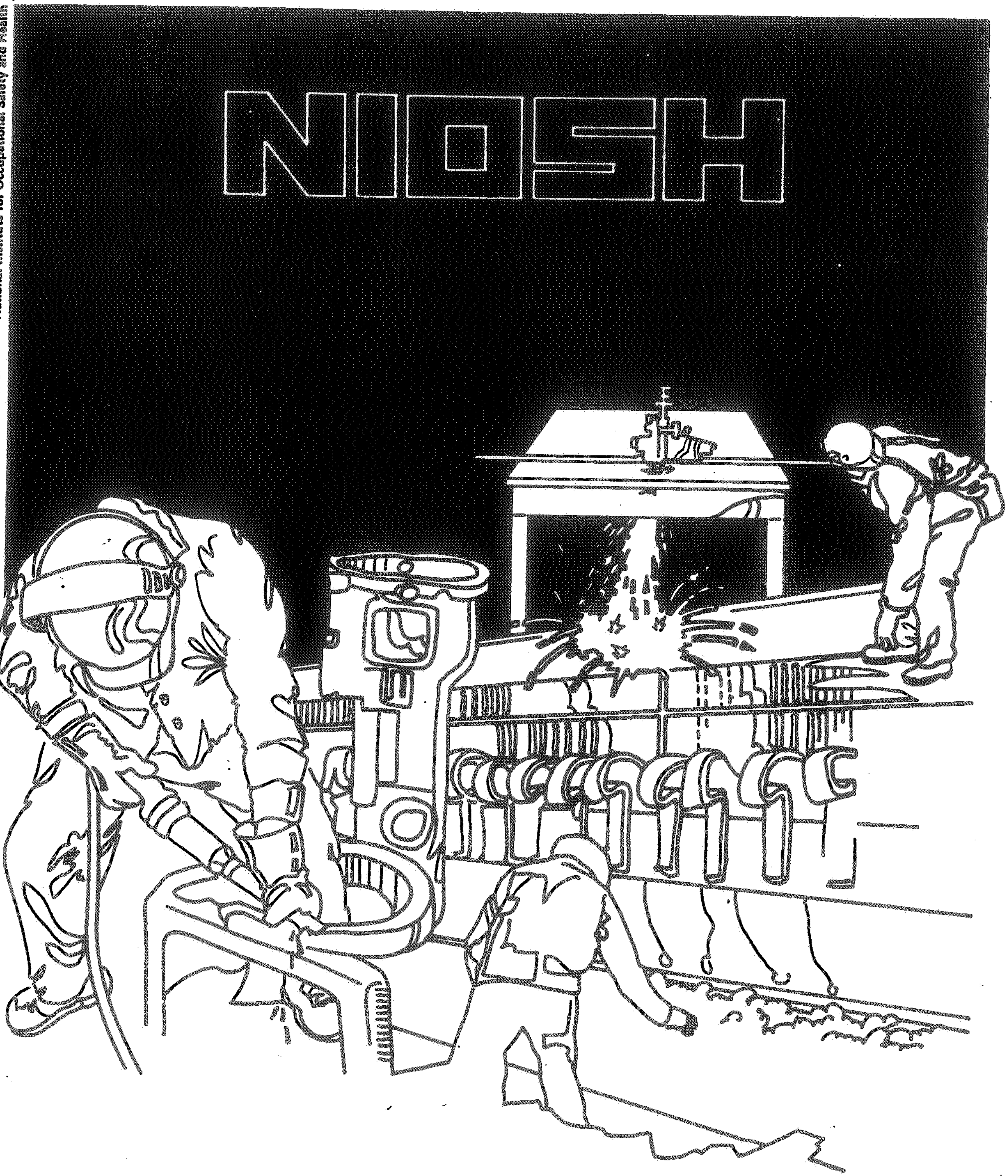
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 82-075-1545
PRATT & WHITNEY AIRCRAFT
WEST PALM BEACH, FLORIDA

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 82-075-1545
DECEMBER 1984
PRATT & WHITNEY AIRCRAFT
WEST PALM BEACH, FLORIDA

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I. SUMMARY

In December 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate occupational exposure to chlorinated solvents at Pratt & Whitney Aircraft (P&WA), West Palm Beach, Florida. The request was prompted by reported findings of elevated blood chloroform levels and an increased prevalence of cancer in the workforce.

Industrial hygiene and medical surveys were conducted in December 1981 and March 1982. The industrial hygiene evaluation included; 1) full shift and short term air sampling using standard charcoal sorbent tubes and a photoionization detector to evaluate current solvent exposures of 30 degreasor operators, 2) review of past industrial hygiene sampling data and, 3) water sampling to evaluate trihalomethane contamination levels. The medical evaluation included; 1) review of the "blood-chloroform" test, 2) pre- and post-shift urine sampling to monitor total trichloro compounds (TCC), 3) questionnaire survey and, 4) evaluation of cancer mortality using a proportional mortality ratio (PMR), a proportional cancer mortality ratio (PCMR) to correct for some inherent biases in the PMR and a case control study to determine if persons who died of cancer were more likely to have worked in areas of higher solvent exposures.

Eight-hour, TWA concentrations ranged from 0.3 to 22.9 ppm for Trichloroethylene (TCE), 0.8 to 7.2 ppm for Perchloroethylene (PERC), and 0.5 to 2.0 ppm for Methylchloroform (MC). All were well below the current OSHA standards (TCE-100 ppm, PERC-100 ppm, MC-350 ppm) and below the 25 ppm considered by NIOSH to be achievable using engineering controls. NIOSH recommends that TCE and PERC be considered human carcinogens and therefore exposures minimized and that MC be handled with caution due to its chemical similarity to TCE and PERC. The urine test results, which measured total trichloro compounds (TTC) in post shift samples and ranged from 0.5 to 83.0 ug/gr, showed good correlation (R=0.92) with the 8-hour TWA exposure data. Peak exposures to degreasing solvents were estimated to be in the 200-300 ppm range. Occasional symptoms such as lightheadedness, headache and eye irritation reported by 20-30% of those interviewed, suggests that peak levels may occasionally exceed these values. Past environmental data indicates that 8-hour TWA exposures to degreasing solvents were generally below 25 ppm back as far as TWA data was available (1973). Analysis of water samples indicated that the new aeration units are maintaining tri-halo-methane (THM) concentrations below 0.2 ppm which is on the low end of the range (0.2-1.0 ppm) normally found in the surrounding localities. It's possible that exposures to background concentrations of chlorinated solvents, which average 2-5 ppm in the plant, are responsible for a significant portion of the reported blood-chloroform concentrations.

A PMR of 156 for all cancers suggests that a 56% increased proportion of mortality due to cancer was present in this group. However, for the seven individual cancer death categories that appeared statistically significant in the PMR analyses, none remained elevated in the PCMR. This indicates that the elevated PMR was artifactual. Furthermore, there was no indication, from the case control study, that those persons who died of cancer were any more likely to have worked in an area of higher degreasing solvent concentrations than their matched controls who died of some other cause.

Eight-hour TWA exposures to chlorinated degreasing solvents are low, but current and past short-term exposure data and worker reports of occasional lightheadedness of short duration suggest a potential health hazard for those operating the vapor degreasers. Based on the data evaluated, we find no excess cancer risk associated with work. Recommendations are made in Table 3 and Section VIII that will reduce peak exposures to degreasing solvents.

KEYWORDS: SIC 3722 (Aircraft Engines and Engine Parts), vapor degreasers, trichloroethylene, perchloroethylene, methyl chloroform, blood-chloroform, total trichloro compounds, cancer

II. INTRODUCTION

In December 1981, NIOSH received a request from P&WA, Government Products Division of United Technologies, West Palm Beach, Florida to evaluate employee exposure to chlorinated hydrocarbons. Subsequent to receiving the P&WA request, a similar request was received from an authorized representative of the International Association of Machinists (IAM), Local 971. Both requests were prompted by a preliminary study that reported (1) an elevated uptake of chlorinated hydrocarbons via the analysis of blood samples (reported as blood chloroform concentrations) taken from 10 P&WA employees; and (2) a possible increase, as high as a nine-fold, in the cancer rate in the workforce.

Our initial efforts were primarily directed at collecting information related to the preliminary study at the P&WA plant and to employee exposures to degreasing solvents. A NIOSH industrial hygienist, occupational physician, and an epidemiologist visited the plant site on December 14-16, 1981 to collect the information necessary to decide what methods could best be used to evaluate the request. On December 22, 1981, a letter was forwarded to Pratt & Whitney and Local 971 that recapped the NIOSH activities of this site visit, identified what NIOSH believed were the main issues that needed to be evaluated and briefly discussed the methods that would be used to study them. On February 24, 1982, a letter was forwarded that discussed the study protocol in more detail was sent.

A follow up environmental/medical survey was conducted on March 15-19, 1982. This survey concentrated on measuring current exposures to degreasing solvents via standard air sampling techniques. Also, a questionnaire was administered and pre and post shift urine samples, to be analyzed for total trichloro compounds, were collected from each worker monitored.

Interim Report No. 1, issued in April, 1982 summarized the findings of the March visit and discussed the blood test used by the contracting University. Although the analytical results of the NIOSH air sampling conducted were not yet available, deficiencies noted in the degreasing operations, along with recommended corrective actions, were presented at that time.

In July 1982, Interim Report No. 2 was issued. This report presented the results of the air sampling, discussed the urine testing and questionnaire data from the March survey, and provided a status report of the issues still pending. Also, results of water samples taken by Water Supply Section of Palm Beach County Health Department and analyzed by EPA were reported.

In August 1983, Interim Report No. 3 was issued. This report presented an evaluation of the epidemiologic studies performed by the contracting university and results of additional epidemiologic evaluations conducted by NIOSH. This report was presented to Pratt & Whitney and the union at the plant site on August 16, 1983.

This final report represents a compilation of the data presented in previous letters and interim reports and includes a review of past exposure data.

III. BACKGROUND

Pratt and Whitney Aircraft is part of United Technologies Corporation. The Government Products Division, which was the subject of this evaluation, is based in West Palm Beach, Florida. This division primarily designs, develops, markets, and supports high performance jet and rocket engines for military use. Established in 1958, the plant is located on a 7,000-acre tract in Palm Beach County near the northern edge of the Everglades. Having a work force of 7200 people, it is reported to be the second largest employer in the state. There are 1465 hourly employees of which 1070 are represented by Local 971, IAM.

