HEALTH HAZARD EVALUATION REPORT 72-84-31
HAZARD EVALUATION SERVICES BRANCH
DIVISION OF TECHNICAL SERVICES

Establishment : Dunham-Bush, Inc.
179 South Street
West Hartford, Connecticut

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MARCH, 1973

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

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HEALTH HAZARD EVALUATION REPORT 72-84
DUNHAM-BUSH, INCORPORATED
WEST HARTFORD, CONNECTICUT

MARCH, 1973

I. SUMMARY DETERMINATION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following written request by an 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 used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees regarding exposure to trichloroethylene in the Pump Room of the South Street Plant and to a variety of contaminants associated with metal fabrication in the Day Street Plant both of Dunham-Bush, Inc., West Hartford, Connecticut.

NIOSH investigators conducted environmental-medical evaluations of these operations on November 21, 1972 and December 18 and 19, 1972. A backup environmental evaluation of the Day Street Plant was made on January 9, 1973.

It has been determined that exposures to trichloroethylene (emanating from vapor degreasers) in the Pump Room of the South Street Plant present a potential toxic hazard to health during periods of normal and high production activity. The hazard is significantly reduced during periods of low production activity. This determination is based on a total of forty-three (43) air samples collected in the Pump Room on November 21, 1972 and December 18, 1972. Twenty-eight (28) of these samples were personal breathing zone samples, and the remainder were area samples. Measured trichloroethylene concentrations found on these two days ranged from 195 to 1,186 mg/m^3. In general, breathing zone concentrations were higher than work area air concentrations. The current occupational health standard promulgated by the U.S. Department of Labor applicable to eight-hour exposures to trichloroethylene is 535 mg/m^3 (Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart G, Paragraph 1910.93, Table G-2). Medical information collected (December 18, 1972) by administration of a medical survey questionaire to nineteen (19) exposed and eleven (11) non-exposed individuals, and also by the collection and analysis of morning and afternoon urine specimens from this study group confirmed the condition of adverse exposure to trichloroethyle

It has been concluded by the NIOSH investigators that trichloroethylene exposures in the Pump Room of the South Street Plant can be significantly reduced by upgrading engineering controls and by changing inappropriate work practices. Specific recommendations to improve the work environment in the Pump Room have been made to plant management in the body of the full report.

It has been determined that several potentially toxic conditions exist within the Day Street Plant. Of most immediate concern is exposure to cadmium fume which presents a serious potential hazard to the health of brazers working in this facility. Airborne cadmium concentrations were measured on December 20, 1972 and on January 9, 1973. A total of seventeen (17) breathing zone and four (4) area air samples were gathered showing cadmium concentrations ranging from 14 to 612 $\mu g/m^3$. Employee eight-hour time-weighted-average exposures ranged from 33 to 326 $\mu g/m^3$. The current occupational health standard promulgated by the U.S. Department of Labor applicable to eight-hour exposures to cadmium fume is 100 $\mu g/m^3$ with an acceptable short term ceiling concentration standard of 300 $\mu g/m^3$ (Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart G, Table G-2). It has been concluded by NIOSH investigators that exposures to cadmium fume could be significantly reduced by providing engineering control. Specific recommendations regarding control practices have been made to management in the body of the full report. Until engineering controls are installed, it is recommended that brazing employees and others in the immediate brazing area be required to wear respirators approved by the U.S. Bureau of Mines for protection against exposure to cadmium fume.

Several other production processes (e.g. welding, spray painting, grit blasting, flame cutting, polyurethane foam filling, degreasing, etc.) have been determined to present potential health hazards (e.g. metal fumes, oxidants, vapors, noise, ultraviolet light, infrared light, etc.). Repeatedly in the literature, these kinds of processes have been shown to be directly related to long term occupational illness when conducted without adequate controls. Through the use of onsite inspection, ventilation measurements, and comparison with federal standards (Federal Register, October 18, 1972, Title 29, Chapter XVII, Subparts E, G, H, I, J, M, N, and Q), it has been documented that approtpiate engineering control is absent in this facility. On this basis, it has been concluded that a potentially toxic work environment does exist in the Day Street Plant and as a result comprehensive recommendations have been made to plant management in the body of the full report to improve the overall working environment in the Day Street Plant.

It must be reported that limited noise measurements were made throughout the Day Street facility. Many noise levels were measured to be in excess of established standards (Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart G, Paragraph 1910.95). Specific recommendations to obviate the noise hazard in this plant have been made to management.

Copies of this summary determination, as well as, the full report of the evaluation are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202. Copies of both have been sent to:

a) Dunham-Bush, Incorporated, West Hartford, Connecticut
b) Authorized Representative of Employees
c) U.S. Department of Labor - Region I

For purposes of informing the approximately 100 "affected employees" who work in the Pump Room of the South Street Plant and in the Day Street Plant, the employer will promptly "post" the Summary Determination in a prominent place(s) near where affected employees work for a period of 30 calendar days.

II. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following written request by an 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 used or found.

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Dunham-Bush, Inc. is engaged in the manufacture of commercial air conditioning equipment. The South Street Plant houses a variety of machining and assembly processes. The Pump Room is an area in the South Street Plant where compressors are assembled. The process of assembling these compressors requires that many of their component parts be degreased before assembly. Compressor parts are degreased in two vapor degreasers which employ trichloroethylene as the degreasing solvent. Vapors escaping from these degreasers into the work environment precipitated the request for a health hazard evaluation in this work area. (See Figure 1, Section VII.)

The Day Street Plant also houses manufacturing processes, but they are of generally larger proportions than those in the South Street Plant. The Day Street Plant basically produces shell and tube heat exchanging equipment. Fabrication of this equipment involves many of the common metal working processes (welding, brazing, silver soldering, degreasing, etc.), as well as, spray painting, foam filling (insulating), grit blasting, and pressure testing. Fumes, vapors, and dusts produced by these fabricating processes precipitated the request for a health hazard evaluation in this work area. (See Figure 2, Section VII.)

III. BACKGROUND HAZARD INFORMATION

A. Standards

The occupational health standards promulgated by the U.S. Department of Labor (Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart G, Tables G-1 and G-2) applicable to the substances of this evaluation are as follows:

Substance	8-hour time weighted average	Acceptable ceiling Concentration	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift.	
			Concentration	Maximum Duration
Trichloroethylene	535 mg/m3*	1,070 mg/m3	1,605 mg/m3	5 minutes in any 2 hours.
Cadmium fume	100 µg/m3**	300 µg/m3	----------	------------
Silver, metal and soluble compds.	10 µg/m3	--------	----------	------------
Copper fume	100 µg/m3	--------	----------	------------
Zinc oxide fume	5 mg/m3	--------	----------	------------
Methylene chloride	1,740 mg/m3	3,480 mg/m3	6,960 mg/m3	5 minutes in any 2 hours.
Toluene-2,4-diisocyanate	140 µg/m3C***	--------	----------	------------

*mg/m3 - approximate milligrams of substance per cubic meter of air.
**µg/m3 - approximate micrograms of substance per cubic meter of air. (1,000 µg = 1 mg)
***C - ceiling value. Employee exposures are not to exceed this level.

In addition to the above substances, employees were found to be exposed to noise. The occupational permissible noise exposures promugated by the U.S. Department of Labor (Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart G, Paragraph 1910.95) are as follows:

Duration per day, hours	Sound level dBA slow response*
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115 ceiling value

*When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: $C_1/T_1 + C_2/T_2 + \ldots + C_n/T_n$ exceeds unity, then, the mixed exposure should be considered to exceed the limit value. C_n indicates the total time of exposure at a specified noise level, and T_n indicates the total time of exposure permitted at that level.

B. Toxic Effects

The following list of substances contains certain physical properties and known toxic effects reported in the scientific literature.

1. Trichloroethylene - Molecular formula $ClCH_2{=}CCl_2$; molecular weight 131.4; boiling point 87.1°C at 760 mmHg; melting point -73°C; solubility 0.1 parts per 100 parts of water at 25°C (mixes freely with alcohols, ethers, and many other organic solvents); flash point - none by standard methods; ignition temperature 463°C.

Many researchers have made attempts to conduct parallel determinations of trichloroethylene exposures and measureable and/or observable effects on either human volunteers or occupationally exposed workers. A brief review of the literature will serve to delineate the effects of trichloroethylene. Note: 100 ppm trichloroethylene = 535 mg/m^3 trichloroethylene.

a. Effects on the Central Nervous System

Steuber (1932)[1] conducted the first extensive medical study when he reviewed a total of 284 cases of trichloroethylene poisoning including 26 fatalities which had occurred in European industrial operations. Steuber reported that the toxic action of trichloroethylene involved primarily the central nervous system although apparent effects were also observed in the gastro-intestinal and circulatory systems. The outstanding characteristic of trichloroethylene overexposure included headache, dizziness, tremors, nausea, and vomiting, sleepiness, fatigue, a feeling and appearance of light headedness or drunkedness increasing to unconsciousness and, in some cases, to death.

Bardody and Vyskocil (1956)[2] studied 75 exposed persons, classified by years of exposure, in one of four groups; less than 1 year, 1-2 years, 2-9 years, and 10+ years. Their findings showed statistically significant (p less than 0.05) increases with duration of exposure, of increased lacrimation (tearing), decreased sensitivity of the hands, increased reddening of skin, and disturbances of sleep. With duration of exposure, significant increases (p less than 0.01) were also found in intolerance to alcohol, tremors, "giddiness" and what they termed "severe neurasthenia syndrome with anxiety states" and bradycardia (abnormally slow heartbeat).

Stopps and McLaughlin (1967)[3] studied volunteer subjects exposed for two and one-half hour periods to 100, 200, 300, and 500 ppm of trichloroethylene. No decriment in performance of complex psychophysiological tests was observed at 100 or 200 ppm but slight changes were detected at 300 ppm and to a greater extent at 500 ppm.

b. Effects on the Heart

Andersson (1957)[4], Ogata (1971)[5], Gutch (1945)[6], Bardody and Vyskocil (1956)[2] and others have noted that exposure to trichloroethylene may either speed or slow the heart rate, depending on the degree of exposure, and

Andersson noted that 77 of the 104 workers she studied showed abnormal EKG tracings with disturbance of cardiac rhythm.

The occurrence of cardiac arrhythmia following exposure to trichloroethylene has been reported for experimental studies with animals as well -- Hunter (1949)[7] with mice and Taylor (1936)[8] with dogs.

c. Effects on the Liver

There are conflicting reports on the exact toxicity of trichloroethylene to the liver. Guyetjeannin, et al (1958)[9] studied 18 workers regularly exposed to trichloroethylene, not alcoholics, and with no history of preexisting liver disease, by electrophoretic separation of various blood constituents and found some abnormalities of cephalin flocculation, total lipids and unsaturated fatty acids and increased B-globulins. Other researchers also looked for liver function changes in exposed individuals but found none.[4]

d. Other Effects

Effects of the skin include reddening and dermographism, skin burns on contact (Maloof, 1949)[10], and generalized dermatitis resulting from only inhalation (McBirney, 1954)[11].

The current occupational health standard for trichloroethylene (See Section III, Part A) is 535 mg/m^3 or 100 ppm.

2. Cadmium Fume - The TLV Committee of the American Conference of Governmental Industrial Hygienists has prepared a concise summary of the toxic effects of exposure to cadmium fume.

> "Inhalation overexposure to the intensely irritating, freshly generated fume of heated cadmium has often produced acute poisoning whose symptomatology, usually delayed for several hours, includes severe tracheobronchitis, pneumonitis and pulmonary edema, with a mortality rate of about 20 per cent and no similarity with chronic cadmium poisoning. Average concentrations responsible for fatal cases have been estimated at 50 mg/m^3([12,13]) and 40 mg/m^3([14]), both for exposures of one hour; and 9 mg/m^3 for five hours[15]. Nonfatal pneumonitis has been reported from concentrations between 2.5 and 0.5 mg/m^3([16]). ---- Those surviving an episode of acute poisoning recover without developing any chronic effects such as proteinuria."

Chronic exposure to levels of cadmium fume too low to produce acute poisoning has been reported to produce a variety of slowly developing, chronic toxic effects. The ACGIH TLV Committee references the following effects resulting from exposures in the range 0.01 to 0.45 mg/m^3: pulmonary emphysema[17,18,19]; proteinuria[17,18,19,20]; atrophic rhinitis with epitaxis, rhinorrhea and glycosuria[19]; anemia[20,21]; and gastrointestinal complaints[21].

The current occupational health standard for cadmium (See Section III, Part A) is 0.1 mg/m^3 or 100 $\mu g/m^3$. The ACGIH TLV Committee will be suggesting in 1973 that the level be lowered to 0.05mg/m^3 or 50 $\mu g/m^3$, and this level will be a ceiling level which should not be exceeded in the working environment.

3. Silver - The TLV Committee of the American Conference of Governmental Industrial Hygienists in their Documentation of the Threshold Limit Values for Substances in Workroom Air, 3rd edition, 1971, have compiled a concise summary of the toxic effects of exposure to silver.

> "Argyria, a cosmetic defect which consists of an unsightly permanent blue gray discoloration of the skin, mucous membranes and eyes, appears to be the main pathologic effect from the accumulation of silver in the body[22]. It may be of two types, a generalized form or localized in the conjunctiva of the eye[23], nasal septum or posterior pharynx[24]. Its occurrence has been principally through its use in medicine by ingestion, injection or topical application; development from inhalation through occupational exposure appears to be very slow and may require years. Localized argyria of the skin is rare[25]."
>
> "The exact air concentration of silver that will result in generalized argyria is not known with certainty, but it can be estimated approximately in the following way. Hill and Pillsbury[22] stated that the gradually accumulated intake of from 1 to 5 grams of silver will lead to generalized argyria. If one assumes a 20 year exposure, a 10 m^3/day respiratory volume during working hours, and a 50% body retention, a level of silver equal to 0.05 mg/m^3 will result in an accumulation of 1.2 grams or a probable borderline amount for the production of argyria."

The current occupational health standard for silver (See Section III, Part A) is 0.01 mg/m^3 or 10 $\mu g/m^3$.

4. Copper Fume - The TLV Committee of the American Conference of Governmental Industrial Hygienists in their Documentation of the Threshold Limit Values for Substances in Workroom Air, 3rd edition, 1971, relate the following effects attributable to exposure to copper fume:

> "Health effects consist of irritation of the upper respiratory tract, metallic or sweet taste, nausea, metal fume fever, and in some instances discoloration of the skin and hair. Concentrations of copper fume from welding operations of 1 to 3 mg/m^3 of air for short periods resulted in altered taste response but no nausea; levels from 0.02 to 0.4 mg/m^3 did not cause complaints[26]."
>
> "Gleason[27], however, found a condition similar to metal fume fever in workers exposed to metallic copper dust in concentrations of the order of 0.1 mg/m^3"

The current occupational health standard for copper fume (See Section III, Part A) is 0.1 mg/m^3 or 100 $\mu g/m^3$.

5. Zinc Oxide Fume - The TLV Committee of the American Conference of Governmental Industrial Hygienists in their Documentation of the Threshold Limit Values for Substances in Workroom Air, 3rd edition, 1971, relate the following effects due to exposure to zinc oxide fume:

"According to Fairhall[28], the toxicity of zinc compounds by mouth is low. Metal fume fever (zinc chills, brass founder's ague, etc.) may result from the inhalation of zinc oxide fume. The symptoms include fever, chills, muscular pain, nausea and vomiting, but complete recovery occurs in 24 to 48 hours. The same effects are produced by the fumes of some other metals, and, according to Turner and Thompson[29], can also result from breathing finely divided zinc oxide dust.

Most authorities agree that metal fume fever itself is a relative innocuous condition. It has been described as temporary and never serious[30], of brief duration and without after-effects[31], never fatal[32], and without medical evidence of chronic effects[33], and an annoyance[34]. Hamilton[35] stated that the weight of evidence was agains the existence of chronic industrial poisoning, although a number of reports to the contrary are in the older literature."

...."Drinker and co-wo-kers[36] concluded that metal fume fever wil not result from concentrations of zinc oxide below 15 mg/m^3."

The current occupational health standard for zinc oxide fume (See Section III, Part A) is 5.0 mg/m^3.

6. Methylene Chloride - Molecular formula CH_2Cl_2; boiling point 40°C at 760 mmHg; vapor density 2.93; vapor pressure 440 mmHg at STP. Dizziness, nausea, paresthesias, headache (sense of fullness in the head), sense of heat, dullness, lethargy and stupor have all been reported in connection with exposure to methylene chloride vapors[37]. Very high concentrations may lead to loss of consciousness. Industrial exposures ranging from 500 to 5000 ppm have lead to poisonings from narcotic effects[38,39,40]. Neurasthenic disorders, digestive disturbances, and liver disease have also been attributed to this chemical. Until quite recently, methylene chloride was considered the least toxic of all the chlorinated hydrocarbons. However, during the last year, Stewart[41] has demonstrated that methylene chloride will induce the formation of carboxyhemaglobin by an unknown mechanism. This will occur with levels as low as 200 ppm. The American Conference of Governmental Industrial Hygienists, TLV Standards Committee has proposed that the acceptable level be lowered from 500 ppm to 250 ppm (870 mg/m^3) until the significance of the work by Stewart is fully understood.

The current occupational health standard for methylene chloride is 500 ppm or 1,740 mg/m^3. (See Section III, Part A)

7. Isocyanates - These compounds are few in number due to the major industrial enterprise necessary for their production. The four most important ones are: toluene diisocyanate (TDI), diphenyl-methane diisocyanate (MDI), naphthylene diisocyanate (NDI), and hexamethylene diisocyanate (HDI).

