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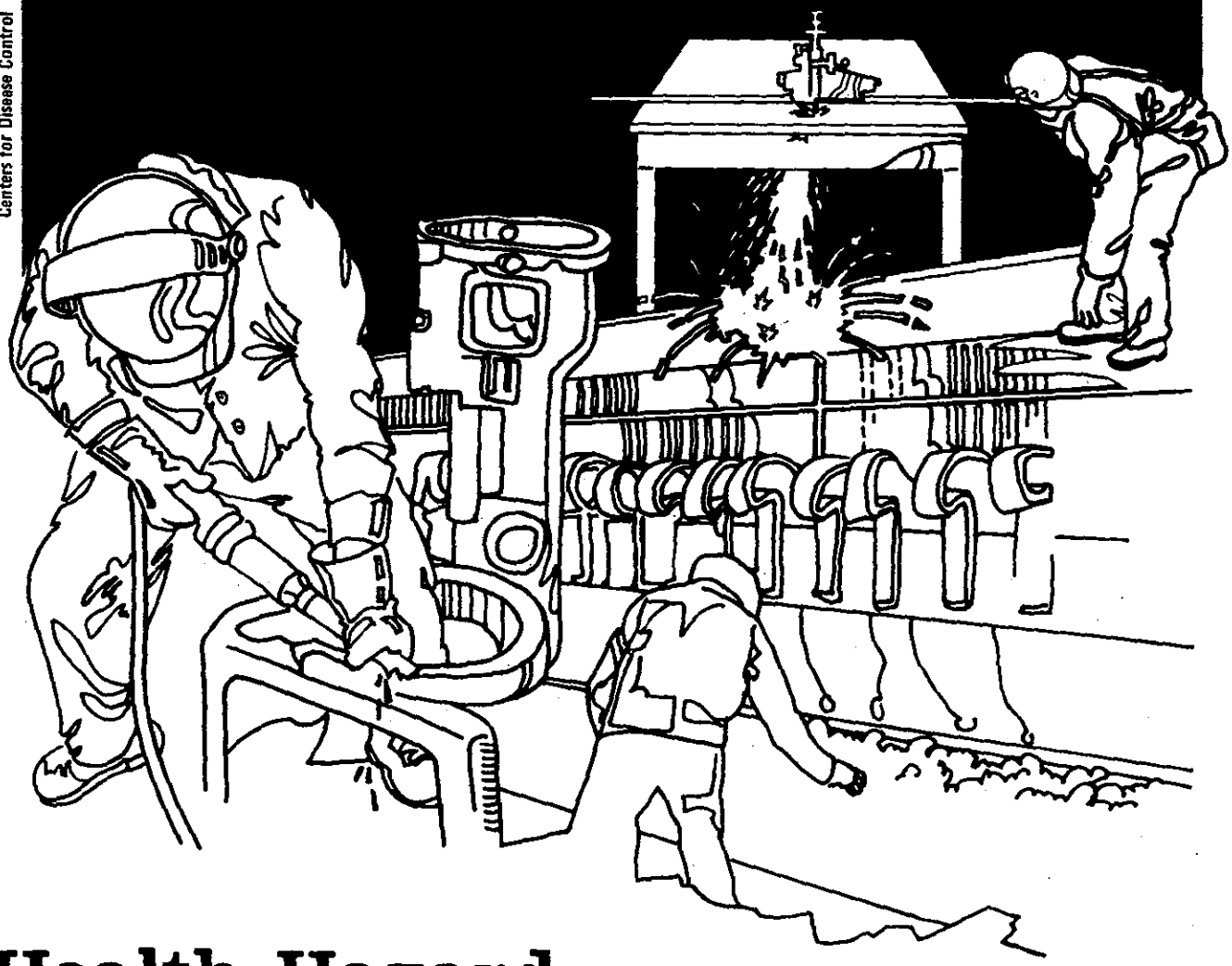

Health Hazard Evaluation Report

HHE 79-012-809
POWERS-FIAT CORPORATION
MONROE, OHIO

REGION-5

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. 699(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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

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16. Abstract (Lim

Area samples were analyzed and employees were given medical evaluations at Powers-Fiat Corporation (SIC-3079) in Monroe, Ohio on six occasions between November 11, 1978 and January 2, 1980. The evaluation was performed in response to a request from Local 8707 of the United Steelworkers of America, for a health hazard evaluation of worker exposure to ketones and acrylic resins during the manufacture of fibrous glass reinforced plastic tubs and showers. Sampling for a variety of chemicals showed that none of the chemicals tested exceeded the recommended OSHA standards. Methyl-ethyl-ketone-peroxide (1338234) (MEKP) was the primary contaminant to which workers were exposed. Values obtained at sampling ranged from 0.11 to 0.17 parts per million (ppm); the recommended standard for MEKP by the American Conference of Governmental Industrial Hygienists is 0.2ppm. Pulmonary function tests of 30 workers were usually normal before and after shifts, with only 5 workers showing significant decreases in function over the shift. Predominant symptoms were nose and throat irritation, headaches, dizziness and breathing problems. One worker had a hyperreactivity to toluene-diisocyanate (26471625). The authors conclude that even though the chemicals tested were below the recommended standards, hazards may exist due to possible additive or synergistic action from combined chemical exposures. Recommendations to prevent overexposure to MEKP include improved work practices, use of protective equipment such as gloves, face shields and respirators, provision of resin removing creams and eyewash fountains for cleanup, and provision of an education program for employees.

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I. SUMMARY

In October, 1978, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Steelworkers of America to evaluate potential exposure to ketones and acrylic resins during the manufacture of fibrous glass reinforced plastic tubs and showers at the Powers-Fiat Corporation, Monroe, Ohio. Tub molders and fibrous glass resin spray operators complained of headaches, sore throats, dizziness, and lack of energy as a result of contaminant exposure in the workplace.

The NIOSH environmental evaluation consisted of personal and general area sampling for styrene, xylene, acetone, methyl ethyl ketone peroxide (MEKP), toluene, ethyl benzene, titanium dioxide, toluene diisocyanate, phthalic acid esters, methyl methacrylate, asbestos, fibrous glass, and total and respirable particulates (fibrous glass resin mixture).

On the days NIOSH sampled, none of the chemicals evaluated exceeded OSHA standards, NIOSH recommended standards, or American Conference of Governmental Industrial Hygienists Threshold Limit Values. Methyl ethyl ketone peroxide (MEKP) was the primary contaminant to which workers were exposed. The highest MEKP levels were found on personal samples taken in booth 4 (0.11 parts per million, ppm), booth 6 (0.17 ppm), and the maintenance man (0.15 ppm). The maintenance man's exposure was from refilling MEKP containers. Approximately 35 toluene diisocyanate (TDI) samples were taken over four different surveys. All TDI results were below the NIOSH recommended standard of 0.005 ppm.