In August 1980, the Palm Beach County Health Department (PBCHD), which has regulatory authority, was notified by P&WA that various volatile organic compounds (VOC's) had been detected in the potable water supply of its facility. The contaminated wells were taken out of service and frequent monitoring was initiated. During the ensuing weeks P&WA met with PBCHD to discuss the extent of the problem and possible corrective actions. In December 1980, an aeration device was added to P&WA's water treatment plant, and three additional aeration units were added in January 1982. The aeration devices allow the VOC's to volatilize prior to the normal treatment process. In a letter to NIOSH dated February 2, 1982, the PBCHD stated that the aeration devices were effectively removing VOC's from the well water. P&W continued frequent monitoring and forwarded periodic reports to the PBCHD.

In an effort to determine what methods might be useful in evaluating whether the contaminated water had adversely affected the health of employees, P&WA contracted with the University of Miami to develop a study protocol. In a letter to P&WA dated November 2, 1981, the university investigators reported elevated blood chloroform levels in P&WA workers studied and the suggestion of a nine-fold increase in crude cancer-associated mortality rates among active employees at the P&WA facility over the past 18 years. This prompted P&WA to request NIOSH to further evaluate exposure to degreasing solvents and cancer mortality.

Although there are literally hundreds of chemicals used at the P&WA facility, the NIOSH investigation concentrated on the issue of exposure to chlorinated degreasing solvents. If other potentially significant exposures were observed during the course of the NIOSH field survey, they were to be brought to the attention of P&WA Health and Safety Personnel for corrective action.

Union officials were made aware of the scope of the NIOSH evaluation and were briefed as to the availability of Fort Lauderdale OSHA to respond to other issues of concern while the NIOSH study was in progress.

There were 15 chlorinated solvent degreasers in operation at the P&WA facility during the time of the NIOSH field visits. Most of the degreasers were manufactured by Detrex, and most were the original units installed in the late 1950's and early 1960's. Two of the degreasers were enclosed with local exhaust ventilation. All were vapor degreasers. Improvements such as roll-top lids and temperature safety switches were added over the years. The primary degreasing solvents used are Trichloroethylene (TCE), Perchloroethylene (PERC) and Methyl Chloroform (MC). Possible routes of exposure include breathing in-plant air contaminated with solvent vapors, skin absorption after direct skin contact with the solvents, and in the past, ingestion of contaminated drinking water. There are approximately 50-60 workers whose jobs requires them to spend part of their work day operating a degreaser.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

1. Water Contamination

Since water pollution is not an issue normally studied by NIOSH, EPA and the Palm Beach County Health Department (the local regulatory agency) were contacted for assistance in studying this issue. Past exposure to solvents in drinking water will probably remain unknown since this type of water analysis data was not available on the P&WA water system prior to 1980. (There was no requirement to run this type of analysis.) Up until March 1982, most of the water sampling was conducted by P&WA with analysis by one of several EPA approved laboratories. During the time frame of NIOSH's followup field survey (March 15-19, 1982) the PBCHD arranged to collect a number of raw and finished water samples for analysis by the EPA laboratory in Athens, Georgia. The sampling and analytical procedures were in accordance with EPA guidelines and are not presented in this report. However, the results are discussed in Section VI.

2. In-Plant Exposure to Degreasing Solvents

a. Current Exposures

It is general procedure when evaluating a workplace that has a large number of employees (>7000 in this case) to select a smaller group of workers who most likely have the highest exposures to monitor first. Accordingly, those individuals who were most likely to operate the vapor degreasers in each area during the time of our survey were evaluated.

Each person monitored wore two sampling devices. One was run for the majority of the shift and estimated that individual's average exposure for that work day. The other was activated only when that person was operating a vapor degreaser. The latter will represent the average exposure while performing degreasing operations. A direct reading instrument (HNU Photoionization Meter) was used to estimate peak exposures during performance of specific degreasing tasks.

Area samples were positioned at selected locations (Table I) to estimate employee exposures in plant areas other than the immediate vicinity of the vapor degreasing units.

All air samples (except HNU data) were taken using standard 150 mg charcoal sorbent tubes and analyzed in accordance with the provisions of NIOSH Method P&CAM 127[1] with the following modifications:

Desorption Process:	Samples and standards were desorbed with 1 mL carbon disulfide containing 1 microliter per milliliter ethyl benzene as an internal standard.
Gas Chromatograph:	Hewlett-Packard Model 5731 equipped with a flame ionization detector.
Column:	12' x 1/8" stainless steel packed with 20% SP-2401, 0.1% Carbowax 1500 on 100/120 mesh Supelcoport.
Oven Conditions:	75°C isothermal.

b. Past Exposures

Past or "historical" environmental data was reviewed to evaluate worker exposures as far back in time as the data permitted.

B. Medical

1. Evaluation of Blood Chloroform Test

The Blood Chloroform Test used by the University hired by P&WA was being developed under contract with EPA.[2] Both EPA and the NIOSH Experimental Toxicology Branch, Division of Biomedical and Behavioral Science were conducted for technical assistance regarding interpretation of results.

2. Pre- and post-shift urine samples were collected from those employees working with degreasing solvents and were analyzed for total trichloro compounds (TTC). TTC compounds were determined by chromic acid oxidation of trichloroethanol to trichloroacetic acid and colorimetric analysis of the latter compound using Fujiwara reaction.[3]

Air sampling techniques can estimate exposure through normal respiration, but will not address possible exposure via skin contact or injestion. Therefore, the urine testing was used, in correlation with the air samples taken on the same employees, to evaluate all three routes of exposure.

3. Questionnaire Survey

A questionnaire designed to obtain work history, medical history and symptom information was administered to all workers who participated in the air monitoring program.

4. Epidemiologic Issues

NIOSH reviewed the epidemiologic evaluation by the university under contract to P&WA and performed the following three additional evaluations: 1) a proportional mortality ratio (PMR), similar to the Universitys' work except with adjustment made for age and calendar time period of death, and cause of death taken from actual death certificates; 2) a proportional cancer mortality ratio (PCMR) to correct for some of the weaknesses inherent in the PMR method; 3) a case/control study to determine if persons who had died from malignant neoplasms were more likely to have worked in areas with higher environmental levels of degreasing solvents (and hence, presumably, higher exposures).

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10-hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a 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 agent 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 primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet 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.

B. Trichloroethylene

Trichloroethylene is a colorless, volatile, nonflammable liquid that is immiscible in water and has a vapor density of 4.45 and a boiling point of 87^{o}C. It is a powerful degreasing and dry cleaning agent and has been used in commerical products such as printing inks, paints, lacquers, varnishes and adhesives. A pharmaceutical grade of TCE was formerly used as a general anesthetic in surgical and obstetrical procedures[5] and as an analgesic for short operative procedures.[6] It has also been used to extract caffine from coffee.

The predominant physiological response is one of central nervous system depression. This is particularly true as a response from acute or short-term exposure. Visual disturbances, mental confusion, fatigue and sometime nausea and vomiting have been observed. The dangers of acute exposure to trichloroethylene may be accentuated by visual disturbances and incoordination, which may lead to poor manual manipulation and, therefore, unsafe mechanical operation.[7] Prolonged skin contact may cause local irritation and blister formation. Under industrial conditions, repeated emersion of the hands in TCE has caused paralysis of the finger.[8] While TCE will penetrate intact skin, it is unlikely that absorption of toxic quantities would occur by this route.[9]

TCE is absorbed readily from the gastrointestinal tract. Liver and kidney injuries in humans attributable to overexposure to TCE are rare.[10]

Intolerance to alcohol is also a well-characterized phenomena among TCE-exposure workers.[12] Not only do many TCE workers become inebriated with consumption of small quantities of alcoholic beverages, but they also are subject to vasodilatation of superficial skin vessels, resulting in skin blotches, a condition known as "degreasers flush".[13] Flushing is most prominent on the face, neck, shoulders, and back. This condition appears to be a benign dermal phenomena of short duration but has lasted for up to 6 weeks after exposure to TCE for 5 days at 200 ppm.[13]

On March 21, 1975 the National Cancer Institute reported preliminary results of a carcinogen bioassay which indicated no carcinogenis effects in rats but the induction of hepatocellular carcinomas in mice.[14,15] After reviewing the NCI study, NIOSH recommended that TCE be considered a suspect human carcinogen and transmitted this message to industry via a Current Intelligence Bulletin[4] and a Special Occupational Hazard Review.[16] NIOSH's initial recommendation for a TCE standard were issued in 1973.[17] This recommended standard, and the Current OSHA standard; both set at 100 ppm, were based upon TCE's known toxic properties at that time and did not include an assessment of its carcinogenic potential. NIOSH considers that a level of 25 ppm, as a TWA, can be uniformly achieved by the use of existing engineering control technology.[16] However, since there is no known safe level of exposure to a carcinogen, the goal should be to minimize exposure to the extent possible.

C. Perchloroethylene

Perchloroethylene (PERC) is a colorless liquid with an ether-like odor detectable at about 50 ppm. This nonflammable solvent is primarily used as a dry-cleaning agent and vapor degreaser. A thorough review of the toxic effects of PERC can be found in the NIOSH Criteria Document.[18] Effects on the central nervous system are most frequently associated with overexposure. These include headache, dizziness, vertigo and, at concentrations greater than 2000 ppm, unconsciousness. Clinical evidence accumulated over the years demonstrates that PERC is toxic to the liver and kidneys in humans. The same NCI study that implicated trichloroethylene as a carcinogen also provided evidence that PERC was carcinogenic in mice but not rats.[15] The 50 ppm exposure criteria recommended by NIOSH in 1976[18] and the current 100 ppm OSHA standard were both based on information known before the NCI study and without knowledge of its carcinogenic potential.

