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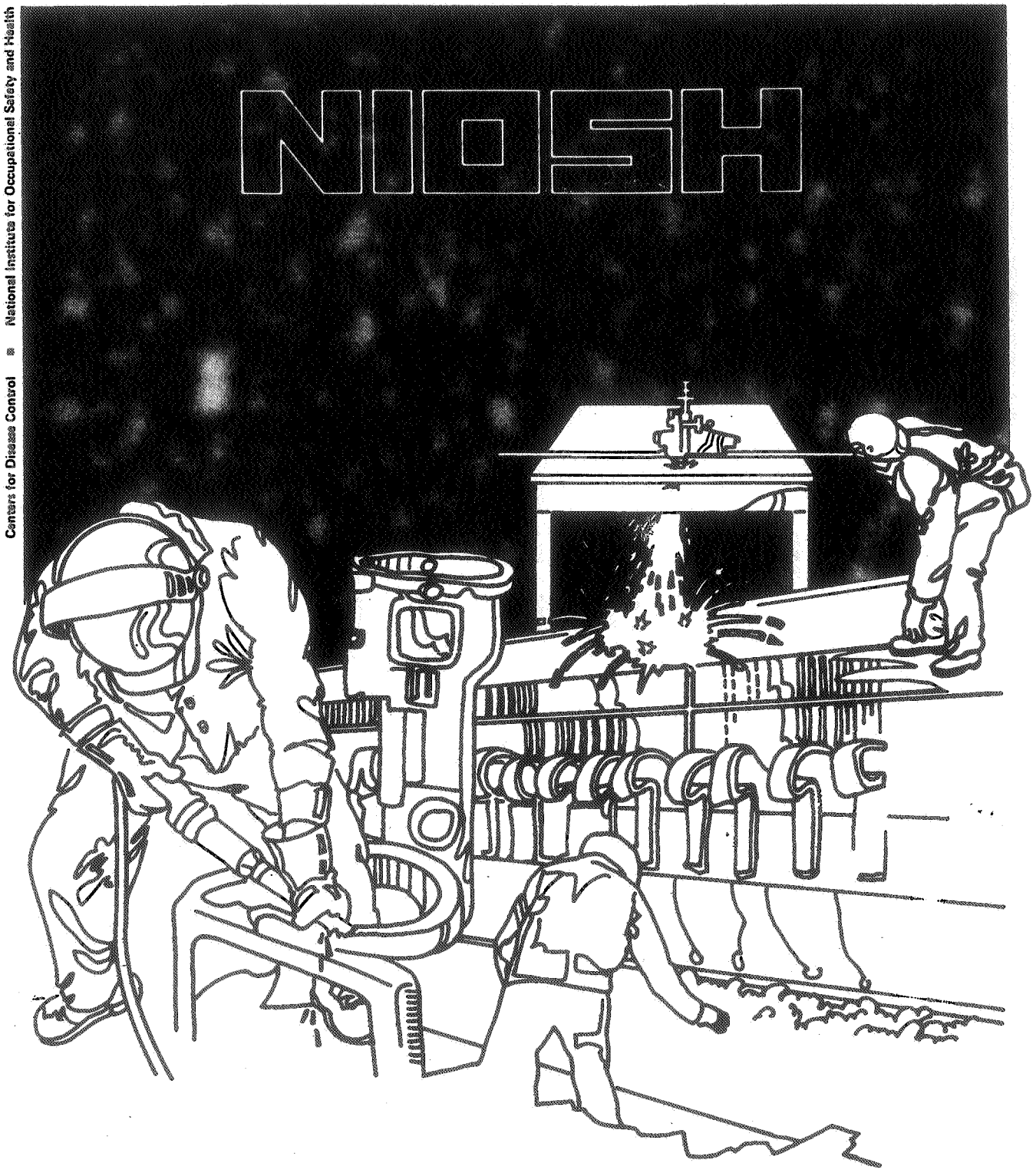

Health Hazard Evaluation Report

HETA 84-459 & 85-110-1905
BUDD COMPANY
NORTH BALTIMORE AND CAREY, OHIO

PREFACE

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

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

HETA 84-459 & 85-110-1905
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BUDD COMPANY
NORTH BALTIMORE AND CAREY, OHIO

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I. SUMMARY

On August 1, 1984, the National Institute for Occupational Safety and Health received a confidential request for a Health Hazard Evaluation at the Budd Company, North Baltimore, Ohio, concerning the use of isocyanates, methylene chloride (MeCl) and various other chemicals, and potential related health effects. On December 18, 1984, NIOSH received an additional request from confidential requestors at a second, similar Budd Company plant in Carey, Ohio, concerning the use of MeCl, resin, isocyanate, styrene and components of SMC (sheet molding compound) and related employee health effects. Environmental and medical evaluations were conducted at the two facilities during January 28-February 8, 1985.

One hundred forty-four full-shift, personal (breathing zone) environmental air samples were collected for MeCl and styrene. Employee exposures to MeCl at the facilities ranged from below the analytical limit of detection (0.01 mg/sample) to 239 parts per million (ppm), averaging 18 ppm. NIOSH considers MeCl to be a suspect occupational carcinogen and recommends that employee exposures be minimized. Exposures to styrene ranged from below the detectable limit (0.01 mg/sample) to 72 ppm, averaging 8 ppm. The NIOSH Recommended Exposure Limit (REL) for styrene is 50 ppm. Forty-one personal samples collected for acetone, toluene, and xylene indicated that exposures to these compounds were below their respective evaluation criteria. Seventy personal samples collected for carbon monoxide (CO) ranged from one to 52 ppm, averaging 9 ppm. The NIOSH REL for carbon monoxide is 35 ppm.

The medical study involved (a) a questionnaire survey of all workers at both plants, and (b) additional testing of a sample of workers selected on the basis of self-reported exposure history, to include equal numbers of those with high- and low-exposure jobs. The additional testing included an additional medical and occupational history questionnaire, a neurobehavioral test battery, analysis of expired air for CO, and analysis of blood for carboxyhemoglobin (COHb) and for indicators of liver function or damage.

COHb levels did not show substantial pre- to post-shift increases in smokers; levels in non-smokers suggested a slight increase. Men with high present and past MeCl exposure were more likely to report neurologic symptoms than men with low present and past exposure. There were no substantial, statistically significant associations between MeCl exposure and neurobehavioral test results. (Neurobehavioral tests measure central and peripheral nervous system function, but may not be as sensitive an indicator of solvent exposure as certain central nervous system symptoms.)

Women with high MeCl exposure had no higher rates of spontaneous abortion and congenital abnormalities, and were no less likely to have had a previous pregnancy, than women with low exposure. Liver function test abnormalities were not associated with MeCl exposure. Workers with jobs involving repetitive motion were significantly more likely to report pain and other sensory effects involving the hand and arm. Workers with jobs involving potential isocyanate exposure were significantly more likely to report nose or throat irritation, wheezing, and cough.

On the basis of the environmental data collected from both of the Budd Company facilities, the NIOSH investigators identified a potential health hazard from overexposure to MeCl. NIOSH considers MeCl to be a potential occupational carcinogen, and recommends that exposures be maintained at the lowest feasible level. The medical study found some evidence of an association between MeCl exposure and neurologic symptoms but did not document any association between MeCl exposure and neurobehavioral test results, neurologic effects, liver function abnormalities, or adverse reproductive outcomes. The medical study suffered from methodologic shortcomings, however, so the lack of a clear association between health effects and MeCl exposure should not be interpreted as the absence of such a relationship. Finally, there were associations between work involving repetitive motion and hand and arm symptoms, and between potential isocyanate exposure and irritative and respiratory symptoms.

KEYWORDS: SIC 3079 (misc. plastic products) diisocynate, methylene chloride, styrene, acetone, toluene, xylene, carbon monoxide, carboxyhemoglobin, neurobehavioral tests, liver function, reproductive outcome, respiratory irritation, cumulative trauma disorders, musculoskeletal

II. INTRODUCTION

On August 1, 1984, NIOSH received a confidential request for a health hazard evaluation at the Budd Company, North Baltimore, Ohio (Plant 1) concerning the use of isocyanates, MeCl and various other chemicals, and potential related health effects. On October 26, 1984, NIOSH was notified of the death of a 26 year old male worker using MeCl in the Budd Company plant in Carey, Ohio (Plant 2) (a sister plant within 40 miles of North Baltimore utilizing similar manufacturing processes). Historical company air sampling data for MeCl at both plants showed concentrations below the OSHA standard of 500 ppm but higher than the (then current) NIOSH REL of 75 ppm averaged over an ten-hour work day. On October 26, 1984 a physician reported two suspected cases of organic brain dysfunction, one at each plant. On December 18, 1984 NIOSH received a second request for a health hazard evaluation from confidential requestors at the Carey Plant concerning: 1) use of MeCl, epoxy resin, methylene bisphenyl diisocyanate, styrene and components of SMC (sheet molding compound--polyester panels), 2) reported acute and chronic clinical findings of central nervous system dysfunction, and 3) elevated carboxyhemoglobin (COHb) levels found among some workers.

A walk-through survey of the Budd Company Plant, North Baltimore, Ohio (Plant 1) was conducted on December 11-13, 1984 to observe the production process and the conditions of chemical usage. Personnel and medical records were reviewed, as were results of environmental monitoring conducted by the Budd Company. A total of 41 workers were interviewed from the three shifts.

Based upon this initial visit to Plant 1, and historical industrial hygiene data indicating similar, if not somewhat higher MeCl exposures at the Budd Company Plant, Carey, Ohio (Plant 2), a follow-up health study was scheduled for both plants during the weeks of January 28-February 8, 1985.

NIOSH has issued two reports since the origination of this project to keep all interested parties apprised of the progress and findings during various stages of the investigation. On July 15, 1985, NIOSH issued a letter providing results of environmental sampling for airborne contaminants and medical monitoring for pre-and post-shift carboxyhemoglobin levels. On April 17, 1986, a letter was issued reporting the detailed methodology of the NIOSH medical study, as well as a preliminary summary of worker responses to neurobehavioral questions and of study participant liver function test results. Study participants were notified of their medical test results on July 6, 1985 and June 25, 1986.

III. BACKGROUND

The Budd Company, at its North Baltimore and Carey, Ohio, facilities, produces molded plastic automobile body parts and skis (skis produced at the North Baltimore facility) in compression mold presses from "sheet molding compound" (SMC). The SMC contained proprietary mixtures of semi-solid styrene and fiberous glass, which were available in large rolled sheets (produced at another of the Budd Company's facilities). The following descriptions of the molding and finishing processes are presented in a general form and pertain to both facilities. The necessary production details will be expanded in discussions of environmental/medical results.

The compression molding operations use steam operated presses (15 at the North Baltimore facility; 28 at Carey). Job titles at these operations and related activities include press operators, cutters, deflashers, and defect repairers. Following is a brief description of each.

Press Operators: These employees cut the SMC to the desired size from the large rolls, place the sheet in the presses, operate the press, and remove the product. Presses are generally operated at 290-315° F for less than one to several minutes per part, depending on the size and configuration of the piece. The types of parts produced range from small items such as headlight housings, to larger items such as trunk lids for the Pontiac Fiero or hoods for Chrysler Ramcharger trucks.

Deflasher: These employees remove "flash" from the molded pieces. Flash occurs when plastic is forced into the seams between the metal mold closure points during compression. Deflashers use hand-operated routing devices, sand paper, files, and drills.

Defect Repair: Defects such as small holes or chips are repaired following deflash by filling with putty and final sanding. Defects are identified by applying "blue wipe"; a mixture of naphtha and blue paint, which highlights any mar on the surface of the part.

Once molded and prepped, the parts are transported to various finishing activities, including bonding, sanding, painting, and packaging. The bonding operations involve items such as deck "lids" (the hood of the rear engine Fiero), where the outer surface is bonded to the inner structural supports. The bonding process is initiated by a "prime wipe" operation, where the lids and structural supports (inner/outer) are placed on metal stands and wiped with MeCl using a sponge or cloth. The purpose is to provide a thoroughly clean and slightly "tacky" surface prior to bonding (glue application). At the time of the evaluation, prime wipe employees were provided dual cartridge half-face respirators equipped with organic vapor filters. Protective clothing included a rubber apron, poly vinyl acetate gloves, and over

shoes. Modifications to this operation at the North Baltimore facility were underway at the time of the evaluation, including re-design of the stands used at the prime wipe operation, installation of local exhaust ventilation, and evaluation of the local exhaust ventilation hood design and capture velocities. Employee interviews indicated that the personal protective equipment had recently been issued, which suggests that previous exposure/dose was somewhat higher than measured during the NIOSH evaluations.

Once wiped, the parts are placed into an automated bonding mechanism which applies isocyanate-containing adhesives, and brings the items to be bonded into contact under pressure for a pre-determined time.

All molded parts are placed on a continuous, automated line which provides transport to the various stages of production. Once bonded, the parts are washed in an automated high temperature/pressure water spray booth (as are all other molded parts); they then proceed to paint booths. Once painted, all parts proceed to the finishing areas, where any defects are repaired. Any scratches or pits are filled with putty, and touch-up paint is applied. The parts are then returned to the spray paint area, or packaged. The isocyanate-containing touch-up paint used in the finish areas is applied from pressurized containers, with air pressure from a centralized source, and paint mixed and supplied from a central paint room.

On a much smaller scale (six employees involved in production), skis are produced in a separate area in the North Baltimore facility, using similar production processes; an upper an lower part is wiped, glued, and forwarded to a finish area.

IV. EVALUATION METHODS

A. Environmental

Environmental monitoring of employee exposures was designed to complement the medical evaluation by determining exposure levels of the various airborne substances among the study group (as selected through questionnaire data) and among the matched control group. Environmental air samples were collected from the breathing zone of employees (personal samples) by attaching sampling media to their lapel for the duration of the work shift. Depending on the operation, charcoal tubes were used to collect either a combination of MeCl and styrene, or MeCl, styrene, acetone, toluene, and xylene. Carbon monoxide samples were collected using long-term direct reading indicator tubes attached to the lapel, and samples for isocyanates and total particulates were collected at various locations. Following is a description of the sampling and analytical methodology used for each substance.

Methylene Chloride, Styrene, Acetone, Toluene, Xylene

Employee exposures to MeCl were measured using standard 150 mg. dual section activated coconut shell charcoal tubes attached to pre-calibrated environmental sampling pumps. The NIOSH Methods Manual No. 1005 (MeCl)[1] recommends sampling MeCl at 10-200 cc/min for up to 2.5 liters (l) per sample. However, due to the relatively large number of samples necessary for this evaluation, an experiment was designed and conducted by the Methods Research Section, DPSE, to determine whether the sampling time and total volume of sampled air could be increased for use under the expected conditions of the evaluation (work place concentrations of less than 100 ppm). From the experiments it was determined to be possible to sample for extended periods of time at flow rates of 50 cc/min or less, with total volumes not to exceed 11.3 liters (l). For certain jobs, the charcoal tubes were analyzed for MeCl and styrene, while for others, the tubes were analyzed for MeCl, styrene, acetone, toluene, and xylene.

The samples collected for MeCl and styrene were analyzed according to NIOSH Method Number 1005 and 1501 (with modifications). The front and back sections of each sample were combined and desorbed for 30 minutes in 1.0 milliliter (ml) of carbon disulfide containing 1 microliter (ul)/ml of toluene as an internal standard. A Hewlett-Packard Model 5711A gas chromatograph (GC) equipped with a flame ionization detector was used in conjunction with a 30m x 0.32mm fused silica capillary column coated internally with 0.5 um of DBWAX. Thermal programming was 50° C to 100° C at a rate of 32° C/minute. The analytical limit of detection was 0.01 mg/sample for both compounds.

Samples collected for MeCl, styrene, acetone, toluene, and xylene, were analyzed according to NIOSH Method Numbers 1500, 1501, and 1003 (with modifications).[1] Initially, the front and back sections of the charcoal tubes were combined, and desorbed for 30 minutes in 1.0 ml of carbon disulfide containing 1 ul/ml of ethyl benzene as an internal standard. A Hewlett-Packard Model 5711A GC was used equipped with a flame ionization detector, in conjunction with a 30m x 0.32mm fused silica capillary column coated internally with 0.5 um of DBWAX. The analysis of xylenes included the O-, m-, and p- isomers. The limit of detection for all substances was 0.01 mg/sample.

Respirable Particulate

To determine employee exposures to respirable particulates resulting from grinding operations in the finish areas, samples were collected on pre-weighed FWSB filters (using cyclones for

particle separation) attached to pre-calibrated environmental sampling pumps operated at 1.7 lpm. The weight of each sample was determined by weighing the sample plus the filter on an electro balance and subtracting the previously determined tare weight of the filter. The tare and gross weighings were done in duplicate.

