U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 76-8-370

FUEL ECONOMY ENGINEERING COMPANY
SPURLOCK POWER STATION
MAYSVILLE, KENTUCKY

MARCH 1977

I. TOXICITY DETERMINATION

A combined environmental-medical evaluation of particulate and vaporous contaminant exposures by workers involved in fabricating glass-reinforced plastic pipe joints has been completed at the Spurlock Power Station, Maysville, Kentucky. A preliminary survey and two follow-up evaluations were conducted during the periods of January 15, 1976, April 29-30, 1976, and June 22, 1976, respectively. The contaminants aerometrically evaluated were asbestos fibers, total and respirable particulate (presumed to consist primarily of fibrous glass and hardened resin), monomeric styrene, methyl ethyl ketone, and polyglycol diamine. The effects of exposure were evaluated by administering health questionnaires, physical examinations, and pulmonary function tests.

Short term toxicity characterized by dermatologic, gastrointestional, neurologic, and respiratory symptoms may have existed as reported by the fabrication workers prior to the preliminary survey and follow-up evaluations. However, it is the judgement of the NIOSH investigators that a toxic exposure to the fabrication workers did not exist on the days of the investigations. The prevalence of present symptoms among workers currently exposed to the aforementioned contaminants did not differ significantly from those of non-exposed workers. Neither past nor current respiratory symptoms in workers were associated with objective evidence of pulmonary dysfunction.

Available health effects data concerning long term exposure to airborne fibrous glass is non-conclusive. However, in view of the experimental studies demonstrating the carcinogenicity of small diameter glass fibers in animals and the possibility of human carcinogenicity posed by a case-control study, the workers may be exposed to potentially toxic concentrations of fibrous glass. Consequently, control of worker exposure to an absolute minimum should be a paramount consideration.

Part VI of this report offers suggested industrial hygiene practices that can help minimize dermal and respiratory exposures to the contaminants apparent in the process of fabricating glass-reinforced plaster pipe joints.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (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:

a) Fuel Economy Engineering Company, St. Paul, Minnesota
b) Fuel Economy Engineering Company, Spurlock Power Station, Maysville, Kentucky
c) United Association of Journeymen and Apprentices of the Plumbers and Pipefitters Industry, Locals 59 and 392, Cincinnati, Ohio
d) President of the Cincinnati Building Trades Council, Cincinnati, Ohio
e) U.S. Department of Labor - OSHA - Region IV
f) NIOSH - Region IV

For the purpose of informing any employees who may still be involved in fabricating glass-reinforced plastic pipe joints, this Determination Report shall be "posted" for a period of at least thirty calendar days in a prominent place(s) readily available to the workers.

III. INTRODUCTION AND BACKGROUND

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an 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 National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of the Cincinnati Building Trades Council representing the United Association of Journeymen and Apprentices of the Plumbers and Pipefitters Industry, Local Union 59 and 392. Members of each local work for the Fuel Economy Engineering Company contracted to fabricate a portion of the glass reinforced plastic (GRP) piping system for the Spurlock Power Station. The request was submitted in response to alleged complaints of skin irritation, conjunctivitis, sore throat, trouble swallowing, nausea, dizziness, headache, chest tightness, and difficulty breathing from employees involved in fabrication of GRP pipe joint welds.

The Eastern Kentucky Co-op is financing the construction of the Spurlock Power Station - Charleston Bottoms Power House - located on the Ohio River near Maysville, Kentucky. Construction of the fossil fuel generation plant, designed to produce 500 megawatts, began in 1973 and is scheduled for completion in early 1977.

IV. HEALTH HAZARD EVALUATION

A. Operations - Conditions of Use

The GRP joint welds are fabricated with room temperature curing polyester or epoxy resins using laminate hand lay-up or bonding adhesive techniques, respectively. However, some of the GRP epoxy joints are effected by an all-mechanical system requiring no adhesive. (Because of this reason, the system was not studied). Laminate lay-up is a method of making a wrapped joint by consolidating by hand layers of brush or roller applied resin in association with glass fiber reinforcements. Whereas, the bonding adhesive technique is a method of evenly distributing an epoxy adhesive on the outside of a tapered spigot and inside surface of an integral bell, which are then fit together. The pipes range from 6 to 36 inches in diameter.

The laminate lay-up technique uses a styrenated-polyester resin. The resin as received is dissolved in monomeric styrene and pre-accelerated through the addition of a cobalt soap. The catalyst is purchased as a colorless liquid containing 60 percent methyl ethyl ketone peroxide (MEKP) in dimethyl phthalate which serves as a diluent and anti-detonator compound. The exact percentages of the constituent compounds present in the catalyzed resin is not known. Literature [1,2] indicates that 30 to 50 percent styrene is necessary to furnish a sufficient cross linking density; and the amount of the cobalt soap required to give an acceptable gelation and setting rate is around 0.1 percent depending on temperature and around 1 percent of the peroxide.

The first step in fabricating a polyester wrapped joint is surface preparation of both ends of the pipe with a hand-held disc grinder to provide a proper bonding surface for applying the resin and glass reinforcement mat. Second, the catalyzed-resin is brushed on the prepared surface, and a precut-glass fiber mat is laid on the pipe and wet-out with the resin as it is wrapped around the pipe. Third, after the resin soaks into the reinforcement, subsequent layers are built up to the required thickness. The number of layers is determined by the pressure rating and size of pipe being joined. Finally, after all the layers of mat have been applied and the joint has gelled or semi-hardened, a final coat of resin is applied. This coating improves the appearance of the finished laminate by obscuring the glass fiber pattern, and it also improves the weather performance.

The epoxy resin system used in the adhesive technique is supplied as a two part system, i.e., the resin and hardener are provided in separate containers with pre-measured volumes necessary for a specified pipe diameter. The resin is the diglycidyl ether of bisphenol A formed by the union of bisphenol A (diphenylol propane) with epichlorohydrin. The principal component of the hardener or curing agent is 2,2' di (3-amino-propoxy) ethyl ether, hereafter referred to as polyglycol diamine. The resin contains several substances which serve as inorganic fillers. Chrysotile asbestos, because of its carcinogenic activity is one of prime concern.

The epoxy joint weld is made by (1) preparing the outer surface of the spigot and inner surface of the bell ends of the pipes with a hand-held disc grinder to remove all dirt and grease to permit optimum bonding; (2) coating the prepared surfaces with the catalyzed-resin; and (3) fitting the section of pipe together.

