HETA 86-441-1913
JULY 1988
MONARK BOAT COMPANY
MONTICELLO, ARKANSAS

NIOSH INVESTIGATOR:
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I. SUMMARY

In July 1986, the United Brotherhood of Carpenters and Joiners of America requested the National Institute for Occupational Safety and Health (NIOSH) to evaluate health problems and occupational exposures to workers at the MonArk Boat Company in Monticello, Arkansas. Following legal and other delays, NIOSH investigators conducted an initial survey at the factory in April 1987. Consultations were held with the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), to determine the extent and findings of OSHA's health inspections at the plant from February through May 1987. NIOSH conducted a follow-up industrial hygiene survey in December 1987 to monitor exposure to styrene in the Work Boat Lamination Area, which was not monitored during the OSHA inspection.

Several problems were found throughout the facility, including the absence of material safety data sheets for numerous chemical products used, and improper use of personal protective equipment, particularly respirators. Average exposures during the work shift to styrene vapor of 29-44 parts per million (ppm) did not exceed NIOSH's recommended exposure limit of 50 ppm, although some short-term exposures (114-250 ppm) did exceed the NIOSH short-term limit of 100 ppm.

Air sampling by OSHA in the spray painting area of the aluminum fishing boat plant documented time-weighted average (TWA) air concentrations of 13 micrograms per cubic meter (ug/m^3) of chromates and 160 ppm (TWA) of toluene; NIOSH's recommended 8-hour exposure limits are 1 ug/m^3 for hexavalent chromium and 100 ppm for toluene. In the work boat production facilities, OSHA measured short-term concentrations at the foaming operation in the rigging shop of 0.21 and 0.57 milligrams per cubic meter (mg/m^3) of methylene bisphenyl isocyanate (MDI), exceeding OSHA's 0.2 mg/m^3 limit. In spray painting operations, several short-term samples for isocyanates revealed levels of 0.7, 2.4, and 3.1 mg/m^3 of methylene bis(4-cyclohexylisocyanate), exceeding the 0.11 mg/m^3 ceiling value recommended by the American Conference of Governmental Industrial Hygienists. Organotin concentrations did not exceed the NIOSH recommended TWA exposure limit due to the short duration (49 minutes) of the operation, but could exceed the 8-hour TWA limit if the operation was conducted for more than 2.5 hours in a day (at the airborne concentrations measured).

On the basis of air monitoring results, it has been determined that health hazards existed from worker exposure to styrene, chromates, toluene, isocyanates, and possibly organotin, at the facility. Recommendations regarding measures to control exposures are contained in Section VII of this report.

KEYWORDS: SIC 3732 (boat building and repairing), styrene, isocyanates, spray painting, fiberglass lamination, chromates, toluene, organotin.

II. INTRODUCTION

In July l986, the United Brotherhood of Carpenters & Joiners of America requested a NIOSH health hazard evaluation (HHE) at the MonArk Boat Company in Monticello, Arkansas. Attached to its request, the union provided a list of health problems among the employees. Also attached was a list of chemicals and trade name products used at the company.

From September l986 until April l987, the NIOSH investigators attempted to schedule and conduct a site visit. A series of obstacles were encountered. The primary issues which resulted in delays included a dispute between the company and the union regarding the union health and safety respresentative's right to participate in the NIOSH survey, scheduling conflicts which were inconvenient to the company, and lengthy OSHA safety and health inspections. By mid-April l987, the OSHA inspection was virtually completed and the union representation issue had been settled, allowing NIOSH investigators to conduct an on-site survey.

On April 28-30, l987, an industrial hygienist and a medical epidemiologist from NIOSH conducted an initial survey. On April 28, an opening conference was held with a management and a labor union representative to discuss the purpose and background for the survey. On April 29, a walk-through survey was conducted of the entire factory to familiarize the NIOSH investigators with the processes, substances used, and working conditions. The management representative explained the manufacturing processes. The union representative pointed out potential exposures that were of concern to the union. The survey included the aluminum and the fiberglass boatmaking operations at both the Patton Street and Conley Street locations.

The industrial hygienist from NIOSH requested copies of material safety data sheets (MSDSs) for certain selected substances of concern. Copies were also requested of reports of previous surveys conducted at the facility by the Arkansas Department of Labor, Occupational Safety and Health Program.