Toluene-2,4-diisocyanate (TDI) - Boiling point 251°C; flash point 270°F; specific gravity of liquid 1.22 (25°/25°C); odor threshold 0.4 ppm. TDI is the most commonly used of the isocyanates. TDI is a well known respiratory irritant, in some cases producing serious allergic reactions in the lungs. Typical mild symptoms of TDI exposure are those due to mucosal irritation, itchiness of the eyes, congestion of the nose, and a dry throat accompanied by a throbbing headache. Greater exposure can cause a severe dry cough, mild chest pain with tightness in the chest[42].

The allergic reaction from TDI may occur in sensitized individuals with extremely small quantities of TDI in the atmosphere (less than 0.14 mg/m^3) and manifest itself usually with asthmatic symptoms. The other isocyanates also have the potential to cause similar symptomatology.

The occupational health standard for TDI is 0.14 mg/m^3 or 140 $\mu g/m^3$. (See Section III, Part A)

IV. HEALTH HAZARD EVALUATION

A. Observational Survey

On November 21, 1972 NIOSH representatives Messrs. Robert Vandervort and Jerome P. Flesch and Dr. Phillip L. Polakoff, arrived at Dunham-Bush, Inc., West Hartford, Connecticut in response to a request for a health hazard evaluation submitted by Mr. ~~Leo Sundyka~~ representing employees of Lodge No. 354 of the International Association of Machinists, Newington, Connecticut. Mr. ~~Sundyka's~~ request described areas in two separate plants operated by Dunham-Bush, Inc. where he felt their were potentially hazardous exposures to contaminants in the workplace. The first potentially hazardous exposures were alleged to occur in the Pump Room of the South Street Plant where employees were being exposed to trichloroethylene vapors escaping from two vapor degreasing tanks. Approximately twenty-five (25) employees in this area were allegedly experiencing drowsiness, dizziness, headaches, and general sick feelings. The second area of concern was the manufacturing area of the Day Street Plant, where employees were allegedly being exposed to contaminants generated by welding, brazing, silver soldering, spray painting, grit blasting, foam insulating, and parts degreasing. Approximately seventy (70) employees in this area were allegedly experiencing headaches, drowsiness, dizziness, fatigue and nausea.

Upon arrival at Dunham-Bush, Inc., the NIOSH representatives were met by Mr. ~~William Lincoln~~, Personnel Director who arranged an immediate meeting with Mr. ~~Robert Elliott~~, Plant Manager. The purpose of the visit and the function of NIOSH and its relation to the Occupational Safety and Health Act of 1970, in particular Section 20(a)(6), was explained to Mr. Elliott. At the conclusion of this meeting the NIOSH representatives met with the following persons who were directly involved with the request:

Mr. ~~William Lincoln~~, Personnel Director
Mr. ~~David Keith~~ Plant Engineer
Mr. ~~Samuel Lawrence~~ Plant Superintendent
Mr. ~~Edward Cushing~~, Manager of Manufacturing and Engineering
Mr. ~~Leo Surdyka~~, Principal Labor Representative

A careful explanation of the request was made to this group and NIOSH's intended plan or action to investigate the alleged hazards was put forth.

Following the meeting with the above persons, an on site observational survey of the Pump Room was made. Messrs. Vandervort and Flesch examined the manufacturing processes present in the Pump Room, taking detailed photographs and preliminary air samples for trichloroethylene. A rough layout of the Pump Room is shown in Figure 1, Section VII. Basically, the Pump Room employees are engaged in the assembly of compressors. A variety of compressor parts are degreased in the two vapor degreasing tanks and then assembled in the areas shown in Figure 1, Section VII.

Preliminary air samples for trichloroethylene were gathered using MSA charcoal tubes designed for sampling organic vapors, and calibrated Drager vapor detector tubes designed for detecting trichloroethylene. Air was drawn through the MSA charcoal tubes by an MSA Model G, battery powered, vacuum pump, operating at one liter per minute air flow rate. The Drager detector tubes were used with their accompanying Drager hand-operated air pump. The MSA charcoal tubes were returned to Cincinnati where they were desorbed with carbon disulfide and analyzed by gas chromatographic techniques. The Drager detector tubes were read on site after five and ten pump strokes. Trichloroethylene concentrations were indicated by advancing changes in the color of the absorbing medium in the Drager tubes. The results of this preliminary sampling are presented in Table I, Section VII.

While Messrs. Vandervort and Flesch were examining processes and taking air samples, Dr. Polakoff interviewed employees, examined health records, and evaluated the health capabilities of the South Street Plant. A brief summary of his findings is presented in the paragraphs to follow.

Major Medical Complaints. All eleven employees who were working on the day shift in the Pump Room were interviewed with respect to their exposure to trichloroethylene. They all presented similar histories of experiencing intermittent feelings of nausea, occasional vomiting, dizziness, and light headedness which was aggravated if they had consumed alcohol before going to work or after starting work.

Employee Profile. There are approximately 480 employees at this Dunham-Bush, Inc. facility. Approximately 295 individuals are engaged in production line activities while the other 185 are involved with administrative, supervisory and clerical duties. The average employee is approximately 40 years of age and has been with the company 5 to 8 years. Labor management relationships are cordial, however, areas of tension are arising due to the fact that there is a new contract under arbitration at the moment. There are also on file approximately 90 grievances that have been submitted to management concerning health hazards, safety hazards, and general working conditions.

OSHA Log. Within the last year there have been some 40 entries listed in OSHA Log #102. These listings include traumatic problems, i.e., crushed fingers, lacerations, bruises, backaches. There was only one listing of a dermatological condition, and there were no other occupationally related conditions.

Health Capabilities. Within the factory there is a health dispensary which is staffed by a Registered Nurse, Mrs. ~~Julienne Nelson~~. Mrs. ~~Nelson~~ has worked for the company for five years and is on duty eight hours a day five days per week. In the evening, employees trained in first aid handle any emergencies which might arise.

The plant retains the services of Dr. ~~Friedberg~~ who is a local general practioner. Dr. ~~Friedberg~~ comes to the plant one day each week to handle medical complaints.

Health Policies. The plant requires pre-employment physical examinations of all new employees. The plant does not perform annual examinations on any of its employees and employees are not examined upon termination of employment. Routine checks such as chest x-rays, urine tests, blood tests, audiometric tests, immunizations, etc. are not offered by the plant. Immunizations have been offered only when severe flu epidemics have occurred and when other establishments have offered immunizations.

During the afternoon of November 21, 1972, an observational survey of the Dunham-Bush, Inc. Day Street Plant was made by the NIOSH representatives. Again, Messrs. Vandervort and Flesch examined processes while Dr. Polakoff interviewed employees.

The Day Street Plant is engaged in the manufacture of shell and tube heat exchange equipment operating on a one work shift bases. The building is being rented by Dunham-Bush, Inc. and was not specifically designed for the processes which were found within it. The building has no windows and only three roll-up doors (roughly 12' by 12') are provided at each end of the building. The roof of the building does have some provision for natural draft ventilation.

Most of the processes observed within the Day Street Plant were elucidated in Mr. ~~Surdyka's~~ request and were previously mentioned in this section. In general, only minimal engineering control has been provided for the many processes which generate airborne contaminants. This situation is compounded by the structual characteristics of the building which afford little provision for natural ventilation. Messrs. Vandervort and Flesch concluded that evaluation of potential hazards in the Day Street Plant would require extensive sampling and environmental measurements, and therefore, concentrated on preparing a plan for environmental work. See Figure 2, Section VII for plant layout.

Employees interviewed in the Day Street Plant gave similar complaints in regard to their working environment. None stated that they had missed any work or felt that the work conditions were acutely detrimental to their health, however, they were unanimous in stating that their work environment was very uncomfortable at times, and that contaminants often built up to levels which made it difficult to breathe and caused headaches, drowsiness, dizziness, fatigue, and nausea in some employees.

In addition to the toxic agents which are generated in the Day Street Plant, it was concluded that a great many safety hazards and significant exposures to physical agents (i.e. ultraviolet and infrared radiation, noise) exist.

B. Environmental Evaluation

The environmental evaluations of the Pump Room in the South Street Plant and of the Day Street Plant were conducted separately and will be discussed separately in this section of the report.

1. Pump Room, South Street Plant

During the initial observational survey of the Pump Room (conducted November 21, 1972), Messrs. Vandervort and Flesch concluded that the major potential hazard in this area was inhalation of trichloroethylene vapors. Preliminary air sampling conducted on November 21, 1972 (sampling procedure described in Section IV, part A.) confirmed that high levels of trichloroethylene were present in the work environment (See Table I, Section VII.).

a. Procedure

On December 18, 1972 a thorough, in-depth environmental survey of the Pump Room was conducted by Mr. Vandervort. Directly following the collection of urine specimens from employees prior to starting the work shift, evaluation of personal exposures to trichloroethylene was begun.

The exposures of eleven of the nineteen employees working in the Pump Room were monitored using personal air sampling equipment. Breathing zone air samples were obtained using MSA charcoal sampling tubes (designed for sampling organic vapors) which were attached near the lapel or collar of each worker being monitored. (Each batch of charcoal tubes received by NIOSH is statistically sampled and subsequently checked for air flow resistance, absorptive, and desorptive characteristics.) The tubes were attached so that they remained in a roughly vertical orientation with the inlet end up. MSA Model G, battery powered, vacuum pumps were used to draw workroom air through the charcoal tubes. These pumps were hung from the trouser belts of the workmen. The connection between sampling tube and vacuum pump was made with flexible tygon tubing. Air sampling rates were maintained at one (1.0) liter per minute by periodically adjusting each pump's calibrated rotameter. Sampling duration ranged from twelve to thirty-five (12 to 35) minutes. Immediately after sampling each tube was sealed with inert, plastic caps. In this manner, twenty-six (26) personal, breathing zone, vapor samples were gathered. In addition, two (2) area samples were collected using the same equipment.

b. Results

These charcoal tube air samples were returned to Cincinnati where they were analyzed by gas chromatographic techniques for trichloroethylene. (Each charcoal tube, vapor sample was desorbed in carbon disulfide and injected into a computer controlled gas chromatograph for individual compound identification by retention time and quantitative measurement of compound presence in the sample by peak area integration.) The results of this sampling and subsequent analysis are displayed in Table II, Section VII. Figure 3, Section VII shows where the samples were gathered in the Pump Room by showing where the employees spent most of their time when working.

Tables III and IV, Section VII display successive reductions of the exposure data. Table III breaks out measured trichloroethylene concentrations by employee and work area. Table IV contains calculated eight-hour, time-weighted-average (8hr-TWA) exposures for each employee monitored. These 8hr-TWA exposures were calculated with the assumption that each worker spent seven hours in the Pump Room and one hour out of the Pump Room during coffee breaks and lunch. For each employee, time spent out of the Pump Room was treated as a period of no exposure to trichloroethylene. The two area samples were converted to 8hr-TWA concentrations in the above manner.

Careful examination of the data in Tables II, III, and IV of Section VII reveals that, in general, the latter portions of the morning and afternoon work periods show the presence of relatively higher concentrations of trichloroethylene. This trend toward higher concentrations as work progressed indicates that the ventilation system servicing the Pump Room does not remove trichloroethylene vapors from the work environment as fast as they are injected into the work environment by the degreasing operations. It is also evident from the data that the 8hr-TWA exposures in Table IV, Section VII are only approximations to actual exposures since no employee was monitored for the full eight hours. However, exposures which were monitored at spaced intervals throughout the work shift do not show extreme fluctuations, and therefore, the 8hr-TWA exposures in Table IV, Section VII are believed to be sufficiently accurate for the purposes of this evaluation.

In addition to measuring air concentrations of trichloroethylene, the air moving capability of each degreaser's exhaust system was measured. Figure 4, Section VII shows schematic aerial views of the two Pump Room degreasers. Indicated on the figure are air velocities (expressed in feet per minute - fpm) measured at several positions along slot exhaust pickups for both degreasers. These air velocities were measured with a calibrated Type 8500, Alnor Thermo-Anemometer. Subsequent calculations of air volumes exhausted by each degreaser's exhaust system (based on degreaser dimensions, slot velocity, and slot size) are also stated on the figure. For the Small Vapor Degreaser, the Exhausting Rate is approximately 400 to 600 cubic feet of air per minute (cfm). For the Large Vapor Degreaser the Exhausting Rate is 400-900 cfm.

c. Conclusions and Recommendations

The preceding seven paragraphs have summarized the environmental measurements made in the Pump Room. The data from these measurements together with observation of the work practices, equipment, and processes employed in the Pump Room, supply sufficient information on which to base the environmental evaluation. The paragraphs to follow contain conclusions, supporting discussion, as well as, recommendations for improvement of environmental quality in the Pump Room.

The trichloroethylene concentrations measured in the Pump Room on November 21, 1972 and on December 18, 1972 are the result of two distinct exposure situations. On November 21, 1972 activity in the Pump Room was relatively high. Both degreasers were operating continuously. In addition to the two degreaser operators, other employees (e.g. from the DBX area) were also degreasing parts. Resulting, measured, trichloroethylene concentrations on this date ranged from 295 to 1,186 mg/m^3 (See Table I, Section VII). These concentrations are average concentrations for the time period and location sampled. (Detector tube samples require 3 to 5 minutes to collect.) 8hr-TWA exposures were not obtained on this date, however, short term data indicates that 8hr-TWA exposures were probably in the range 400 to 900 mg/m^3.

On December 18, 1972 activity in the Pump Room was relatively low. Degreasers were operating intermittently and only degreaser operators were degreasing parts. Large baskets of small parts were not being degreased. Resulting short term exposure to trichloroethylene were measured to range from 195 to 655 mg/m^3 (See Table II or III, Section VII). 8hr-TWA exposures ranged from 170 to 420 mg/m^3 (See Table IV, Section VII).

It is concluded from sampling data and observations that the magnitude of employee exposure to trichloroethylene in the Pump Room is directly related to the level of work activity. In addition, several problems with the degreasing operations were observed to contribute to trichloroethylene exposure. (1) Many of the parts requiring degreasing have cavities (which are not readily emptied) which carry degreasing solvent out of the degreaser when the parts are removed (See Photo No. 1, Section VII). There is no exhaust controlled area within which to place these parts while the solvent evaporates from their cavities. Time does not permit allowing the trapped solvent to evaporate completely while the part is inside the degreaser suspended above the bath. (2) Degreaser operators, as well as, other Pump Room employees were observed to be improperly operating the degreasers. Parts were sometimes abruptly immersed and raised from the degreasing baths causing unnecessary splashing of solvent and vapor turbulence. Many of the parts with easily emptied cavities were not properly rotated so as to dump out solvent before removal of the parts from the degreasers. Parts were observed to be sprayed with hot solvent while in a position above the condensing coils of the degreaser (See Photo No. 2, Section VII).

The above problems are complicated by the lack of good exhaust control for either degreaser. As previously mentioned, the exhausting rates for the Small and Large Vapor Degreasers are 400 to 600 cfm and 400 to 900 cfm respectively (See Figure 4, Section VII). The American Conference of Governmental Industrial Hygienists (ACGIH) in their Industrial Ventilation: A Manual of Recommended Practice recommend that higher air exhausting rates would be more appropriate for vapor degreasers of the size found in the Pump Room. Figure 5, Section VII, which was taken from the above ACGIH publication, specifically deals with solvent degreasing tanks. Using the formula for recommended exhausting capacity ($Q = 50LW$) and inserting the approximate dimensions of the two Pump Room vapor degreasers, it can be calculated that the Small and Large Vapor Degreasers should have exhausting capacities of 750-1200 cfm and 1250-1800 cfm respectively. This would suggest that each degreaser's exhaust system could be substantially improved. (Note: When initially installed, the exhuast capacities may have been greater. Possibly a thorough cleaning of the ductwork and servicing of the exhaust fans would help. If the systems were serviced shortly before our evaluation, then to increase capacity a new fan and motor and/or ductwork may be necessary.)

It can only be concluded from the foregoing discussion that trichloroethylene exposures in the Pump Room are unnecessarily high. The following recommendations are made in the interest of improving the control of trichloroethylene vapors and thereby minimizing employee exposures.

1. Only enough heat should be supplied to the degreasing baths to obtain satisfactory degreasing efficiency. Excess heat only contributed to solvent loss and employee exposure.

2. Parts should never be plunged into or rapidly removed from the degreasing baths. Careful handling will minimize splashing and disturbance of exhaust and condensing currents.

3. All parts to be degreased should be degreased at an elevation well below the condensing coils of the degreasers. Failure to observe loss and employee exposure.

4. All parts with cavities which are readilly emptied should be rotated while in the degreasers so as to thoroughly discharge captured solvent.

5. The exhaust systems for each of the degreasers should be improved. Exhaust capacities could be doubled without adversely affecting solvent loss.

6. At the output side of each degreaser, a section of the roller conveyor should be outfitted with downdraft exhaust ventilation so that parts which cannot be removed dry from the degreaser will have a place to dry off. Fifty (50) cfm of exhaust capacity has been recommended for each square foot of drying area (See Figure 5, Section VII). At present, solvent carried by parts from the degreasers, escapes into the workroom environment and significantly contributes to employee exposures at the degreasers and wherever the parts are subsequently handled.

7. The brazing station near the foreman's area (See Figure 1, Section VII) should be provided with local exhuast ventilation. This ventilation would remove the potential for exposure to phosgene (a highly irritant gas which can be formed when trichloroethylene vapors contact high heat, e.g. brazing torch, or ultraviolet radiation).