Isocyanates

Isocyanates are used as catalysts in the bonding glue and in the touch up paints. At the direction of the Division of Physical Sciences and Engineering, NIOSH, environmental air samples for isocyanates were collected from stationary positions in these areas using pre-calibrated MSA Model G sampling pumps, by drawing work room air through glass impingers containing 15 ml. of 1-(2-methoxy phenyl) piperazine (Method 5505). These samples were analyzed for toluene-2,4-diisocyanate (TDI), Methylene bisphenyl diisocyanate (MDI), and Total Reactive Isocyanate Groups (TRIG). Each impinger solution was measured volumetrically and all of the samples were brought to exactly 15 ml. with toluene prior to analysis. Ten microliters of acetic anhydride were added to a 2 ml aliquot taken from each impinger solution. This was evaporated to dryness under a stream of nitrogen and heated at 45 ^{o}C. Two-hundred microliters of methanol were added to the resulting residue and allowed to sonicate for 20 minutes before analyzing by high performance liquid chromatography. Standards were prepared by making appropriate dilutions of a solution of known concentration of 1-(2-methoxy phenyl) piperazine and the piperazine derivatives of 2,4-TDI and MDI. The analysis is based on the conversion of the isocyanate in the sample to its corresponding urea derivative. Standards were prepared using the urea derivative dissolved in methanol.

B. Medical

1. Selection of participants

An exposure and medical symptom screening questionnaire (Appendix #1) was distributed to workers at Plant 1 (North Baltimore) and Plant 2 (Carey) on each shift as workers arrived at the time clock. At Plant 1 approximately 502 and at Plant 2 approximately 537 questionnaires were distributed over three shifts beginning with the second shift (1/28/85), third shift (1/28/85) and then first shift (1/29/85). These were collected by the end of the each shift. The returned questionnaires were then grouped according to plant and by shift. Scheduling considerations dictated that 70 individuals could participate in the medical study at Plant 1 and 84 at Plant 2.

Participants for further testing were selected upon the basis of their self-reported current and past MeCl exposure history. Individuals with the longest reported exposures were preferentially selected. Nonsmokers were also preferentially selected because carbon monoxide from cigarette smoking increases venous carboxyhemoglobin and expired carbon monoxide measurements. Individuals with self-reported low MeCl exposure were then matched to the MeCl-exposed individuals on the basis of sex, age (± 5 years), education, smoking status, and race. Fourteen individuals per shift were selected for the study. At Plant 1, 28 workers were selected from the first and second shifts, and 14 from the third shift. At Plant 2, 28 workers were selected on each shift. A number of alternates were chosen for each shift in the event that a primary individual (worker initially chosen for the study) declined to participate. If the selected worker declined to participate or was not present, an alternate worker was selected to best match the remaining member of the selected pair based upon the same matching criteria. In certain instances, ideal matches could not be made with available alternates. In these cases the most immediately available alternate, or in some cases, any willing available worker was chosen. All workers participating in this study read and signed a consent form (approved by the NIOSH Human Subjects Review Board) describing the study and its risks.

2. Testing Protocol

a. A 15-20 minute self-administered exposure history, medical history and neurobehavioral questionnaire was completed. This included the Swedish-16 neurobehavioral questionnaire field tested by Hogstedt et al.[2] These are listed in Appendix A.

b. A one-hour neurobehavioral testing battery was completed. Testing methodology and milieu for each test are outlined in Appendix B.

c. Pre- and post-shift venous carboxyhemoglobin (COHb) samples were obtained. (Normal range: less than 2% in nonsmokers; 2 to 12% in smokers) COHb values were determined utilizing a CO-oximeter.

d. Pre- and post-shift, as well as pre-neurobehavioral testing expired air CO concentrations were measured. Workers were instructed to take a full inspiration, hold their breath for 20 seconds,[3] and then exhale air into a plastic sample bag. This air sample was

then analyzed by a Wilks Infrared Analyzer, Model 103 direct reading instrument. The upper limit of CO measurement was 50 ppm. Many of the participants who smoked registered 50 ppm both pre- and post shift. Therefore, smokers were excluded from the analyses of cross-shift expired CO changes.

e. Serum analysis for the following indicators of liver function or damage using standard automated techniques were used.

	Normal Range
alkaline phosphatase (AP)	15 - 45 I.U./l
glutamic oxalacetic transaminase (SGOT)	15 - 50 I.U./l
glutamic pyruvic transaminase (SGPT)	10 - 75 I.U./l
total bilirubin (TB)	0.30 - 1.30 mg/dl
direct bilirubin (DB)	0.04 - 0.20 mg/dl
gamma glutamyl transpeptidase (GGTP)	5 - 50 mU/ml

I.U./l = international units per liter
mg/dl = milligrams/deciliter

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the

level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists° (ACGIH) Threshold Limit Values (TLV°s), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV°s are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV°s usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures. Table 1 presents the evaluation criteria for the airborne substances evaluated during the health hazard evaluation, along with a brief summary of their primary health effects. Following is a more detailed description and background information for these compounds.

B. Specific Substances

1. Methylene Chloride

Methylene chloride (MeCl) is a volatile, aliphatic, organic solvent that is easily absorbed through the lungs (55% retention of inspired concentration at rest, and 24-35% with exercise),[4] by direct skin contact,[5] and by ingestion.[6]

Methylene chloride is excreted unchanged (95%) through the lungs and small amounts via the kidney. The metabolism of MeCl to carbon monoxide (CO) is felt to occur via the process of microsomal oxidative dechlorination. This occurs primarily in

the liver, but these microsomes are also present in the lungs and kidneys.[7]

Methylene chloride is an irritant of the skin and eyes. In cases of accidental poisonings in humans, notable effects have included cardiovascular effects, central nervous system depression, behavioral changes, mucous membrane irritation, pulmonary tract irritation and edema, as well as elevated carboxyhemoglobin (COHb) levels.[6]

Individuals exposed to MeCl may experience an elevation in COHb levels as MeCl is partly metabolized to CO. The rise in COHb levels may be sufficient to stress individuals with underlying cardiac or pulmonary disease. Three myocardial infarctions, including a death following paint stripping in a basement, have been reported.[8]

The NIOSH Recommended Exposure Limit (REL) for MeCl was 75 ppm, [261 milligrams per cubic meter (mg/m^3)], as a time-weighted average (TWA) for up to a 10-hour workday, 40-hour workweek with a 500 ppm (1,740 mg/m^3) peak exposure concentration as determined over any 15-minute sampling period during the workday. The REL was based on the need to prevent significant interference with the delivery of oxygen to the tissues of the body and abnormalities in functions of the central nervous system (CNS) as a result of the production of carboxyhemoglobin attendant to metabolism of MeCl. The toxicities of MeCl and carbon monoxide are additive.[9] Because of this additive effect, provisions for calculating a reduced REL for MeCl in the presence of CO were included in the document, Criteria for a Recommended Standard....Occupational Exposure to Methylene Chloride published by NIOSH.

Measurements of MeCl in blood (as carboxyhemoglobin) or in expired air (as carbon monoxide) can be used as a measure of the magnitude of MeCl exposure. Interpretation of blood carboxyhemoglobin and expired CO measurements in smokers is difficult because cigarette smoke contains carbon monoxide which may also elevate these measurements.

The experimental literature on the effects of MeCl and carbon monoxide indicate that COHb is the biological indicator that best correlates with the neurobehavioral effects of both chemicals.[10] The major effects attributed to MeCl and carbon monoxide exposure are incoordination, limb numbness and tingling, disorientation and confusion, vigilance deficits, time estimation losses, and remote memory impairment.[11-14]

A recent National Toxicology Program (NTP) report[6] reviewed the results of toxicology and carcinogenesis studies of MeCl inhalation exposed groups of in 50 males and 50 females F344/N rats and B6C3F1 mice, 6 hours per day, 5 days per week, for 102 weeks. The exposure concentrations used were: 0, 1000, 2,000, or 4,000 ppm for rats and 0, 2,000, or 4,000 ppm for mice. The study concluded that: "Under the conditions of these inhalation studies, there was some evidence of carcinogenicity of dichloromethane for male F344/N rats as shown by an increased incidence of benign neoplasms of the mammary gland. There was clear evidence of carcinogenicity of dichloromethane for female F344/N rats as shown by increased incidences of benign neoplasms of the mammary gland. There was clear evidence of carcinogenicity of dichloromethane for male and female B6C3/f_1 mice, as shown by increased incidences of alveolar/bronchiolar neoplasms and of hepatocellular neoplasms." Therefore, in 1986, NIOSH recommended that MeCl be regarded as a "potential occupational carcinogen," and that exposure be controlled to the lowest feasible level.[15]

2. Styrene

Styrene is a colorless liquid and is absorbed through the lungs and skin. It's odor threshold is 0.1 ppm. It is an irritant of the eyes, mucous membranes, skin, and is a CNS depressant. Prolonged or repeated exposures may lead to dermatitis secondary to defatting of the skin.[17] CNS effects have been reported among experimental subjects exposed to a TWA of 100 ppm. Frequently reported effects have been fatigue, dizziness, headache, nausea, poor memory and drowsiness. Clinical studies of workers exposed to styrene have demonstrated slower reaction times, impaired balance and abnormal electroencephalograms (brain wave tests).[18] Styrene is metabolized to benzoic acid, conjugated with glycine and excreted in the urine as hippuric acid.[16]

3. Toluene Diisocyanate (TDI)

TDI belongs to a group of compounds called diisocyanates, or simply isocyanates. Occupational exposure to isocyanates has well-recognized adverse health effects. Isocyanates are irritants of the skin, eyes, and respiratory tract. Repeated exposure can lead to the development of allergic sensitization in some persons, resulting in asthma-like reactions (immediate, delayed, or both) at concentrations much lower than those producing irritation. Other chronic effects that have been reported include impairment of pulmonary function (one-second

forced expiratory volume (FEV_1) and forced vital capacity (FVC), shortness of breath, bronchitis, and hypersensitivity pneumonitis (another type of allergic lung disorder).

The OSHA standard for TDI is a ceiling concentration of 20 ppb. Because this criterion is not adequate to prevent either cases of isocyanate-induced asthma or excess group declines in lung function, NIOSH recommends that exposure to TDI not exceed a 10-hour time-weighted average concentration of 5 ppb nor a 10-minute ceiling concentration of 20 ppb. Furthermore, NIOSH recommends the use of supplied-air respirators, operated in the pressure demand mode when any level of an airborne isocyanate is detected.

TDI has been reported to be mutagenic, and has been found to cause cancer in rats and mice. Based on these studies, NIOSH has initiated a mortality study of workers exposed to TDI.

VI. RESULTS AND DISCUSSION

A. Environmental

As previously discussed, environmental monitoring of employee exposures was designed to complement the medical evaluation by determining exposure levels to the study participants as well as the control groups. Exposure levels among these groups, and how they pertain the questionnaire and biological data, are discussed in the Medical results section. The following general discussion of environmental data is categorized by compound and area of the facility. Exposure summaries by plant and job category are presented in tables 2 and 3. Individual environmental sampling results by job category and operation are presented in tables 4 through 16.

The highest relative MeCl exposures were measured at the bonding operations which involve the use of MeCl as a pre-clean/pre-treatment solvent for the automotive panels prior to glue application. The "prime wipe" employees at this operation typically used dual cartridge organic vapor respirators, gloves, and aprons. Eleven full-shift samples at the North Baltimore facility ranged from "non-detected" to 154 ppm, averaging 55 ppm. At Carey, the MeCl exposures ranged from 2 to 239 ppm, averaging 66 (14 samples). The enhanced local exhaust ventilation in use at the North Baltimore plant (under evaluation and revision and the time of the survey) was likely responsible for the lower exposures. Press operators and press-side finishers at the Carey facility had the next highest average exposures; exposure concentrations ranged

from non-detected to 91 ppm, averaging 13 ppm (26 personal, full-shift samples). Exposure levels measured during the same tasks at the North Baltimore facility ranged from 1 to 33 ppm, averaging 5 ppm (17 personal, full-shift samples). The differences in the exposure concentrations is most likely due to the proximity of the presses to the bonding operations in the facilities, and differences in local exhaust ventilation. Four "finish" jobs monitored revealed relatively higher MeCl exposures than expected (Tables 6 & 9). These higher levels are probably due to MeCl used as a general solvent for cleaning spray-paint applicators, and various other tasks. The highest exposure to MeCl was measured at Carey facility in a non-MeCl use area (233 ppm MeCl). No explanation is offered for this unusually high result. MeCl was measured at significantly lower concentrations in all other jobs monitored at both facilities, indicating widespread, relatively low exposures.

A similar (although relatively lower) exposure pattern was observed for styrene; higher exposures were measured in the use areas (presses), with progressively lower exposures with increasing distance from the presses in all other plant areas. Press operators' styrene exposures ranged from 25 to 72 ppm, averaging 41 ppm at the North Baltimore facility (7 full-shift samples), and from less than the limit of detection to 34 ppm, averaging 13 ppm at the Carey plant (15 full-shift samples). "Finishing" areas near the presses in both facilities had similar exposure patterns, with average levels of 6 and 11 ppm (table 5, 11). A possible contributing factor to the widespread styrene, and perhaps MeCl exposures, is the type of ventilation. Air recirculating units are located above the presses, presumably to recirculate the heat generated by the presses. These units generally disperse air to the finish and packing areas. However, they may also serve to disperse styrene vapors generated from the press operations.

Full-shift carbon monoxide (CO) exposure determinations were obtained simultaneously with several MeCl and styrene environmental samples. Thirty-five samples obtained from the North Baltimore facility ranged from 1 to 12 ppm, averaging 6 ppm. At the Carey plant, 35 CO personal samples ranged from 2 to 52 ppm, averaging 13 ppm. It must be noted that several of the long-term indicator tube samples had positive bias due to interference from airborne MeCl; generally in concentrations of 60 ppm MeCl or greater. Saturation, or full length of stain indications were noted during the evaluation, particularly at operations with relatively high MeCl use. Full length of stain or saturation of the indicator tubes would normally infer CO concentrations of 75 to 100 ppm or greater. Because of the high levels indicated, yet no observed

source of environmental CO, concentrations were checked using a direct reading portable instrument. This instrument showed CO concentrations similar to those obtained with the indicator tubes in areas without excessive MeCl. Suspect CO results are identified in the tables of environmental results. Two excessive CO exposures were identified among press operators at the Carey plant, which could not be attributed to MeCl interference; particularly one exposure of 37 ppm CO, with a non-detected MeCl exposure.

Environmental monitoring for total reactive isocyanate groups (TRIG) was conducted in areas of the plants where isocyanates were contained in the paint or the glues. Exposure concentrations for the nine full-shift area samples reported by the NIOSH analytical laboratories ranged from 22 to 64 micrograms per cubic meter (ug/m^3). However, in information transmitted to the NIOSH investigators in July, 1987, (Appendix D) it appears that these values are erroneous (i.e., these values over estimated the airborne isocyanate concentrations). Historical monitoring by the Budd Company and OSHA did not detect airborne isocyanates. Based upon the analytical problems encountered during analysis of the NIOSH isocyanate samples, it seems reasonable to accept the historical data as the best estimate of airborne isocyanate within the facilities.

Employee exposures to airborne particulate were measured at several finishing operations and jobs located near these operations, particularly the press operators (Table 15). Particulates are generated when the molded parts are "finished" near the presses by employees using sanders and drills to remove flash from edges or to smooth seam mars. The particulate is primarily the hardened resin and fibrous glass embedded in resin aerosolized by the abrasive action. Exposures ranged from 0.1 to 1.1 mg/m^3, averaging 0.4 (9 full-shift, personal samples). This type of particulate is probably best defined as a nuisance substance (i.e., not biologically detrimental). However, deposits in the eyes and upper respiratory passages can lead to irrative symptoms.

Employee exposures to acetone, toluene, and xylene were monitored at locations where the touch-up paint was applied and at neighboring areas (tables 8 & 14). In general, the exposures were well within the respective evaluation criteria for the individual compounds, and no additive criteria were exceeded (for substances with similar toxic effects, such as these solvents).

B. Medical

1. Participants

Of approximately 1039 exposure screening questionnaires

distributed, 764 (73.5%) were returned. One hundred fifty-four workers were selected for study participation, and 151 were ultimately tested. Table 17 summarizes: 1) the number of exposure questionnaires which were returned for each shift, 2) the number of primary study participants selected, 3) the number of alternates listed, 4) the total number of workers ultimately studied, 5) the number of alternates ultimately used in the study, and 6) the number of workers not on the original study list (primary or alternate) that were studied.

At Plant 1 on the first shift, 8 of the originally selected workers did not participate in the study. Six alternates were substituted, as well as two workers who did not appear on either list. On the second shift five workers were substituted with three alternates and two unlisted workers. On the third shift three workers were substituted by three alternates. At plant 2 on the first shift, three alternates were substituted and on second shift three alternates were substituted. On the third shift only 25 workers were tested because only three alternates and two unlisted workers were willing to volunteer.