The medical epidemiologist from NIOSH informally interviewed concerned workers and workers selected at random in all areas during the walk-through survey. The OSHA Form 200 log of occupational injuries and illnesses was reviewed. The workers had a variety of health complaints, but there was no specific problem reported by multiple workers with similar exposures.

A report of the findings and recommendations from the initial survey was provided to management and union representatives on May 22, 1987.

Subsequently, consultations were held with OSHA to review OSHA's monitoring results from inspections conducted virtually throughout the facility. The NIOSH industrial hygienist conducted a styrene exposure monitoring survey on December 1, 1987 in the Work Boat Lamination Area, the only area of interest not monitored by OSHA. NIOSH did not conduct air sampling elsewhere in the plant, because it was deemed that OSHA had already monitored the other areas adequately.

III. BACKGROUND

Process Description

This plant manufactured a large variety of boats including aluminum fishing boats, aluminum pontoon boats, and fiberglass and aluminum work boats. At the time of the initial survey, the plant also manufactured recreational fiberglass boats, but this product line has subsequently been discontinued. The plant has been in operation for approximately 27 years and, at the time of the NIOSH site visit, employed about 200 hourly production workers and about 45 salaried managerial and administrative staff.

Manufacturing facilities were located at two different addresses in the town. Company offices, recreational boat divisions, and the work boat lamination area were located at the Patton Street facility. The work boat manufacturing areas, except for the fiberglass lamination area, were located at the Conley Street facility. In 1988, the Patton Street manufacturing facilities were sold to another company; this sale consisted of essentially all of the recreational aluminum boat product line. Although many of the areas and operations involved in the initial investigation have been discontinued or sold, the findings and recommendations are nevertheless included in this report to provide a complete record of the investigation conducted into the hazards which the union requested NIOSH to evaluate.

The production of aluminum fishing boats involved primarily sheet metal working and welding operations. Jobs involving chemical exposure were primarily in the painting area. The aluminum hulls were wiped by hand with a wash thinner containing xylene and toluene to remove residual oil prior to painting. After drying, a zinc chromate primer and then synthetic vinyl enamel paints (containing toluene and xylene) were applied in spray-painting operations. At the time of the initial survey, a dip tank containing a wood preservative was located in this area for treating seats or other exposed wooden components. After the initial survey, this operation was discontinued and replaced by pre-treated wood.

At the Patton Street facility, there was an area used for the production of fiberglass-reinforced plastic resin (FRP) hulls and other components for work boats (non-recreational). The hull mold was sprayed with a gel coat consisting of vinyl ester or polyester resins containing free styrene monomer and methyl ethyl ketone peroxide (MEKP) catalyst. Hull (or deck) lamination was applied in alternating layers of fiberglass and epoxy-acrylate resin. Fiberglass was used in one of three forms, woven roving, cloth, or mat. The principal hazardous chemicals in the resin were styrene monomer and MEKP catalyst. The dried resin surface was sanded using electrical disk-type grinders before the next layer of lamination was applied. Small parts were also manufactured using appropriate molds and a similar hand-application process. Ventilation consisted of three wall vents for exhaust and three heated wall vents to supply make-up air. Personal protective equipment for workers consisted of organic vapor cartridge respirators, latex gloves, and Tyvek disposable clothing.

At the time of the initial survey, there was also a recreational fiberglass boat manufacturing area at the Patton Street facility. A polyester gel coat spray was first applied to the hull mold. In the subsequent lamination process, fiberglass roving was applied through a chopper spray gun. Resin lamination (containing styrene) was applied by hand-operated rollers. Flexible ducts over the hull lamination were used for local exhaust ventilation. Gloves and disposable Tyvek suits were used for skin protection. Urethane foam was mixed and sprayed into the hulls for flotation. Toxic components in the foam spray operation included 4,4'-diphenylmethane diisocyanate (MDI), amines, fluorocarbons, and dibutyltin. Since the initial survey, the company has discontinued the manufacture of recreational fiberglass boats.

A number of different buildings were used at the Conley Street facility for the manufacture of work boats. Operations included machine and fabrication shops, welding shops, rigging shops, and spray painting operations. The primary operations of concern in this evaluation were the use of urethane foams to repair pre-molded parts (isocyanate exposure), welding inside the confined space of the interior of boat hulls, and toxic paint components including isocyanates (urethanes) and organotins.