2. Day Street Plant

During the initial observational survey of the Day Street Plant (conducted November 21, 1972), Messrs. Vandervort and Flesch concluded that there were many potential health hazards associated with a variety of processes contained within the Day Street Plant. It will be stated at the outset of this section that the general environmental conditions found within the Day Street Plant reflected little regard for good industrial hygiene and safety practices. Several processes (e.g. welding, brazing, flame cutting, etc.) which produce significant quantities of deleterious air contaminants, as well as, physical agents (e.g. ultra-violet and infrared radiation, noise, etc.) were observed to have little or no effective engineering control. The situation is further aggravated by the close proximity of the various processes, lack of appropriate partitioning, and by the absence of effective plant ventilation either mechanical or natural.

In circumstances such as these, where well known, potentially hazardous processes or materials are being employed with substandard or no control, the matter of determining each employee's resulting risk of health impairment is impractical and would not directly serve the cause outlined by the Occupational Safety and Health Act of 1970. That is, proving that indeed a hazard does exist when welding, etc. are conducted with inadequate control, does not enhance our ability to "assure safe and healthful working conditions" for employees. In this case, it was more to the point to evaluate potentially serious acute exposures so that immediate remedial steps could be taken. Proven control techniques will be suggested for those routine processes and substances which are recognized to be potentially hazardous, but which are not acutely serious potential health hazards.

Thorough, indepth environmental surveys of the Day Street Plant were conducted by Mr. Vandervort on December 19, 1972 and January 9, 1973. A discussion of these surveys and their findings will follow.

a. Brazing and Silver Soldering

The Day Street Plant employs approximately 6 to 10 workers in brazing and silver soldering processes. With but one exception (See Photo No. 3, Section VII), none of these brazing or silver soldering stations have been provided with local exhaust ventilation. This situation is complicated by the fact that cadmium bearing materials are being used at some of the brazing and silver soldering stations. The combination of no effective local exhaust ventilation, poor general ventilation, and the use of cadmium containing materials, demanded careful evaluation of the resulting potentially serious exposures to metal fumes.

Exposures to metal fumes were evaluated on December 19, 1972 and on January 9, 1973 during normal work activity using personal air sampling equipment. Breathing zone air samples were obtained using Millipore Type HA, cellulose ester filters (37mm diameter, 0.45 micrometer pore size) held in open face, three stage Millipore disposable aerosol monitors. The aerosol monitors were attached near the collar or lapel (in an inverted orientation) of each worker being monitored. Workroom air was drawn through each filter by an MSA Model G, battery powered, vacuum pump. These pumps were hung from the trouser belts of the workmen. The connection between aerosol monitor and vacuum pump was made with flexible tygon tubing. Air sampling rates were maintained at one (1.0) liter per minute by periodically adjusting each pump's calibrated rotameter. Sampling duration ranged from 105 to 207 minutes. Immediately after sampling, each aerosol monitor was sealed with a cap and plugs. In this manner, sixteen personal, breathing zone samples were gathered. In addition, four area samples were gathered using the same equipment.

These membrane filter air samples were returned to Cincinnati where they were analyzed after wet ashing by an atomic absorption spectrophotometer. The detection limit of this method is approximately 0.01 micrograms of metal per filter. Those samples collected on December 19, 1972 were analyzed for cadmium alone, while the samples collected on January 9, 1973 were analyzed for cadmium, silver, copper, and zinc. The results of this sampling and subsequent analyses are displayed in Tables V and VI, Section VII. Figures 6 and 7, Section VII show the sampling locations for the samples contained in Tables V and VI, respectively.

Table VII, Section VII contains calculated eight-hour, time weighted-average (8hr-TWA) exposures to cadmium for each employee monitored on December 19, 1972 and January 9, 1973. These 8hr-TWA exposures were calculated with the assumption that each worker spent seven hours in the brazing area and one hour out of this area for breaks and lunch. For each employee, time spent away from the brazing area was treated as a period of no exposure to cadmium. Table VII also contains two area concentrations which were calculated using the 8hr-TWA format.

The exposure data contained in Tables V, VI, and VII, Section VII reveal that significant exposures to cadmium do occur in the Day Street Plant. The data also show that all employees in the brazing area are being exposed to cadmium and not just those directly using cadmium bearing materials. Exposures to silver, copper, and zinc are of much less concern individually, however, one cannot rule out the possibility of additive toxic effects from the combined exposure to such metals.

b. Foam Filling Operation

The foam filling operation along Aisle No. 2 (See Photo No. 4, Section VII) was recognized, during the initial observational survey, to be a potentially very hazardous operation. One of the foam components contains isocyanate compounds. Ordinarily, the safe handling of isocyanate containing materials requires extensive engineering control or personal protective equipment or both. As is apparent from Photo No. 4, no engineering control has been provided for this operation. In addition, the employee conducting the foam filling was wearing only cloth gloves and safety glasses as protective equipment. From an industrial hygiene standpoint it was, thus, imperative that environmental samples be collected in this area.

On December 19, 1972 several air samples were collected in the foam filling work area. Unfortunately, an error was made in the preparation of the absorbing solution and as a result no reliable data was obtained. A second set of samples was obtained on January 9, 1973. Air samples were gathered using midget impingers and MSA Model G, battery powered, vacuum pumps. Approximately 15 milliliters of absorbing solution (concentrated hydrochloric acid and glacial acetic acid in water) were used in the first of two midget impingers. The second impinger was dry and served as a moisture trap to safeguard the air pump. Workroom air was drawn through the absorbing solution at a rate of (1.0) liter per minute. This flow rate was maintained by adjusting each pump's calibrated rotameter. Sampling durations ranged from 10 to 27 minutes. After sampling, each absorbing solution was rinsed from the lead impingers (fresh absorbing solution was used as the rinse liquid) into sample bottles. The samples were returned to Cincinnati where they were treated with n-naphthylethylenediamine. The optical density of each sample was read immediately and again after two hours. The results of this sampling and subsequent analyses are displayed in Table VIII, Section VII.

As is apparent from the data in Table VIII, no measurable levels of isocyanate as toluene diisocyanate (TDI) or diphenylmethane diisocyanate (MDI) were found in the foam filling area. The approximate limit of detection of this method is one microgram of isocyanate per air sample. In conversation with the General Latex and Chemical Corporation of Ashland, Ohio, it was confirmed that the foam product in use (Vultafoam, Part A 16F-1602) contains only small quantities of MDI. It must be emphasized that this material has the potential to produce toxic effects in workers and should be handled in a manner consistent with the precautions stated by its manufacturer on the product labels.

c. Spray Painting Operations

Exposure to paint spray and paint solvents was also recognized as a potentially serious health hazard during the initial observational survey. The Day Street Plant has two booths where spray painting is conducted. (See Figure 2, Section VII.) The employee exposure to paint spray and paint solvents at each of these booths was evaluated on December 19, 1972 during normal spraying activity. Personal sampling equipment (MSA charcoal sampling tubes, MSA pumps) was used in the same manner as was described for trichloroethylene sampling in the Pump Room of the South Street Plant. Sampling durations ranged from 18 to 32 minutes. Samples were analyzed in Cincinnati by a gas chromatographic technique very similar to the one previously outlined for trichloroethylene analysis. The results of this sampling and analysis are displayed in Table IX, Section VII.

Although a complete gas chromatographic scan was made of these air samples, only methylene chloride was found to be present in quantitatively important levels. (See Table IX, Section VII.) Levels of methylene chloride in the range 1 to 74 mg/m^3 do not present an appreciable hazard to health. Toluene and xylene were also found in these air samples, but they were present in levels below 1 mg/m^3 and, therefore, do not present an appreciable hazard to health.

Each spray booth's exhaust system was evaluated in conjunction with air sampling on December 19, 1972. Air face velocities were measured at the filters and at the entrances of each booth using a calibrated, Type 8500, Alnor Thermo-Anemometer. Figures 8 and 9, Section VII show front elevations of each booth with air velocities placed on the figures at the approximate points of air velocity measurement. Air velocities are expressed in feet per minute (fpm). The air moving capabilities of these booths appear adequate for the contaminants involved, as long as small parts are being painted. These measurements will be discussed later with respect to recommendations for improvement of the Day Street Plant's work environment.

d. Exposure to Noise

In addition to measuring air contaminants, a brief survey of employee exposure to noise was made on December 19, 1972. Noise exposures were measured using a calibrated, Type 1565-B, General Radio, South-Level Meter. (It must be stated that this instrument will not accurately measure impulse noise, and that values read from this instrument under impulse noise conditions will be much lower than the true impulse noise levels.) The results of this survey are presented in Table X, Section VII. Comparison of measured noise levels to permissible noise exposures presented in Section II, Part A of this report, clearly indicates a need for a noise abatement program and the use of hearing protection devices.

e. General Environmental Observations

Aside from the detailed environmental evaluations described to this point, each work area in the Day Street Plant was carefully observed. A discussion of the observed potential hazards presented by each work area will follow. (Refer to Figure 2, Section VII.)

Aisle No. 1 - Welding Booths

Each of the welding booths or areas along Aisle No. 1 lacked adequate exhaust ventilation. No local exhaust ventilation was observed. The small axial wall fans and pedestal fans provided in some of the booths are ineffective in removing or diluting air contaminants generated in these areas and are not examples of good ventilation practice. (See Photo No. 5, Section VII.)

Most of the welding booths have only minimal shielding. Employees working across the aisle or in adjacent work areas are not adequately shielded from harmful ultraviolet radiation.

During grinding and chipping operations, employees are exposed to excessive levels of noise. Use of hearing protection devices was not observed.

Aisle No. 1 - Fin Punching, Tube Bundle Assembly and Water Test Areas

Employees along this side of Aisle No. 1 are not adequately shielded from ultraviolet radiation generated from across the aisle welding booths.

Aisle No. 1 - Sawing and Flame Cutting Area

The only mechanical ventilation observed for this area was a small axial wall fan near one of the flame cutting stations. Thus, air contaminants generated in this area are not removed or diluted in accordance with good practice.

Employees in this work area are being exposed to excessive levels of noise and were not observed to be wearing hearing protection devices.

Aisle No. 1 - Spray Booth

Many parts which must be painted at this site are too large to be placed entirely within the spray booth. Consequently, the booth's exhaust system does not capture all the overspray. On occasion the employee painting in this booth was observed to be painting without wearing a respirator.

Noise exposure in this work area warrants the use of hearing protection devices.

Aisle No. 2 - Spray Booth

Many parts which must be painted at this site are too large to be placed entirely within the spray booth. Consequently, the booth's exhaust system does not capture all of the overspray.

Aisle No. 2 - Foam Filling Area

The foam filling materials in this working area are not being used in accordance with their manufacturers instructions or in accordance with good practice. No provision has been made to protect the worker from breathing vapors emitted by the foam and no effective provision has been made to protect the worker's skin from prolonged contact with the foam components.

Aisle No. 2 - Heavy Assembly Welding

No ventilation has been provided for the welding conducted along Aisle No. 2. Very heavy stock is welded routinely. Only scanty shielding is provided to protect adjacent workers from exposure to ultraviolet radiation. Noise exposures in this area far exceed permissible limits and employees were observed not to be wearing hearing protection devices.

Aisle No. 2 - Heavy Flame Cutting

No ventilation has been provided for any of the flame cutting along Aisle No. 2. Flame cutting employees are exposed to flame cutting air contaminants, ultraviolet radiation, and excessive levels of noise. Flame cutting employees were observed not to be wearing hearing protection devices.

Aisle No. 2 - Large Tube Bundle Assembly Area

Employees working in this area are not adequately protected from ultraviolet radiation generated in the adjacent welding areas. Excessive noise exposures occur in this work area during parts of each working shift Employees were observed not to be wearing hearing protection devices durin incidents of high noise exposure.

Aisle No. 2 - Grit Blasting Chamber

A non-silica, ferrous metal blasting grit is being employed. No easily accessible observation ports have been provided for this chamber so that the worker can be checked on periodically while the blasting procedure is being conducted. The air supply system for the air supplied hood worn by the blasting employee must be routinely serviced. A standard procedure for filter changing and cleaning was not elucidated by the employees working near this operation. Air inlet and exhaust ports within the chamber have been designed in a manner that results in poor working visibility within the chamber during the blasting procedure. Only one exhaust port in the rear of the chamber has been provided. (See Photo No. 6, Section VII.)

Aisle No. 3 - Welding Booths

No ventilation has been provided for any of the welding conducted along Aisle No. 3. Furthermore, minimal shielding has been provided. As a result, employees working across the aisle and in adjacent work areas are exposed to ultraviolet radiation.

Aisle No. 3 - Brazing and Silver Soldering Areas

A form of exhaust ventilation has been provided for only one of the brazing stations. (See Photo No. 4, Section VII.) None of the brazing or silver soldering stations have been provided with local exhaus ventilation in accordance with good practice. Brazing employees are being exposed to ultraviolet radiation from nearby welding operations. Some brazing employees use a highly alkaline material (Oakite) to clean parts. They are not equipped with adequate personal protective equipment. As has been stated earlier, brazing employees are also exposed to cadmium, copper, silver, and zinc metal fumes.

Aisle No. 3 - Trichloroethylene Vapor Degreaser

Unfortunately, this degreaser was not being used during the visits made to the Day Street Plant. For demonstration purposes, an employee did turn on the degreaser's exhaust system and solvent heating system. Exhaust velocities at the slot inlet at the top of the degreaser were measured with a calibrated, Type 8500 Alnor Thermo-Anemometer. Figure 10, Section VII displays a sketch of this degreaser and the measured air velocities. The exhaust air currents are seriously disrupted by a space heater located near the degreaser. The problem is compounded by the fact that the solvent heating system is not properly controlled and causes large volumes of trichloroethylene vapor to rise past the condensing coils, past the slot exhausts and into the working environment. The air current provided by the previously mentioned space heater causes these vapors to be transported into the welding and brazing areas. This situation obviously results in potentially high exposures to trichloroethylene and possibly to phosgene formed by contact of the trichloroethylene vapors with the intense heat or ultraviolet radiation generated in the brazing and welding operations. (Trichloroethylene breaks down to phosgene in a one to three ratio, i.e. one part of trichloroethylene forms three parts of phosgene. Hydrogen chloride can also be formed by this breakdown process.) Unfortunately the degreaser could not be operated long enough to permit environmental sampling. However, vapors emitted from the degreaser were in such concentration that they could be observed as a cloud or fog drifting from the degreaser.

f. Recommendations

As was mentioned at the start of this section on the Day Street Plant, many potential hazards exist in the facility. The foregoing discussion has elucidated the complex nature of the environmental conditions and the almost total lack of engineering control (local or general). In the interest of improving the overall quality of the work environment in the Day Street Plant and thereby safeguarding the health of the employees working in the facility, the following recommendations are made.

(1) Welding Operations: Welding operations should be upgraded to comply with regulations set forth by the U.S. Department of Labor (Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart Q - Welding, Cutting, and Brazing). This will require installation of local exhaust ventilation for all portable welding operations and either local or booth type ventilation for stationary welding operations. Much improved and more extensive shielding will also be necessary.

(2) Brazing and Silver Soldering Operations: These operations are also covered by the U.S. Department of Labor regulations referenced in the preceding recommendations. Local exhaust ventilation of the portable hood type or stationary table type should be provided for all brazing and silver soldering operations (See Photos No. 7 and 8, Section VII). As an interim measure employees directly involved with the use of cadmium bearing materials and employees working adjacent to employees using these materials should be provided with respirators approved by the U.S. Bureau of Mines for protection against cadmium fume.

(3) Spray Painting Operations: The exhausting capacities of each of the two spray booths as measured on December 19, 1972 were adequate for parts sprayed within the booths as long as the painters wear approved respirators. Additional booth space is needed for painting large objects. Enlarging either of the existing booths without increasing their exhaust capacity would result is a substandard situation. If the new booths which are reportedly on order for the Day Street Plant are of the dry filter type, they will have to perform at least as efficiently as the present booths and the painters should continue to wear approved respirators while painting. The U.S. Department of Labor has set standards for spray finishing operations. These standards are outlined in the October 18, 1972 Federal Register, Title 29, Chapter XVII, Subparts G and H. It is suggested that these standards be reviewed before installation of new booth equipment.

(4) Foam Filling Operation: As previously mentioned, no engineering control has been provided for this operation. Although no TDI or MDI were found in the work atmosphere, the manufacturer of the foam material does recommend that these materials be used in well ventilated area. Possibly, one of the existing spray booths could be converted for control of this operation when the new booths are installed. It must be stated that if any other isocyanate containing foam product is to be used in the future, every effort should be made to determine whether the new product contains toluene diisocyanate (TDI) or diphenylmethane diisocyanate (MDI). These materials can present a serious hazard to health if not properly handled.

(5) Grit Blasting Chamber: The grit blasting chamber does not meet design standards set forth by the U.S. Department of Labor, Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart G, Paragraph 1910.94 - Ventilation. It is recommended that these regulations be consulted and the necessary modifications of the chamber made.

(6) Trichloroethylene Vapor Degreasing Tank: This vapor degreasing tank does not meet the standards set forth by the U.S. Department of Labor, Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart G, Paragraph 1910.94 - Ventilation. It is recommended that these regulations be consulted and the necessary modifications of the degreasing tank made. As an interim measure, the degreasing tank should only be operated when absolutely necessary. The solvent heating system should be carefully controlled to prevent dangerous over heating. The space heater near the degreasing tank should be oriented so that the air current it causes will not upset the degreasing tank exhaust control currents.