Upon completion of the study it was found that some workers had misclassified their MeCl exposures; this made a matched-paired analysis impossible. In addition, review of industrial hygiene data indicated that certain individuals had styrene exposures; many of these individuals had been previously categorized as L/L (defined later). In view of this information, individual exposure designations were recategorized based upon: job title, current and past MeCl and styrene exposures, past job title and work history. All current press operators (individuals felt to have the highest styrene exposures) were placed in a new group-- CPOG (current press operators group). An additional group was created to accommodate individuals with significant exposures to both styrene and MeCl (Mixed). All individuals that company records listed as press operators in the past were removed from the L/L group and placed in the past press operator group (PPOG). Individuals were excluded from the study for four reasons: data reliability problems, ethanol consumption of greater than 25 drinks per week, history of epilepsy, and inability to determine a definite exposure category. The following defines these groups:

a. Low current MeCl exposure/low past MeCl exposure/low styrene exposure (L/L)--These individuals were currently (on the day of testing) exposed to less than 20 ppm MeCl, had a job history compatible with probable low MeCl exposure, and were not currently working or had not worked

as a press operator for more than 3 months in the prior 5 years. There were 61 workers in this group.

b. Low current MeCl exposure/high past MeCl exposure/low styrene exposure (L/H)--These individuals were currently (on the day of testing) exposed to less than 20 ppm MeCl, but their job history indicated significant MeCl exposure for at least three months in the past 5 years. These individuals generally held job titles with characteristically low MeCl exposures, but some individuals with current job titles associated with higher MeCl exposures were included in this group because their MeCl levels on the day of the study were less than 20 ppm. All subjects did not currently, or had not worked as a press operator for more than 3 months in the prior 5 years. There were 24 workers in this group.

c. High current MeCl exposure/high past MeCl exposure/low styrene exposure (H/H)--These individuals had current measured MeCl exposures greater than 20 ppm, and had worked in jobs characterized by relatively high MeCl exposures for at least three months in the past 5 years. They did not currently, or had not worked as a press operator for more than 3 months in the prior 5 years. There were 17 workers in this group.

d. Current press operators/low current and past MeCl exposure (CPOG)--These individuals currently carried the job title of press operator for at least three months, and had low current and past MeCl exposures as defined above. There were 14 workers in this group.

e. Methylene chloride and styrene exposure (MIXED)--These individuals fell into three categories:

   i. Two workers with history of MeCl and styrene exposure each for at least three months in the last five years.

   ii. Two workers with current H/H MeCl classification with a past history of styrene exposure for greater than three months in the last five years.

   iii. Four workers with CPOG classification with MeCl concentrations measured on the test day of greater than 20 ppm.

f. Past press operators (PPOG)--Three workers who did not currently work, but had worked as a press operator for more than 3 months in the prior 5 years. They did not have a history of MeCl exposure.

g. Individuals excluded (Excluded) from the neurobehavioral portion of the study are listed below:

i. Eight individuals who drank on average, 25 or more alcoholic beverages per week (ETOH)

ii. Two individuals having a history of seizures (EPI)

iii. Eight individuals whose exposure category was unclear (? CAT)

iv. Four individuals with data reliability problems (? DATA)

2. Exposure Group Characterizations

Tables 18 and 19 summarize the MeCl and styrene exposures among the male and female study participants by exposure groups.

The mean MeCl concentration for males in the H/H group was 73.9 ppm (range: 23.1 ppm to 239.7 ppm). All of the other groups had mean MeCl exposures below 5.1 ppm, except the mixed group, having 17.6 ppm. This higher exposure occurred because certain press operators had concurrent MeCl exposures greater than 20 ppm. The excluded group also had higher MeCl exposures. Some of these individuals would have been placed in the L/L category, but on the day of the study had MeCl levels less than 20 ppm. These MeCl levels may have occurred because they worked in areas near MeCl use.

The mean MeCl concentration for females in the H/H group was 100.9 ppm (range: 32.9 ppm to 154.4 ppm). All of the other groups had mean MeCl exposures below 5.7 ppm, except the MIXED group, which had a mean of 28.8 ppm, and the excluded group, a mean of 35.1 ppm.

The mean styrene concentration for CPOG males was 29.4 ppm [range: not detectible (ND) to 71.6 ppm]. All other tested groups had mean styrene exposures less than 7.5 ppm, except the excluded group (11.1 ppm). The mean styrene concentration of CPOG females was 20.1 ppm (range: ND to 34.5 ppm). All except the MIXED group had mean styrene exposures less than 7.2 ppm. Concurrent MeCl and styrene exposures in the MIXED group account for their mean 10.5 ppm styrene exposure.

3. Demographics and Personal History

Table 20 summarizes the age distribution among exposure categories divided by males and females. There were no significant age differences among individuals in exposure categories.

Table 21 summarizes the highest average grade achieved in school for each group. This information was obtained from company records because there were inconsistent responses to this question on the questionnaire. Table 22 summarizes the average drinks consumed each week by members of each exposure category. Males in the H/H and L/L groups consumed 10.6 and 6.1 alcoholic drinks/week, respectively. This difference is not statistically significant. Table 23 examines the time during the workshift that workers performed their tests; fatigue may affect test performance. There were significantly more L/H females than L/L females performing their tests during the last two hours of the workshift 75% (9/12) vs 17.5% (7/40) ($p<0.001$--Mann Whitney), respectively. Table 24 summarizes the shift distribution among exposure groups. There were 17 fewer workers tested during the third shift. There were no statistically significant differences between groups. Table 25 summarizes the occurrence of head injury among groups; no significant differences were found.

4. Neurologic Symptoms

Appendix A contains the Swedish 16 Questionnaire with one minor change. The word "pressure" was substituted for "oppression." Questions were also grouped according to neuro-functioning, e.g., memory, affect lability, vegetative symptoms, paresthesia, tiredness, and libido. Additional neurobehavioral questions were asked on both questionnaires 1 and 2. These are listed in Appendix C and are grouped as neurobehavioral, motor, fatigue, sensory, cognitive, and anxiety complexes.

Table 26 and 27 summarize the responses to each Swedish 16 question, for males and females, respectively. (There were no females in the PPOG group.) In males there appears, for the most part, to be a consistently higher positive response rate among the H/H, L/H and MIXED exposure groups. Though differences for individual symptoms are not statistically different, the H/H group has a higher prevalence for 14 of the 16 symptoms ($p=0.002$, 1-tailed sign test). Both low and high MeCl and styrene exposed females generally reported a greater percent of all symptoms than males. No consistent response pattern of low vs. higher solvent-exposed female workers was observed.

Hogstedt, et al[2] compared Swedish 16 Questionnaire responses of 229 Swedish mixed-solvent-exposed to 173 non-solvent-exposed male workers. Table 28 summarizes these data and compares them with 21 low and 28 high MeCl (H/H+L/H+MIXED) exposed male workers from this NIOSH study.

The NIOSH study workers (both low and high MeCl exposures) reported more symptoms in general, but demonstrated a pattern similar to that seen in the Swedish study. This may in part be due to the probability that there are few workers in these plants that have consistently low MeCl exposures. For example, MeCl may be used by some finishers (individuals generally thought to have low exposures) to work on certain parts as needed, or they might work in areas contiguous to areas of MeCl usage (bonding and prime wiping). In fact, several individuals with job titles and job histories suggestive of low MeCl exposures had elevated MeCl concentrations (greater than 20 ppm) measured from their personal air monitoring detector tubes on the day of the study and were therefore disqualified (questionable exposure category) from further study analysis. The relatively high frequency of problems buttoning, especially among the low solvent exposed group, may be related to reported carpal tunnel symptoms. Many individuals in the L/L group were finishers, and their jobs require repetitive motions.

Hogstedt, et al[2] have suggested that young solvent exposed men (less than 28 years of age) indicating more than 4 of 16 symptoms, and those 28 years of age or older indicating more than 6 of 16 symptoms, see a physician for neurological evaluation. Since our study group appeared to have a higher symptom complaint rate as a whole than the Swedish study group, we examined the occurrence of more than 6 versus 6 or fewer symptoms among the different exposure groups in males and females regardless of age (see Table 29).

Complaints of more than 6 symptoms are seen more often in the H/H and MIXED groups than in the L/L group (46.2 and 66.7% versus 28.6%, respectively). These differences were not statistically significantly. Symptom patterns among females do not show a trend, and there are no significant differences between the L/L group and any other listed exposure group. Fifty-two percent of females and 28.6% of males complained of more than six symptoms. This difference was not statistically significant.

Tables 30-32 summarize the p-values (Mann-Whitney test) for question symptom groupings for comparisons of the L/L group

with the H/H, L/H, MIXED, CPOG + PPOG, and the L/H + H/H exposure groups. These comparisons determine if individuals within solvent exposure groups have indicated more "yes" responses to questions within a question grouping (e.g. motor, cognitive) than individuals in the L/L group. A "+" indicates that more symptoms, within that question grouping, were experienced by a solvent exposed group, and a "-" indicates that more symptoms were experienced by the L/L group. P-values of less than 0.10 will be noted because of the small group sizes, and that data trends may be informative. More males in the H/H and L/H + H/H groups indicated motor problems ($p=0.0259$ and $p=0.0475$, respectively). Motor symptoms were also more frequent in the MIXED group ($p=0.0913$ for males, $p=0.0606$ for females). Positive responses to the general neurobehavioral question category were more frequent among the male H/H, MIXED, and L/H + H/H groups ($p=0.0430$, $p=0.0524$ and $p=0.0855$, respectively). Symptoms of fatigue were more frequent among the male H/H group and the female MIXED group ($p=0.0868$ and $p=0.0475$). The male H/H and L/H + H/H groups also reported more symptoms on the entire Swedish 16 Questionnaire than the L/L group ($p=0.0868$ and 0.0539, respectively). While few of these multiple comparisons yielded p-values of less than 0.05, there was a consistent pattern of the H/H group (especially men) reporting more symptoms than the L/L group.

C. Carbon Monoxide Exposure

Table 33 summarizes the mean pre- and post- shift COHb measurements for smokers and nonsmokers in each group. For smokers there is no appreciable cross-shift change. This probably resulted from the fact that a recently smoked cigarette may elevate COHb levels. Of note, however, is the highest recorded COHb of 17.5% among smokers. This is well above the normal COHb range (2-12%) for smokers. This particular worker had a MeCl exposure of 239.7 ppm. The mean cross-shift COHb change for nonsmokers in the L/L group increased from 1.8% to 2.4%, versus 2.0% to 3.7% for the H/H group. The H/H group had median MeCl exposures of 56.1 ppm for males and 108.2 ppm for females (Table 18). One would expect COHb levels to fall between 2.9% and 5.7% in individuals breathing MeCl at levels of 50 ppm and 100 ppm at rest (not excersizing) continuously over 7.5 hours, respectively, when pre-exposure COHb's averaged between 0.8-1.3%.[9] One would expect to find COHb levels of 9.5 - 10.0% after breathing 250 ppm MeCl for 7.5 hours.[9] Considering the magnitude of air exposures, plus the potential of skin absorption following skin contact, one would expect the cross-shift increase in COHb to be somewhat higher than is seen in

the H/H group. This discrepancy may in part be due to the use of gloves and dual cartridge respirators by some workers using MeCl at Plant 1. For example, the COHb level of one nonsmoking worker (not wearing a respirator) and exposed to 58.6 ppm MeCl increased over the workshift from 1.9% to 5.2%. Another nonsmoker utilizing both respirator and gloves, and exposed to 77.4 ppm, experienced a COHb cross-shift change of 1.4 to 2.1%. A similarly clad worker exposed to 83 ppm MeCl experienced a 2.1 to 3.6% cross-shift COHb increase. In nonsmokers the cross-shift expired carbon monoxide concentrations (ppm) generally paralleled those seen with COHb levels (Table 34).

Cross-shift increases in COHb may reflect exposure to MeCl and/or carbon monoxide.

D. Neurobehavioral Testing Analysis

1. Test for Incoordination - (Santa Ana Test)

The mean number of pegs turned by all subject groups was very similar; the range was between 19 and 22 (Table 35). None of the group differences was significant. Four subjects were excluded from this analysis because of an apparent misunderstanding of the instructions.

2. Test for Peripheral Sensory Changes - (Optacon)

Male L/L subjects had a higher (worse) tactile perception threshold (2.8) than H/H subjects (2.4) in the left index finger, but female L/L subjects had a lower (better) left index finger threshold (2.6) than H/H subjects (3.1), as seen in Table 35. The thresholds of the right hand index finger were identical for males in these groups. No statistically significant differences were found on this test between these or the other groups compared statistically in the study. Most group means were similar, with the exception of the right index finger in CPOG females. Since the variability was high for the right finger and the mean score of the left index finger was within the range of the other groups, an explanation in terms of chemical exposures is ruled out and mechanical injury (e.g. repetitive hand motions) seems the more likely explanation. The mean scores of the left index finger were fairly uniform and did not demonstrate a decreased finger sensitivity among solvent-exposed workers.

Three individuals were not tested because of time consideration, four additional persons were excluded from this

analysis because of an apparent misunderstanding of the instructions, and two others were not included for unspecified reasons.

3. Test for Time Estimation Accuracy and Concentration (Dual Task)

The mean difference in estimation was very similar for all groups, varying from an error of 1.1 to 1.4 seconds overall (Table 36). H/H females demonstrated the least amount of error and H/H males demonstrated the largest error (along with the MIXED group), as compared to all other groups within their gender. The standardized mean was the highest, as evidenced by having the largest error score, in H/H group females, but there were essentially no difference between scores in the males. While the H/H group did better than the others, the differences were slight. None of the differences analyzed was statistically significant on the test.

In the primary (time estimation) task, male L/L subjects made a slightly smaller error (mean difference) (7.1) than H/H subjects (7.4), but female L/L subjects made a larger error (7.4) than their H/H counterparts (6.4), as shown in Table 36. L/H subjects, those recently switched to the higher exposure conditions, had the largest error, respectively, in male and female subject groups, but no analyzed group differences were significant in this, the primary task. In the secondary task, squares missed, the male and female H/H groups had the lowest number of squares missed (i.e., the best score), 10.9 in the males and 17.8 in the females (Table 37). The L/L group males and females had the third lowest score in their respective grouping. CPOG males (22.3) and mixed females (20.3) had the poorest scores relative to other groups within their gender. No group differences evaluated were significant in this, the secondary task.

4. Test for Vigilance Deficits

Male H/H subjects made fewer correct detections (8.6) than any other group of male subjects (except the mixed group with only three subjects), but the reverse was the case in female subjects (8.8). Male L/L subjects had a smaller number of false alarms (8.6) than male H/H subjects (9.0), but the reverse was the case for the female subjects, where the L/L subjects had the highest score (15.2) and H/H the lowest score (4.2) of all female subject groups.

Past data would lead us to expect about an 80% rate of critical stimulus identification in unexposed subjects.[18] A detection

rate of about 9.5 of the first 12 or 10.4 of the 13 critical signals. All but the male MIXED group had a mean between 7.8 and 9.5 for all 13 signals (Table 37), which is low but reasonably close. This would suggest that most subjects, including the exposed subjects, responded fairly normally. It was also expected from previous research[18] that all groups would increase false alarm rates (incorrect identifications) in the last of the three 500-second periods as compared to the first. The false alarm rate remained relatively constant across the three 500-second time periods. False alarms in the third period were actually lower in female subjects, and they were lower in about half and higher in half of the male groups. It is not clear why the expectation was not met, but as noted above, the differences are relatively slight. This could suggest, however, that the test period was too short to establish a classic vigilance paradigm or that outside distractions were more salient that expected at the site of this test.

No significant group differences were found in the performance tests reported above. All of the differences noted above were slight and did not present a pattern that suggested any sort of negative effects related to the exposure groupings. In cases where differences appeared in one gender, the trend was either absent or, more often, just the reverse in the other gender. In large measure, these reversals reflected the fact that there were very small mean differences between the groups, relative to their standard deviations. Thus, the differences may not have been contradictory, but rather slight variations around a population mean.

Acute exposure studies to both MeCl and carbon monoxide have produced performance decrements on a dual task and an auditory vigilance test after two hours exposure to 200 ppm MeCl, or once a carboxyhemoglobin (COHb) level of 5% was reached. At higher exposure concentrations (800 ppm for 4 hours), psychomotor performance is also impaired.[19] And there is also some indication of correlations between COHb levels and eye-hand coordination performance as well as dual task performance in a study of changes across shifts in toll booth collectors exposed to a mean of 23 ppm carbon monoxide yielding mean COHb levels in the 4% range.[20] There have been no studies conducted on people exposed chronically and exclusively to MeCl, aside from the present one, and other acute exposure studies have shown neurobehavioral effects only at higher exposure levels.[7,21] Thus, since the mean exposure of the H/H group, the group exposed to the highest concentration, was

73.9 ppm and 100.9 ppm for males and females respectively; and their mean COHb increased from 2.0% to 3.7%, the results found in the present study tend to fit the established pattern, suggesting a lack of effects below COHb levels of 5.0% following chronic MeCl exposure.[21] Conclusions from this study's results are limited, however, because participants were tested after varying lengths of exposure.

E. Reproductive Outcome

Four birth outcome questions were asked on questionnaire #1 to which 713 of 764 workers responded. The first question asked if since beginning work at the Budd Plastics Corporation, had the worker (or spouse) been pregnant (including miscarriages). If the response was yes, information was asked about the total number of pregnancies while at Budd, the occurrence of unintentional miscarriage, and children with congenital abnormalities. Table 38 lists the number of positive responses to these questions. There were no individuals with more than one child with congenital abnormalities; therefore, a denominator of the toal number of pregnancies conceived while working at Budd was used.

