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. HE 78-3-555

WARMINSTER FIBERGLASS
SOUTHAMPTON, PENNSYLVANIA

JANUARY 1979

I. TOXICITY DETERMINATION

An evaluation of the fabrication operations at the Warminster Fiberglass plant was conducted during the periods of November 14-15, 1977 and July 24-28, 1978. Environmental assessment was accomplished by obtaining measurements of airborne exposures to organic vapors, methylethyl ketone peroxide (MEKO), compounds containing cobalt, fibrous glass and total dust. The primary airborne contaminants to which fabrication workers were exposed were found to be MEKO and styrene vapor with less significant exposures to vapors of acetone.

It is the judgement of the investigator that workers were exposed to potentially toxic concentrations of MEKO as evidenced by personal samples in excess of the 1.5 milligram per cubic meter recommended ceiling Threshold Limit Value (TLV) of the American Conference of Governmental Industrial Hygienists. There were also instantaneous peak measurements of styrene in excess of 600 parts per million (ppm), the Federal Standard maximum peak. Six of eleven workers from the fabrication areas who were interviewed, reported one or more symptoms consistent with overexposure to organic vapors and MEKO. Worker exposures to airborne vinyl toluene, methyl methacrylate, cobalt containing compounds, and fibrous glass were less than the detection limit of the sampling and analytical methods used.

Recommendations for control of the plant environment are contained within the body of the report.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources 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) Warminster Fiberglass, Southampton, Pennsylvania
b) Fischer & Porter, Warminster, Pennsylvania
c) Authorized Representative of Employees - Independent Union of Rotameter Workers, Warminster, Pennsylvania
d) U.S. Department of Labor - Region III
e) NIOSH - Region III

For the purpose of informing the approximately 80 "affected employees" the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

III. INTRODUCTION

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 the employer alleging that "fiberglass assemblers were complaining of irritating fumes causing eye, nose, throat and skin irritations."

A SHEFS I Report was sent to company and worker representatives on December 7, 1977 which contained findings and recommendations as an outcome of the November 14-15, 1977 initial visit. A letter report containing detailed environmental results was sent to company and worker representatives on June 7, 1978.

IV. HEALTH HAZARD EVALUATION

A. Process Description - Conditions of Use

The operations performed at the plant are common polyester resin spray-up and lay-up processes. The resin is a styrene modified polyester resin using methylethyl ketone peroxide as a catalyst. The styrene serves two purposes: it acts as a vehicle and also crosslinks with the polyester resin to form the final polymer. There are minor constituents (less than 1%) in the resin to act as an accelerator which is commonly cobalt naphthenate and a thixotropic additive. The methylethyl ketone peroxide (MEKO) which is the reaction catalyst is used in concentrations by weight ranging from one to four percent of a 30 percent or 60 percent mixture of MEKO in dimethyl phthalate based on the total amount of the resin and styrene mixture. The amount of MEKO used depends upon ambient conditions; at higher temperatures lesser amounts of catalyst are necessary and vice versa. Humidity may also affect the amount of catalyst used although temperature is usually the major determining factor.

A variety of products are manufactured at this facility; the major products being produced at the time of the July 1978 evaluation were several sizes of

enclosures intended for protection of delicate instruments and equipment and components of water pollution control equipment. Larger products are produced using components of the spray-up process; smaller, miscellaneous products are manufactured by either spray-up or by hand lay-up techniques.

Another process operation in the plant is the compression molding of parts which are formed in matched metal dies under pressure and heat using an uncured blank containing fibrous glass reinforcement and impregnated with a polyester resin containing approximately 15-20 percent styrene. The catalyst utilized in this operation is benzoyl peroxide or perbenzoate and the reaction is catalyzed by both heat and the introduced catalyst. This process represents approximately 20 percent of the plant's production at this time although plans are to expand production by the use of this technique in the future with a curtailmant of manufacture by the spray-up and lay-up processes.