(7) Employees working with alkaline cleaners should be provided with synthetic rubber gloves, aprons and chemical goggles.

(8) Exposures to Excessive Noise: As has already been mentioned, the limited noise exposure survey conducted on December 19, 1972 revealed that many of the employees in this facility are being exposed to excessive noise. This situation should be remedied by reducing the noise level produced by some of the existing equipment or by providing hearing protection devices for employees in high noise exposure areas or both. It is suggested that a thorough noise exposure survey be made to identify and quantitate all excessive noise exposures. Failure to institute a noise abatement and hearing protection program will perpetuate the existing situation which is not in accordance with regulations promulgated by U.S. Department of Labor which were stated in Section II, Part A of this report. For a more complete stating of noise exposure standards refer to Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart G, Paragraph 1910.95 - Occupational Noise Exposure.

C. Medical Evaluation

The medical evaluations of the Pump Room in the South Street Plant and of the Day Street Plant were conducted separately and will be discussed separately in this section of the report.

1. Pump Room, South Street Plant

To ascertain the severity of the trichloroethylene vapor problem in the Pump Room, several approaches were used. On our first plant visitation (November 21, 1972), a thorough walk through inspection was performed during which time all concerned employees, working on the first shift, were interviewed. On our second plant visitation (December 18, 1972), questionnaires (See Appendix A, Section VIII) were administered to all employees involved with the process. Urine samples were obtained and the process was reinspected to see if any changes were instituted during the interval between visits.

During the initial plant visitation, one could readily smell the pungent vapors of trichloroethylene throughout the Pump Room; these odors were strongest in those areas in closest proximity to the degreasing tanks. A sensation of nausea and weakness overcame NIOSH personnel involved in this investigation. Subjectively, the odors didn't seem to be as strong on the second visit nor did the level of production seem as high.

In the pump room, it was observed that none of the exposed individuals wore respirators. The individuals working around the degreasing tanks wore cloth gloves, which, most of the time, are wet with solvent. Dry gloves weren't readily available. Safety glasses are worn by all the workers.

a. Medical Questionnaire

From the questionnaire which was completed by 19 individuals exposed to trichloroethylene on a routine basis and another 11 individuals who have minimal to zero exposure to trichloroethylene the following results were obtained.

Eight years is the average length of job exposure to trichloroethylene in this plant.

For those exposed to trichloroethylene fumes the following symptoms (as expressed in percentage of exposed individuals complaining of) have been experienced during working hours: burning or itching eyes (73%), tiredness (70%), heart palpitations (58%), cough (58%), weakness (53%), and dizziness (52%).

Fifty percent of the exposed workers complained of changes in skin color and a feeling of severe intoxication following the consumption of small amounts of alcohol during their non-working hours.

Less frequently indicated symptoms included nervousness, headaches, nasal stuffiness, and redness of eyes. Only one out of the 19 individuals exposed to trichloroethylene stated that they experienced no ill-effects from this solvent.

None (0%) of the non exposed control individuals complained of any of the above stated symptomatology.

The questionnaire reflects the varied symptomatology of the exposed workers during their period of employment in the Pump Room, but does not necessarily indicate the presence of symptomatology on the day of the environmental-medical evaluation.

b. Biological Sampling

Urine samples were collected from 19 workers exposed to trichloroethylene vapors, nine controls and two NIOSH staff. The urine samples were collected prior to the start of the workshift and again after the workshift ended. Approximately 8 hours was the time interval between urine sampling. Six samples were split with the identity withheld from the analyst until after the analyses were complete. Samples were obtained on December 18, 1972 and delivered to NIOSH's Clinical Laboratory on December 22, 1972. Samples were analyzed during the period of December 22, 1972 to January 4, 1973.

Trichloroethylene in the body is mainly metabolized in the liver and excreted in the urine as the by-products trichloroethanol and trichloroacetic acid. At this time whether deleterious effects can result from these metabolites is unknown.

The urine samples were analyzed by Larry Lowry, Ph.D., Chief, Clinical Chemistry Section, Toxicology Branch, NIOSH. The following is his report:

> After a search of the literature, it was decided that trichloroacetic acid (TCA) in urine would be analyzed by two methods. The first method (R. Frant and J. Westendorp, Medical Control on Exposure of Industrial Workers to Trichloroethylene, Arch. of Ind. Hyg. & Occ. Med. 1 308-318, 1950) was the one referred to indirectly by the TLV documentation for trichloroethylene. A second method of more recent origin was also used (S. Tanaka and M. Ikeda, A Method for Determination of Trichloroethanol and Trichloroacetic Acid in Urine, Br. J. Ind. Med. 25 214-219, 1968). In the latter paper, evidence was presented that indicated trichloroethylene exposure was more directly related to trichloroethanol in urine than to trichloroacetic acid in urine. Each sample was, therefore, analyzed for trichloroacetic acid (TCA) by two methods and for trichloroethanol (TCE) be one method. In addition, prior experience from this laboratory and others has shown that urine data from spot urine samples is much more meaningful if expressed on a milligram per gram creatinine basis than on a milligram per liter basis. A total of 66 creatinine determinations, 55 TCE's and 172 TCA's were run along with appropriate blanks and standards. Creatinines were run using the Technicon Auto Analyzer.

Table XI, Section VII shows the results of TCA determinations by Both methods expressed on a mg/l basis. TCA determined by the Tanaka procedure compare favorably to those analyzed by the older Frant procedure. Values by the latter procedure appear to be 10-20% lower than the Tanaka method. This would be expected because the Frant method uses an alkaline acetone extraction of urine which one would not expect to be completely quantitative. It must be emphasized that only about 40 samples could be analyzed per day (33 samples plus 7 standards and blanks) so that each group of 66 urines took two days to analyze.

The Tanaka method although not much quicker proved superior in every way to the Frant procedure, showing excellent reproducibility, wide range, consistent color variations in both standards and urine samples and lack of sensitivity to carbon dioxide. The results shown in Table: XII, XIII, and XIV, Section VII were obtained by the Tanaka procedure and expressed both on a mg/l and mg/g creatinine basis.

Table XII, Section VII shows the results of the split samples. Reproducibility, in general, was very good. The lower limits of detection are about 2 mg/l or mg/g creatinine and values below 10 show considerable variation. Values in the exposed individuals show excellent precision.

Table XIII, Section VII shows results of TCE, TCA in terms of mg/l and mg/g, and creatinine as g/l of urine. Samples are grouped by control, exposed, and NIOSH staff, by AM and PM urine samples. Controls show no detectable TCA or TCE expressed either as mg/l or per gram creatinine. Since the level of detection is around 2 mg/l or 2 mg/g creatinine, non exposed workers have less than this level, in agreement with previous literature reports.

Exposed workers, however, show a wide range of exposure as judged by urinary excretion of TCA and TCE. Examination of Table XIII and summary data of Table XIV, Section VII shows that TCA as mg/l does not follow any consistent trend such as low AM and high PM values. TCA expressed as mg/g creatinine is better but again, mean AM and PM values show no significant trend. The data showing the largest change and most consistent trends is the TCE expressed as mg/g creatinine. This data shows all AM values lower than after shift PM values and seems to cover a wider range. This observation is in agreement with Tanaka who found that TCE in mg/l was directly related to trichloroethylene exposure up to 200 ppm whereas TCA values (mg/l) level off below the current occupational exposure standard of 100 ppm or 535 mg/m^3.

Recent work reported by Ogata, et al[5] has shown that trichloroethanol is rapidly excreted in urine after exposure to trichloroethylene. On the other hand, trichloroacetic acid is excreted in the urine most rapidly 42 to 69 hours after exposure ceases. In this case, urine samples were collected on a Monday and, thus, the trichloroacetic acid values include residual trichloroacetic acid resulting from the previous week's exposure to trichloroethylene. Therefore, in this study trichloroethanol levels are most useful in evaluating exposure to trichloroethylene.

From our medical investigation based on personal inspection of the work environment, administration of a health oriented questionnaire, and biological urine assays one can feasibly make the following supported observations.

(1) The lack of appropriate protective equipment (eg. gloves, aprons, etc.) and inappropriate materials handling practices contributes to the elicit employee symptomatology.

(2) Based on personal medical interviews and data collected from medical survey questionnaires, it can be concluded that a majority of the individuals present in the Pump Room have, at one time or another, suffered adverse clinical symptoms which might affect their health and safety as well as the health and safety of their fellow workers.

(3) Urine assays for the metabolic derivatives of trichloroethylene (i.e., trichloroethanol, trichloroacetic acid) showed that the workers were exposed to varying levels of trichloroethylene in their work atmosphere.

2. Day Street Plant

To evaluate the severity of health hazard and potential health hazards in the Day Street operation of Dunham Bush, two approaches were utilized. They being, two thorough walk through inspections and the questioning of all concerned employees about their present health status.

Two walk through inspections were carried out on November 21, and December 19, 1972 in the Day Street Plant. On those dates the various industrial processes were examined and the potential health hazards noted.

To date none of these processes can be implicated, as the cause of a deleterious health effect, however, any one of them has the potential to lead to an individually or combined adverse health effect at any given time.

In an attempt to gather further information about the working conditions in this particular facility, all of the employees were afforded the opportunity to discuss personal job related health problems with this medical investigator. Conversations were held with some 30 workers.

The following pertinent information was elicited. None of the workers stated that they missed work due to what they felt were job related illnesses. The majority of workers felt that the major problems existing within this factory were the excessive noise levels and the very poor ventilation. Many complained of difficulty in breathing, that is the air is "dirty and stagnant." They suffered from nasal congestion and upper resipratory tract irritation. The OSHA health log did not supply any additional relevant facts. On our second plant visitation, all the workers were sent home early due to a lack of sufficient heat in the building.

No physical examinations were performed or biological samples obtained on either visitation.

V. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on a collaborative environmental-medical study of the South Street Plant, Pump Room and of the Day Street Plant.

A. Pump Room, South Street Plant

It has been determined that a potentially toxic environment exists within the Pump Room. It has been documented that concentrations of trichloroethylene in workroom air in the Pump Room vary widely (195 to 1,186 mg/m^3) in response to work practices, level of production activity, and general environmental conditions. It is concluded that, during periods of normal to high production activity (8hr-TWA exposures to trichloroethylene in excess of $\approx$500 mg/m^3), that a completely unhealthful work environment exists. Employees under these conditions can suffer adverse symptomatology which may result in an injury to themselves or to their fellow workers. During periods of low production activity (8hr-TWA exposures to trichloroethylene up to $\approx$500 mg/m^3), adverse symptomatology is possible but not as likely to occur.

It is recommended that:

(1) The Pump Room work environment be changed by instituting the specific recommendations stated in Section IV, Part B[1]). These recommendations should reduce trichloroethylene exposures to an acceptable and safe level.

(2) Consumption of alcoholic beverages be strictly prohibited during working hours. (It is well known that consumption of alcohol prior to, during or following exposure to trichloroethylene results in an exaggerated state of intoxication.)

(3) Large, readily visible, warning signs be provided near the two degreasers stating the potential hazards of trichloroethylene.

(4) Urine samples be taken and analyzed for trichloroethylene metabolic products at six month intervals to serve as a qualitative indicator of excessive trichloroethylene exposure.

(5) The use of synthetic rubber gloves be made manditory for all those individuals handling parts that are wet with trichlorotheylene.

(6) Until recommended environmental controls are in operation, employees operating the two degreasers should wear respirators approved by the U.S. Bureau of Mines for protection against trichloroethylene.

B. Day Street Plant

It has been determined that several toxic conditions exist within the Day Street facility. Of most immediate concern is exposure to cadmium which presents a serious hazard to health (8hr-TWA exposures to cadmium 33 to 326 $\mu g/m^3$). Several production processes (e.g., welding, spray painting, grit blasting, flame cutting, polyurethane foam filling, degreasing, etc.) present potential health hazards (e.g., metal fumes, oxidants, vapors, noise, ultraviolet and infrared radiation). Repeatedly in the literature, these kinds of processes have been shown to be directly related to long term occupational illness when conducted without adequate controls. It has been demonstrated that appropriate control is absent in this facility (See Section IV, Part B[2]).

It is recommended that:

(1) Ventilation be provided in the Day Street facility to upgrade engineering control of contaminant generating processes to federal specifications (See Section IV, Part B[2]), and to provide a temperate working environment for all employees,

(2) Individuals working in the Aisle No. 3 brazing area be required to wear respirators approved by the U.S. Bureau of Mines for protection against cadmium fumes until appropriate engineering control is installed.

(3) A complete evaluation of exposures to noise should be made in the Day Street facility and a noise abatement-hearing conservation program be instituted immediately in accordance with U.S. Department of Labor standards (Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart G, Paragraph 1910.95). The plant physician has been provided a packet of pertinent information to facilitate the institution of such a program.

(4) Personal protective equipment should be provided for employees exposed to hazards which can not be adequately abated by engineering controls. At no time should personal protective equipment be substituted for engineering controls when engineering controls are feasible and in accordance with required practice.

(5) Prominent warning signs, specifying the associated hazards, should be provided wherever hazardous materials are used.

(6) Shielding be provided for all welding operations so that workers in adjacent work areas are protected.

(7) The general sanitation (i.e., washrooms, lunchrooms, etc.) of the facility be upgraded to conform with U.S. Department of Labor Regulations (Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart J).

(8) First aid facilities and trained first aid personnel be made available in the Day Street facility.

(9) Means of egress be improved to conform to U.S. Department of Labor Regulations (Federal Register, October 18, 1972, Title 29, Chapter XVII, Subpart E).

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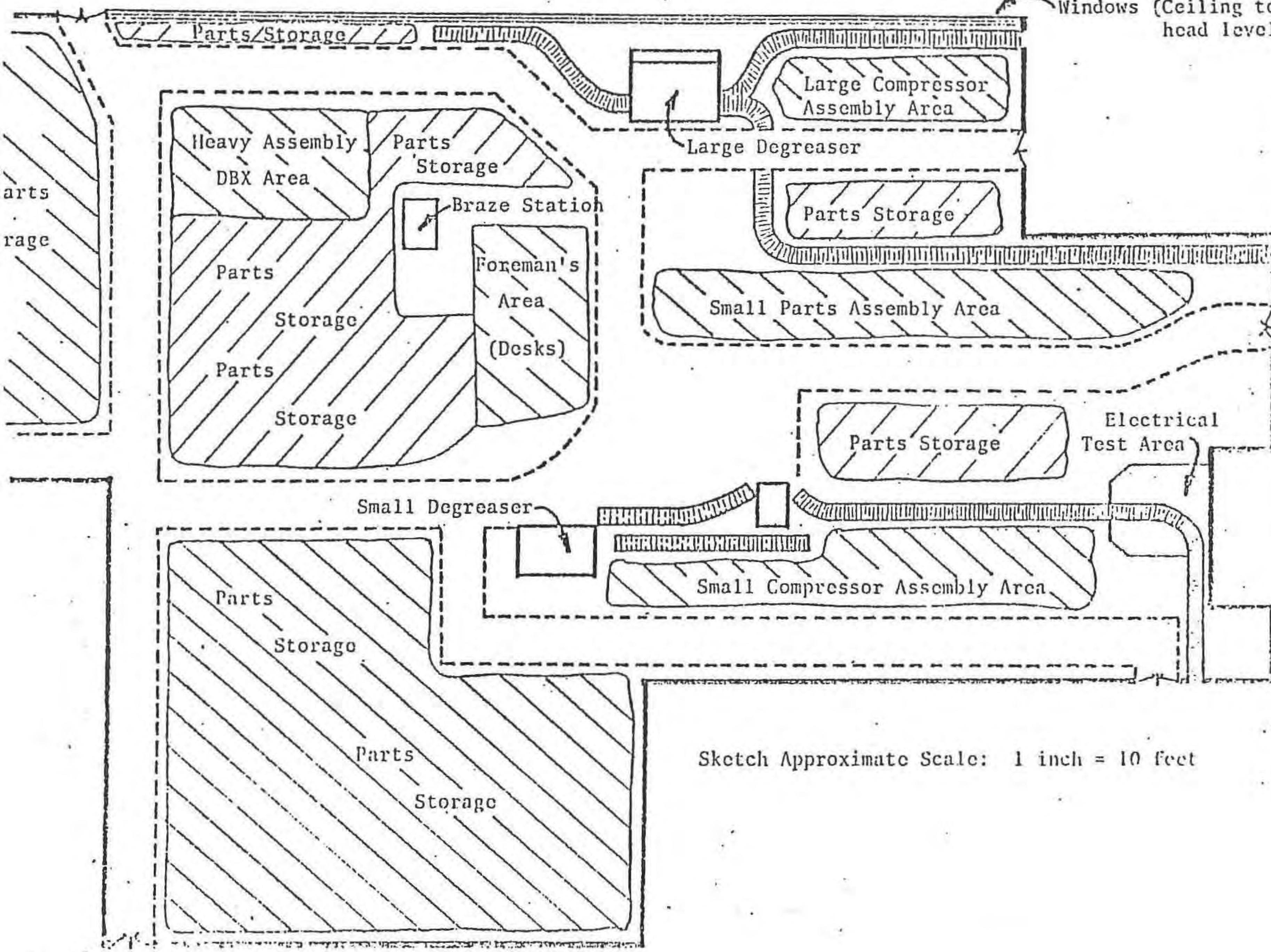
VII. FIGURES, TABLES, AND PHOTOGRAPHS