Medical interviews with workers showed that the predominant symptoms developing over the shift were nose and throat irritation, headaches or dizziness, and breathing problems. Pre- and post-shift pulmonary function testing was conducted on 30 workers. The pulmonary function testing failed to show any work-related chronic changes. Only five workers showed clinically significant decreases in function over shift, without any pattern by job category. One worker, however, had a dose-related, non-allergic hyper-reactivity to TDI, documented by a private physician.

Although none of the chemical agents sampled by NIOSH exceeded individual OSHA standards or NIOSH recommended standards, the additive or possible synergistic action from combined chemical exposure may lead to health effects in the worker. Therefore, on this basis, a potential hazard may exist for sprayers (including painters) from intermittent exposures to various solvents, MEKP, and toluene diisocyanate, which may cause respiratory irritation and/or sensitization. Recommendations concerning respiratory protection and work practices are provided in Section VII of this report.

KEYWORDS: SIC 3079 (Reinforced plastics), pharmacologic response, respiratory problems, toluene diisocyanate, methyl ethyl ketone peroxide, combined organic vapor exposures.

II. INTRODUCTION

Under the Occupational Safety and Health Act of 1970, NIOSH investigates the toxic effects of substances found in the workplace. On October 23, 1978, NIOSH received a request from the United Steelworkers of America, Local 8707, for a health hazard evaluation of worker exposure to ketones and acrylic resins during the manufacture of fibrous glass reinforced plastic tubs and showers. The request was generated following worker complaints of headaches, sore throats, dizziness, and lack of energy.

Powers-Fiat was visited by NIOSH on six different occasions: November 11, 1978, November 30, 1978, March 8, 1979, July 26, 1979, November 19, 1979, and January 2, 1980. Except for the initial survey, environmental measurements were taken on each visit and toxicity determinations were made for each chemical or group of chemicals evaluated. Worker interviews at the worksite indicated that some workers were experiencing respiratory difficulty. Initially, company medical records of employees were reviewed, then the medical evaluation was expanded to include pre- and post-shift pulmonary function testing of all hourly workers in the plant. A time-activity chart for this health hazard evaluation is shown in Table I.

III. BACKGROUND

A. Process Description/Conditions of Use.

The Powers-Fiat Corporation in Monroe, Ohio, manufactures thermoformed fibrous glass reinforced modular tubs and showers. The tub or shower stalls are molded from a methyl methacrylate sheet approximately 7' x 5' x 1/4". The sheets are heated by infrared ovens located 2 feet above an aluminum mold which has the converse shape of the tub or shower modular unit. After heating for approximately 15 minutes at a temperature of 375° F., the softened acrylic sheet is pulled into the mold by a vacuum pump. There are five molds in this plant and approximately six mold operators.

After the units are thermoformed and allowed to air cool, they are lifted out of the mold and carried to a ventilated paint spray booth, where a urethane paint mixture is sprayed onto the backside of the modular units for uniform opaqueness. There is one paint spray booth and two paint sprayers. After painting, the units are allowed to air dry on racks behind the spray booth, which is centrally located to the molding and fibrous glass spraying operators.

After drying, the units are carried to one of six ventilated lamination spray booths where an acrylic resin (styrene mixture), a catalyst (MEKP), and chopped fibrous glass are sprayed and rolled on the modular units for reinforcement. There are usually two operators per lamination booth: one worker operates the hand sprayer while the other worker, using a roller much like those employed for painting, rolls the newly applied lamination to remove gas bubbles and insure that the resin and fibrous glass are thoroughly compressed and mixed. The modular units are usually sprayed twice; each time the lamination is allowed to gel and air dry between the first and second coat.

The last major steps are trimming excess lamination from the modular units and drilling holes for plumbing. The units are then packaged and shipped.

Although there are booths and hoods with ventilation for individual processes, the whole operation is carried out in a single room which is maintained at 80°-90° F. to allow satisfactory curing of resins and paints. Tubs and shower stalls are stacked in the general work areas for curing and drying without any special ventilation.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Styrene, xylene, toluene, ethyl benzene, methyl methacrylate, and acetone were collected on charcoal tubes connected to sampling trains and pumps calibrated at 50 cubic centimeters per minute (cc/min). Personal and general area samples were collected for these contaminants. Analysis was by gas chromatography, where the limit of detection for each sample was 0.01 mg for toluene, xylene, methyl methacrylate, and styrene; and 0.02 mg for ethyl benzene and acetone.[1]

Personal and general area samples were also collected for methyl ethyl ketone peroxide using a midget bubbler and an absorbing solution of dimethyl phthalate. Sampling trains and pumps were connected to the midget bubblers with a calibrated flow rate of 1 liter per minute (lpm). Due to rapid decomposition of this compound, MEKP was analyzed at the plant site. A color reagent, diphenylcarbohydrazide, was added to the bubbler solution and spectrographic analysis made. Quantitation of MEKP was done by comparing spectrograph absorbance levels with prepared standards. The limit of detection for MEKP is 0.01 micrograms per milliliter.

Fibrous glass and titanium dioxide (TiO_2) were collected on AA filters, while respirable and total particulates containing fibrous glass and hardened resin were collected on DM 800 pre-weighed filters. Fibrous glass was analyzed according to NIOSH method P & CAM 239 using phase contrast microscopy. Titanium dioxide was analyzed using NIOSH method P & CAM 173. The limit of detection was 20 micrograms of TiO_2.

Respirable and total particulates were weighed on a Perkin-Elmer model AD-2 electrobalance. Sampling pumps for all contaminants collected on filters ranged between 1.0 and 1.7 lpm.

Toluene diisocyanate (TDI) was collected using impingers with Marcali solution. Analysis of TDI was done by spectrophotometer using NIOSH method P & CAM 141. Bulk samples of urethane paint were also analyzed for free TDI by liquid chromatography and a modification of NIOSH method P & CAM 240.

Bulk samples of sprayed fibrous glass and resin mixtures were collected and analyzed for phthalic acid esters (phthalates), and a maleic and phthalic anhydrides. Other bulk samples were taken from the molding area for asbestos analysis.

Ventilation measurements were taken at all spray booths in the plant using a Kurz air velocity meter (Model 441).

B. Medical

Twenty-five workers were interviewed, in person, by phone, or by mail, regarding past or present work-related illness (Table II). Additional information on some of these workers was obtained from private physicians.

In November 1979 all workers then on duty were given pre- and post-shift pulmonary function tests, pre- and post-shift questionnaires for acute symptoms, and medical questionnaires, including a respiratory questionnaire similar to one developed by the Medical Research Council of Great Britain.[2] The follow-up study groups included 13 men and 17 women. Twenty-three were white and the other seven black. Mean age was 32.6 years, with a range of 19 to 57 years.