NIOSH's current recommendation that it is prudent to handle PERC in the workplace as if it were a human carcinogen, and therefore exposure be minimized, was issued in a Current Intelligence Bulletin in 1978.[19]

D. Methy Chloroform (MC)

Methyl Chloroform (1,1,1-Trichloroethane), like TCE and PERC is a central nervous system depressant. It is a colorless liquid used primarily as a degreasing agent. Because of its reactivity with magnesium and aluminum, inhibitors are generally added to increase the stability of the solvent. Like many solvents, MC will defat the skin and cause redness and scaliness. Absorption through the skin can occur but is not a significant route of exposure.[20] Exposure to the vapor of MC at a concentration of 500 ppm for 7-hours a day, five days a week did not cause any significant systemic toxic effects in rats, ginnea pigs, rabbits or monkeys.[21] MC is poorly metabolized and is excreted unchanged in the expired air of animals and human test subjects.[22] In concentrations greater than 5000 ppm cardiac sensitization was observed in dogs[23] and deaths due to anesthesia and/or cardiac sensitization have been reported under poor ventilation conditions in industry.[21,24] The OSHA standard for MC is 350 ppm. NIOSH recommended a 350 ppm ceiling level standard in 1976[11], but, in a more recent document[26] recommends that MC be handled with caution due to its chemical similarities to TCE and PERC, which are considered suspect human carcinogens.

VI. RESULTS AND DISCUSSION

A. Environmental

1. Water Contamination

The following water samples were collected by the Palm Beach County Health Department and analyzed for Volatile Organic Compounds (VOC) by EPA in Athens, Georgia.

a. Composite Raw
b. Plant Effluent (finished)
c. Rocket Support (finished)
d. Old Office Building (finished)

Additional samples were collected at the same time and analyzed for pesticides/herbicides, heavy metals, secondary contaminants and various physical parameters. These samples were processed by the Palm Beach County Health Department's laboratory.

a. Composite Raw
b. Plant Effluent (finished)
c. A9 & 10 Stand
d. Rocket Support
e. B Area (MMT)
f. E Area (EDR)
g. C Area (turbo jet)
h. C 11 Area
i. New Office Building
j. Shops (manufacturing, maintenance and support buildings)

The results of the analysis of these water samples were reviewed and discussed with EPA and the Palm Beach County Health Department. One "raw" and three "finished" water samples were analyzed for 27 organic compounds. The only organic compound in significant amounts was chloroform, which was present in concentrations of 0.210, 0.130, and 0.180 ppm in the three finished water samples. The chloroform was formed as a result of the chlorination process, which can convert organic substances in the raw water to chloroform. The 0.1 to 0.2 ppm chloroform level, which makes up the Tri-halo-methane (THM) level is on the low end of what might be expected in that area of Florida. THM levels of 0.2 to 1.0 are typically found in the community water supply systems.

2. Inplant Exposure to Degreasing Solvents

a. Current

At the time of the NIOSH field survey (March 16-18, 1982), there were 14 vapor degreasers in operation. There were 10 in the manufacturing building; 2 in Test area C, 1 in RL10 Assembly; 1 in the Salvage Yard, and 1 in the Rocket Support building. Information on the location and type of degreaser, shift sampled, number of employees monitored and number of area samples obtained, is presented in Table 1. The locations of the 10 degreasers evaluated in the manufacturing building are shown in Figure 1. Sampling results are presented in Table 2 (3 pages) by job and work area and are summarized below.

Trichloroethylene, perchloroethylene, and methyl chloroform were being used as degreasing solvents. Twenty-nine degreaser operators were monitored for both long- and short-term solvent exposure. These individuals were the only workers engaged in degreasing activities during the survey. Eleven area air samples were collected in locations away from the degreasers to determine exposures of "non-degreasing" personnel and of degreasing operators for that portion of the day when they are not actually operating a degreaser. The total time each worker was operating a degreaser ranged from 1.5 to 147 minutes. Only one worker (plater) spent more than 30 minutes during his 8-hour work shift degreasing parts. There are occasions when the solvent degreasers can be utilized for longer time periods, such as when the RL10 Assembly goes into a production cycle.

Trichloroethylene Results

Long-term (5 to 8 hours) personal breathing zone (PBZ) air concentrations ranged from 0.3 to 22.9 ppm, except for one mechanic engaged in a degreaser cleaning activity who was exposed to 38.8 ppm. However, this worker was wearing a respirator (half-mask with organic cartridges). Therefore, his actual exposure was probably much less, depending on the protection factor afforded by the respirator. Eighty-three percent (24 of 29) of the exposures were less than 5 ppm. Exposures of the four workers monitored in RL10 Assembly, Test Area C, ranged from 13.9 to 22.9 ppm.

Exposures measured while the workers were engaged in degreasing tasks, ranged from non-detectable (ND) to 233 ppm. The ND result was due to the small air volume sampled and the fact that this worker operated only a PERC degreaser, not a TCE degreaser.

Peak exposures were evaluated, as degreasing tasks were performed, using a direct-reading photoionization detector. The instrument appeared to be performing well in the field and the results were consistent with the short-term charcoal tube samples. However, due to problems during post calibration (inadequate instrument response), the accuracy of peak exposure data is uncertain. A segment of the strip chart recording is presented in Figure 3 to demonstrate the fluctuations in solvent vapor concentrations above the degreasing unit as degreasing tasks are performed. TCE peak exposures are estimated to be at least in the 200 to 300 ppm range.

Area air samples indicated that TCE concentrations averaged 2.2 ppm in the plating area and 0.4 ppm in the medical department and other areas of the main manufacturing building. This type of sample in the RL 10 Assembly building, Test Area C, ranged from 14.7 to 22.5 ppm.

Perchloroethylene Results

The PERC degreaser on the A-line in the plating area was the only one of the three PERC units being used. The PERC units in the salvage yard and the shuttle area were not in use on the survey dates.

Long-term PBZ sample results ranged from 0.8 to 7.2 ppm in the plating area and were less than 1.2 ppm in all other areas. Short-term PBZ exposures during degreasing operations ranged from 1.9 to 66.4 ppm in the plating area and were less than 1.2 ppm in other areas. Peak exposures ranged from 200 to 300 ppm during degreasing tasks.

Area air sampling in the plating area indicated that 1 to 2 ppm of PERC is a background for that area. All other areas of the plant, away from the immediate vicinity of a degreaser, averaged 0.5 ppm or less.

Methyl Chloroform Results

The two MC degreasers were located in the tube bending and sheet metal areas of the main manufacturing building. Long-term PBZ samples for the workers in these two areas ranged from 0.5 to 2.0 ppm. Short-term PBZ exposures (during degreaser operation) ranged from 23.0 to 106 ppm. During the time that degreasing tasks were being monitored at the sheet metal MC degreaser, peak exposures were in the 50 ppm range.

Combined Exposure

In most cases, a degreaser operator's primary exposure will be to the vapor of the solvent he is working with, with a secondary exposure to much lower background concentrations of the other two solvents if they are being used in the same building. The exception occurs when a degreaser operator uses more than one type of degreaser, such as in the plating area where any of the workers can use either a TCE or PERC unit. Since health effects of TCE and PERC can be additive, it is appropriate to sum the individual TCE and PERC exposure levels. Long-term combined exposures to TCE and PERC ranged from 1.9 to 11.2 ppm with a mean of 5.2 ppm.

Deficiencies Noted in Degreasing Operations

During the course of March 16-18, 1982 field survey, the degreasing units and work practices were evaluated at each degreasing operation. Although long-term TWA exposures were generally low, peak exposure data indicated numerous equipment or work practice deficiencies. These deficiencies are listed for each degreaser in Table 3 along with recommended corrective actions. This table was included in Interim Report No. 1 which was sent to the company and union in April, 1982.

b. Past Exposures

Evaluation of past exposures depends on the availability of historical environmental data. P&WA supplied data that was obtained during the time frame 1963-1982. The data is summarized below.

1963-1972

Air samples were taken using gas detector tubes such as those manufactured by Drager, Gastec, MSA and Kitagawa. This technique produces "grab" sample data which is of very short duration (usually less than a minute) and often is a better measure of how well the degreaser was working than of worker exposures. This technique is generally accepted to produce results accurate to plus or minus 25%.

Air samples were taken at the degreasers at least once during each year between 1963 and 1972 and sometimes twice.

Fifteen surveys were conducted. Results ranged from 0-400^{+} ppm (apparently, 400 ppm was the highest value interpretable on the detector tube). Measurements greater than 400 ppm were obtained in 9 of the 15 surveys at one or more degreasers. Most of this data cannot be directly compared to long-term (8-hour) or even short-term (15 minutes) exposure criteria since the sampling duration was, most likely, less than 1 minute. (Until 1971, there were no OSHA standards or NIOSH recommended standards.)

There is very little air sampling data indicating air concentration of degreasing solvent vapors in areas away from the immediate vicinity of the degreasers. In 1964, 65 and 66, 6 measurements were taken in front of the safety office in the manufacturing building; they ranged from 0 to 30 ppm. There were no data available for the office areas or medical department in the main manufacturing building.

<u>1973-1980</u>

During this period environmental data provided for review was obtained at P&WA by a chemical manufacturer as a service offered in support of its products. Surveys to measure exposure to degreasing solvents were conducted in May 1973, December 1974, October 1975 and March 1980. Measurements were taken using a Gas Tech® Halide Meter. During these surveys, 22 degreaser operators were evaluated for an 8-hour work shift. The 8-hour TWA's ranged from 3 to 96 ppm. These were calculated using breathing zone exposure for the duration of specific degreasing tasks and representative breathing zone exposures while the workers were away from the degreasing units. Only three were above 25 ppm, and these were obtained during different surveys and on different degreasers. Short-term sampling efforts during performance of specific degreasing tasks measured concentrations ranging from 0 to 1100 ppm. A summary of the 8-hour TWA and peak exposure data is presented in Table 4. These data indicate that the primary degreasing solvents during these years were TCE and Chloroethene VG (inhibited form of methyl chloroform). The higher peak values were associated with deficiencies either in the operation of the degreasing equipment or in poor work practices. Recommendations to help reduce exposures were provided with each survey report.

