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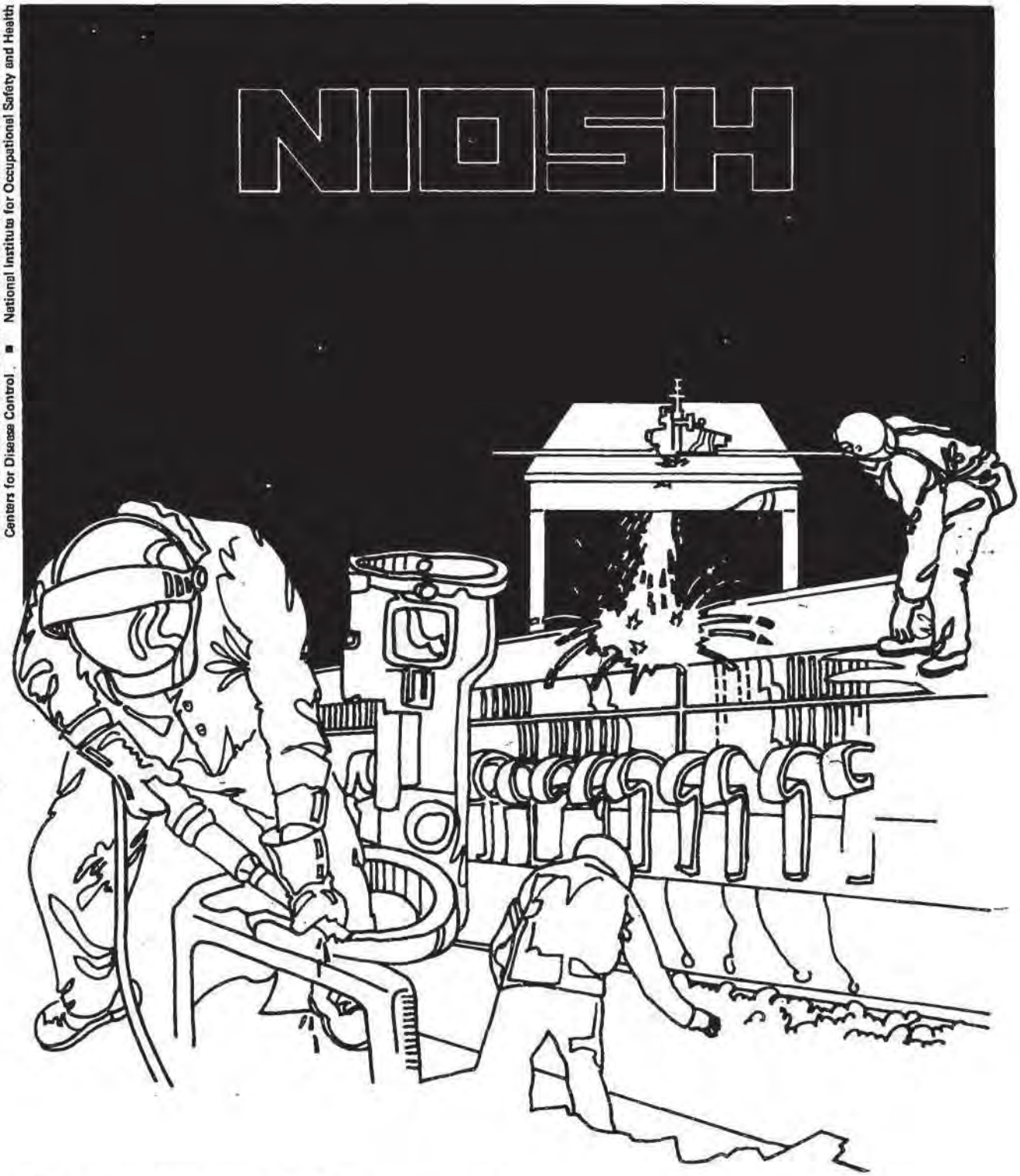

Health Hazard Evaluation Report

HETA 82-377-1376
D & F CORPORATION
WARREN, MICHIGAN

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.

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D & F CORPORATION
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I. SUMMARY

On September 7, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate occupational exposures at the D & F Corporation, Warren, Michigan. The requestor was concerned with skin rashes and eye irritation among employees working at wood model making, fixture and mold building, and machining operations.

In November 1982, NIOSH investigators conducted an initial survey of the facility. In February and April 1983, environmental surveys were conducted during which personal breathing zone and area air samples were collected, and interviews were conducted with employees in the various areas of the plant to identify any work related health problems.