IV. EVALUATION METHODS

Prior to the NIOSH Health Hazard Evaluation (HHE) at this company, the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), had conducted very extensive inspections throughout the facilities in response to a complaint of alleged unsafe and unhealthy working conditions filed by the union. From February through May of 1987, an OSHA industrial hygienist conducted worker exposure monitoring in virtually every area of the production facilities at both locations, except in the

work boat lamination area where operations had been severely curtailed due to lack of orders for the product. The OSHA monitoring was so extensive that no additional sampling by NIOSH was done in most areas.

OSHA's monitoring results were obtained and reviewed to ascertain whether the specific chemical exposures of concern in the NIOSH HHE had already been evalated by OSHA, and if so, whether an overexposure problem existed. The OSHA Area Office in Little Rock furnished OSHA's sampling results. A meeting was held on August 17, 1987 with the OSHA industrial hygienist to discuss each sample, particularly the exact locations where the samples were collected and whether citations had been issued. After reviewing OSHA's monitoring activities and results, it was determined that OSHA had already evaluated all the areas of concern in the NIOSH HHE, except for the work boat lamination area.

The NIOSH industrial hygienist conducted a survey on December 1, 1987 in the work boat lamination area. Styrene vapor was sampled by drawing air at a rate of 0.05 liters per minute (Lpm) through a glass tube packed with 150 mg of activated charcoal. The air was drawn through the tubes using belt-mounted, battery-powered, miniature air sampling pumps. After sampling, the tubes were capped and submitted to the laboratory for analysis. Samples were analyzed by gas chromatography according to NIOSH Analytical Method 1501 with modifications.[1] An adequate sampling and analytical method does not exist at this time for measuring airborne MEKP catalyst. Work practices and personal protective equipment were reviewed to evaluate possible skin contact with MEKP.

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 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 becomes 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, Occupational Safety and Health Administration (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 exposure limits, 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 employers are legally required to meet those levels specified by an OSHA standard.

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

Airborne exposure limit criteria for the substances evaluated in this investigation are provided in Table 1.

STYRENE

Styrene is irritating to the eyes, nose, throat, upper respiratory system, and skin. Repeated skin contact may produce rash, cracking, or inflammation of the skin due to defatting. Styrene is also neurotoxic, producing depression of the central nervous system. The current OSHA standard for styrene is 100 parts of styrene vapor per million parts of air (ppm) averaged over an eight-hour work shift, with a ceiling level of 200 ppm (for up to 15 minutes), and maximum peak exposure of 600 ppm for five minutes in any three-hour period. The ACGIH TLVs and the NIOSH recommended exposure limits are 50 ppm as an eight-hour time-weighted average (TWA), and 100 ppm for short-term (15-minute) exposures. However, the current recommended exposure limits may not be adequate, since some studies have shown effects at levels below 50 ppm. There is also a possibility that styrene may be a carcinogen, although the evidence is not conclusive at this time.[2]

ISOCYANATES

Isocyanates are irritants to the eyes, skin, and respiratory tract. Severe respiratory irritation may lead to bronchitis and pulmonary edema. Other symptoms of overexposure may include nausea, vomiting, and abdominal pain.

Repeated exposure to isocyanates may lead to development of respiratory sensitization. Exposure of sensitized individuals to isocyanates may cause an asthmatic reaction with wheezing, shortness of breath, and cough.

Skin contact with liquid isocyanates may cause redness, swelling, and blistering. Eye contact with the liquid may produce severe irritation and permanent damage.

ORGANOTIN COMPOUNDS

Organotin compounds may enter the body by inhalation or by absorption through the skin. Direct contact with these substances may produce skin burns. When airborne, these compounds may cause irritation of the skin, eyes, throat, and mucous membranes, producing symptoms such as itching, sore throat, and cough. Organotin compounds may cause liver and nervous system damage. Headache and vomiting may be symptoms of neurotoxic effects of these substances.

TOLUENE AND XYLENE

Prolonged skin contact with these liquids may dissolve the skin's natural oils, causing dryness, cracking, and dermatitis. These substances may enter the body by absorption of the liquid through the skin, or by inhalation of vapors. The vapors are irritating to the eyes, nose, throat, mucous membranes, and respiratory tract. Toluene and xylene are neurotoxins, producing depression of the central nervous system (CNS). Symptoms of exposure may include muscular weakness, incoordination, mental confusion, headaches, nausea, and dizziness.

