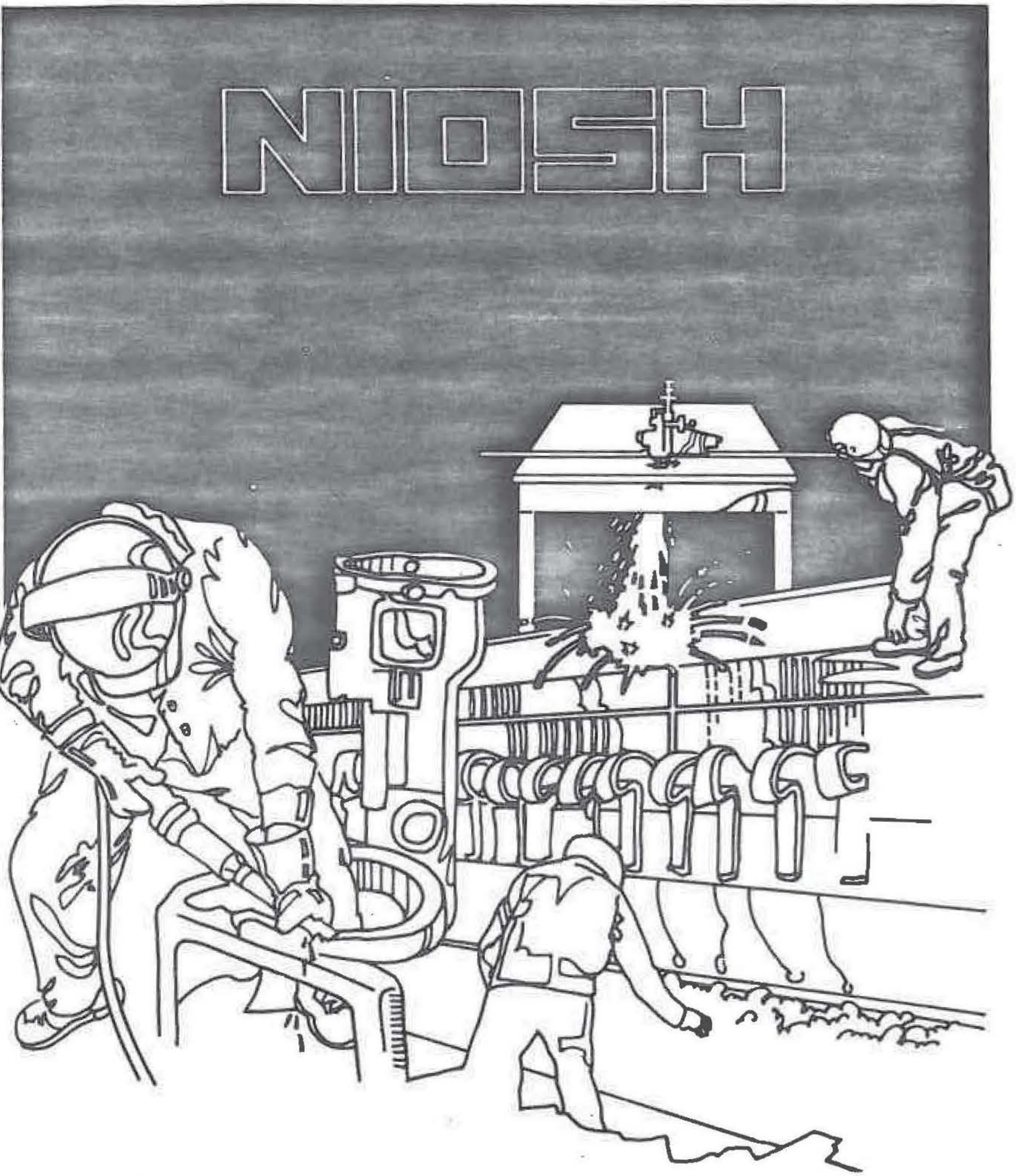
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 78-135-1333
INTERNATIONAL BROTHERHOOD
OF PAINTERS AND ALLIED TRADES
ELECTRIC BOAT DIVISION
OF GENERAL DYNAMICS CORP.
GROTON, CONNECTICUT

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 78-135-1333
AUGUST 1983
INTERNATIONAL BROTHERHOOD OF PAINTERS
AND ALLIED TRADES
ELECTRIC BOAT DIVISION OF GENERAL DYNAMICS CORP.
GROTON, CONNECTICUT

NIOSH INVESTIGATORS:
John R. Love, BS, Ch.E.
Michael T. Donohue, PA-C

I. SUMMARY

On October 12, 1978, the National Institute for Occupational Safety and Health was requested to investigate reports of rashes, dizziness, fainting, and nausea among painters involving painting and grit blasting operations. In July, August, October 1979, May 1980, and March 1981, NIOSH made site visits to Electric Boat to conduct environmental sampling and medical evaluations.

Employees engaged in grit blasting operations were potentially overexposed to metal fumes: iron (range of values - 5 to 474 mg/m^3), lead (0.05 to 11 mg/m^3), copper (1 to 15 mg/m^3), nickel (0.04 to 0.4 mg/m^3), chromium III (0.18 to 2.5 mg/m^3), beryllium (0.006 to 0.134 mg/m^3), aluminum (45 mg/m^3), and magnesium (1.0 to 5.5 mg/m^3). Exposures ranged up to 268 times the recommended exposure limits.

Employees engaged in painting operations were potentially overexposed to solvents: methyl isobutyl ketone (230 mg/m^3), methyl cellosolve (108 mg/m^3), and cellosolve (27 to 475 mg/m^3). Exposures ranged up to 25 times the recommended exposure limits.

Questionnaire results indicated that less than 25% of the study cohort use either an air-supplied or cartridge-type respirators.

Among the 246 participants in the medical study, the most commonly reported symptoms were eye irritation (42% of respondents), nasal congestion (30%) and throat irritation (27%). Of 86 workers who reported solvent exposure more than 33% of their work time, 21 (24%) reported dizziness, compared to 20 (14%) of the 147 other workers ($x^2 = 4.38$, $p<0.05$).

Elevation in serum glutamic oxaloacetic transaminase, one of the four liver enzymes measured, was associated with reported solvent exposure in the preceeding month. Two parameters of pulmonary function, one-second forced expiratory volume and forced vital capacity, were associated with years of reported asbestos exposure, but none of the pulmonary function parameters were associated with total years of work at Electric Boat.

Based on environmental data, NIOSH concludes that the potential for significant exposure of workers to metal fumes and solvent vapors exists unless a more conscientious respiratory protection program is maintained. Health effects were consistent with reported solvent exposure. Recommendations for health promotion, better health surveillance, and environmental control are presented in Section VII of this report.