The initial step in manufacturing an item by the spray-up technique is to spray a mold with the polyester resin containing pigment and mineral fillers, referred to as gel coat. The gel coat is applied with a spray gun onto the mold of the desired final product. This initial step in the case of enclosures, flumes, and the larger products is followed by spraying the resin mixture and chopped roving (chopped fibrous glass strands) using a chopper gun on top of the gel coat layer; the required amounts of resin and catalyst are automatically metered with a chopper gun; this gun may be operated so that resin and MEKO and chopped roving are applied simultaneously, operated to apply resin and MEKO, and operated with acetone only for cleanup. The operators adjust the ratio of MEKO to resin as necessary based upon the curing characteristics of the resin. The resin and chopped roving are rolled by hand after spraying by one or two workers while the resin is still fluid. This coat in the manufacture of enclosures is followed by application of a layer of polyurethane foam insulation before the resin has set up. The insulation is sealed into the walls of enclosures and the tops are fabricated separately and then are attached. No new manufacture of water pollution control equipment components requires different molds but follows the same general procedures although there is no application of insulation.

Hand lay-up processes differ considerably in that no spraying of the resin occurs. The manufacture of enclosures referred to as "cherry pickers" was monitored during the evaluation. Following application of a gel coat the resin system is applied by hand with a brush; reinforcement is provided by a woven fibrous glass sheet which is fitted into place over the mold and impregnated with resin by brush. The peroxide catalyst is mixed with the resin system and therefore both are applied with a brushing of the mixture.

Ventilation is provided at those areas where the larger products are fabricated. These hoods are 12 feet wide by 7 feet 2 inches high and are designed to exhaust 12,400 cfm; there are a total of 12 spray booths in the plant.

There are approximately 80 workers employed at the plant, the majority of these workers, about 65, are employed as fabricators and would have the greatest potential for exposure to the chemical substances used in the plant. Other occupations in the plant are leadmen, materials handlers, technicians, truck drivers, tool supply, and shipping/receiving clerk.

B. Evaluation Progress and Design

1. Initial Survey - November 14-15, 1977

Personal samples were obtained to evaluate worker exposure to organic vapor contaminants, fibrous glass particulates, and cobalt and total particulates. Detector tubes were used to estimate worker exposure during application of a fibrous glass reinforced coating to the cargo carrying interior of a truck. Non-directed health questionnaires were obtained from the workers with the greatest potential for exposure to chemical substances.

2. Follow-up Evaluation - July 25-27, 1978

Personal and area samples to determine worker exposure to organic vapors and the catalyst, MEKO, received primary emphasis during this phase of the study. A few samples were obtained to estimate exposures to fibrous glass and cobalt containing particulate.

C. Methods of Evaluation

Organic vapors - samples for determination of airborne concentrations of organic vapors were collected by adsorbing vapors onto charcoal contained in glass sampling tubes. Air was drawn through the tubes at a flow rate of 50 or 100 cubic centimeters (cc)/minute with vacuum sampling pumps. Personal samples were obtained by attaching the pump to the worker's belt with the charcoal sampling tube contained in a holder attached to the lapel of the worker. The sampling tubes were transmitted to the laboratory for analysis by gas chromatography. The limit of detection for this method was 0.01 milligrams (mg) for each individual organic compound per charcoal tube.

Cobalt - samples for determination of airborne concentrations of cobalt compounds were obtained with mixed esters of cellulose membrane filters (0.8 u average pore size) contained in closed-face cassettes. Air was

drawn through the filter at a flow rate of 1.5 liter/minute with a vacuum pump attached to the belt of the worker. The amount of cobalt on the filter was determined by an atomic absorption analytical method. The limit of detection for this method was 0.001 mg of cobalt per filter.

Fibrous glass - samples for measurement of airborne fibrous glass particulates were collected with mixed esters of cellulose membrane filters)0.8 micron (u) average pore size) contained in an open-face cassette attached to the lapel of the worker. Air was drawn through the filter at a flow rate of 1.5 liter/minute with a vacuum pump attached to the belt of the worker. Fibrous glass identification and quantification was accomplished with a microscope using 400-450X magnification and phase contrast illumination.

MEKO-air was drawn through a midget impinger containing 15 milliliters of dimethyl phthalate sampling solution at a flow rate of one liter/minute using a battery operated vacuum pump. The sampling period was usually 15 minutes in length but was increased in length when process conditions required it. The samples were analyzed on site, utilizing a colorimetric method adapted for field use. The lower limit of quantitation in this evaluation was 7.5 ug/sample. Total particulate-air was drawn through a vinyl chloride filter contained in a closed-face cassette at a low rate of 1.5 liters/minute. Weight gain was determined gravimetrically.