ZINC CHROMATE

Chromates contain chromium in the hexavalent state, designated as chromium VI compounds. Chromates are irritating and corrosive to the skin and respiratory tract, and can cause skin ulcers. Kidney damage and lung irritation can result from chromate exposure. NIOSH considers zinc chromate a carcinogenic form of chromium VI, and believes that exposure may increase the risk of lung cancer.

VI. RESULTS, DISCUSSION, AND CONCLUSIONS

Initial Survey - April 28-30, 1987

Problems with respirator maintenance and usage were found throughout the facilities. Respirators were dirty, poorly maintained, and were not cleaned and stored in a clean, uncontaminated environment. Filters were dirty, and cartridges were seldom changed. It was obvious that management and supervisory officials had not inspected respirators and did not enforce proper respirator usage. Many of workers did not wear their respirators properly. Some workers did not tighten the chin strap preventing adequate face to facepiece sealing. A number of workers wore beards while performing jobs requiring respirator usage.

In the area of hazard communication, material safety data sheets (MSDSs) were not readily accessible. MSDSs were not available in the work areas. All MSDSs were kept in one central location in the Human Resources office. Even when NIOSH requested copies of certain ones, an extensive search was required to locate them, and several were not found. There were virtually no labels or warning signs in the work areas to warn employees of the toxic substances to which they are exposed, or the attendant health and safety hazards.

A variety of other potential safety and health problems were found:

- failure of some employees to wear eye protection where eye hazards existed
- failure of some employees to wear hearing protection where noise hazards existed
- failure of management/supervisors to enforce established eye protection, hearing protection, and respirator requirements
- welding inside boat hulls and in other confined spaces
- exhaust fans not operable in paint spray booths at the Conley Street facility
- flammable solvents stored in containers which are not approved safety containers
- at the Conley Street facility, a very cluttered and disorderly chemical storage shed with one 55-gallon chemical drum not labelled, and two 55-gallon drums (presumed for chemical waste) not labelled and open

Styrene Survey - December 1, 1987 Work Boat Lamination Area

The TWA exposures (shown in Table 2) of the lamination workers did not exceed the OSHA, ACGIH, and NIOSH criteria. Short-term exposures were measured using Drager brand 10/b direct - reading gas detector tubes. The gel coat application process was completed within a 30-minute time period, and was done only once during the day. The gel coat operator wore an organic vapor cartridge respirator during the gel coat spraying. Detector tube readings taken in the operator's breathing zone were 80 ppm and 90 ppm. The hull mold was too large to fit in the spray booth, so the gel coat was applied outside and in front of the booth with the fan on to provide exhaust ventilation. The operator's respirator needed to be cleaned, and the cartridges needed changing.

Detector tube readings from the breathing zones of hull laminators during the day were 50 ppm, 200-250 ppm (fan temporarily turned off), and 75-80 ppm (fan turned on again). For small parts laminators, breathing zone detector tube readings were 120 ppm, 35 ppm, 60 ppm, and 150 ppm. These short-term exposures generally exceed the ACGIH and NIOSH criteria of 50 ppm (for

eight-hour TWA exposures), and some of the exposures exceed the NIOSH and ACGIH short-term exposure limit of 100 ppm.

Most of the hull and small parts lamination workers did not wear respirators or gloves. Several workers used their bare hands to smooth freshly-applied resin, exposing their skin directly to styrene and MEKP. Workers also took breaks and ate food at a table in the corner of the area, exposing themselves to additional chemicals by ingestion of contaminants.

Most workers wore no respiratory protection when sanding or grinding (by hand or mechanically) laminated fiberglass. Sanding and grinding create respiratory exposures to fiberglass and styrene resin dust.

OSHA Monitoring Results - February - May 1987

Except for the NIOSH measurements taken in the Work Boat Lamination Area, all other monitoring of areas of concern was conducted by OSHA during their health inspections between February and May of 1987. Results are shown in Table 3.