"Pre-shift" pulmonary function testing was done early in the shift on a Monday utilizing two Medistor electronic spirometers with pneumotachographs. Care was taken to utilize the same machine and same technician pre- and post-shift for any individual. Because of some problems with interpretation, the two spray painters were retested January 2, 1980, pre- and post-shift following the holiday.

Changes in function over shift was evaluated, as well as predicted values calculated using the formulas of Morris[3] and Lapp[4].

V. EVALUATION CRITERIA

Airborne exposure limits for the protection of the health of workers have been recommended or promulgated by several sources. These limits are established at levels designed to protect workers occupationally exposed to a substance on an 8 or 10-hour day, 40-hour per week basis over a normal working lifetime. For this investigation, the criteria used to assess the degree of health hazards to workers were selected from three sources:

1. Threshold Limit Values (TLV's): Guidelines for Airborne Exposures Recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) for 1980.

2. OSHA Standard: The air contaminant standards enforced by the U.S. Department of Labor - Occupational Safety and Health Administration - as found in the Federal Register - 29 CFR 1910.1000 (Table Z-1).

3. NIOSH Recommended Standards: Criteria Document Guidelines for controlling employee exposure to various contaminants in the occupational environment.

Environmental evaluation criteria are in Table III. For purposes of this investigation, the most stringent criterion is used when there is more than one listed.

A. Environmental

Respirable Dusts (Fibrous glass and hardened resin particulates)

The respirable dusts were presumed to consist primarily of fibrous glass and hardened resin particles. No exposure criteria (NIOSH, ACGIH, or OSHA) exist for cured polyester or epoxy particulate, the available toxicological data indicate that they would be categorized as nuisance particulates. Tissue reaction, if any, to nuisance type dust is characterized by the following histologic features: (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.

The NIOSH Criteria Document on occupational exposure to fibrous glass suggests that the hazard potential of fibrous glass is greater than that of nuisance dust, but less than that of coal dust or quartz.[5]

Organic Solvents (Ketones in particular)

Organic solvents in general can cause irritation of eyes, nose, and throat. Repeated local contact with the skin can lead to defatting and drying and/or rash. The most common systemic effects are headache, fatigue, and sleepiness. Some solvents have disagreeable odors which can cause nausea and digestive upset.[6]

Different solvents will produce the individual symptoms to different degrees. In mixtures, the effects of the various solvents are usually additive.[6]

Styrene (Phenyl Ethylene)

This substance causes eye and mucous membrane irritation at 200-400 ppm, and drowsiness and listlessness, muscle weakness, and unsteadiness at 800 ppm.[7] Transient nausea, vomiting, loss of appetite, and general weakness have been described. Impaired night vision, slight gastric irritation, and leukopenia with relative lymphocytosis have been reported at exposures of 25-50 ppm.[8] Exposure to levels around 200 ppm did not affect the hemopoietic system (blood cell forming). The available toxicological literature showed no evidence of cumulative toxicity resulting from styrene vapor exposure.[9] However, styrene has a structural similarity to vinyl chloride (a carcinogen), and handling and spraying with this chemical should be done in a prudent manner.

Acetone

May produce a dry, scaly, and fissured dermatitis after repeated exposure. High vapor concentrations may irritate the conjunctiva and mucous membranes of the nose and throat. Systemically, high concentrations will produce symptoms of headache, nausea, lightheadedness, vomiting, dizziness, lack of coordination, and unconsciousness.[10]

Toluene

May cause irritation of the eyes, respiratory tract, and skin. Repeated or prolonged contact may cause fissured dermatitis. Acute systemic exposure results in central nervous system depression. Other symptoms include headache, dizziness, fatigue, and drowsiness.[10]

Xylene

Like acetone and toluene, xylene vapor can cause irritation to the eyes, nose, and throat. Repeated or prolonged contact with xylene may lead to dermatitis. Acute exposure to xylene vapor may cause central nervous system depression. At high concentrations xylene vapor may cause dizziness, staggering, drowsiness, and unconsciousness.[10]

Methyl Ethyl Ketone Peroxide (MEKP)

This substance is used to initiate polymerization of plastic monomers. Little human exposure data are available, but available animal studies suggest that it is moderately toxic. Exposed animals show liver and kidney damage at moderate to high levels. Animal experiments also show that it is less toxic than benzoyl peroxide, which has a TLV of 5 mg/M^3. Hence, a standard of 1.5 mg/M^3 standard was considered reasonably safe.[10]

Titanium Dioxide (TiO_2)

The ACGIH (1980) has classified titanium dioxide as a nuisance particulate with a Threshold Limit Value of 10 mg/M^3. Although titanium dioxide is relatively non-toxic, high concentrations can cause some pulmonary irritation.[11]

Asbestos

Available studies provide conclusive evidence that exposure to asbestos fibers causes asbestosis[12] and cancer[13] in man.

Asbestosis is a chronic lung disease caused by inhalation of asbestos fibers and is characterized by diffuse interstitial fibrous, frequently associated with pleural fibrosis (thickening) or plueral calcification. The

characteristic x-ray changes are small, irregular opacities in the lower and middle lung fields. Usually the pneumoconiosis becomes evident 20-40 years after the first exposure, and progresses even after the exposures have ceased.[14] 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.[15] Mesothelioma is a cancer of the lining of the chest (pleura) or the abdominal cavity (peritoneum). Other sites of cancer associated with exposure to asbestos fibers include the gastrointestinal tract and larynx.

Urethane Paints

Urethane paints depend on the polymerization of a diisocyanate in their curing. The diisocyanates in general (and toluene diisocyanate in particular) cause irritation of eyes, nose, throat, and the lower respiratory tract by both a direct irritative and an allergic mechanism. Initial allergic sensitization may be manifest by respiratory difficulty developing during the evening following the exposure. Once a person becomes sufficiently sensitized, very low levels of exposure may cause severe asthmatic attacks. Recommended exposure levels to the diisocyanates are believed to be sufficiently low to protect the non-sensitized worker and make sensitization unlikely. Once a person has become sensitized, it is likely he will have to avoid all exposure to diisocyanates, as no safe levels have been found. Single heavy exposures have been associated with sensitization.[16]

Methacrylate Resins

Methyl methacrylate monomer is an irritant of eyes, nose, throat, and skin and has been reported to cause allergic skin sensitization. Systemic effects can include increased irritability, fatigue, headache, sleepiness, nausea and upset stomach.[17] Toxic effects decrease with the degree of polymerization, so the fully reacted polymer is inert.