D. Evaluation Criteria

1. Environmental

The three primary sources of environmental evaluation criteria considered in this report are: (1) NIOSH Criteria Documents with recommended standards for occupational exposure, (2) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's) with supporting documentation, and (3) Federal occupational health standards, promulgated by the Occupational Safety and Health Administration, U.S. Department of Labor. For the substances evaluated during this study, the primary environmental criteria used were:

Substance	Standard or Guide	
	ppm*	mg/M^3**
Acetone	250 (1)***	590
Cobalt	----	0.1 (2,3)
Methyl ethyl ketone	200 (a)	590
Methyl ethyl ketone peroxide	C+0.2 (2)	C+1.5
Styrene	100 (2,3)****	420
Fibrous Glass	----	3,000,000 fibers/M^3++

* Parts of vapor per million parts of contaminated air by volume at 25^{o}C and 760 mm Hg pressure.

** Milligrams of substance per cubic meter of air.

*** Reference numbers in parentheses refer to the source(s) from the above discussion from which the standard or guide was obtained.

**** The OSHA Standard includes a ceiling concentration of 200 ppm not to be exceeded for 5 minutes in any 3 hours with a maximum peak of 600 ppm.

\+ Ceiling limit which should never be exceeded.

++ Having a diameter $\leq$3.5 um and a length $\geq$ 10um as a time-weighted average.

Occupational health exposure limits for individual substances are generally established at levels designed to protect workers occupationally exposed on an 8-hour per day, 40-hour per week basis over a normal working lifetime.

Although sources other than the Federal Standard were considered in this study for arriving at a Toxicity Determination, the only legally enforceable standard is the Federal Standard which is administered by the Occupational Safety and Health Administration of the Department of Labor.

2. Toxic Effects of Primary Substances Evaluated

The criteria used to determine a toxic response to the substances under investigation consist of symptoms and signs which each substance produces when a toxic exposure occurs. A brief review of the known pathophysiological effects of the primary substances evaluated are contained below.

a. Styrene

Styrene vapor at concentrations of 200 to 400 ppm were found to have transient irritant effects on the eyes.[1] Styrene sickness characterized by symptoms of headache, sleepiness, nausea, vomiting, general weakness, and loss of appetite has occurred among workers exposed to styrene vapor.[2] Exposure to levels around 200 ppm did not affect the hemopoietic system.[3] It has been reported that chronically exposed workers have prolonged single reaction time.

b. Acetone

Primary effect is a narcotic-type action, eye, nose and throat irritation, drowsiness, loss of muscle control and coma at higher doses. Repeated exposure of unprotected hands and arms may result in dermatitis due to removal of natural oils from the skin.

c. Methylethyl Ketone Peroxice (MEKO)

Little human data is available but 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[3] than benzoyl peroxide which has a TLV of 5 mg/M^3 as compared to the 1.5 mg/M^3 recommendation for MEKO.[4]

d. Fibrous Glass

The known pathophysiologic effects of fibrous glass were very well summarized by Lucas, et. al. of NIOSH and are directly quoted.[5]

"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 0.00012 to 0.004 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 0.00018 inches do not irritate human skin; while fibers with diameters greater than 0.00021 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.6-10 A retrospective mortality study conducted by NIOSH [11] among 1,448 workers occupationally exposed to large diameter glass fibers failed to demonstrate any risk or 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).

e. Cobalt

Used in the process as cobalt naphthanate or cobalt octoate. Cobalt and cobalt chloride have been reported to cause changes in red blood cell morphology and have been described as a goitrogenic agent.

Rockhold [12] in 1955 investigated the toxicity of the following naphthenates: cobalt, copper, calcium, manganese and zinc. He reported that metal naphthenates show a low acute and oral toxicity for rats (lethal doses LD_{50}) between 4 grams/kilogram (g/kg) and over 6 g/kg. Because of the low toxicity and the low concentration at which they are used, metal naphthenates, especially those of cobalt, manganese and calcium can be used without damage in materials intended for use in the food industry.

f. Cured Resins

Animal experiments have been performed to determine the biological activity of cured polyester resins. Reports by Schepers et. al. 13-15 on animal exposures to polyester-fibrous glass dust (generated from cutting, sawing and planing of cured reinforced plastic) indicated a general pulmonary response comparable to that produced by mineral dusts.

