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EGG HARBOR YACHT, INC.
EGG HARBOR CITY, NEW JERSEY

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I. SUMMARY

In April 1988, the National Institute for Occupational Safety and Health (NIOSH) was requested by a group of employees to evaluate respiratory complaints in a fiberglass-reinforced plastic boat manufacturing facility.

In November 1988, an initial site visit and worker health interviews were conducted at the Egg Harbor Yacht, Inc., Egg Harbor City, New Jersey. It appeared at that time that an excessive number of respiratory complaints was present in the workers, and in March 1989, a combined medical and environmental survey was conducted at the facility.

Results of personal breathing zone samples from workers in the fiberglass molding area showed an average styrene concentration of 46.8 ppm. Over 78% of the measurements from this area were above the NIOSH action level of 25 ppm, and 35% of samples were above the NIOSH REL, OSHA PEL, and ACGIH TLV of 50 ppm. In addition, of four breathing zone samples for total wood dust from workers in woodworking areas, three were above the ACGIH TLV of 1 mg/m^3. Styrene exposure measurements from the production line, in contrast, were all below the NIOSH action level. Acetone concentrations from personal breathing zone samples were also below the NIOSH REL of 250 mg/m^3.

Questionnaire responses from the workers showed a high prevalence of respiratory symptoms. No clear relationship between symptoms or lung functional changes and measured exposures was observed, however.

Considering all of the data from the medical and environmental survey, the NIOSH investigators conclude that a health hazard does exist from exposure to styrene in the molding areas, and exposure to wood dust in the woodworking areas at Egg Harbor Yacht, Inc. Recommendations are offered regarding exposure monitoring, engineering and administrative controls, personal protection, and medical monitoring of workers.

Keywords: SIC 3732 (Boat building and repairing), styrene, fiberglass, wood dust, boat manufacturing

II. INTRODUCTION

On April 12, 1988, the National Institute for Occupational Safety and Health (NIOSH) received a valid, confidential request for a health hazard evaluation at Egg Harbor Yacht, Inc., Egg Harbor City, New Jersey. NIOSH was requested by a group of employees at Egg Harbor Yacht, Inc. (hereinafter referred to as Egg Harbor Yacht) to evaluate respiratory complaints from exposures in the mold room areas, the production lines, and the woodworking shops.

On November 9, 1988, investigators from NIOSH and the State of New Jersey Department of Health (NJDOH) conducted an initial site visit at Egg Harbor Yacht. During the site visit, the industrial hygienists reviewed company records and inspected the workplace, while the medical officers interviewed workers from the different areas of the plant. During the course of the site visit, Egg Harbor Yacht management rescinded their cooperation with the investigation, forcing the NIOSH and NJDOH investigators to leave the premises prior to completion of the worker interviews. In reviewing the data obtained from the 65 interviews completed prior to interruption of the investigation, it appeared that an excessive number of respiratory complaints were present in the workers. Consequently, a warrant was obtained on March 28, 1989, and served to officials at Egg Harbor Yacht. On March 29-30, 1989, the NIOSH and NJDOH investigators conducted industrial hygiene and medical surveys. After completion of these surveys, a response letter was written to Egg Harbor Yacht on May 19, 1989, which included recommendations for the use of dedicated personal protective equipment, establishment of respiratory protection and hearing conservation programs, the repair and upgrade of local exhaust ventilation systems, and the purchase of powered hand tools with anti-vibration grips.

III. BACKGROUND

Egg Harbor Yacht is a manufacturer of fiberglass-reinforced plastic (FRP) boats, specializing in fishing and sporting yachts. At the time of the survey, Egg Harbor Yacht employed approximately 200 hourly workers, operating for one 10-hour shift per day, four days per week. The NIOSH investigators estimate that approximately 60-70% of the work force is of Hispanic origin, and for many Spanish is their primary language.

The hull, deck, and some smaller boat parts are fabricated from polyester-base resin, gel coat (pigmented resin), and split strand glass fiber (roving) using either hand or spray lay-up techniques. An initial layer of gel coat is applied to the FRP mold. The pigments in the gel coat give color to the FRP, as this layer is the outside surface of the molded part. Next, layers of woven roving are manually laid-up on the gel coated mold, and the polyester resin is applied using a brush and/or spray system. This process is repeated, building-up the FRP to a desired level of thickness. For some FRP parts, it is not possible to use layers of

woven roving to build-up the mold. In these instances, a chopper gun is attached to the resin sprayer. With this configuration, the worker can deliver chopped strands of roving with the polyester resin, building-up the FRP part layer by layer in a mat-like style. After the roving and resin are applied to the mold, workers roll-out the structure, compacting the resin and the roving to conform to the contour of the mold. The polyester resin systems used in these operations typically contain styrene and acetone.