A joint weld is fabricated at the location of its use. The locations include inside trenches and pits of varying depths, inside and beneath buildings, and in completely open areas. Consequently, the available ventilation to remove the vapors and airborne particulate varies with each location. During the first year (1975) of fabrication no mechanical ventilation was used, except for a pedestal fan occasionally used during surface preparation. In the Spring of 1976, "jectair air movers" with the capability of locally exhausting approximately 3500 standard cubic feet per minute (scfm) of air were used during all fabrication work.

B. Hazard Identification - Conditions of Exposure

Approximately 20 persons are exposed to particulate and vaporous contaminants during fabrication of polyester and epoxy reinforced plastic pipe joints. Exposure occurs during pipe surface preparation, resin make-up, polyester lay-up, and epoxy application. Each resin system involves potential exposures to substances that are used or evolved during the fabrication process. These substances are discussed below. Substances such as a cobalt soap, dimethyl phthalate and others also may be present, but based upon their known toxicological activity, and/or low percentage in the resin, and/or vapor pressure at the conditions of use, they will not be mentioned.

a. Pipe Surface Preparation: Exposure substances include particulates from the polymerized polyester and epoxy resins, and fibrous glass generated during abrasive sanding of the pipe. Additionally, the cured epoxy pipe contains varying concentrations (< 1.5 percent by weight) of crysotile asbestos fibers dependent upon the diameter of pipe. Emittance of the asbestos fibers bonded by the resin may occur during sanding.[3]

b. Polyester Resin Make-up and Lay-up: Concurrent exposure to monomeric styrene, methyl ethyl ketone peroxide (MEKP), and methyl ethyl ketone (MEK) are expected during make-up and lay-up procedures.

Because of styrene's known toxicological activity and percentage (30 to 50) contained in the resin, it may constitute the principal chemical hazard that the workers are exposed to while performing these procedures. The routes of exposure are inhalation of vaporous styrene and skin contact with the liquid styrenated-resin. A study [4] reported that the highest concentrations of styrene vapor were measured during the initial mixing of the styrenated-resin and catalyst. The next highest during application of the laminate, and from then on it decreased as the resin approached complete cure. Most likely this concentration sequence would also apply to the airborne levels of MEKP (i.e. the highest level during the initial mixing of the concentrated MEKP catalyst (60 percent by volume) with the resin; then decreasing as the catalyst is diluted (< 1 percent by volume) by the resin). Because a satisfactory analytical and sampling technique for MEKP was not available, this could not be determined.

Chemically, MEKP, behaves in a manner similar to hydrogen peroxide, giving off oxygen under certain conditions. After the oxygen is given off, a residual compound - MEK - is produced with a toxicity of its own. However, because of the small amount of MEKP used, the workers are exposed to minimal concentrations of MEK.

c. Epoxy Resin Make-up and Application: Exposure to vaporous and liquid polyglycol diamine occurs during resin make-up and application. As stated during polyester resin make-up and lay-up procedures, peak airborne concentrations also are expected during the initial mixing, then decrease as the resin cures.

C. Evaluation Study Design

Reinforced plastic pipe fabrication began in the Spring of 1975 and proceeded steadily until late 1975, at which time worker complaints prompted submission of a Health Hazard Evaluation Request. According to union and management representatives the major portion of the fabrication work had been completed during this period and primarily involved glass-reinforced polyester pipe. Subsequently, a preliminary environmental investigation was completed on January 15, 1976. The survey included observation of work practices, administration of health questionnaires, and limited environmental sampling. The sparsity of available work prevented NIOSH from gathering sufficient qualitative and quantitative data to adequately characterize and assess the etiologic agent(s) responsible for the alleged symptoms of exposure. Thus, further field study was deemed necessary. However, winter temperatures and work stoppage prevented an immediate follow-up visit.

Because the initial investigation suggested a high rate of dermatologic, respiratory, and constitutional symptoms associated with fabrication of GRP pipe joints, workers engaged in the process began using respirators, protective clothing, barrier creams, and local exhaust ventilation equipment. Coincidentally, early in 1976, the polyester laminate joint fabrication system was largely replaced by an epoxy system. Thus, the original working conditions for which the Health Hazard Evaluation was undertaken in part, no longer existed by March or April of 1976. Furthermore, relatively fewer workers were engaged in pipe joint fabrication by that time.

To characterize and assess the environmental levels of the polyester and epoxy resin constituents and employee health effects from exposure, environmental-medical surveys were conducted on April 29-30, and June 22, 1976. Environmental air sampling was conducted at several fabricating areas which provided data on existing contaminant levels as well as data on exposure situations or conditions that may have existed during 1975 in some instances. For example, the contaminant levels were measured during fabrication of a polyester pipe chase underneath the power station office building without any mechanical ventilation. Thus, approximating past exposure conditions of fabricating in a confined space without any mechanical ventilation. To evaluate the acute effects of exposure to the vapors and particulates, a health questionnaire survey of past and present symptoms of exposed and unexposed workers was undertaken on April 29, 1976. Because of the unexpected high prevalence of current respiratory symptoms among formerly exposed workers, further evaluation was deemed necessary. A limited physical examination and pulmonary function tests were conducted on June 22, 1976. All workers still working at the site who were interviewed during the questionnaire survey were invited to participate.

D. Evaluation Methodology

a. Environmental Methodology

Individual workers' exposures to total and respirable particulate, asbestos, monomeric styrene, methyl ethyl ketone, and polyglycol diamine were measured using personal sampling techniques. The workers' wore a personal sampling apparatus consisting of a battery-powered pump and some type of device placed at the breathing zone, such as a filter or solid sorbent tube, appropriate for the particular air contaminant being measured. The methods for collection and analyses for these substances are discussed below.

1. Total and Respirable Particulate: The total and respirable dusts were presumed to primarily consist of fibrous glass and hardened resin with some asbestos fibers. The total dust level was measured by drawing air at a flow rate of 1.5 or 2 liters per minute (lpm) through a pre-weighed vinyl membrane filter mounted in a closed face cassette and then weighing the amount of dust collected.

The respirable dust concentration was measured by drawing air at a flow rate of 1.7 lpm through a size-selective device. The device consisted of a 10-mm nylon cyclone to remove the non-respirable fraction of the total dust prior to collection of the respirable portion on a pre-weighed vinyl membrane filter for gravimetric analysis as described for total dust.

Data compiled by Corn and Bien (1971) indicate that cyclone samplers do not reproducibly sample and aerodynamically separate fibrous material.[5] However, these studies did not attempt to calibrate the 10-mm cyclone for the size selective sampling of fibrous aerosols. Such was undertaken by Oritz and Ettinger (1976), which provided data on the reproducibility and practicality of using this sampler for size selective sampling of fibrous glass dusts.[6] Thus, it was judged by this author, that the cyclone method was suitable for the purpose of this measurement.