FIGURE 1

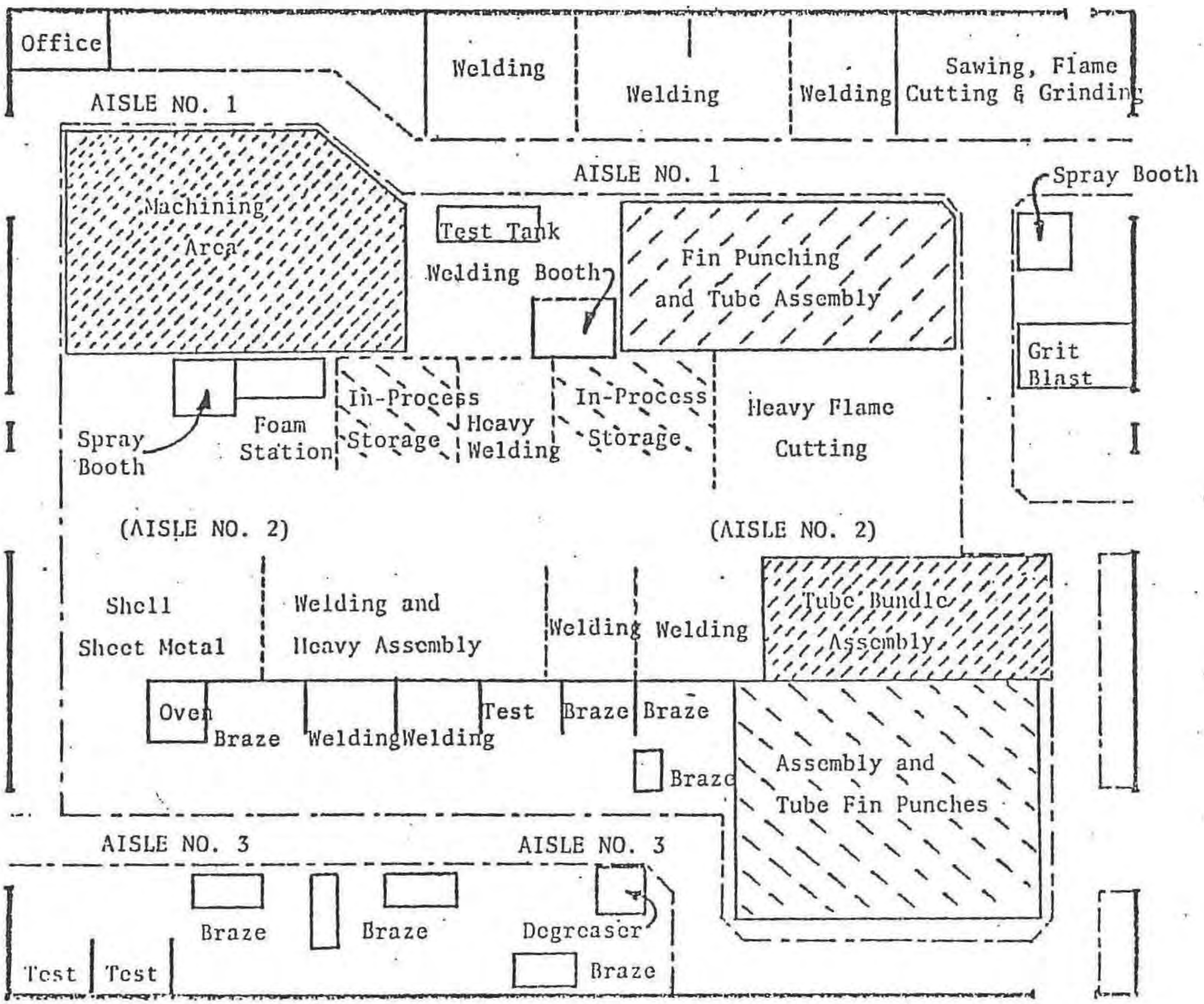
DUNHAM-BUSH, INC. -------------- SOUTH STREET PLANT--PUMP ROOM



Sketch Approximate Scale: 1 inch = 10 feet

FIGURE 2

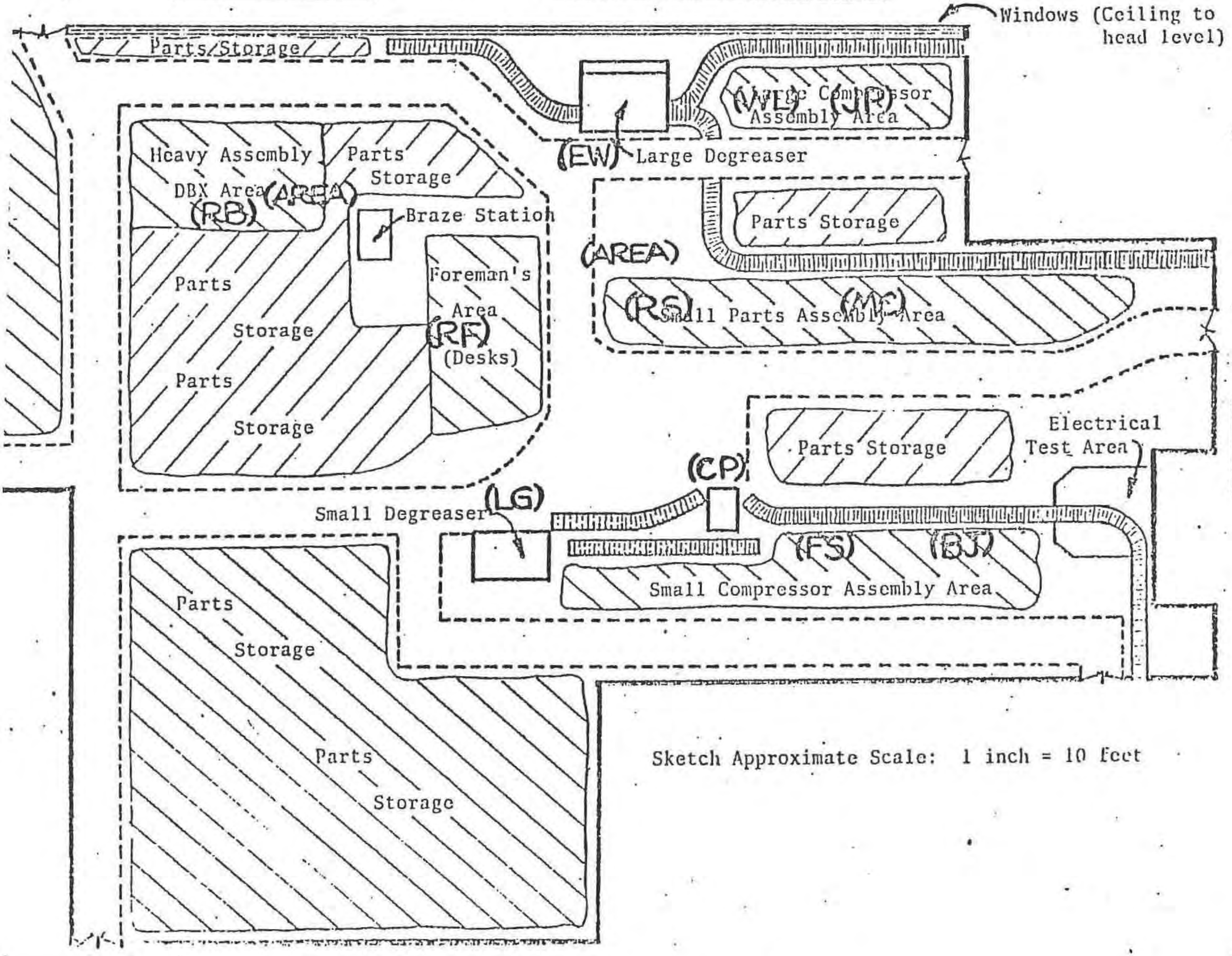
DUNHAM - BUSH, INC. ------------ DAY STREET PLANT



Approx. Scale: 1 inch = 25 feet

FIGURE 3

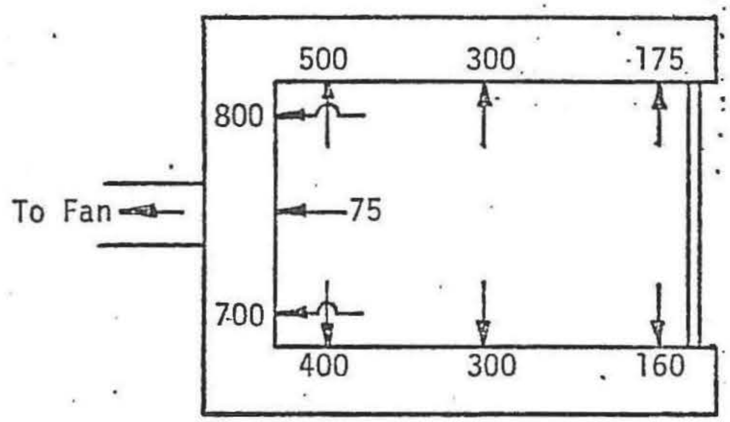
DUNHAM-BUSH, INC. -------------- SOUTH STREET PLANT--PUMP ROOM



Sketch Approximate Scale: 1 inch = 10 feet

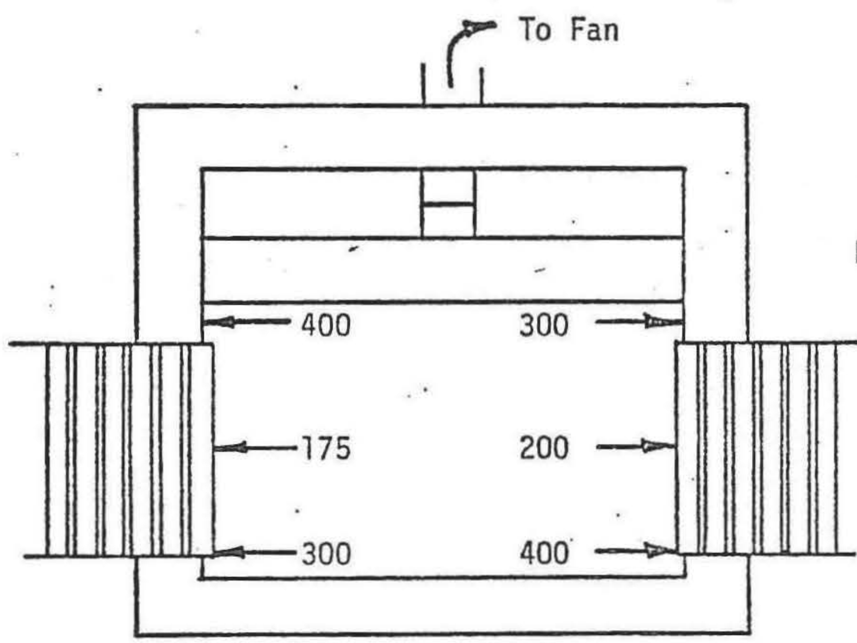
FIGURE 4: Pump Room -- Vapor Degreaser Ventilation Measurements*

A. Small Vapor Degreaser - Air Velocities in Feet per Minute (fpm)



Exhausting Rate:
Q = 400 to 600 cu.ft./min.

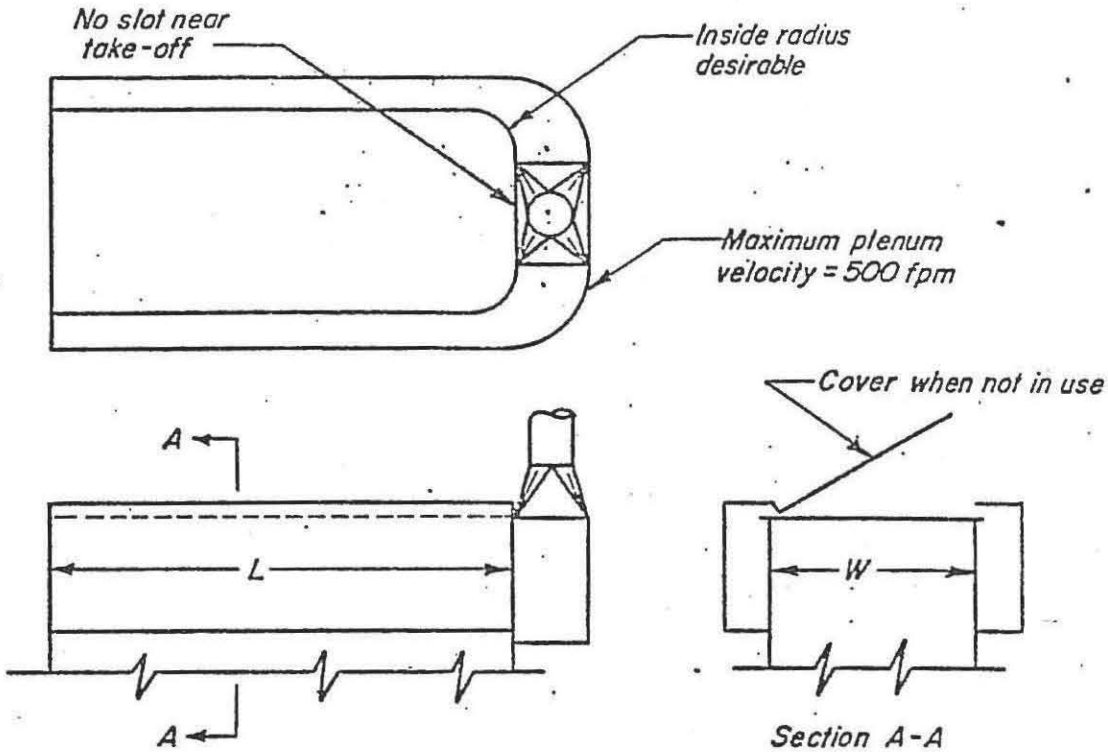
B. Large Vapor Degreaser - Air Velocities in Feet per Minute (fpm)



Exhausting Rate:
Q = 400 to 900 cu.ft./min.

*Air velocities measured with a Type 8500, Alnor Thermo-Anemometer.

FIGURE 5



Q = 50LW
Slot velocity = 1000 fpm maximum
Entry loss = 1.78 slot VP + 0.25 duct VP
Duct velocity = 2500-3000 fpm

Also provide: 1. *Separate flue for combustion products if direct-fired unit.*
2. *For cleaning operation, an air-line respirator is necessary.*
3. *For pit units, the pit should be mechanically ventilated.*

NOTE: Provide downdraft grille for parts that cannot be removed dry; Q = 50 cfm/sq.ft grille area.