<u>October/November 1981 (Area Samples)</u>

Over 100 samples were collected by P&WA to measure air concentrations of TCE, PERC, MC, Chloroform and Carbon Tetrachloride in both production and nonproduction areas. Essentially all were area samples (as compared to breathing zone samples). The samples were collected and analyzed in accordance with a currently acceptable charcoal tube method. No detectable levels of carbon tetrachloride or chloroform were found in any of the samples. The degreasing solvents were found in concentrations of less than 5 ppm in non-production areas (many were non-detectable), 5-10 ppm in production areas, and 10-30 ppm near degreasers. Sampling times were not included in the data reviewed. (This summary of data is not presented in more detail because the vast majority of the data are well below what would reasonably be expected to be of any health significance based on current knowledge.) The obvious conclusion that the closer to the degreasers the higher the air concentrations of the degreasing solvent vapors is apparent.

January 1982 (Breathing Zone Samples)

Approximately 117 air samples were collected by P&WA to estimate degreasing operators exposure to TCE, PERC and MC in the Plating and Zyglo, and Tube Assembly areas of the main manufacturing building. Samples were collected and analyzed in accordance with a currently acceptable charcoal tube technique. The data are summarized in Table 5.

Employee exposures (8-hour TWA) ranged from ND to 20 ppm for TCE in 96% (48 of 50) of the samples taken. The other two 8-hour, TWA exposures, 50 and 90 ppm, were taken in the breathing zone of zyglo workers who did not use the zyglo degreaser, but brushed parts with TCE in the zyglo inspection booth. Results of sixty of 62 (97%) 4-hour, samples for TCE analysis ranged from 1-30 ppm. The other two were 93 and 130 ppm and were also obtained on zyglo workers not using a degreaser but brushing parts with TCE in the inspection booth. Short-term (less than 15 minute) exposure data for TCE were not obtained except for two, 15-minute and three, 5-minute samples in the plating area. These samples ranged from ND to 30 ppm.

Exposure to PERC ranged from 1-10 ppm in 15, 8-hour TWA samples and 1-16 ppm in 25, 4-hour TWA samples obtained from workers in the Plating area. Results of two, 15-minute samples were ND and 60 ppm and of three, 5-minute samples were <10-230 ppm.

Sixteen of 19 8-hour TWA exposures to MC in the zyglo area ranged from ND to 3 ppm. One worker's exposure to MC was measured at 23, 30 and 60 ppm on 3 consecutive days which was 10 to 20 times higher than his coworkers doing the same job.

B. Medical

1. Evaluation of Blood Chloroform Test

The blood test used by the university hired by P&WA is being developed under contract to EPA as an aid in studying the effects of water disinfection techniques such as chlorination. Test results are reported as blood chloroform levels even though there may not be any chloroform in the blood. During the analysis, a blood serum sample is purged at 115°C for 30 minutes. It is during this time period that chlorinated substances in the blood sample can be converted to chloroform.

This theory was confirmed when split samples sent to another laboratory which were analyzed for chloroform, did not contain chloroform. The purging temperature was 70°C (45°C lower than the University's method) which was thought not to be hot enough to convert the chlorinated substances in the blood to chloroform. Trichloroethylene, which is the primary degreasing solvent at P&WA, is metabolized in the body to trichloroacetic acid and, at 115°C, would be converted to chloroform.

The university has reported that "normal" values of the blood chloroform test are below 25 ppb. P&WA employees were found to have levels of up to 2000 ppb. This nearly 100-fold increase, which at first seems alarmingly high, may be expected in those individuals exposed to air concentrations of trichloroethylene as low as 5 ppm (1/20 of the current OSHA standard). For example, a worker will breath in approximately 5 cubic meters of air during a typical workday. If this air contains 5 ppm, or 27 mg/m^3 of TCE, he will have taken in approximately 135 mg ($5m^3$ x 27 mg/m^3) or 135000 micrograms of TCE during that work shift. Approximately 70% of this is absorbed by the body and 30% is exhaled. Therefore, 94,500 ug (70% of 135000) of TCE is available to be metabolized by the body and further converted to chloroform via the purging step in the analysis of the blood. In contrast, a worker who drinks 1 liter of water that contains 1000 ug/L of Tri-chlorinated solvents would have approximately 1000 ug available to be absorbed, metabolized and converted to chloroform. Although this is a crude analysis, it serves to illustrate the fact that workers in a plant where background levels of chlorinated solvent could approach 5 ppm may be expected to have a 100-fold increase in the blood "chloroform" according to the test used by the University.

A review of the blood data thus far indicate the results on P&WA employees at the Government Products Division are higher than for a group of people in Dade County and other parts of the country. As discussed above, this difference may be explained due to the background air concentrations of solvent vapors in the plant.

The blood test is experimental. There are many factors that may influence the test results, such as diet and medication, that are not clearly understood. It is not possible at this time to associate a health risk with the blood levels reported in P&WA workers. Exposure to air concentrations of 5% or less of the current OSHA standards for the chlorinated solvents used at P&WA may be responsible for the highest blood levels found.

2. NIOSH Urine Testing

Thirty post-shift urine samples were analyzed. The results were normalized by expressing the concentration of TTC in terms of milligrams per gram of creatinine. Under conditions of no occupational exposure, the amount of TTC found in a urine sample would not be expected to exceed 2 mg/gr.

All of the samples analyzed have detectable levels of TTC but most are relatively low as judged by the study reported by Ikeda.[25] TTC concentrations ranged from 0.5 to 83.4 mg/g creatinine. Three of the workers had urine TTC levels approaching the levels (65-80 mg/g) expected with an environmental concentration of 25 ppm of TCE. All three workers were in the Test Area C, RL 10 Assembly, which is consistent with the environmental data and general exposure histories obtained by interview and first-hand observation.

The TTC urine concentrations correlated well with the air concentrations, having a correlation coefficient (R value) of 0.92. However, a wider spread of the data and some additional data points for the exposure range of 5 to 15 ppm would have supported a more meaningful interpretation of the relationships between the urine and air data.

Because so few of the post-shift urine TTC concentrations were substantially elevated, the pre-shift urine samples were not analyzed.

3. NIOSH Questionnaire

Occupational health questionnaires were administered to the 30 survey participants. Age and employment characteristics of the study population are shown in Table 6. The respondents were divided into three groups according to the typical daily length of exposure at the degreasing tanks.

Five of the 11 employees who spent less than 15 minutes per day at the degreasing tanks spontaneously reported health problems which they perceived as work-related. Within this group, dermatitis was the primary complaint for three persons, with headache, eye irritation, and skin irritation also being reported. One of the twelve employees that spent 15 to 30 minutes per day at the degreasing tanks reported headache as a work-related problem.

Of the seven employees who spent more than 30 minutes per day at the degreasing tanks, two reported skin cancer as a perceived work-related health problem.

The distribution of positive responses, characterizing the symptoms experienced by the 30 P&WA employees, revealed that lightheadedness, skin irritation, and headache were the symptoms most commonly reported (Table 7). Shortness of breath, dizziness, and eye irritation were other frequent complaints. Symptoms were most commonly reported in conjunction with performing duties at or in the immediate vicinity of the degreasing tanks. Symptoms were generally reported to occur "occasionally," and typically they were of short duration and mild severity. Serious abnormalities associated with exposures to the degreasing tanks were not reported. There was no discernable difference in pre-, during-, and post-shift symptom frequency. The symptom frequencies were similar to those found at a degreasing operation in a tube company in Pennsylvania[22], where lightheadedness and skin irritation were also very common complaints among the work force.

There appeared to be no distinct pattern among the three exposure groups; the 11 workers in the less than 15-minute category had a greater relative number of central nervous system symptoms, headache, and skin irritation than did the seven workers who had more than 30-minute exposure per day to degreasing tanks. The greater than 30-minute exposure group had more shortness of breath and dizziness than those of the shortest exposure (less than 15 minutes/day) category. The intermediate (15 to 30 minutes) exposure group had more complaints of headache and lightheadedness. Overall, there is no obvious dose response pattern. Likewise, there was no pattern when chronologic patterns of symptoms were considered within a working day; that is, pre-shift patterns of complaints were not different from during- and post-shift patterns of symptoms.

4. Epidemiologic Issues

   a. Review of the University's Study

      The report of excess cancer was based upon an epidemiologic investigation performed by the university of deaths that had occurred among P&WA employees between 1963 and 1980. These deaths had been collected and assembled over the years by an employee of the Medical Benefits Office for a non-epidemiologic purpose. We estimate the study was performed on about 300 deaths. We further estimate that there would be between 3,000 and 4,500 deaths in a population this size and age. The university investigators determined 3-year running averages of what they term "cancer death rates" (defined as average number of known cancer deaths divided by the average yearly plant census) and the relative 3-year proportions of cancer deaths to total deaths (Table 8). There was no apparent adjustments made for age, calendar time period, sex or race. These rates were compared to one another over time, and the investigators concluded that cancer-associated mortality had increased by more than nine times from the 3-year interval 1964-65-67 (there were no deaths known for the year 1966) to 1978-79-80. Further, they concluded that the rates of cancer have risen uninterrupted since the mid-1960's. Then they reported that the proportion of deaths from cancer relative to all deaths rose from 10% in the mid 1960's to 35% by 1980.

b. Proportional Mortality Ratio (PMR) Study

In order to evaluate the validity of the University's conclusions, NIOSH personnel requested the identities of all known deceased P&WA employees. We were given a list of 240 names of persons for who an application had been made for death benefits. Of these, all but 12 died in the same year as their date of last employment. This suggests that the list of deceased we were provided died, for the most part, while employed at P&WA. A copy of each official death certificate was requested from the vital statistics office of the state in which the death occurred. This certificate was sent to a qualified nosologist who determined the cause of death from the death certificate diagnoses, and assigned the proper International Classification of Disease (ICD) code. This ICD death code was used in all subsequent NIOSH analyses. Cause of death was determined for all but one person.

Proportional mortality can be validly calculated from a sample of deaths <u>if</u> the sample is truly representative of the total population of deaths. Although it would be unlikely that a group of about 240 deaths drawn from employees who for the most part died while actively employed would be representative of the total population, we conducted a Proportional Mortality Ratio (PMR) analysis for the purpose of comparing to the one performed by the university. The primary difference between the two was that we corrected by adjusting for age, calendar time period and cause of death. Cause-specific proportions of death from a comparison population (the U.S. white male population specific for 5-year age and calendar time period) were applied to the total number of deaths that occurred among the study population to generate the expected number of cause-specific deaths. The observed number of deaths was divided by the expected number to derive a PMR.