Among 250 male respondents, there were 73 (29.2%) who reported that their wife had at least one pregnancy, with a total of 113 pregnancies reported. Twelve reported that their wives had had at least one miscarriage, and three reported having children with some type of birth abnormality. Among 463 female respondents there were 91 (19.7%) who reported at least one pregnancy, with a total of 136 pregnancies during employment. Nineteen (21.4%) reported unintentional miscarriages and 5 reported having children with some type of birth abnormality.

Also listed in Table 38 are the occurrences of birth outcomes among both the male and female workers within each solvent exposure category. The number of reproductive events in these groups were too small for any meaningful statistical analysis.

Twenty-nine percent of male workers' wives, but only 19.7% of the current female workers reported pregnancies during their employment at Budd. These figures may have resulted from working females having had their families before beginning work at Budd or having postponed pregnancy because of work. However, the data NIOSH has collected cannot rule out workplace effects on fertility rates in female or male employees. It is interesting that there are fewer (16.9% versus 21.4%) miscarriages among the wives of male workers than among female workers. Though this difference is not statistically significant, several investigators have found that

males are less likely to recall their wives' various pregnancy outcomes (including miscarriage).[22] This difference may be the result of male underreporting of spouse miscarriage.[23]

Estimates of the normal occurrence of spontaneous miscarriage range from 10-20% of all pregnancies between 8-28 weeks gestation.[24] While the 21.4% prevalence of spontaneous miscarriage among female Budd workers appears slightly elevated, there is no means available to determine if it represents a true excess. Hemminki reported in two studies increased risks for spontaneous abortion among plastic and styrene production workers.[25]

The NIOSH questionnaire asked one question about congenital abnormalities and was intended for screening only. This question did not differentiate major from minor birth defects. Major and minor birth defects are reported to be 2% and 10% respectively. Therefore, the congenital problems reported by workers are listed at the bottom of the table without categorization.

There are few studies reporting the effects of MeCl on the reproductive system. There is limited evidence that it is not teratogenic or embryolethal in maternally sub-toxic doses in animals. There is some evidence of an increase in anomalies and postnatal behavioral changes in offspring of pregnant rats that had been exposed to 4500 ppm MeCl.[27] The significance of these changes is not known.

A recent National Toxicology Program (NTP) report on the toxicology and carcinogenesis of MeCl in rats and mice reported dose-related increases in the incidences of testicular atrophy in male mice and uterine and ovarian atrophy in female mice.[6] The report implied that these effects might have been related to the increased occurrence of liver and lung neoplasms with increasing MeCl exposures (0, 2,000 or 4,000 ppm breathed 6 hours per day, 5 days per week, for 102 weeks).

F. Hand and Arm Effects

There were seven questions on questionnaire #1 that addressed the occurrence of symptoms and conditions affecting the forearms, wrists, or hands. Questionnaire responses of individuals holding job titles involving frequent repetitive movements (finisher, prime wiper, paint and pack, press side/blue wipe, press operator, bonder, deflasher, and painter) were compared to those of individuals with jobs involving little repetitive motion (repair, maintenance, paint and bond tech, inspector, shipper, slitter, utility, production technician, production tender, office, managerial, janitorial).

The high repetitive motion group, during the month prior to the study, had statistically significantly higher prevalences of numbness or tingling in the hands, forearm soreness, being awakened from sleep by numbness, tingling or pain in the arms or hands, and wrist or forearm discomfort during normal activities outside of work (Table 39). There were, however, no statistically significant group differences with respect to history of carpal tunnel syndrome (CTS), ganglionic cyst, or wrist tendonitis. It is possible that individuals with such conditions (a) were transferred to job titles with less repetitive motion, or (b) may have had surgery to correct this problem.

The responses to the four symptom question are not necessarily diagnostic of any particular medical condition. Such symptoms may occur simply from muscle fatigue or may be associated with tendonitis, referred pain from the neck and/or shoulder, or carpal tunnel syndrome.

Cumulative trauma disorders of the upper extremities are most frequently seen in people whose jobs require high speed repetitive motions, particularly in a posture which produces high biomechanical forces. Some assembly line work and meat cutting are examples of occupations where arm and hand problems are frequently found.

G. Respiratory and General Irritative Symptoms

Individuals with potential isocyanate exposure were compared to those without potential isocyanate exposure with respect to prevalence of irritative and respiratory symptoms. Finishers (excluding press side), paint and pack, paint and bond technicians, and painters were considered to have potential isocyanate exposures. Prime wipe, press side/blue wipe, press operator, bonder, deflasher, repair, maintenance, inspector, shipper, slitter, utility, production tender, managerial and janitorial job titles were considered, for purposes of this analysis, not to have isocyanate exposure.

All symptoms were more prevalent among potential isocyanate-exposed workers; the differences for nose or throat irritation, wheezing, and cough were statistically significant at the 0.05 level (Table 40).

H. Liver Function

A total of 149 venous blood samples were analyzed for liver function abnormalities. The following liver function tests were completed: total bilirubin, direct bilirubin, alkaline phosphatase,

SGOT, SGPT, and GGTP. One individual had an isolated elevation in total bilirubin (TB) to 1.39 mg/dl (normal range: 0.30-1.30 mg/dl). Another worker (L/L group) had a TB of 1.58 mg/dl, with a minor elevation in direct bilirubin (DB) to 0.35 mg/dl (normal range: 0.04-0.20 mg/dl). Six workers (2 L/L, 1 L/H, 1 CPOG, 1 ETOH, 1 Mixed) had very mild elevations of DB. None of the eight aforementioned workers had elevations of any other liver function tests. Four workers (1 L/L, 1 L/H, 1 CPOG, 1 ? DATA) had very mild alkaline phosphatase (AP) elevations ranging from 46-51 I.U./l (normal range: 15-45 I.U./l). One worker had of GGTP of 128 mU/ml (normal range: 5-50 mU/ml) and a SGPT of 109 (normal range: 10-75 I.U./l). This individual indicated sporadic usage of MeCl for 10-19 hours/week for a year, and was also exposed to other solvents and paints. Three individuals (1 L/H, 1 CPOG, 1 L/L) had isolated SGOT elevations ranging from 55-127 I.U./l (normal range: 15-50 I.U./l).

In summary, 16 of 149 participants had one or more abnormal liver function tests. Fourteen had elevations of only one test, and only two, with SGOT elevations, had results higher than one could attribute to laboratory error. One of these individuals had worked with MeCl in the past, the second had not. The worker with the GGTP and SGPT elevations did have exposure to multiple solvents and paints, and additional questionnaire data did not indicate medical conditions or medication use which might be responsible for these elevations. The worker with the total and direct bilirubin elevations indicated no solvent exposures.

VII. CONCLUSION

Employee exposures to MeCl were measured at all locations monitored in both facilities. The primary source of exposure is the prime wipe operation prior to glue application within the bonding areas. A secondary source is the use of MeCl as a general cleaning solvent at various jobs and locations. Due to its potential carcinogenic effect, NIOSH recommends that MeCl exposures be maintained at the lowest feasible level. All but one of the time-weighted average exposures to styrene were below the NIOSH REL of 50 ppm. However, the NIOSH RELs should not be considered as upper limits of exposure, and every effort should be made to reduce levels as low as practical.

This study found some evidence of an association between MeCl exposure and neurologic symptoms. Specifically, men with high present and past exposure were more likely to report symptoms than men with low present and past exposure. There were also associations between (a) work involving repetitive motion and hand and arm symptoms, and (b) jobs involving potential isocyanate exposure and irritative and respiratory

symptoms. There were no consistent, statistically significant associations between MeCl exposure and neurobehavioral test results, liver function abnormalities, or adverse reproductive outcomes.

Since certain central nervous system symptoms may be a more sensitive indicator of solvent exposure than effects detectable by neurobehavioral tests, the findings of this study are consistent with MeCl exposure. The interpretation of the results is limited, however, by other methodologic problems. First, there was a substantial non-participation rate among those initially selected for the follow-up medical study. This may have resulted in a biased (unrepresentative) sample of the workforce. Second, because of unanticipated exposure to styrene and incorrect reporting of exposure to MeCl by some workers, the original study design could not be followed. Instead, multiple, newly designated exposure groups were created, and comparisons between groups were made without the benefit of matched analyses. This certainly reduced the power of the study and may have introduced other biases. Finally, estimates of exposure to MeCl were based primarily on air concentrations. However, skin absorption and respirator use may have substantially affected actual exposures. Thus, some participants may have been assigned to inappropriate exposure groups, thereby reducing the likelihood of detecting an association between exposure and health effects.

VIII. RECOMMENDATIONS

1. Due to the carcinogenic potential of MeCl, an alternate method of pre-cleaning the plastic body panels should be sought (i.e., substitution with a less toxic solvent). In the interim, supplied air respirators should be provided to the employees engaged in the prime wipe operation. To prevent MeCl exposures to neighboring workers, these areas should be enclosed and ventilated. An environmental air monitoring program must accompany this endeavor to assure the containment of MeCl vapors.

2. All use of MeCl as a general cleaning solvent in any area of the facilities should be discontinued.

3. Recirculation of warm air generated by the presses is not recommended. The warm, styrene laden air, which is dispersed to other plant areas, is causing unnecessary exposures.

4. A continued program of isocyanate monitoring is recommended. Due to its sensitization potential, NIOSH recommends that in the presence of any measurable airborne isocyanate, supplied air respirators should be used. All respirator use should be accompanied by a complete respirator program as described in the OSHA standards, 29 CFR 1910.134.

5. Jobs involving repetitive hand and arm motion should be evaluated and redesigned to reduce the physical stresses associated with the postures, forces, and frequency of movements required to do the work. A comprehensive ergonomic evaluation is beyond the scope of NIOSH's health hazard evaluation program, but consultations and assistance in evaluation of specific problems are available.

IX. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods. Vol 2, 3rd ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1984. (DHEW (NIOSH) publication no. 84-100).

2. Hogstedt C, Hane M and Axelxon O, "Diagnostic and Health Care Aspects of Workers Exposed to Solvents", In Zenz, C. (Ed) Developments in Occupational Medicine, Chicago: Year Book Medical Publishers, Inc., 1980.

3. Jones RH, Ellicott MF, Cadigan JB and Gaensler EA. "The Relationship Between Alveolar and Blood Carbon monoxide Concentrations During Breathholding", J Lab & Clin Med 51: 553-564, 1958.

4. Astrand I, "Uptake of Solvents in the Blood and tissues of Man: A Review," Scand. J. Work Environment and Health 1: 199-218, 1975.

5. Steward RD and Dodd HC, "Absorption of Carbon Tetrachloride, Trichloroethylene, Tetrachloroethylene, Methylene chloride, and 1,1,1 - Trichloroethane Through the Human Skin", Industrial Hygiene J 25: 439-46, 1964.

6. National Toxicology Program (NTP) Technical Report Series No. 306 (1985) Toxicology and Carcinogenesis Studies of Dichloromethane (Methylene Chloride) (Cas No. 75-09-2) In F344/N Rats and B6C3F1 Mice (Inhalation Studies).

7. Kubic V and Anders M, "Metabolism of Dihalomethanes to Carbon Monoxide. II. In Vitro Studies. Drug Metab. Dispose. 3(2): 104-112.

8. Steward RD, Hake CL: Paint-remover hazard. JAMA 235:398;1976.

9. National Institute for Occupational Safety and Health. Criteria for a recommended standard--occupational exposure to methylene chloride. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication No. (NIOSH) 76-138).

10. Putz, VR, Johnson, BL and Setzer, JV. "A Comparative Study of the Effects of Carbon Monoxide and Methylene Chloride on Human Performance", Journal of Environmental Pathology and Toxicology, Volume 2, 1979, pp. 97-112.

11. American Conference of Governmental Industrial Hygienists (ACGIH) Documentation of the Threshold Limit Values, 4th Ed., Cincinnati, OH; ACGIH, Pub. Office, 1982.

12. Norton, S. Toxicology of the central nervous system in Toxicology, Admur, J., and Klassen, R.D., eds. New York: Macmillan, 1980.

13. Beard, R.R. Inorganic compounds of oxygen, nitrogen, and carbon. In: Patty's Industrial Hygiene and Toxicology, Vol. 2, Clayton, G.D. and Clayton, F.E., eds. New York: John-Wiley-Interscience 1981/1982.

14. Ginsberg, M.D. Carbon Monoxide. In: Experimental and Clinical Neurotoxicology, Spencer, P.S. and Schaumburg, H.H., eds. Baltimore: Williams and Wilkins, 1980.

15. National Institute for Occupational Safety and Health. Current intelligence bulletin 46--methylene chloride. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1986. (DHHS (NIOSH) publication no. 86-114).

16. Proctor NH and Hughes JP, Chemical Hazards of the Workplace, J.B. Lippincott Company, Philadelphia, 1978.

17. Criteria for a Recommended Standard...Occupational Exposure to Styrene. DHHS(NIOSH) Pub. No. 83-119.

18. Warm, J.S. and Jerison, H.J. The psychophysics of vigilance. In: J.S. Warm (ed.) Human Performance, New York: Wiley and Sons Ltd., 1984.

19. Winneke, G., Kastka, J. and Fodor, G.G. Disturbances of vigilance and visual-motor performance resulting from air pollution and drugs. In: M. Horvath, (ed.) Adverse Effects of Environmental Chemicals and Psychotropic Drugs. New York: Elsevier Scientific Publishing Co., 1973.

20. Johnson, B.L., Cohen, H.H., Struble, R., Setzer, J.V.S., Anger, W.K., Gutnick, B.D., McDonough, T., and Hauser, P. Field evaluation of carbon monoxide exposed toll collectors. In: C. Xintaras, B.L. Johnson, and I. DeGroot (eds.) Behavioral Toxicology. Washington, D.C.: U.S. Government Printing Office, 1974.

21. Dick, R.D., and Johnson, B.L. Human Experimental Studies. In: Zoltan Annau (ed) Neurobehavioral Toxicology, Baltimore, MD, Johns Hopkins Press.

22. Selevan, SG, "Evaluation of Data Sources for Occupational Pregnant Outcome Studies", Ph.D. Disertation, Univ. of Cincinnati, 1980.

23. Selevan, SG, "Design Considerations in Pregnancy Outcome Studies of Occupational Populations", Scand J Work Envir Health 7:76-82, 1981.

24. Ed. Bloom AD. Guidelines for studies of Human Populations Exposed to Mutagenic and Reproductive Hazards. Proceedings of Conference held January 26-27, 1981 in Washington, D.C., March of Dimes Birth Defects Foundation.

25. Hemminki K, Franssila E and Vainio H, "Spontaneous Abortions Among Female Chemical Workers in Finland:, Intl Arch of Occup & Envir Health 45:123-126, 1980.

26. Hemminki K, Saloniemi I, Luoma K, Salonen T, Partanen T, Vainio H and Hemminki E. "Transplacental Carcinogens and Mutagens: Childhood Cancer, Malformations and Abortions as Risk Indicators" J of Tox & Envir Health 6 (5-6):1115-1127, 1980.

27. Barlow SM and Sullivan FM. Reproductive Hazards of Industrial Chemicals: An Evaluation of Animal and Human Data. Academic Press: New York, 1982.

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TABLE 1

EVALUATION CRITERIA

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
JANUARY 28-FEBRUARY 8, 1985

Substance	Evaluation Criteria (ppm) NIOSH	OSHA	ACGIH	Primary Health Effects
Acetone	250	1000	750	Inhalation of acetone vapor in high concentrations produces dryness of the mouth and throat, dizziness, nausea, incoordinated speech, drowsiness, and in extreme cases coma. Inhalation of small quantities of acetone vapor over long periods causes irritation of the respiratory tract, coughing, and headache.
Carbon Monoxide	35	50	50	Carbon monoxide combines with hemoglobin to form carboxhemoglobin which interferes with the oxygen carrying capacity of the blood, resulting in a state of tissue hypoxia, progressively characterized by headache, dizziness, drowsiness, nausea, vomiting, collaps, coma, and death.
Methylene Chloride	LFL*	500	100	High vapor concentrations may affect the nervous system, leading to light-headedness, nausea, vomiting, and headache, plus irritation of the eyes and respiratory tract. Because it causes cancer in research animals, NIOSH considers MeCl a potential occupational carcinogen.
Styrene	50	100	50	Acute exposure to high concentrations may produce irritation of the upper respiratory tract, nose, and mouth, followed by symptoms of narcosis, cramps, and death due to respiratory center paralysis. Effects of short-term exposure to styrene under laboratory conditions include prolonged reaction time and decreased manual dexterity.

CONT.

TABLE 1 (Cont.)