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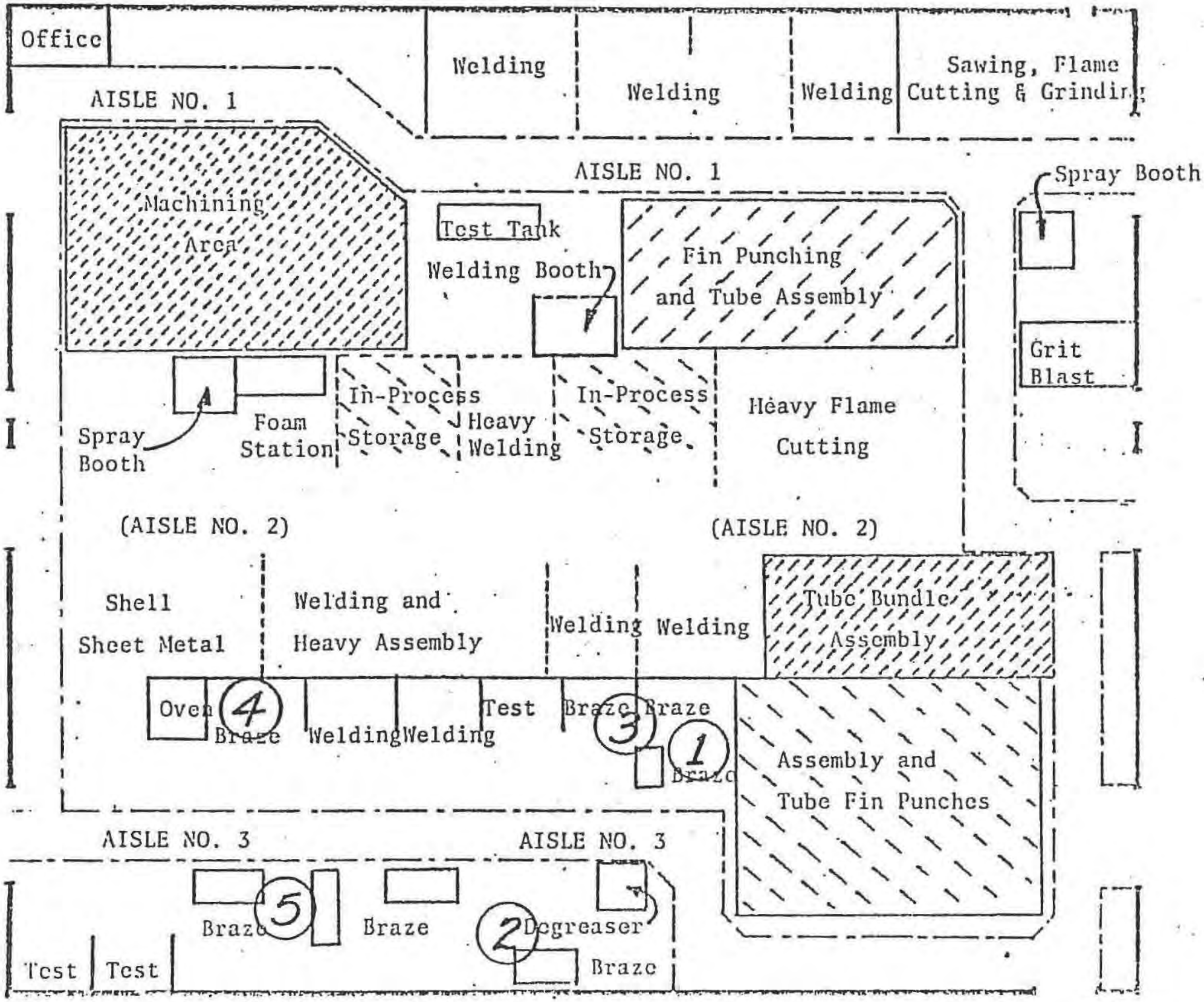
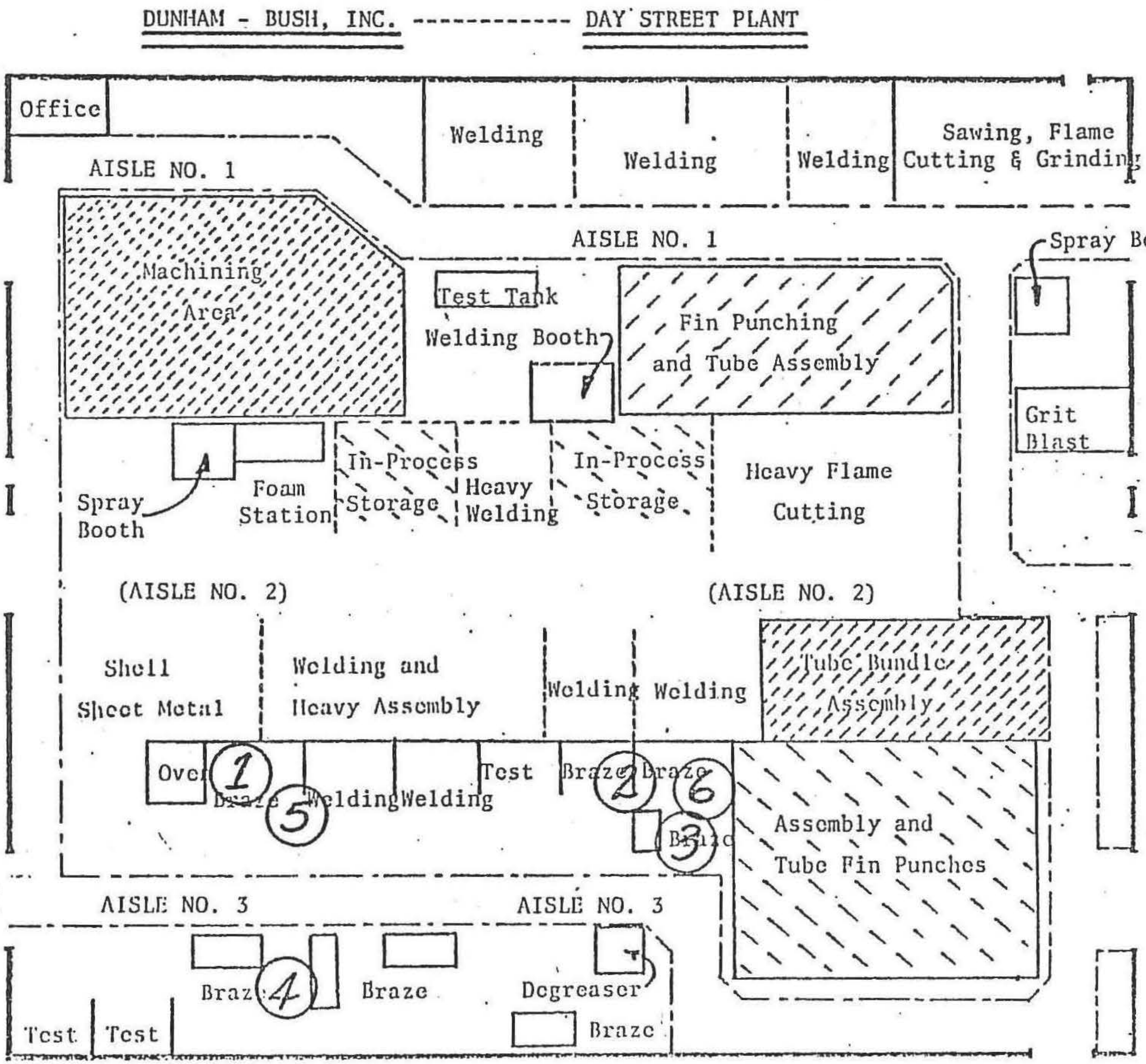
FIGURE 6: Sampling Locations for Cadmium Sampling Conducted 12/19/72.

DUNHAM - BUSH, INC. ----------- DAY STREET PLANT



Approx. Scale: 1 inch = 25 feet

FIGURE 7: Sampling Locations for Cadmium, Silver, Copper, and Zinc
Sampling Conducted 1/9/73.



Approx. Scale: 1 inch = 25 feet

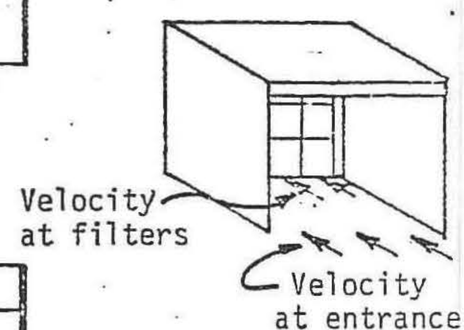
FIGURE 8: Aisle No. 2, Spray Booth -- Ventilation Measurements*
(Measurements made 12/19/72)

A. Air face velocities measured at the booth filters in Feet per Minute.

120	240	190	130
150	200	160	160
150	170	140	110
90	110	90	110

Edge of filter section

B. Air face velocities measured at the booth entrance in Feet per Minute.



140	110	100
150	120	130
130	120	130

*Air velocities measured with a Type 8500, Alnor Thermo-Anemometer.

FIGURE 9: Aisle No. 1, Spray Booth -- Ventilation Measurements*
(Measurements made 12/19/72)

A. Air face velocities measured at booth filters in Feet per Minute.

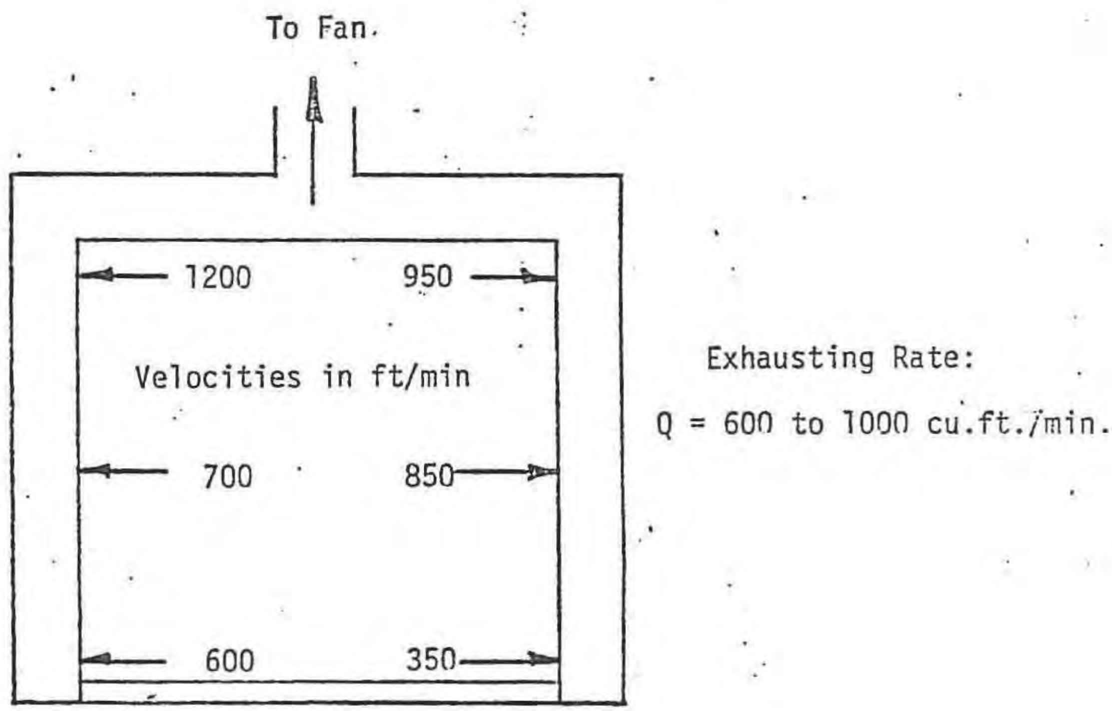
180	140	110	100	90	100	90
100	100	90	80	90	90	90
100	100	80	90	85	85	100
40	60	50	50	40	70	50

B. Air face velocities measured at the booth entrance in Feet per Minute.

70	100	90
80	100	110
80	80	100

*Air velocities measured with a Type 8500, Alnor Thermo-Anemometer.

FIGURE 10: Aisle No. 3, Vapor Degreaser -- Ventilation Measurements*
(Measurements made 12/19/72)



*Air velocities measured with a Type 8500, Alnor Thermo-Anemometer.

TABLE I: Preliminary Trichloroethylene Air Sampling Results. (Samples collected 11/21/72)

Sample No.	Type	Location	Job		Time ON	Time OFF	Sample Vol. liters	Trichloroethylene mg/m³
33	Area*	Large Compressor Assembly Area			10:37 AM	11:08 AM	31	457
34	B.Z.**	At Large Vapor Degreaser	Degreaser Operator	(C)	10:25 AM	11:12 AM	37	1,186
35	B.Z.	At Small Vapor Degreaser	Degreaser Operator	(S)	10:30 AM	11:11 AM	41	466
36	Area	Small Compressor Assembly Area			10:42 AM	11:10 AM	28	405
DT 1	D.T.***	At Small Vapor Degreaser					0.5	535
DT 1	"	"					1.0	590
DT 2	D.T.	Over Large Vapor Degreaser					0.5	535
DT 2	"	"					1.0	560
DT 3	D.T.	At Large Vapor Degreaser					0.5	670
DT 3	"	"					1.0	860
DT 4	D.T.	Small Compressor Assembly Line					0.5	400
DT 4	"	"					1.0	375
DT 5	D.T.	Large Compressor Assembly Line					0.5	350
DT 5	"	"					1.0	295

*Area--Sample collected in work area

**B.Z.--Sample collected in worker's breathing zone.

***D.T.--Air concentration measured with vapor detector tube. Measurement at 5 and 10 [illegible]

TABLE II: Trichloroethylene Concentrations - - - Breathing Zone and Area Samples
(Samples collected 12/18/72)

Sample No.	Type	Location	Job	Time ON	Time OFF	Sample Vol. liters	Trichloroethylene mg/m^3
01	B.Z.*	At Small Vapor Degreaser	Degreaser Operator (LG)	8:53 AM	9:17 AM	24	412
02	B.Z.	Large Compressor Assembly Area	Compressor Assembler (JP)	8:54 AM	9:23 AM	29	202
03	B.Z.	At Large Vapor Degreaser	Degreaser Operator (EW)	8:57 AM	9:32 AM	35	310
04	B.Z.	Lead End of Small Compressor Line	Leadman Small Comp. Assembly (CP)	8:59 AM	9:14 AM	15	341
05	B.Z.	Large Compressor Assembly Area	Compressor Assembler (WL)	9:01 AM	9:18 AM	17	295
06	B.Z.	Entire Shop	Foreman (RF)	9:02 AM	9:20 AM	18	229
09	B.Z.	At Small Vapor Degreaser	Degreaser Operator (LG)	9:33 AM	9:53 AM	20	304
07	Area**	Heavy Assembly DBX Area		9:29 AM	9:51 AM	22	195
10	Area	In Aisle Between Degreasers	-	9:26 AM	9:52 AM	26	268
11	B.Z.	At Large Vapor Degreaser	Degreaser Operator (EW)	9:56 AM	10:23 AM	27	655
12	B.Z.	Small Compressor Assembly Line	Compressor Assembler (FS)	9:58 AM	10:24 AM	26	337
13	B.Z.	Small Assembly Area	Small Parts Assembler (MC)	10:01 AM	10:25 AM	24	346

*B.Z.--Sample collected in worker"s breathing zone.

**Area--Sample collected in work area.

TABLE II: Continued

Sample No.	Type	Location	Job	Time ON	Time OFF	Sample Vol. liters	Trichloroethylene mg/m³
14	B.Z.	Large Compressor Assembly Area	Compressor Assembler (JP)	10:04 AM	10:27 AM	23	327
15	B.Z.	At Small Vapor Degreaser	Degreaser Operator (LG)	10:52 AM	11:12 AM	20	462
16	B.Z.	Lead End of Small Compressor Line	Leadman Small Comp. Assembly (CP)	10:53 AM	11:14 AM	21	334
17	B.Z.	Large Compressor Assembly Area	Compressor Assembler (WL)	10:56 AM	11:15 AM	19	327
18	B.Z.	Small Parts Assembly Area	Small Parts Assembler (RS)	10:58 AM	11:16 AM	18	354
19	B.Z.	At Large Vapor Degreaser	Degreaser Operator (EW)	11:11 AM	11:23 AM	12	512
20	B.Z.	At Small Vapor Degreaser	Degreaser Operator (LG)	12:29 PM	12:51 PM	22	395
21	B.Z.	Small Compressor Assembly Line	Compressor Assembler (BJ)	12:31 PM	12:57 PM	26	357
23	B.Z.	At Large Vapor Degreaser	Degreaser Operator (EW)	12:37 PM	1:03 PM	26	485
24	B.Z.	Heavy Assembly DBX Area	Assembler (RB)	12:42 PM	1:11 PM	29	231
25	B.Z.	Large Compressor Assembly Area	Compressor Assembler (WL)	12:45 PM	1:12 PM	27	413
26	B.Z.	At Large Vapor Degreaser	Degreaser Operator (EW)	2:15 PM	2:44 PM	29	644
27	B.Z.	Lead End of Small Compressor Line	Leadman Small Comp. Assembly (CP)	2:16 PM	2:43 PM	27	515

TABLE II: Continued

Sample No.	Type	Location	Job	Time ON	Time OFF	Sample Vol. liters	Trichloroethylene mg/m3
28	B.Z.	Large Compressor Assembly Area	Compressor Assembler (WL)	2:18 PM	2:45 PM	27	350
29	B.Z.	At Small Vapor Degreaser	Degreaser Operator (LG)	2:19 PM	2:42 PM	23	580
30	B.Z.	Small Assembly Area	Small Parts Assembler (RS)	2:20 PM	2:46 PM	26	428

TABLE III: Trichloroethylene Concentrations by Employee and Work Area
(Samples collected 12/18/72)

Name	Location	Job	Total Sampling Time (min)	Trichloroethylene Conc. (mg/m^3)
LG	At Small Vapor Degreaser	Degreaser Operator	24	412
"	"	"	20	304
"	"	"	20	462
"	"	"	22	395
"	"	"	23	580
EW	At Large Vapor Degreaser	Degreaser Operator	35	310
"	"	"	27	655
"	"	"	12	512
"	"	"	26	485
"	"	"	29	644
CP	Lead End of Small Compressor Line	Leadman Small Comp. Assembly	15	341
"	"	"	21	334
"	"	"	27	515
WL	Large Compressor Assembly Area	Compressor Assembler	17	295
"	"	"	19	327
"	"	"	27	413
"	"	"	27	350
JP	Large Compressor Assembly Area	Compressor Assembler	29	202
"	"	"	23	327
FS	Small Compressor Assembly Line	Compressor Assembler	26	337
BJ	Small Compressor Assembly Line	Compressor Assembler	26	357
RS	Small Parts Assembly Area	Small Parts Assembler	18	354
"	"	"	26	428
MC	Small Parts Assembly Area	Small Parts Assembler	24	346
RF	Entire Shop	Foreman	18	229
RB	Heavy Assembly DBX Area	Assembler	29	231
	Heavy Assembly DBX Area	(Area Sample)	22	195
	In Aisle Between Degreasers	(Area Sample)	26	268

TABLE IV: Employee Eight-Hour Time-Weighted-Average Exposures to Trichloroethylene. (Samples Collected 12/18/72)

Name	Location	Job	Total Time Sampled (min)	8hr-TWA Exposure to Trichloroethylene* (mg/m^3)
LG	At Small Vapor Degreaser	Degreaser Operator	109	380
EW	At Large Vapor Degreaser	Degreaser Operator	129	420
CP	Lead End of Small Comp. Line	Leadman Small Comp. Asmbly.	63	360
WL	Large Compressor Assembly Area	Compressor Assembler	90	310
JP	Large Compressor Assembly Area	Compressor Assembler	52	220
FS	Small Compressor Assembly Line	Compressor Assembler	26	300
BJ	Small Compressor Assembly Line	Compressor Assembler	26	310
RS	Small Parts Assembly Area	Small Parts Assembler	44	330
MC	Small Parts Assembly Area	Small Parts Assembler	24	300
RF	Entire Shop	Foreman	18	200
RB	Heavy Assembly DBX Area	Assembler	29	200
	Heavy Assembly DBX Area	(Area Sample)	22	170
	In Aisle Between Degreasers	(Area Sample)	26	230

*Exposures calculated on the basis of 7 hours in the Pump Room and 1 hour out of the Pump Room for breaks and lunch.