Personal breathing zone and area air samples showed time weighted average (TWA) concentrations of total wood dust ranging from 0.37 to 4.0 milligrams per cubic meter of air (mg/M^3), with a mean of 1.7 mg/M^3. Five of seven personal samples were above the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) of 1 mg/M^3 for hardwood dust. NIOSH/MSHA approved respirators were worn by some employees during wood working operations, and should have significantly reduced their actual exposures.

Area samples collected during the storage and use of "impreg" (a generic name for a captivo wood impregnated and laminated with phenol/formaldehyde resin) revealed low concentrations of formaldehyde (0.18 and 0.12 parts of contaminant per million parts of air [ppm] using a sorbent tube method, and 0.083 ppm using an impinger method), but phenol was not detected. NIOSH recommends formaldehyde exposure be reduced to the lowest feasible level. The current OSHA standard for formaldehyde is 3.0 ppm as an 8-hour TWA. Results of the personal and area samples collected during the use of epoxy resins showed a TWA concentration of Bisphenol A of 0.002 mg/M^3 in one of three samples, but no detectable levels of aliphatic polyamines, diglycidyl ether of Bisphenol A, or epichlorohydrin in any of the samples collected. No environmental criteria currently exists for Bisphenol A. Personal breathing zone samples collected during welding operations showed TWA concentrations of total welding particulate of 1.2, 2.0, and 2.8 mg/M^3. All samples were below the ACGIH TLV of 5.0 mg/M^3 for total welding particulate.

The employees interviewed at the wood and plastics operations did not report a substantial number of work related health problems. The most frequent problem, occasional episodes of dermatitis, was reported by five of thirty employees. Other more isolated complaints included occasional skin and mucous membrane irritation, headaches, and noise.

On the basis of the data obtained during this investigation, NIOSH has determined that a potential health hazard from exposure to hardwood dust existed during the time of this survey. Recommendations designed to reduce exposure to wood dust and other substances used in the facility are included in the full body of this report.

KEY WORDS: SIC 3999, wood model making, hardwood dust, impreg, formaldehyde, phenol, mold building, epoxy resin.

II. INTRODUCTION

On September 7, 1982, an authorized representative of the employees at the D & F Corporation, Warren, Michigan, requested a NIOSH health hazard evaluation. The requestor was concerned with skin rashes and eye irritation among employees working at wood model making, fixture and mold building, and machining operations.

On November 2, 1982, NIOSH investigators conducted an initial survey of the facility. This included an opening conference with representatives of management and the union, followed by a walk-through inspection of the workplace. Interviews were randomly conducted with employees in the various areas of the plant to identify any work related health problems. On February 16-17, 1983, an environmental survey was conducted during which personal breathing zone and area air samples were collected. On April 27-28, 1983, a follow-up survey was conducted during which additional environmental samples were collected. The results of the environmental surveys were transmitted by letter to the requestor, company, and union on August 25, 1983.

III. BACKGROUND

The D & F Corporation produces wood models, plastic duplications, prototypes, molds, and fixtures for the automobile industry. Production operations are conducted in a building approximately 30,000 square feet in area. At the time of the initial survey, the company employed approximately 95 production workers over two shifts, with the length of each shift ranging from 8-10 hours.

A. Wood Model Making

Wood model making is a highly skilled craft in which the model maker converts engineering drawings to three dimensional wood models with overall tolerances of up to 10/1000 of an inch. Construction of the model initially requires the use of powered wood working equipment including table saws, routers, planers, radial arm saws, shapers, jointers, sanders, band saws, grinders, etc. These tools are used to assemble the frame and provide the "rough" outline of the model. However, the majority of the work is accomplished through the use of hand held tools, requiring extensive concentration by the model maker so that the finished model meets the required specifications.

A variety of materials are used in construction of the wood models. Die models, which require the strictest tolerance, are usually constructed from impreg, a generic name for a plastic wood which is composed of thin sheets of captivo wood impregnated and laminated with a 30% phenol-formaldehyde resin. The low moisture content of this wood enables it to retain critical dimensions over a period of many years. For prototype and experimental models which do not require such close tolerances, softer and more easily worked woods are utilized. These include; pine, jelutong, plywood, cherry, and red mahogany. Additionally, epoxy laminates and glues, wood tooling aids, and fillers are also utilized during the course of model construction.