2, Asbestos: Airborne samples of asbestos were collected on a 37mm, 0.8 micrometer (μm) pore size membrane filter mounted in an open face cassette; sampling flow rate of 2 lpm.[7] The sampling periods ranged from 2 to 27 minutes dependent on filter loading determined by visual inspection. A sample should not be too dense, since samples in which particles overlap must be rejected as uncountable. The samples were analyzed by first clearing the membrane filter to make it optically transparent followed by fiber counts at 400 to 500x magnification by phase contrast optical microscopy. Petrographic microscopy was used to distinguish the asbestos fibers from the fibrous glass fibers. Asbestos fibers are defined as those particles with a length greater than (>) 5 μm and a length-to-diameter ratio of 3 to 1 or greater. This technique, by which only fibers longer than 5 μm are counted, is recognized as only an index of total fiber exposure and does not imply that shorter fibers do not pose a health hazard.

3. Monomeric Styrene and Methyl Ethyl Ketone: Air was drawn through a 150 mg charcoal tube to concurrently trap these organic vapors. Consecutive air samples were collected at a flow rate of 0.2 lpm to establish a time-weighted average exposure concentration and peak period samples were collected at a flow rate of 1 lpm to address the ceiling value criteria for these substances. The analytes were desorbed from the charcoal with carbon disulfide and analyzed by gas chromatography.[8] The limit of analytical detection was 0.01 mg per sample for styrene and MEK.

4. Polyglycol Diamine: The amine vapors were collected on a 150 mg silica gel tube at a flow rate of 400 cubic centimeters per minute (cc/minute). Because the amine could not be chromatographed, a general colorimetric method for aliphatic amines was used for analysis. The limit of detection was 0.02 mg amine per sample.

b. Medical Methodology

1. Questionnaire Survey: On April 29, 1976, an attempt was made to interview all workers currently exposed to the substances involved in fibrous glass pipe joint fabrication, all workers still employed at the site who were previously exposed, and a comparable number of pipefitters who worked at the site but were not exposed.

Survey data included age (all participants were white male), relevant work history, smoking history, and presence of various dermatologic, ocular, respiratory, and constitutional symptoms. For purposes of categorization, "formerly exposed" workers are those whose exposure occurred in 1975 and early 1976 prior to the institution of personal protective measures and the increased use of the epoxy system; "currently exposed" workers are those whose exposure occured in 1976. All participants were asked about both present and previous symptoms, the latter defined for formerly exposed workers as symptoms occurring during the time they were exposed in 1975, and for currently and non-exposed workers as symptoms occurring six months previously (i.e. the latter part of 1975).

2. Physical Examination and Pulmonary Function Tests: All workers still working at the site who were interviewed during the questionnaire survey were invited to participate. The examination was limited to inspection of skin color, chest configuration, breathing pattern, and percussion and ausculation of the chest. Pulmonary function was tested with a waterless, portable spirograph apparatus (Vitalograph™). Each person was required to perform five forced expiratory volume maneuvers; the best was selected to determine the following lung function parameters: (1) forced vital capacity (FVC), (2) one-second forced expiratory volume ($FEV_{1.0}$), and (3) maximal mid-expiratory flow volume (MMEF). The predicted normal values were derived from the nomogram by Kamburoff and Wortowitz.[9] Abnormal function was considered present when $FEV_{1.0}$ or FVC was less than 80% of predicted values or when MMEF was less than 50% of predicted normal.

E. Evaluation Criteria

a. Environmental Criteria

NIOSH [40] recommends the following criteria for occupational exposure to airborne asbestos fibers. No employee may be exposed to an 8-hour time-weighted average airborne concentration of asbestos fibers in excess of 100,000 fibers greater than 5 micrometers in length per cubic meter (or 0.1 fiber >5 μm/cc) of air, as determined on the basis of a 40-hour work week. No employee may be exposed to airborne concentrations of asbestos fibers in excess of 500,000 fibers greater than 5 micrometers in length per cubic meter (or 0.5 fibers >5 μm/cc) of air, as determined over a period up to 15 minutes.

"This recommended standard of 100,000 fibers < 5 μm in length per M^3 is intended to (1) protect against the non-carcinogenic effects of asbestos and (2) materially reduce the risk of asbestos-induced cancer (only a ban can assure protection against carcinogenic effects of asbestos)."[40]

The total and respirable dusts were presumed to consist primarily of fibrous glass and hardened resin particles. Though no recognized U.S. environmental criteria (NIOSH, ACGIH, OR OSHA) exists for cured polyester or epoxy particulate, the available toxicological data [10-13] indicate that they would be categorized as nuisance particulates. The ACGIH (1976) has categorized fibrous glass (<7 μm diameter) as a nuisance particulate. A nuisance type dust is characterized by the following histologic features:[14] (1) The architecture of the air spaces remains intact. (2) Collagen (scar tissue) is not formed to a significant extent. (3) The tissue reaction is potentially reversible. Data derived from animal models demonstrate the carcinogenicity of small diameter glass fibers [15-19] and the possibility of human carcinogenicity has been posed by a case-control study.[20] In view of the implication derived from such data that glass fibers are potentially carcinogenic for man, this author believes that a nuisance categorization of the total and respirable dusts (because of their fibrous glass constituent) is inappropriate. Thus, exposure to airborne fibrous glass should be kept at an absolute minimum. NIOSH is currently preparing a criteria document for a recommended standard for fibrous glass.

To date, the available literature reveals that criteria for occupational exposure to polyglycol diamine does not exist.

The standards for occupational exposure to monomeric styrene and methyl ethyl ketone are those promulgated by the U.S. Department of Labor - OSHA (Federal Register, July 1, 1975, Volume 39, Title 29, Part 1910, Subpart Z, Section .1000). These standards follow:

Material	8-hour time weighted average	*Acceptable ceiling concentration	Acceptable maximum peak above the acceptable ceiling concentration for 8-hour shift	
			Concentration	Maximum duration
Methyl ethyl ketone	200 ppm**			
Styrene (Monomeric)	100 ppm	200 ppm	600 ppm	5 minutes in any 3 hours

*An employee's exposure to monomeric styrene shall not exceed at any time during an 8-hour shift the 200 ppm limit, except for a 5 minute period, and up to a concentration not exceeding the maximum duration and concentration allowed in the column under *"acceptable maximum peak ... for an 8 hour shift.

**Parts of vapor per million parts of contaminated air by volume.

b. Medical Criteria

The medical criteria used to determine a toxic response to the substances under investigation consist of symptoms and signs which each agent produces when a toxic exposure occurs. A brief review of the known pathophysiological effects of the substances and supplemental references follows. Interpretation of pulmonary testing is included in the Medical Methodology Section of this report.