Aluminum Fishing Boat Plant

In the spray painting area of the aluminum fishing boat plant, paint and primer spraying operations were sampled. The airborne concentration of chromate of 13 ug/m^3 as TWA in the breathing zone of the primer spraying operator did not exceed the OSHA permissible exposure limit of 100 ug/m^3, but did exceed the NIOSH recommended exposure limit of 1 ug/m^3 for carcinogenic chromium VI. In the paint spraying operation, the airborne level of toluene at the spray operator of 160 ppm for the sampling period, and 147 ppm expressed as an 8-hour TWA, did not exceed the OSHA permissible exposure limits shown in Table 1. However, the TWA exceeded the NIOSH and ACGIH criteria, and the actual concentration during the sampling period exceeded the ACGIH STEL. Since toluene and xylene exhibit the same CNS effects, the exposures are sometimes considered additive. Using the formula for mixed (combined) exposures in the OSHA regulations, the combined toluene and xylene concentrations exceed the OSHA PEL by 61%. These findings demonstrate the necessity to improve the effectiveness of the spray booth operation, and in the interim, the need for an effective respirator program for the spray painters.

The concentration of toluene (about 35 ppm) measured by detector tubes in the operation where residual oil is wiped from the hulls using a wash thinner prior to painting, was not excessive. During the NIOSH survey, workers were observed performing the operation while wearing beards underneath their respirators. The cartridges were very dirty and had not been changed for a long time.

Recreational Fiberglass Lamination Area

Styrene concentrations were generally not excessive in this operation, and did not exceed OSHA PELs. However, two out of seven short-term (15-minute) samples exceeded the ACGIH STEL of 100 ppm. MDI levels in the foam operation were 0.039, 0.013, and 0.013 mg/m^3, and did not exceed the ceiling value of 0.2 mg/m^3.

Work Boat Division - Conley Street Facility

Short-term (15-minute) samples for MDI were collected in the foaming operation at the rigging shop. Two sample concentrations, 0.21 mg/m^3 and 0.57 mg/m^3, exceeded the PEL of 0.2 mg/m^3.

In the paint spraying operations, samples were collected for two isocyanate compounds, MDI and MBCHI, associated with urethane paints. No MDI was detected. However, three very high levels of MBCHI, 0.74, 2.4, and 3.1 mg/m^3, exceeded the ACGIH ceiling value of 0.11 mg/m^3. OSHA has no published PEL for MBCHI. Clearly, isocyanate exposure should be a major occupational health concern at the Conley Street facility.

Organic tin compounds were also sampled in a spray painting operation which lasted only 49 minutes. Due to the short duration of the operation, the 8-hour average exposure of 0.039 mg/m^3 did not exceed the 0.10 mg/m^3 limit. However, the concentration measured for the 49-minute period was 0.38 mg/m^3, a level which would clearly be excessive if this operation lasted more than 2 1/2 or 3 hours.

The isocyanate and organotin sampling data demonstrate the need for improvements in air contaminant control in spray painting operations at the Conley street facility. In the interim, the painters need an effective respiratory protection program.

Welding inside the confined space below deck inside boat hulls was of concern to the union. The OSHA inspector sampled for aluminum oxide, chromium, and nickel, but did not detect any exposures exceeding the PELs. However, the OSHA inspector did confirm that welding inside the hull is considered a confined space welding operation. The employer must either provide mechanical ventilation of the confined space or provide air-line welding respirators.

VII. RECOMMENDATIONS

Due to the sale of some facilities and product lines, and the discontinuation of others, some of these recommendations may not apply to current operations of the company. Nevertheless, these recommendations are provided to insure a complete report and to provide employees and managers with all pertinent findings and corrective actions which would be appropriate.

Many of the recommendations deal with corrections of improper use of personal protective equipment. However, it should be emphasized that, to the extent feasible, engineering controls are the preferred method to provide a safe workplace.

The following recommendations were made in the May 22, 1987 report following the initial survey:

l. Management officials and supervisors should insure the proper use of personal protective equipment, when and where needed. Merely providing safety glasses, ear plugs, and respirators to workers for their use and care is not sufficient to meet the employer's responsibility to provide a safe and healthful workplace by elimination or control of hazards. Where personal protective equipment is necessary for control of safety and health hazards, the employer must insure proper care and use of the equipment. As a first step, supervisors and workers should be trained in the importance of using the equipment, the detrimental effects which the hazard could produce, and the proper use and care of protective equipment. Subsequently, the established requirements for use and care must be enforced. First-line supervisors should be responsible for enforcement on a daily basis. Periodic inspections by a safety official or committee may be useful. The wearing of safety glasses should be enforced whenever eye hazards are present. The wearing of hearing protection should be enforced in high-noise areas.