B. Medical

Pulmonary Function Testing

The pulmonary function tests included measurements of forced vital capacity (FVC), 1-second forced expiratory volume (FEV_1), and calculation of the ratio FEV_1/FVC. FVC measures the total amount of air one can force out of his lungs after breathing in as deeply as possible. FEV_1 measures the amount of air one can breathe out in the first second. The FVC can be impaired by restrictive lung disease, such as pulmonary fibrosis. FEV_1 can be impaired by cigarette-related lung damage or some other conditions causing

obstruction to air flow. Any condition that impairs FVC also impairs FEV_1, but the reverse is not true. Conditions that impair FEV_1 do not necessarily impair FVC. The FEV_1/FVC ratio is also used to help evaluate obstructive lung disease.

Some exposures to substances that irritate the lungs and bronchi will cause a temporary decrease in pulmonary function over the work shift.

In interpreting the results, the best test results are used. They are compared to "predicted values" which take into account age, height, sex, and race. Pulmonary function is considered "normal" if the best FEV_1 and the best FVC are each 80 percent or more of their respective predicted values and the FEV_1/FVC ratio using the best values is 70 percent or more. It is expected that a person's test results will vary somewhat from time to time. A drop in results over shift of less than 10 percent in FVC or FEV_1, and of less than 6 percent for FEV_1/FVC is considered within normal variation. A drop greater than this over the workshift may indicate a problem with exposures to noxious substances in the workplace.

VI. RESULTS AND DISCUSSION

A. Environmental

Air Samples: The results of environmental sampling are shown in Tables IV through VII. Methyl ethyl ketone peroxide (MEKP) is the primary airborne contaminant to which workers are exposed (range 0.026 to 0.17 ppm). Since the MEKP concentrations in Table IV are based on time-weighted average exposure, there is a high probability that ceiling values were exceeded in four of five workers sampled. Compared to other organic vapor concentrations measured by NIOSH, MEKP was relatively higher among the "spray-up" (laminators) operators and the maintenance man. The spray-up operators were exposed because they prime their fibrous-glass-resin spray guns with MEKP until a desired pressure of 30 pounds per square inch (psi) is reached. Once primed, another trigger is depressed to laminate the tubs and showers. Priming the spray gun, and possibly poor work practices, contributed to the MEKP exposure.

The maintenance man had one of the highest exposures to MEKP (0.15 ppm). One of his jobs was to refill the 1.5-gallon MEKP containers for all six spray-up booths during the spray-up operators' lunch, and at shift change. During MEKP container refill, all local exhaust ventilation systems are turned off (to save energy) by the workers before they leave the plant floor. The maintenance man goes to each spray-up booth and releases pressure from the containers via a pop-off valve, unscrews the lid, and hand pours MEKP solution from a 1-gallon jug into each container. The maintenance operator is primarily exposed as a result of releasing pressure from the pop-off valve which aerosolizes the MEKP.

Styrene, xylene, toluene, acetone and methyl ethyl ketone peroxides have similar health effects in humans. Because of this, the results for individual substances were summarized and compared to combined criteria of 1.0 (Table V) by the method outlined in the American Conference of Governmental Industrial Hygienists Threshold Limit Values booklet.[18] Combined exposures ranged from 0.08 to 0.61.

Table VI contains environmental data from personal and area sampling in the acrylic sheet thermoforming mold area. Four compounds were identified by gas chromatography/mass spectrometry (GC/MS) analysis: styrene, xylene, toluene, and ethyl benzene. All identified compounds were within the environmental criteria of ACGIH (1980) and OSHA standards. Methyl methacrylate was again measured in this same area on July 26, 1979. Detectable levels of this potential sensitizing agent were found, but did not exceed NIOSH, OSHA, or ACGIH environmental criteria for this compound.

Results of personal sampling for respirable dust (i.e., fibrous-glass and hardened resin particulates), for spray-up operators and machine and hand trimmers, were below the environmental criterion of 5.0 mg/M^3 as recommended by ACGIH; Although the respirable dust concentration for the machine trim operator (Dolphin molds) was below the environmental criterion for respirable dust on the day NIOSH sampled, there is potential for high airborne dust exposure from this operation. Poorly maintained vacuum systems, holes in flexible vacuum duct work, and poorly fitted gaskets around the doors of the trim machine could lead to higher dust concentrations. Use of an air hose to blow off excess dust from these tubs could also contribute to the dust problem.

Bulk Samples: A bulk sample of fibrous-glass and resin particulates was submitted for analysis of phthalic acid esters (phthalates), moleic acid, and phthalic anhydrides. The chromatographic analyses of the different sample extracts did not reveal any peaks in the chromatograms. The procedure for the conversion of anhydrides to esters and subsequent chromatographic analysis of the sample did not show any peaks. Therefore, it can be concluded that the sample did not have any free (unreacted) anhydrides or esters.

Laboratory analysis of a bulk piece of insulation fabric taken from the tub molding area revealed that this fabric was made of approximately 70 percent chrysotile asbestos.

A second bulk sample of dust taken from a ledge around the tub mold contained 2-5 percent chrysotile asbestos. NIOSH recommended that this asbestos fabric be replaced by a less hazardous insulation fabric such as fibrous-glass. This was done one month after reporting findings to company management.

Ventilation: There are seven spray booths in this plant: six for lamination, and one for paint spraying. Each spray booth contains approximately fifteen 20" x 20" filtered exhaust openings on the back wall of the booth. Each booth has an 18" plenum, and a propeller fan to exhaust the contaminated air through the roof. Face velocities on each booth were taken using an air meter (Kurz Model 441). Results are summarized in Table VII. Ventilation measurements

taken on the second ventilation survey showed a significant decrease in face velocities in most spray booths when compared to face velocities on the first and third ventilation surveys. The reason for this discrepancy is not definitely known. Filter banks in these booths were cleaned and new filters were put in just prior to the first and third NIOSH ventilation surveys, and changes in static pressure between clean and dirty filter banks may account for some face velocity changes. Recommendations were made to patch holes in spray booth duct work between November 1979 and January 1980, which also improved ventilation efficiency. Additional exhaust fans are located in the ceiling and walls of the building.

Exhaust capacities were compared to the ACGIH recommendations for Auto Spray Paint Booths[18] for airless spray painting. The recommended exhaust capacity is 60 cubic feet per minute (cfm) per square foot of cross-sectional area, or approximately 6522 cubic feet per minute for these booths. Except for the second survey results, booth ventilation was adequate for removing contaminants from the workplace. Filter changes are usually done on a demand basis. Some of the spray-up operators were wearing 8500 series 3M respirators when spraying in the booths. Management was informed these respirators are not NIOSH approved.

There is a make-up air system which is centrally located in the plant that adds 65,000 cfm of air to the building. The make-up air is heated before coming into the building. The make-up air system helps in decreasing building static pressure, which improves the efficiency of booth ventilation.

B. Medical

Pre- and post-shift pulmonary function testing is used to demonstrate acute effects from exposure to a noxious agent. Table VIII gives the mean change in function over shift by history of exposure to urethane paint in the past and by current smoking habits. There was no significant association between urethane paint exposure and acute pulmonary function changes, although 5 individuals did show clinically significant decreases in function over shift.