KEYWORDS: SIC 3731 (Ship Building and Repairing), respiratory protection, blasting, painting, metals, solvents.

II. INTRODUCTION

On October 12, 1978, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate worker complaints of rashes, dizziness, fainting, and nausea among workers at the Electric Boat Division of General Dynamics Corporation in Groton, Connecticut.

Electric Boat was visited by NIOSH on five occasions: in July 1979, August 1979, October 1979, May 1980, and March 1981. Environmental sampling and medical evaluations were performed during the course of these visits. Interim reports were issued in September 1979 and July 1980.

III. BACKGROUND

The Electric Boat Division of General Dynamics Corporation constructs and retrofits nuclear submarines under contractural agreement with the United States Navy. The two types of submarines manufactured at Electric Boat are the Trident class and the Fast-Attack class. Electric Boat employs about 25,000 workers (predominately trades people), approximately 1,000 of whom are painters.

Electric Boat painters are involved in the blasting, cleaning, and painting of ballast tanks and outer hulls. Each of the surfaces to be painted is first blasted to remove any old paint or rust before painting is started. "Black Beauty" (copper slag) is used as replacement blast material for silica sand because of its low free silica content, desirable physical properties, economic feasibility, availability, and assumed health and safety qualities. Upon removal of the blasting material, solvents are used to clean the area, followed by application of a primer coat of paint using compressed-air spray-guns. After sufficient drying, a final coat of paint is applied. Depending on the surface to be worked, the amount of time needed to complete the blasting, cleaning, and spraying cycle may range from several hours for a small section of ballast tank to several days for an outer hull.

The painters at Electric Boat are potentially exposed to numerous toxic chemicals and physical agents. Their work exposes them not only to the hazards of the painting trade (paints, solvents, noise, and blasting materials) but to a variety of fumes, dusts, vapors, and radiation generated by the other shipyard operations.

IV. EVALUATION DESIGN

A. Environmental

In order to assess potential exposure of employees in painting and grit blasting operations, personal breathing zone air samples were collected with specialized collection media and portable air sampling pumps. Sampling time for each sample varied, but in general approximated the duration of the work procedure under evaluation. Sampling and analytical parameters are listed below.

Substance	Sampling Media	Sample Flow Rate (Lpm)	NIOSH Analytical Method
General solvents	100/50 mg, standard activated charcoal tubes	0.05-0.2	P&CAM 127[1]
General metals	Millipore AA (0.8u pore size) 37mm filters	1.5-1.7	P&CAM 173[2]
Methanol	100/50 mg, standard silica gel tubes	0.2	P&CAM S-59[3]
Triethylenetetramine	100/50 mg, standard silica gel tubes	0.2	Analysis by gas chromatography unsuccessful

B. Medical

The medical evaluation of the painters included (1) a health questionnaire containing questions regarding symptoms associated with solvent exposure (nausea, lethargy, headache, etc.), mucous membrane irritation, and respiratory symptoms; (2) blood tests, including liver enzymes, creatinine concentration, and blood lead concentration; (3) a limited physical examination, including inspection of the eyes, nose, throat, and skin; auscultation of the chest; and in a 30% random sample of participants, blood pressure measurement; and (4) pulmonary function tests. Demographic information collected on all study participants included: age, race, sex, height, and smoking, alcohol, and occupational histories.

V. EVALUATION CRITERIA

A. General

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental criteria for assessment of a number of chemical and physical agents. These criteria are intended to recommend levels of exposure to which most workers may be exposed for up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. However, it is 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 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)[4], and (3) the U.S. Department of Labor (OSHA) occupational health standards.[5] 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 agents are used; the NIOSH-recommended standards, by contrast, are based primarly 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 required to meet those levels specified by an OSHA standard.

For the purposes of this evaluation, the most stringent exposure level has been adopted for comparison, since this should provide maximum protection for the worker (see Table 1).

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Specific Substances

1. Aluminum[4]

The effects on the human body caused by the inhalation (breathing) of minimal amounts of aluminum dust and fumes are not known with certainty at this time. Present data suggest that pneumoconiosis might be a possible outcome of massive inhalation. The symptoms of long-term overexposure have included shortness of breath, cough, and weakness. Typically, there may be X-ray evidence of fibrosis and occasional pneumothorax. At autopsy, there is generalized interstitial fibrosis (thickened lung tissue), predominately in the upper lobes, with pleural thickening and adhesions. Particles of aluminum are found in the fibrotic lung tissue.

2. Chromium[4,6,7]

Under environmental conditions where oxygen is present, chromium exists in three principle forms: elemental chromium or chromium metal; trivalent chromium or chromium (III), including chromite and soluble chromous and chromic salts; and hexavalent chromium or chromium (VI) compounds as chromates, dichromates, or chromic acid anhydride (CrO_3). Chromium metal and its insoluble salts are considered to be relatively non-toxic. The soluble chromic and chromous salts have no established toxicity, although sensitization dermatitis may occur. Chromium (VI) compounds are known to cause penetrating sores of the skin; ulceration and perforation of the nasal septum; inflamation of the mucous membrane; and may cause kidney or liver damage, tooth erosion and discoloration, and perforated eardrums. Some forms of chromium (VI) cause lung cancer.

3. Copper[4]

Health effects from exposure to copper fumes consist of irritation of the upper respiratory tract and metal fume fever, which is characterized by a history of recent exposure to metal fume and the transient nature of flu-like illness, often occuring upon first exposure of the workweek, with a tolerance developing during the workweek. Other symptoms of excessive copper exposure may include a metallic or sweet taste, and in some instances discoloration of the skin and hair.

4. Beryllium[8,9]

Beryllium and its compounds are highly toxic substances. Entrance to the body is almost entirely by inhalation. The acute systemic effects of exposure to beryllium primarly involve the respiratory tract and are manifest by a non-productive cough, substernal pain, moderate shortness of breath, and some weight loss. The character and speed of onset of these symptoms, as well as their severity, are dependent on the type and extent of exposure. An intense exposure, although brief, may result in severe chemical pneumonitis with pulmonary edema.

Chronic beryllium disease is an intoxication arising from inhalation of beryllium compounds, characterized primarly by respiratory symptoms of weakness, fatigue, and weight loss (without cough or shortness of breath at the onset), followed by non-productive cough and shortness of breath. Frequently, these symptoms and detection of the disease are delayed from five to ten years following the last beryllium exposure, but they may develop during the time of exposure. The symptoms are persistent and frequently are precipitated by an illness, surgery, or pregnancy. Chronic beryllium disease usually is of long duration with periods of exacerbation and remission.