1. Asbestos: Available studies provide conclusive evidence that exposure to asbestos fibers causes asbestosis[21-24] and cancer[25-27] in man.

Asbestosis is a chronic lung disease due to inhalation of asbestos fibers and is characterized by diffuse interstitial fibrous, frequently associated with pleural fibrosis (thickening) or pleural calcification. The characteristic x-ray changes are small irregular opacities in the lower and middle lung fields. Asbestosis is a progressive disease which may develop fully in seven to nine years, depending on exposure levels. Usually the pneumoconiosis becomes evident 20-40 years after the first exposure, and progresses even after the exposures have ceased.[22] Breathlessness on exertion may be the most sensitive symptom index related to exposure.

Bronchogenic carcinoma and mesothelioma occur among persons exposed to asbestos fibers. There is a marked enhancement of the risk of bronchogenic carcinoma (lung cancer) in those exposed to asbestos who also smoke cigarettes. [28,33] Mesothelioma is a cancer of the lining of the chest (pleura) or the abdominal cavity (peritoneum). Other types of cancer occurring from exposure to asbestos fibers include gastrointestinal tract and larynx.

2. Fibrous Glass: The known pathophysiologic effects of fibrous glass were very well summarized by Lucas and Rosensteel of NIOSH and are directly quoted.[29]

"Fibrous glass is currently incorporated into an extremely wide range of plastic resin systems utilized in today's modern technologies. Fibrous glass fiber diameters can be varied within close tolerances during manufacture and usually range from .00012 to .004 inches depending upon the characteristics needed in the eventual application or product. This variation in diameter is important since it has been shown that fibers less than .00018 inches do not irritate human skin; while fibers with diameters greater than .00021 inches commonly do so. Apparently fine fibers lack the rigidity to penetrate the skin surface. While nearly all glass fibers, regardless of their ultimate use, are coated with various binders, lubricants or coupling agents, no component of allergic sensitization has yet been demonstrated in fibrous glass dermatitis. This is probably due to the fact that the resin systems are usually in a fully cured state prior to human exposure. Clinically, fibrous glass produces a miliarial eruption with tiny red papules. Generally, the itching is intense and is usually entirely out of proportion with the objective findings. Secondary lesions from scratching are usually evident.

Fortunately, superficial infections are rarely observed. In the vast majority of employees exposed to fibrous glass, the discomfort or dermatitis is relatively mild and quickly abates as "hardening" occurs. "Hardening" to fibrous glass will occur in almost all employees who have any degree of continuous exposure. This phenomenon, however, is not seen where only an intermittent or episodic type exposure occurs. Glass fibers once airborne, may also result in eye and upper respiratory tract irritation."

The carcinogenicity of small diameter glass fibers has been demonstrated in laboratory animals.[15-19] A retrospective mortality study conducted by NIOSH[20] among 1,448 workers occupationally exposed to large diameter glass fibers failed to demonstrate any risk of malignant respiratory disease even following 20 years from onset of exposure. However, this study did demonstrate a significant excess of non-malignant respiratory disease (excluding pneumonia and influenza). In addition, a case-control study from this same population did demonstrate an association of borderline significance between respiratory tract cancer and worker exposure at processes producing small diameter glass fibers (1-3 micrometers).

3. Monomeric Styrene: Styrene vapor at concentrations of 200 to 400 ppm were found to have transient irritant effects on the eyes.[30] Styrene sickness characterized by symptoms of headache, sleepiness, nausea, vomiting, general weakness, and loss of appetite has occurred among workers exposed to styrene vapor.[31] Exposure to levels around 200 ppm did not affect the hemopoietic system.[32] The available toxicological literature showed no evidence of cumulative toxicity resulting from styrene vapor exposure.

4. Cured Resins: Animal experiments have been performed to determine the biological activity of cured polyester and epoxy resins. Reports by Schepers et al [10-12], on animal exposures to polyester-fiber glass dust (generated from cutting, sawing and planing of cured reinforced plastic) indicated a general pulmonary response comparable to that produced by mineral dusts. Ruttner[13] showed the relative inactiveness of cured epoxy dust. In his experiments fine epoxy resin-silicon dust proved to be less fibrogenic in interperitoneal test in mice than pure silicon.

5. Methyl Ethyl Ketone (MEK): MEK vapors may cause eye and mucous membrane irritation.[30] In humans,[34] concentrations of 300 ppm or higher, usually give rise to complaints of headache, throat irritation and other symptoms of respiratory discomfort. At 500 ppm, nausea and vomiting have been reported.[34]

6. Polyglycol Diamine: Published literature on the toxicological properties of this epoxy hardener is indeed meagre. The only data available to NIOSH was that contained in a product information brochure provided by the manufacturer.[35] The toxicological properties listed in the aforementioned guide are directly quoted.

> BAKELITE® Liquid Epoxy Hardener ZZL-0822 is moderately toxic. Skin contact or breathing of vapors of BAKELITE® ZZL-0822 should be avoided or sensitization may result. The liquid may also cause skin irritation and eye injury."

BAKELITE® Epoxy Hardener	Single Oral LD_{50}, Rats g./kg.	Single Skin Penetration LD_{50}, Rabbits ml./kg	Single Inhalation Concentrated Vapor or Specific Concentration in ppm, Rats	Primary Skin Irritation Rabbits	Eye Injury Rabbits
ZZL-0822	4.29 ml	2.50	killed 2/12	Burns	Severe

F. Evaluation Results and Discussion

a. Environmental Evaluation

Employee exposure to airborne asbestos fibers total and respirable dusts, monomeric styrene, methyl ethyl ketone, and polyglycol diamine, during fabrication of glass reinforced plastic pipe joints have been assessed. Lack of a satisfactory sampling and analytical technique for methyl ethyl ketone peroxide (the polyester resin catalyst) prevented any environmental assessment of this substance.

1. Asbestos

The cured epoxy pipe contains chrysotile-asbestos in a concentration ranging from approximately 0.3% by weight to a maximum of 1.5% by weight, dependent upon the diameter of the pipe. Although the asbestos fibers are "locked in" or bound by the epoxy resin, air sampling was conducted to determine if the abrading action of the grinding wheel during pipe surface preparation could release these fibers. All determinations of airborne concentrations of asbestos fibers were made by the membrane filter method at 400-450x magnification with phase contrast illumination.