Model making activities are conducted in five different areas of the facility; 3 rooms on the building's west side, one area in the center of the building, and one room on the building's northeast side. With the exception of the northeast side model shop, which has its own air handling system, general ventilation is achieved through openings in the building's structure. Portable shop vacuums are present in all of the wood shops for general cleanup, and are also utilized as a source of local exhaust ventilation on several of the portable power tools. A separate area of the building, referred to as the wood shop, contains the large powered woodworking equipment, with each machine individually equipped with local exhaust ventilation. NIOSH/MSHA approved disposable dust respirators are made available to all employees.

B. Plastic Shop Operations

In the area of the facility referred to as the plastic shop, the surfaces of wood models are reproduced to form plastic duplications and production molds. In this process, a parting agent is initially applied to the surface of the wood model, followed by the addition of several layers of epoxy and fiberglass cloth. Each mold is then backed with plywood and/or a metal frame in addition to an assortment of hinges, clamps, and other hardware. In a similar manner, a second cast may be constructed from the surface of the plastic model, which results in a plastic duplication of the original model. This may in turn be used to create a cast aluminum or iron mold.

Epoxy resin and hardener systems are the primary materials used in these operations. The resins and hardeners are stored and mixed in a separate area of the plastics shop. An automatic stirrer in the mixing area is equipped with local exhaust ventilation that exhausts through a wall into the adjacent hallway. Following mixing, the resin is applied to the surface of the model with a brush, and then covered with a layer of fiberglass cloth. The cloth often requires hand pressing to ensure proper adherence to the contours of the model. Rubber and plastic gloves are made available to the employees for this purpose. Small containers of various solvents (e.g.: kerosene, acetone, Solvent 311, and methyl alcohol) are utilized when working with the resins. In addition, small quantities of other materials (e.g. styrene, urethane hardeners, and polyester resins) are occasionally utilized for some molds. No local exhaust ventilation is present in the general work area where the plastics operations occur. Openings in the building structure provide the only source of general ventilation; although, a relatively high-ceiling (approximately 35 ft) does allow for appreciable dilution of any volatile vapors.

C. Miscellaneous Operations

A variety of other activities are conducted to support the plastic duplication and fixture building activities. Spray painting of plastic models is conducted in a spray booth equipped with local exhaust ventilation; however, on occasion, large "stack" models may require painting in the shop area. A separate booth equipped with local exhaust ventilation is used for grinding metal and plastics, along with other miscellaneous tasks. A welding booth is also present in the southwest corner of the building, and utilizes a modified window type exhaust fan as its source of ventilation.

IV. MATERIALS AND METHODS

A. Environmental

On February 16-17, and April 27-28, 1983, environmental surveys were conducted by the NIOSH investigators in order to assess the exposures of personnel involved in the various wood, plastic, and metal working operations. During these surveys, personal samples, collected near the breathing zone of the employees, and area air samples were collected using battery-powered sampling pumps connected via Tygon® tubing to the collection media. The selection of substances for the environmental evaluation was primarily based on the substances' irritant potential, the amount of and conditions of use, the presence of engineering controls, and the results of previous environmental studies of exposures in similar operations. A brief discussion of the nature and the number of samples collected, and the method of sampling and analysis follows:

Wood Dust - Since a variety of different types of wood are utilized in the construction of wood models, samples were collected to determine exposures of wood model makers and wood shop employees to total wood dust during the course of their daily activities. Thirteen pre-weighed 37-millimeter (mm) polyvinylchloride (PVC) filter samples collected at 1.5 liters of air per minute (Lpm) were analyzed gravimetricly for total particulate weight.

Impreg - Since impreg contains a phenol/formaldehyde resin, sampling was conducted to determine if the individual components of the resin might be liberated during the storage or use of the wood. In order to assess the possible presence of formaldehyde, two separate sampling and analytical methods were employed. Two Supelco® XAD-2 solid sorbent resin tube samples were collected at 50 cc/min and analyzed by NIOSH method P&CAM 354 for formaldehyde.[1] In addition, six impinger samples containing sodium bisulfite solution were collected at 1.0 Lpm and analyzed by NIOSH method 125 for formaldehyde.[1] To assess the possible presence of phenol, two bubbler samples containing 0.1 Normal sodium hydroxide solutions were collected at 1.0 Lpm and analyzed by NIOSH method S333 for phenol.[1]

Epoxy Resins - Due to the widespread use of these substances throughout the facility, three separate epoxy resins were selected for evaluation (these resins were primarily diglycidyl ethers of Bisphenol A - formed through the condensation reaction of epichlorohydrin and Bisphenol A). In order to assess the possible presence of the resins and their components in the workroom air, three 37-mm glass fiber filter samples were collected at 1.6 Lpm and analyzed by NIOSH method P&CAM 333 for Bisphenol A and the diglycidyl ether of Bisphenol A.[1] Additionally, three charcoal tube samples were collected at 100 cubic centimeters of air per minute (cc/min) and analyzed by NIOSH method P&CAM 127 for epichlorohydrin.[1]