TABLE V: Cadmium Concentrations by Employee and Work Area (Samples collected 12/19/72)

Sample No.	Type	Location (See Figure 6)	Job		Time ON	Time OFF	Sample Volume liters	Cadmium µg/m^3**
CD 01	B.Z.*	No. 1	Brazer	(JS)	9:23 AM	11:08 AM	105	161
CD 02	B.Z.	No. 2	Unit Assembler	(BL)	9:20 AM	11:07 AM	107	46
CD 03	B.Z.	No. 3	Asmbly. Brazer	(MJ)	9:16 AM	11:09 AM	113	44
CD 04	B.Z.	No. 4	Brazer	(EW)	9:14 AM	11:06 AM	112	259
CD 05	B.Z.	No. 4	Brazer	(EW)	12:53 PM	2:54 PM	121	99
CD 06	B.Z.	No. 3	Asmbly. Brazer	(MJ)	12:55 PM	2:54 PM	119	50
CD 07	B.Z.	No. 1	Brazer	(JS)	12:58 PM	2:57 PM	119	210
CD 08	B.Z.	No. 5	Brazer	(WM)	1:00 PM	2:53 PM	113	44

*B.Z.--Sample collected in worker's breathing zone
**µg/m^3--Micrograms per cubic meter of air.

TABLE VI: Cadmium, Silver, Copper, and Zinc Concentrations by Employee and Work Area.
(Samples collected 1/9/73)

Sample No.	Type	Location (See Fig. 7)	Job	Time ON	Time OFF	Sample Vol. (liters)	Cadmium (μg/m³)**	Silver (μg/m³)	Copper (μg/m³)	Zinc (μg/m³)
CD 01	B.Z.*	No. 1	Brazer (EW)	7:42 AM	10:55 AM	193	45	1	8	11
CD 04	B.Z.	No. 2	Asmbly. Brazer (MJ)	7:45 AM	10:55 AM	207	88	5	15	30
CD 05	B.Z.	No. 3	Brazer (JS)	7:48 AM	11:13 AM	205	612	6	13	112
CD 06	B.Z.	No. 4	Brazer (CH)	7:50 AM	10:59 AM	189	54	3	13	20
CD 02	Area	No. 5	Area Sample	7:54 AM	10:57 AM	183	56	3	9	18
CD 08	Area	No. 6	Area Sample	7:59 AM	10:58 AM	179	60	6	7	22
CD 10	B.Z.	No. 1	Brazer (EW)	12:00 Noon	2:59 PM	179	68	5	45	31
CD 14	B.Z.	No. 2	Asmbly. Brazer (MJ)	12:03 PM	2:57 PM	174	57	3	43	22
CD 12	B.Z.	No. 3	Brazer (JS)	12:01 PM	2:23 PM	142	27	N.D.***	4	7
CD 13	B.Z.	No. 4	Brazer (CH)	12:02 PM	2:56 PM	174	57	6	30	54
CD 11	Area	No. 5	Area Sample	11:55 AM	2:56 PM	168	30	1	11	22
CD 15	Area	No. 6	Area Sample	11:58 AM	2:54 PM	176	14	N.D.	3	17

*B.Z.--Sample collected in worker's breathing zone.
**μg/m³--Micrograms of contaminant in one cubic meter of air.

***N.D.--Indicates that less than one microgram of the contaminant was present.

TABLE VII: Employee Eight-Hour Time-Weighted-Average Exposures to Cadmium. (Samples Collected 12/19/72 and 1/9/73)

Name	Job	Total Time Sampled (min)	Date	8hr Time-Weighted-Average Exposure to Cadmium (ug/m^3)*
JS	Brazer**	224	12/19/72	164
JS	Brazer**	347	01/09/73	326
EW	Brazer**	233	12/19/72	154
EW	Brazer	372	01/09/73	49
MJ	Asmbly. Brazer	232	12/19/72	41
MJ	Asmbly. Brazer	381	01/09/73	65
BL	Unit Assembler	107	12/19/72	40
WM	Brazer	113	12/19/72	39
CH	Brazer	363	01/09/73	49
	Area No. 5***	351	01/09/73	38
	Area No. 6***	355	01/09/73	33

*Exposures calculated on the basis of 7 hours of brazing and 1 hour out of the brazing area for breaks and lunch.
**Worker using cadmium bearing material.
***See Figure 7 for sampling location.

TABLE VIII: Results of Isocyanate Air Sampling--Foam Filling Area
Samples Collected 1/9/73)

Sample No.	Description of Sampling Location	Time Start	Time Stop	Isocyanate Concentration (ug/m^3)*
IS 01	Adjacent to foam storage tanks.	8:13 AM	8:40 AM	< 1**
IS 03	Over foam storage tanks	8:44 AM	9:03 AM	"
IS 04	Near worker's breathing zone	8:49 AM	8:59 AM	"
IS 05	Near worker's breathing zone	9:40 AM	9:51 AM	"
IS 06	Over waste foam dump area	9:40 AM	9:58 AM	"
IS 08	Near worker's breathing zone	1:59 PM	2:16 PM	"
IS 09	Near worker's breathing zone	2:32 PM	2:44 PM	

*Micrograms of isocyanate compound (TDI or MDI) per cubic meter of air.

**All samples were found to contain less than one microgram of isocyanate compound (TDI or MDI).

TABLE IX: Results of Air Sampling -- Spray Painting Booths (Samples collected 12/19/72)

Sample No.	Type	Location	Job	Time ON	Time OFF	Sample Volume (liters)	Methylene Chloride (mg/m^3)**
32	B.Z.*	Aisle No. 2 (Front) Spray Booth	Spray Painter (DR)	9:38 AM	10:10 AM	32	64
34	B.Z.	"	"	10:12 AM	10:44 AM	32	54
35	B.Z.	"	"	10:47 AM	11:14 AM	27	63
36	B.Z.	"	"	1:20 PM	1:40 PM	20	36
38	B.Z.	"	"	1:43 PM	2:12 PM	29	74
33	B.Z.	Aisle No. 1 (Rear) Spray Booth	Spray Painter (JL)	1:04 PM	1:22 PM	18	< 1
37	B.Z.	"	"	1:22 PM	1:45 PM	23	3
39	B.Z.	"	"	1:45 PM	2:07 PM	22	4

*B.Z.--Sample collected in worker's breathing zone.
**mg/m^3--Milligrams contaminant per cubic meter of air.

TABLE X: Results of Noise Exposure Survey -- (Measurements made 12/19/72)

Location	Operation	No. Exp.	Hrs. Exp.	Noise I S	Exposure C I	HPD Y N	dBA Machine	dBA Operation
Day Street Plant Aisle 1 - Front	Coffee Break (Background Level)	35	8	S	C	N		70-72
Day Street Plant Aisle 1 - Left	Sheet Sawing 173	1	1.5	S	I	N	115-120	90-95
Day Street Plant Aisle 1 - Left	Welding Dept. 26 Chipping Slag	7	0.6	I	I	N	112-120	90-100
Day Street Plant Aisle 1 - Right	Tube Assembly Area	4	8	S	C	N		82-85
Day Street Plant Aisle 1 - Back	Paint Spray Booth	1	8	S	C	N		90-95
Day Street Plant Aisle 1 - Back	Metal Sawing	3	4	S	I	N	105-110	100-105
Day Street Plant Back Aisle	Grit Blasting (Outside Chamber)	1	4	S	I	N		95-100
Day Street Plant Aisle 2 - Back	Machine Grinding 29F	4	2	S	I	N	110-120	95-105
Day Street Plant Aisle 2	Welding 29F	1	8	S	C	N		80-90
Day Street Plant Aisle 2	Hammering 29F	1	0.5	I	I	N		115-120
Day Street Plant Aisle 2	Welding	1	7.5	S	I	N	85-90	80-85
Day Street Plant Aisle 2	Removing splatters from metal	6	0.8	S	I	N	115-120	100-105
Day Street Plant Aisle 2 - Middle	Center of Aisle 2	15	8	S	C	N		90-95
Day Street Plant Aisle 2 - Front	Foaming Area	1	8	S	C	N		90
Day Street Plant Aisle 2 - Front	Paint Spray Booth	1	8	S	I	N	100-105	90-100

Noise: I = Impulse, S = Steady
Exposure: C = Continuous, I = Intermittent
HPD (Hearing Protection Devices): Y = Yes, N = No
dBA: Sound Level in decibels (Measured using A-weighting network and slow meter response.)

TABLE XI: Comparison of Trichloroacetic Acid Methods

(Samples were selected and run in small batches on different days and read against a standard curve prepared on the day of analysis.)

Method 1: Tanaka & Ikeda (1968)
Method 2: Frant & Westendorp (1950)

Sample No.	TCA mg/l Method 1	TCA mg/l Method 2	Sample No.	TCA mg/l Method 1	TCA mg/l Method 2
1	73	65	27	ND	ND
2	52	48	28	3	5
3	138	125	29	ND	3
4	104	74	30	ND	ND
5	61	52	31	45	47
6	106	91	32	ND	3
7	46	31	33	ND	6
8	30	21	34	ND	3
9	20	18	35	97	85
10	7	5	36	ND	5
11	ND	ND	37	39	38
12	77	62	38	ND	ND
13	ND	ND	39	ND	ND
14	ND	ND	40	ND	ND
15	31	27	41	ND	ND
16	44	40	42	54	48
17	193	173	43	ND	3
18	21	21	44	50	47
19	197	196	45	46	45
20	98	89	46	72	68
21	12	11	47	26	28
22	ND	3	48	4	7
23	ND	ND	49	35	43*
24	58	58	50	30	41*
25	ND	ND	51	13	33*
26	4	3	52	44	68*

TABLE XI: Continued

Sample No.	TCA mg/l Method 1	TCA mg/l Method 2
53	65	79*
54	38	45*
55	93	115*
56	120	145*
57	35	99*
58	8	39*
59	ND	ND
60	ND	4
61	3	7

Note: Samples marked with * were incorrectly analyzed due to a laboratory mistake in dilution of sample accounting for generally elevated values.

TABLE XII: Trichloroacetic Acid, [illegible]
Determinations on Split [illegible]

Specimen Number	TCA mg/l	Creatinine g/l	TCA mg/g Creatinine	[illegible]	[illegible]
61	3	0.7	4	[illegible]	[illegible]
10	7	0.7	10	[illegible]	[illegible]
62	27	1.8	15	[illegible]	[illegible]
47	26	1.8	14	[illegible]	[illegible]
63	ND	2.2	ND	[illegible]	[illegible]
60	ND	2.2	ND	[illegible]	[illegible]
64	13	1.3	10	91	[illegible]
50	30	1.3	23	83	[illegible]
65	ND	1.9	ND	ND	ND
43	ND	1.9	ND	ND	ND
66	ND	2.8	ND	ND	ND
23	ND	2.8	ND	ND	ND

ND - Not distinguishable from zero. Limits of detection are approximately 2 mg/l.

TABLE XIII: Results of Urine Determinations by Employee
(Controls-NIOSH Staff-Exposed)

Name	Sample No.	AM PM	Creatinine g/l	TCA mg/l	TCA mg/g Creatinine	TCE mg/l	TCE mg/g Creatinine
Controls							
KK	13	AM	2.1	ND	ND	ND	ND
KK	39	PM	0.9	ND	ND	ND	ND
WM	14	AM	0.6	ND	ND	ND	ND
WM	40	PM	0.6	ND	ND	ND	ND
PR	22	AM	2.6	ND	ND	ND	ND
PR	43	PM	1.9	ND	ND	ND	ND
AG	25	AM	1.7	ND	ND	ND	ND
AG	41	PM	0.5	ND	ND	ND	ND
AA	26	AM	3.5	4	ND	3	ND
AA	38	PM	3.0	ND	ND	ND	ND
WL	27	AM	1.7	ND	ND	ND	ND
WL	59	PM	1.2	ND	ND	ND	ND
TM	28	AM	2.0	3	ND	ND	ND
TM	33	PM	2.7	ND	ND	ND	ND
HB	29	AM	1.3	ND	ND	ND	ND
HB	32	PM	1.5	ND	ND	ND	ND
TK	30	AM	1.2	ND	ND	ND	ND
TK	34	PM	1.7	ND	ND	ND	ND
NIOSH Staff							
RV	11	AM	1.8	ND	ND	ND	ND
RV	60	PM	2.2	ND	ND	132	60
PP	23	AM	2.8	ND	ND	ND	ND
PP	36	PM	2.5	ND	ND	63	25
Exposed							
FS	1	AM	1.4	73	52	28	20
FS	42	PM	0.5	54	108	119	238
CP	2	AM	2.0	52	26	75	37
CP	21	PM	0.6	45	75	168	280
AD	3	AM	1.7	138	81	108	64
AD	46	PM	1.1	72	65	146	133
LG	4	AM	1.3	104	80	23	18
LG	35	PM	1.1	97	88	269	244
JP	5	AM	1.7	61	36	39	23
JP	44	PM	1.5	50	33	172	115

TABLE XIII: Continued

Name	Sample No.	AM PM	Creatinine g/l	TCA mg/l	TCA mg/g Creatinine	TCE mg/l	TCE mg/g Creatinine
Exposed - Continued							
FS	6	AM	1.1	106	96	50	45
FS	53	PM	1.5	65	43	260	173
DC	7	AM	2.6	46	18	35	13
DC	45	PM	2.5	46	18	338	135
BJ	8	AM	0.9	30	33	19	21
BJ	52	PM	2.1	44	21	240	114
EW	9	AM	1.7	20	12	37	22
EW	47	PM	1.8	26	14	135	75
WL	10	AM	0.7	7	10	ND	ND
WL	48	PM	1.2	4	3	196	163
RB	12	AM	1.4	77	64	27	22
RB	49	PM	0.8	35	44	119	149
RC	15	AM	2.0	31	15	25	12
RC	54	PM	1.7	38	22	135	79
MC	16	AM	1.5	44	29	56	37
MC	37	PM	2.0	39	19	112	56
RS	17	AM	2.0	193	96	103	51
RS	55	PM	0.8	93	116	159	199
RB	18	AM	0.5	21	42	11	22
RB	51	PM	0.8	13	16	119	149
RC	19	AM	1.8	197	109	151	84
RC	57	PM	1.3	35	27	190	146
EF	20	AM	1.7	98	58	87	51
EF	56	PM	1.7	120	71	196	115
NL	21	AM	0.6	12	20	4	7
NL	50	PM	1.3	30	23	83	64
RR	24	AM	1.3	58	43	73	56
RR	58	PM	1.9	8	4	234	123

Abbreviations:
- TCA - Trichloroacetic Acid
- TCE - Trichloroethanol
- TTC - Total Trichloro Compounds (TCE = TTC - TCA)
- ND - Not distinguishable from zero. Limits of detection approximately 2 mg/l.

TABLE XIV: Summary of Exposure Data. - Urine Analyses

	TCA mg/l	TCA mg/g Creatinine	TCE mg/l	TCE mg/g Creatinine
Controls				
Range AM & PM	ND-4	ND	ND	ND
Exposed				
AM Range	7-197	10-109	0-151	0-84
Mean	72	48	53	34
σ_s	56	31	39	21
PM Range	4-120	3-116	73-338	56-280
Mean	48	43	179	145
σ_s	30	35	57	61
NIOSH Staff				
PP				
AM	ND	ND	ND	ND
PM	ND	ND	63	25
RV				
AM	ND	ND	ND	ND
AM	ND	ND	132	60

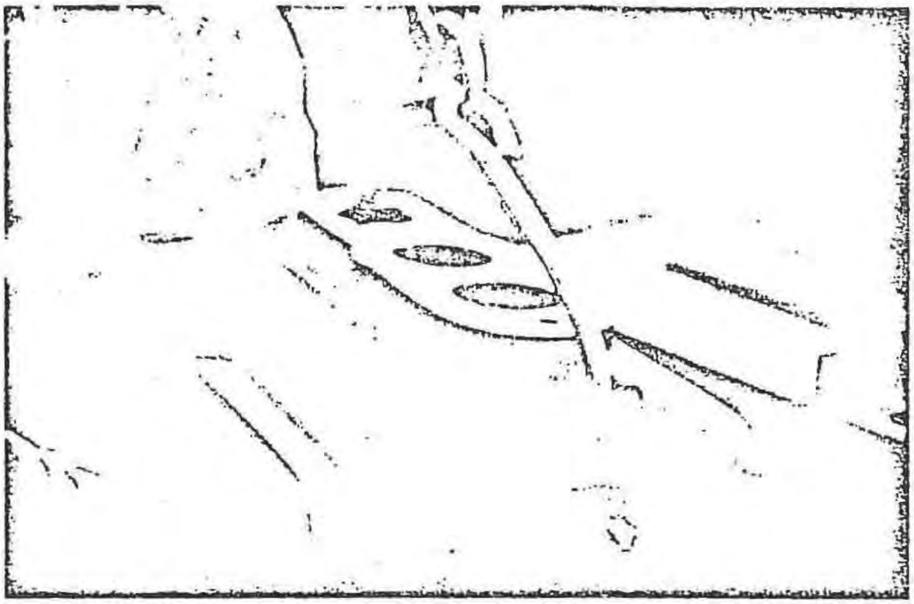


PHOTO NO. 1 - Large casting with many cavities; not easily rotated so that solvent can be discharged.