The concentrations of asbestos fibers generated during surface preparation of a 12 inch diameter glass-reinforced epoxy pipe were measured at the breathing zone of two pipe fitters (Nos. 1 and 2) on June 22, 1976. Pipe fitter No. 1 was responsible for rotating the pipe, while pipe fitter No. 2 operated a hand-held compressed air powered disc grinder. The measured concentrations for the "actual sample period" are shown in Table 1. Nine personal samples were collected; 4 and 5 samples, respectively. All samples showed asbestos fiber concentrations less than (<) the minimum detectable limit by the phase contrast microscopy technique. The differences in minimum detectable levels reported (<100,000 or <400,000 fibers) may be due to a number of factors such as air volume of the sample, microscope field counting area, number of microscopic fields counted and presence or absence of non-fibrous particles.

2. Total and Respirable Airborne Particulate

Total and respirable airborne particulate levels generated during surface preparation of 18, 8.5 and 14 inch diameter glass-reinforced polyester pipes were measured on January 15, and April 29-30, 1976, respectively. Surface preparation of the respective pipes was conducted at three different locations: (1) Inside an open building. (2) Inside an approximately 5 to 6 foot deep water meter pit (Pump Station No. 2). (3) Underneath the power station office building. The particulate was presumed to consist primarily of fibrous glass and hardened resin, among other constituents such as the aforementioned asbestos fibers. Total particulate include those particles which are respirable and non-respirable. Whereas, respirable particulate are particles of a size capable of reaching parts of the respiratory tract where they may elicit a toxic response. A diameter of 7.1 micrometers (aerodynamic diameter) is generally accepted as the cut-off point between respirable and non-respirable particles. Particles above this size will be effectively trapped in the nasal passages on inhalation to be swallowed and discarded via the gastrointestinal tract.

The personal breathing concentrations of respirable and total particulate are summarized in Tables 2, 3, and 4. The concentrations of respirable particulate ranged from 0.10 to 1.14 mg/M^3 (average of 0.68 mg/M^3) and the concentration of total particulate ranged from 1.21 to 3.65 mg/M^3 (average of 1.92 mg/M^3). The highest levels (respirable and total) were measured at the breathing zone of pipe fitter No. 2 who operated a disc sander during surface preparation of an 18 inch diameter pipe (Table 2). The concentrations of respirable particulate ranged from 0.82 to 1.14 mg/M^3 (average 0.98 mg/M^3) and the concentrations of total particulate ranged from 1.46 to 3.65 mg/M^3 (average of 2.45 mg/M^3). An 18 inch diameter pedestal fan provided mechanical ventilation during surface preparation of the 18 inch diameter pipe. Significantly lower concentrations were measured during surface preparation of the 8.5 and 14 inch diameter pipes (Tables 3 and 4, respectively). The concentrations of respirable particulate ranged from

0.10 to 0.89 mg/M^3 (average of 0.45 mg/M^3) and the concentrations of total particulate ranged from 1.21 to 1.83 mg/M^3 (average of 1.52 mg/M^3). The decrease in particulate levels was attributable to a 3500 scfm local ject-air exhauster positioned at the grinding surface; a control measure first introduced on the day (April 29, 1976) of sampling. Because fibrous glass particles have been shown to have carcinogenic activity in animals and fibrous glass was a constituent of the particulate measured, it is difficult to place the above data into an occupational health perspective relative to concentration. Other than stating that, if an 8-hour TWA were calculated from the maximum personal exposure concentrations of respirable and total particulate measured, the respective levels would be 0.25 and 0.81 mg/M^3. Furthermore, the actual exposure concentration of fibrous glass particles would be some percentage of these figures.

3. Monomeric Styrene and MEK

Personal breathing zone concentrations of monomeric styrene were measured during polyester resin make-up and laminate lay-up operations in conjunction with fabrication of the aforementioned 18, 8.5 and 14 inch diameter pipe joints (Tables 5, 6 and 7, respectively). The fabrication areas were the same as those listed for particulate sampling during surface preparation. Methyl ethyl ketone (MEK) levels were also concurrently measured during fabrication of the 8.5 and 14 inch diameter joints.

The levels of monomeric styrene measured during fabrication of an 18 inch diameter joint were less than 6% of the selected environmental criteria (Table 5). However, the data obtained most likely are not truly representative of the workers' exposures because the sampling strategy was not designed to address the acceptable ceiling concentration or acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift for styrene which would have been a better index of exposure in contrast to the long term (4.8 hrs.) samples as taken, i.e. peak exposure concentrations during resin make-up and lay-up could have been measured and not diluted by the long term sampling performed. Consequently, a short term and peak period sampling strategy was developed to assess the concentrations of monomeric styrene during fabrication of 8.5 and 14 inch diameter joints on April 29-30, respectively. Short term samples were collected to determine if the workers' cumulative exposure during resin make-up through lay-up exceeded the 100 ppm standard determined as a TWA for an 8-hour workday. The cumulative exposure periods for these procedures on the respective study dates were 80 and 66 minutes. Peak period samples were ten minute samples necessary to determine if the maximum exposure level occurring during make-up and lay-up exceeded the acceptable ceiling concentration (200 ppm) or acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift (600 ppm).

A total of 4 short term breathing zone samples were taken during the combined resin make-up and laminate lay-up periods on April 29-30, (Tables 6 and 7, respectively). The vapor levels ranged from 1.7 to 10.2 ppm and 23.4 to 25.3 ppm, respectively. The 8-hour TWA exposures were both less than 4% of the 100 ppm standard. Thirteen peak period samples were collected. Of these, 3 during resin make-up and the remainder during laminate lay-up. The vapor levels during make-up ranged from 31.3 to 136.4 ppm (average of 78.1 ppm) and those during lay-up from 0.2 to 65.6 ppm (average of 23.1 ppm), which are below the ceiling standards of 200 and 600 ppm. The short term and peak period exposure data appear to be consistent with a previously referenced paper[4]. It reported that the highest concentrations of monomeric styrene vapor occur during the initial mixing of the styrenated-resin and catalyst, which then decreases during lamination as the resin approaches curing. The concurrent levels of MEK measured were less than 0.8 ppm, which is below the 200 ppm occupational health standard. It is the opinion of this author that the environmental levels of monomeric styrene and MEK measured on April 29-30 are probably representative of the concentrations encountered during GRP pipe fabrication under similar conditions of exposure. These conditions include joint fabrication in relatively confined areas or spaces, no mechanical exhaust ventilation, fabrication of 8.5 to 14" diameter pipe joints, and ambient temperatures around 70°F. However, during the summer months of 1975 when the health complaints were the greatest, larger diameter joints (24-36 inches) were being fabricated and the ambient temperatures were considerably higher, thus it is reasonable to assume the vapor levels were also higher.