Beryllium is a carcinogenic substance which may be associated with cancer of the lung.

5. Iron[4]

Overexposures to iron over a prolonged period may produce an asymptomatic condition called siderosis, an accumulation of iron particles in the lungs. After the worker leaves exposure, the iron dust is slowly eliminated from the lungs over a period of years.

6. Lead[10]

Inhalation of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/deciliter whole blood are considered to be normal levels which may result from daily environmental exposure. The new Occupational Safety and Health Administration (OSHA) standard for lead in air is 50 ug/m^3 calculated as an 8-hour time-weighted average for daily exposure. The standard also dictates that workers with blood lead levels greater than 50 ug/deciliter must be immediately removed from further lead exposure and, in some circumstances, workers with lead levels of less than 50 ug/deciliter must also be removed. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels decline to below 40 ug/deciliter and they can return to lead exposure areas.

Inorganic lead is a heavy metal which can be absorbed into the body by ingestion or inhalation. Upon absorption, the lead becomes bound primarily with the red blood cells and is distributed throughout the body into the soft issues, particularly kidneys and liver. Over a period of time the lead is redistributed and deposited into hard tissues such as bone, teeth, and hair. Lead absorption is cumulative and elimination from the body is extremely slow. The absorbed lead affects each body system it comes in contact with including the red blood cells.

The symptoms most often associated with lead intoxication (plumbism) are loss of appetite, constipation, abdominal pains (intestinal colic), anorexia, headaches, tremor, anemia, fatigue, and peripheral motor paralysis of certain extensor muscles (wrist and/or ankle drop). Generally, pallor, anemia, and emaciation are present in plumbism. Rarely, an indication of significant lead absorption may also be a blue line along the gums, often referred to as a "lead line".

Inorganic lead had been shown to be mutagenic (damages chromosomes) and teratogenic (causes birth defects). It can cross the placental barrier and can affect fetal development. Lead is eliminated from the body via urine and feces.

7. Nickel[4,11]

Nickel can exist in both soluble and insoluble forms. Epidemiologic evidence suggests that the hazard presented by insoluble nickel compounds is not as great as that presented by soluble forms. Nickel has been reported to cause "nickel itch," an allergic dermatitis. An increase in nasal, sinus, and lung cancer has been noted in workers employed in nickel refineries, although the specific carcinogenic (cancer causing) agent is still not defined. Metallic nickel introduced into the pleural cavity, muscle tissue, and subcutaneous tissue has been shown to be carcinogenic in test animals.

8. Magnesium[4]

The only sign of acute toxicity of magnesium in man is metal fume fever and associated leukocytosis (proliferation of white blood cells) resulting from the inhalation of freshly generated magnesium oxide (MgO) fume. It has been reported that MgO dust can cause slight irritation of the eyes and nose. There is no evidence that the inhalation of Mg dust has led to lung injury as long as exposures were limited to recommended criteria.

9. Methyl Isobutyl Ketone[4,12]

MIBK has a strong odor and can cause moderate transient eye and nasal irritation. It is also a central nervous system depressant and is narcotic at high concentrations. Other health effects reported include loss of appetite, headache, stomach ache, nausea, and vomiting.

10. Methyl and Ethyl Cellosolve[13,14,15,16]

Methyl cellosolve exerts its effects primarily on the hematopoietic (blood forming) and central nervous systems, although the vapor is also a mild irritant. Cases of toxic encephalopathy and macrocytic anemia have been reported from industrial exposures that may have been as low as 25 to 75 ppm. Symptoms were headache, drowsiness, lethargy, and weakness. Manifestations of central nervous system instability included ataxia, dysarthria, tremor, and somnolence. These effects are usually reversible. In acute exposures, the central nervous system effects were the most pronounced, while prolonged exposure to lower concentrations produced primarily evidence of depression of ethrocyte formation. Anemia may be pronounced.

Ethyl cellosolve is a colorless liquid with a sweetish odor, which can affect the body if it is inhaled, swallowed, or comes in contact with the eyes or skin. It can enter the body through damaged skin. In animal experiments cellosolve has caused liver, kidney, and lung damage, and anemia due to the destruction of red blood cells. Acute exposure may result in deep unconciousness, pulmonary edema, and severe kidney and liver damage. Symptoms from repeated overexposure to vapors are fatigue and lethargy, headache, nausea, loss of appetite, and tremor.

Recently, evidence resulting from experimental data on animals has indicated that these glycol ethers may be toxic to the reproductive system. Japanese scientists demonstrated mouse testicular atrophy and leukopenia after oral administration of methyl and ethyl cellosolve. Methyl cellosolve showed increased sperm abnormalities and other anti-fertility effects in test animals.

11. Silica Sand Substitutes[17]

The fibrogenic potential of coal and copper slags (Black Beauty) used as substitutes for silica sand in abrasive blasting operation has been assessed in rats. The test animals were given a single pulmonary intralobar instillation of 20 mg of test material and were sacified 10 months after dosing. Pulmonary fibrosis was seen in copper slag-treated animals. Granulomas were seen in the lungs of all treatment groups. The results of this study emphasize the need for bioassay of silica sand replacement for fibrogenic potential in spite of the low free silica contents of these materials.

VI. RESULTS AND DISCUSSION

A. Environmental

Tables 2, and 3 and 4 contain the results of the air sampling data for the two work procedures considered, grit blasting and painting, respectively, which were collected during three different site visits. In some cases, field data were inadequate to provide a complete account of sampler location and description of the process monitored. These deficiencies are noted in the tables. Therefore the work procedure/location heading in the tables will refer to the writers' subjective evaluation of field data. For example, "Blast/705" means the writer interpreted the field data to indicate that the majority of work was spent grit blasting a surface on hull number 705. Accordingly, "spray" means spray painting and "brush" means brush painting. Some environmental samples were not submitted for analysis. Our laboratory was not able to analyze environmental samples for triethylenetetramine by gas chromatography because of elution problems. Area samples are not reported due to incomplete location descriptions. No distinction is made between samples collected under confined space conditions and those collected otherwise.

The following summary presents only those personal breathing zone samples which exceeded the environmental criteria used in this evaluation.

