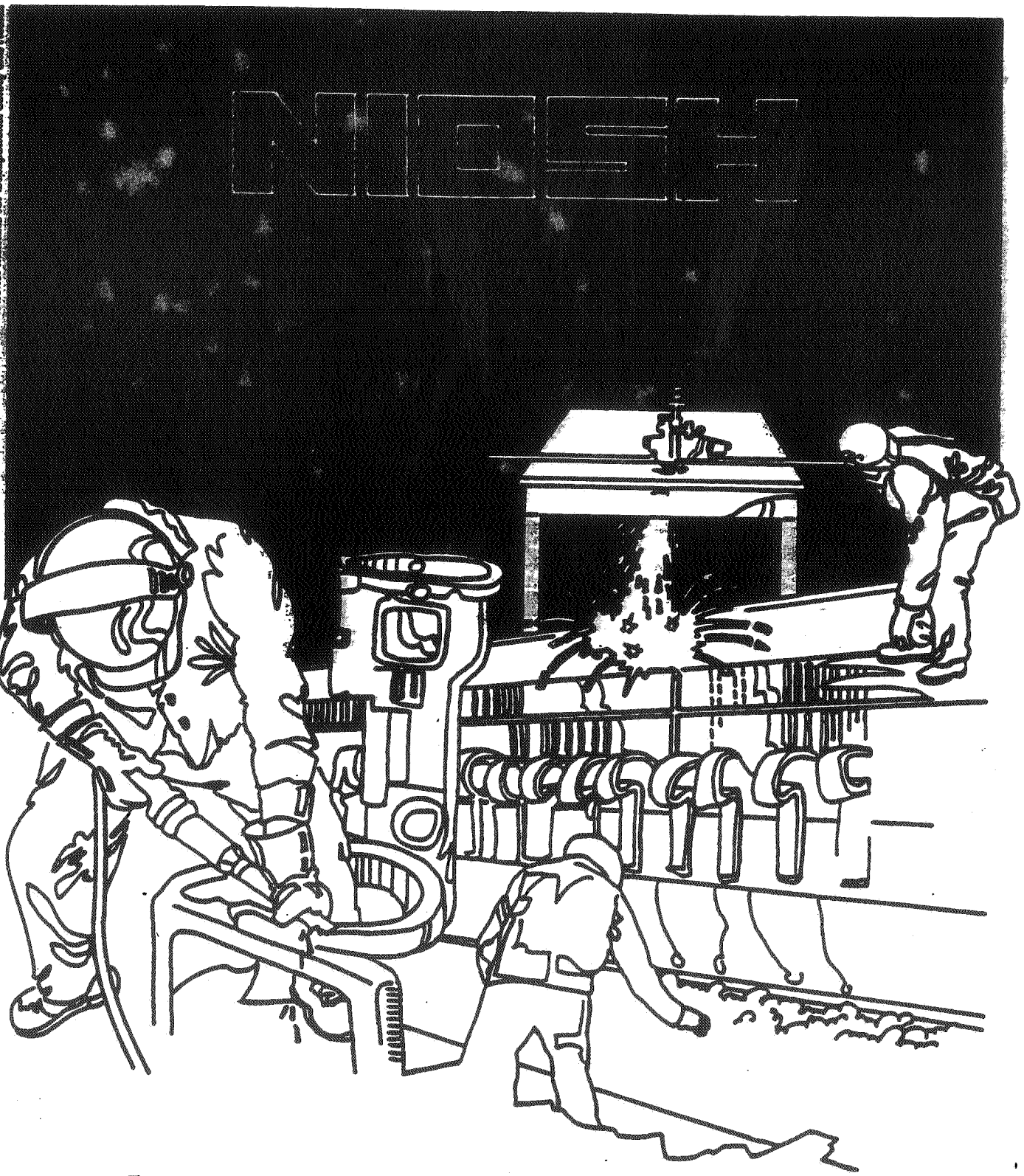
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
Centers for Disease Control • National Institute for Occupational Safety and Health




# Health Hazard Evaluation Report

HETA 83-128-1485
HENRY R. HINCKLEY & COMPANY
SOUTHWEST HARBOR, MAINE

## 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 83-128-1485
JULY 1984
HENRY R. HINCKLEY & COMPANY
SOUTHWEST HARBOR, MAINE

NIOSH INVESTIGATORS:
MICHAEL S. CRANDALL, C.I.H.
RICHARD W. HARTLE, C.I.H.

## I. SUMMARY

On February 1, 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate exposures to substances used in the construction of fibrous glass reinforced plastic and wood boats at Henry R. Hinckley & Company, Southwest Harbor, Maine. Approximately 75 workers are in production and service at Hinckley. On March 24, 1983 NIOSH investigators conducted a walk-through survey. On April 25-29, 1983 a follow-up, plant-wide survey was conducted. NIOSH investigators obtained personal and area air exposure measurements for styrene monomer, acetone, general paint, varnish and solvent vapors, wood dust, lead fume and other particulates, and noise.

Exposure to styrene in the lamination shop averaged 100 mg/m$^3$ for 14 personal, full-shift samples (range 18-258 mg/m$^3$). Three of these exceeded the NIOSH recommended standard of 215 mg/m$^3$ (OSHA standard, 425 mg/m$^3$). Two of three personal, 15-minute ceiling samples (range 267-840 mg/m$^3$) exceeded the NIOSH recommended standard of 425 mg/m$^3$ (OSHA standard, 850 mg/m$^3$). Acetone exposures (range, 6-147 mg/m$^3$), although below its individual exposure criterion, will have an additive effect with the styrene exposures.

Two samples measured concurrent short term exposures to toluene and xylene in the mast shop. Toluene exposures were 590 and 692 mg/m$^3$ and the respective xylene concentrations were 200 and 192 mg/m$^3$. The NIOSH recommended 15-minute exposure criteria are 750 mg/m$^3$ for toluene (OSHA, 1120 mg/m$^3$) and 870 mg/m$^3$ for xylene (OSHA, none). When considered singularly, there were no overexposures. When considered as additive, since these compounds cause similar acute health effects, these exposures exceed both the NIOSH and ACGIH combined exposure criteria.

In main assembly and the prefab shop, wood dust concentrations for 29 TWA full-shift personal samples averaged 2.2 mg/m$^3$ (range 0.7 - 16.2 mg/m$^3$, S.D. + 3). Twenty-one of these exceeded 1 mg/m$^3$. The ACGIH recommends a 1 mg/m$^3$ time-weighted average (TWA) TLV for hard wood dusts.

Noise exposures measured among the carpenters at Hinckley averaged 82.4 dBA-slow response and ranged from 76.1 to 89.1 dBA. Three TWA exposures were over 85 dBA. NIOSH recommends that an 8-hour TWA exposure to noise not exceed 85 dBA(slow response). The OSHA noise exposure standard is 90 dBA(slow response) for an 8-hour TWA exposure.

Full-shift TWA cellosolve exposures to painters (7 samples) ranged from 1.2 to 5.7 mg/m$^3$ (average 5.9 mg/m$^3$). Cellosolve (2-ethoxyethanol) and cellosolve acetate (2-ethoxyethyl acetate) are regarded as having the potential to cause adverse reproductive effects in male and female workers. NIOSH recommends that exposure to these compounds be limited to the lowest extent possible. The OSHA standards for an 8-hour TWA are 740 mg/m$^3$ for cellosolve and 540 mg/m$^3$ for cellosolve acetate.

The remaining exposures which were quantitated at this plant were well below applicable criteria.

Based on these results, the NIOSH investigators concluded that there was a health hazard from overexposure to wood dusts in the carpentry areas, styrene in the lamination shop, and combined solvent exposures in the lamination shop (styrene and acetone) and the mast shop (toluene and xylene). There were also potential health hazards from exposure to cellosolve and cellosolve acetate among the painters and noise exposures in the carpentry areas. Recommendations are made in Section IX to reduce these exposures in the form of using existing ventilation in the lamination shop, installing exhaust fans in the mast shop, and protective equipment use for the carpenters and painters.