Table IX groups symptoms and pulmonary function changes developing over shift by general job category and smoking habits. The main symptoms developing over shift were nose and throat irritation, headaches or dizziness, and breathing problems. Sprayers reported significantly more headaches or dizziness and breathing problems than did other workers. The statistically significant difference between smokers and non-smokers in developing symptoms is more fully explored in Table X. It appears that the smoking workers are less likely to develop symptoms than are the non-smokers, and non-sprayers are less likely to develop symptoms than sprayers. The results reflect these two factors plus a statistically significant difference in smoking habits between sprayers and other workers (Table XIII).

Table XI, A & B, presents the results of questioning workers about health problems experienced at work. Almost all workers reported problems at one time or another. The only statistically significant differences involved smoking workers reporting more frequent breathing problems and headaches or weakness.

Tables XII, XIII, and XIV, deal with chronic changes in breathing ability and pulmonary function.

Decreases in FEV_1 and the FEV_1/FVC ratio are associated with smoking (see Table XII). This is an expected finding. History of exposure to urethane paint did not make any difference. Tables XIII and XIV presents the relation between a history of chronic lung problems, smoking habits, history of exposure to urethane paint, and decreased pulmonary function. Smoking relates to a problem with wheezing (and probably any history of chronic chest illness and to a decrease in FEV_1 and/or FEV_1/FVC ratio). There did not appear to be a relationship to work.

In conclusion, although the air at work caused symptoms from time to time among the work force, particularly the sprayers, the pre- and post-shift pulmonary function testing failed to show any consistent work-related acute changes. However, five workers in diverse jobs did show a clinically significant decrease in function over shift.

History of exposure to urethane paint did not appear specific to health problems except for one worker who was extensively evaluated by private physicians. This worker was hospitalized for inhalation challenge testing to TDI at airborne concentrations of 0.03 ppm and 0.0165 ppm. Forced expiratory volume in one second (FEV_1) decreased 31.2% and 12.5%, respectively, compared to pre-challenge tests.They found a dose-related, non-allergic hyper-reactivity to toluene diisocyanate, a situation not previously reported in the literature.[19]

C. Summary

Workers were environmentally and medically evaluated for exposure to a variety of chemicals, including ketones, acrylic resins, and isocyanates used in the manufacture of thermoformed modular tubs and showers. Employees complained of headaches, sore throats, dizziness, and lack of energy; these symptoms are consistent with solvent and other chemical exposures in the reinforced plastics industry. Environmental results have indicated all chemicals evaluated individually were within OSHA standards, and where applicable, NIOSH recommended levels. However, when chemicals were grouped for their combined effect, the results may be additive or synergistic and may pose a potential health hazard to the workers. Sensitizing agents such as toluene diisocyanate were hard to isolate as a causative agent for health effects due to the lack of positive environmental findings. However, inhalation challenge testing proved that one worker had a non-allergenic sensitization to TDI despite the fact that four different surveys failed to detect it in the work environment.

Most workers reported health problems from time to time from work exposures, the sprayers (paint and resin) being most affected.

In conclusion, solvent vapors, in general, could present a serious problem to workers if preventive maintenance is not performed on machines and ventilation on a regular basis, and sensitizing agents such as TDI could be a problem to hypersensitive workers. In addition, there is increasing evidence of adverse health effects due to combined actions of tobacco use and exposure to chemical agents in the workplace.

VII. RECOMMENDATIONS

1. Modify curing and paint drying area of the modular tubs and showers to eliminate general contaminating of room air.

2. See Diisocyanate Criteria Document (NIOSH 78-215) for medical surveillance for those exposed. Also, see Ketone Criteria Document (NIOSH 78-173) for additional surveillance.

3. Preventive maintenance should be performed on a scheduled basis for cleaning and changing filters on all spray booths. Paint booth filters should be changed twice weekly, and spray-up booths once per week.

4. Residual pressure from the methyl ethyl ketone peroxide container should be released through the spray gun while booth ventilation is on, rather than through the pop-off valve, to avoid MEKP aerosol from getting into eyes and breathing-zone.

5. Good work practices are encouraged when spraying modular tubs and showers.

    A. MEKP (peroxide catalyst) should be sprayed toward the back of the spray booth when pressurizing the catalyst container.

    B. Fibrous-glass gel coat should not be hand rolled by one worker while the other is spraying.

    C. Spraying to the side, front, or floor of the booth should be discouraged.

    D. Cardboard floors put in spray booths to collect residual fibrous-glass resin spray should be changed daily.

6. A face shield and protective gloves should be worn when mixing and dispensing MEKP.

7. Finishers should be furnished a NIOSH approved dust respirator for use when drilling holes in tub and shower units for plumbing, and for finish sanding of these units.

8. The automatic "Dolphin" machine trimmer should be routinely maintained, refitted with tight-fitting gaskets around the doors, and worn out flexible duct work connected to dust collectors replaced.

9. An organic vapor respirator (NIOSH approved) should be worn by the material mixer when mixing any chemicals to be used at this plant.

10. Continued use of fibrous glass curtains rather than asbestos curtains around the infrared mold ovens is encouraged.

11. A. The employees involved in sanding and buffing operations, where contact with fibrous glass-containing resins is highly probable, should wear loose fitting clothing and change it daily. Tight-fitting clothing such as collars and cuffs encourages the entrapment of any airborne fibrous glass spicules and may result in skin irritation and dermatitis.

    B. In order to prevent dermatologic 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 disposable clothing of nonsoluble plastic such as polyethylene.

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

13. Eyewash fountains should be installed in areas where chemical splashes may occur. In particular, an eyewash fountain should be installed in the chemical mixing area.

14. An education program should be instituted to teach employees, particularly those in fabrication, the hazards associated with substances in use, appropriate protective measures, and first aid procedures.