Employees engaged in grit blasting operations were potentially overexposed to:

Nickel: 3 of 4 samples exceeded 0.015 mg Ni/m^3. Highest exposure was 9 times the criterion.
Lead: 9 of 17 samples exceeded 0.05 mg Pb/m^3. Highest exposure was 220 times the criterion.
Copper: 7 of 17 samples exceeded 1.0 mg Cu/m^3. Highest exposure was 15 times the criterion.
Iron: 9 of 17 samples exceeded 5.0 mg Fe/m^3. Highest exposure was 95 times the criterion.
Chromium (III): 8 of 17 samples exceeded 0.05 mg Cr(III)/m^3. Highest exposure was 49 times the criterion.
Magnesium: 3 of 12 samples exceeded 1.0 mg Mg/m^3. Highest exposure was 2 times the criterion.
Beryllium: 6 of 17 samples exceeded 0.0005 mg Be/m^3. Highest exposure was 268 times the criterion.
Aluminum: 1 of 12 samples exceeded 10 mg AL/m^3. This exposure was 5 times the criterion.
Total Particulate: 2 of 5 samples exceeded 10 mg/m^3. However, visual inspection of these samples revealed large sized particles loose in the filter holder, leading to the suspicion that they represented something other than airborne particulate.

Due to the proximity of grit blasting operations to painting operations, painters were also potentially overexposed to total particulate. One of 10 (10%) samples exceeded 10 mg/m^3. This exposure was 1.4 times the criterion.

Employees engaged in painting operations were potentially overexposed to two glycol ethers and methyl isobutyl ketone.

Methyl Cellosolve: 1 sample exceeded 16 mg methyl cellosolve/m^3. This exposure was 7 times the criterion.
(Ethyl) Cellosolve: 3 of 8 samples exceeded 19 mg cellosolve/m^3. Highest exposure was 25 times the criterion.
Methyl Isobutyl Ketone: 1 of 49 samples exceeded 205 mg MIBK/m^3. This exposure slightly in excess of the criterion.

In addition, one other painter had a combined solvent exposure slightly in excess of the recommended exposure limit. The ACGIH uses the following formula to calculate combined solvent exposure, assuming that the toxic effect of each solvent is similar and hence additive:

$$\frac{C_1}{L_1} + \frac{C_2}{L_2} + \ldots + \frac{C_n}{L_n} = 1,$$

where C_1 is the measured concentration of the substance and L_1 is the recommended exposure limit for that substance. If the resulting sum exceeds 1.0, then an overexposure has occurred. The one painter's exposure value was 1.01.

Based on the environmental data, it appears that there is significant potential for exposure to grit blasting materials (from grit and blasted metal) substantially in excess of recommended criteria to those engaged in this practice and others stationed in the same area. Many of the metals to which these employees are exposed are very toxic, some of which (beryllium and nickel) have been implicated in various forms of cancer. It is important to minimize exposure, particularly to these metals. In situations where engineering or administrative control measures are not feasible, respiratory protection is an appropriate means of control. However, a respirator program must be properly designed, and an ongoing system of supervision in place, in order for it to be effective. U.S. Code of Federal Regulations (CFR) 1910.134(b) outlines the components of a good respirator program.[5] Another useful document is the NIOSH Guide to Industrial Respiratory Protection.[18]

On the days of NIOSH sampling, all employees monitored wore full-face air-supplied respirators (hence, the "potential" exposure qualifier placed on each air sample); however, the data shown in Table 4 indicate that only 14% of the medical study participants reported using air-supplied respirators. Although another 10% reported using a combination of air-supplied or cartridge respirators, this represents a combined total of less than 25% of employees involved in the existing respirator program, and points to the need for a re-evaluation of this program, particularly its training and use [(1910.134(b)(3)] and surveillance [1910.134(b)(8)] provisions.

Painters in nearby areas also are exposed to excessive concentrations of particulate. It is probable that this particulate exposure is due in part to metal fumes generated by blasting. No further definitive information on particulate composition is available since the total particulate samples were analyzed gravimetrically (weighing) rather than by individual metal analysis.

Conversely, grit blasting employees and painters are probably exposed to similar concentrations of paint solvents. This cannot be confirmed since blasting employees were not evaluated for solvent exposure. However, the data in Table 5 indicate that solvent exposure generally is not excessive.

This evidence in no way implies that potential solvent exposure should be neglected. Painting in confined spaces, or a heavy work load, may change the degree of exposure. We advise that the painting employees continue to be included in the respiratory protection program. This is particularily true for those employees involved in spray painting. Exposures appear to be four or more times greater than during brush painting.

One painter was found to be potentially excessively exposed to methyl and ethyl cellosolve and two others overexposed to ethyl cellosolve. The recent information available on these glycol ethers indicates that these solvents should be treated as reproductive system toxins and exposure should be minimized. One painter was potentially overexposed to MIBK.

B. Medical

A total of 246 painters (217 male and 29 female) comprised this study group. They were randomly selected from the 424 union painters at the shipyard. One hundred thirty-one individuals participated from the first shift, with 78 and 37 workers from the second and third shifts, respectively (Table 5).

The 246 study participants included 76% white, 19% black, 4% Hispanic, and 1% Asian. The mean age of the painters was 42 years and the mean length of their employment at Electric Boat was 11.5 years.

Historical reports of overexposure to asbestos were common among workers with eight or more years work experience at Electric Boat. These exposures occurred primarily in the course of submarine overhaul and/or retrofit (see Table 6). Overhaul/retrofit work was performed at both the Electric Boat shipyard, Groton, Connecticut, and at a naval base on the coast of Spain. Since the introduction of alternative forms of insulation for the reactor vessel and its complex of piping, asbestos use in the shipyard and on the submarines is slowly being phased out.

The most common work-related symptoms among the painters were those of eye, nose, and throat irritation (Table 7). There was a slight trend for workers with solvent exposure more than 33% of their work time to report headache, queasy stomach, drowsiness and dizziness more often than those with less solvent exposure (Table 8).

The prevalance of dizziness was significantly higher (p=.04) for those painters reporting solvent usage greater than 33% of their work time in the preceeding month. Fifty-five (22%) of 246 participants had one or more abnormal liver enzyme tests. These tests may be elevated due to a liver disease, bone disease, or muscle damage. Slight elevations, however, may be normal for any particular individual. Each liver enzyme test may also be elevated due to alcohol and/or drug ingestion (i.e., barbiturates and anti-convulsants).

Table 9 shows that elevations in three of four liver enzyme levels were statistically associated with alcohol ingestion. Only elevated SGOT levels were associated with the previous month's amount of solvent exposure after correcting for alcohol.

Pulmonary function tests were performed as part of the initial medical screening. Because we were unsure of the accuracy of these findings, we repeated these lung function tests on a subsequent visit. The results of the second round of testing correlated highly with the first round. The results of the first round were therefore used in the epidemiologic analysis (Table 10). These PFT data reveal statistically significant decrements in the painters' breathing function based on their reported asbestos exposure and smoking history. There was no statistically significant association with years of Electric Boat employment.

The study groups' creatinine and blood lead levels were found to be within accepted normal limits. The limited physical examinations given the workers revealed no significant group abnormalities.