2. Improve the respirator program throughout the factory.

   Respirators should be cleaned daily and stored in sealed containers in a sanitary location. Cartridges and filters should be changed daily, or when the resistance to breathing becomes noticeable (filters), or when odors can be detected coming through the cartridge. Respirators should be checked and inspected regularly by management/supervisory officials for cleanliness, changing of filters and cartridges, proper use, wear and tear, and integrity of functional parts such as inhalation and exhalation valves. Beards cannot be allowed for workers in jobs which require respirator usage for adequate protection.

3. Material Safety Data Sheets (MSDSs) should be made readily accessible to workers.

   A chemical substances inventory should be compiled for each work area. Copies of MSDSs for those substances present in the area should be kept readily available and accessible to workers in the area.

4. Use approved safety containers for storage of flammable solvents in the work areas.

11. Label chemical contents clearly on all containers.

6. At the Conley Street facility paint spray booths, resume operation of the exhaust ventilation fans as quickly as possible.

The next set of recommendations are made to address problems in the work boat lamination area as a result of the December 1987 survey.

7. When sanding or grinding on fiberglass-plastic laminated surfaces, always wear eye protection and respirators to protect from dust exposure.

8. Lamination operators should always wear gloves and should not wash their skin with solvents.

9. Lamination of small parts should be done in the spray booth when possible.

10. Respirators should be worn by laminators whenever styrene concentrations exceed 50 ppm.

The final set of recommendations reflect the findings of the OSHA monitoring:

11. In the spray painting area of the aluminum fishing boat plant, improvements should be made in the exhaust ventilation and/or work practices to reduce the levels of zinc chromate and solvents in the operators' breathing zones. In the interim, the painters should be provided with an effective respiratory protection program.

12. An effective respiratory protection program should be provided to all workers at the Conley Street facility who work with isocyanates in foaming operations or who work with urethane and organotin paints.

13. At the Conley Street facility, foaming operations using isocyanates, and spray painting operations, should be targeted for ventilation improvements to maintain airborne concentrations below occupational health limits.

14. Whenever welding is performed in confined spaces, such as below deck inside boat hulls, mechanical ventilation or airline respirators should be used to protect workers from inhaling welding contaminants. If materials present could be exploded by welding, mechanical ventilation must be provided to maintain airborne concentrations below explosive levels.

15. Workers exposed to isocyanates should be provided with a medical surveillance program which should include preplacement and annual medical examinations with particular emphasis on the respiratory system. These examinations should include detailed medical and work histories and pulmonary function tests. For further guidance, refer to the NIOSH criteria document for diisocyanates, "Criteria for a Recommended Standard ... Occupational Exposure to Diisocyanates", NIOSH publication no. 78-215.

16. Workers exposed to styrene should be provided with a medical surveillance program which should include preplacement and annual medical examinations giving special attention to the nervous system, skin, respiratory tract, liver, and eyes. For further guidance, consult the NIOSH criteria document for styrene, "Criteria for a Recommended Standard ... Occupational Exposure to Styrene", NIOSH publication no. 83-119.

Information about the availability of NIOSH publications can be obtained from the NIOSH publications office at telephone no. (513) 533-8287.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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IX. DISTRIBUTION AND AVAILABILITY

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 ninety (90) days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati, Ohio address.

Copies of this report have been sent to:

1. United Brotherhood of Carpenters and Joiners of America, Washington, D. C.
2. Local Union #2306, United Brotherhood of Carpenters and Joiners of America, Monticello, Arkansas
3. MonArk Boat Company, Monticello, Arkansas
4. U.S. Department of Labor, OSHA, Region VI
5. Appropriate health and safety agencies of the State of Arkansas

For purposes of informing the "affected employees", the employer will promptly "post" this report for a period of thirty (30) calendar days in prominent places throughout the factory where it will be accessible to the affected employees.

X. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods. Vol. 2, 3rd ed., Cincinnati, OH: National Institute for Occupational Safety and Health, 1984. (DHHS (NIOSH) publication 84-100).