KEYWORDS: SIC (3732) Boat building and repair
acetone, aluminum, cellosolve (2-ethoxyethanol), cellosolve acetate (2-ethoxyethyl acetate), cyclohexanone, hexamethylene diisocyanate (HDI), lead (fume), methyl Iso-butyl Ketone (MIBK), naphthalene, nuisance particulates, styrene-monomer, toluene, 1,1,1,-trichloroethane, V,M & P Naptha, wood dust, xylene

## II. INTRODUCTION

In February 1983, NIOSH received a request for a health hazard evaluation at Henry R. Hinckley & Company, Southwest Harbor, Maine. The requestors asked NIOSH to evaluate the possible health hazards from exposure to materials utilized in fiberglass reinforced plastic (FRP) boat construction. The materials identified in the request were: styrene, polyester and epoxy resins, catalysts, accelerators, solvents, cleaners, paints, wood dusts, and lead.

NIOSH conducted a walk-through survey on March 24, 1983. A follow-up survey was conducted on April 25-29, 1983.

## III. BACKGROUND

Henry R. Hinckley & Company began as a wooden boat building company in 1932. Around 1950 the switch to FRP began. They currently build 12-15 FRP auxiliaries, or sailing yachts equipped with a supplementary inboard engine, per year. They can vary in length from 40 to 64 feet.

Hinckley employs approximately 100 workers and normally operates one 8-hour shift per day. About 72 employees are involved in production and service. Production and service activities are conducted in five buildings at the Hinckley plant site. These are briefly described below, with approximate number of workers per shift in parentheses.

A. Fiberglass shop (10 workers) - The hull, deck and some smaller parts are fabricated here from fibrous glass mat and woven roving, and polyester resin using hand lay-up techniques. Alternating layers of mat and woven roving are applied and saturated with catalyzed resin from a spray system. These layers are individually rolled-out by hand to conform to the contour of the mold. Once the desired thickness is attained the piece is removed from the mold. This shop was clean, and local and general exhaust with make-up air were provided.

B. Main assembly building (55 workers) - The FRP parts for all but the 64 foot yachts are moved from the fiberglass shop to the line in main assembly. The carpentry, spray varnish, machine and mast shops are in this building. Here the yachts are completely assembled and finished, except for exterior painting, mast and sails. This includes engine, fuel and water tanks, electrical, plumbing and steering systems, custom wooden interiors with galleys and showers, and sailing accoutrements.

In the carpenter shops all planers and large saws had local ventilation. Hearing protection was provided, as were dust masks, but use was not mandatory. The spray varnish shop also had local ventilation.

C. 64 assembly (number of workers varies, 1-5) - This building has three large bays. The 64 foot Hinckleys are assembled here. The building is also used for exterior hull and bottom painting. Hull painting is contracted to a local painter. Bottom painting is performed by Hinckley painters. Final detailing on models other than the 64 prior to commissioning may be performed here.

D. Keel shed (1-2 workers) - Lead is received in 65 pound pigs, melted and mechanically poured into an iron keel mold. The melt may take five hours and the pour fifteen to twenty minutes. The smelter has a canopy hood and the shed has ample natural ventilation. Blood lead levels are monitored pre- and post-shift on the day of a keel pour. This happens about once a month.

E. Service building (7 workers) - This building has a large bay for yacht repair and overhaul, a smaller bay for on-site vehicle and machine maintenance, and electronics and upholstery shops.

## IV. EVALUATION DESIGN AND METHODS

### A. Environmental

NIOSH collected personal breathing-zone and general area air samples on April 26-29, 1983, to evaluate workers' exposure to organic vapor contaminants, and wood, metal and fiber particulates during the manufacture of sailing yachts. The collection and analytical methodologies are presented in Table I.

Personal and general area noise level monitoring was conducted on April 27-29, 1983. Metrosonics, Inc. db-301 Metrologger sound level dosimeters were used. Results were printed out immediately following the shift using a Metrosonics, Inc. db-652 Metroreader.

## V. EVALUATION CRITERIA

### A. Environmental Criteria

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

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

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

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

## B. Toxicological Effects of Exposure

The following agents are considered to be the important exposures at the Hinckley plant.

### 1. Styrene (monomer)[1]

Styrene is readily absorbed by the respiratory and gastrointestinal systems, and the skin. Exposures to styrene have caused CNS depression; subjective complaints included headache, fatigue, sleepiness, nausea, malaise, difficulty in concentrating, and a feeling of intoxication. Decrements in balance, coordination, and manual dexterity tests have also been reported, as have slower reaction times and abnormal EEGs. Styrene vapor is also an irritant to the eyes and upper respiratory system, and liquid styrene is a skin irritant.

Various clinical studies have suggested that stryene exposure has affected liver function.

Limited human data suggest that styrene might be teratogenic, but several studies with expermental animals indicate that it is not. Most, but not all, in vitro studies suggest that styrene is not mutagenic, but some mammalian studies, including observations of several groups of styrene workers, suggest cytogenetic changes may result from working with styrene. An increased rate of spontaneous abortions was observed in one group or FRP workers, but not in another group. Styrene has been associated with an increase in lung tumors (although not consistently among species) in two experimental animal studies, while another study showed an elevation, though not statistically significant, in the combined incidence of leukemia and lymphosarcoma in female rats. Mortality studies of styrene workers have shown no excesses in overall cancer incidence. However, excesses of deaths, though not statistically significant, have been reported in the specific cancer categories "Lymphatic and Hematopoietic, except Leukemia" and "Leukemia."

Most of the styrene absorbed by humans is excreted in the urine as mandelic and phenylglyoxylic acids, and the urinary concentrations of the two or of just mandelic acid reflect amounts of styrene absorbed through the respiratory tract and through the skin (as well as through the gastrointestinal tract, if poor hygiene and work practices allow ingestion).

Evaluation Criteria ($mg/m^3$)

| Applied for this report (NIOSH) | | OSHA |
|---|---|---|
| TWA | 215 | 425 |
| Ceiling | 425 | 850 |
| maximum | - | 2550 |

2. Acetone[2]

Acetone has been reported to cause narcosis or signs of CNS depression. Eight workers exposed to acetone at a concentration greater than 12,000 ppm (28,500 $mg/m^3$) felt dizzy, lightheaded and reported weakness of the legs. Another study noted lightheadedness and headache in workers exposed for eight hours at an average 1000 ppm (2400 $mg/m^3$). CNS disturbances, such as dizziness, inebriation, somnolence and headache were reported among workers in a cellulose acetate fibers production plant. Exposures ranged from 307 to 918 ppm (730-2200 $mg/m^3$). The authors attributed these effects to accumulation of acetone in the body resulting from repeated exposures.

Acetone has also been reported to produce irritation of the eyes, skin and upper respiratory tract. Adverse effects on skin include intracellular edema and disruption of the cells of the keratin layer; this due to the lipid-solvent properties of acetone. This defatting ability suggests that liquid acetone may cause dermatitis. Eye, nose and throat irritation were reported in a small group of workers exposed to acetone vapor for eight hours at an average concentration of 500 and 1000 ppm (1200 and 2400 $mg/m^3$).

No reports implicated acetone as a mutagen or carcinogen.

Evaluation Criteria ($mg/m^3$)

| Applied for this report (NIOSH) | | OSHA |
|---|---|---|
| TWA | 590 | 2400 |

3. Toluene[3]

Clinical tests revealed that toluene exerts CNS effects following inhalation of the vapor. Effects include muscular weakness, headache, nausea, impaired coordination, mental confusion, dizziness and anorexia. Few effects were noted below 200 ppm (750 $mg/m^3$). Vapor exposure above 200 ppm also illicited irritative responses of the eyes and respiratory tract.