After molding, the boat parts are moved to the production line area for assembly of the yacht. Some FRP work is performed on the three production lines. Many of the parts or sections of the yacht are made of wood. These parts are built and assembled in the woodworking area. This area contains workers using tools and equipment typically associated with carpentry (e.g., lathes, drills, saws, etc.). Egg Harbor Yacht uses teak and mahogany woods in the woodworking areas. Other work performed on the production lines includes the installation of the electrical and plumbing systems, the engine and drive trains, the custom interiors with galleys and showers, the fuel and fresh water tanks, and the installation of other boating and/or sporting accoutrements.

IV. EVALUATION DESIGN AND METHODS

A. Industrial Hygiene

The industrial hygiene survey consisted of personal breathing zone air sampling for styrene and acetone in the mold room and production line areas, and for respirable wood dust in the woodworking areas. Temperature and relative humidity also were measured, and photographs were taken of work practices and procedures.

Styrene and Acetone

Styrene and acetone were measured using NIOSH Methods 1501 and 1300, respectively.[1] The samples were collected by drawing air through a sorbent tube containing 150 milligrams (mg) of activated charcoal at a nominal flow rate of 0.05 liters per minute (lpm), using calibrated, battery-powered sampling pumps. The samples were desorbed with 1 milliliter (ml) of carbon disulfide containing 1 microliter per ml of benzene as an internal standard. Each sample was analyzed by gas chromatography with a flame ionization detector (GC-FID). The limit of detection (LOD) for these methods is 0.02 mg per sample for both styrene and acetone; the limits of quantitation (LOQ) for these methods were 0.06 mg per sample for acetone, and 0.05 mg per sample for styrene.

Wood Dust

Personal breathing zone air samples for wood dust were obtained by drawing air through a tared polyvinyl chloride filter (37 mm diameter, 5 micron pore size) at a nominal flow rate of 1.7 lpm using a calibrated, battery-powered sampling pump. Both total and respirable dust were measured using this method. After sampling, the filters were stored in an environmentally controlled room to allow for stabilization. A determination of the weight of dust deposited on each sample was made by weighing the samples on an electrobalance and subtracting the previously determined tare weights. The instrumental precision of this method was 0.01 mg per weighing.

B. Medical

The medical portion of this study consisted of a questionnaire to document symptoms, personal habits, and work histories; and spirometry to measure changes in the lung function of the study participants. In the initial site visit, all mold room workers and a random selection of workers in other areas of the plant were requested to appear for an interview. During the subsequent survey, all workers who had been selected to participate in the initial interviews were asked to undergo the medical evaluation. Questionnaire responses were compared when workers were grouped with respect to exposures and job category. Relationships were sought between spirometric measures and estimates of exposure, taking into account tobacco use, since changes in lung function can be attributed to factors other than workplace exposures. These comparisons were evaluated to determine if increased symptoms and/or reductions in lung function were associated with job categories or workplace exposure(s).

Questionnaires

Questionnaires were adapted from those used by NIOSH in previous studies of cotton dust-exposed workers. Occupational history and tobacco use were documented by the questionnaire. All questions were translated into Spanish, and, where appropriate, a Spanish speaking individual was available to administer the questionnaire and to handle any language-related difficulties during the survey. Cigarette smoking was quantified as pack-years (total years smoked multiplied by average number of packs smoked each day).

Symptoms were defined based upon the subject's responses to sequences of questions. "Bronchitis" was defined as productive cough on most days for at least three months each year. "Cough" was similarly defined, with or without expectoration. "Dyspnea" was considered present if shortness of breath occurred walking at an ordinary pace on level ground. "Wheeze" was present if the symptom occurred as often as once each week. "Asthma" was defined as

attacks of shortness of breath with wheezing, with normal breathing between attacks. A "chest illness" was recorded if the worker had been off work for a respiratory problem for as long as one week at any time in the past three years. A positive response to "Do you usually have a stuffy, itchy, or runny nose?" was labeled "rhinitis". All subjects were asked "During the past month have you had a chest cold or flu?" Finally, to determine the timing of certain symptoms, participants were asked "Is your chest tight or your breathing difficult on any particular day of the week?", and "Do you cough on any particular day of the week?"