Painters at Electric Boat are usually the last trade to work shipboard prior to a launch. This "last-in" duty necessitates a general cleanup of the work leavings of other trades. The painters often clean up after riggers, welders, lead burners, pipe fitters, electricians, etc. The cross-contamination of the painters' work areas by both the substances and by-products of the other trades work must be underscored. Clean up duties portend possible exposure to the entire spectrum of substances used by the other shipyard workers. Due to these potential exposures to other hazardous materials it becomes difficult to isolate any substances(s) and/or physical agents(s) as being the cause of the painters health complaints.

Asbestos is related not only to mesothelioma but to more common lung cancers. Smokers who are exposed to asbestos, have a risk of developing lung cancer 92 times higher than that of non-smokers. Cigarette smoke enhances the development of cancer and is a synergist or cocarcinogen in the presence of asbestos.

VII. RECOMMENDATIONS

1. First-line yard supervisors should be given increased responsibility and accountability for the health and safety program of Electric Boat. This responsibility may inhance employee involvement in the respirator program.

2. Better coordination between the Engineering and Safety Departments concerning the ventilation of tanks and confined spaces should be instituted. Responsibility for ventilation unit checkouts, tagging procedures, and set-ups should be clearly defined in order to prevent the inadvertent use of contaminated make-up air and the venting of exhaust air into occupied compartments.

3. A written standard operating procedure for the respiratory protection program should be constructed following the guidelines as set forth by the Occupational Safety and Health Act, Part 1910.134. As a companion guide, the NIOSH Guide to Industrial Respiratory Protection should be consulted when re-developing the respiratory protection program.

4. A preventable hazard at Electric Boat is mixed solvent/alcohol exposure. Solvents and alcohol may work in combination to harm the liver and nervous system. With so many trades relying on the "buddy" system as a standard safety procedure, no employee should have to depend on a co-worker whose reaction maybe impaired by a combined solvent/alcohol exposure. The Electric Boat employee assistance program should aid affected workers in confronting and successfully resolving their alcohol problem. Assistance in the ongoing development of the program could be sought from Electric Boat's insurance carrier.

VIII. REFERENCES

1. National Institute for Occupational Safety and Health. Manual of Analytical Methods, 2nd Edition, Volume I, P&CAM 127. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW Publication No. (NIOSH) 77-157A).

2. National Institute for Occupational Safety and Health. Manual of Analytical Methods, 2nd Edition, Volume I, P&CAM 173. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW Publication No. (NIOSH) 77-157A).

3. National Institute for Occupational Safety and Health. Manual of Analytical Methods, 2nd Edition, Volume 2, P&CAM S-59. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW Publication No. (NIOSH) 77-157A).

4. American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values for Substances in Workroom Air. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1981.

5. Occupational Safety and Health Administration. Occupational Safety and Health Standards for General Industry, 29 CFR 1910. Washington, D.C.: Occupational Safety and Health Administration, 1980.

6. National Institute for Occupational Safety and Health. Criteria for a Recommended Standard --- Occupational Exposure to Chromium (VI). Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1975. (DHEW Publication No. (NIOSH) 76-129).

7. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to chromic acid. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973. (DHEW publication no. (NIOSH) 73-11021).

8. Statement of Edward J. Baier, Deputy Director, National Institute for Occupational Safety and Health, to Department of Labor - OSHA Public Hearing. August 19, 1977.

9. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to beryllium. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1972. (DHEW publication no. (NIOSH) 72-10268).

10. National Institute for Occupational Safety and Health. Criteria for a Recommended Standard --- Occupational Exposure to Lead (Revised). Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1978. (DHEW Publication No. (NIOSH) 78-158).

11. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to inorganic nickel. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-164).

12. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to ketones. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1978. (DHEW publication no. (NIOSH) 78-173).

13. Patty FA. Patty's industrial hygiene and toxicology. Vol II--toxicology, 3rd revised ed. New York: John Wiley & Sons, 1978.

14. Nagano, YE., et al. Testicular atrophy of mice induced by Ethylene Glycol Monoalkyl Ethers. JAP. J. Industrial Health 1979; 21:29-35.

15. Nagano, YE., et al. Testis Disorders due to cellosolves. Rodo Eisei 1977; 18:24-27.

16. McGregor, DB., et al. Bis (2-methoxyethyl ether and 2-methoxyethanol: Results from multiple assay for genotoxic potential. Mversk Research International Limited, Musselburgh, EH21 7UB, Scotland.

17. MacKay, GR, and LE Stettler, et al. Fibrogenic potential of slags used as substitutes for sand in abrasive blasting operations. AIHAJ 1980; 81(11): 836-842.

18. National Institute for Occupational Safety and Health. A Guide to Industrial Respiratory Protection. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-189).

19. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to benzene. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1974. (DHEW publication no. (NIOSH) 74-137).

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:

Clifford L. Moseley, C.I.H.
Supervisory Industrial Hygienist
Industrial Hygiene Section

Michael T. Donohue, PA-C
Physician Assistant/Certified
Medical Section

Acknowledgements:

James D. McGlothlin
Michael King
Raymond L. Ruhe
Kevin McManus
Lawrence McLouth

Medical Support:	Thomas Wilcox, M.D. Eugene Schwartz, M.D. Linda Frederick, R.N.
Technical Support:	Shiu Tao Lee G. Robert Schutte James Collins Connie Hollins Donald Morrison Dottie Nurrie
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies
Report Typed By:	Jacqueline Grass Clerk/Typist Industrial Hygiene Section

X. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. Electric Boat Division of General Dynamics Corporation
2. Local Union President, Internation Brotherhood of Painters and Allied Trades
3. NIOSH, Region I
4. OSHA, Region I

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

Table 1

Environmental Criteria

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut
HETA 78-135

Substance	Recommended Exposure Level 8-hr. TWA, mg/M^3	Reference	Corresponding OSHA PEL
Aluminum	10	ACGIH[4]	-
Iron, as oxide	5	ACGIH	10
Titanium	10	ACGIH	-
Copper, dust and mist	1	OSHA[5]	1
Nickel, metal*	0.015	NIOSH[10]	1
Lead	0.05	NIOSH[9]	0.05
Chromium (III)	0.05	NIOSH[7]	1
Chromium VI*	0.001	NIOSH[6]	-
Beryllium*	0.0005	NIOSH[8]	0.002
Magnesium	1	ACGIH	-
Total particulate	10	ACGIH	-
Benzene*	3.2**	NIOSH[19]	32
Xylene	435	OSHA	435
Toluene	375	OSHA	375
Freon 113	7600	OSHA	7600
1,1,1-Trichloroethane	1900	OSHA	1900
Methyl isobutyl ketone	205	ACGIH	410
Ethyl Amyl Ketone	130	OSHA	130
Diisobutyl Ketone	140	NIOSH[11]	290
Methyl Cellosolve	16	ACGIH	80
(Ethyl) Cellosolve	19	ACGIH	-
Methanol	260	ACGIH	260