Hardeners - Since epoxy resins require a curing agent to bring about the molecular reaction which causes the resin to harden, exposure to these substances were also evaluated. The majority of the resins used in the plant were the thermosetting type, which predominantly utilize aliphatic polyamines as the hardening agent.[2] In order to assess the possible

presence of these substances, six citric acid coated silica gel tube samples were collected at 100-200 cc/min and analyzed by NIOSH P&CAM 276 for identifiable aliphatic polyamines.[1]

Welding Fumes - Various types of welding, utilizing mild steel base metals, are routinely conducted in the welding booth area, and occasionally in the shop area of the plant. In order to assess employee exposures to welding fumes, three pre-weighed 37-mm PVC filter samples were collected at 1.5 Lpm and analyzed by gravimetric weighing for total particulate weight.

The location, duration, and other information pertinent to sample collection and analysis is provided in Tables 1 - 6.

B Medical

Brief interviews were conducted with 30 employees (including some supervisory) at their work stations during the initial survey visit of November 3, 1982, and during the follow-up site visit on February 16 and 17, 1983. The purpose of the interviews was to determine the relative extent of and types of health problems the employees were experiencing, if the health problems were potentially job related, and whether the frequency and consistency of the reported health effects warranted further documentation and study.

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 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

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 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.

A. Wood Dusts

The principal health effects reported from exposure to wood dust are dermatitis, respiratory disease, and nasal cancer. Nasal cancer, however, has been reported only in wood workers in the furniture industry using certain types of hardwoods. Allergenic woods such as certain members of the birch, pine, dogwood, beech, mahogany, mulberry, and myrtle families may cause asthma and contact dermatitis in sensitized individuals. Recent investigations have found impairment of nasal mucocilliary clearance from wood dust, and one study noted that mucostasis increases in direct proportion to the dust concentration (63% at 25.5 mg/M^3 and 11% at 2.2 mg/M^3). Since some researchers argue that impaired mucocilliary function may play a role in the development of nasal cancer due to prolonged retention of wood dust in the nasal cavity, ACGIH recommends a TLV of 1 mg/m^3 for hardwood dusts, and a TLV of 5 mg/M^3 for soft wood dusts.[3] Currently, no OSHA standard exists specifically for occupational exposure to wood dust.

B. Formaldehyde

The primary health effects of exposure to formaldehyde are irritation of the respiratory tract, eyes, and skin. Concentrations of 0.1 to 5 parts of formaldehyde per million parts of air (ppm) can cause eye, nose, and throat irritation. Formaldehyde has been shown to induce a rare form of nasal cancer in laboratory animals and to have mutagenic activity in several test systems. Although humans and animals may differ in their susceptibility to specific chemical compounds, any substance that produces cancer in experimental animals should be considered a cancer risk to man.[4] The current Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for formaldehyde is 3.0 ppm as an eight-hour time weighted average (TWA).[5] The NIOSH recommended standard for occupational exposure to formaldehyde was 1.0 ppm based on any 30 minute sampling period. This recommendation was designed to prevent irritation effects. However, NIOSH recommended in a Current Intelligence Bulletin issued in April 1981, that formaldehyde be

handled as a potential carcinogen. Safe levels of exposure to carcinogens have not been demonstrated, but the probability of developing cancer should be reduced by decreasing exposure. Therefore, it is recommended that as a prudent public health measure, engineering controls and stringent work practices be employed to reduce occupational exposure to the lowest feasible limit.[4]

C. Phenol

Phenol vapor is capable of causing irritation to the eyes, mucous membranes, and skin. Systemic absorption can cause central nervous system effects as well as liver and kidney damage. The NIOSH recommended standard for phenol is 20 mg/M^3 as a TWA, and 60 mg/M^3 for a 15-minute ceiling. The current OSHA standard for phenol is 19 mg/M^3 as an 8-hour TWA.[6]

D. Diglycidyl Ether of Bisphenol A (DGEBPA) and Bisphenol A (BPA)

Toxicological information on glycidyl ethers is limited, but available data indicates that these compounds are primary eye and skin irritants, and potential skin sensitizing agents. Some glycidyl ethers have been shown to be mutagenic and tumorigenic in laboratory studies. In addition, recent studies indicate that some of the glycidyl ethers may cause testicular atrophy and hematopoietic abnormalities in various species of laboratory animals.[7] Since the vapor pressure of these substances is relatively low, dermal contact is usually the major route of exposure; and in addition to producing irritation and sensitization, high doses may be absorbed through the skin and cause systemic effects.[8] Currently, there are no specific occupational standards for exposure to DGEBPA or BPA.