Toluene is an excellent fat solvent. Repeated or prolonged skin contact with liquid toluene will cause drying and fissuring of the skin, and dermatitis. Liquid toluene is poorly absorbed through the skin so that systemic intoxication by percutaneious absorption is improbable.

Investigators studying workers whose only solvent exposure was to toluene concluded that early chronic toluene intoxication in man is best evidenced by enlargement of the liver and enlarged red blood cells. The authors of another study of workers concluded that chronic inhalation of toluene vapor in the order of 200 ppm did not significantly affect the rate of chromosone changes in peripheral blood lymphocytes, and that the toxic affects of toluene on chromosones may be a function of individual susceptibility.

Evaluation Criteria ($mg/m^3$)

| Applied for this report (NIOSH) | | OSHA |
|---|---|---|
| TWA | 375 | 750 |
| ceiling | 560 | 1120 |

4. Xylene[4,5]

The effects of xylene exposure are considered to be similar to those of toluene, with xylene being acutely more toxic. The most frequent symptoms among workers exposed to xylene include headache, fatique, irritability, nausea, anorexia and flatulence. Neurological disturbances, and injury to heart, liver, kidneys and the nervous system are also reported.

Irritation to the eyes, nose and throat was noted in human experimental subjects when exposed to 200 ppm (870 $mg/m^3$) xylene.

Evaluation Criteria ($mg/m^3$)

| Applied for this report (NIOSH) | | OSHA |
|---|---|---|
| TWA | 435 | 435 |
| ceiling | 655 | - |

All of the above solvents have similar irritative and CNS effects. If workers are exposed to more than one of these concurrently it is likely that the effects would be additive. This is the reason for applying the lower evaluation criteria to exposures presented in this report.

5. Wood dust[5]

The principal health effects reported from exposure to wood dust are dermatitis, respiratory disease and cancer.

Reports on contact dermatitis are found for both domestic and exotic woods. Reports on respiratory hyper-sensitivity among wood workers are more prevalent. Granulomatous pneumonitis, acute airway obstruction, asthma and other allergic reactions of the respiratory tract have been related to specific wood exposures, including oak, cedar and mahogany.

Impairment of nasal mucociliary clearance was found in woodworkers in the furniture industry. Certain workers in the furniture industry are at risk to contract nasal cancer, which is rare in the general population. The trades principally affected are wood machinists, cabinet makers and chair makers.

An increased incidence of adenocarcinoma of the nasal cavity and ethmoid sinus has been demonstrated among wood workers in the furniture industries of Europe and the United States. The woods being used in these industries included oak, beech, mahogany, walnut and others.

Evaluation Criteria ($mg/m^3$)

| Applied for this report | (ACGIH) | OSHA |
|---|---|---|
| TWA | 1 | 15 |

6. Noise[5,6]

Hearing occurs when sound waves cause vibrations of the ear drum, the middle ear bones, and the fluids of the inner ear. The resulting movement of delicate hair cells in the inner ear produces electrical impulses that are transmitted to the brain via the auditory nerve.

Exposure to intense noise causes hearing losses which may be tempory, permanent, or a combination of the two. These impairments are reflected by elevated thresholds of audibility for discrete frequency sounds, with the increase in dB required to hear such sounds being used as a measure of the loss. Temporary hearing losses, also called auditory fatigue, represent threshold losses which are recoverable after a period of time away from the noise. Such losses may occur after only a few minutes of exposure to intense noise. During prolonged and repeated hazardous noise exposures, some of the nonregenerative hair cells of the inner ear may gradually be destroyed, leading to nonrecoverable threshold losses and further hearing impairment. Thus, noise-induced hearing loss, although slow, painless, and insidious at its onset, becomes permanent.

The criteria used represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect on their ability to hear and understand normal speech. The values should be used as guides in the control of noise exposure, and due to individual susceptibility, should not be regarded as fine lines between safe and dangerous levels.

Evaluation Criteria (dBA)

| Applied for this report | (NIOSH) | OSHA |
|---|---|---|
| TWA | 85 | 90 |
| Action level | - | 85 |

7. Other exposures

The effects of exposure to other agents measured during this evaluation, and their evaluation criteria are in Table 2.

## VI. RESULTS

The following results are summarized in Table 3. Detailed sample information is contained in Appendix A. Tables indicated in parentheses are in the appendix.

Personal protective equipment (PPE) in the form of respirators for organic vapors and particulates, and hearing protectors were available to the workers. The use of the PPE was at the workers' discretion.

### A. Environmental

#### 1. Styrene

The major exposure to styrene occurs in the lamination shop. The fourteen TWA styrene exposures to laminators ranged from 18 to 258 $mg/m^3$ and averaged 100 $mg/m^3$ (S.D. + 85). Three samples (2/12, 6/16 and 8/18 from Table A1) all from hull laminators exceeded the recommended TWA criteria (NIOSH) of 215 $mg/m^3$. The OSHA 8-hour TWA standard is 425 $mg/m^3$.

Ceiling (15-minute) and maximum (5-minute) exposure samples were collected to measure short-term exposure (Table A2). Ceiling samples ranged from 267 to 840 $mg/m^3$ and averaged 573 $mg/m^3$ (S.D. + 288). The recommended criteria (NIOSH) is 425 $mg/m^3$. The OSHA ceiling standard is 850 $mg/m^3$. Maximum exposure results ranged from 18 to 340 $mg/m^3$ and averaged 165 $mg/m^3$ (S.D. $\pm$ 108). The OSHA maximum exposure PEL is 2550 $mg/m^3$.

Styrene exposure measured in other parts of the plant ranged from 0.6 to 64.8 mg/m3 and averaged 8.8 mg/m3 (S.D. $\pm$ 17.8, Table A8).

2. Acetone

Acetone is the most abundant concurrent exposure with styrene in the lamination shop. Personal TWA acetone exposure levels here ranged from 6 to 147 mg/m$^3$, and averaged 62 mg/m$^3$ (S.D. $\pm$ 45, Table A1). None of the exposures exceeded the recommended criteria (NIOSH) of 590 mg/m$^3$ or the OSHA standard of 2,400 mg/m$^3$. Acetone exposures measured in other parts of the plant ranged from "None Detected" (ND) to 105 mg/m$^3$ (Tables A6-A8).

3. Toluene

Worker TWA exposure to toluene ranged from 0.8 to 48 mg/m$^3$ for 26 samples and averaged 7.0 mg/m$^3$ (S.D. $\pm$ 7.0, Tables A6-A8). No personal exposure exceeded the recommended TWA criteria of 375 mg/m$^3$ (NIOSH) or the OSHA standard of 750 mg/m$^3$.

Two personal 30-minute samples, MST 1 and MST 2 (Table A3), exceeded the recommended ceiling criteria (ACGIH) of 560 mg/m$^3$ with concentrations of 590 and 692 mg/m$^3$ respectively, but did not exceed the OSHA ceiling of 1120 mg/m$^3$. During this period the two workers cleaned and clear-coated a mast. The cleaning solvent (not identified) was toulene based. The clear-coat, trade name FF-111, was 77% xylene and exposure is discussed in the next section.

Toluene was detected in every organic vapor sample collected outside of the lamination shop.

4. Xylene

Xylene full-shift TWA exposures ranged from 0.4 to 14 mg/m$^3$ and averaged 2.5 mg/m$^3$ (S.D. $\pm$ 3.5) in 26 personal samples (Tables A6-A8). The recommended (NIOSH) and OSHA criteria are 435 mg/m$^3$. Two 30-minute personal samples in the mast shop (Table A3), MST 1 and MST 2, were 200 and 192 mg/m$^3$ respectively (recommended ACGIH short-term exposure criteria, 655 mg/m$^3$).

Xylene was detected in all but two personal organic vapor samples outside of the lamination shop.