* Suspected Carcinogen
** Ceiling

Table 2

Environmental Data: Grit Blasting Operations

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut
HETA 78-135

Work Procedure/ Location	Sampling Duration (minutes)	Substance Sampled for, in mg/M^3, 8-hour TWA									
		Nickel Metal	Lead	Copper Dust & Mist	Iron Oxide	Chromium III	Magnesium	Beryllium	Aluminum	Titanium	Total Particulate
Blast/705	273	-[b]	0.01	0.01	0.22	ND[c]	0.01	ND	ND	-	-
Blast/705	345	-	0.10	0.23	2.95	0.01	0.08	ND	0.19	-	-
Blast/705	92	-	0.01	0.02	0.38	ND	0.01	ND	ND	-	-
Blast/705	104	-	0.74	1.00	22.23	0.18	0.58	0.007	2.36	-	-
Blast/705	113	-	0.05	.10	1.59	0.01	0.04	ND	0.12	-	-
Blast/705	152	-	ND	0.01	0.06	ND	0.01	ND	ND	-	-
Blast/705	152	-	3.31	4.41	120.13	0.60	1.09	0.016	9.07	-	-
a	192	-	1.08	1.60	44.17	0.26	0.96	0.004	3.19	-	-
a	186	-	0.05	0.12	1.22	0.01	0.03	ND	0.06	-	-
Blast/705	142	-	11.00	14.73	474.93	2.46	1.35	0.135	45.42	-	-
Blast/705	306	-	0.03	1.06	30.55	0.39	0.71	0.006	3.05	-	-
Blast/705	214	-	0.03	2.58	78.46	0.43	1.59	0.027	6.01	-	-
Blast/705	148	0.40	0.02	1.13	152.78	0.36	-	ND	-	-	45.89[d]
Blast/705	131	0.008	0.13	0.01	0.96	0.01	-	ND		-	2.31
Blast/705	180	0.14	0.14	0.06	9.72	0.26	-	ND	-	-	3.69
Blast/87	294	ND	ND	0.01	0.09	ND	-	ND	-	-	0.37
Blast/87	294	0.04	0.02	0.04	5.42	0.03	-	ND	-	-	12.25[d]
Sand & Brush/[a]	390	-	-	-	-	-	-	-	-	0.28	-
Limit of Detection (mg/sample)		0.015	0.003	0.002	0.01	0.004	0.02	0.0005	0.02	0.06	0.01
Recommended Exposure Limit		0.015	0.05	1.0	5.0	0.05	1.0	0.0005	10	10	10

a field data inadequate for complete description
b no analysis for this substance
c below analytical limit of detection
d sample contained material too large to have been airborne

[redacted] [redacted] [redacted]

Table 3

Environmental Data: Painting - Brushing Operations

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut
HETA 78-135

Work Procedure/ Location	Sampling Duration (minutes)	Benz	Tol	Xyl	Freon 113	1,1,1-T	MiBk	EAK	DiIk	MeCL	MeC	EtC	Tol P	FeOx	Mg	Pb	Cr(III)
Brush/a	377	-b	NDc	62.83	-	-	-	-	7.85	15.71	-	-	-	-	-	-	-
Brush/727	418	-	ND	34.83	-	-	-	-	8.71	26.13	-	-	-	-	-	-	-
Brush/727	432	-	-	-	-	-	-	-	-	-	-	ND	-	-	-	-	-
Brush/726	315	-	ND	6.56	-	-	-	-	-	19.69	-	-	-	-	-	-	-
Brush/701	425	-	-	8.85	-	-	-	-	8.85	-	-	-	-	-	-	-	-
Brush/701	426	-	-	35.50	-	-	-	-	17.75	-	-	-	-	-	-	-	-
Brush/703	97	-	0.21	ND	ND	3.12	ND	-	-	1.25	-	-	-	-	-	-	-
Brush/703	98	-	0.21	ND	ND	2.60	ND	-	-	1.04	-	-	-	-	-	-	-
Brush/698	214	-	1.45	28.07	7.07	11.44	0.41	-	-	4.78	-	-	-	-	-	-	-
Brush/703	226	-	1.04	12.50	0.83	6.46	0.21	-	-	2.40	-	-	-	-	-	-	-
Spray/762	225	-	0.10	0.83	4.47	2.40	ND	-	-	ND	-	-	-	-	-	-	-
Brush/726	321	-	0.21	0.52	6.15	1.56	ND	-	-	ND	-	-	-	-	-	-	-
Brush/799	298	-	0.83	16.78	0.63	6.57	ND	-	-	ND	-	-	-	-	-	-	-
Brush/799	183	-	0.05	1.35	1.15	0.83	ND	-	-	5.21	-	-	-	-	-	-	-
Brush/726	315	-	0.62	21.91	8,34	3.96	8.66	-	-	ND	-	-	-	-	-	-	-
Brush/726	385	-	0.02	1.04	0.03	ND	0.59	-	-	ND	-	-	-	-	-	-	-
Brush/726	384	-	1.35	0.73	13.55	8.86	0.21	-	-	3.75	-	-	-	-	-	-	-
Brush/699	366	-	1.36	1.14	2.19	7.62	0.31	-	-	4.17	-	-	-	-	-	-	-
Brush/726	423	-	2.61	1.36	10.22	29.02	0.84	-	-	11.47	-	-	-	-	-	-	-
Brush/699	354	-	1.36	1.04	2.19	7.30	0.31	-	-	3.75	-	-	-	-	-	-	-
Brush/726	364	-	2.84	1.05	29.21	17.85	0.42	-	-	7.45	-	-	-	-	-	-	-
Brush/726	394	-	0.83	2.60	13.54	7.08	0.11	-	-	1.15	-	-	-	-	-	-	-
Brush/726	394	-	.4.06	2.61	19.81	34.41	0.62	-	-	14.59	-	-	-	-	-	-	-
Brush/726	401	-	0.71	0.51	8.43	5.68	ND	-	-	2.74	-	-	-	-	-	-	-
Brush/726	412	-	2.09	1.04	14.58	12.50	0.21	-	-	5.31	-	-	-	-	-	-	-
Brush/699	353	-	0.32	0.42	6.26	2.92	ND	-	-	22.95	-	-	-	-	-	-	-
Brush/698	333	-	0.83	1.78	0.73	11.46	0.31	-	-	5.95	-	-	-	-	-	-	-
Brush/726	174	-	ND	0.42	0.31	0.31	ND	-	-	ND	-	-	-	-	-	-	-
Brush/726	367	-	0.11	1.25	0.41	0.31	ND	-	-	ND	-	-	-	-	-	-	-
Brush/726	368	-	0.11	7.29	0.62	ND	3.96	-	-	ND	-	-	-	-	-	-	-
Brush/726	364	-	2.29	0.83	19.82	7.29	0.42	-	-	6.67	-	-	-	-	-	-	-
Brush/726	160	-	0.52	0.21	3.12	4.26	ND	-	-	1.77	-	-	-	-	-	-	-
Brush/726	371	-	0.73	2.50	1.98	3.75	0.31	-	-	ND	-	-	-	-	-	-	-