E. Results and Discussion

1. Initial Survey - November 14-15

On November 14, 1977, shortly after arrival at the plant, the cargo carrying interior of a truck was scheduled for application of the fibrous glass reinforced coating. The NIOSH team was asked to evaluate this exposure. Due to time constraints, it was feasible to only obtain detector tube measurements of worker exposure; results range from 200 to 400 parts per million of styrene. Half-face organic vapor respirators with goggles were utilized by the workers. Based upon detector tube results and observation of the subject operation, the recommendations outlined were made to the company and employee representatives:

a. Full-face respiratory protection should be provided for the workers due to ability of styrene to produce eye irritation. The company is planning a trial with an air supplied respirator. This approach was endorsed by the NIOSH project officer.

b. A portable exhaust ejector was in use with the suction located in the truck cargo area during spraying and rollout. However, the exhaust of the ejector was located several feet from the exhaust hood. It was recommended during the work that the ejector exhaust be moved several feet so as to be contained within the hood. (This change was made immediately by the supervisor upon this recommendation.)

c. A pedestal fan was being used to blow air on the workers. However, the fan adversely affects the capture of the exhaust hood and whatever additional ventilation may be provided is negated by the disruption of the capture by the exhaust hood. Use of the pedestal fan should be discontinued.

d. One worker did not wear gloves to protect his hands and arms from exposure to the resin system; he was observed cleaning his hands by submerging them in a pan of acetone during the coating procedure. The practice of cleaning exposed skin with acetone should <u>not</u> be continued. <u>ALL</u> workers should wear impervious gloves (gauntlets if necessary) with cotton liners when working with the uncured resin. Additional liners should be provided for comfort reasons, so that as a set becomes wet from perspiration they can be replaced and wet liners allowed to dry. It was

observed at the time of the follow-up visit in July 1978 that the practice of using acetone to clean hands and arms had considerably lessened.

A number of discrepancies were noted in the use of respirators during the visit. Inspection of inhalation and exhalation valves revealed that many could not seat properly due to buildup of debris, cloth face inserts were utilized by some workers to provide comfort, thus preventing an effective seal between the respirator and the wearer's face, and filter covers were observed to be virtually clogged in some cases.

a. A greater emphasis upon worker training in the proper fit, use, inspection, and storage of respirators is necessary.

b. An adequate storage area for each worker's respirator should be provided. Workers should be encouraged to use it.

c. The project officer was provided with a copy of the respirator program. Although the plan may be adequate as written, a much greater training and follow-up effort is necessary to insure that it is properly implemented.

Samples were obtained on November 15 to determine worker expsoure to several contaminants. Table I contains results for personal exposures to organic vapors. The primary organic vapor exposures are to styrene and acetone which are shown in Table I. Analyses were also performed for vinyl toluene and methyl methacrylate, but all results for these two substances were below the limit of detection of the sampling and analytical method used in this evaluation. The environmental criteria for styrene and acetone are indicated in the Table; the results for styrene were all less that 50 percent of this criteria while acetone results were 25 percent or less of this criterion. The reported concentrations for acetone should be considered as minimum results since the amounts of acetone on the back-up sections of charcoal tubes were greater than that which would assure quantitative results. This effect is not unusual in multi-substance exposures to organic substances where one substance adsorbs more readily than another substance. Table II contains results of samples to measure fabricators' exposures to cobalt and fibrous glass particulates; results for two samples or each of these contaminants were less than the analytical limit of detection. The resin room attendant's exposure to total airborne dust was determined to be 0.61 mg/M^3 on this day.

During this initial visit, eleven workers were questioned in a non-directed manner to determine if health problems or complaints existed that the workers believed were related to their work. Each of six workers reported one or more complaint to the investigators. The reported symptoms were:

five with eye irritation, two with dizziness or lightedheadedness, one with headaches, one with nose bleed, and one with hypertension. Five workers did not have any complaints. It cannot be determined whether the complaints are work related or not. However, eye irritation is a common symptom of styrene overexposure, and in Table VI the reported peak levels of styrene vapor would be sufficient to cause eye irritation which was experienced by the NIOSH investigators at times. The respirators worn by the workers during spray-up fabrication are half-face which do not provide eye protection.