5. Wood dust

Wood dust concentrations for 29 full-shift TWA samples averaged 2.2 mg/m$^3$ (S.D. ± 2.9) and ranged from 0.7 to 16.2 mg/m$^3$. There were 21 personal samples (Table A4) which exceeded the recommended 1 mg/m$^3$ exposure criteria for hardwood dusts (ACGIH). One sample, #1004, at 16.2 mg/m$^3$, exceeded the OSHA 8-hour TWA standard for nuisance dusts of 15 mg/m$^3$. All wood dust samples were collected on carpenters working in the main line and prefab areas of main assembly.

6. Noise

Noise exposure ranged from 76.1 to 89.1 dBA (average 82.4dba) in 20 personal full shift dosimeter samples (Table A5). Ten samples from workers on the line in main assembly ranged from 76.1 to 85.6 dBA and averaged 80.8 dBA (S.D. ± 3.2). The ten samples from the prefab area ranged from 76.9 to 89.1 dBA and averaged 83.9 dBA (S.D. ± 3.4). One sample from the line, A3, and four from prefab, P1, P5, P9 and P10, exceeded the recommended criteria of 85 dBA (NIOSH/ACGIH) with exposures of 85.6, 86.4, 86.5, 85.5 and 89.1 respectively. None exceeded the OSHA 90 dBA 8-hour standard.

One area sample placed next to a surface planer, P11, showed an exposure of 86.0 dBA.

7. Other exposures

Other exposures at this plant included numerous hydrocarbon vapors and lead. The exposure levels are presented in Tables A6-A9. Among these agents the exposures to cellosolve (2-ethoxyethanol) and cellosolve acetate (2-ethoxyethyl acetate) are noteworthy. Painter exposure to cellosolve ranged from 1.2-5.7 mg/m$^3$ and averaged 3.2 mg/m$^3$ (S.D ± 1.4). Cellosolve acetate exposures ranged from 1.9 to 14.2 mg/m$^3$ and averaged 5.9 mg/m$^3$ (S.D ± 3.9). NIOSH recommends that exposure to these compounds be limited to the lowest extent possible[7]. The ACGIH is recommending a lowering of their TLV's from 185 to 19 mg/m$^3$ for cellosolve, and from 270 to 27 mg/m$^3$ to cellosove acetate. Otherwise, the exposures to other organic hydrocarbons are much lower than the listed exposure criteria.

One exposure to hexamethylene diisocyanate (HDI) was found in the spray room. The concentration was 0.01 mg/m$^3$ for a 30-minute sample (recommended ceiling exposure criteria, NIOSH, 0.14 mg/m$^3$) while spraying Durathane®.

One worker was refinishing the exterior woodwork on a yacht in the service bay. A full-shift varnish dust sample showed an exposure of 19 mg/m$^3$. This exceeds the OSHA 15 mg/m$^3$ 8-hour nuisance dust standard.

One full-shift sample for fibrous glass was collected on a worker cutting fibrous glass mat and woven roving in the lamination shop. This workers' exposure was 0.01 fibers per milliliter (ml) of air (NIOSH recommends 3 fibers/ml).

## VII. DISCUSSION

The exposure data show that employees at the Hinckley plant are exposed to numerous toxic agents simultaneously, but generally at low levels. The notable exceptions are exposures to styrene and acetone in the glass shop, toluene and xylene in the mast shop, and wood dusts and noise to carpenters in the main assembly building. In these areas there are exposures exceeding the recommended criteria, but not necessarily the OSHA standard.

### Lamination Shop

In a few instances in the lamination shop worker exposure to styrene exceeded the recommended criteria for TWA and ceiling exposures. All were in the hull lamination area. Acetone in combination with styrene poses an additional exposure threat. The fraction of the combined exposure criteria* for each sample is in Table A1. Styrene is the major contributor to this combined exposure. When these workers were sampled the existing local exhaust systems were not being used.

When compared to other NIOSH exposure data for the reinforced plastic boat building industry, exposures to styrene at Hinckley during this survey are relatively low. The overall average in the lamination shop was 100 mg/m$^3$ (23.5 ppm) for styrene at Hinckley. In seven other plants studied by NIOSH, plant averages in lamination ranged from 146 (34.3 ppm) to 461 mg/m$^3$ (108 ppm) and averaged 280 mg/m$^3$ (65.8 ppm).[8] The lamination shop at Hinckley was not in full production, since there was no deck lay-up being done. In general, exposures may be higher if both hull and deck are laminated simultaneously.

### Mast Shop

It is also shown that the toluene and xylene exposure in the mast shop, when combined, as with styrene and acetone, will exceed even the NIOSH recommended criteria, which is more conservative than the ACGIH TLV's (Table A3). The addition of exhaust ventilation to this area for use during mast cleaning and clear-coating should reduce this exposure.

*Combined Exposure = C1/L1 + C2/L2+...+ Cn/Ln where C = contaminant concentration and L = exposure criteria. The value of the combined exposure should be less than one.

Carpenters

Wood dust exposure is of concern because of the association of exposure with nasal cancer. The wood used at Hinckley included teak, mahogany, ash, oak and cherry. Although particular wood dusts responsible for induction of nasal cancers in woodworkers have not been identified in a satisfactory manner, the hard woods are more frequently cited in the literature.[9,10]

All of the large woodworking equipment at Hinckley was locally exhausted, however the condition of the systems were not evaluated during this survey. Some workers did wear "disposable-type" dust masks. Wood dust exposure is not limited to the carpenters. At least one painter in the spray room does sanding before finishing. Area samples located at his work station indicated exposures of 0.4 and 1.8 $mg/m^3$ on successive days.

Noise

Average noise levels were higher for those workers in prefab than on the line in main assembly. These workers spend more time around woodworking equipment. Three of the over-exposures used power sanders a large part of the day (P-5, P-9, P-10 in Table A5). A tool which is particularly loud is the surface planer. During operation the noise levels at the operator exceeded 95 dBA. This machine was used only intermittently during this evaluation, perhaps an hour a day. However it made a contribution to all workers' exposure.

When workers are exposed to sound levels exceeding the NIOSH recommended standard (85 dBA), feasible engineering controls should be implemented to reduce levels to permissible limits. The current OSHA noise standard requires employers to administer a continuing effective hearing conservation program whenever employee noise exposures equal or exceed an 8-hour TWA sound level of 85 dBA (slow-response).

For workers exposed at or above an 8-hour TWA level of 85 dBA, OSHA's hearing conservation program requires noise exposure monitoring and employee notification exposures, audiometric testing, the use of hearing protective devices, where necessary, and employee education.

The concern at this plant is not with single agent exposures. Multiple exposures pose problems, because the ways in which they act together on body systems is unknown. They may act additively or one compound may enhance the action of another making the combination greatly more toxic. Therefore, it is recommended that any future exposure data be compared to the most recent, generally the most stringent, exposure criteria, as was done with this evaluation.

## VIII. CONCLUSIONS

Occupational exposures at the Henry R. Hinckley & Company plant include inhalation of organic hydrocarbon vapors, lead fume, wood dusts and nuisance particulates; skin contact with polyester resin, paints, varnishes and a variety of solvents; and noise. In general, a worker's exposure is to numerous hydrocarbons at levels well below applicable criteria. This should not be considered trivial since effects of these exposures are at best additive. However, a health hazard did not appear to exist in these general exposures.

The following exposures are considered to be health hazards at the Hinckley plant when compared to the recommended criteria:

A. Hull laminators' exposure to styrene, and combined exposure to styrene and acetone.

B. Mast workers' exposure to toluene, and combined exposure to toluene and xylene.

C. Carpenters' exposures to wood dust.

Potential health hazards also exist to painters who are exposed to cellosolve (2-ethoxyethanol) and cellosolve acetate (2-ethoxyethyl acetate) during the application of Z-Spar®, AWLGRIP® and Defthane®, and to carpenters due to exposure to high noise levels.

## IX. RECOMMENDATIONS

The following recommendations are made so that existing health hazards may be abated:

A. The use of existing local exhaust systems for hull lay-up work should be required procedure.

B. Exhaust ventilation should be installed in the mast shop and its use required during cleaning and clear-coating of masts.