There were 239 deaths considered in the analysis. (One death dropped out as cause was not determined) The average age of death was 51 years. Of these deaths, 74 were due to a malignant neoplasm, while only 47.4 were expected. That yielded a PMR (observed deaths divided by expected deaths) of 1.56. Stated another way, a 56% increased proportion of mortality due to cancer appeared to be present in this group. The excess was apparent across all 5-year age groups and 5-year calender time periods, although there was no apparent upward trend for either (Tables 9a & 9b). For the general death category of malignant neoplasms, almost every specific malignancy had an elevated PMR; seven were statistically significant (Table 10). These included cancers of the digestive organs, pancreas, respiratory system, lung, skin, brain, and leukemia. Conversely, almost every non-malignant cause of death had a lower than expected PMR. Among these were a 5% deficit in deaths due to diseases of the circulatory system, a 36% deficit in death due to digestive system diseases, and a 62% deficit from all non-malignant respiratory diseases.

c. Proportional Cancer Mortality Ratio (PCMR) Study

Because a PMR study can only evaluate the proportion of one cause of death relative to another, a deficit in one cause of death will make another cause of death appear to be disproportionally high, even when the overall rate of death is the same as expected. In this case, deficits of non-cancer deaths could make the proportion of cancer deaths appear artificially high. To evaluate just the cancer deaths Proportional Cancer Mortality Ratios (PCMRs) were calculated. In all other ways, the expected numbers of specific cancer deaths were calculated as they were in the PMR analysis.

There were 74 cancer deaths considered in the PCMR analysis. The average age of death was 55. For the seven cancer death categories that appeared to be statistically significant in the PMR analysis, none remained elevated in the PCMR (Table 11).

d. Case/Control Study

Even though the deaths were not chosen in a way that allowed reliable proportional mortality analyses (i.e., not chosen randomly to be representative of the entire population of deaths) there is no apparent reason to believe that they were selected because of any particular work history. Therefore, it was possible to perform meaningful analyses to determine if the individuals who died of cancer were more likely to have worked in an area where degreasing solvents were present than those who died of some other cause of death.

A case was defined as any death due to a malignant neoplasm. There were 74 of these deaths. For each case, a matched control was selected from the remainder of the deaths on the basis of three things: 1) closest age; 2) closest date of first employment; and 3) closest duration of employment.

Detailed work histories were obtained from P&WA for each of these 148 individuals, and those work histories were coded into a computer file. All jobs were evaluated as to the amount of exposure to degreasing solvents. They were then ranked 1, 2, or 3 depending if they represented "background" exposure, intermediate exposure, or highest exposures, respectively. Only exposures that were directly the consequence of the job were considered; all persons at the plant were considered to have the same potential for exposure via the plant drinking water.

A NIOSH case/control analysis computer program was used to determine "odds ratios". (The "odds ratio" is the term used to express the probability of the workers who died of cancer to have experienced the exposure. It is derived from the rate of cases who had exposure and the rate of controls who had exposure. Odds ratios greater than 1.0 indicate an excess risk; values less than 1.0 indicate a deficit.) The odds ratios were tested for statistical significance by calculating a 95% "confidence interval." (This is an interval that the true odds ratio would lie outside of only 5% of the time because of chance alone. Therefore, if the confidence interval does not include 1.0, there is a 95% certainty that the observed effect is not due to chance, but rather due to something else.) Odds ratios were calculated and tested for statistical significance for the following comparisons to determine if exposure to degreasing solvents was more likely among persons who died from cancer:

1) those with lowest exposures to those with intermediate exposure

2) those with lowest exposures to those with highest exposures

3) those with lowest exposures to those with intermediate and/or highest exposure.

There is no indication from these analyses that those persons who died of cancer were any more likely to have worked in an area of higher degreasing solvent concentration than their matched controls who died of some other cause (Table 12). Because the odds ratio is an estimate of risk, it can be said that persons with higher exposures to degreasing solvents were no more likely to have died of cancer than those with a backround level of exposure. If exposure to degreasing solvents in the amounts encountered at the P&WA facility resulted in cancer, one would expect to see more cancer deaths as exposure increased.

e. Further Discussion of Epidemiologic Issues

We have no direct knowledge of how the university determined causes of death, nor which deaths they considered to be due to cancer. Consequently, we could not check the accuracy of their data.

The university calculated what they term "associated mortality rates" by taking the total number of deaths that were reported to them for each year and dividing it by the plant population for that same year. Each year that a rate of death was calculated, the rate was averaged with it's adjacent years to create "three year moving averages". This procedure was used to calculate cause specific rates for cancer and cardiovascular deaths. Determining a true rate of death requires knowledge of all extant deaths in the study population, A crude rate could then be drawn by dividing the total yearly population at risk by the yearly deaths. Since the disease of concern is cancer, which normally requires years of latency to manifest, it is essential that all persons at risk, both current and former employees, be counted. Since this was not the case in the work performed by the University, we consider their approach to calculating death rates to be very crude and consequently, to have little use in evaluating mortality among P&WA workers.

Regarding the proportional mortality ratio study (PMR) results, it would be extraordinarily unlikely that any chemical exposure would cause malignancies of multiple sites while simultaneously causing lower than expected deaths in almost every non-cancer cause of death. Results like these immediately lead one to question the validity of the data being analyzed. For some reason there seemed to be a greater propensity for cancer deaths to make it into the sample we studied than deaths due to other diseases, resulting in what most likely is an artifactual disproportionate number of cancer deaths. Comparison of the list of deaths that were supplied to the University with those used in our PMR analysis revealed that most of the deaths were the same (231 deaths out of the 240 we examined). Consequently, our and the University's data sets suffer the same deficiencies. This problem is common in PMR studies. One way to correct for the problem is to conduct a PCMR study, the theory being that although there may be a bias affecting the selection of cancer versus non-cancer deaths, this bias should not be as strong for the selection of different types of cancer. Since there was no disproportion of any particular cancer death within the category of all cancers, the observations of disproportionate mortality made by the University and us were most likely spurious and were, in all likelihood, caused by the relatively small, biased sample of deaths. This assumption is further supported by the fact that, although degreasing chemicals are very commonly used in industry, we are not aware of the existance of previous reports implicating them as the cause of multiple types of cancer.

VII. CONCLUSIONS

A. Water Contamination

In summation of the water issue (solvent contamination), information obtained from the Palm Beach County Health Department, who has been closely monitoring this issue, it is probable that the current quality of the potable water on the P&WA premises is equal to, and probably exceeds that of the water in most of the surrounding communities that are on a community, chlorinated distribution system.

B. Inplant Exposures to Degreasing Solvents

Review of past air sampling data provided by P&WA resulted in the following conclusions.

1. Data obtained since 1973 suggests that 8-hour, TWA exposures to degreasing solvents were generally maintained below 25 ppm in the main manufacturing building. Similiar data from other areas such as the RL 10 Assembly Area, where there is a higher potential for significant exposures due to low ceilings and more confined work areas, is very scarce.

2. Short-term and peak sampling data, from as far back as results were available (1963), document exposures in the range of 400 to 1000 ppm during the performance of degreasing tasks in surveys conducted up to 1980. These data suggested problems with the degreasing units and/or poor work practices. The higher values were not always from the same degreaser indicating the need for close surveillance of all the degreasers. Peak exposure levels obtained by NIOSH in 1982 (200-300 ppm), although lower than those previously mentioned, were also associated with problems with the degreasers and poor work practices.

C. Workers' Health

An evaluation of current exposure to the degreasing solvents using air sampling and biological testing in a small number of workers, but those considered to have the highest potential for exposure, did not indicate a significant problem in this area. These methods were used to account for all possible routes of exposure (air, skin, injection). Also, review of the questionnaires administered to each worker monitored, more than half of whom were over age 50 and had greater than 10 years seniority, did not suggest the presence of chronic health effects in this sample of workers.

D. Epidemiologic Issues

Based upon an evaluation of the methods of investigation used by the University, and on the results of a case/control analysis performed by NIOSH investigators, we have concluded that there is no evidence of any unusual patterns of mortality, nor is there any more likelihood for a person who worked in an area with higher exposure to degreasing solvents to have died of cancer than someone who worked in an area with only backround levels.

The only approach to definitively determing the mortality experienced by P&WA employees would be to conduct a full scale retrospective cohort mortality study. It is possible to conduct such a study at this facility. The plant's personnel record system (which would be needed to perform this kind of study) is adequate. However, these studies require that the vital status of all former employees be ascertained, an activity that requires a great amount of time and resources. Without evidence of a problem existing at the facility, the value of conducting such a study is a matter of supposition.

VIII. RECOMMENDATIONS

A. Exposure to Degreasing Solvents

Specific recommendations concerning each vapor degreaser were forwarded in Interim Report No. 1 and are included in this report in Table 3. Once deficiences are corrected, the extent of employee exposures will depend on 3 primary factors:

1. How well the degreasers are maintained
2. Work practices (education of degreaser operators)
3. Supervisory surveillance to insure proper work practices are being followed.

While 8-hour TWA exposures were relatively low the short-term exposure reached concentrations that should not be considered acceptable. Establishing programs relative to the 3 factors mentioned above should effectively lower peak or short-term exposures and even further reduce 8-hour TWA exposures.

B. Other Exposures

There are numerous chemicals besides degreasing solvents used at P&WA. While the Safety and Health unit has a good general awareness of the chemicals used in the plant, at the time of this evaluation, it was possible that a chemical could be ordered and used without the knowledge of the Safety and Health staff. This could result in misuse and adverse health effects. We recommend that chemical procurements be monitored by the Safety and Health staff to insure safe usage. While this will take a considerable effort in the beginning, a record of authorized users of frequently used chemicals can be established so that the number of chemical procurements needing review can be minimized.

As mentioned earlier, this report dealt primarily with exposure to degreasing solvents. Other exposures need to be continually evaluated and monitored were necessary to minimize the potential for work-related illness. Many situations have already been evaluated, but since research activities often introduce new exposures, continued management and worker support is vital for an effective occupational safety and health program.