Spirometry/Pulmonary Function Tests (PFTs)

Spirometry was performed using a dry rolling-seal spirometer interfaced to a computer terminal with tape and disk storing capabilities. At least five maximal expiratory maneuvers were recorded for each person. All values were corrected to BTPS (body temperature, pressure, saturated with water vapor). The largest forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) were selected for analysis regardless of the curves on which they occurred. The ratio of the FEV_1 divided by the FVC (FEV%) was calculated. The spirometer and methods met the quality control recommendations of the American Thoracic Society (ATS).[26] Spirometry was performed before and at least six hours after the beginning of the workshift.

V. EVALUATION 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 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, including recommended exposure limits (RELs), 2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor, OSHA permissible exposure limits (PELs). 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 by the Occupational Safety and Health Act of 1970 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.

A. Styrene

The major routes of worker exposure for styrene are inhalation and dermal absorption. Styrene vapor is an eye and respiratory tract irritant, and liquid styrene is a dermal irritant. The major target organ for workers exposed to styrene is the central nervous system (CNS), with exposure producing health effects such as headache, fatigue, drowsiness, nausea, malaise, difficulty in concentrating, and a feeling of intoxication. Decrements in balance, coordination, manual dexterity, and reaction time have also been associated with styrene exposure.[2,3] Workers exposed to concentrations averaging 50 parts per million (ppm) have demonstrated acute effects on neuropsychological tests of verbal learning skills and other abilities.[4] Styrene can be absorbed through the skin, and repeated or prolonged skin exposure can lead to dermatitis.[5] Human studies on the reproductive effects among workers exposed to styrene are limited and have revealed conflicting results, without consistent evidence of adverse effects.[2,6-9] Presently, styrene is not considered to be a potential occupational carcinogen.[10-12]

The OSHA PEL, ACGIH TLV, and NIOSH REL agree that exposure to styrene should not exceed an 8-hour time weighted average concentration of 50 ppm.[10-12] In addition to this, NIOSH has established an action level of 25 ppm.[2] Due to interday variability of exposures, a worker's single TWA exposure that is below the NIOSH REL of 50 ppm does not necessarily indicate that exposures on other days would also be below the REL. If a worker's TWA exposure is at or above the 25 ppm action level, NIOSH believes that sufficient

probability exists that on other days exposures could exceed the NIOSH REL of 50 ppm. The action level helps ensure adequate protection of workers from the variability in workplace styrene exposures.

B. Acetone

Acetone is considered to be of low risk to health except at very high levels, as it has been used for years without many reported adverse health effects.[13] Acetone is irritating to the eyes, skin, and upper respiratory tract.[3,13] At airborne levels above 1000 ppm, acetone tends to cause dizziness, lightheadedness, and headache.[14] Exposure to high levels (over 10,000 ppm) has also been associated with CNS depression, narcosis, loss of consciousness, a feeling of intoxication, and weakness in the legs.[3]

The NIOSH REL for acetone of 250 ppm (for up to a 10-hour TWA) will be used in evaluating the air sampling data presented in this report.[12] For comparison purposes, the OSHA PEL and ACGIH TLV for acetone are 8-hour TWA exposures of 750 ppm.[10,11]

C. Wood Dust

Exposure of workers to wood dust, including hard woods such as teak and mahogany, has been reported to result in numerous health effects including allergic reactions,[15] chronic non-allergenic respiratory disease,[16] and both nasal and sinus cancer.[17] Obstructive respiratory effects[16], development of lung fibrosis,[18] and impairment of the mucociliary clearance mechanism [19] also have been reported.

The OSHA PEL for soft and hard wood dust is an 8-hour TWA of 5 milligrams of wood dust per cubic meter of air (mg/m^3).[10] The ACGIH TLV for hard wood dust is 1 mg/m^3, and 5 mg/m^3 for soft wood dust, as 8-hour TWAs.[11] The PELs and TLVs are based on total dust levels. Presently, NIOSH has yet to establish an REL for wood dust.[12] The ACGIH TLV for hard wood dust of 1 mg/m^3 will be used to evaluate the air sampling results presented in this report.