2. Occupational Medicine - Principles and Practical Applications, 2nd Ed., Carl Zenz, editor, pp 1032-1035, Yearbook Medical Publishers, Chicago, Ill., 1988.

TABLE 1

Published Exposure Limits and Guidelines
for Selected Substances Sampled
(As of 1987)

Substance	Maximum Allowed or Recommended Concentrations		Source of Criteria
	STEL	TWA	
Methylene bisphenyl isocyanate (MDI)	0.2mg/m^3 (ceiling)		ACGIH (1987 current value)
		0.055 mg/m^3	ACGIH (1986-87) (proposed new value)
	0.2 mg/m^3 (ceiling)		OSHA
	0.2 mg/m^3 (ceiling)		NIOSH
Methylene bis (4-cyclo-hexylisocyanate)	0.11 mg/m^3 (ceiling)		ACGIH (1987 current value)
		0.055 mg/m3	ACGIH (1986-87) (proposed new value)
Methyl ethyl ketone peroxide	1.5 mg/m^3 (ceiling)		ACGIH
Styrene	100 ppm	50 ppm	ACGIH, NIOSH
	200 ppm	100 ppm	OSHA
Tin, organic compounds		0.1 mg/m^3	ACGIH, OSHA, NIOSH
Toluene	150 ppm	100 ppm	ACGIH
	300 ppm	200 ppm	OSHA
	200 ppm	100 ppm	NIOSH

TABLE 1 (continued)

Published Exposure Limits and Guidelines
for Selected Substances Sampled
(As of 1987)

Substance	Maximum Allowed or Recommended Concentrations		Source of Criteria
	STEL	TWA	
Xylene	150 ppm	100 ppm	ACGIH
OSHA		100 ppm	
	200 ppm	100 ppm	NIOSH
Zinc chromate	------	50 ug/m^3, as Cr (chromium VI compounds)	ACGIH (1987 current value)
		10 ug/m^3, as Cr (Carcinogen class A1) (confirmed human carcinogen)	ACGIH (1987-88) (proposed new value)
	100 ug/m^3 (ceiling) (as chromates)	—	OSHA
	—	1 ug/m^3, as Cr (VI) (carcinogenic chromium VI)	NIOSH

TABLE 1 (continued)

Abbreviations:

S T E L: short-term exposure limit; the maximum concentration to which workers may be exposed for no longer than 15 minutes at a time

T W A: time-weighted average; the average concentration for an 8-hour workday

Ceiling: a concentration that should not be exceeded

ACGIH: American Conference of Governmental Industrial Hygienists

OSHA: Occupational Safety and Health Administration, U.S. Department of Labor

NIOSH: National Institute for Occupational Safety and Health

Units:

mg/m^3: milligrams of contaminant per cubic meter of air

ug/m^3: micrograms of contaminant per cubic meter of air

ppm: parts of contaminant per million parts of air, by volume

TABLE 2
Styrene Sampling Results *
Work Boat Lamination Area
MonArk Boat Company
Monticello, Arkansas
HETA 86-441
December 1, 1987

Personal Exposure Monitored	Airborne Styrene Vapor Level (ppm)
Hull Laminator	32 ppm
Hull Laminator	29 ppm
Hull Laminator	32 ppm
Hull Laminator	29 ppm
Hull Laminator	33 ppm
Small Parts Laminator	39 ppm
Small Parts Laminator	44 ppm
Small Parts Laminator	33 ppm

OSHA Permissible Exposure Limit (8-hour TWA) = 100 ppm

ACGIH Threshold Limit Value (8-hour TWA) = 50 ppm

NIOSH Recommended Exposure Limit (8- to 10 hr.-TWA) = 100 ppm

ppm = Parts of styrene vapor per million parts of air, by volume

TWA = Time-weighted average (average value during an entire shift)

* Measured by collection on charcoal tubes, analyzed by gas chromatography.