C. The local exhaust systems for the woodworking machinery should be inspected for integrity, and tested to ensure that they are functioning within design parameters. A periodic maintenance and repair schedule for these systems should be instituted if one does not already exist. Daily housekeeping should include the vacuum cleaning of floors and other flat surfaces in the wood working areas to remove particulates which may be reentrained by machine operation on subsequent days. Respiratory protection should be provided to and worn by workers exposed to hard wood dusts. This may be in the form of a disposable respirator, such as the 3-M 9910® series.

D. The surface planer should be isolated in some fashion to reduce its influence on the general noise exposure. The planer operator should be provided and required to wear adequate hearing protection while operating this machine.

Periodic maintenance and replacement of worn parts on wood working equipment, both large machines and hand held power tools, will ensure the lowest noise and vibration levels from this equipment. When buying replacement tools and machinery, consult sales literature and purchase tools with low noise ratings.

Hearing protection should be provided to those in the wood working areas of the plant. Especially for workers who may use power tools for an extended time period.

E. Workers using Z-Spar® Captain's Varnish 1015, Durathane®, and AWLGRIP® should do so in well ventilated areas. Cabins and other confined areas where these materials are being used should have make-up air and exhaust ventilation provided. If adequate ventilation is not feasible, respiratory protection should be used (NIOSH/MSHA approved for organic hydrocarbon vapor). Cartridge respirators are adequate only if there is enough fresh air ($O_2$), otherwise an air supplied unit is necessary. Exposed skin should be covered since these substances can penetrate the skin. Substitution of these materials with those not containing cellosolve or cellosolve acetate should be considered.

## X. REFERENCES

1. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to styrene. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1983. (DHHS (NIOSH) publication no. 83-119)

2. 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).

3. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to toluene. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973. (DHEW publication no. (NIOSH) 73-11023).

4. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to xylene. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1975. (DHEW publication no. (NIOSH) 75-168).

5. American Conference of Governmental Industrial Hygienists. Documentation of the threshold limit values. 4th ed. Cincinnati, Ohio: ACGIH, 1980.

6. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to noise. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973. (DHEW publication no. (NIOSH) 73-11001).

7. National Institute for Occupational Safety and Health. Current intelligence bulletin 39 -- glycol ethers: 2-methoxyethanol and 2-ethoxyethanol. Cincinnati, Ohio: National Institute for Occupational Safety and Health 1983. (DHHS (NIOSH) publication no. 83-112)

8. Crandall, M.S. Worker Exposure to Stryene Monomer in The Reinforced Plastic Boat-Making Industry. AIHA J. 42(7): 499-502, July, 1981.

9. Whitehead, L.W. Health effects of wood dust--relevance for an occupational standard. AIHA J. 43(9): 674-678, September, 1982.

10. Wills, J.H. Nasal carcinoma in woodworkers: a review. JOM 24(7), July, 1982.

11. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods. Vol 1, 2nd ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW (NIOSH) publication no. 77-157-A).

12. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods. Vol 7, 2nd ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS (NIOSH) publication no. 82-100).

13. Monsanto Research method MR-240. NIOSH contract 210-750052, April, 1976.

14. American Conference of Governmental Industrial Hygienists. Threshold limit values for chemical substances and physical agents in the workroom environment with intended changes for 1982. Cincinnati, Ohio: ACGIH, 1982.

15. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1983.

16. National Institute for Occupational Safety and Health. Occupational diseases: a guide to their recognition. Revised ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW (NIOSH) publication no. 77-181).

17. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to diisocyanates. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1978. (DHEW publication no. (NIOSH) 78-215).

18. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to 1,1,1-trichloroethane (methyl chloroform). Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-184).

19. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to refined petroleum solvents. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-192).

## XI. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:

Michael S. Crandall, C.I.H.
Industrial Hygiene Engineer
Industrial Hygiene Section

Acknowledgements:

Richard W. Hartle, C.I.H.
Industrial Hygienist
Industrial Hygiene Section

Analytical Support:

Measurements Development Section, and
Measurements Support Section,
Measurements Research and
Support Branch,
Division of Physical Sciences and
Engineering
Cincinnati, Ohio 45226

UBTL
Salt Lake City, Utah 84108

Originating Office: Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies

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

1. Henry R. Hinckley & Company, Southwest Harbor, Maine
2. Requestors
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.

# APPENDIX A

# EXPOSURE DATA

Table 1

Sampling and Analytical Methodology
Henry R. Hinckley & Company
Southwest Harbor, Maine
HETA 83-128

April 25-29, 1983

| Substance | Collection Device | Flow Rate (LPM) | Analysis | Detection limit/ Sample | Reference |
|---|---|---|---|---|---|
| Styrene | Charcoal | 0.02 | Gas Chromatography | 0.01 mg | NIOSH P&CAM 127[11] |
| Acetone | Charcoal | 0.02 | Gas Chromatography | 0.01 mg | NIOSH P&CAM 127[11] |
| Solvents (varnish) | Charcoal | 0.02 | Gas Chromatography | 0.01-0.02 mg | NIOSH P&CAM 127[11] |
| Solvents (general) | Charcoal | 0.10 | Gas Chromatography | 0.01-0.02 mg | NIOSH P&CAM 127[11] |
| Naphtha (varnish) | Charcoal | 0.02 | Gas Chromatography | 0.01 mg | |
| Wood Dust | PVC Filter | 1.5 | Gravimetric | | |
| Varnish Dust | PVC Filter | 1.0 | Gravimetric | | |
| Fibrous Glass | AA Filter | 1.5 | Phase Contrast Microscopy | .03 Fibers/field | NIOSH P&CAM 239[11] |
| Aluminum Alloy Particulate | AA Filter | 1.5 | ICP/AES[i] | 1.0 ug | NIOSH P&CAM 351[12] |
| Lead Fume | AA Filter | 1.5-2.0 | AAS[ii]/Graphite Furnace | 0.3 ug | |
| Hexamethylene Diisocyanate (HDI) | Glass Fiber Filter | 1.0 | HPLC[iii] | 0.15 ug | NIOSH P&CAM 239[11] |
| HDI | Impinger | 1.0 | HPLC | 0.15 ug | MR 240[13] |

i inductively coupled plasma/atomic emission spectrometry
ii Atomic absorption spectrophotometer
iii High pressure liquid chromatography

Table 2
Exposure Summary

Henry R. Hinckley & Company
HETA 83-128
April 26-29, 1983

| Substance | Exposure Range Found ($mg/m^3$) | Exposure Criteria ($mg/m^3$) NIOSH | ACGIH[14] | OSHA[15] | Effects of Exposure[16] |
|---|---|---|---|---|---|
| Acetone | ND-179 | 590[2] | 1780 | 2400 | irritation of eyes, nose, throat; headache dizziness; dermatitis |
| Aluminum | 3.0-3.9 | - | 10 | 15 | necrosis of cornea (particles deposited in eye); dermatitis, conjunctivitis, irritation of mucous membranes of upper resp. system; pneumoconiosis |
| Cellosolve (2-ethoxyethanol) | 1.2-5.7 | LEP[7] Lowest Extent Possible (LEP) | 185(19) | 740 | human: irritation of eyes, nose, throat; drowsiness, weakness, shaking; headache, fatigue, staggering, personality change, decreased mental ability; encephalopathy, bone marrow depression Animal: teratogenic, embyotoxic (pregnant rats, and rabbits); testicular atrophy (mice), microscopic testicular changes (mice, rats and dogs).[16] |
| Cellosolve Acetate (2-ethoxyethyl acetate) | 1.9-14.2 | LEP[7] | 270 (27) | 540 | See cellosolve |
| Cyclohexanone | ND - 1.2 | - | 100 | 200 | irritation of eyes, mucous membranes; dermatitis; CNS depressant |
| Hexamethylene Diisocyanate (HDI) | ND - 0.01 | 0.03[17] | - | - | irritation of eyes, skin, upper and lower respiratory tract; sensitization; asthma, chronic impairment of respiratory function[15] |