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

1. Pratt & Whitney Aircraft
2. International Association of Machinists, Local 971
3. NIOSH, Region IV
4. OSHA, Region IV
5. Palm Beach County Health Department
6. Florida State Health Department

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

TABLE 1

Environmental Sampling Site Data
Pratt & Whitney Aircraft
HETA 82-075

March 16-19, 1982

DEGREASER NUMBER (note 1)	LOCATION	SAMPLING DATE	WORKSHIFT SAMPLED	NUMBER OF WORKERS MONITORED PER SHIFT	NUMBER OF AREA SAMPLES	DEGREASING SOLVENT
	Manufacturing Bldg.					
	Plating Area	3-16-82	1,2	8, 1st Shift	4 total,	
2	A Line			4, 2nd Shift	1 in Medical and	PERC(note 3)
1	B Line				1 outside plating	TCE
3	D Line				office each shift	TCE
3a	Sonic					TCE
4	Sheet Metal	3-17-82	1	2	2 total,	MC
					1 @ tube bending	
11	Tube Bending	" "	1	5	Desk, 1 in ofc area	MC
6	Shuttle	" "	1	2		PERC
5	Zyglo	3-18-82	2	1	2 total,	TCE
					1 in Assembly	
7	Assembly, Exp.	" "	2	2	Area, 1 in ofc area	TCE
9	Assembly, O & R	" "	2	2		TCE
	Test Area C, RL-10 Assembly	3-19-82	1	4	3 total,	
	Cleaning room				1 in clean rm.	TCE
	Other degreaser				1 in Crib	TCE
					1 in ofc area	TCE
	Salvage Yard	note (2)	--	--		PERC
	Rocket Support	note (2)	--	--		TCE

note (1): The degreaser number was assigned for purposes of identifying the location of each degreaser in the manufacturing building (see Figure 1).

note (2): No air sampling done at these two sites, degreasers were started up. The HNU instrument was used to evaluate vapor levels.

note (3): PERC-Perchloroethylene, TCE-Trichloroethylene, MC-Methyl Chloroform (1,1,1-Trichloroethane).

TABLE 2

Organic Vapor Results (ppm)

Pratt & Whitney Aircraft
West Palm Beach, Florida
HETA 82-075

March 16-18, 1982

JOB DESCRIPTION/ LOCATION	SAMPLE TYPE(a)	TRICHLOROETHYLENE		PERCHLOROETHYLENE		METHYL CHLOROFORM	
		LONG TERM(b)	SHORT TERM(c)	LONG TERM	SHORT TERM	LONG TERM	SHORT TERM
Plating, 1st Shift, March 16th							
Platers helper	P	2.5	52.6 [13]	2.5	13.7	---(d)	---
Plater	P	2.5	27.4 [24]	2.1	14.8	---	---
Plater	P	4.0	4.1 [147]	7.2	18.0	---	---
Plater	P	0.5	ND(e)	3.3	66.4 [9]	---	---
Plater	P	1.7	121.0 [3]	0.8	< 19	---	---
Plater	P	2.1	(f)	7.1	(f)	---	---
Plater	P	0.6	(f)	1.3	(f)	---	---
Outside Plating Ofc.	A	2.2	---	2.3	---	---	---
Medical Ofc. Area	A	0.4	---	0.3	---	---	---
Mechanic	P	38.8(g)	---	2.2	---	---	---
Plating, 2nd Shift, March 16th							
Plater helper	P	ND	ND	6.2	45.8 [29]	---	---
Plater	P	4.2	233.8 [6]	1.7	2.5	---	---
Plater	P	1.2	30.4 [8]	1.4	1.9	---	---
Plater	P	2.0	21.5 [13.5]	3.3	48.1	---	---
Outside Plating Ofc.	A	0.3	---	1.4	---	---	---
Medical Ofc. Area	A	0.5	---	0.4	---	---	---
Sheet Metal, 1st Shift, March 17th							
Sheet Metal Worker	P	0.7	1.2	0.6	0.9	1.0	23.0 [8]
Sheet Metal Worker	P	0.6	ND	1.1	ND	0.6	(f)

(Continued)

TABLE 2 (Continued)

JOB DESCRIPTION/ LOCATION	SAMPLE TYPE(a)	TRICHLOROETHYLENE LONG TERM(b)	TRICHLOROETHYLENE SHORT TERM(c)	PERCHLOROETHYLENE LONG TERM	PERCHLOROETHYLENE SHORT TERM	METHYL CHLOROFORM LONG TERM	METHYL CHLOROFORM SHORT TERM
Tube Bending, 1st Shift, March 17th							
Tube Bender	P	0.7	ND	0.4	ND	0.5	55.1 [1.5]
Tube Bender	P	0.8	ND	0.4	ND	1.0	51.4 [2.5]
Tube Bender	P	0.7	2.9	0.4	ND	1.4	67.8 [6.5]
Tube Bender	P	0.7	4.2	0.4	ND	2.0	106.1 [4.5]
Shuttle Area, 1st Shift, March 17th							
Broach Operator	P	0.3	(f)	0.6	(f)	ND	(f)
Bench Mechanic	P	0.7	(f)	0.7	(f)	1.0	(f)
Front Office Area	A	0.4	---	0.4	---	0.3	---
Tube Shop Foreman's Desk	A	0.8	---	0.4	---	0.1	---
Zyglo Area, 2nd Shift, March 18th							
Inspector	P	3.5	14.4 [6.5]	0.5	ND	0.2	ND
Assembly, Experimental, 2nd Shift, March 18th							
Cleaning Processor	P	2.5	26.1 [21.5]	0.5	0.7	ND	ND
Assembler	P	9.0	91.9 [29.5]	0.5	0.5	ND	ND
Assembly, O & R, 2nd Shift, March 18th							
O & R Assembler	P	4.6	187 [7.0]	0.5	1.1	ND	ND
Assembler, Bearing Line	P	4.8	213.7 [7.0]	0.5	ND	ND	ND
Experimental Assembly, Foremans Desk	A	0.8	---	0.5	---	ND	---
Front Office Area	A	0.8	---	0.3	---	ND	---

(Continued)

TABLE 2 (Continued)

JOB DESCRIPTION/ LOCATION	SAMPLE TYPE(a)	TRICHLOROETHYLENE LONG TERM(b)	TRICHLOROETHYLENE SHORT TERM(c)	PERCHLOROETHYLENE LONG TERM	PERCHLOROETHYLENE SHORT TERM	METHYL CHLOROFORM LONG TERM	METHYL CHLOROFORM SHORT TERM
Test Area C, RL 10 Assembly, 1st Shift, March 19th							
Assembler	P	22.9	59.2 [49.0]	---	---	---	---
Assembler	P	18.9	202.6 [6.0]	---	---	---	---
Assembler	P	13.9	(f)	---	---	---	---
Assembler	P	18.7	17.2 [25.0]	---	---	---	---
Bench Top, Cleaning Room	A	22.5	---	---	---	---	---
Crib Attendants Desk	A	14.7	---	---	---	---	---
Front Office Desk	A	15.1	---	---	---	---	---

Notes:
(a) P - personal breathing zone sample; A - area sample
(b) Long term samples were full shift samples (7-8 hours) except for the RL 10 Assembly area, Test Area C where sampling durations ranged from 5 to 6 hours.
(c) Short term samples monitored exposures while working at a degreaser only. Sampling pumps were turned on when worker went up to a degreaser and off when he left the degreaser. The number in brackets [ ] is the total time in minutes that the worker spent at a degreaser during the shift.
(d) The notation "---" indicates that this solvent was not being used in the area, therefore, no analysis was run or this type sample was not collected.
(e) ND - no detectable amount found during the analysis
(f) Indicates that worker did not operate degreaser, therefore, the sample was not submitted for analysis. In a few cases, the operator spent less than 30 seconds, therefore, the sample was not submitted.
(g) This worker was wearing an organic vapor respirator for the majority of this sampling period.

Deficiencies Noted in Degreasing Operations
and Recommended Corrective Action
Pratt & Whitney Aircraft
HETA 82-075

March 16-20, 1982

LOCATION	DEFICIENCIES NOTED	RECOMMENDED CORRECTIVE ACTION/COMMENTS
Plating		
"A" Line	1. Rolltop cover inoperative.	1. Repaired by end of survey.
	2. Spray nozzle too short to permit spraying below vapor zone.	2. Lengthen spray nozzle.
	3. Hoist speed on 3 hoists that service "A" line were operating at 44 ft/min.	3. Check all hoists used for degreasing and set to the recommended 11 ft/min or less.
"B" Line	1. (note) Down for cleaning during our survey in this area. Up again by end of week.	
Sonic Cleaner	1. Operated for periods of 30 min. or longer without cover. Vapors dragged out by air currents from open windows.	1. Fabricate cover that seals around handles on basket.
Sheet Metal	1. Holster for the sprayer was too high. The top of the sprayer, when placed in the holster, interferred with the closing of the cover.	1. Lower the holster.
Assembly, Exp.	1. Spray nozzle too short.	1. Lengthen nozzle.
	2. Spray nozzle/hose connection was leaking.	2. Repair.
	3. Operator had to maintain pressure on close button until cover was closed or opened.	3. Rewire switch so cover closed automatically.
	4. Vapor level was riding 12-16 inches above cooling coils at start of shift. Operators reported it frequently come within 8" of the top of tank.	4. Check and adjust operating temperatures.

TABLE 3 Cont.

Deficiencies Noted in Degreasing Operations
and Recommended Corrective Action
Pratt & Whitney Aircraft
HETA 82-075

March 16-20, 1982

LOCATION	DEFICIENCIES NOTED	RECOMMENDED CORRECTIVE ACTION
Assembly, Exp.	5. Synthetic cloths used to lower certain parts. Straps become saturated with solvent and became an emission source as the part was removed.	5. Use metal hooks or baskets instead of these straps.
	6. One part cleaned (gold-plated tank) was filled and emptied above vapor zone.	6. Search for a better way of cleaning this part or devise a way of performing the cleaning in the vapor zone.
Assembly, O & R	1. Solvent boiling too vigorously.	1. Re-set temperature
	2. Hoist speed was 18 ft/min.	2. Change to 11 ft/min or less.
Test Area C, RL10 Assembly	1. Leakage through degreaser window on RL-10 Assembly side when clean room window on opposite side of degreaser is open.	1. Maintain tighter seal on window and install latch system to lock window shut when clean room window is open.
	2. Operators needed to lean into enclosed space above degreaser to hang parts. They held their breath during this operation. The turbulence caused by the positive pressure resulted in high vapor concentrations in the breathing zone of operator.	2. Install hoist system.
	3. Although not observed during this survey workers reported the need to clean parts using solvents on the bench tops.	3. Install exhaust hood in this area.
	4. Rooftop Stack height on degreaser exhaust was too low resulting in the potential for re-entry of exhausted vapors.	4. Raise stack height.
Rocket Support	1. Solvent boiling too vigorously	1. Re-set temperature.
	2. Rooftop Stack height on degreaser exhaust too short.	2. Raise stack height.