4. Polyglycol Diamine

Airborne levels of polyglycol diamine (the main component in the epoxy hardener) were measured during fabrication of the "ring or bell end" of a ten inch diameter glass-reinforced epoxy pipe on June 22, 1976. No amine was detected on either of two personal breathing zone samples collected over a period of 12 minutes. The limit of detection for the analytical method was 0.02 mg amine/charcoal tube. Because of such meager data, much can not be said about airborne exposure concentrations of this amine. However, due to the dermal and respiratory sensitizing capabilities of this amine, the use of personal protective and ventilation equipment should be of paramount consideration.

B. Medical Evaluation

1. Questionnaire Survey Results

Fourty-one workers were interviewed: 19 were never exposed; 16 were formerly, but not currently exposed; 3 were both currently and formerly exposed; and 3 were currently, but not formerly exposed.

For purposes of data analysis symptoms were grouped. Dermatologic symptoms included rash, itching, and cracked, red, or inflamed skin. Ocular symptoms included eye discomfort and redness. Minor respiratory symptoms included nasal discomfort, coryza, sneezing, sore throat, and trouble swallowing. Major respiratory symptoms included choking sensation, difficulty breathing, and chest discomfort. Constitutional symptoms included headache, dizziness, fatigue, sleepiness, general weakness, nervousness, altered appetite, and unintentional weight loss.

There was no significant difference among the various exposure categories with respect to mean age, mean duration of work as a pipefitter, or prevalence of smoking (Table 8). There were only six currently exposed workers; they did not differ significantly from non-exposed workers with respect to prevalence of present symptoms (Table 9).

Formerly exposed workers reported a significantly greater previous prevalence of major respiratory, dermatologic, and ocular symptoms, and of nausea or vomiting, than non-exposed workers (Table 10). In addition, formerly exposed workers had a greater prevalence of current major respiratory symptoms than did unexposed workers (Table 9); this difference was not related to cigarette smoking.

2. Physical Examination and Pulmonary Function Tests Results

All 25 employees still at the site participated. One, for unknown reasons, did not have the physical examination; another did not have the spirograph test because of chest and abdominal wall muscular discomfort that prevented maximal inspiration and forced expiration.

No significant abnormalities of skin color (i.e. cyanosis, pallor, plethora) were found, nor did anyone have breathing pattern abnormalities (i.e. forced or prolonged expiration, high respiratory rate, wheezing, or labored breathing). No percussion abnormalities were detected. Adventitious breath sounds were noted in two cases: right-sided ronchi were present in a 53-year-old smoker with a history of surgery for a "collapsed" right lung, and bilateral ronchi were present in a 47-year-old smoker. The 53-year-old man was both formerly and currently exposed to the pipe joint fabrication process; the 47-year-old man was not exposed.

Eight workers, including both of those with ronchi, had chest configurations (increased antero-posterior diameter and/or widened infrasternal angle) suggestive of chronic obstructive pulmonary disease. This finding was not associated with exposure to pipe joint fabrication, smoking, or duration of employment, but it was associated with age (Tables 11 and 12).

Of the 24 workers who had the spirograph examination, 20 had normal pulmonary function; i.e. FVC and FEV 1 were each 80% of predicted normal, and MMEF was $\geq$50% of predicted normal. In three cases pulmonary function was abnormal, and in one case the test was unsatisfactory for interpretation. FVC, FEV 1, and MMEF were all low in the worker who had pulmonary surgery in 1972; he is a 53-year-old heavy smoker, was formerly and currently exposed to pipe joint fabrication, had past and present major respiratory symptoms, had an abnormal chest configuration, and had adventitious breath sounds. FEV 1 and MMEF were low in a 59-year-old non-smoker, never exposed to pipe joint fabrication, who had no respiratory symptoms and a normal chest examination. FEV 1 was low in a 41-year-old heavy smoker, never exposed to pipe joint fabrication, who had no respiratory symptoms; his chest was not examined.

3. Discussion

The symptoms associated with pipe joint fabrication work are compatible with short term exposure to the materials involved and the airborne dust and vapors generated. Fibrous glass is a known skin and mucous membrane irritant[29,36]. The components of the styrenated-polyester resin system and its residual vapors have been associated with dermatologic, gastrointestinal, neurologic, and respiratory symptoms[2,30,31,34,37]. In this study, neither past nor current respiratory symptoms are associated with objective evidence of pulmonary dysfunction. A recent NIOSH study[38] of workers having prolonged exposure to the same materials also failed to demonstrate an association between exposure and pulmonary dysfunction.

The lack of a significant increased prevalence of symptoms in workers who had only recent exposure is probably due to the use of personal protective measures and mechanical air exhaust equipment. Additionally, an association between exposure and symptoms may not have been detected because of the relatively small number of currently exposed workers. Finally, the epoxy system, which largely replaced the polyester system, may not be as productive of equally potent irritants; polyglycol diamine is the only irritant of significant quantity contained in the epoxy system, whereas the polyester resin system contains styrene and MEKP in addition to, and in greater concentration than polyglycol diamine.

The study[38] mentioned above found no association between continuous heavy exposure and various hematologic and biochemical abnormalities. It follows then, that because the workers in this study were, in effect, no longer highly exposed, routine physical and laboratory examinations would not likely have revealed any exposure-related abnormalities and were thus not attempted. This study and the previous study suggest that short-term toxicity is limited to symptoms unassociated with significant physiologic dysfunction and, except for respiratory symptoms, are reversible upon cessation of exposure. The persistence of respiratory symptoms in workers no longer exposed is not explained by the available data.

V. CONCLUSIONS

Particulate and vaporous contaminant exposures of workers involved with laminate lay-up and bonding adhesive techniques, used to fabricate glass-reinforced plastic pipe joint welds, have been evaluated by a NIOSH environmental-medical team. The contaminants aerometrically evaluated were asbestos fibers, total and respirable particulate (presumed to consist primarily of fibrous glass and hardened resin), monomeric styrene, methyl ethyl ketone, and polyglycol diamine. The effects of exposure were evaluated by administering health questionnaires, physical examinations, and pulmonary function tests.

Short term toxicity characterized by dermatologic, gastrointestinal, neurologic, and respiratory symptoms may have existed as reported by the fabrication workers prior to the preliminary NIOSH investigation conducted on January 15, 1976. Because the preliminary investigation suggested a high rate of the aforementioned symptoms, the workers began using personal protective and exhaust ventilation equipment during joint fabrication procedures. Thus, the original working conditions for which the Health Hazard Evaluation was undertaken, in part no longer existed by March or April of 1976.

Some environmental data gathered indicated that acute toxicity could have occurred under conditions of exposure such as high ambient temperatures and joint fabrication in confined areas or spaces without adequate ventilation or personal protective equipment.