E. Epichlorohydrin

Short-term exposure to epichlorohydrin may cause irritation of the eyes, respiratory tract, and skin. Repeated or prolonged skin contact may cause skin burns. A person may become sensitized to this chemical so that even small amounts cannot be tolerated. Recent information contained in a NIOSH Current Intelligence Bulletin indicates epichlorohydrin may cause a significant increase in respiratory cancer and chromosomal abberations in the peripheral lymphocytes of exposed workers, and has been shown to cause an increase in nasal carcinomas in rat inhalation studies. The NIOSH recommended standard for epichlorohydrin was 0.5 ppm as a TWA, and 5 ppm for a 15-minute ceiling; however, based on the data contained in the Current Intelligence Bulletin, NIOSH recommends minimizing exposure to this substance pending further evaluation of its carcinogenic potential. The current OSHA standard is 5 ppm as an 8-hour TWA.[9]

F. Aliphatic Amines

Aliphatic amines are generally utilized in the liquid form and often exhibit a strong ammonia-like odor. These substances can cause irritation of the skin and mucous membranes in both the liquid and vapor states. Repeated skin contact can, in certain cases, cause

sensitization. Vapors given off at high temperatures may cause irritaton of the respiratory tract and the lungs, and repeated inhalation may give rise to asthmatical attacks.[2] The ACGIH TLV for ethylenediamine is 10 ppm as an 8-hour TWA, and 1 ppm for diethylene triamine as an 8-hour TWA.[3]

G. Welding Fumes

A consideration of the constituents of welding fume is of primary importance in assessing worker exposure to toxic agents. The more toxic compounds (e.g. chromium - present in stainless steel) will have a greater effect in small quantities than will the less noxious compounds. However, since the effects of exposure to many different compounds at the same time is considered cumulative, total fume concentration is often measured. Conclusions based on total fume concentration are generally adequate in the absence of the identification of the specific toxic constituents. ACGIH recommends a TLV of 5 mg/M^3 for an 8-hr TWA for total welding particulate.[3] The OSHA standard for total airborne particulate is 15 mg/M^3 for an 8-hr TWA.[5]

VI. RESULTS

A. Environmental

Personal breathing zone and area air samples collected for total wood dust revealed TWA concentrations ranging from 0.37 to 4.0 mg/M^3, with a mean of 1.7 mg/M^3. When examined by job, the highest average personal exposures were detected for the wood shop employee (2.6 mg/M^3), followed by the model makers (1.8 mg/M^3). All three personal samples collected for the wood shop employee were above the ACGIH TLV for hardwood dust of 1.0 mg/M^3. Two of four personal samples collected for wood model makers were above the ACGIH TLV, but in both instances the work activity included a substantial amount of time using powered equipment in the wood shop. Although in most instances, exposures were to a combination of hard and soft wood dusts, the more restrictive criteria for hardwood dust has been utilized in this report. A complete listing of the results is provided in Table 1.

Phenol was not detected in area samples collected during the environmental survey of February 16, 1983, near the impreg stock area and in the wood working shop where impreg was being sanded; however, formaldehyde was detected in these areas at concentrations of 0.18 and 0.12 ppm, respectively. During the follow-up survey of April 28, 1983, using a more sensitive sampling and analytical method, a detectable level of formaldehyde (0.083 ppm) was found in only one of three area samples. All concentrations were below the current OSHA standard of 3 ppm. A complete listing of these results is provided in Tables 2, 3, and 4.

Results of the samples collected for epoxy resin components did not reveal detectable concentrations of epichlorohydrin or DGEBPA. Bisphenol A was detected in one of the three samples at a concentration of 0.002 mg/M3. No detectable levels of aliphatic polyamines were

found in any of the four personal and area samples collected during the use of the epoxy resin hardeners. Concentrations of all substances were well below their corresponding environmental criteria. A complete listing of these results is provided in Table 5.

Personal breathing zone samples collected for total welding particulate revealed TWA concentrations of 1.2 and 2.0 mg/M^3 in samples collected during welding in the booth, and 2.8 mg/M^3 in a sample collected during welding out of the booth. All samples were below the ACGIH TLV of 5.0 mg/M^3. A complete listing of these results is presented in Table 6.