TABLE 4

Summary of Air Sampling Data[1]
HETA 82-075

1973-1980

SURVEY DATE	NUMBER OF DEGREASING UNITS SURVEYED	SOLVENT TYPE[2]	8 HR. TWA[3] RANGE (PPM)	PEAK EXPOSURES[3] RANGE (PPM)
5/2/73	5	TCE	5-26	0-1000
12/5/74	3	TCE	6-15	12-1100
10/1/75	11	TCE, MC	3-96[4]	0-665
3/13/80	4	TCE, MC	3-11	0-900

Note (1): Data obtained by a chemical manufacturer using a Gas Tech® Halide Meter.
(2): TCE - Trichloroethylene; MC - Methyl Chloroform (inhibited).
(3): Data obtained in breathing zone of degreaser operator. Peak data usually meant less than 5 minute sample time.
(4): Exposure for 9 of 11 workers ranged from 3-13 ppm. Two workers' exposures were 50 and 96 ppm.

TABLE 5

Summary of Air Sampling Data[1]
HETA 82-075

January 1982

LOCATION	NUMBER OF SAMPLES[2]	CONCENTRATION (PPM) TCE	PERC	MC
Plating	15, 8 hr, TWA	ND-6	1-10	ND
	25, 4 hr, TWA	1-30	1-16	ND-1
	2, 15 min	ND	ND-60	ND
	3, 5 min	<15-30	<10-230	ND
Zyglo	16, 8 hr, TWA	2-90[3]	-	-
	35, 4 hr, TWA	2-130[4]		
Tube & Assembly	19, 8 hr, TWA	1-2	ND	ND-60[5]
	2, 4 hr, TWA	ND-1	ND	ND

Note (1): Samples taken by P&WA Industrial Hygienist using currently acceptable charcoal tube technique.

(2): All were breathing zone samples.

(3): 14 of 16 samples ranged from 2-20 ppm. Two were 50 and 90 ppm (P&WA investigator noted that either worker used a degreaser).

(4): 33 of 35 samples ranged from 2-20 ppm. Two were 93 and 130 ppm (neither worker used degreaser but both used 6 oz can of TCE in inspection booth to brush parts).

(5): 16 of 19 samples ranged from ND-3ppm. One worker had exposure values of 23, 30 and 60 ppm on 3 consecutive days which were 10 to 20 times higher than other Tube & Assembly workers doing the same job. P&WA Health and Safety Office was to follow up.

TABLE 6

Study Population

Pratt & Whitney Aircraft
Government Products Division
West Palm Beach, Florida
HETA 82-075

March 15-19, 1982

Total Participants = 30

AGE CATEGORIES	# OF WORKERS
21-30	4
31-40	5
41-50	4
51-60	10
greater than 60	7

LENGTH OF EMPLOYMENT	# OF WORKERS
less than 10 years	9
10-15	9
16-20	5
greater than 20	7

TIME @ DEGREASER/SHIFT	# OF WORKERS
less than 15 min.	11
15-30	12
greater than 30	7

TABLE 7

Percentage of Total Positive Responses to Selected Symptoms
By Length of Exposure to Degreasing Tanks

Pratt & Whitney Aircraft
West Palm Beach, Florida
HETA 82-075

March 1982

SYMPTOMS	DAILY EXPOSURE		
	<15 MINUTES	15 - 30 MINUTES	>30 MINUTES
Lightheadedness	21%	25%	19%
Sleepiness	21%	8%	0
Skin Irritation	36%	14%	19%
Headache	33%	30%	5%
Shortness of Breath	9%	17%	28%
Dizziness	18%	11%	24%
Eye Irritation	18%	8%	0
Cough	12%	14%	14%
Rapid Heart Beat	9%	0	0
Dyspnea on Exertion	15%	0	14%
Nausea	6%	11%	0
Fatigue	3%	0	0
Confusion	3%	5%	0
Weakness	6%	0	0
Nosebleed	3%	0	0
	n = 11	n = 12	n = 7

TABLE 8

UNIVERSITY OF MIAMI
Crude Cancer Associated Mortality Raters and Per Cent of Total Deaths Due to Cancer Among Active Employees of the Pratt and Whitney Aircraft Group. Three Year Moving Averages.

1963-1980

YEARS	AVERAGE YEAR CENSUS	AVERAGE NUMBER OF CANCER DEATHS	AVERAGE CANCER ASSOC. MORT. RATE (DEATHS/100,000 PERSON-YEARS)	AVERAGE NUMBER OF TOTAL DEATHS	AVERAGE PERCENT CANCER MORTALITY
1963-64-65	5731	1.67	29	10.33	16%
1964-65-67	5250	0.67	13	9.67	7%
1965-67-68	5050	1.33	26	11.67	10%
1967-68-69	5010	2.33	47	13.00	18%
1968-69-70	5533	3.33	60	15.33	22%
1969-70-71	5892	3.67	62	16.67	22%
1970-71-72	5955	4.00	67	18.67	21%
1971-72-73	5799	4.67	81	20.00	23%
1972-73-74	5513	4.67	85	19.33	24%
1973-74-75	5112	4.67	91	17.00	27%
1974-75-76	4935	5.00	101	15.00	33%
1975-76-77	5466	5.33	98	14.00	38%
1976-77-78	6387	6.67	104	18.33	36%
1977-78-79	7404	8.33	113	24.00	35%
1978-79-80	7661	9.33	122	27.67	34%

TABLE 9a

Proportional Mortality For All Malignant Neoplasms
By Five Year Age

AGE	OBSERVED CANCER DEATHS	PROPORTIONAL MORTALITY RATIO
30-34	2	1.42
35-39	3	2.11
40-44	0	0.0
45-49	13	2.01
50-54	12	1.54
55-59	22	1.75
60-64	20	1.60
65-69	1	1.01
70-74	1	4.75
All Ages	74	1.56

TABLE 9b

Proportional Mortality for All Malignant Neoplasms
By Five Year Calender Time

YEAR	OBSERVED CANCER DEATHS	PROPORTIONAL MORTALITY RATIO
1965-69	4	1.77
1970-74	21	1.20
1975-79	41	1.80
1980-	8	1.65
All Years	74	1.56

TABLE 10

Cause Specific Proportional Mortality for 239 Deaths

CAUSE OF DEATH	OBSERVED	EXPECTED	PMR
Infective Disease	3	1.74	1.73
Turberculosis	0	0.57	0
All Cancers	74	47.70	* 1.56
Buccal Cavity	1	1.64	0.61
Digestive Organs	18	11.11	* 1.62
Esophagus	2	1.14	1.76
Stomach	4	1.77	2.26
Large Intestine	3	3.71	0.81
Rectum	1	1.15	0.87
Liver	1	0.62	1.61
Pancreas	6	2.41	* 2.49
Respiratory System	30	17.89	* 1.68
Larynx	0	0.73	0
Lung	29	17.01	* 1.71
Prostate	1	1.33	0.75
Testis	2	0.57	3.51
Kidney	0	1.31	0
Bladder	1	0.91	1.10
Skin	4	1.23	* 3.26
Eye	0	0.04	0
Brain	5	2.06	* 2.43
Thyroid	0	0.09	0
Bone	0	0.30	0
Hematopoietic	8	5.47	1.46
Lympho Sarcoma	2	1.14	1.75
Hodgkin's Disease	0	0.86	0
Leukemia	5	2.08	* 2.40
Other Lymphatic	1	1.30	0.77
Benign Neoplasm	0	0.68	0
Allergic, Endocrine	4	4.07	0.98
Asthma	0	0.24	0
Diabetes Mellitus	1	3.04	0.33
Diseases of Blood	1	0.46	2.18
Mental Disorders	1	2.28	0.44
Nervous System	10	12.11	0.83
CNS	9	9.64	0.93
Circulatory	85	89.41	0.95
Rheumatic Heart	1	2.05	0.49
ASHD	73	75.87	0.96
Respiratory Disease	4	10.56	0.38
Pheumonia	0	3.86	0
Emphysema	2	2.57	0.78
Digestive System	9	14.02	0.64
Ulcer	2	1.07	1.87
Liver	2	9.24	0.22

(cont.)

TABLE 10 (Continued)

Genito-Urinary	0	1.90	0
Nephritis	0	0.72	0
Diseases of Skin	0	0.13	0
Disease of Bones	0	0.45	0
Non-Specific	0	3.84	0
External Causes	43	49.12	0.88
Accidents	32	31.89	1.00
Suicide	8	10.62	0.75
Total Residual	5	1.62	3.08
Cancer Residual	4	3.45	1.16

* statistically significant ($p<0.05$)

TABLE 11

Cause Specific Proportional Cancer Mortality for 74 Deaths

CAUSE OF DEATH	OBSERVED	EXPECTED	PCMR*
All Cancers	74		
Buccal Cavity	1	2.65	0.38
Digestive Organs	18	7.77	1.01
Esophagus	2	1.87	1.07
Stomach	4	2.81	1.42
Large Intestine	3	5.91	0.51
Rectum	1	1.82	0.55
Liver	1	0.99	1.01
Pancreas	6	3.96	1.54
Respiratory System	30	29.20	1.03
Larynx	0	1.20	0
Lung	29	27.79	1.04
Prostate	1	2.00	0.50
Testis	2	0.56	3.51
Kidney	0	2.11	0
Bladder	1	0.44	0.70
Skin	4	1.83	2.19
Eye	0	0.06	0
Brain	5	3.01	1.66
Thyroid	0	0.15	0
Bone	0	0.35	o
Hematopoietic	8	7.56	1.06
Lympho Sarcoma	2	1.64	1.22
Hodgkin's Disease	0	1.01	0
Leukemia	5	2.75	1.82
Other Lymphatic	1	2.02	0.49
Cancer Residual	4	5.32	0.75

* Although some PCMR's were elevated (>1), none were statistically significant ($p<0.05$).