The prevalence of present symptoms among workers currently exposed to the polyester and/or epoxy resin contaminants did not differ significantly from that of non-exposed workers.

Neither past nor current respiratory symptoms in workers are associated with objective evidence of pulmonary dysfunction. A study conducted by Rosensteel and Meyer [38] of boat hull lamination workers having prolonged exposure to the same materials also failed to demonstrate a causal relationship between exposure and pulmonary dysfunction.

The available health effects data concerning long term exposure to airborne fibrous glass is non-conclusive. In view of the experimental studies demonstrating the carcinogenicity of small diameter glass fibers in animals and the possibility of human carcinogenicity posed by a case-control study, worker exposure to airborne glass fibers should be kept at an absolute minimum.

VI. RECOMMENDATIONS

The following are suggested industrial hygiene practices that can help minimize dermal and respiratory exposures to the contaminants apparent in the process of fabricating glass-reinforced plastic pipe joints.

1. Engineering Control: The most effective control of any contaminant is control at the source of generation. Use of the 3500 scfm ject-air exhauster during surface preparation, resin make-up and application procedures should be continued. However, emphasis should be placed on positioning the exhauster as near the point of contaminant generation as possible.

2. Respirators: In view of the fact that respirators are used, a respirator program should be initiated and enforced by management with union support. OSHA through 29 CFR Part 1910.134, established the requirement for preparing a formal respiratory protection program for control of occupational diseases caused by breathing air which contains certain contaminants. A NIOSH document, titled "A Guide to Industrial Respiratory Protection", will serve as a reference source with information for establishing and maintaining a respiratory program which meets the requirements of 29 CFR Part 1910.134 [39].

   Respirators used should be those certified under the NIOSH respirator standards, 30 CFR, Part 11.

   Respirators should be issued with caution. There might be individuals in the group for whom wearing a respirator carries certain specific dangers, i.e. highly increased resistance to airflow in a person with compromised pulmonary function may be associated with acute respiratory insufficiency. Therefore, pulmonary function testing should be carried out prior to requiring any person to wear a respirator.

3. Apprisal of Employees of Hazards: All employees involved in fabrication should be instructed as to the hazards of their jobs, and in the personal protection and first aid procedures applicable to these hazards.

4. Protective Clothing: The employees involved in sanding and buffing operations where contact with fibrous glass containing resins is highly probable should wear loose fitting clothing and changed daily. Tight fitting clothing such as collars and cuffs encourages the entrapment of any airborne fibrous glass spicules and aggravates the dermatitis or may result in skin irritation.

In order to prevent dermatogic effects from contact with liquid styrene or MEK peroxide or the epoxy hardener, employees exposed routinely to such contact should be provided with gloves and aprons made of neoprene or nonsoluble plastic such as polyethylene.

5. Barrier Creams: In operations where protective clothes such as gloves would hinder the work or engender a significant safety problem a protective barrier cream should be used. Suitable barrier creams effective against fibrous glass spicules, styrene, MEK peroxide and the epoxy hardener are commercially available. The cream should be provided to the employee and used regularly, and instruction in the use should be constantly reviewed.

   Resin-removing creams should be avialable to employees with a supply of clean rags or paper towels. Use of organic solvents for washing hands and other contacted areas should be strongly discouraged.

6. Eye Contact: PREVENT EYE CONTACT. The use of chemical-type safety or face shield is advisable during resin make-up. Suitable eye wash facilities should be available in areas where chemical splashes may occur. Portable chemical splash bottles may suffice.

7. Labelling of Materials: Appropriate warning labels should be affixed to all materials used. These labels should apprise the workers of potential hazards (such as flammability) and provide directions for emergency action in the event of accidental over exposure via inhalation, ingestion, etc.

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The staff of NIOSH wish to express their thanks to the following management and labor representatives and all others for their assistance in completing this study.

Management	Labor
Charles Sankler	Lou Morstadt
Rod Miller	Tom Herms
Marvin Morrison	Vince Eby
	Al Johnson

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TABLE

Personal Breathing Zone Concentrations of Asbestos Fibers
Measured During Surface Preparation of a 12 Inch Diameter Glass-Reinforced Epoxy Pipe

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

June 22, 1976

Job Classification	Sample Period	Sample Volume Liters	*Measured Airborne Concentrations Fibers >5μm in length/M^3 of air
Pipe Fitter No. 1	1015-1030	30	N.D.
"	1030-1037	14	N.D.
"	1125-1152	54	N.D.
"	1245-1247	4	N.D.
Pipe Fitter No. 2	1020-1035	30	N.D.
"	1035-1037	4	N.D.
"	1125-1144	38	N.D.
"	1145-1152	14	N.D.
"	1245-1247	4	N.D.

*Denotes that no asbestos fibers were detected on the membrane filters.

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"	1125-1152	54	N.D.
"	1245-1247	4	N.D.
Pipe Fitter No. 2	1020-1035	30	N.D.
"	1035-1037	4	N.D.
"	1125-1144	38	N.D.
"	1145-1152	14	N.D.
"	1245-1247	4	N.D.

*Denotes that no asbestos fibers were detected on the membrane filters.

Table ∠

Personal Breathing Zone Concentrations of Airborne Particulate
Measured During Surface Preparation of an 18" Diameter GRP Pipe

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

January 15, 1976

*Job Classification	Sample Period	Sample Volume Liters	Measured Air Concentration - mg/M^3	
			Respirable	Total
Pipe Fitter No. 1	0830-1017	182.	0.99	
"	0830-1017	214.		2.24
Pipe Fitter No. 2	0830-1017	177.	1.14	
"	0830-1017	208.		3.65
Pipe Fitter No. 3	0830-1018	184.	0.82	
"	0830-1018	216.		1.46

*Pipe Fitter No. 2 operated the disc sander

Table [illegible]

Personal Breathing Zone Concentrations of Airborne Particulate
Measured During Surface Preparation of an 8.5" Diameter GRP Pipe

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

April 29, 1976

*Job Classification	Sample Period	Sample Volume Liters	Measured Air Concentration - mg/M^3 Respirable	Measured Air Concentration - mg/M^3 Total
Pipe Fitter No. 1	1014-1125	121.	0.38	
"	1014-1125	142.		1.32
Pipe Fitter No. 2	1014-1125	121.	0.89	
"	1014-1125	142.		1.71

*Pipe Fitter No. 2 operated the disc grinder

Table

Breathing Zone Concentrations of Airborne Particulate
Produced During Surface Preparation of a 14" Diameter GRP Pipe