15. Air hoses should not be used to clean up dust. Vacuum cleaners should be used for such cleanup.

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X. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are currently available, upon request, from NIOSH, Division of Technical Services, Publication Dissemination, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of the report have been sent to:

1. President, United Steelworkers of America
2. Plant Manager, Powers-Fiat Corporation
3. Local Union President, United Steelworkers of America
4. OSHA, Region V
5. NIOSH, Region V

Table I

Powers-Fiat Corporation
Monroe, Ohio
HE 79-12

Time-Activity Chart

Initial Visit

A. Environmental
B. Medical

November 11, 1978

Environmental Sampling

1. respirable particulates
2. styrene, xylene, toluene, acetone, ethyl benzene
3. methyl ethyl ketone peroxide
4. titanium dioxide
5. worksite interviews

November 30, 1978

Environmental Sampling

1. toluene diisocyanate
2. fibrous glass (particulates)
3. phthalic acid esters

March 8, 1979

Environmental Sampling

1. methyl methacrylate
2. TDI

July 26, 1979

Environmental

1. styrene
2. TDI

Medical

3. pre-post shift pulmonary function testing

November 19, 1979

Environmental

1. TDI

Medical

2. Follow-up pre-post shift pulmonary function testing (2 workers)

January 2, 1980

TABLE II

Job Breakdown of Workers Included in
Medical Aspects of Health Hazard Evaluation 79-12

Powers-Fiat
Monroe, Ohio

Job Category	Interviews (in person, mail, phone) Fall 1978 - Spring 1979	Pre- and Post-Shift Pulmonary Function Testing and Questionnaires November 1979 - January 1980
Molders	6	4
Painters, Spray	3	2
Sprayers, Resin	4	9
Trimmers	2	2
Packers	1	1
Material Handlers	2	4
Labor Pool	0	3
Fork Lift Operators	1	2
Maintenance	1	2
Inspectors	2	1
Supervisors	1	0
Laboratory Technician	1	0
Office Worker	1	0
Total	25	30

TABLE III

Environmental Evaluation Criteria

Powers-Fiat Corporation
Monroe, Ohio
HE 79-12

Substance	Recommended Environmental Limit	Source	Primary Health Effects	OSHA Standard
Fibrous glass-resin spray (respirable dusts)			Respiratory irritation	5 mg/M^3
Fibrous glass (total)	5 mg/M^3	NIOSH	Upper resp. irritation	10 mg/M^3
Styrene	200 ppm ceiling 600 ppm (5 min)	NIOSH	Eye & nose irritation, drowsiness, defatting of skin	100 ppm
Xylene	100 ppm 200 ppm (10 min. ceiling)	NIOSH	Dizziness, eye, nose & throat irritation, dermatitis	100 ppm
Toluene	300 ppm (ceiling) 100 ppm 200 ppm (10 min. ceiling)	OSHA NIOSH	Fatigue, dizziness, headache, dermatitis	200 ppm
Acetone	1000 ppm 200 ppm	OSHA NIOSH	Eye, nose & throat irritation, headaches, dizziness, dermatitis	1000 ppm
Methyl Ethyl Ketone Peroxide (MEKP)	0.2 ppm	ACGIH	Skin & mucous membrane irritation, dermatitis	----
Ethyl Benzene	100 ppm	ACGIH	Eye & mucous membrane irritation, headache, dermatitis	100 ppm

Table III, Cont'd.

Substance	Recommended Environmental Limit	Source	Primary Health Effects	OSHA Standard
Titanium Dioxide (TiO_2)	10 mg/M^3	ACGIH	Respiratory difficulty	15 mg/M^3
Toluene Diisocyanate	.005 ppm .02 ppm (20 min ceiling)	NIOSH	Nose & throat irritation, abdominal pain, asthma, bronchitis	.02 ppm (ceiling)
Phthalic Acid Esters (phthalic anhydride)	1 ppm	ACGIH	Conjunctivitis, upper resp. irritation	2.0 ppm
Methyl Methacrylate			Eye, nose & throat irritation, dermatitis	100 ppm
Asbestos (Chrysotile)	0.1 fibers/cc	NIOSH	Lung cancer	2 fibers 5 um/cc

Table IV

Results of Personal Sampling for Exposure to Airborne Methyl Ethyl Ketone Peroxide (MEKP)

Powers-Fiat Corporation

November 30, 1978

Activity/Area	Time of Sample	Time Weighted Average Exposure in ppm MEKP*	Averaged MEKP Values**
Spray-up Booth #6	4 hr 35 min (morning)	0.026	0.07
	2 hr 0 min (afternoon)	0.170	
Spray-up Booth #5	4 hr 26 min (morning)	0.068	0.05
	1 hr 57 min (afternoon)	0.029	
Spray-up Booth #4	4 hr 19 min (morning	0.113	0.09
	1 hr 55 min (afternoon)	0.036	
Spray-up Booth #3	4 hr 14 min (morning)	0.113	0.09
	1 hr 53 min (afternoon)	0.033	
Maintenance Man	0 hr 36 min (afternoon)	0.15	0.15
	0 hr 41 min (shift change)	0.145	

*Environmental Criterion ACGIH (1980) Ceiling Limit of 0.2 ppm for MEKP;

**Average Concentrations based on formula $\frac{C_1T_1 + C_2T_2}{T_1 + T_2}$; where C = Concentration (ppm); T = Time

TABLE V

Results of Personal and Area Sampling for Exposure to Organic Vapors

Powers-Fiat Corporation
Monroe, Ohio
HE 79-12

November 30, 1978

Location	Activity/Area Sampled	Time of Sample	Time Weighted Average Exposure (ppm) Styrene	Xylene	Toluene	Acetone	MEKP	Combined Exposure*
Booth #1	Operator #1	6 hr 5 min	12.0	0.13	0.31	37.0	----	0.16
	Operator #2	6 hr 5 min	9.6	0.26	0.30	54.9	----	0.15
Booth #2	Operator #1	5 hr 55 min	11.4	0.13	0.31	69.1	----	0.18
	Operator #2	5 hr 55 min	27.3	0.14	0.32	103.0	----	0.37
Booth #3		6 hr 7 min	----	----	----	----	0.09	0.45
Booth #4	Operator #1	6 hr 0 min	12.5	0.11	0.13	26.4	0.09	0.61
	Operator #2	6 hr 0 min	10.7	0.15	0.18	21.0	----	----
Booth #5	Operator #1	5 hr 50 min	5.4	0.13	0.15	0.5	0.05	0.32
	Operator #2	5 hr 55 min	5.5	0.14	0.16	13.4	----	----
Booth #6	Operator #1	6 hr 5 min	6.1	0.13	0.45	22.0	0.07	0.43
	Operator #2	5 hr 54 min	5.9	0.18	0.40	24.8	----	----
	Painter #1	5 hr 38 min	4.3	0.45	1.22	6.1	----	0.07
	Painter #2	5 hr 45 min	3.6	0.39	0.79	4.6	----	0.06
	Material Handler #1	5 hr 45 min	11.6	0.14	0.16	10.0	----	0.13
	Material Handler #2	5 hr 45 min	11.8	0.16	0.18	0.8	----	0.12
	Material Mixer	6 hr 0 min	4.6	0.44	0.34	15.5	----	0.08
	Lamination Drying Area General Area	5 hr 45 min	8.4	0.27	0.31	1.0	----	0.08
	Modular Rack General Area	5 hr 35 min	6.8	2.0	2.31	1.0	----	0.10
	Painted Modular Drying Area General Area	5 hr 28 min	4.2	0.2	0.61	1.8	----	0.05
Environmental Criteria -	ACGIH:		100.0	100.0	200.0	1,000.0	0.2	
	NIOSH:		-----	100.0	100.0	250.0	---	
	OSHA :		100.0	100.0	200.0	1,000.0	---	

* Combined exposure criteria not to exceed 1.0 as outlined by the American Conference of Governmental Industrial Hygienists 1980 Threshold Limit Values.