continued

Table 2 continued

| Substance | Exposure Range Found ($mg/m^3$) | Exposure Criteria ($mg/m^3$) NIOSH | ACGIH[14] | OSHA[15] | Effects of Exposure[16] |
|---|---|---|---|---|---|
| Lead (fume) | .001-.002 | - | 0.15 | 0.05 | Fatigue, sleep disturbance, headache, aching bones and muscles, constipation, abdominal pains, decreased appetite; anemia, pallor, "lead line" on gums, decreased hand-grip strength; loss of kidney function. |
| Methyl Iso-butyl Ketone (MIBK) | ND - 4.5 | 200[2] | 205 | 410 | Irritation of eyes, nose, throat; dermatitis; headache, nausea, lightheadeness, vomiting, dizziness, uncoordination, unconsciousness; peripheral neurapathy. |
| Naphthalene | ND - 0.2 | - | 50 | 50 | Erythema and dermatitis; eye irritation, inhaling high concentrations may cause headache, confusion, excitement, malaise, profuse sweating, nausea vomiting, abdominal pain; liver, kidney and blood disorders. |
| Nuisance Particulates | 19.1 | - | 10 (total dust)<br>5 (respirable dust) | 15<br>5 | Reduced visibility; may cause unpleasant deposits in eyes, ears and nasal passages, or cause injury to skin or mucous membranes by chemical or mechanical action.[5] |
| Styrene-monomer | (TWA) 0.6 - 258<br>(ceiling) 267 - 840<br>(Max) 18 - 340 | 215[1]<br>425<br>- | 215<br>425<br>- | 425<br>850<br>2550 | Irritation of eyes, nose, throat, skin; acute exposure to high concentration may produce irritation of mucous membranes, symptoms of narcosis, cramps and death due to respiratory center paralysis; proglonged reaction time, decreased manual dexterity. |

continued

Table 2 continued

| Substance | Exposure Range Found ($mg/m^3$) | Exposure Criteria ($mg/m^3$) NIOSH | ACGIH[14] | OSHA[15] | Effects of Exposure[16] |
|---|---|---|---|---|---|
| Toluene | 0.8 - 18.1 | 375[3] | 375 | 750 | irritation of eyes respiratory tract and skin; dermatitis; acute exposure causes central nervous system depression (headache, dizziness, fatigue, muscular weakness, drowsiness, incoordination, collapse and coma. |
| 1,1,1, - trichloroethane | ND-127 | 1910[18] | 1900 | 1900 | liquid and vapor irritate eyes; dermatitis; acute exposure symptoms include dizziness, incoordination, drowsiness, increased reaction time, unconsciousness and death. |
| V,M & P Naphtha | 3.0-9.0 | 350[19] | 1350 | 400 | irritation of eyes, mucous membranes of upper respiratory tract and skin; skin photosensitivity and burning; acute exposure may cause inebriation, headache and nausea; dizziness, convulsions and unconsciousness may result. |
| Wood dust | 0.7-16.2 | - | 1(hardwood) 5(softwood) | 15 | Wood dusts may be toxic, irritants or allergenic; toxic wood effects; headache, anorexia, nausea, vomiting, bradycardia, dyspnea or somnolence. Irritant wood effects; dermatitis and mucous membrane irritation. Allergenic wood effects; allergic manifestations including asthma and contact dermatitis in sensitized workers. It is believed that inhalation of fine hard wood dusts causes nasal cancer[5] |

continued

Table 2 continued

| Substance | Exposure Range Found ($mg/m^3$) | Exposure Criteria ($mg/m^3$) NIOSH | ACGIH[14] | OSHA[15] | Effects of Exposure[16] |
|---|---|---|---|---|---|
| Xylene | ND-6.6 | 435[4] | 435 | 435 | Irritation of eyes, nose and throat; dermatitis; acute exposure to high concentrations may cause dizziness, staggering, drowsiness and unconsciousness; also pulmonary edema, andrexia, nausea, vomiting and abdominal pain. |

ND - None Detected
TWA - Time Weighted Average for 8-hour exposure
Ceiling - 15-minute exposure
Max - 5-minute exposure
LEP - Lowest Extent Possible

Table 3
Exposure Summary
HETA 83-128

Henry R. Hinckley & Company
April 26-29, 1983

| Substance | Plant Area | Sample Type* | Concentration ($mg/m^3$) Range | Mean | Criteria ($mg/m^3$) Recommended | OSHA |
|---|---|---|---|---|---|---|
| Styrene | Lamination | TWA | 18-256 | 100 | 215 (NIOSH) | 425 |
| Styrene | Lamination | 15-min | 267-840 | 573 | 425 (NIOSH) | 850 |
| Styrene | Lamination | 5-min | 18-340 | 165 | - | 2550 |
| Styrene | Other | TWA | 0.6-65 | 8.8 | 215 (NIOSH) | 425 |
| Acetone | Lamination | TWA | 6-147 | 62 | 590 (NIOSH) | 2400 |
| Acetone | Other | TWA | ND*-105 | - | 590 (NIOSH) | 2400 |
| Toluene | Mast Shop | 30-min | 590-692 | 641 | 560 (ACGIH) | 1120 |
| Toluene | Other | TWA | 0.8-34 | 7.0 | 375 (NIOSH) | 750 |
| Xylene | Mast Shop | 30-min | 192-200 | 196 | 655 (ACGIH) | - |
| Xylene | Other | TWA | 0.4-14 | 2.5 | 435 (NIOSH) | 435 |
| Wood Dust | Assembly | TWA | 0.7-16.2 | 2.2 | 1 (ACGIH) | - |
| Cellosolve | Assembly | TWA | 1.2-5.7 | 3.2 | LEP*(NIOSH) | 740 |
| Cellosolve Acetate | Assembly | TWA | 1.9-14.2 | 5.9 | LEP (NIOSH) | 540 |
| Noise | Assembly/ Pre-fab | TWA | 76.1-89.1dBA | 82.4dBA | 85dBA (NIOSH) | 90dBA |

*LEP - Lowest Extent Possible
TWA - Time Weighted Average for 8-hour exposure
ND - None Detected
Ceiling - 15-minute exposure
Max - 5-minute exposure

Table A1
Lamination Shop Vapor Sampling Results
HETA 83-128

Henry R. Hinckley & Company
April 26-29, 1983

| Job | Lay-up Task | Sample # | Duration | Concentration ($mg/m^3$) Styrene | TWA | Acetone | TWA | Combined Exposure |
|---|---|---|---|---|---|---|---|---|
| Laminator | Small parts | 1 | 0809-1237 | 63 | 49 | 92 | 99 | .40 |
| | | 11 | 1237-1622 | 33 | | 107 | | |
| Laminator | Hull | 2 | 0806-1234 | 181 | 220 | 153 | 121 | 1.23 |
| | | 12 | 1234-1622 | 266 | | 84 | | |
| Laminator | Glass cutter | 3 | 0808-1236 | 43 | 37 | 51 | 35 | .23 |
| | | 13 | 1236-1623 | 30 | | 15 | | |
| Laminator | Deck | 4 | 0758-1230 | 63 | 56 | 35 | 24 | .30 |
| | | 14 | 1230-1621 | 49 | | 12 | | |
| Laminator | Deck | 5 | 0756-1222 | 49 | 26 | 16 | 9 | .14 |
| | | 15 | 1236-1620 | 1 | | 1 | | |
| Laminator | Hull | 6 | 0802-1233 | 84 | 216 | 139 | 106 | 1.18 |
| | | 16 | 1233-1621 | 373 | | 67 | | |
| Laminator | Deck | 7 | 0759-1227 | 48 | 38 | 9 | 6 | .19 |
| | | 17 | 1227-1622 | 25 | | 2 | | |
| Laminator | Hull | 8 | 0803-1231 | 184 | 258 | 97 | 81 | 1.34 |
| | | 18 | 1231-1623 | 384 | | 63 | | |
| Laminator | Glass-cutter | 100 | 0723-1254 | 22 | 18 | 66 | 65 | .19 |
| | | 200 | 1254-1625 | 13 | | 64 | | |
| Laminator | Small parts | 101 | 0725-1256 | 71 | 52 | 179 | 147 | .49 |
| | | 201 | 1256-1624 | 22 | | 96 | | |
| Laminator | Hull | 102 | 0716-1251 | 210 | 153 | 45 | 29 | .76 |
| | | 202 | 1251-1622 | 63 | | 2 | | |
| Laminator | Hull | 103 | 0718-1248 | 67 | 71 | 60 | 67 | .44 |
| | | 203 | 1248-1622 | 77 | | 77 | | |
| Laminator | Hull | 105 | 0716-1244 | 179 | 179 | 62 | 62 | .94 |
| Laminator | Foreman | 107 | 0727-1243 | 46 | 30 | 17 | 11 | .16 |
| | | 207 | 1243-1622 | 8 | | 2 | | |
| Detection Limit (mg/sample) | | | | 0.01 | | 0.01 | | |
| Criteria ($mg/m^3$): | NIOSH | | | | | 215 (50ppm) | | 590 |
| | ACGIH | | | | | 215 | | 1,780 |
| | OSHA | | | | | 425 (100 ppm) | | 2,400 |