VI. RESULTS AND DISCUSSION

A. Industrial Hygiene

The results from the personal breathing zone air sampling for wood dust are presented in Table 1 of this report. The sampling protocol was designed to measure and compare workers' exposures to both respirable and total wood dust. As stated previously, Egg Harbor Yacht uses primarily teak and mahogany hard woods. All of the respirable dust concentrations were equal to or below 0.5 mg/m^3; conversely, 3 of the 4 (75%) total wood dust levels were equal to or above the ACGIH TLV of 1 mg/m^3. The average total dust levels

measured during this study were 1.2 mg/m^3; the average respirable dust levels were 0.26 mg/m^3. These data indicate that approximately 22% of the dust is respirable; i.e. has an aerodynamic diameter of less than 10 micrometers and is capable of reaching the alveolar regions of the lungs upon inhalation. Hence, a large portion of the dust exposure would be deposited in the nose, throat, and upper respiratory tract regions of the human body.

Tables 2 (March 29) and 3 (March 30) present the results from the personal breathing zone air sampling for styrene and acetone in the molding and production line areas. Workers in the molding areas were exposed to an average styrene concentration of 46.8 mg/m^3, with 8 of 23 (35%) of these exposure measurements being above the NIOSH REL, OSHA PEL, and ACGIH TLV of 50 ppm. In addition to this, 18 of 23 (78%) of these measurements were above the NIOSH action level of 25 ppm. Workers' exposure to styrene in the molding areas ranged from 11.2-120.4 ppm. In contrast, workers in the adjacent production line areas were exposed to an average styrene concentration of 2.7 ppm, and these exposures ranged from 2.3-3.6 ppm. It should be noted that most of the styrene and acetone exposure in workers in the production line areas is secondary in nature, with the vapor concentrations originating from the resin applications being performed in the molding areas. All of the measured acetone exposure concentrations for the above molding and production line workers were below the NIOSH REL of 250 ppm. A sample taken on a welder measured styrene and acetone exposure levels of 1.0 and 8.5 ppm, respectively. An area air sample taken in the cafeteria measured a styrene concentration of 4.6 ppm and an acetone concentration of 1.8 ppm.

B. Medical

Questionnaires

Questionnaires were collected from 52 workers during the medical survey. Eight subjects did not satisfactorily complete the symptom questions and/or the smoking habit questions. Therefore, demographics and symptom information are available on 44 workers. All the participants were male. Ages ranged from 18 to 61 years, with a mean age of 35 years and a standard deviation of 11 years. The racial distribution of the subjects can be found in Table 4. The tenure of these workers in the boat manufacturing industry ranged from 0.5 years to 21 years, with a mean tenure of 5 years and a standard deviation of 5 years. It was not possible to restrict the tenure calculation to the number of years spent solely at Egg Harbor Yacht, as many workers did not give specific company names in their occupational histories. Job locations of the participants on the day of the survey were distributed as indicated in Table 5. Cigarette use is indicated in Table 6.

Of these 44 participants, industrial hygiene samples for personal exposure to styrene and acetone were collected on 22. Only one of these individuals did not work in either the mold room or on the production line. This person's IH results were excluded from the analysis. Personal air samples for seven individuals were available from both survey days; for these workers the mean of the two exposures was used in the analysis.

Results were tabulated based upon each worker's responses to the queries defining a symptom. Symptom prevalence was tabulated and compared when workers were categorized by job classification into two groups: (1) assembly-workers who worked on the three production lines, or (2) moldroom-workers who worked primarily in the molding areas. Six other individuals who worked primarily in various other locations, such as woodworking were not included in these analyses. (Tables 7 and 8)

In the entire group (N=44), of the 14 subjects that reported cough, three (21%) reported that they coughed on a particular day of the week, including two on Mondays and one on Saturdays. Twenty-four participants (55%) answered "YES" to the question "Does your chest ever feel tight or your breathing become difficult?". Of these subjects, four (17%) reported that this occurred on a particular day of the week (2-Mondays; 1-Tuesdays; 1-Fridays).