Table VI

Results of Modular Molding Personal and General Area Sampling for Organic Vapors (Gas Chromatograph-Mass Spectrometer Analysis)

Powers-Fiat Corporation

November 30, 1978

Area Sampled	Time of Sample	Time Weighted Average Exposure in ppm			
		Styrene	Xylene	Toluene	Ethyl Benzene
Modular Mold (Personal)	7 hr 25 min	3.6	1.2	0.9	0.05
Modular Mold #1 General Area	7 hr 20 min	12.3	2.7	1.8	0.19
Dolphin Mold General Area	7 hr 20 min	3.3	1.1	0.8	0.04
Environmental Criteria: ACGIH		100.0	100.0	200.0	100.0
NIOSH		--	100.0	100.0	--
OSHA		100.0	100.0	200.0	100.0

TABLE VII

Powers-Fiat Corporation
Monroe, Ohio
HE 79-12

Ventilation Measurements for Spray Booths

Location	Booth Dimensions (Sq. ft.) Height	Width	11/30/78 xfpm*	11/30/78 xcfm	11/19/79 xfpm	11/19/79 xcfm	1/2/80 xfpm	1/2/80 xcfm
Booth #1	7'7"	12'7"	----	----	64	6107	----	----
Booth #2	7'8"	12'7"	162	15,629	89	8586	176	16,979
Booth #3	7'6"	12'7"	----	----	67	6323	137	12,929
Booth #4	7'8"	12'6"	121	11,596	57	5439	132	12,650
Booth #5	7'7"	12'1"	140	13,359	61	5590	133	12,187
Booth #6	----	----	----	----	----	----	----	----
Booth #7	7'0"	12'0"	104	8770	35	2940	82	6888

* x = Average Face Velocity

---- = Not Measured. Booth #6 was not operating.

Recommended exhaust capacity is 60 cubic feet per minute (cfm) per square foot of cross-sectional area, or approximately 6522 cfm for these booths.

TABLE VIII

Pulmonary Function Testing Results
Percent Change Over Shift by Smoking Habits and Exposure to Urethane Paints
(Mean Values ± Standard Deviation)

Powers-Fiat
Monroe, Ohio

November 1979 - January 1980

	Number	FVC Percent Change	FVC Percent Change	FEV_1 Percent Change	FEV_1 Percent Change	FEV_1/FVC Percent Change	FEV_1/FVC Percent Change
Exposed to urethane paints							
Current Smokers	12	+3.03±8.93		±1.51±9.84		-1.39±6.84	
Non-Smokers and Ex-Smokers	8	-1.82±6.17		-0.92±7.27		+0.85±2.45	
Total Exposed	20		+1.09±8.14		+0.54±8.77		-0.50±5.53
Not Exposed to urethane paints							
Current Smokers	5	-3.98±5.48		-3.64±4.93		+0.42±3.62	
Non-Smokers and Ex-Smokers	4	-2.55±3.82		+1.28±11.36		+3.80±9.08	
Total Non-Exposed	9		-3.34±4.59		-1.46±8.20		+1.92±6.38
Totals							
Current Smokers	17	±0.97±8.56		-0.01±8.86		-0.86±6.02	
Non-Smokers and Ex-Smokers	12	-2.07±5.32		-0.19±8.37		+1.83±5.33	
Grand Totals	29		-0.29±7.44		-0.08±8.51		+0.26±5.80

TABLE IX

Symptoms Developing Over Shift by General Job Category, Smoking Habits

Powers-Fiat
Monroe, Ohio

November 1979 - January 1980

Symptoms	Sprayers-Paint and Resin	Molders	Labor Pool, Material Handlers, and Trimmers	Maintenance Fork Lift, Inspector, Packer	Total	Current Smokers	Non-Smokers and Ex-Smokers
Total Number of Workers	11	4	8	6	29	17	12
Throat Irritation	4	1	1	0	6	2	4
Eye Irritation	2	0	1	0	3	2	1
Nose Irritation	2	1	0	2	5	2	3
Headache or Dizziness	6α	0	0	0	6	3	3
Breathing Problems	4β	0	0	0	4	1	3
Stomach Complaints	1	0	0	1	2	0	2
Urinary Complaints	0	0	0	0	0	0	0
Skin Complaints	1	0	2	0	3	2	1
Any Symptoms	8δ	1	3	3	15	6ε	9ε
No Symptoms	3δ	3	5	3	14	11ε	3ε
Decreased Pulmonary Function Over Shift	2*	2	1+	0	5+	3+	2

α Sprayers vs. Others - Statistically significant difference p=0.001 (Fisher's exact test).
β Sprayers vs. Others - Statistically significant difference p=0.014 (Fisher's exact test).
δ Sprayers vs. Others - Suggestive significance p=0.082 (Fisher's exact test).
ε Statistically significant difference p=0.041 (Fisher's exact test).
* Both were spraying resin, not paint.
+ One additional worker had changes not interpretable within this study.

TABLE X

Symptoms Developing Over Shift by Spraying Status and Current Smoking Habits

Powers-Fiat
Monroe, Ohio

November 1979 - January 1980

	Current Smokers		Non-Smokers and Ex-Smokers		Totals
	Observed	Expected	Observed	Expected	
Sprayers					
With Symptoms	3	4.7	5	3.3	8
Without Symptoms	1	1.8	2	1.2	3
Non-Sprayers					
With Symptoms	3	4.1	4	2.9	7
Without Symptoms	10	6.4	1	4.6	11
Totals	17		12		29

Chi^2 = 7.934 (d.f.=3) p=0.048 (statistically significant)

Considering Smoking Non-Sprayers (13) vs. All Others (16)
Chi^2 = 5.7.7 (d.f.=1) p=0.019 (statistically significant)

TABLE XI A

Work-Related Health Problems by General Job Category, Smoking Habits, and Exposure to Urethane Paints
(Interview Results)

Powers-Fiat
Monroe, Ohio

November 1979

Health Complaints	Sprayers Paint and Resin	Molders	Labor Pool, Material Handlers, and Trimmers	Maintenance, Fork Lift, Inspector, Packer	Total	Current Smokers	Non-Smokers and Ex-Smokers	History of Urethane Paint Exposure	No History of Urethane Paint Exposure
Total Number of Workers	11	4	9	6	30	18	12	21	9
Exposure to Urethane Paint	8	2	8	3	21	13	8	21	0
Health Problems with Urethane Paint	2	1	3	0	6	5	1	6	NA
Spontaneous History of Any Job-Related Health Problem (Urethane Paint Included)	7	3	7	1	18	14	4	14	4
Spontaneous History of Health Problems Not Identified as Job-Related	9	4	8	6	27	17	10	19	8

NA = Not Applicable.