Table A2
Styrene Ceiling Concentration sampling Results/Hull Lamination
HETA 83-128

Henry R. Hinckley & Company
April 26-29, 1983

| Sample # | Styrene Concentration ($mg/^3$) Duration | 15 min ceiling | 5 min maximum |
|---|---|---|---|
| C1 | 1359-1414 | 267 | |
| M1 | 1359-1404 | | 300 |
| M2 | 1406-1411 | | 220 |
| M3 | 1411-1416 | | 340 |
| C11 | 1045-1100 | 613 | |
| M4 | 1045-1050 | | 172 |
| M5 | 1052-1057 | | 64 |
| M6 | 1058-1103 | | 146 |
| C12 | 1442-1451 | 840 | |
| M7 | 1442-1447 | | 70 |
| M8 | 1447-1452 | | 152 |
| M9 | 1452-1457 | | 18 |
| Criteria: NIOSH | | 425 | - |
| ACGIH | | 425 | - |
| OSHA | | 850 | 2,550 |

Table A3
Mast Shop Sampling Results
HETA 83-128

Henry R. Hinckley & Company
April 26-29, 1983

| Job | Task | Sample # | Duration | Concentration ($mg/m^3$) Toluene | Xylenes | Combined* NIOSH | Combined* ACGIH | Aluminum | Magnesium | Total Metals | TWA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mast Finishing | clean and clear coat | MST 1 | 1602-1635 | 590 | 200 | 1.0 | 1.4 | - | - | - | |
| Mast Finishing | clean and clear coat | MST 2 | 1602-1635 | 692 | 192 | 1.1 | 1.5 | - | - | - | |
| Mast Prep | grinding/buffing | AL 1 | 1239-1601 | - | - | | | 3.0 | 0.1 | 3.2 | 1.3 |
| Mast Prep | grinding/buffing | AL 2 | 1239-1601 | - | - | | | 3.9 | 0.2 | 4.2 | 1.8 |
| Detection Limit (mg/sample) | | | | 0.01 | 0.01 | | | | | | |
| Quantitation Limit (ug/sample) | | | | | | | | 1.0 | 1.0 | | |
| Criteria: NIOSH | | | | 750 | 870 | | | | | | |
| ACGIH | | | | 560 | 655 | | | | | | 10 |
| OSHA | | | | 1120 | - | | | | | | 15 |

*Combined Exposure = (C1/L1) + (C2/L2)+...+(Cn/Ln)
C = Concentration Measured
L = Exposure Criteria

Table A4
Wood Dust Sampling Results
HETA 83-128

Henry R. Hinckley & Company
April 26-29, 1983

| Job | Location | Sample # | Duration | Wood Dust Concentration ($mg/m^3$) |
|---|---|---|---|---|
| Carpenter | Assembly | 838 | 0749-1619 | 2.1 |
| Carpenter | Assembly | 825 | 0801-1613 | 0.7 |
| Carpenter | Assembly | 826 | 0750-1440 | 1.1 |
| Carpenter | Assembly | 837 | 0747-1618 | 2.0 |
| Carpenter | Assembly | 819 | 0754-1617 | 0.3 |
| Carpenter | Assembly | 831 | 0757-1624 | 2.4 |
| Carpenter | Assembly | 989 | 0804-1622 | 1.0 |
| Carpenter | Assembly | 830 | 0753-1613 | 2.4 |
| Carpenter | Assembly | 824 | 0759-1544 | 1.3 |
| Carpenter | Assembly | 820 | 0721-1610 | 0.9 |
| Carpenter | Assembly | 834 | 0725-1632 | 0.6 |
| Carpenter | Assembly | 841 | 0728-1625 | 1.3 |
| Carpenter | Assembly | 828 | 0730-1628 | 0.7 |
| Carpenter | Assembly | 840 | 0748-1617 | 1.0 |
| Carpenter | Assembly | 821 | 0803-1617 | 2.1 |
| Carpenter | Assembly | 833 | 0741-1615 | 1.4 |
| Carpenter | Assembly | 835 | 0738-1610 | 1.7 |
| Carpenter | Assembly | 827 | 0751-1620 | 2.2 |
| Carpenter | Assembly | 839 | 0736-1613 | 2.8 |

continued

Table A4 continued

| Job | Location | Sample # | Duration | Wood Dust Concentration ($mg/m^3$) |
|---|---|---|---|---|
| Carpenter | Pre-fab | 983 | 0723-1628 | 1.1 |
| Carpenter | Pre-fab | 982 | 0725-1619 | 0.8 |
| Carpenter | Pre-fab | 999 | 0733-1627 | 6.2 |
| Area | Pre-fab | 992 | 0746-1630 | 0.4 |
| Carpenter | Pre-fab | 822 | 0751-1627 | 4.4 |
| Carpenter | Pre-fab | 1002 | 0743-1619 | 2.7 |
| Carpenter | Pre-fab | 984 | 0736-1115 | 3.0 |
| Carpenter | Pre-fab | 1004 | 0733-1619 | 16.2 |
| Area | Pre-fab | 1000 | 0744-1620 | 1.8 |
| Carpenter | Pre-fab | 998 | 0740-1619 | 2.6 |
| | Criteria: | NIOSH | | - |
| | | ACGIH | | 1 (hardwoods) 5 (softwoo |
| | | OSHA | | 15 |

Table A5
Noise Survey Exposure Results
Main Assembly and Pre-Fab Areas
HETA 83-128

Henry R. Hinckley & Company
April 26-29, 1983

| Job | Sample | Noise Level (dBA-slow response) |
|---|---|---|
| Main Assembly | | |
| Carpenter | A1 | 83.3 |
| Carpenter | A2 | 80.9 |
| Carpenter | A3 | 85.6 |
| Carpenter | A4 | 80.7 |
| Carpenter | A5 | 80.5 |
| Carpenter | A6 | 84.9 |
| Carpenter | A7 | 76.2 |
| Carpenter | A8 | 80.4 |
| Carpenter | A9 | 76.1 |
| Carpenter | A10 | 79.7 |
| Pre-fab | | |
| Carpenter | P1 | 86.4 |
| Carpenter | P2 | 83.9 |
| Painter | P3 | 76.0 |
| Carpenter | P4 | 84.4 |
| Carpenter | P5 | 86.5 |
| Carpenter | P6 | 83.6 |
| Carpenter | P7 | 82.0 |
| Carpenter | P8 | 81.0 |
| Carpenter | P9 | 85.5 |
| Carpenter | P10 | 89.1 |
| Area (planer) | P11 | 86.0 |