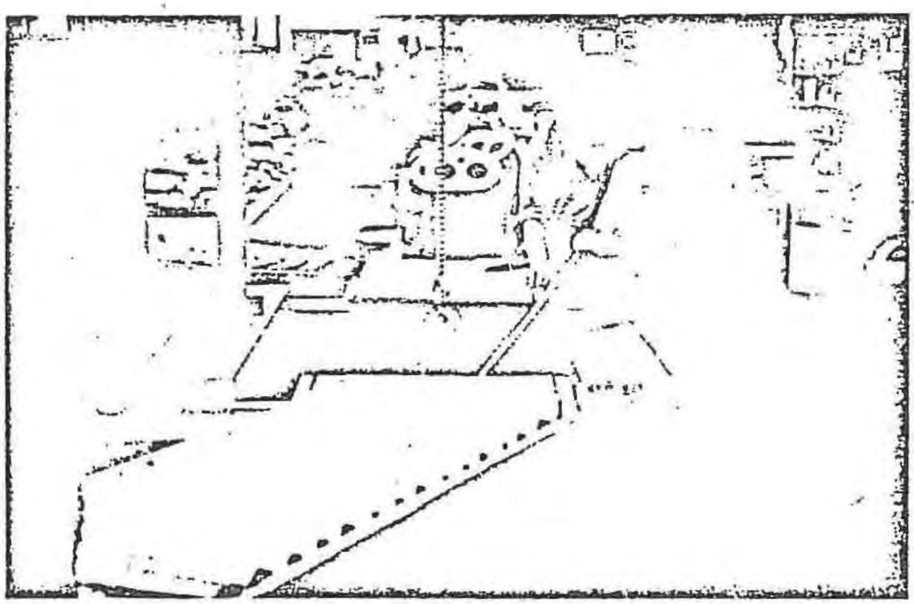


PHOTO NO. 2 - Degreaser being improperly used; part being degreased at too high an elevation.

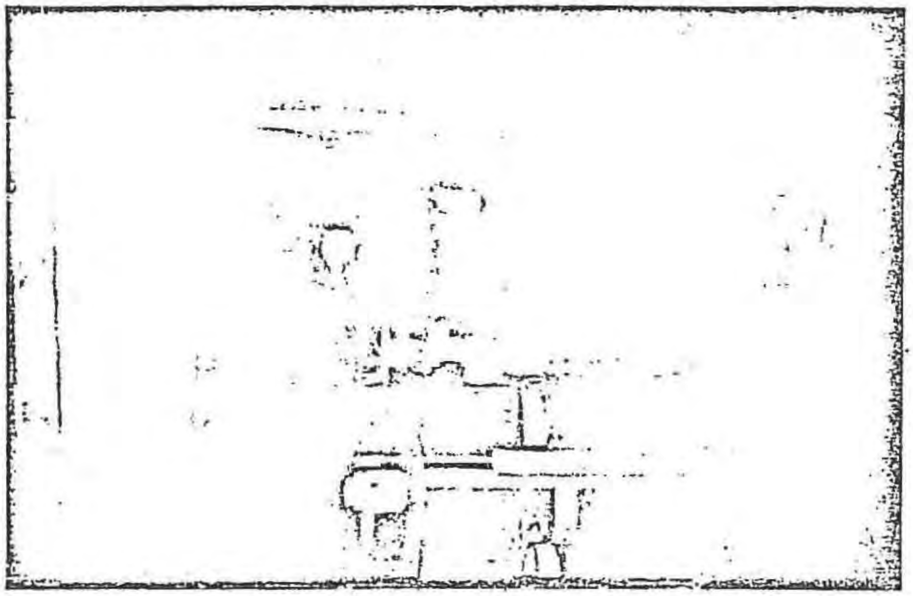


PHOTO NO. 3 - Brazing station with a form of ventilation. Note: Overhead exhaust draws air contaminants through worker's breathing zone.

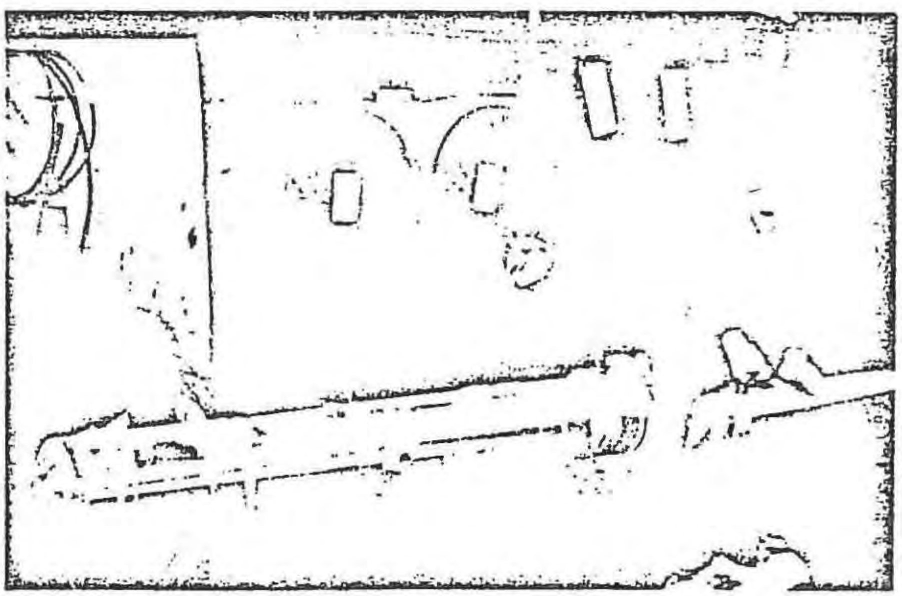


PHOTO NO. 4 - Foam Filling Operation: No engineering control; inadequate personal protective equipment.

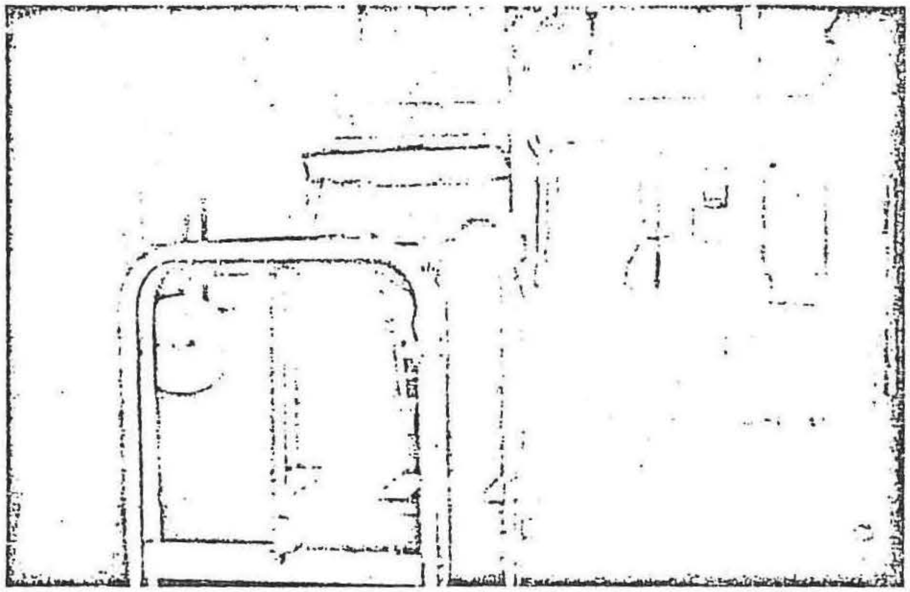


PHOTO NO. 5 - Welding Booth: Small axial wall fan and pedestal fan only sources of ventilation.

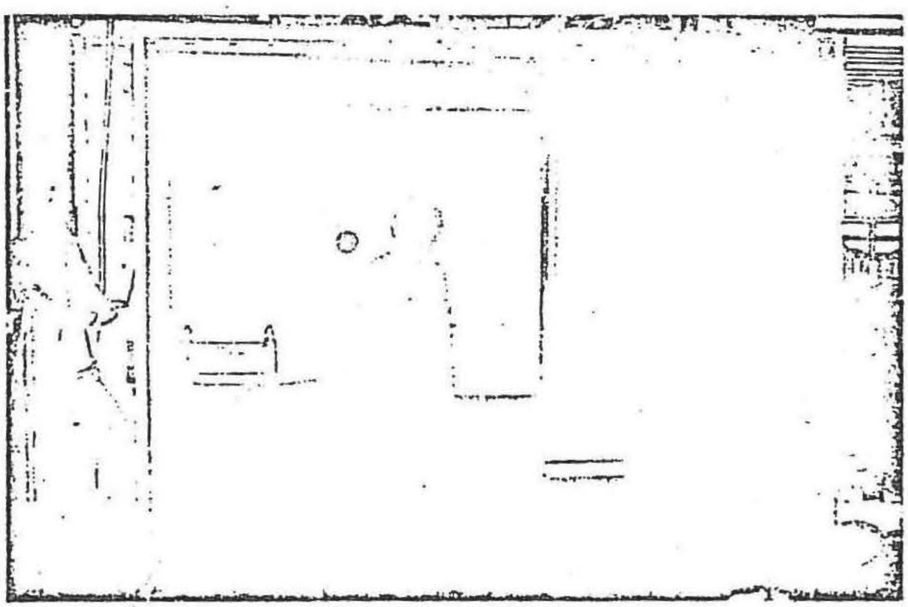


PHOTO NO. 6 - Grit Blasting Chamber: Single exhaust pickup in rear wall of chamber; no easily accessible observation ports.

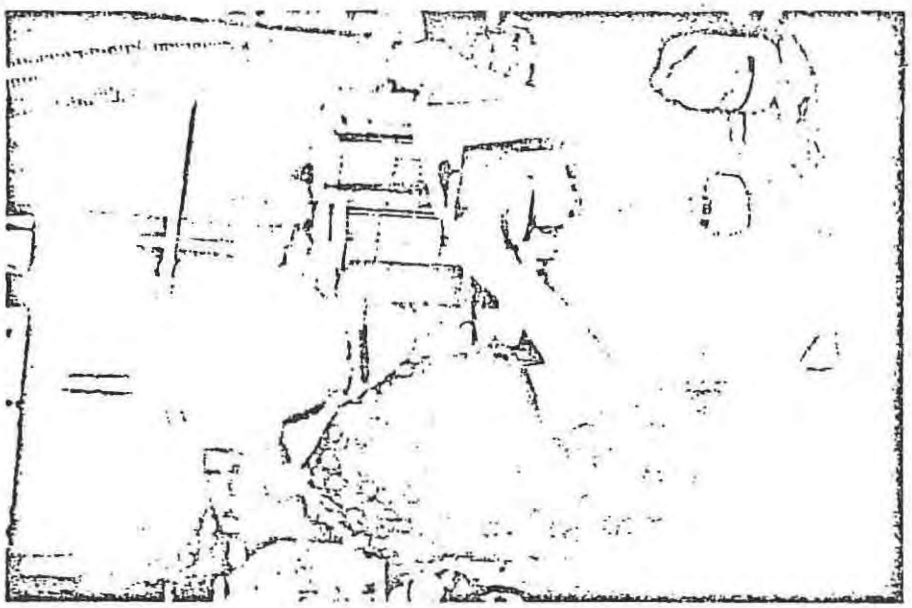


PHOTO NO. 7 - Appropriate local exhaust ventilation observed in South Street Plant.

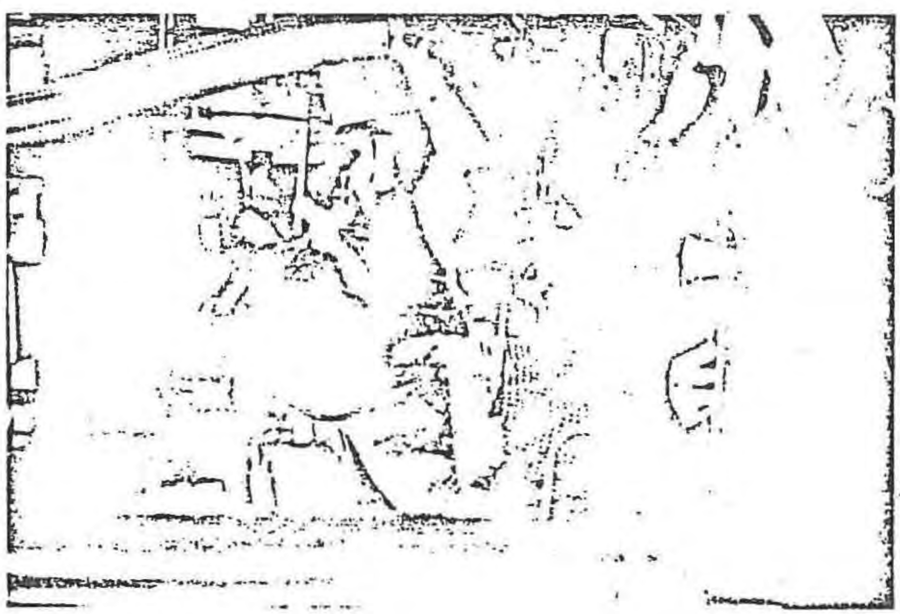


PHOTO NO. 8 - Appropriate local exhaust ventilation observed in South Street Plant.

VIII. Appendix A

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
HEALTH SERVICES AND MENTAL HEALTH ADMINISTRATION
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
518 POST OFFICE BUILDING
CINCINNATI, OHIO 45202

Air Compressor Fabricators Study
Medical Questionnaire

CONSENT

I hereby voluntarily agree to participate in a study of air compressor fabricators to exposure to trichloroethylene and its by-products to be conducted by the U.S. Public Health Service. I agree to answer questions about my health which have a bearing in this study.

I agree to give a sample of my urine to determine whether I have had a significant exposure to trichloroethylene fumes. I am aware that medical information will be used for statistical purposes only unless I authorize otherwise. I am also aware that I may withdraw from the study at any time.

DATE______________________________ SIGNATURE______________________________

AUTHORIZATION FOR RELEASE OF MEDICAL INFORMATION

I hereby request that the Public Health Service inform my personal physician

Dr.______________________________

Street______________________________City______________________________

and the company physician of

Company Name:______________________________City______________________________

of any significant medical findings from this study.

SIGNATURE______________________________

Note: Strike out the words "and the company physician Company Name:____________ City___________", if the worker prefers that the significant medical findings from this study be sent only to his personal physician.

Information obtained in this study will be kept confidential in accordance with U.S. Public Health Service Regulation (42 DFR Part 1).

EMPLOYEE STUDY NUMBER:____________

Name____
Last First Middle

Address____
Street

____
City State Zip Code

Social Security Number:_____/_____/_____

Date of Birth:____________________ Sex: Male_____ Female_____
Month. Day Year

USE THE ACTUAL WORDING OF EACH QUESTION. PUT "X" IN APPROPRIATE SQUARE AFTER EACH QUESTION. WHEN IN DOUBT RECORD "NO".

---

(1) Job Title - Fill in Blank_______________________________

Length of employment on this particular job_______________________

Which shift_______________________________

(2) Are you exposed on a routine basis to trichloroethylene fumes? Yes ☐ No ☐

(3) How long has the use of trichloroethylene been a part of your work procedure?

0 to less than 1 year ☐

1 year to less than 5 years ☐

5 years to less than 10 years ☐

more than 10 years ☐

(4) Have you ever experienced any of the following symptoms during working hours:

	Never	(1--2x/per month) Sometimes	(> 1x/per week) Frequently
Nausea	____	____	____
Vomiting	____	____	____
Dizziness	____	____	____
Weakness	____	____	____
Nervousness	____	____	____
Burning or itching eyes	____	____	____
Chest pain	____	____	____
Tearing	____	____	____
Cough	____	____	____
Frequent headaches	____	____	____
Tiredness	____	____	____
Rashes	____	____	____
Swelling of eyelids	____	____	____
Weight loss	____	____	____
Sneezing	____	____	____
Insomnia	____	____	____
"Runny nose"	____	____	____
Numbness or tingling sensations	____	____	____
Hoarseness	____	____	____
Nasal Stuffiness	____	____	____
Shortness of breath	____	____	____
Skin sores	____	____	____
Upset stomach	____	____	____
Vomiting	____	____	____
Redness of eyes	____	____	____
Hives	____	____	____
Diarrhea	____	____	____
Excessive thirst or arising	____	____	____
Loss of appetite	____	____	____
Changes in skin color	____	____	____
Heart palpitations	____	____	____
Dryness and cracking of skin	____	____	____

(3)

(5) Have you ever left work due to any of the above symptoms: Yes ☐ No ☐

If yes, state which symptoms and how frequently: ______________________

____

____

____

(6) Have you been treated by a physician for any of these problems: Yes ☐ No ☐

(7) Have you ever been treated for:

	Yes	No
Heart trouble	☐	☐
Liver trouble	☐	☐
Kidney trouble	☐	☐
Chest trouble	☐	☐
High blood pressure	☐	☐
Nervous problems	☐	☐

(8) Do you drink alcoholic beverages: Yes ☐ No ☐

If yes:

	1 per day	2 to 3 per day	4 to 5 per day	more than 6 per day
beer (bottles)	____	____	____	____
wine (glasses)	____	____	____	____
liquor (shots)	____	____	____	____

(9) Do you smoke now: Yes ☐ No ☐

If yes:

	Number per day	Number years
Cigarettes	____	____
Cigars	____	____
Pipes	____	____
Snuff	____	____

Have you ever smoked: Yes ☐ No ☐

If yes:

	Number per day	Number years	How many years since last smoked
Cigarettes	____	____	____
Cigars	____	____	____
Pipes	____	____	____
Snuff	____	____	____

(10) Have you ever suffered any job related injuries: Yes ☐ No ☐

Please state which ____

____

____