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

April 30, 1976

*Job Classification	Sample Period	Sample Volume Liters	Measured Air Concentration - mg/M^3	
			Respirable	Total
Pipe Fitter No. 1	1035-1140	111.	0.10	
"	1035-1140	130.		1.21
Pipe Fitter No. 2	1035-1140	111.	0.41	
"	1035-1140	130.		1.83

*Pipe Fitter No. 2 operated the disc grinder

Table 5

Personal Breathing Zone Concentrations of Monomeric Styrene
Measured During Polyester Resin Make-Up and Laminate Lay-Up of an 18" Diameter GRP Pipe Joint

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

January 15, 1976

Job Classification	Sample Period	Sample Volume Liters	Measured Air Concentration-ppm	Comments
Pipe Fitter No. 1	1020-1513	41.3	5.3	Make-Up and Lay-Up
Pipe Fitter No. 2	1019-1513	41.8	0.7	Laminate Lay-Up
Pipe Fitter No. 3	1020-1513	41.8	1.0	Laminate Lay-Up

Tab._ 6

Personal Breathing Zone Concentrations of Monomeric Styrene and Methylethylketone (MEK)
Measured During Polyester Resin Make-Up and Laminate Lay-Up of an 8.5" Diameter GRP Pipe Joint

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

April 29, 1976

Job Classification	Sample Period	Sample Volume Liters	Measured Air Concentrations-ppm		Comments
			Monomeric Styrene	MEK	
Pipe Fitter No. 1	1345-1505	15.4	10.2	0.4	Make-Up & Lay Up
Pipe Fitter No. 1	1321-1331	10.0	31.3	0.7	Resin Make-Up
Pipe Fitter No. 1	1355-1405	10.0	20.5	0.3	Laminate Lay-Up
"	1450-1500	10.0	0.2	<0.3	" "
Pipe Fitter No. 2	1345-1505	16.1	1.7	<0.3	Make-Up & Lay-Up
Pipe Fitter No. 2	1321-1331	10.0	7.1	<0.3	Laminate Lay-Up
"	1355-1405	10.0	6.4	<0.3	" "
"	1450-1500	10.0	0.2	<0.3	" "

Table

Personal Breathing Zone Concentrations of Monomoric Styrene and Methylethylketone (MEK)
Measured During Polyester Resin Make-Up and Laminate Lay-Up of 14" Diameter Pipe Joint

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

April 30, 1976

Job Classification	Sample Period	Sample Volume Liters	Measured Air Concentrations-ppm		Comments
			Monomeric Styrene	MEK	
Pipe Fitter No. 1	1335-1441	17.1	25.3	<0.3	Make-Up & Lay-Up Cycle
Pipe Fitter No. 1	1330-1340	10.0	136.4	<0.3	Resin Make-Up
"	1345-1355	10.0	61.1	<0.3	Laminate Lay-Up
"	1420-1430	10.0	24.9	<0.3	" "
Pipe Fitter No. 2	1335-1441	15.4	23.4	<0.3	Laminate Lay-Up Cycle
Pipe Fitter No. 2	1330-1340	10.0	65.6	<0.1	Laminate Lay-Up
"	1345-1355	10.0	16.7	<0.1	" "
"	1420-1430	10.0	28.0	<0.1	" "
Pipe Fitter No. 3	1420-1430	10.0	66.5	<0.1	Resin Make-Up

Table 8

Age, Work History, and Smoking History of Pipe Fitters

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

April 1976

	Currently exposed only	Currently and formerly exposed	Formerly exposed only	Total currently exposed	Total formerly exposed	Total ever exposed	Never exposed
Number of Workers	3	3	16	6	19	41	19
Mean age (years)	39	53	41	46	43	43	44
Mean duration of work as pipefitter (years)	16	20	18	18	18	19	20
% Current cigarette smokers	100	33	56	67	53	54	47
% Past cigarette smokers	100	33	63	67	58	56	47

Table 9

Current Symptoms in Pipe Fitters

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

April 1976

	Currently exposed only	Currently and formerly exposed	Formerly exposed only	Total currently exposed	Total formerly exposed	Never exposed
Respiratory, major, % with symptoms	0	33	@38*	17	37	@@5*
Respiratory, minor only, % with symptoms	33	33	25	33	32	21
Nausea/Vomiting, % with symptoms	0	33	0	17	5	0
Constitutional, % with symptoms	33	33	31	33	32	32
Ocular, % with symptoms	0	33	38**	17	37	11**
Dermatologic, % with symptoms	0	67	0	33	11	11

* P = .024 (Fisher's exact test, 1-tailed)

** P > .05 (Fisher's exact test, 1-tailed)

@ 3 smokers and 3 non-smokers

@@ 1 non-smoker

Table 10

Previous Symptoms in Pipe Fitters

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

April 1976

	Currently only	Currently and formerly	Formerly only	Total currently	Total formerly	Never exposed
Respiratory, major, % with symptoms	0	33	50	17	47*	5*
Respiratory, minor only, % with symptoms	33	33	25	33	**** 32	**** 25
Nausea/Vomiting, % with symptoms	0	67	25	33	32**	5**
Constitutional, % with symptoms	67	67	63	67	**** 63	**** 37
Ocular, % with symptoms	0	100	69	50	*** 74	*** 16
Dermatologic, % with symptoms	0	67	81	33	*** 79	*** 5

* $P = .004$ (Fisher's exact test, 1-tailed)
** $P = .045$ (Fisher's exact test, 1-tailed)
*** $P < .001$ (Fisher's exact test, 1-tailed)
**** $P > .05$ (Fisher's exact test, 1-tailed)

Table 12

Age, Work History, and Smoking History
(Information Obtained April 1976)
In Pipe Fitters Who Were Examined June 1976

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

	Normal examination	Abnormal physical findings	Total	% with abnormalities
All examinees	16	8	24	33
Past smokers	9	3	12	25
Current smokers	10	3	13	23
Never smokers	6	5	11	45
Mean age (years)	36*	52*	41	
Mean duration of work as pipefitter (years)	15**	23**	17	

* $P < .001$ (Student's t-test, 2-tailed)

** $P > .05$ (Student's t-test, 2-tailed)

Table 11

Physical Findings in Pipe Fitters

Spurlock Power Station
Fuel Economy Company
Maysville, Kentucky

June 1976

	Currently only	Currently and formerly	Formerly only	Total currently	Total formerly	Never Exposed	Total employees
Number examined	1	3	10	4	13	10	24
Number with Abnormal Findings	0	3	1	3	4	4	8
% with Abnormalities	0	100*	10	75	31	40*	33

* $P > .05$ (Fisher's exact test, 1-tailed)