Table AC
Pre-Fab and Assembly Organic Vapor Sampling Results
HETA 83-128

Henry R. Hinckley & Company
April 26-29, 1983

| Job | Location | Sample # | Duration | Concentration (mg/m³) Acetone | Toluene | Xylenes | MIBK | 1,1,1,-trichloroethane | Cyclohexanone | Naphthalene | Naphtha Total | Naphtha % aromatics |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Painter | 64 Bldg | O-1 | 0826-1558 | ND | 3.7 | 2.8 | 0.9 | ND | ND | ND | 52 | 36 |
| Painter | 64 Bldg | O-2 | 0828-1558 | ND | 2.9 | 1.4 | ND | ND | ND | ND | 24 | 38 |
| Area-inside cabin | 64 Bldg | O-3 | 1040-1554 | ND | 3.4 | ND | 1.7 | ND | ND | ND | 38 | 31 |
| Painter | 64 Bldg | O-4 | 0840-1556 | ND | 18.1 | 5.3 | 1.1 | ND | ND | ND | 59 | 51 |
| Area-inside cabin | 64 Bldg | O-5 | 0843-1603 | ND | 1.4 | 1.4 | ND | ND | ND | ND | 51 | 38 |
| Painter | main assembly | O-102 | 0859-1624 | 1.2 | 4.6 | 2.3 | 3.4 | 1.2 | 1.2 | ND | 69 | 19 |
| Area-inside cabin | main assembly | O-103 | 0902-1620 | 1.1 | 5.6 | 2.2 | 4.5 | 2.2 | ND | ND | 90 | 18 |
| Painter | main assembly | O-104 | 0859-1615 | 1.2 | 5.0 | 2.5 | 2.5 | 1.2 | ND | ND | 50 | 20 |
| Painter | Service | O-203 | 0822-1539 | ND | 10.3 | 2.6 | 2.6 | 5.1 | ND | ND | 61 | 22 |
| Painter | 64 Bldg | CT 7 | 0838-1602 | ND | 3.9 | 0.5 | 0.5 | ND | ND | 0.2 | - | - |
| Detection Limit (mg/sample) | | | | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | | |
| Criteria: | NIOSH | | | 590 | 375 | 435 | 200 | 1,910[+] | - | - | 350[++] | |
| | ACGIH | | | 1,780 | 375 | 435 | 205 | 1,900 | 100 | 50 | 1350 | |
| | OSHA | | | 2,400 | 750 | 435 | 410 | 1,900 | 200 | 50 | 400 | |

[+]ceiling
[++]for naphtha containing <20% aromatics

Table A7
Pre-Fab and Assembly Organic Vapor Sampling Results
HETA 83-128

Henry R. Hinckley & Company
April 26-29, 1983

| Job | Location | Sample # | Concentration ($mg/m^3$) Duration | Acetone | Toluene | Xylenes | MIBK | Cellosolve | Cellosolve Acetate | 1,1,1,Trichloro-Ethane | Naphtha Total | Naphtha % aromatics |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Painter | Spray room | 0-202 | 0740-1603 | ND | 6.1 | ND | ND | 3.1 | 5.1 | 31.6 | 15 | 35 |
| Painter | Pre-fab | 0-204 | 0743-1628 | ND | 4.7 | ND | ND | 5.7 | 14.2 | 15.1 | 18 | 44 |
| Painter | Spray room | 0-205 | 0739-1603 | ND | 9.2 | 0.9 | ND | 2.7 | 5.5 | 30.3 | 9.0 | 50 |
| Painter | Spray room | 0-301 | 0745-1628 | ND | 9.2 | 1.1 | ND | 3.4 | 5.0 | 67.8 | 18 | 31 |
| Painter | Bottom Painting | 0-302 | 0754-1617 | ND | 12.5 | 1.9 | ND | 3.8 | 1.9 | 6.7 | 3.9 | 67 |
| Painter | Pre-fab | 0-304 | 0748-1618 | ND | 9.8 | 2.9 | ND | 2.9 | 5.9 | 127 | 3.0 | C7 |
| Painter | 64 Bldg | CT 107 | 0818-1230 | ND | 4.8 | 0.4 | ND | 1.2 | 4.0 | 28.6 | - | - |
| | Detection Limit (mg/sample) | | | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | | 0.01 |
| | Criteria: NIOSH: | | | 590 | 375 | 435 | 200 | LEP+ | LEP+ | 1,1910++ | 350** | |
| | ACGIH: | | | 1,780 | 375 | 435 | 205 | 165(19)* | 270(27)* | 1,900 | 1350 | |
| | OSHA: | | | 2,400 | 750 | 435 | 410 | 740 | 540 | 1,900 | 400 | |

+lowest extent possible
++ceiling
*intended change
**for naphtha with <20% aromatics

Table A8
Organic Vapor Sampling Results
HETA 83-128

Henry R. Hinckley & Company
April 26-29, 1983

| Job | Location | Sample # | Duration | Concentration ($mg/m^3$) Acetone | Toluene | Xylenes | MIBK | Styrene | Other Hydrocarbons |
|---|---|---|---|---|---|---|---|---|---|
| Mechanic | main assembly | CT 1 | 0807-1622 | 4.0 | 2.2 | 0.6 | ND | 9.1 | 2.0 |
| Electrician | main assembly | CT 2 | 0806-1548 | 3.6 | 2.9 | 0.9 | ND | 7.1 | 2.2 |
| Helper | main assembly | CT 3 | 0810-1615 | 105 | 12.3 | 0.4 | ND | 64.8 | 2.0 |
| Seamstress | upholstery | CT 5 | 0819-1449 | 1.3 | 2.5 | 0.8 | 0.3 | 1.0 | 5.1 |
| Seamstress | upholstery | CT 6 | 0820-1449 | ND | 1.8 | 1.3 | 0.5 | 0.8 | 5.0 |
| Seamstress | upholstery | CT 10 | 0849-1449 | ND | 5.1 | 1.2 | ND | 0.6 | ND |
| Carpenter | main assembly | CT 101 | 0742-1620 | ND | 1.5 | 0.6 | ND | 3.7 | 7.7 |
| Fiberglass | main assembly | CT 102 | 0745-1626 | 4.9 | 0.8 | 0.4 | ND | 4.3 | 4.0 |
| Carpenter | main assembly | CT 103 | 0748-1617 | ND | 2.6 | 1.4 | ND | 2.6 | 4.1 |
| Painter | main assembly | CT 104 | 0756-1611 | 2.4 | 34.0 | 0.9 | ND | 3.0 | 15.0 |
| Carpenter | main assembly | CT 105 | 0753-1612 | 1.0 | 1.6 | 0.6 | ND | 2.7 | 10.3 |
| Helper | main assembly | CT 106 | 0810-1616 | 1.4 | 11.3 | 6.6 | 0.2 | 6.4 | 13.9 |
| Detection Limit (mg/sample) | | | | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.1 |
| Criteria: NIOSH | | | | 590 | 375 | 435 | 200 | - | |
| ACGIH | | | | 1,780 | 375 | 435 | 205 | 215 | |
| OSHA | | | | 2,400 | 750 | 435 | 410 | 425 | |

Table A9
Lead Sampling Results
HETA 83-128

Henry R. Hinckley & Company
April 26-29, 1983

| Job | Location | Sample # | Duration | Concentration ($ug/m^3$) 15-minute | Concentration ($ug/m^3$) 8-Hour TWA |
|---|---|---|---|---|---|
| Area | Keel Shed | L1 | 0732-1452 | 1.1 | 1.0 (area) |
| Keel Pouring | Keel Shed | L2 | 1217-1231 | 75.0 | 2.2 (personal) |
| Area | Keel Shed | L3 | 1219-1234 | 30.0 | 0.9 (area) |
| | Detection Limit (ug/sample): | | 0.3 | | |
| | Criteria: NIOSH ($ug/m^3$) | | | | - |
| | ACGIH | | | | 150 |
| | OSHA | | | | 50 |