EVALUATION CRITERIA

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
JANUARY 28-FEBRUARY 8, 1985

Substance	Evaluation Criteria (ppm) NIOSH	OSHA	ACGIH	Primary Health Effects
Toluene	100	200	100	May cause irritation of the eyes, respiratory tract, and skin, with acute exposures predominantly resulting in central nervous system depression, characterized (progressively) by headache, dizziness, fatigue, muscular weakness, drowsiness, incoordination with staggering gait, skin paresthesias, collaps, and coma.
Xylene	100	100	100	May cause irritation of the eyes, respiratory tract, and skin. High exposure may result in central nervous system depression and minor reversible effects upon the liver and kidneys.[5]

TABLE 2

EXPOSURE SUMMARY

BUDD COMPANY
NORTH BALTIMORE, OHIO

JANUARY 30-FEBRUARY 4, 1985
HETA 84-459

Location/Operation	# Samples	Descriptive Statistics (ppm)[1] Range	Mean	S.D.[2]
Bonding				
Methylene Chloride	11	ND -154.4	55.4	52.6
Styrene	11	ND - 10.4	6.5	3.4
CO	4	6 - 12	9	3
Finishing Areas (No Touch-Up Painting)				
Methylene Chloride	6	3.3 - 7.5	4.6	1.6
Styrene	6	0.5 - 8.3	4.6	2.8
CO	5	3 - 8	6	2
Press Side Finish & Deflash				
Methylene Chloride	10	0.8 - 32.9	5.6	9.6
Styrene	10	1.4 - 18.2	10.5	5.5
CO	6	2 - 8	5	2
Press Operators				
Methylene Chloride	7	1.2 - 10.1	3.9	3.4
Styrene	7	25.4 - 71.6	40.8	15.5
CO	2	3 - 9	6	2
Miscellaneous Exposure Groups				
Methylene Chloride	11	ND - 5.3	2.5	1.7
Styrene	11	1.1 - 9.4	4.6	2.9
CO	6	2 - 8	6	2
Touch-up/Spray Paint Areas				
Methylene Chloride	22	0.7 - 84.2	11.3	22.9
Styrene	22	ND - 31.5	7.8	7.1
Acetone	22	ND - 1.1	0.2	0.3
Toluene	22	ND - 2.2	0.3	0.6
Xylene	22	ND - 1.3	0.3	0.4
CO	12	1 - 9	6	3

1 ppm = parts of vapor per million parts of air
2 Samples with non-detectable analytical results were treated as "0" for these calculations.

TABLE 3

EXPOSURE SUMMARY
BUDD COMPANY
CAREY, OHIO

FEBRUARY 4-8, 1985
HETA 85-110

Location/Operation	# Samples	Descriptive Statistics (ppm)[1] Range	Mean	S.D.[2]
Bonding				
Methylene Chloride	14	2.2 - 239	65.7	62.6
Styrene	14	ND - 13.6	4.0	4.0
CO	7	5 - 35	22	13
Finishing Areas (No Touch-up)				
Methylene Chloride	8	ND - 18.4	4.5	6.9
Styrene	8	ND - 8.0	4.7	4.5
CO	2	4 - 7	6	2
Press Side Finish (No Touch-up)				
Methylene Chloride	11	ND - 58.6	12.2	19.9
Styrene	11	ND - 16.4	6.1	5.1
CO	7	7 - 17	10	4
Press Operators				
Methylene Chloride	15	ND - 90.5	13.7	24.5
Styrene	15	ND - 33.9	12.7	10.5
CO	8	3 - 52	16	18
Miscellaneous Exposure Groups				
Methylene Chloride	10	ND - 46.8	10.3	14.1
Styrene	10	ND - 8.2	5.2	2.4
CO	3	5 - 29	16	18
Touch-up/Spray Paint Areas				
Methylene Chloride	19	ND - 233	13.6	53.1
Styrene	19	ND - 10.7	3.8	3.1
Acetone	19	ND - 0.3	0.0	0.0
Toluene	19	ND - 1.4	0.5	0.4
Xylene	19	ND - 1.1	0.3	0.4
CO	8	2 - 10	6	3

1 ppm = parts of vapor per million parts of air
2 Samples with non-detectable analytical results were treated as "0" for these calculations.

TABLE 4

METHYLENE CHLORIDE / STYRENE / CARBON MONOXIDE EXPOSURES
BONDING AREA

BUDD COMPANY
NORTH BALTIMORE, OHIO

JANUARY 30-FEBRUARY 4, 1985
HETA 84-459

Sample #	Date	Duration	Operation	Exposure Concentration (ppm)[1] MeCl[2]	Styrene	CO
033	1/30	1503-2305	Prime Wipe	137.4	7.0	S[3]
028	1/30	1504-2305	Prime Wipe	3.3	9.1	6
058	1/30	1508-2308	De-Rope	2.7	8.9	7
324	1/31	0657-1503	Prime Wipe	154.4	10.4	S
313 & 345	1/31	0700-1459	Prime Wipe	30.8	7.6	9
231 & 258	1/31	2243-0654	Prime Wipe	25.6	3.5	12
242 & 228	1/31	2231-0705	Prime Wipe	68.1	6.3	S
100	2/1	1504-2130	Prime Wipe	43.4	10.0	-
170 & 235	2/1	1442-2252	Prime Wipe	60.1	7.4	-
137	2/4	0656-1503	Bonding	ND[4]	ND	-
229	2/4	0646-1330	Ski Room Bond	83.0	1.5	-

1 ppm = parts of vapor per million parts of air.
2 MeCl = Methylene chloride.
3 MeCl Chloride interference; saturated indicator tube.
4 ND = Non-detected analytical result.

TABLE 5

METHYLENE CHLORIDE / STYRENE / CARBON MONOXIDE EXPOSURES
FINISHING AREAS (No Touch-up Painting)

BUDD COMPANY
NORTH BALTIMORE, OHIO

JANUARY 30-FEBRUARY 4, 1985
HETA 84-459

Sample #	Date	Duration	Operation	Exposure Concentration (ppm)[1] MeCl[2]	Styrene	CO
050	1/30	1503-2126	Lid (1st Prime)	3.3	5.5	5
003	1/30	1503-2306	Qrtr (1st Prime)	3.7	8.3	3
303	1/31	0646-1507	Qrtr (1st Prime)	4.6	4.6	6
309	1/31	0643-1455	Lid (1st Prime)	5.0	2.3	8
318	1/31	2230-0650	Qrtr (1st Prime)	7.5	6.4	7
261	2/1	0650-1505	Qrtr (1st Prime)	3.6	0.5	-

[1] ppm = parts of vapor per million parts of air.
[2] MeCl = Methylene chloride.

TABLE 6

METHYLENE CHLORIDE / STYRENE / CARBON MONOXIDE EXPOSURES
PRESS SIDE FINISH AND DE-FLASH

BUDD COMPANY
NORTH BALTIMORE, OHIO

JANUARY 30-FEBRUARY 4, 1985
HETA 84-459

Sample #	Date	Duration	Operation	Exposure Concentration (ppm)[1] MeCl[2]	Styrene	CO
052	1/30	1455-2153	Deflash (Press #4)	2.0	8.9	5
054	1/30	1508-2309	Deflash (Press #8)	3.9	14.2	8
344	1/31	0644-1506	Deflash (Press #4)	3.1	11.9	4
339	1/31	0657-1455	Finish (various)	3.2	6.0	2
350	1/31	0651-1459	Finish (Press #4)	3.3	15.9	3
210	1/31	2233-0653	Finish (Press #6)	2.0	8.2	5
075	2/1	1440-2248	Finish (Press #7)	2.5	18.2	-
348	2/1	1440-2252	Finish (Press #4)	1.9	15.5	-
247	2/1	1435-2259	Std Dvr (Press #4)	0.8	4.4	-
105	2/4	0643-1330	Ski Room Finish	32.9	1.4	-

[1] ppm = parts of vapor per million parts of air.
[2] MeCl = Methylene chloride.

TABLE 7

METHYLENE CHLORIDE / STYRENE / CARBON MONOXIDE EXPOSURES
PRESS OPERATORS

BUDD COMPANY
NORTH BALTIMORE, OHIO

JANUARY 30-FEBRUARY 4, 1985
HETA 84-459

Sample #	Date	Duration	Location	Exposure Concentration (ppm)[1] MeCl[2]	Styrene	CO
015	1/30	1508-2307	Press #2	1.2	38.6	9
342	1/31	0638-1508	Press #2	1.5	31.7	3
304	1/31	2232-0654	Press #8	10.1	50.1	S[3]
220	2/1	1435-2259	Press #8	7.3	71.6	-
148	2/1	1436-2258	Press #9	2.1	25.4	-
147	2/4	0651-1459	Press #3	2.3	33.9	-
077	2/4	0649-1501	Press #3	2.7	34.5	-

1 ppm = parts of vapor per million parts of air.
2 MeCl = Methylene chloride.
3 Methylene Chloride interference; saturated indicator tube.

TABLE 8

METHYLENE CHLORIDE / STYRENE / CARBON MONOXIDE EXPOSURES
MISCELANEOUS EXPOSURE GROUPS

BUDD COMPANY
NORTH BALTIMORE, OHIO

JANUARY 30-FEBRUARY 4, 1985
HETA 84-459

Sample #	Date	Duration	Operation	Exposure Concentration (ppm)[1] MeCl[2]	Styrene	CO
018	1/30	1459-2304	Maintenance	1.0	2.1	6
053	1/30	1457-2304	Maintenance	1.7	2.3	6
341	1/31	2235-0701	Inspection	4.6	9.4	5
204	1/31	2249-0701	Janitor	1.4	1.9	7
267	1/31	2251-0701	Fork Lift	2.8	4.1	8
239	1/31	2251-0657	Maintenance	1.8	6.4	2
256	2/1	1452-2259	Repair	1.8	8.6	-
153	2/1	1439-2252	Inspection	5.3	4.6	-
133	2/1	1433-2300	Maintenance	ND[3]	1.1	-
040	2/4	0638-1502	Slitter	2.4	7.3	-
109	2/4	0641-1507	Inspection	4.5	2.3	-

1 ppm = parts of vapor per million parts of air.
2 MeCl = Methylene chloride.
3 ND = Non-detected analytical result.

TABLE 9

SOLVENT / CARBON MONOXIDE EXPOSURES
TOUCH-UP/SPRAY-PAINT AREAS

BUDD COMPANY
NORTH BALTIMORE, OHIO

JANUARY 30-FEBRUARY 4, 1985
HETA 84-459

Sample#	Duration	Operation	Concentration (ppm)[1] MeCl[2]	Styrene	Acetone	Toluene	Xylenes	CO
016	1511-2310	Lite Finish	84.2	5.3	1.1	1.4	0.9	5
027	1503-2309	Paint & Pack	1.9	11.7	0.3	ND[3]	0.6	7
296	0650-1449	Paint & Pack	2.0	11.3	0.3	0.4	0.5	9
321	0638-1505	Merc Finish	2.3	11.1	ND	ND	0.3	4
302	0641-1505	Cadlc Finish	3.2	6.4	ND	ND	ND	6
350	2236-0650	Merc Finish	1.8	9.6	ND	ND	0.6	1
243	2240-0700	Paint & Pack	3.5	10.0	0.8	ND	0.5	4
127	0645-1501	Paint & Pack	2.8	11.3	0.3	0.4	0.5	2
275	2240-0657	Cowl Finish	19.2	2.9	ND	ND	ND	8
263	2246-0650	Paint & Pack	4.0	31.5	ND	ND	ND	-
276	1432-2254	Quarter Finish	1.8	3.3	ND	ND	0.5	-
154	1437-2300	Cadlc Finish	2.6	7.8	ND	0.3	0.6	-
211	1441-2248	Cwn Vic Finish	1.9	11.9	ND	ND	ND	-
212	1452-2246	Flair Finish	77.4	8.6	ND	ND	ND	-
282	0705-1500	Lid Finish	2.3	0.9	ND	0.5	ND	-
334	0658-1500	Lid Finish	4.4	3.4	ND	0.7	0.2	-
219	0655-1506	Bnvl Finish	8.9	17.4	0.7	0.8	0.7	-
102	0636-1439	Paint & Pack	0.7	0.6	ND	ND	ND	-
017	1500-2306	Quarter Bootn	3.4	3.3	0.3	0.2	0.3	8
340	0700-1333	Ski Paint Booth	7.1	2.6	0.6	2.2	1.3	8
215	2232-0657	Main Pnt Booth	8.6	0.4	0.5	0.3	ND	5
101	0703-1503	Quarter Booth	5.2	ND	ND	ND	ND	-

1 ppm = parts of vapor per million parts of air.
2 MeCl = Methylene chloride.
3 ND = Non-detected analytical result.

TABLE 10

METHYLENE CHLORIDE / STYRENE / CARBON MONOXIDE EXPOSURES
BONDING AREA

BUDD COMPANY
CAREY, OHIO

FEBRUARY 4-6, 1985
HETA 85-110

Sample #	Date	Duration	Operation	Exposure Concentration (ppm)[1] MeCl[2]	Styrene	CO
279	2/5	0635-1457	De-Rope	33.9	7.5	11
249	2/5	0643-1500	Bond	139.0	8.3	S[3]
140	2/5	0645-1458	Prime Wipe	106.5	7.7	S
114	2/5	2252-0703	Bond	38.5	4.7	31
180 & 268	2/5	2243-0702	Bond	33.0	0.8	31
085	2/5	2256-0530	De-Rope	91.2	4.5	S
047	2/5	2245-0703	Prime Wipe	33.7	3.7	35
135	2/6	1452-2128	Bond	2.2	ND[4]	7
034	2/6	1438-2247	Bond	31.8	13.6	5
452	2/6	1954-2130	Bond	62.4	ND	S
456	2/7	0640-1457	Bond	239.7	1.8	-
476	2/7	2239-0659	Bond	23.1	1.4	-
443 & 434	2/7	2245-0652	Bond	65.4	1.3	-
446	2/7	2238-0642	De-Rope	19.0	1.3	-

1 ppm = parts of vapor per million parts of air.
2 MeCl = Methylene chloride.
3 Methylene Chloride interference; saturated indicator tube.
4 ND = Non-detected analytical result.

TABLE 11

METHYLENE CHLORIDE / STYRENE / CARBON MONOXIDE EXPOSURES
FINISHING AREAS (No Touch-up Painting)

BUDD COMPANY
CAREY, OHIO

FEBRUARY 4-8, 1985
HETA 85-110

Sample #	Date	Duration	Location	Exposure Concentration (ppm)[1] MeCl[2]	Styrene	CO
094	2/5	0654-1500	J Car	ND[3]	0.9	7
311	2/6	1443-2254	K Car	0.5	ND	4
498	2/7	0638-1326	K Car	1.1	7.5	-
079	2/7	2232-0657	Rework (lite)	12.4	4.9	-
412	2/7	2250-0641	K Car	1.4	13.3	-
439	2/8	1432-2247	K Car	0.8	6.3	-
482	2/8	1435-2249	Lite Finish	18.4	4.4	-
466	2/8	1449-2258	Cadlc	1.2	0.5	-

1 ppm = parts of vapor per million parts of air.
2 MeCl = Methylene chloride.
3 ND = Non-detected analytical result.

TABLE 12

METHYLENE CHLORIDE / STYRENE / CARBON MONOXIDE EXPOSURES
PRESS-SIDE FINISH (No Touch-up)

BUDD COMPANY
CAREY, OHIO

FEBRUARY 4-8, 1985
HETA 85-110

Sample #	Date	Duration	Location	Exposure Concentration (ppm)[1] MeCl[2]	Styrene	CO
056	2/5	0648-1456	Press	1.2	6.0	10
310	2/5	0638-1458	Press #25	58.6	16.4	S[4]
108	2/5	0650-1459	Press #14	1.8	7.9	13
167	2/5	0639-1500	Press #5	1.6	12.2	7
031	2/5	2237-0528	Press # 13	1.7	6.0	17
074	2/5	2254-0701	Press # 6	38.6	4.2	12
254	2/6	1447-2258	Lite Presses	1.2	2.0	9
474	2/7	0657-1500	Press #11	2.5	1.5	-
403	2/7	2254-0658	Press #16	25.9	1.3	-
437	2/8	1441-2254	Press #10	1.0	9.4	-
465	2/8	2445-2256	Press #9	ND[5]	ND	-

1 ppm = parts of vapor per million parts of air.
2 MeCl = Methylene chloride.
3 Methylene Chloride interference; saturated indicator tube.
4 ND = Non-detected analytical result.

TABLE 13

METHYLENE CHLORIDE / STYRENE / CARBON MONOXIDE EXPOSURES
PRESS OPERATORS
BUDD COMPANY
CAREY, OHIO

FEBRUARY 4-8, 1985
HETA 85-110

Sample #	Date	Duration	Location	Exposure Concentration (ppm)[1] MeCl[2]	Styrene	CO
088	2/5	0629-1457	Press #29	0.3	ND[3]	3
107	2/5	0634-1501	Press #6	ND	1.7	37
090	2/5	2241-0656	Press #5	1.9	17.5	7
161	2/5	2245-0703	Press #12	1.2	15.6	8
291	2/5	2250-0704	Lite Presses	40.8	11.4	52
155	2/6	1440-2252	Press #8 (puller)	2.4	10.3	7
223	2/6	1450-2250	Press #12 (puller)	2.4	9.5	6
044	2/6	1429-2255	Press #2	1.5	15.5	6
458	2/7	0658-1458	Press #25	26.9	30.4	-
487	2/7	0639-1500	Press #28	90.5	12.4	-
422	2/7	2235-0659	Press #13	1.2	2.4	-
008	2/8	1443-2256	Press #5	0.8	23.3	-
603	2/8	1436-2254	Press #28	2.1	ND	-
421	2/8	1437-2257	Press #13	1.3	33.9	-
431	2/8	1439-2254	Press #30	22.3	5.8	-

1 ppm = parts of vapor per million parts of air.
2 MeCl = Methylene chloride.
3 ND = Non-detected analytical result.