2. Follow-up Study - July 25-28, 1978

A primary focus of the follow-up study was to ascertain MEKO exposures during the construction of fibrous glass reinforced (FGR) products utilizing the styrene-modified polyester resin spray-up process and the MEKO catalyst. Table III contains the sample results obtained July 25 to determine MEKO airborne exposures. Samples were varied to some extent as experience was gained with the sampling and analytical method. It is apparent that the workers' exposures did not exceed the recommended ceiling TLV of 1.5 mg/M^3 for the entire sampling period; however, the actual spray-up generally consumes 15 to 25 minutes in length and would probably account for all of the MEKO exposure period unless there is some residual MEKO mist present or MEKO vapor accounts for significant exposure during the hand working of the resin-chopped fibrous glass mat.

In any case, a review of the analytical results for samples S-3 through S-7 inclusively revealed that all would have exceeded the TLV if the sampling period had been reduced to a nominal 15 minute sampling period and if the only significant exposure occurred during actual spraying of the resin and catalyst. Therefore, further samples to evaluate MEKO exposure were planned during actual spraying activities only and were to be approximately the 15 minutes in length required to apply the resin and fibrous glass chopped mat. A fifteen minute period is also a commonly used sampling time to evaluate ceiling TLV's.

The results for the MEKO samples obtained on July 26 are contained in Table IV; sample times were reduced considerably from those of July 25 with the maximum sample period being 28 minutes. Seven of the twelve results were in excess of the 1.5 mg/M^3 ceiling TLV with samples S-8, S-9, and S-11 ranging from four to eight times the recommended limit of 1.5 mg/M^3. The analyst reported the solution in impinger samples S-8 and S-9 had a turbid appearance prior to analysis which might represent a positive interference with the analysis. For this reason, the S-8 and S-9 results may be erroneously high. There is a possibility that the suspension was pigment from the gelcoat spray in sample S-8 and the appearance of the suspension was consistent with the color of the gel coat pigment being used. However, no gel coating was performed by the worker wearing sample S-9 during the sampling period and no explanation for the turbid appearance was apparent to the investigator. The most important point to be observed from Table IV is that of the remaining ten samples, five were in excess of the TLV and the remaining five, with one exception, approached the TLV.

At Booth 11 where all of the samples except two were obtained on July 26, the spray-up work was performed from within the enclosure which tends to contain the generated vapors and mist. Although the work is adjacent to a ventilation hood, the enclosure is perpendicular to the face of the booth which considerably reduces the effectiveness of the ventilation.

A difference was apparent between the ventilation at Booth 11 and that at Booths 12 and 13. The spray-up at Booths 12 and 13 was performed on a horizontal surface about a foot off the floor with the two hoods located at the edge of the work area approximately 10 to 15 feet from the location of the worker during spray-up. The results for samples obtained under these conditions on July 27 with the exception of samples S-22 through S-24 are contained in Table V. In all cases, the exposures at Booths 12 and 13 were less than the 1.5 mg/M^3 ceiling TLV. The author would judge the difference in exposure level between Booth 11 and Booths 12 and 13 to be due to more adequate ventilation at Booths 12 and 13. This contention is further supported by the result of sample S-22, the only sample obtained at Booth 11 on July 27, which was in excess of the TLV and at a level consistent with the results measured at Booth 11 on July 26. The sample identified as S-25 was obtained where the worker was utilizing the hand lay-up technique; there was no MEKO detected in this impinger sample. The result of S-25 further supports the earlier observation that the primary exposure occurs from spray-up aerosol generation in that the resin/catalyst mixture was brushed onto the mold and therefore the only generation mechanism would be from evaporation of the catalyst which did not occur to a measurable degree.

Table VI contains the results obtained on July 26 and 27 to evaluate worker exposure to organic vapors. All samples were analyzed for styrene, acetone, vinyl toluene, and methyl methacrylate. Vinyl toluene and methyl methacrylate were not detected for any of the charcoal tubes; these substances were included in the laboratory request since empty containers indicated their use in the past and the possibility of cross-contamination or inadvertant operator use could not be completely discounted. The time-weighted results for styrene and acetone are presented in Table VI; sample times were considerably less than a full 8-hour shift since sampling was geared to the spray-up fabrication process, although the results should be considered generally to represent maximum exposures. The results for peak styrene measurements are also reported and it can be seen that at times the 600 ppm peak was exceeded at Booth 11 while significant peaks were measured at Booths 12 and 13 but all less than 600 ppm; the substantially reduced peaks at Booths 12 and 13 compared to Booth 11 was probably due to the ventilation differences discussed earlier in conjunction with the MEKO sample results. The result for sample CT6B is especially significant since it demonstrates a level of 200 ppm, equal to the Federal Standard which is not to be exceeded for more than five minutes. Since the workers' exposures are intermittent due to the nature of the fabrication work, there were very likely periods of time when the 200 ppm ceiling was exceeded.