(continued)

Table 3 (continued)

Work Procedure/ Location	Sampling Duration (minutes)	Benz	Tol	Xyl	Freon 113	1,1,1-T	MiBk	EAK	DiIk	MeCL	MeC	EtC	Tol P	FeOx	Mg	Pb	Cr(III)
Brush&Spray/726	334	-	0.10	3.33	0.42	0.21	ND	-	-	ND	-	-	-	-	-	-	-
Brush/87	218	-	ND	0.21	0.84	0.42	ND	-	-	ND	-	-	-	-	-	-	-
Brush/87	214	-	ND	0.10	0.21	0.10	ND	-	-	ND	-	-	-	-	-	-	-
Brush/698	407	-	-	-	-	-	-	-	-	-	-	-	14.30	-	-	-	-
Brush/726	400	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	ND	0.01
Limit of Detection (mg/sample)		0.002	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	-	0.02	0.003	0.003
Recommended Exposure Limit		3.2	375	435	7600	1900	205	130	140	261	16	19	10	5	1.0	0.05	0.5

Key: Benzene = Benz; Toluene = Tol; Xylene = Xyl; Freon 113 = F-113; 1,1,1-Trichloroethane = 1,1,1-T; Methyl isobutyl ketone = MiBk; Ethyl Amyl Ketone = EAK; Diisobutyl Ketone = DiIk; Methylene Chloride = MeCL; Methyl Cellosolve = MeC; (Ethyl) Cellosolve = EtC; Total Particulate = Tol P; Iron Oxide = FeOx; Magnesium = Mg; Lead = Pb; Chromium (III) = Cr(III).

a. Field data inadequate for complete description
b. No analysis for this substance
c. Below analytical limit of detection

Table 4

Environmental Data: Painting - Spraying Operations
and Operations Where Insufficient Data Exists to Categorize

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut
HETA 78-135

Work Procedure/ Location	Sampling Duration (minutes)	Benz	Tol	Xyl	Freon 113	1,1,1-T	MIBk	EAK	DIBk	MeCl	MeC	EtC	Tol P	FeOx	Mg	Pb	Cr(III)
a	368	-b	2.30	69.00	-	-	-	-	15.33	-	-	-	-	-	-	-	-
a	374	-	NDc	70.13	-	-	-	-	15.58	-	-	-	-	-	-	-	-
a	629	-	-	-	-	-	-	-	-	-	-	ND	-	-	-	-	-
Spray/701	417	-	-	-	-	-	-	-	-	-	-	ND	-	-	-	-	-
Spray/702	273	-	5.69	113.75	-	-	-	-	51.19	-	-	-	-	-	-	-	-
Spray/703	150	-	-	-	-	-	-	-	-	-	-	475.00	-	-	-	-	-
Spray/702	106	-	-	-	-	-	-	-	-	-	-	ND	-	-	-	-	-
Spray/702	108	-	-	-	-	-	-	-	-	-	-	145.46	-	-	-	-	-
a/726	318	-	ND	66.25	-	-	-	-	ND	-	-	-	-	-	-	-	-
a/726	369	-	-	-	-	-	-	-	-	-	-	ND	-	-	-	-	-
a/727	334	-	ND	6.96	-	-	-	-	ND	-	-	-	-	-	-	-	-
a/726	316	-	ND	6.58	-	-	-	-	-	46.08	-	-	-	-	-	-	-
a	77	-	-	-	-	-	-	-	-	-	108.92	27.73	-	-	-	-	-
Spray/705d	254	0.53	8.89	100.74	-	-	3.56	50.45	26.07	-	-	-	-	-	-	-	-
Spray/705	291	0.37	7.44	68.26	-	-	3.10	40.33	19.65	-	-	-	-	-	-	-	-
a	520	0.53	1.02	28.70	-	-	1.85	28.70	22.22	-	-	-	-	-	-	-	-
a	432	0.08	1.32	83.52	-	-	230.77	16.49	0.55	-	-	-	-	-	-	-	-
a	520	0.52	1.28	29.53	-	-	1.67	31.50	22.64	-	-	-	-	-	-	-	-
a	96	0.16	0.39	38.18	-	-	0.10	33.28	12.73	-	-	-	-	-	-	-	-
a	100	0.22	3.12	45.93	-	-	0.18	21.13	12.86	-	-	-	-	-	-	-	-
a	98	0.20	3.18	41.45	-	-	0.10	19.28	11.57	-	-	-	-	-	-	-	-
a	89	ND	0.52	32.33	-	-	68.83	0.21	ND	-	-	-	-	-	-	-	-
a	82	ND	ND	0.84	-	-	1.37	0.11	ND	-	-	-	-	-	-	-	-
Spray/762	225	-	0.10	0.83	4.47	2.40	ND	-	-	ND	-	-	-	-	-	-	-
a/726	317	-	1.15	9.60	8.03	1.35	0.31	-	-	ND	-	-	-	-	-	-	-
a/726	281	-	1.67	11.47	8.76	9.48	-	-	-	0.31	-	-	-	-	-	-	-
Spray/726	354	-	ND	1.36	ND	0.21	ND	-	-	ND	-	-	-	-	-	-	-
Spray/726	345	-	0.21	2.50	ND	0.31	ND	-	-	ND	-	-	-	-	-	-	-
Spray/a	326	-	ND	35.47	ND	ND	38.60	-	-	ND	-	-	-	-	-	-	-
Spray/a	209	-	ND	19.79	ND	ND	39.58	-	-	ND	-	-	-	-	-	-	-
Shopman	395	-	2.49	1.83	18.26	23.06	0.48	-	-	10.57	-	-	-	-	-	-	-
Spray/98	251	-	0.21	0.52	0.31	3.85	ND	-	-	1.56	-	-	-	-	-	-	-

(continued)