Workers were grouped by the results of personal breathing zone air measurements, when available. Three exposure groupings were determined for styrene, as follows: Low exposure group: less than 25 ppm (NIOSH action level), Intermediate exposure group: 25 to 49 ppm, and High exposure 50 ppm and above (over the PEL). Symptom prevalences and tobacco use were compared in workers exposed at each level. (Tables 9 and 10)

Overall, participating workers showed a high prevalence of symptoms, as defined in the methods section, of cough, phlegm, wheeze, rhinitis, recent flu-like illnesses, and chest tightness/breathing difficulty. Fewer workers had dyspnea, asthma, or respiratory symptoms which occurred on a specific day of the week. When symptoms were compared by styrene exposure groups, no clear pattern emerged.

Spirometry

Due to technical problems, post-shift spirometry data was not available for the entire study group. Therefore, only pre-shift (baseline) spirometry measures have been utilized. Of the 44 subjects, baseline spirometry was available for 39 (89%). Knudson's (1983) prediction equations with a 0.85 correction for black workers, were used to calculate the percent of predicted FVC and FEV1 for each participant.[27] No correction was applied for

Hispanic workers. Restrictive and obstructive lung disease patterns were detected by comparing the observed FVC and FEV1/FVC%, respectively, to the lower limit of normal for FVC and FEV1/FVC% defined by using Knudson's (1983) prediction equations along with the 95th percentiles for his age groups.

The results of pre-shift spirometry are shown for the two work areas. (Table 11) In the entire group for whom spirometry results are available (N=39), four subjects (10%) showed evidence of an obstructive lung pattern and 2 subjects (5%) showed evidence of a restrictive lung volume.

Workers were also grouped as above by exposures to styrene. (Table 12) Mean FEV1, FVC, and FEV1/FVC% were calculated for workers grouped by exposure. The workers in the highest styrene exposure group had the lowest mean values for these spirometry measurements. However, when recognized predictors of spirometry, such as age and height, were taken into account, no relationship between lung function and exposure was seen.

VII. CONCLUSIONS

During the initial site visit, workers were randomly selected for interview. The results of these interviews confirmed a high prevalence of respiratory tract symptoms. The prevalence of symptoms found in the follow-up survey may have been affected by reduced participation. However, this appears unlikely to have been an important bias, since the symptoms detected in the medical survey were similar in proportion and type to those documented during the initial site visit. Respiratory tract symptoms have previously been reported in workers exposed to styrene.[21,22,23,24] No clear relationship of symptoms or spirometry findings to the measured airborne levels of styrene was observed in the current survey. Small numbers and variable participation may have affected the survey results. Also, no adjustment of the predicted values was made for Hispanic workers.

In considering all of the data from the medical and industrial hygiene studies performed during this study, the NIOSH investigators conclude that a health hazard does exist from exposure to styrene in the molding areas, and exposure to wood dust in the woodworking areas at Egg Harbor Yacht.

VIII. RECOMMENDATIONS

1. Engineering controls, such as fixed local exhaust ventilation, should be used whenever possible to reduce exposure to styrene. In some situations, fixed local exhaust is not feasible and a movable hood with a flexible duct may be used. General ventilation may be

necessary where local exhaust ventilation cannot be used, and may be used to supplement local exhaust ventilation. All exhaust ventilation should be designed and operated to prevent the accumulation and recirculation of airborne styrene in the workplace and to effectively maintain safe levels of styrene vapor. Recommended examples of good ventilation system design for molding areas in the FRP boat-making industry have been published.[28] Since Egg Harbor Yacht uses fixed hull molds, these may be fitted with a push-pull ventilation system, sweeping air from bow to stern while workers laminate counter current to airflow. Whenever exhaust ventilation systems are used to control styrene exposures, the following requirements should apply:

a. Exhaust hoods and ductwork should be constructed of fire-resistant materials.

b. Ventilation systems should be equipped with alarms, flowmeters, or other devices to indicate malfunction or blockage of the system. These systems should be inspected at the beginning of each workshift.

c. The hood design, capture velocity, and flow rate should be chosen to capture styrene vapors effectively.

d. Clean make-up air should be provided according to the OSHA General Industry Standards, 29 CFR 1910.252.

e. The efficacy of new engineering controls should be tested by performing industrial hygiene monitoring on the workers using that work station. This monitoring should document a reduction of styrene vapors in the breathing zone of the worker(s) to a level below the NIOSH action level of 25 ppm.