Table VII contains a compilation of those organic vapor and MEKO personal samples which were obtained simultaneously. Quick inspection of this table indicates a general correlation of higher styrene exposures (say greater than 50 ppm) with the higher (greater than 1.0 mg/M^3) MEKO results. Therefore, the sample results for the evaluation seem to be in reasonable agreement. The peak styrene and ceiling MEKO results have already been discussed, but the combination of significant time-weighted styrene and acetone results for sample periods of up to two hours as well as peak styrene and MEKO exposures in excess of the ceiling could result in worker symptoms consistent with overexposure to these substances. Even though workers usually wear respirators during spray-up, the half-face respirators in use would not provide any eye protection.

During the follow-up survey, samples were obtained to evaluate worker exposure to airborne cobalt, fibrous glass fibers, and total particulate. One sample for each of cobalt and fibrous glass fibers were less than the detection limit of the sampling and analytical methods. The exposure to total aerosol was evaluated for one fabricator who would be primarily exposed to uncured and cured polyester resin aerosols. The exposure was to a concentration of 2.7 mg/M^3 although there is not a specific standard or guide for either cured or uncured airborne polyester resin particulate. This concentration is below the ACGIH TLV of 10 mg/M^3 for nuisance particulate which is the only comparison that can be made although it has not been established that either cured or uncured polyester resins are nuisance aerosols.

A brief survey of the compression molding area was conducted on July 28, 1978. The results of detector tube measurements are contained in Table VIII. These measurements were made at times that were judged to represent maximum exposures. The exposure for the sample at the bracket manufacturing station was the highest of the four compression molding stations. The higher exposure at that location appeared to be associated with the practice of unwrapping and stacking the impregnated parts prior to curing near the operator's breathing zone.

V. CONCLUSIONS

1. Workers were exposed to levels of MEKO in excess of the ACGIH TLV during spray-up fabrication as measured during the follow-up evaluation of July 25-28, 1978.

2. Peak levels of styrene in excess of the existing 600 ppm Federal Standard for peak measurements were measured in two instances. Although levels exceeded 600 ppm in only two instances, these measurements were made during typical fabrication spray-up processes and would occur frequently during spray-up processes. One sample for styrene was exactly

equal to the 200 ppm ceiling Federal Standard not to be exceeded for five minutes; the total sample time for this sample was 119 minutes.

3. Worker exposures to airborne vinyl toluene, methyl methacrylate, cobalt, and fibrous glass were less than the detection limit of the sampling and analytical methods used to evaluate them. Although polyester resins are not classed as nuisance aerosols, two measurements of fabricator exposure to total dust were less than 10 mg/M^3, the ACGIH TLV for nuisance dust.

VI. RECOMMENDATIONS

The recommendations below are in addition to those that have already been outlined in Section IV. E. 1. of this report in which the initial survey findings were discussed.

1. The ventilation at Booth 11 needs to be improved as evidenced by the MEKO exposures. At the time of the exit interview, a company representative stated that a downdraft system was being considered for this booth. The NIOSH investigator was in agreement that this approach appeared to be the most feasible option considering the work location, nature of fabrication, and location of the existing ventilation hood.

2. The practice of removing dust from clothing or skin by the use of compressed air should be discontinued. Dust should be removed by vacuuming instead.