TABLE 14

METHYLENE CHLORIDE / STYRENE / CARBON MONOXIDE EXPOSURES
MISCELLANEOUS EXPOSURE GROUPS

BUDD COMPANY
CAREY, OHIO

FEBRUARY 4-8, 1985
HETA 85-110

Sample #	Date	Duration	Operation	Exposure Concentration (ppm)[1] MeCl[2]	Styrene	CO
283	2/5	0631-1500	Q.C.	2.7	6.2	15
252	2/5	0650-1437	Tool Setter	2.7	5.7	29
144	2/6	2253-0703	Material Handler	12.2	8.2	5
424	2/7	0634-1500	Hanger/Sweeper	1.0	4.4	-
470	2/7	0635-1455	Parts Hanger	46.8	6.4	-
428	2/7	0653-1325	Prod. Tender	13.9	5.7	-
481	2/7	0640-1501	Air Blow	ND[3]	ND	-
427	2/8	1440-2257	Material Handler	2.3	5.6	-
413	2/8	1444-2236	Fork Lift	16.5	2.6	-
445	2/8	1438-2251	Slitter	4.4	7.5	-

1 ppm = parts of vapor per million parts of air.
2 MeCl = Methylene chloride.
3 ND = Non-detected analytical result.

TABLE 15

SOLVENT / CARBON MONOXIDE EXPOSURES
TOUCH-UP/SPRAY-PAINT AREAS

BUDD COMPANY
CAREY, OHIO

FEBRUARY 4-8, 1985
HETA 85-110

Sample#	Duration	Operation	Concentration (ppm)[1] MeCl[2]	Styrene	Acetone	Toluene	Xylenes	CO
084	2233-0703	Cowl Panel	1.0	3.7	ND[3]	0.6	ND	2
233	2245-0656	Paint & Pack	1.2	8.5	ND	1.1	0.5	9
067	2259-0703	Lift Gate	ND	ND	ND	1.4	ND	-
171	2233-0701	J Car	ND	0.4	ND	1.0	ND	8
025	1444-2257	Press #3	1.2	7.5	ND	ND	ND	2
087	1433-2254	Paint & Pack	1.9	10.7	ND	0.7	1.1	7
278	1451-2256	Hoods	ND	2.2	ND	ND	ND	9
455	0648-1455	Aries	232.6	4.1	ND	0.5	0.9	-
493	0650-1459	Paint & Pack	2.2	6.1	ND	0.5	0.7	-
435	0639-1500	Paint & Pack	ND	ND	ND	ND	ND	-
411	2242-0649	Citation Bond	0.4	5.1	0.3	0.4	0.2	-
484	2250-0655	Cowl	ND	ND	ND	ND	ND	-
459	2236-0640	J Car	1.2	5.3	ND	0.4	ND	-
601	1434-2255	Ramcharger	ND	4.4	ND	ND	ND	-
438	1433-2256	J Car	0.4	5.0	ND	0.3	0.7	-
080	0637-1501	Paint Booth	4.6	1.3	ND	0.6	0.3	4
454	0643-1500	Paint Booth	0.6	4.9	ND	0.4	0.7	-
480	0652-1458	Paint Booth	ND	ND	ND	0.6	ND	-
131	0636-1458	Paint Tech.	11.7	2.5	ND	0.9	ND	10

1 ppm = parts of vapor per million parts of air.
2 MeCl = Methylene chloride.
3 ND = Non-detected analytical result.

TABLE 16
RESPIRABLE DUST EXPOSURES

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO

JANUARY 30-FEBRUARY 8, 1985
HETA 84-459; 85-110

Sample #	Date	Duration	Operation	Exposure Concentration (mg/m^3)
North Baltimore Plant				
3175	1/31	0819-1425	Deflash - Press #2	0.06
3179	1/31	0831-1433	Deflash - Press #11	0.11
3183	1/31	0827-1429	Stud Drive - Press #8	0.21
Carey Plant				
3185	2/5	2343-0623	Finish - Press #8	0.32
3189	2/5	2354-0627	Operator - Press #22	0.54
3186	2/5	2348-0621	Operator - Press #13	0.26
3190	2/5	2339-0625	Finish - K Car	0.39
3188	2/5	2333-0626	Finish - AMC Lift Gate	1.05
3183	2/8	1540-1043	Finish - AMC Lift Gate	0.79

TABLE 17

STUDY PARTICIPATION

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

	Number of Questionnaire #1's	Selected study group	Alternates listed	Number ultimately studied	Number alternates used	Number non-listed workers
PLANT 1						
shift						
1	141	28	14	28	6	2
2	100	28	10	28	3	2
3	150	14	6	14	3	0
PLANT 2						
shift						
1	129	28	8	28	3	0
2	136	28	10	28	3	0
3	108	28	4	25	3	2

TABLE 18

SUMMARY OF METHYLENE CHLORIDE EXPOSURE (ppm)

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	N	Mean	S.D.	Median	Min	Max
Males						
CPOG	7	3.4	3.7	1.9	0.3	10.0
L/H	12	5.1	6.3	3.0	0.0	19.0
MIXED	2	17.6	18.7	17.6	4.4	30.8
EXCLUDED	11	33.8	32.6	33.0	0.0	106.5
PPOG	3	4.2	2.5	3.1	2.4	7.1
L/L	21	2.2	1.4	1.8	0.0	5.2
H/H	12	73.9	61.9	56.1	23.1	239.7
Females						
CPOG	7	1.4	0.9	1.3	0.0	2.7
L/H	11	5.7	6.9	2.2	0.0	19.2
MIXED	7	28.8	30.2	22.3	3.6	90.5
EXCLUDED	5	35.1	37.1	25.9	1.0	84.2
L/L	40	2.6	3.5	1.9	0.0	17.4
H/H	4	100.9	56.2	108.2	32.9	154.4

TABLE 19

SUMMARY OF STYRENE EXPOSURE (ppm)

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	N	Mean	S.D.	Median	Min	Max
Males						
CPOG	7	29.4	26	25.4	0.0	71.6
L/H	12	3.9	3.1	3.5	0.0	9.1
MIXED	2	7.5	0.1	7.5	7.5	7.6
EXCLUDED	11	11.1	11.5	7.4	0.8	33.9
PPOG	3	7.3	4.7	7.3	2.6	11.9
L/L	21	6.8	4.9	6.0	0.0	15.9
H/H	12	4.1	2.3	4.1	1.3	7.5
Females						
CPOG	7	20.1	14.8	23.3	0.0	34.5
L/H	11	3.8	3.5	3.4	0.0	9.6
MIXED	7	10.5	9.7	8.2	0.5	30.4
EXCLUDED	5	3.8	3.4	3.7	0.0	8.6
L/L	40	5.8	4.7	5.5	0.0	18.2
H/H	4	7.2	4.0	8.4	1.4	10.4

TABLE 20

SUMMARY OF AGE

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	N	Mean	S.D.	Median	Min	Max
Males						
? CAT	4	28.3	5.6	30.5	20.0	32.0
CPOG	7	29.0	8.1	28.0	20.0	40.0
ETOH	6	30.2	9.6	27.5	21.0	48.0
? DATA	3	22.0	3.6	21.0	19.0	26.0
L/H	12	29.3	7.8	27.5	20.0	49.0
MIXED	3	27.7	3.8	26.0	25.0	32.0
PPO	3	28.3	4.5	28.0	24.0	33.0
L/L	21	29.0	5.5	29.0	20.0	38.0
EPI	2	27.0	7.1	27.0	22.0	32.0
H/H	13	26.2	4.5	26.0	19.0	35.0
Females						
? CAT	4	36.8	15.3	32.0	25.0	58.0
CPOG	7	31.9	6.3	29.0	25.0	40.0
ETOH	2	31.0	5.7	31.0	27.0	35.0
? DATA	1	26.0	----	----	----	----
L/H	12	30.0	6.3	29.5	19.0	42.0
MIXED	7	28.4	3.8	29.0	21.0	33.0
L/L	40	29.7	6.6	29.5	20.0	47.9
H/H	4	30.0	7.0	29.5	24.0	37.0

TABLE 21

SUMMARY OF SCHOOLING (highest grade)

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	N	Mean	S.D.	Median	Min	Max
Males						
? CAT	4	11.0	1.4	11.5	9.0	12.0
CPOG	7	12.0	0.0	12.0	12.0	12.0
ETOH	6	12.0	0.0	12.0	12.0	12.0
? DATA	3	13.0	1.7	12.0	12.0	15.0
L/H	12	11.9	0.3	12.0	11.0	12.0
MIXED	3	11.7	0.6	12.0	11.0	12.0
PPO	3	12.0	0.0	12.0	12.0	12.0
L/L	21	11.7	1.1	12.0	9.0	14.0
EPI	2	12.0	0.0	12.0	12.0	12.0
H/H	13	11.8	0.4	12.0	11.0	12.0
Females						
? CAT	4	11.8	0.5	12.0	11.0	12.0
CPOG	6	12.0	0.0	12.0	12.0	12.0
ETOH	2	12.0	0.0	12.0	12.0	12.0
EXCLU	1	12.0	----	----	----	----
L/H	12	11.4	1.0	12.0	9.0	12.0
MIXED	7	11.7	0.5	12.0	11./0	12.0
L/L	40	11.8	0.7	12.0	9.0	12.0
H/H	4	12.0	0.0	12.0	12.0	12.0

TABLE 22

SUMMARY OF DRINKS/WEEK

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	N	Mean	S.D.	Median	Min	Max
Males						
? CAT	4	9.8	9.8	8.5	1.0	21.0
CPOG	6	5.7	5.3	4.0	1.0	15.0
ETOH	1	35.0	----	----	----	----
? DATA	3	11.7	3.5	12.0	8.0	15.0
L/H	9	6.2	4.1	6.0	2.0	15.0
MIXED	2	7.0	1.4	7.0	6.0	8.0
PPO	3	4.0	2.0	4.0	2.0	6.0
L/L	14	6.1	6.9	3.5	0.0	24.0
EPI	1	5.0	----	----	----	----
H/H	9	10.6	7.6	8.0	3.0	24.0
Females						
? CAT	2	2.5	0.7	2.5	2.0	3.0
CPOG	4	2.3	2.9	1.5	0.0	6.0
ETOH	1	45.0	----	----	----	----
? DATA	1	0.0	----	----	----	----
L/H	9	4.1	4.3	2.0	0.0	14.0
MIXED	5	6.4	5.9	4.0	2.0	16.0
L/L	25	4.7	4.0	4.0	0.0	16.0
H/H	2	2.5	0.7	2.5	2.0	3.0

TABLE 23

NEUROBEHAVIORAL TESTING/QUESTIONNAIRE BY TIME ADMINISTERED DURING SHIFT

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	hr 1	hr 2	hr 3	hr 4	hr 5	hr 6	hr 7	Total
CPUG	3 (18%)	3 (18%)	3 (18%)	2 (12%)	1 (6%)	2 (12%)	3 (18%)	17
L/H	2 (9%)	0	2 (9%)	3 (13%)	3 (13%)	8 (35%)	2 (22%)	23
MIXED	1 (10%)	4 (40%)	3 (30%)	1 (10%)	0	1 (10%)	0	10
EXCLD	1 (6%)	1 (6%)	1 (6%)	3 (17%)	5 (28%)	4 (22%)	3 (17%)	18
L/L	12 (20%)	8 (13%)	9 (15%)	12 (20%)	9 (15%)	7 (11%)	4 (7%)	61
H/H	2 (12%)	4 (24%)	4 (24%)	1 (6%)	1 (6%)	0	5 (29%)	17
Total	21	20	22	22	19	22	20	146

TABLE 24

GROUP BY SHIFT

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	1st Shift	2nd Shift	3rd Shift	Total
CPUG	7 (41%)	7 (41%)	3 (18%)	17
L/H	7 (30%)	10 (43%)	6 (26%)	23
MIXED	4 (40%)	4 (40%)	2 (20%)	10
EXCLUDED	7 (39%)	6 (33%)	5 (28%)	18
L/L	23 (38%)	24 (39%)	14 (23%)	61
H/H	7 (41%)	4 (24%)	6 (35%)	17
Total	55	55	36	146

TABLE 25

GROUP BY HEAD INJURY

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	Head Injury	No Head Injury	Total
CPOG	2 (12%)	15 (88%)	17
L/H	4 (17%)	20 (83%)	24
MIXED	3 (30%)	7 (70%)	10
EXCLUDED	3 (17%)	15 (83%)	18
L/L	9 (15%)	52 (85%)	61
H/H	0	17 (100%)	17
Total	21	126	147

TABLE 26

EXPOSURE GROUPS - MALE
NUMBER YES RESPONSES/PERCENT

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Swedish-Io Questionnaire	L/L n=21	L/H n=12	H/H n=13	CPOG+PPOG n=10	MIX n=3
Memory	5 (24%)	5 (42%)	7 (54%)	3 (30%)	2 (67%)
Relative	7 (33%)	7 (58%)	3 (23%)	3 (30%)	2 (67%)
Notes	9 (43%)	6 (50%)	5 (39%)	4 (40%)	2 (67%)
Go back	8 (38%)	7 (58%)	9 (69%)	5 (50%)	2 (67%)
Meaning	7 (33%)	3 (25%)	5 (39%)	3 (30%)	2 (67%)
Concentration	5 (24%)	6 (50%)	4 (31%)	4 (40%)	2 (67%)
Irritated	5 (24%)	4 (33%)	6 (46%)	4 (40%)	1 (33%)
Tired	7 (33%)	5 (42%)	8 (62%)	3 (30%)	3 (100%)
Depressed	4 (19%)	4 (33%)	7 (54%)	4 (40%)	1 (33%)
Libido	3 (14%)	0	2 (15%)	3 (30%)	1 (33%)
Palpitations	3 (14%)	2 (17%)	3 (23%)	2 (20%)	1 (33%)
Pressure	9 (43%)	6 (50%)	9 (69%)	3 (30%)	2 (67%)
Perspire	3 (14%)	3 (25%)	5 (39%)	0	2 (67%)
Headache	9 (43%)	7 (58%)	7 (54%)	4 (40%)	0
Tingling	6 (29%)	3 (25%)	6 (46%)	6 (60%)	1 (33%)
Buttoning	3 (14%)	0	2 (15%)	3 (30%)	0

TABLE 27

EXPOSURE GROUPS - FEMALE
NUMBER YES RESPONSES/PERCENT

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Swedish-16 Questionnaire	L/L n=40	L/H n=12	H/H n=4	CPOG+PPOG n=7	MIX n=7
Memory	19 (48%)	8 (67%)	0	1 (14%)	2 (29%)
Relative	16 (40%)	6 (50%)	2 (50%)	0	3 (43%)
Notes	21 (54%)	7 (58%)	1 (25%)	3 (43%)	4 (57%)
Go Back	28 (70%)	10 (83%)	4 (100%)	1 (14%)	4 (57%)
Meaning	8 (20%)	7 (58%)	0	0	3 (43%)
Concentration	18 (45%)	9 (75%)	2 (50%)	1 (14%)	3 (43%)
Irritated	28 (70%)	8 (67%)	2 (50%)	4 (57%)	4 (57%)
Depressed	28 (70%)	8 (67%)	2 (50%)	4 (57%)	4 (57%)
Tired	20 (50%)	9 (75%)	3 (75%)	5 (71%)	7 (100%)
Sex	10 (25%)	9 (75%)	0	3 (43%)	3 (43%)
Palpitations	9 (23%)	3 (25%)	1 (25%)	3 (50%)	3 (43%)
Pressure	23 (58%)	7 (58%)	2 (50%)	5 (71%)	5 (71%)
Perspire	5 (13%)	2 (17%)	1 (25%)	2 (29%)	3 (43%)
Headache	32 (80%)	8 (67%)	4 (100%)	4 (57%)	6 (86%)
Tingling	22 (55%)	8 (67%)	1 (25%)	6 (86%)	4 (57%)
Buttoning	3 (8%)	0	1 (25%)	0	2 (29%)

APPENDIX A

(Question groupings for the Swedish - 16 Questionaire)

FORGETFULNESS:

1. Do you have a short memory? 1____YES 2____NO

2. Have your relatives told you that you have a short memory? 1____YES 2____NO

3. Do you often have to make notes about what you must remember? 1____YES 2____NO

4. Do you often have to go back and check things you have done such as turned off the stove, locked the door, etc.? 1____YES 2____NO

ABSENTMINDNESS:

5. Do you generally find it hard to get the meaning from reading newspapers and books? 1____YES 2____NO

6. Do you often have problems with concentrating? 1____YES 2____NO

AFFECT LABILITY:

7. Do you often feel irritated without any particular reason? 1____YES 2____NO

8. Do you feel depressed for no particular reason? 1____YES 2____NO

VEGETATIVE:

9. Do you have palpitations of the heart even when you don't exert yourself? 1____YES 2____NO

10. Do you sometimes feel pressure in your chest? 1____YES 2____NO

11. Do you perspire without any particular reason? 1____YES 2____NO

12. Do you have a headache at least once a week? 1____YES 2____NO

PARATHESIAS:

13. Do you often have painful tingling in some part of your body? 1____YES 2____NO

14. Do you have any problems with buttoning and unbuttoning? 1____YES 2____NO

TIREDNESS:

15. Are you abnormally tired? 1____YES 2____NO

LIBIDO:

16. Are you less interested in sex than what you think is normal? 1____YES 2____NO

APPENDIX B - NEUROBEHAVIORAL TESTING METHODS
BUDD COMPANY
NORTH BALTIMORE AND CAREY, OHIO
HETA 84-459 & 85-110

A. Test Setting

Testing was conducted in the NIOSH Medicoach (Medical Coaches, Inc.; Oneonta, NY), a converted 7'6" (wide) by 7' (high) by 40' (long) semi-trailer. The Medicoach was divided such that there were three areas available for neurobehavioral testing. The Santa Ana, Time Estimation and Dual Task tests were administered in a 9'3" long segment of the trailer, separated from the remaining areas by a curtain (Room #1). The 30-min vigilance test was administered in a 7'1" section of the trailer separated from other test areas by a small walled-off, (Room #2) unused room. The Optacon test was administered at the third station located between the other two test stations (Room #3). This room also served as the intake and questionnaire completion area. A degree of isolation of the stations was needed to assure reasonable results because distracting auditory or visual stimuli could affect performance on these tests. During testing, a low level audible conversation could periodically be heard in each test station, and there was constant and frequent activity at the intake location where the Optacon was administered.