2. Exhaust ventilation systems in the woodworking areas should be repaired and upgraded to reduce the workers's exposure to wood dust. Engineering controls should be designed, and installed on all woodworking operations which presently have no such controls to reduce exposure. These controls should conform to the recommended guidelines given in the above 1a through 1e.

3. Respiratory protection should be provided to all workers in the molding and woodworking areas, and/or those potentially exposed to hazardous concentrations of styrene and wood dust, when the following situations occur: 1) when engineering controls are not a technically feasible means to reduce exposure, 2) in the interim before the installation and testing of new engineering controls, and 3) when engineering controls have not successfully lowered styrene exposures below the NIOSH action level of 25 ppm or wood dust exposure levels below the ACGIH TLV of 1 mg/m^3. When respirators

are used, a complete respiratory protection program should be provided, with minimum standards for such a program set forth in the OSHA General Industry Standards, 29 CFR 1910.134. For styrene, we recommend that workers be provided with a NIOSH-approved air-purifying respirator with a sorbent cartridge capable of removing styrene vapors. Workers potentially exposed to wood dust should be provided with a NIOSH-approved respirator capable of removing particulate matter. If industrial hygiene monitoring documents a change in exposure levels, or exposure to contaminants not measured during the NIOSH surveys at Egg Harbor Yacht, the NIOSH Respirator Decision Logic[20] should be used to select the proper respirator.

4. Egg Harbor Yacht should institute a medical monitoring program for all workers potentially exposed to styrene and wood dust. This monitoring program should consist of both preplacement and periodic medical examinations, which are defined below:

   a. The preplacement medical examination should consist of comprehensive work and medical histories, a smoking history, a comprehensive medical examination with emphasis on the respiratory, nervous, and hepatic systems, and a baseline pulmonary function test which measures both forced vital capacity and forced expiratory volume in one second.

   b. Until exposures are documented to be consistently below the NIOSH action level of 25 ppm, workers should be given a periodic medical examination on an annual basis. This should include updates of the work, medical, and smoking histories, a medical examination with emphasis on the respiratory, nervous, and hepatic systems, including a pulmonary function test which measures both forced vital capacity and forced expiratory volume in one second.

   c. Workers or potential workers having medical conditions, such as disorders of the nervous, respiratory, and/or hepatic systems, should be counseled on the possibility of increased risk of impairment to their health from exposure to styrene and wood dust.

   d. All medical records must be maintained by the employer for the duration of employment plus 30 years for all workers subject to exposure to styrene in the workplace.

5. Egg Harbor Yacht should implement an exposure monitoring program for all workers potentially exposed to styrene and wood dust, as well as any other hazardous substances that may be used in the workplace.

This program should consist of sampling of air from the worker's breathing zone to measure the worker's exposure concentration to a specific chemical or substance. The purpose of this exposure monitoring is to determine whether exposures to any chemical or physical agent may exceed the applicable exposure limits. Exposure monitoring surveys should be performed on a annual basis, or whenever changes in work processes or conditions are likely to lead to a change in exposures. Though not all workers have to be monitored, sufficient samples should be collected to characterize the workers' exposures. Variations in work habits and production schedules, worker locations, and job functions should be considered when developing exposure monitoring protocols. All workers participating in the monitoring should be informed of the results, and the employer must maintain these records for a period of 30 years.

6. All efforts should be made to prevent styrene from coming in contact with workers' skin. Workers should be prohibited from handling resin-soaked roving without the use of a glove which is impermeable to styrene.

7. Eating, drinking, and smoking should be prohibited in all work areas. Until smoking can be eliminated from the workplace, it should be allowed only outside or in designated areas with independent exhaust ventilation such that smoke is not recirculated within the building. Workers who smoke should be counseled on how smoking may exacerbate the adverse effects of other respiratory hazards.

8. All labels and warning signs should be printed in both English and in the predominant language of non-English reading workers.