Table 4 (continued)

Work Procedure/ Location	Sampling Duration (minutes)	Benz	Tol	Xyl	Freon 113	1,1,1-T	MiBk	EAK	DiIk	MeCL	MeC	EtC	Tol P	FeOx	Mg	Pb	Cr(III)
Spray/762	223	-		-	-	-	-	-	-	-	-	-	0.53	-	-	-	-
Spray/a	361	-	-	-	-	-	-	-	-	-	-	-	7.24	-	-	-	-
Spray/a	359	-	-	-	-	-	-	-	-	-	-	-	4.28	-	-	-	-
Spray/KC	401	-	-	-	-	-	-	-	-	-	-	-	2.79	0.12	-	-	-
Spray/Northyard	358	-	-	-	-	-	-	-	-	-	-	-	1.86	1.14	-	-	-
Spray/Northyard	366	-	-	-	-	-	-	-	-	-	-	-	0.35	0.02	-	-	-
Spray 728	361	-	-	-	-	-	-	-	-	-	-	-	1.38	0.10	-	-	-
a/87	220	-	-	-	-	-	-	-	-	-	-	-	0.35	0.08	-	-	-
Spray/98	261	-	-	-	-	-	-	-	-	-	-	-	0.23	-	-	-	-
Clean/728	390	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.01	0.03
Clean/728	245	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	ND	0.02
Limit of Detection (mg/sample)		0.002	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	-	0.02	0.003	0.003
Recommended Exposure Limit		3.2	375	435	7600	1900	205	130	140	261	16	19	10	5	1.0	0.05	0.5

Key: Benzene = Benz; Toluene = Tol; Xylene = Xyl; Freon 113 = F-113; 1,1,1-Trichloroethane = 1,1,1-T; Methyl isobutyl ketone = MiBk; Ethyl Amyl Ketone = EAK; Diisobutyl Ketone = DiIk; Methylene Chloride = MeCL; Methyl Cellosolve = MeC; (Ethyl) Cellosolve = EtC; Total Particulate = Tol P; Iron Oxide = FeOx; Magnesium = Mg; Lead = Pb; Chromium (III) = Cr(III).

a. Field data inadequate for complete description
b. No analysis for this substance
c. Below analytical limit of detection
d. Additive solvent exposure exceeds 1.0

Table 5

Participation In Study

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut
HETA 78-135

Shift	Total Number of Participants	% Participation
1	131	53
2	78	32
3	37	15
Total	246	100

Table 6

Summary Statistics of Reported Exposure to Asbestos
From Questionnaire Survey

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut
HETA 78-135

Questions	Yes		No		Unknown	
	N	%	N	%	N	%
Did you ever work with or been exposed to asbestos at E.B.	164	67	66	27	16	7
During 1950-65	73	30	38	15	135	55
During 1966-75	133	54	13	5	100	41
During 1976-79	68	28	43	17	135	55
Diagnosed as having asbestos by a physician	6	2	182	74	58	24

Grade of exposure to asbestos	N	%
1. slight	44	18
2. moderage	54	22
3. substantial	39	16
4. severe	10	4
5. none or unknown	99	20

Length of Exposure to asbestos	N	%
>3 years	126	52
<3 years	118	48
Mean		4
Standard Deviation		5.42

Table 7

Symptoms Among Painters at Work

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut
HETA 78-135

Health Problems	n	%
Burning, Itching or Watery Eyes	103	42
Stuffy or Runny Nose	73	30
Sore Scratchy Throat or Hoarse Voice	65	27
Chronic Phlegm	60	24
Skin Problems	59	24
Chronic Cough	56	23
Headaches	54	22
Fatigue	48	20
Queasy Stomach	46	19
Dizziness	42	17
Bronchitis	38	15
Drowsiness	35	14

Table 8

Symptoms at Work by Amount of Solvent Exposure

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut
HETA 78-135

Group Health Problems	Solvent Exposure Group Reported Exposure Time <33% (n=147) n	 %	 >33% (n=86) n	 %	Total (n=233) n	 %	X2*	p**
Headache	31	21	22	26	53	23	0.62	0.43
Fatique	27	18	16	19	43	18	0.002	0.96
Queasy Stomach	24	16	20	23	44	19	1.70	0.19
Drowsiness	17	12	16	19	33	14	2.33	0.13
Dizziness	20	14	21	24	41	18	4.38	0.04**
Number of Symptoms								
1	33	22	14	16	47	20		
2	10	7	12	14	22	9		
3	9	6	12	14	21	9		
4	6	4	4	5	10	4		
5	3	2	1	1	4	2	8.65 (d.f.=4)	0.12

* Chi-square (X^2): a statistical test of the relationship between two variables; e.g., the relationship between the reported dizziness and solvent exposure.

**p: The effect is significant at the $p \leq .05$ level

Table 9

Multiple Regression and Multivariate Analysis
of Liver Function (N=190)

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut
HETA 78-135

Liver Enzyme Tests	Percent of Reported Solvent Exposure in Last Month		Alcohol Consumption			
			Last 48 hrs.		usual in a day	
	F*	p**	F	p	F	p
Alkaline Phosphatase	0.32	0.57	0.38	0.54	5.09	0.03
SGGT	1.87	0.17	5.03	0.03	4.59	0.03
SGPT	0.93	0.34	2.97	0.09	1.91	0.17
SGOT	6.29	0.01	3.85	0.05	1.49	0.22

*F = A statistical test of the relationship between two population variables; e.g., solvent exposure and a test abnormality. The larger the value, the greater the relationship.

**p = A measure of the probability that a relationship or association occurs by chance. The smaller the value, the greater probability that the association is not due to chance alone. The conventional pivotal point of statistical significance is p=0.05.

Table 10

Multiple Regression and Multivariate Analysis of Pulmonary Function (n=159)

Electric Boat Division
General Dynamics Corporation
Groton, Connecticut
HETA 78-135

Multiple Regression	Smoking		Years Of Asbestos Exposure		EB Work Years	
	F*	p**	F	p	F	p
FEF 25/75	0.00	0.96	4.07	0.05	0.50	0.48
FEV_1/FVC	4.01	0.05	0.23	0.63	0.38	0.54
FEV_1	24.12	0.01	4.47	0.04	0.85	0.36
FVC	49.21	0.01	3.19	0.08	0.34	0.56

*F = A statistical test of the relationship between two population variables; e.g., smoking and abnormal FEV/FVC. The larger the value, the greater the relationship.

**p = A measure of the probability that a relationship or association occurs by chance. The smaller the value, the greater probability that the association is <u>not</u> due to chance alone. The conventional pivotal point of statistical significance is p=0.05.