B. Neurobehavioral Tests

The following behavioral tests were used to assess potential differences between exposure groups. The simple reaction time test was also administered, but technical problems caused these data to be uninterpretable and caused the latency data from the time estimation test and Dual Task to be relatively crude and thus only marginally useful. Also, the only group comparisons that were made were those between L/L and H/H, between L/L and L/H, and between L/L and CPOG. Data from combined groupings are included in the following Tables for information and consistency with other sections of the report, but statistical analyses were not conducted.

1. Test for Incoordination

Santa Ana Test - The Santa Ana Test, developed at the Finnish Institute for Occupational Health (FIOH), has been used successfully in a variety of worksite studies (Johnson, B. L. and Anger, W. K. Behavioral Toxicology. In: Environmental and Occupational Medicine, W. Rom, Ed. Boston: Little, Brown, 1983) as a measure of manual dexterity.

The test instrument consists of a board with 48 square depressions, arranged in 12 columns of 4 depressions, and a cylindrical peg with a square base fitted in each depression. The board was placed on a table top (covered with a 3 cm-thick pad) 72 cm above the floor. The subject, who remained standing during the test, used his/her preferred hand to pick up the pegs, rotate them 180°, and replace them in the square holes. The subject was given 30 seconds to rotate as many pegs as possible. The test required approximately 2 minutes to complete, including instructions. The primary measure was the number of pegs turned 180° (a continuous measure). The group comparisons were made utilizing the non-parametric M-rank procedure (SAS Supplemental Library User's Guide 1983 Edition. SAS Institute Inc. Box 8000, Carey, N.C. 27511-8000). Considering sex and age groups as blocking variables.

2. Test for Peripheral Sensory Changes

Optacon - The Optacon was implemented as a screening device for peripheral neuropathy by Arezzo and Schaumberg (Arezzo, J. C. and Schaumburg, H. H. The use of the Optacon^{R} as a screening device. Journal of Occupational Medicine, 1980, 22:461-4). at Albert Einstein Medical College and is now well established for this purpose. It also identifies individuals with loss of finger sensitivity due to reasons such as carpal tunnel problems.

The subject was seated on a drafting-style chair 68 cm from the floor at a table 96 cm from the floor in Room #3. This room also served as the intake and questionnaire completion area so that there was frequent activity where the Optacon test was administered. The subject was asked to place his/her right index finger in the cradle-like area of the Optacon with the other fingers off of the Optacon and the wrist on the table. Vibratory stimuli were presented at varying amplitudes, and the subject was requested to indicate when he/she could feel the vibration in order to determine the tactile threshold of the right and left index finger. Each subject was given an example of the vibratory stimulus and acknowledged that he/she felt it. The subject was instructed to look at the green light on the Optacon and to give a "yes" response if the green light appeared and he/she felt the stimulus, or to give a "no" response if they observed the green light but did not feel the stimulus.

Each subject started with their right index finger. A positive stimulus was given starting between 6 to 8 volts (representing the amplitude) and was decreased in whole integers until the subject gave three of four "no" responses to four positive stimuli. Then the positive stimulus was increased by whole integers until the subject gave at least three "yes" responses to four positive stimuli. The stimulus was then decreased by 0.1 volts until three of four "no" responses to four positive stimuli were elicited. The stimulus was

then increased by 0.1 volts until three of four "yes" responses were made to a positive stimulus, this voltage value was recorded. The same index finger was then retested by reversing the procedure such that a very low voltage stimulus first was given and increased until the subject indicated that he or she could feel the stimulus. These same procedures were repeated with the left index finger. Periodically negative stimuli were presented to determine if false positive responses were being elicited. In some cases, trials were repeated when the subject did not appear to understand the instructions or seemed to improve dramatically on the second hand. Whenever this occurred, trial 2 replaced trial 1 for purposes of the analyses. This test was completed in 5-10 minutes. The average of the two values for each finger was the variable of comparison. Group comparisons were made utilizing the nonparametric M-rank procedure; sex and age groups were considered as blocking factors.

3. Test for Time Estimation Accuracy and Concentration

Time Estimation Test - Variants of this test have been shown to be sensitive to the effects of carbon monoxide, but the findings have not been replicated in numerous attempts to do so (Laties, V. G. and Merigan, W. H. Behavioral effects of carbon monoxide in animals and man. Annual Review of Pharmacology and Toxicology, 1979, 19:357).

The True Estimation Test is controlled by an Apple Computer and presented on an Amdek 300A amber video display terminal (VDT) placed on a table 72 cm above the floor. The subject was seated on a chair 46 cm above the floor at a viewing distance of about 50 cm from the screen, and he/she was given a hand-held 3-button response apparatus. A 1-cm square stimulus was presented to the subject for various periods of time ranging from 1 to 19 secs. The subject was then required to press the left push button to duplicate the amount of time the square was on the screen. As training, the subject was given one practice trial in which a 5-second stimulus was presented, with feedback at the end of the trial as to how close he/she was to 5 seconds (to the nearest 0.1 second). If the estimate was more than one second in error, the practice trial was repeated, until the subject was within 1 second in accuracy. Then, the formal test began, using the following order of stimulus presentation times in seconds: 5, 19, 1, 5, 15, 2, 4, 12, 8, 3, 16, 2, 7, 12, 6, 1. The overall test required approximately 5 min to complete 16 trials. The actual time the button was pressed was recorded for each stimulus to the nearest second. The mean of the stimulus presentations times minus the mean of the subject responses served as one measure (termed mean difference), and the standardized mean (the group standard deviation divided by the mean of all subjects in a group, and multiplied by 100) served as the other measure derived from this test. Four subjects were excluded from the analyses due to data recording errors. The groups were compared utilizing nonparametric procedures.

Dual Task - This high-demand test was used to identify effects that might be produced by symptoms of disorientation and confusion. Variants of this test have been successful in detecting effects of low-level short-term methylene chloride and carbon monoxide exposures in experimental subjects (Putz, V. R., Johnson, B. L. and Setzer, J. V. A comparative study of the effects of carbon monoxide and methylene chloride on human performance. Journal of Environmental Pathology Toxicology, 1980, 2:97).

In this test, the same monitor, 3-button response apparatus and subject location were used as in the time estimation test. This task required the subject to attend simultaneously to the time estimation test as the primary task, but also to a secondary task which was to respond to a blinking 0.5 cm square light of 0.3-seconds duration by pressing on the right-most push button on the hand-held response apparatus with a single rapid press. The subject was allowed 1.5 seconds to respond to the blinking light by pressing the button for it to be counted as correct. The times in the time estimation portion of the task varied between 1 second and 19 seconds, and the trials always followed the same sequence (5, 19, 1, 5, 15, 2, 4, 12, 8, 3).

A practice trial was given on which an estimation stimulus was presented for five seconds; the blinking (secondary task) stimulus appeared almost immediately after the estimation stimulus appeared. After the estimation stimulus terminated (in 5 seconds), and the subject began to make his/her estimate of the duration by pressing the left button, another blinking (secondary) stimulus was presented. If the subject failed to press the right button when the second blinking stimulus appeared (during the estimation period), and many subjects did fail to do so, then the practice trial was repeated and the subject was encouraged to be sure to press the right button when they saw the blinking stimulus at the top of the screen. Because the task was so difficult, the subjects were warned: "The second task makes the whole test much more difficult, so you will make some mistakes--don't worry about any mistakes, just do your best." The test was begun when the practice trial was completed with no more than 1.5 seconds estimation error, and when the subject successfully responded to the second blinking (secondary) stimulus.

The dual task is essentially two tasks which run concurrently; therefore, the data from these two tasks were assessed independently. The error in time estimation was treated exactly as in the time estimation test above, using only the measure of mean difference. In the secondary task, the number of correct responses to blinking lights was subtracted from the number presented. (This latter number was estimated--the true number is within approximately $\pm$ 1 of the estimate, an error that would not affect the results.) The mean latency of response (time taken to respond to the blinking secondary stimulus) was analyzed, using the first 20 response latencies (to the nearest whole number). Each variable was compared between groups utilizing the M-rank procedure.

4. Test for Vigilance Deficits

Vigilance Test - A vigilance task is intended to be a boring test which presents a large number of "standard" signals which are to be ignored, interspersed with a small number of "critical" signals to which the subject is to respond by pressing a button. Such tasks have been used in a variety of experiments to identify the effects of alcohol consumption (e.g., Erwin et al., 1978), and it has been used successfully in one worksite study where methyl chloride-exposed subjects demonstrated poorer performance than unexposed referents [1. Repko, J.D., Jones, P. D., Garcia, L. S. and Schneider, E. J. Behavioral and neurological effects of methyl chloride. DHEW (NIOSH) Pub. No. 77-125, 1977, Washington, D.C.: US Government Printing Office. 2. Erwin, C. W., Wiener, E. L., Linnolila, M. I. and Truscott, T. R. Alcohol-induced drowsiness and vigilance performance. Journal of Studies on Alcohol, 1978, 39:505-515].

In this test, the subject was seated on a 61 cm-high chair, facing an Amdek 300A amber VDT on a 100 cm-tall cabinet, or at about the same height as the subject's face. The distance between the subject and the screen varied between 50 and 60 cm as the subjects assumed different positions over the course of the test. There was a small fluorescent light in the room, 108 cm above and to the right of the screen. In the test (under control of user-developed software), a single visual bar (1 cm x 4 cm) was presented in the middle of the VDT by an Apple IIe microprocessor for the first 300 msec out of every second. The bar was occasionally longer on the right by 0.5 cm. This was the critical signal to which the subject was to respond by pressing a button on a Mach II game controller or "joystick" (CH Products; San Marcos, CA).

There were 1505 1-second periods in this test, and the critical signals occurred during 13 of those 1-sec periods. Responses given within two seconds of the critical signal were counted as correct responses. Four critical signals occurred in each of the three 8.3 minute periods (500 seconds), into which the presentations were arbitrarily divided, with an additional signal in the last five seconds. The number of critical signals detected, as well as the number of responses when no critical signal ahd been presented (termed false alarms) were measured. One subject either misunderstood the instructions or purposefully responded inaccurately, and that person's data were eliminated from the analysis on this test.

APPENDIX C

(Question groupings from both questionnaire #1 and questionnaire #2)

NEUROBEHAVIORAL:

Do you find that you have the following symptoms more often than other people your age, for the amount of activity you do?

Fatigue
1____YES
2____NO

Sleeping longer than usual
1____YES
2____NO

Dizziness/light headedness
1____YES
2____NO

Irritability
1____YES
2____NO

Difficulty concentrating
1____YES
2____NO

Problems with memory
1____YES
2____NO

Depression
1____YES
2____NO

MOTOR:

Do you frequently lose your balance?
1____Yes
2____NO

Do you have a tremor (trembling of your hands)?
1____YES
2____NO

Do you have slurred speech or difficulty pronouncing words?
1____YES
2____NO

Do you stumble frequently?
1____YES
2____NO

Do you frequently have unexplained weakness in your muscles?
1____YES
2____NO

FATIGUE:

Are you abnormally tired? 1____YES 2____NO

Do you sleep more hours than you think you should? 1____YES 2____NO

SENSORY:

Do you often have painful tingling in some part of your body? 1____YES 2____NO

Do you have unexplained buring in your hands or feet? 1____YES 2____NO

COGNITIVE:

Do you generally find it hard to get the meaning from reading newspapers and books? 1____YES 2____NO

Do you often have problems with concentrating? 1____YES 2____NO

Do you often have trouble thinking of the right words to make yourself clear to others? 1____YES 2____NO

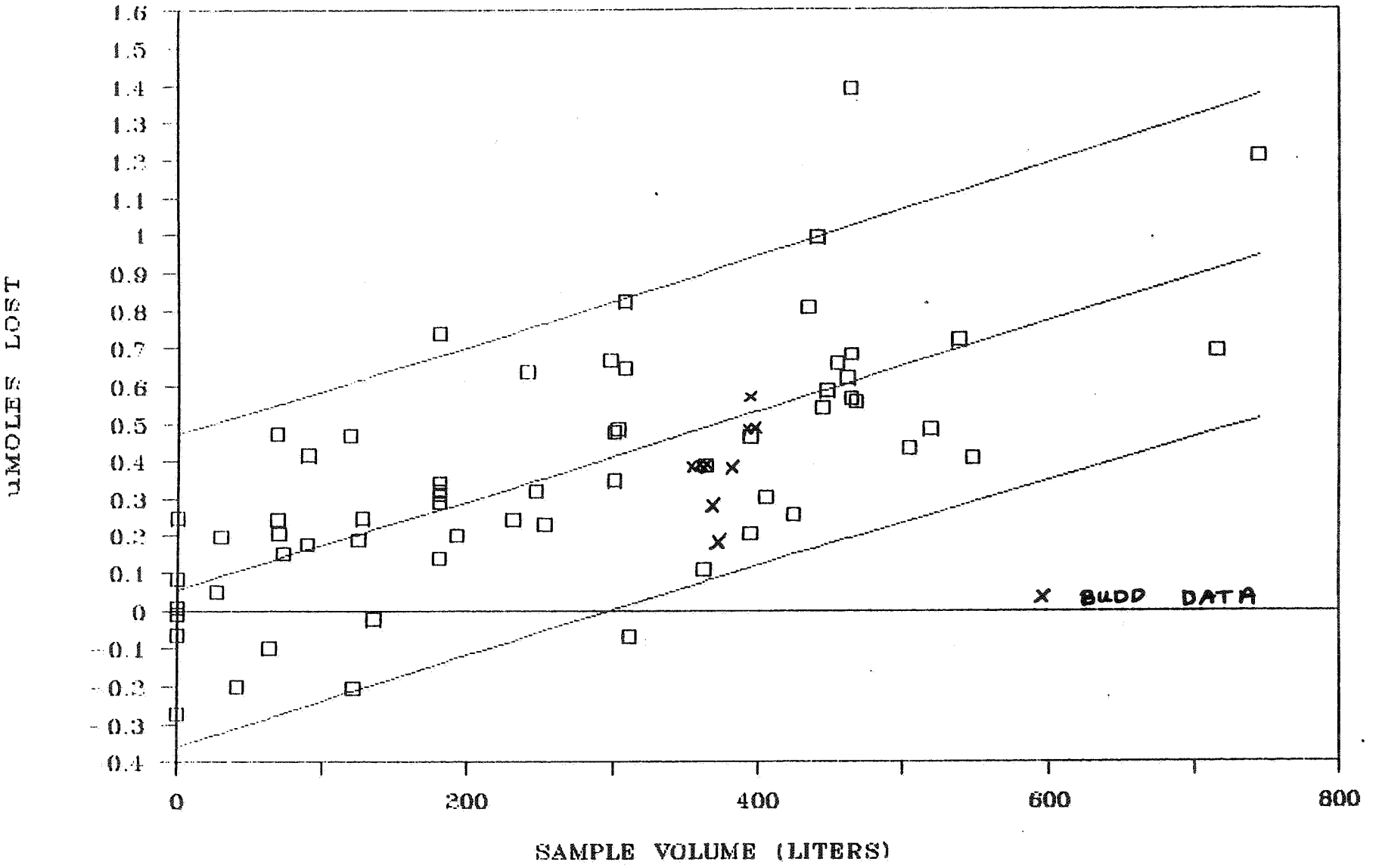
ANXIETY COMPLEX:

Do you have palpitations of the heart even when you don't exert yourself? 1____YES 2____NO

Do you sometimes feel pressure in your chest? 1____YES 2____NO

Do you perspire without any particular reason? 1____YES 2____NO

APPENDIX D



Plot of sample volume versus micromoles of 1-(2-methoxyphenyl)piperazine lost during sampling. Data indicated by squares are results from laboratory samples obtained sampling isocyanate-free atmospheres (including six points supplied by Dr. Dharmarajan of Mobay). The linear regression line and the 95% confidence limits of this data are shown. The x's on the plot are field sample values.