TABLE 3

Selected Sampling Results from OSHA Inspection

MonArk Boat Company
Monticello, Arkansas
HETA 86-441

February - May 1987

Sampling Date	Product, Process, or Substance Sampled	Measured Airborne Concentration During Sampling Period &(As TWA)		Evaluation Criteria STEL	Evaluation Criteria TWA
	Aluminum Fishing Boat Plant				
2/12/87	Toluene (wash thinner)	30-35 ppm (detector tube)	--	150 ppm (ACGIH)	100 ppm (ACGIH, NIOSH)
2/12/87	Toluene (spray painting)	160 ppm	(147 ppm)	150 ppm (ACGIH)	100 ppm (ACGIH, NIOSH)
2/12/87	Xylene (spray painting)	94 ppm	(88 ppm)	150 ppm (ACGIH)	100 ppm (ACGIH, NIOSH, OSHA)
2/25/87	Chromates (paint primer)	14 ug/m^3	(13 ug/m^3)	100 ug/m^3 (OSHA) (ceiling)	1 ug/m^3 (NIOSH)
	Work Boat Lamination Area				
	Not sampled by OSHA				
	Recreational Fiberglass Lamination Area				
3/10/87	Styrene (lamination helper)	31 ppm	(28 ppm)	100 ppm (ACGIH, NIOSH)	50 ppm (ACGIH, NIOSH)

TABLE 3 (continued)

HETA 86-441

Sampling Date	Product, Process, or Substance Sampled	Measured Airborne Concentration During Sampling Period (As TWA)		Evaluation Criteria STEL	Evaluation Criteria TWA
3/10/87	Styrene (chopper gun helper)	36 ppm	(33 ppm)	100 ppm (ACGIH)	50 ppm (ACGIH)
3/10/87	Styrene (chopper gun helper) (15-minute samples)	140 ppm 114 30 35 22 78 26	------	100 ppm (ACGIH)	N/A
3/11/87	Styrene (Gel coat operator)	36 ppm	(32 ppm)	100 ppm (ACGIH)	50 ppm (ACGIH)
3/11/87	Methyl ethyl ketone peroxide	Not sampled (No adequate sampling and analytical method)			
3/11/87	Methylene bisphenyl isocyanate (MDI) (foam operator) (15-minute samples)	0.039 mg/m^3 0.013 mg/m^3 0.013 mg/m^3	------ ------ ------	0.2 mg/m^3 (ceiling) (ACGIH, OSHA, NIOSH)	N/A

TABLE 3 (continued)

HETA 86-441

Sampling Date	Product, Process, or Substance Sampled	Measured Airborne Concentration During Sampling Period	As TWA	Evaluation Criteria STEL	TWA
	Work Boat Division - Conley Street Facility				
2/10/87	Methylene bisphenyl isocyanate (MDI) (Foaming operation in Rigging Shop)	0.0007 mg/m^3 (15-min. sample)	------	0.2 mg/m^3 (ceiling) (ACGIH, OSHA, NIOSH)	N/A
2/25/87	Methylene bisphenyl isocyanate (MDI) (Foaming operation in Rigging Shop)	(15-min. samples) 0.16 mg/m^3 0.21 0.57	------	0.2 $mg/^3$ (ceiling) (ACGIH, OSHA, NIOSH)	N/A
2/24/87	Organotins (painting)	0.38 mg/m^3 (operation lasted for 49 min.)	(0.039 mg/m^3)	------	0.10 mg/m^3 (ACGIH, OSHA, NIOSH)
3/12/87 and 5/13/87	Methylene bisphenyl isocyanate (MDI) (Painting)	(15-min. samples) N.D. N.D.	------ ------	0.2 mg/m^3 (ceiling) (ACGIH, OSHA, NIOSH)	N/A
5/13/87	Methylene bis(4-cyclo-hexylisocyanate) (painting)	(15-min. samples) 0.052 mg/m^3 0.180 N.D. N.D. N.D. 2.4 3.1 0.74	------	0.11 mg/m^3 (ceiling) (ACGIH)	------

TABLE 3 (continued)

Abbreviations:

S T E L: short-term exposure limit; the maximum concentration to which workers may be exposed for no longer than 15 minutes at a time

T W A: time-weighted average; the average concentration for an 8-hour workday

Ceiling: a concentration that should not be exceeded

ACGIH: American Conference of Governmental Industrial Hygienists

OSHA: Occupational Safety and Health Administration, U.S. Department of Labor

NIOSH: National Institute for Occupational Safety and Health

Units:

mg/m^3: milligrams of contaminant per cubic meter of air

ug/m^3: micrograms of contaminant per cubic meter of air

ppm: parts of contaminant per million parts of air, by volume