B. Medical

In general, the employees interviewed at the wood and plastics operations did not report a substantial number of work related health problems. The most frequent problem, occasional episodes of dermatitis, was reported by five employees. Other more isolated complaints included occasional irritation, headaches, and noise. Situations cited by the employees as contributing to unnecessary exposures within the facility included spray painting outside of the booth, and the failure of employees to replace lids on solvent containers and other substances used in the workroom area. Since no consistent abnormalities were identified among the employees, further epidemiologic follow-up was not conducted.

VII. DISCUSSION AND CONCLUSIONS

A. Survey Results

The results of the environmental samples indicated that wood dust was found to be in excess of the evaluation criteria during the surveys. All three personal samples collected for the wood shop employee, and 2 of 4 personal samples collected for wood model makers were above the ACGIH TLV of 1.0 mg/M3 for hardwood dust. As would be expected, the major source of the wood dust exposure was the operation of powered wood working machinery. This was confirmed through visual observation, as well as, the environmental findings. Although the majority of the machines were equipped with local exhaust ventilation, it was not always effective in controlling dust generation. Some types of machines (e.g. routers and shapers), by virtue of their design, do not allow for effective dust control with traditional ventilation systems. Often times, dust particles are directed with such force, or in a direction such that the flow of air into duct work is unable to effectively capture them. In such instances, the use of a NIOSH approved dust respirator would be appropriate as a supplement to the existing local exhaust ventilation.

Area samples, collected for the purpose of assessing the possibility that resin components might be liberated during the storage or use of impreg, did not reveal any detectable levels of phenol. Low levels of formaldehyde were detected in the two solid sorbent tube samples collected during the initial environmental survey (average 0.15 ppm); however, the more sensitive impinger samples collected during the

subsequent survey revealed a detectable concentration of formaldehyde (0.08 ppm) in only 1 of 3 samples. In both instances, the measured levels of formaldehyde were only slightly above the limits of quantitation of the analytical methods utilized.

Sampling efforts in the plastics shop were concentrated among those employees who were working with the three major epoxy resin systems. The results of these samples did not indicate a significant airborne exposure to either the resins, the resin components, or the hardeners. Other recent environmental studies conducted in wood and plastic model shops have shown similar findings.[10,11]

Exposure during the welding activity conducted out of the booth was somewhat higher than that for the welding done within the booth. This would appear to indicate that the ventilation within the booth is somewhat effective; however, modification of the existing system to allow for a side-draft local exhaust ventilation would most likely result in a more effective removal of welding contaminants.

Many additional substances were used throughout the plant that were not evaluated during this survey. This was due largely to the variability in the quantities, frequencies, and manner in which they were used, and does not imply that these materials are not capable of presenting a health hazard. Company policy should dictate that material safety data sheets be obtained for all materials brought into the plant. The individual components of these materials should then be evaluated to ensure that proper engineering controls, work practices, and personal protection are implemented when necessary.

B. Additional Considerations - Cancer Mortality in Wood Model Makers

In recent years, a concern has arisen over studies indicating the possibility of excess deaths from cancer among employees of automobile wood die and model shops. A NIOSH proportionate mortality study of deceased white male workers, utilizing the death benefit records of the Pattern Makers League of North America, revealed statistically significant excesses in the proportion of deaths from colon cancer, brain cancer, and leukemia in those shops using predominantly wood.[12] A seperate cancer incidence study of the General Motors model makers, conducted by the Michigan Cancer Foundation, revealed a higher than expected occurrence of colo-rectal cancer when compared with local cancer rates.[13] A third cancer mortality and incidence study which utilized both wood shop and control employees, conducted by the Memorial Sloan-Kettering Cancer Center, found excess deaths due to bladder and colon cancer, and a higher than expected rate of colon cancer.[14]

Currently, additional studies are being conducted by NIOSH and a variety of other researchers to further examine this issue. To date, industrial hygiene surveys have not indentified a particular workplace source or contaminant responsible for excess cancers of this type. Therefore, it would seem prudent to minimize exposures to all potentially carcinogenic substances whenever possible. During the survey it was noted that recent efforts had been made by the company and the union directed at reducing exposures, particularly to wood dust, through the use of portable and fixed local exhaust ventilation systems, increased

housekeeping efforts, and the use of personal protective equipment. This effort should be continued, with constant attention being given to maintaining existing ventilation systems and implementing improvements where possible. In addition, the need for keeping employees informed of the proper use of personal protective equipment, and the need for good work practices and personal hygiene should continue to be stressed.