TABLE 28

PERCENT POSITIVE RESPONSES TO SWEDISH-16 QUESTIONNAIRE

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Questions	NIOSH L/L n=30	NIOSH MC* n=28	Swedish Low Sol n=173	Swedish High Sol n=229
Memory	23.8	50.0	30.0	49.0
Relatives	33.3	42.9	24.0	42.0
Notes	42.9	46.4	11.0	28.0
Go Back	38.1	64.3	16.0	39.0
Meaning	33.3	35.7	7.0	22.0
Concentration	23.8	42.9	9.0	28.0
Irritated	23.8	39.3	13.0	34.0
Depression	19.1	42.9	6.0	21.0
Tired	33.3	57.1	6.0	31.0
Libido	14.3	10.7	1.0	11.0
Palpitations	14.3	21.4	5.0	13.0
Pressure	42.9	60.7	12.0	34.0
Perspire	14.3	35.7	10.0	20.0
Headache	42.9	50.0	14.0	27.0
Tingling	26.9	35.7	10.0	28.0
Buttoning	14.3	7.1	1	1

*MC = H/H+L/H+Mixed

TABLE 29

SWEDISH - 16 QUESTIONNAIRE
POSITIVE RESPONSE TO >6 VS ≤ 6 AMONG EXPOSURE GROUPS

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

EXPOSURE GROUP	Males		Females	
	>6 "YES" RESPONSES	<6 "YES" RESPONSES	>6 "YES" RESPONSES	<6 "YES" RESPONSES
L/L	6/21 (28.6%)*	15/21 (71.4%)	21/40 (52.5%)	19/40 (47.5%)
L/H	4/12 (33.3%)	8/12 (66.7%)	9/12 (75.0%)	3/12 (25.0%)
H/H	6/13 (46.2%)*	7/13 (53.8%)	2/2 (50.0%)	2/2 (50.0%)
CPOG+PPOG	2/7 (28.6%)	5/7 (71.4%)	2/7 (28.6%)	5/7 (71.4%)
MIX	2/3 (66.7%)	1/3 (33.3%)	5/7 (71.4%)	2/7 (28.6%)

* Odds ratio = 0.214; 95% confidence interval: 0.41 - 11.72

TABLE 30

SUMMARY OF p-VALUES (Mann-Whitney test) FOR QUESTION SYMPTOM GROUPINGS

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Symptom Groupings	L/L versus H/H (n = 21) (n = 13) male (p - value)		L/L versus H/H (n = 40) (n = 4) female (p - value)		L/L versus L/H (n = 21) (n = 12) male (p - value)		L/L versus L/H (n = 40) (n = 12) female (p - value)	
General Neurobehavioral	+	(0.0430*)	+	(0.8207)	+	(0.4344)	+	(0.2253)
Memory	+	(0.2171)	+	(0.6314)	+	(0.1987)	+	(0.3072)
Motor	+	(0.0197*)	+	(0.4087)	+	(0.3381)	+	(0.4389)
Sensory	+	(0.2122)	+	(0.2882)	-	(0.7813)	+	(0.9357)
Cognitive	+	(0.8923)	+	(0.4568)	+	(0.1637)	+	(0.0120*)
Anxiety Complex	+	(0.1010)	+	(0.9139)	+	(0.4599)	+	(0.8720)
Fatigue	+	(0.0287*)	+	(0.2035)	±	(0.9835)	+	(0.2096)
Swedish 16	+	(0.0775*)	+	(0.6372)	+	(0.1639)	+	(0.1695)

+ indicates that more symptoms were experienced by the solvent exposed group.
- indicates that more symptoms were experienced by the L/L group.
* indicates a p-value less than 0.1000.

TABLE 31

SUMMARY OF p-VALUES (Mann-Whitney test) FOR QUESTION SYMPTOM GROUPINGS

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Symptom Groupings	L/L versus Mixed (n = 21) (n = 3) male (p - value)		L/L versus Mixed (n = 40) (n = 7) female (p - value)		L/L versus CPOG+PPOG (n = 21) (n = 10) male (p - value)		L/L versus CPOG (n = 40) (n = 7) female (p - value)	
General Neurobehavioral	+	(0.0408*)	+	(0.4411)	+	(0.8085)	-	(0.9639)
Memory	+	(0.1796)	-	(0.6918)	+	(0.9089)	-	(0.0188*)
Motor	+	(0.0780*)	+	(0.0606*)	+	(0.2872)	-	(0.7101)
Sensory	-	(0.9581)	-	(0.7392)	+	(0.2974)	+	(0.9367)
Cognitive	+	(0.4239)	+	(0.5253)	+	(0.5756)	-	(0.2687)
Anxiety Complex	+	(0.2382)	+	(0.0951*)	+	(0.4756)	+	(0.2312)
Fatigue	+	(0.0946*)	+	(0.0475*)	-	(0.6337)	+	(1.0000)
Swedish 16	+	(0.2518)	+	(0.4535)	-	(0.4819)	-	(0.3290)

+ indicates that more symptoms were experienced by the solvent exposed group.
- indicates that more symptoms were experienced by the L/L group.
* indicates a p-value less than 0.1000.

TABLE 32

SUMMARY OF p-VALUES (Mann-Whitney test) FOR QUESTION SYMPTOM GROUPINGS

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Symptom Groupings	L/L versus L/H+H/H (n = 21) (n = 3) male (p - value)		L/L versus L/H+H/H (n = 40) (n = 7) female (p - value)	
General Neurobehavioral	+	(0.0855*)	+	(0.2526)
Memory	+	(0.1286)	+	(0.5285)
Motor	+	(0.0475*)	+	(0.7856)
Sensory	+	(0.5288)	-	(0.6931)
Cognitive	+	(0.3577)	+	(0.0779*)
Anxiety Complex	+	(0.1413)	+	(0.8478)
Fatigue	+	(0.1725)	+	(0.1021)
Swedish Io	+	(0.0539*)	+	(0.3529)

+ indicates that more symptoms were experienced by the solvent exposed group.
- indicates that more symptoms were experienced by the L/L group.
* indicates a p-value less than 0.1000.

TABLE 33

SUMMARY DATA FOR CARBOXYHEMOGLOBIN

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	N	Mean	S.D.	Median	Min	Max
Smoking; Pre-shift						
CPOG	10	7.5	1.4	7.7	3.6	9.5
L/H	9	6.9	2.5	7.4	2.3	10.3
MIXED	5	7.3	1.9	6.7	5.8	10.6
EXCLUDED	9	8.5	1.2	8.2	6.7	10.7
L/L	36	7.3	2.9	7.6	1.8	13.5
H/H	10	7.8	2.6	7.7	4.6	14.1
Non-Smoking; Pre-shift						
CPOG	7	1.8	0.6	2.0	1.2	2.8
L/H	14	2.5	2.2	1.8	1.3	9.6
MIXED	5	2.3	1.2	1.9	1.4	4.4
EXCLUDED	7	2.1	1.0	1.9	0.9	3.8
L/L	24	1.8	0.5	1.6	1.0	3.2
H/H	7	2.0	0.5	2.0	1.4	2.7
Smoking; Post-shift						
CPOG	10	7.5	1.7	6.9	5.9	11.6
L/H	9	7.2	1.8	7.9	3.6	9.0
MIXED	5	8.6	2.2	8.0	7.0	12.4
EXCLUDED	11	8.7	1.5	8.9	5.9	10.8

Cont.

TABLE 33 (Cont.)

SUMMARY DATA FOR CARBOXYHEMOGLOBIN

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	N	Mean	S.D.	Median	Min	Max
Smoking: Post-shift (continued)						
L/L	37	7.2	2.1	6.9	3.0	11.0
H/H	10	9.4	3.7	7.9	5.7	17.5
Non-Smoking; Post-shift						
CPDG	7	2.2	0.6	2.1	1.6	3.9
L/H	14	2.5	0.8	2.3	1.3	3.9
MIXED	5	4.0	1.4	3.8	2.4	6.3
EXCLUDED	7	4.5	2.1	4.9	1.4	7.8
L/L	22	2.4	0.8	2.3	1.3	4.1
H/H	7	3.7	1.7	3.6	1.7	6.2

TABLE 34

SUMMARY DATA FOR EXPIRED CARBON MONOXIDE (parts per million)

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
January 28 - February 8, 1985

Group	N	Mean	S.D.	Median	Min	Max
Non-Smoking; Pre-shift						
CPUG	7	15.3	4.5	15.0	10.0	22.0
L/H	15	20.3	10.2	17.0	10.0	50.0
MIXED	5	20.2	8.1	21.0	10.0	28.0
EXCLUDED	7	21.3	1.9	22.0	19.0	23.0
L/L	24	16.8	5.4	17.0	8.0	30.0
H/H	7	19.9	5.9	21.0	12.0	28.0
Non-Smoking; Post-shift						
CPUG	7	17.7	9.7	14.0	8.0	37.0
L/H	15	23.2	9.6	22.0	12.0	50.0
MIXED	5	29.2	10.3	28.0	15.0	41.0
EXCLUDED	7	33.3	11.9	33.0	15.0	50.0
L/L	24	20.8	6.9	19.5	10.0	34.0
H/H	6	30.5	10.9	29.0	19.0	47.0

TABLE 35

SANTA ANA AND OPTACON MEAN SCORES AMONG FEMALES AND MALES

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
JANUARY 28-FEBRUARY 8, 1985

Exposure Group	Pegs Turned in Santa Ana Test				Optacon (volts)					
	Males		Females		Males			Females		
	N	Pegs	N	Pegs	N	Left	Right	N	Left	Right
H/H	13	21 (3)*	4	21 (4)	12	2.4 (0.7)	2.9 (1.0)	4	3.1 (0.6)	3.1 (0.4)
L/H	12	21 (3)	12	22 (3)	11	2.7 (0.7)	2.9 (0.4)	11	2.5 (1.0)	2.6 (0.8)
L/L	20	22 (4)	37	21 (3)	17	2.8 (0.8)	2.9 (1.0)	39	2.6 (0.7)	3.1 (0.9)
CPOG	7	21 (4)	7	21 (2)	6	3.0 (1.1)	3.2 (1.0)	7	2.5 (0.6)	3.6 (1.8)
L/H+H/H	25	21 (3)	16	22 (3)	23	2.5 (0.7)	2.9 (0.8)	15	2.7 (0.8)	2.7 (0.7)
CPOG+PPOG	10	21 (4)	0	-	8	2.9 (1.0)	3.1 (1.0)	0	-	-
MIXED	3	19 (2)	7	22 (3)	3	2.5 (0.4)	2.9 (0.7)	7	2.9(0.8)	3.3(0.6)

* = mean (standard deviation)

TABLE 36

MEAN DIFFERENCE AND STANDARDIZED MEAN FOR MALE AND FEMALE SUBJECTS IN THE TIME ESTIMATION TEST

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
JANUARY 28-FEBRUARY 8, 1985

Exposure Group	MALES			FEMALES		
	N	Mean Difference	Standardized Mean	N	Mean Difference	Standardized Mean
H/H	12	1.4 (0.7)	23 (4)	4	1.1 (0.5)	26 (9)
L/H	12	1.1 (0.5)	24 (9)	12	1.2 (0.6)	23 (6)
L/L	18	1.2 (0.4)	23 (9)	38	1.4 (0.6)	21 (7)
CPOG	6	1.3 (0.6)	23 (8)	7	1.4 (0.6)	21 (8)
**L/H+H/H	24	1.3 (0.6)	23 (7)	16	1.2 (0.6)	24 (7)
**CPOG+PPOG	9	1.2 (0.5)	24 (8)	0	-	-
MIXED	3	1.4 (0.3)	21 (5)	7	1.3 (0.5)	19 (4)

* = mean (standard deviation)

TABLE 37

MEAN DIFFERENCES AND MEAN SQUARES MISSED
IN THE DUAL TASK, FOR MALES AND FEMALES

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
JANUARY 28-FEBRUARY 8, 1985

	MALES			FEMALES		
Exposure Group	N	Mean Difference	Squares Missed	N	Mean Difference	Squares Missed
H/H	8	7.4 (3.1)*	10.9 (5.9)	4	6.4 (0.8)	17.8 (8.2)
L/H	9	8.8 (2.6)	18.9 (14.6)	8	8.1 (1.8)	10.9 (6.1)
L/L	14	7.1 (1.3)	15.6 (8.1)	27	7.4 (1.4)	11.3 (6.9)
CPOG	6	6.4 (1.5)	22.3 (10.3)	7	6.7 (1.5)	13.6 (14.2)
L/H+L/L	17	8.1 (2.8)	15.1 (11.4)	12	7.5 (1.5)	13.2 (6.4)
CPOG+PPOG	9	6.6 (1.3)	19.9 (12.1)	0	-	-
MIXED	3	7.7 (4.0)	16.0 (8.2)	4	7.0 (1.7)	20.3 (15.2)

* - mean (standard deviation)

TABLE 38

REPRODUCTIVE OUTCOME AMONG MALE AND FEMALE WORKERS
AND AMONG SOLVENT EXPOSURE GROUPS

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
JANUARY 28-FEBRUARY 8, 1985

(Males and Females Grouped Together)

Groups	#reported at at least one pregnancy/ # of respondents	total # of pregnancies reported	#reporting at least one unintentional miscarriages/ # of respondents	#reporting at least one child with a congenital problem/ # of pregnancies
All questionnaire #1 Respondents				
All Males	73/250 (29.2%)	113	12/71 (16.9%)	3/113 (2.7%)
All Females	91/463 (19.7%)	136	19/89 (21.4%)	5/136 (3.7%)
All Combined	164/713 (23.0%)	249	31/160 (19.4%)	8/249 (3.2%)
All Neurobehavioral Study Participants				
ALL PPOG+CPOG	5/16 (31.3%)	8	0/4 (0)	1/8 (12.5%)
All L/H	4/22 (18.2%)	5	1/4 (25.0%)	0/5 (0)
All Mixed	5/10 (50%)	12	1/5 (20.0%)	1/12 (8.3%)
All L/L	17/55 (30.9%)	22	5/17 (29.4%)	0/22 (0)
All H/H	6/14 (42.9%)	7	1/6 (16.7%)	0/7 (0)

*Congenital Abnormalities:

A. Male Worker's Offspring: (no kidneys or genitals, enlarged heart, abnormal penile foreskin)

B. Female Worker's Offspring: (hole in heart, abnormal sized kidney, congenital hearing loss, minimal brain dysfunction/kidney dysfunction)

C. Four Other Workers Reported: (a SIDS death, a platelet problem, premature bowel problems, and obstruction in bowels)

TABLE 39

HAND AND ARM SYMPTOMS AND CONDITIONS

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
JANUARY 28-FEBRUARY 8, 1985

Symptom or condition	Job involving repetetive motion: Yes — Number of participants	Yes — Number and (%) with condition	No — Number of participants	No — Number and (%) with condition	Relative Risk	95% confidence interval
Numbness, tingling or paresthesias	550	250 (45.5)	110	34 (31)	1.47	1.12 - 1.92
Soreness or pain in forearm	549	233 (42.4)	110	27 (25)	1.73	1.27 - 2.35
Hand or forearm symptoms causing awakening from sleep	548	197 (36.0)	111	23 (21)	1.73	1.22 - 2.46
Wrist or forearm discomfort interfering with normal activities	545	194 (35.6)	111	23 (21)	1.72	1.21 - 2.44
History of carpal tunnel syndrome	539	74 (14)	110	9 (8)	1.68	0.89 - 3.18
History of ganglionic cyst	533	30 (5.6)	109	11 (10)	0.56	0.29 - 1.08
History of wrist tendonitis	540	80 (15)	109	14 (13)	1.15	0.68 - 1.75

TABLE 40

IRRITATIVE AND RESPIRATORY SYMPTOMS

BUDD COMPANY
NORTH BALTIMORE & CAREY, OHIO
HETA 84-459; 85-110
JANUARY 28-FEBRUARY 8, 1985

Symptom	Number of participants	Potential isocyanate exposure*: Yes — Number and (%) with condition	Potential isocyanate exposure*: No — Number of participants	Potential isocyanate exposure*: No — Number and (%) with condition	Relative Risk	95% confidence interval
Eye irritation	374	166 (25.3)	281	108 (16.5)	1.15	0.96-1.39
Nose or throat irritation	375	256 (39.0)	281	158 (24.1)	1.21	1.08-1.37
Shortness of breath	374	148 (22.5)	283	94 (14.3)	1.19	0.97-1.46
Wheezing	373	113 (17.4)	277	62 (9.5)	1.35	1.04-1.76
Cough	375	205 (31.4)	279	120 (18.4)	1.27	1.08-1.49
Chest pain	374	117 (17.9)	281	68 (10.4)	1.29	1.00-1.66

*See text for definition.