9. The use of powered hand tools has been associated with a condition known as vibration white finger (Raynaud's Phenomenon) in some workers. Only powered hand tools that minimize vibration should be used at Egg Harbor Yacht. Gloves also aid in reducing the effects of vibrating hand tools on the worker.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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Copies of this report have been sent to:

1. Egg Harbor Yacht, Inc.
2. New Jersey Health Department
3. NIOSH Regional Office
4. OSHA

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

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Table 1

Results from Air Sampling for Total and Respirable Wood Dust
Egg Harbor Yacht
HETA 88-262
March 29-30, 1989

Job Location	Sample Time	Sample Volume[1]	Concentration[2] Total	Concentration[2] Respirable
		March 29, 1989		
Woodworking	0742-1623	886	--	0.1
Woodworking	0745-1656	937	--	0.5
		March 30, 1989		
Production Line	0657-1710	989	--	0.1
Production Line	0705-1547	887	--	0.3
Woodworking	0700-1610	935	--	0.3
Woodworking	0732-1547	842	1.7	--
Woodworking	0743-1550	763	1.0	--
Woodworking	0745-1550	760	1.5	--
Woodworking	0737-1158	444	0.6	--
OSHA PEL	5.0			
ACGIH TLV	1.0			

[1] Sample volumes are expressed in liters of air.

[2] Concentrations are in milligrams of wood dust per cubic meter of air.

Table 2

Results from Air Sampling for Styrene and Acetone
Egg Harbor Yacht
HETA 88-262
March 29, 1989

Worker Location	Elapsed Sample Time (minutes)	Sample Volume[1]	Concentration[2] Styrene	Acetone
Molding Areas	344	17.2	21.7	7.4
Molding Areas	437	21.9	17.8	5.0
Molding Areas	527	26.3	29.5	59.6
Molding Areas	482	24.1	42.9	20.3
Molding Areas	244	12.2	29.0	22.9
Molding Areas	471	23.5	73.0	20.3
Molding Areas	454	22.7	40.4	2.0
Molding Areas	485	24.3	59.0	21.3
Molding Areas	405	20.3	11.9	8.3
Molding Areas	442	22.1	35.1	7.2
Molding Areas	448	22.4	11.2	6.6
Molding Areas	484	24.2	28.2	12.0
Molding Areas	421	21.0	53.7	12.6
Welder	528	26.4	1.0	8.5
Area Air Sample in Cafeteria	527	25.4	4.6	1.8
NIOSH REL			50.0	250.0
ACGIH TLV			50.0	750.0
OSHA PEL			50.0	750.0

[1] Sample volumes are expressed in liters of air.

[2] Concentrations are in parts per million of styrene or acetone.

Table 3

Results from Air Sampling for Styrene and Acetone
Egg Harbor Yachts, Inc.
HETA 88-262
March 30, 1989

Worker Location	Elapsed Sample Time	Sample Volume[1]	Concentration[2] Styrene	Acetone
Molding Areas	531	26.5	67.4	31.5
Molding Areas	544	27.2	38.1	28.8
Molding Areas	552	27.3	34.0	11.1
Molding Areas	522	26.1	80.5	25.5
Molding Areas	579	28.9	38.4	15.2
Molding Areas	548	27.4	62.6	15.5
Molding Areas	458	22.9	23.0	7.5
Molding Areas	350	17.5	45.7	21.4
Molding Areas	321	16.1	112.4	33.8
Molding Areas	327	16.4	120.4	46.2
Production Line	563	28.1	3.6	31.6
Production Line	578	28.9	2.3	16.0
Production Line	565	28.3	2.3	5.8
Production Line	579	28.9	2.4	16.0
Production Line	559	28.0	2.8	60.2
Production Line	553	26.2	2.6	67.6
Production Line	533	26.7	2.6	7.1
NIOSH REL			50.0	250.0
ACGIH TLV			50.0	750.0
OSHA PEL			50.0	750.0

[1] Sample volumes are expressed in liters of air.

[2] Concentrations are in parts per million of styrene or acetone.

Table 4

Racial Distribution in Participating Workers
Egg Harbor Yacht
HETA 88-262
March 30, 1989

Race	N	%
White		
Hispanic	24	55
Non-Hispanic	5	11
Not Classified	2	5
Black		
Hispanic	1	2
Non-Hispanic	3	7
Other		
Hispanic	9	21

Table 5

Job Location of Participating Workers
Egg Harbor Yacht
HETA 88-262
March 30, 1989

Location	N	%
Mold Room	15	34
Production	22	50
Wood Shop	3	7
Warehouse	1	2
Maintenance	2	5
Welding	1	2

Table 6

Cigarette Smoking in Participating Workers
Egg Harbor Yacht
HETA 88-262
March 30, 1989