TABLE 12

Case/Control Analysis of 74 Known Cancer Deaths and Their Matched Controls
Risk Factor = Exposure to Degreasing Solvents

	EXPOSED CASES	EXPOSED CONTROLS	UNEXPOSED CASES	UNEXPOSED CONTROLS	ODDS RATIOS	CONFIDENCE INTERVALS
Comparison #1 (backround to intermediate)	19	29	50	40	0.50	0.24 - 1.05
Comparison #2 (backround to high)	4	4	32	32	1.00	--- - ---
Comparison #3 (backround to intermediate & high)	26	35	48	39	0.61	0.31 - 1.17

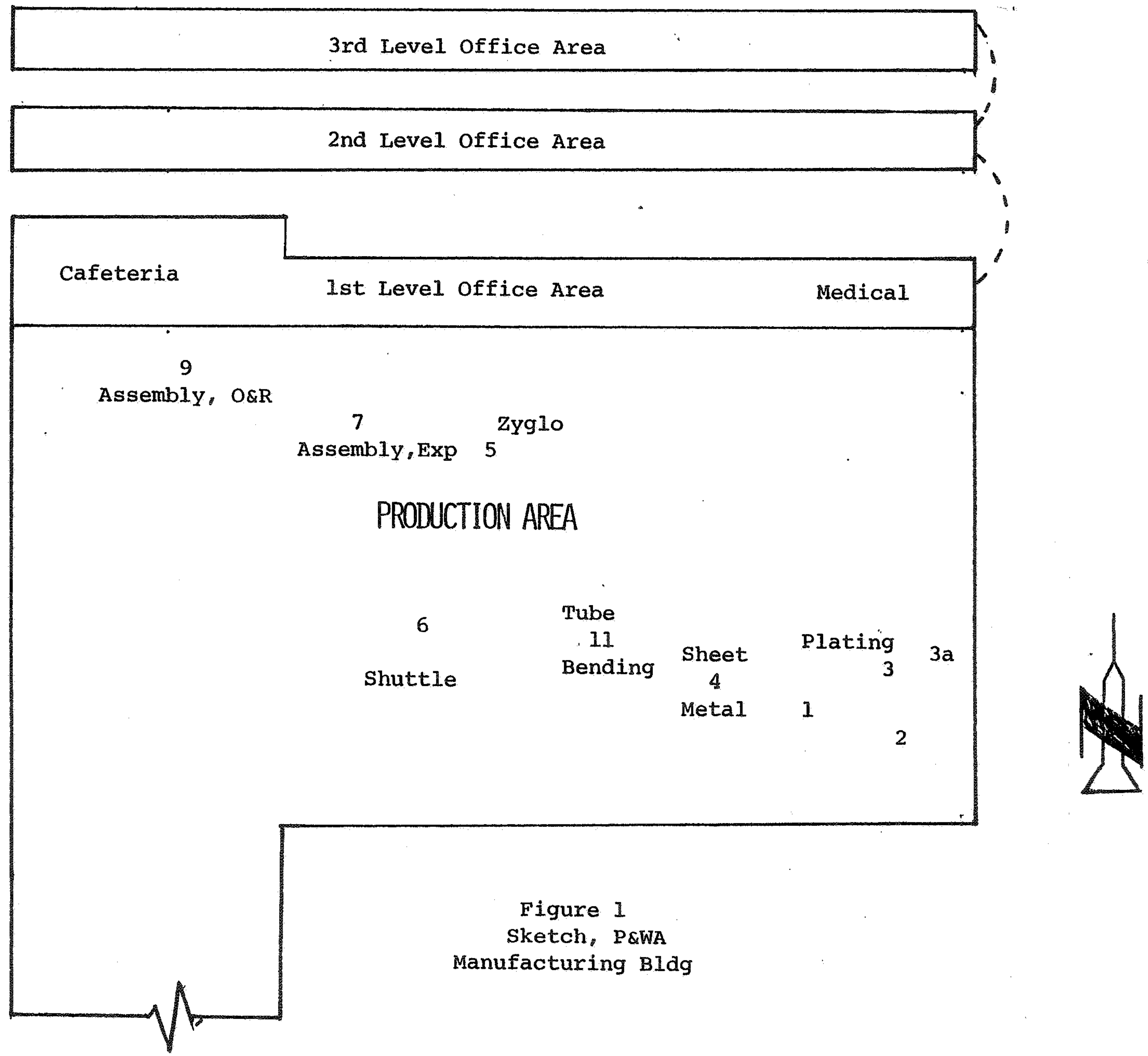


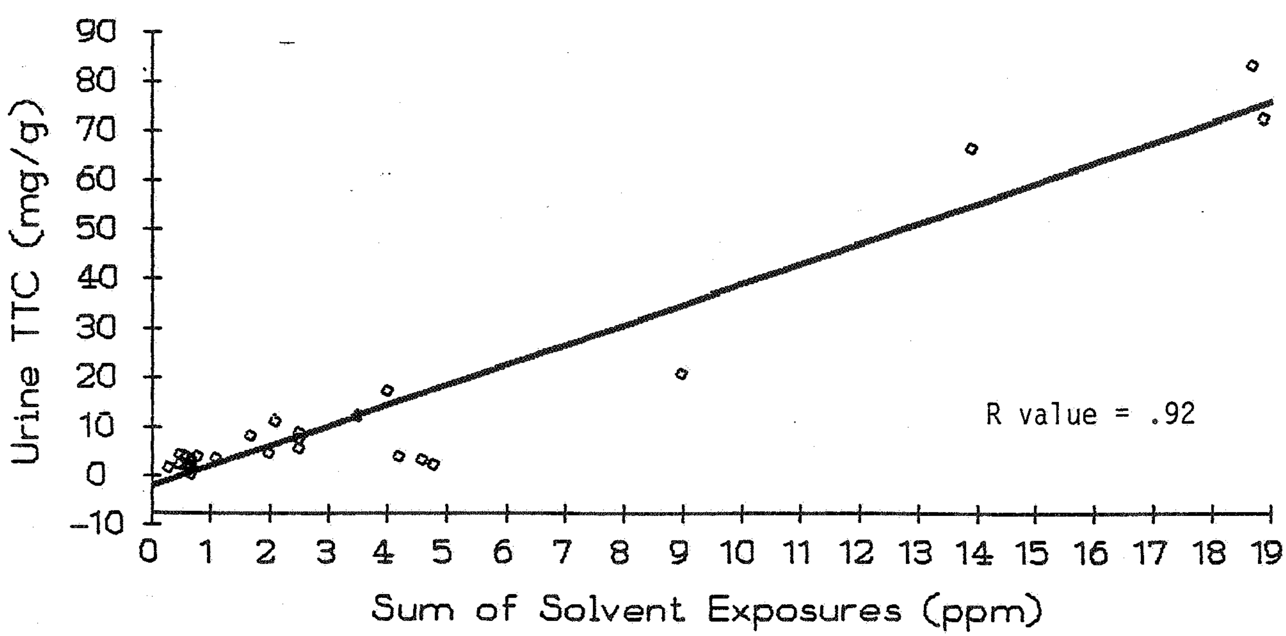
Figure 1
Sketch, P&WA
Manufacturing Bldg

FIGURE 2

SOLVENT EXPOSURE vs URINE TRICHLORO COMPOUNDS

PRATT & WHITNEY

HETA 82-075



200

ppm

100

0

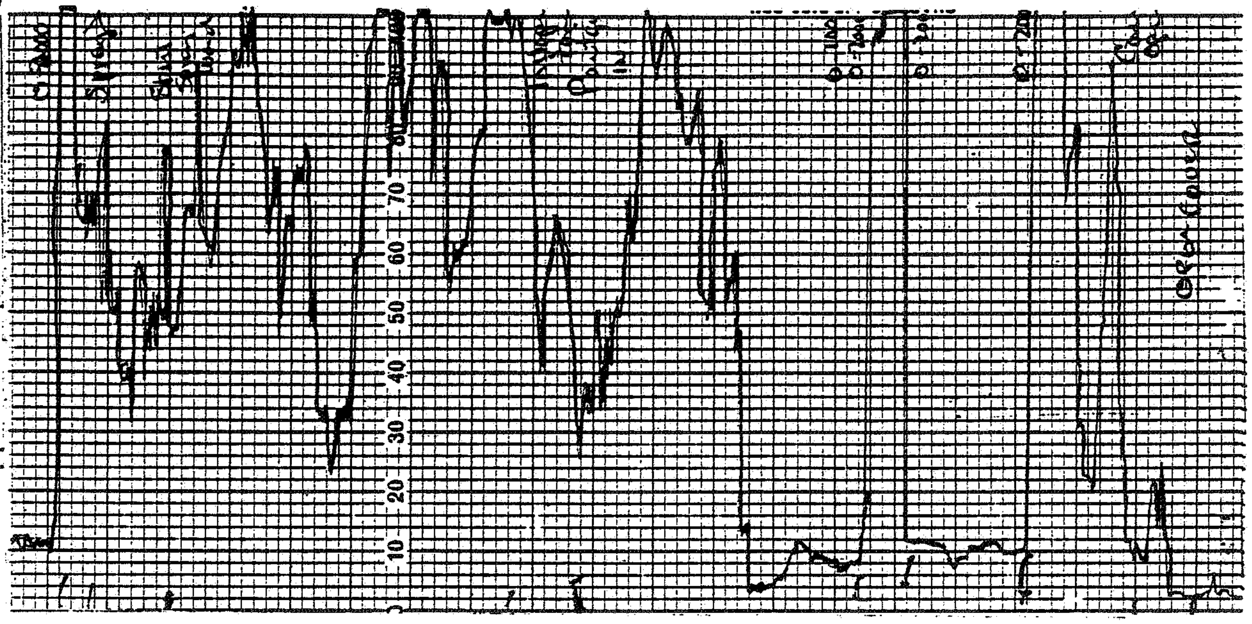


Chart Speed, 10 cm/hr

Figure 3
Plating, D-Line
TCE Vapor Degreaser
HETA 82-075

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