VIII. RECOMMENDATIONS

Based on the results of environmental monitoring and observations of employee work practices, the following recommendations are made in order to reduce employee exposures.

A. Wood Working

1. Engineering Controls - The local exhaust ventilation systems at woodworking machinery should be regularly inspected to insure that they are properly operating, and on-going efforts should be made to improve these systems where possible. Sufficient flow rates should be maintained to capture and carry away the generated wood dust. Specifications for air flow (capture and transport velocities) as well as recommendations for ventilation system design for a variety of these machines can be found in the ACGIH publication, Industrial Ventilation.[15]

2. Personal Protective Equipment - Employees should be encouraged to utilize NIOSH/MSHA approved dust respirators during use of machinery in the wood shop (e.g. shaper, router, and sander operation) and during the use of hand-held powered wood working tools (belt sanders etc.) which often generate large amounts of dust. Additionally, since precision hand sanding often places the workers breathing zone close to the point of dust generation, respirators should be made available for this activity also, particularly when working with impreg and other hardwoods. Safety glasses and face shields should continue to be utilized when using any powered woodworking equipment.

3. Work Practices, Housekeeping, and Personal Hygiene - Workers should be discouraged from using compressed air to clean clothing, machinery, or their work area. Portable vacuums should be utilized for this purpose whenever possible in order to avoid the resuspension of dust in the work environment. A regular housekeeping schedule should be established in order to remove dust from equipment, work areas, and overhead structures. Employees involved in these activities should utilize full length clothing and respiratory protection. Vacuums and wet methods of cleaning should be used in preference to dry sweeping.

B. Plastic Shop

1. Engineering Controls - Ventilation in the mixing room could be improved through the addition of a hood to the existing duct. Exhausting of this system to the outside of the building would provide less opportunity for contaminants to be recirculated into the workroom area. Local exhaust ventilation systems within the paint

booth and grinding booths should be regularly inspected to insure effective contaminant removal. Employees should be constantly reminded of the proper use of the ventilation systems, e.g. spray painting should be conducted in a manner such that the object being painted is between the operator and the exhaust pick-up at all times. Mixing and application of epoxies should be conducted in well ventilated areas, and jobs requiring the use of large amounts of epoxies or solvents should be conducted utilizing the existing local exhaust ventilation whenever possible.

2. Personal Protective Equipment - Rubber or latex protective gloves should be utilized at all times when working with epoxies. NIOSH/MSHA approved respirators designed for protection against paint, lacquer, and enamel should be utilized during any spray painting which is conducted outside of the spray booth.

3. Work Practices, Housekeeping, and Personal Hygiene - All solvent and epoxy containers should be tightly capped when not in use and properly stored or discarded at the end of the work shift. Employees should wash skin immediately after any contact with epoxies, and avoid wiping epoxies on work clothing where further skin contact can occur.

C. Welding

1. Engineering Controls - Protective screens should be utilized when welding is conducted out of the welding booth to protect nearby employees from possible eye injury/burns from exposure to ultraviolet radiation. In most welding situations, the use of portable fans as a means of local exhaust ventilation is not recommended. However, for repetitive welding in a fixed position (e.g. occasional welding tasks conducted in the shop area) the use of a cross draft air flow at 90° to the welder (controlled at less than 100 fpm in order to maintain weld integrity) would be beneficial.[16]

2. Personal Protective Equipment - For welding operations conducted for long periods of time or where alloy or coated metals are encountered, the proper respiratory protection should be worn.

D. General

1. Any eating or storage of food, drinking, or smoking at work stations should be discouraged.

2. Material Safety Data Sheets should be obtained for all materials utilized in the facility. These should be consulted as necessary to determine the proper precautions to be taken when working with the various materials.

3. An increase in the general ventilation within the facility would have a positive effect in reducing general contaminant concentrations. Proposed guidelines indicate that between 3 and 4 room air changes per hour would be appropriate for model shops with local exhaust ventilation supplementation, although a greater exchange would be recommended for plastic shops without local exhaust ventilation.[17]

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Services (NTIS), Springfield, Virginia. 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 the following:

1. D & F Corporation
2. Requestor
3. Pattern & Model Maker' Association of Warren and Vicinity, Local Union
4. U.S. Department of Labor, OSHA - Region V
5. NIOSH Regional Offices/Divisions