Cigarette Smoking Habit	N	%	Pack Years Mean	SD
Never	14	32	-	-
Former	12	27	6.8	9.9
Current	18	41	16.3	14.5

Table 7

Demographics, Tenure, and Smoking in Mold Room and Production Workers
Egg Harbor Yacht
HETA 88-262
March 30, 1989

	Mold Room N=15		Production N=22	
	Mean	SD	Mean	SD
Age	33	11	36	11
Height (cm)	170	8	169	8
Boat Manufacturing Tenure (years)	4	5	7	6
Cigarette Pack Years	7.5	11.5	6.4	8.5
	N	%	N	%
Cigarette Smoking Habit				
Never	6	40	6	27
Former	3	20	7	32
Current	6	40	9	41

Table 8

Symptom Prevalence by Job Location
Egg Harbor Yacht
HETA 88-262
March 30, 1989

Symptom	Mold Room N=15		Production N=22	
Cough	4/15	27%	9/22	41%
Bronchitis	7/14	50%	13/22	59%
Dyspnea	2/15	13%	3/21	14%
Wheeze	6/15	40%	6/22	27%
Asthma	0/15	0%	2/22	9%
Chest Illness	1/15	7%	3/22	14%
Rhinitis	8/15	53%	14/22	64%
Chest Tightness/ Breathing Difficult	5/15	33%	17/22	77%
Chest Cold/Flu in the Past Month	8/15	53%	11/22	50%

Table 9

Demographics by Styrene Exposure Categories
Egg Harbor Yacht
HETA 88-262
March 30, 1989

Exposure level: Number of Workers:	STYRENE (ppm) 0 to < 25 N=9		25 to < 50 N=7		50 and higher N=5	
	Mean	SD	Mean	SD	Mean	SD
Age	37	9	29	12	35	12
Boat Manufacturing Tenure (years)	9	7	4	7	5	5
Cigarette Pack Years	5.9	7.6	8.9	14.3	7.8	10.8
	N	%	N	%	N	%
Cigarette Smoking Habit						
Never	3	33	2	29	2	40
Former	3	33	2	29	1	20
Current	3	33	3	43	2	40
Worker Location						
Mold Room	2	22	7	100	5	100
Production	7	78	-	-	-	-

Table 10

Symptoms by Styrene Exposure Categories
Egg Harbor Yacht
HETA 88-262
March 30, 1989

Exposure level: Number:	Styrene (ppm) 0 to < 25 N=9		25 to < 50 N=7		50 and higher N=5	
	N	%	N	%	N	%
Cough	3/9	33	3/7	43	1/5	20
Phlegm	4/9	44	4/6	67	3/5	60
Dyspnea	2/9	22	2/7	29	0/5	0
Wheeze	2/9	22	3/7	43	3/5	60
Asthma	1/9	11	0/7	0	0/5	0
Chest Illness	1/9	11	0/7	0	1/5	20
Rhinitis	5/9	56	5/7	71	2/5	40
Chest Cold/Flu in Past Month	5/9	56	7/7	100	1/5	20
Chest Tight/ Breathing Difficult	7/9	78	3/7	43	2/5	40

Table 11

Pulmonary Function Test Results by Job Location
Egg Harbor Yacht
HETA 88-262
March 30, 1989

	Mold Room N=12		Production N=21	
	Mean	SD	Mean	SD
FVC (l)	4.51	0.63	4.43	0.69
FEV1 (l)	3.70	0.65	3.56	0.63
FEV1/FVC (%)	81.8	4.6	80.3	8.1
% Predicted FVC	108.0	12.0	104.5	15.3
% Predicted FEV1	105.3	11.3	100.8	17.9

Table 12

Pulmonary Function Measures by Styrene Exposure Categories
Egg Harbor Yacht
HETA 88-262
March 30, 1989

Exposure Level: Number:	Styrene (ppm)					
	0 to < 25 N=9		25 to < 50 N=7		50 and higher N=5	
	Mean	SD	Mean	SD	Mean	SD
FVC (l)	4.45	0.77	4.79	0.51	4.13	0.65
FEV1 (l)	3.64	0.89	4.00	0.51	3.23	0.62
FEV1/FVC (%)	80.7	9.3	83.3	2.1	78.1	6.1
% Predicted FVC	102.6	18.4	108.7	9.8	114.0	16.3
% Predicted FEV1	99.6	19.7	107.3	11.0	106.4	16.3