TABLE XI B

Work-Related Health Problems by General Job Category, Smoking Habits, and Exposure to Urethane Paints
(Interview Results)

Powers-Fiat
Monroe, Ohio

November 1979

Health Complaints	Sprayers Paint and Resin	Molders	Labor Pool, Material Handlers, and Trimmers	Maintenance, Fork Lift, Inspector, Packer	Total	Current Smokers	Non-Smokers and Ex-Smokers	History of Urethane Paint Exposure	No History of Urethane Paint Exposure
Total Number of Workers	11	4	9	6	30	18	12	21	9
Detailed Questioning									
Throat Irritation									
Usually or Often	6	1	3	1	11	7	4	7	4
Seldom	1	1	3	1	6	4	2	3	3
Eye Irritation									
Usually or Often	2	1	2	0	5	2	3	3	2
Seldom	1	1	5	0	8	6	2	7	1
Nasal Irritation									
Usually or Often	5	3	4	2	14	8	6	11	3
Seldom	1	1	1	0	3	2	1	2	1
Breathing Problems									
Usually or Often	3	1	3	2	9	8*	1*	7	2
Seldom	3	1	3	0	7	5	2	7	0
Digestive Problems									
Usually or Often	1	0	1	1	3	2	1	2	1
Seldom	2	0	3	0	5	3	2	5	0
Urinary Problems									
Usually or Often	1	0	0	0	1	1	0	1	0
Headaches, Weakness or Unconsciousness									
Usually or Often	2	1	2	1	6	6**	0**	5	1
Seldom	4	0	0	0	4	1	3	3	1
No Symptoms Reported	1	0	0	2	3	0	3	2	1

* = Statistically significant difference p=0.040 (Fisher's exact test)
** = Statistically significant difference p=0.031 (Fisher's exact test)

TABLE XII

Pulmonary Function Testing Results
Best Values by Smoking Habits and Exposure to Urethane Paints
(Mean Values ± Standard Deviation)

Powers-Fiat
Monore, Ohio

November 1979 - January 1980

	Number	FVC		FEV_1		FEV_1/FVC	
		Percent Predicted	Percent Predicted	Percent Predicted	Percent Predicted	Percent Predicted	Percent Predicted
Exposed to urethane paints							
Smokers and Ex-Smokers	14	81.69±13.57		79.53±11.12*		77.61±9.13+	
Non-Smokers	7	86.54±13.35		93.56±9.13*		86.14±7.11+	
Total Exposed	21		83.31±13.37		84.20±12.30		80.45±9.29
Not Exposed to urethane paints							
Smokers and Ex-Smokers	6	89.17±11.14		85.88±8.32		75.27±5.83	
Non-Smokers	3	87.60±13.26		93.83±9.35		86.57±9.68	
Total Non-Exposed	9		88.64±11.24		88.53±8.33		79.03±8.75
Totals							
Smokers and Ex-Smokers	20	83.94±13.15		81.44±10.57**		76.90±8.19α	
Non-Smokers	10	86.86±12.58		93.64±8.08**		86.27±7.39α	
Grand Totals	30		84.91±12.82		85.50±11.30		80.03±9.00

* Statistically significant difference t=2.2094 (d.f.=19) p=0.042
** Statistically significant difference t=2.7385 (d.f.=28) p=0.011
\+ Suggestive significance t=1.9334 (d.f.=19) p=0.072
α Statistically significant difference t=2.6402 (d.f.=28) p=0.014

TABLE XIII

History of Respiratory Problems, Pulmonary Function Changes and Smoking Habits
by General Job Category, Smoking Habits, and History of Exposure to Urethane Paint

Powers-Fiat
Monroe, Ohio

November 1979

	Sprayers Paint and Resin	Molders	Labor Pool, Material Handlers, and Trimmers	Maintenance, Fork Lift, Inspector, Packer	Total	Current Smokers and Ex-Smokers	Non-Smokers	History of Urethane Paint Exposure	No History of Urethane Paint Exposure
Total Number of Workers	11	4	9	6	30	20	10	21	9
Respiratory History									
Chronic Bronchitis	3	2	4	2	11	8	3	6	5
Wheezing	2	3	7	1	13	12α	1α	9	4
Recurrent Chest Illness	1	2	4	1	8	7	1	6	2
Any Chronic Chest Problem	5	4	7	3	19	15β	4β	12	7
Decreased Pulmonary Function									
Decreased FVC only	2	1	0	1	4	2	2	2	2
Decreased FEV_1 and/or FEV_1/FLV Ratio only	3	1	1	0	5	5**	0**	4	1
Combined Decrease	0	0	3	2	5	4**	1**	4	1
Any Decreased Function	5	2	4	3	14	11	3	9	5
Smoking Habits									
Current Smokers	4δ	3	8	3	18	18	-	13	5
Ex-Smokers*	0	1	0	1	2	2	--	1	1
Non-Smokers	7δ	0	1	2	10	--	10	7	3

* Both Ex-Smokers quit smoking before working at Powers-Fiat.
** Any decrease in FEV_1 or FEV_1/FVC vs. Smoking Habits shows a suggestive significance p=0.062 (Fisher's exact test).
α Statistically significant difference p=0.011 (Fisher's exact test).
β Suggestive significance p=0.071 (Fisher's exact test).
δ Smoking Habits of Sprayers statistically significantly different from the rest of the workers (ex-smokers excluded) p=0.019 (Fisher's exact test).

TABLE XIV

Decreased Pulmonary Function by History of Chronic Respiratory Problems and Smoking Habits

Powers-Fiat
Monroe, Ohio

November 1979 - January 1980

	Decreased FVC only	Decreased FEV_1 or FEV_1/FVC only	Decrease in Both	Total With Decreased Function	No Decreased Function	Total
Chronic Bronchitis						
Smokers and Ex-Smokers	1	3	3	7	1	8
Non-Smokers	0	0	0	0	3	3
Total	1	3	3	7	4	11
Wheezing						
Smokers and Ex-Smokers	1	3	2	6	6	12
Non-Smokers	0	0	1	1	0	1
Total	1	3	3	7	6	13
Recurrent Chest Illness						
Smokers and Ex-Smokers	0	0	1	1	6	7
Non-Smokers	0	0	1	1	0	1
Total	0	0	2	2	6	8
Any Chronic Chest Problem						
Smokers and Ex-Smokers	1	4	3	8	7	15
Non-Smokers	0	0	1	1	3	4
Total	1	4	4	9	10	19
No History of Chronic Chest Problems						
Smokers and Ex-Smokers	1	1	1	3	2	5
Non-Smokers	2	0	0	2	4	6
Total	3	1	1	5	6	11
Totals	4	5	5	14	16	30

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