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

TABLE 1
RESULTS OF ENVIRONMENTAL SAMPLES COLLECTED FOR TOTAL WOOD DUST
AT THE D & F CORPORATION

Sample Date (1983)	Sample Type	Job Title/ Location	Sample Time (minutes)	Sample Volume (liters)	TWA Concentration Total Wood Dust (mg/M3)
2/16	Personal	Wood Shop Operator	319	478	2.0
2/16	Personal	Model Maker	292	438	1.7
2/16	Area	Right Side of Router	357	536	0.60
2/16	Personal	Model Maker	288	432	0.79
2/16	Area	Above Shapers	355	532	2.2
2/17	Area	Above Table Saw	357	536	0.45
2/17	Personal	Wood Shop Operator	264	396	2.5
2/17	Personal	Model Maker	110	165	0.48
4/28	Personal	Wood Shop Operator	263	394	3.3
4/28	Personal	Model Maker	256	384	4.0
4/28	Area	Above Shapers	287	430	0.37

TABLE 2
RESULTS OF ENVIRONMENTAL SAMPLES COLLECTED FOR PHENOL
AT THE D & F CORPORATION

Sample Date (1983)	Sample Type	Sample Location	Sample Time (minutes)	Sample Volume (liters)	TWA Concentration Phenol (mg/M3)
2/16	Area	Above Impreg Stock	107	107	< LOQ
2/16	Area	Near Sanders	101	101	< LOQ
2/16	Blank	-	-	-	< LOQ

< LOQ - Less than limit of quantitation of 0.03 mg/sample (approximately 0.08 ppm for a 100 liter sample).

TABLE 3
RESULTS OF ENVIRONMENTAL SAMPLES COLLECTED FOR FORMALDEHYDE
USING SOLID SORBENT TUBES* AT THE D & F CORPORATION

Sample Date (1983)	Sample Type	Sample Location	Sample Time (minutes)	Sample Volume (liters)	TWA Concentration Formaldehyde (ppm)
2/16	Area	Above Impreg Stock	312	13.5	0.18
2/16	Area	Near Sanders	304	13.8	0.12
2/16		Blank	-	-	< LOQ

< LOQ - Less than limit of quantitation of 2 ug/sample (approximately 0.12 ppm for a 12 liter sample).

*NIOSH Method P&CAM 354

TABLE 4
RESULTS OF ENVIRONMENTAL SAMPLES COLLECTED FOR FORMALDEHYDE USING IMPINGERS* AT THE D & F CORPORATION

Sample Date (1983)	Sample Type	Sample Location	Sample Time (minutes)	Sample Volume (liters)	TWA Concentration Formaldehyde (ppm)
4/28	Area	Above Impreg Stock	60	60	< LOQ
4/28	Area	Above Shapers	60	60	0.083
4/28	Area	Near Sanders	60	60	< LOQ
4/28	Blank	-	-	-	< LOQ

< LOQ - Less than limit of quantitation of 0.25 ug/ml absorber (approximately 0.068 ppm for a 60 liter air sample).

*NIOSH Method P&CAM 125

TABLE 5
RESULTS OF ENVIRONMENTAL SAMPLES COLLECTED FOR BISPHENOL A, DIGLYCIDYL ETHER OF BISPHENOL A*, AND EPICHLORIHYDRIN* AT THE D & F CORPORATION

Sample Date (1983)	Sample Type	Sample Location	Sample Time (minutes)	Sample Volume (liters)	TWA Concentration Bisphenol A (mg/M3)
2/16	Area	Mixing Room	335	536	< LOQ
2/16	Personal	Plastics Lay-up	276	442	0.002
2/16	Personal	Plastics Lay-up	317	507	< LOQ
	Blank	-	-	-	< LOQ

< LOQ - Less than limit of quantitation of 0.5 ug Bisphenol A /sample (approximately 0.001 mg/M^3 for a 500 liter air sample).

* For all of the above samples, Diglycidyl Ether of Bisphenol A (DEGBA) and Epichlorohydrin were not found above the limits of quantitation:
DGEBA: 0.5 ug/sample (approximately 0.001 mg/M^3 for a 500 liter air sample)
Epichlorohydrin: 0.01 mg/sample (approx. 0.075 ppm for a 35 liter air sample).

TABLE 6
RESULTS OF ENVIRONMENTAL SAMPLES COLLECTED FOR TOTAL WELDING FUME AT THE D & F CORPORATION

Sample Date (1983)	Sample Type	Job Duty/ Location	Sample Time (minutes)	Sample Volume (liters)	TWA Concentration Total Welding Fume (mg/M3)
2/17	Personal	Welding - In Booth	297	446	1.2
2/17	Personal	Welding - In Shop	270	405	2.8
4/28	Personal	Welding - In Booth	254	381	2.0