3. The work stations at Booths 12 and 13 should be relocated so as to be directly in front of the exhaust hoods.

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Table I

Concentrations of Airborne Organic Vapors - Personal Samples

Warminster Fiberglass Company
Warminster, Pennsylvania

November 15, 1977

Job Description	Plant Number	Sample Identification	Sample Time (min)	Concentration - ppm Styrene	Acetone
Fabricator 1	1	CT1, CT12	403	48	105
Fabricator 2	1	CT2, CT13	393	30	107
Fabricator 3	1	CT3, CT14	391	22	76
Fabricator 4	1	CT4, CT15	389	16	37
Fabricator 5	1	CT5, CT16	387	21	40
Finisher	1	CT6, CT17	377	18	30
Fabricator 6	1	CT7, CT18	378	14	72
Fabricator 7	1	CT8, CT19	372	15	67
Fabricator 8	1	CT9, CT20	373	18	52
Fabricator 9	1	CT10, CT21A	355	9	49
Molder 1	2	CT21	125	21	80
Molder 2	2	CT22	123	31	246
Environmental Criteria				100	250

*The amount of acetone quantitated for the back-up section of the charcoal tube was greater than 1/3 of the reported value. The results, therefore, may not be quantitative.

Table II

Concentrations of Airborne Particulates - Personal Samples

Warminster Fiberglass Company
Warminster, Pennsylvania

November 15, 1977

Job Description	Plant Number	Sample Identification	Sample Time (min)	Concentration of Contaminant
Resin Room Attendant	1	V3166	316	0.61 mg/M^3*
Fabricator 1	1	AA3	132	<0.012 mg/M^3**
Fabricator 2	1	AA4	138	<0.011 mg/M^3**
Fabricator 3	1	AA1	128	<18000 fibers/M^3***
Fabricator 4	1	AA2	130	<18000 fibers/M^3***

* - Milligrams per cubic meter of total particulate, presumably consisting primarily of polyester resin - there is not a recommendation for an occupational exposure limit at the present time.

** - Milligrams per cubic meter (mg/M^3) of cobalt, the proposed recommendation of ACGIH for occupational exposure is 0.05 mg/M^3.

*** - Fibers per cubic meter of fibrous glass, NIOSH recommendation for occupational exposure limit is 3,000,000 fibers per cubic meter of air having a diameter equal to or less than 3.5 micrometers and a length equal to or greater than 10 micrometers as a time weighted average concentration (up to 10 hour work shift, 40 hour workweek).

Table III

Results of Personal Sampling to Determine
Methylethyl ketone peroxide (MEKO) Exposures

Warminster Fiberglass Company
Southampton, Pennsylvania

July 25, 1978

Sample No.	Location	Worker Activity (See Footnotes)	Sample Time (Hr:Min)	MEKO Concentration (mg/M^3)
S-1	Booth 3	1, 2	2:05	n.d.[3]
S-2	Booth 3	1, 2	2:05	n.d.[3]
S-3	Booth 3	1, 2	2:05	0.2
S-4	Booth 11	1, 2	2:50	1.0
S-5	Booth 11	1, 2	2:50	0.8
S-6	Booth 11	1, 2	1:00	0.5
S-7	Booth 11	1, 2	1:00	n.d.[3]
Environmental Criteria - ACGIH TLV -				1.5

1. Application by spraying of polyester resin, MEKO catalyst, and chopped fibrous glass roving
2. Compaction of chopped roving and resin mat by hand rolling
3. MEKO was not detected in sample, limit of detection for the analytical method was 7.5 ug per 15 ml of impinger solution

Table IV

Results of Personal Sampling to Determine Airborne MEKO Exposures

Warminster Fiberglass Company
Southampton, Pennsylvania

July 26, 1978

Sample No.	Location	Worker Activities (See Footnotes)	Sample Time (Hr:Min)	MEKO Concentration (mg/M^3)
S-8	Booth 11	1	0:16	8.4[4]
S-9	Booth 12/13	2	0:15	6.7[4]
S-10	Finishing Area	3	0:15	0.6
S-11	Booth 11	1	0:15	13.
S-12	Booth 11	2	0:12	1.3
S-13	Booth 11	2	0:25	1.2
S-14	Booth 11	2	0:10	2.6
S-15	Booth 11	2	0:17	2.0
S-16	Booth 11	2	0:20	3.5
S-17	Booth 11	2	0:15	2.8
S-18	Booth 11	1	0:28	1.4
S-19	Booth 11	1	0:15	0.3
Environmental Criteria - ACGIH TLV -				1.5

Footnotes

1. Application of surface coating by spraying of pigmented polyester resin (gel coat) and MEKO catalyst.
2. Application by spraying of polyester resin, MEKO catalyst and chopped fibrous glass roving. Resin and roving mat is compacted with hand rollers.
3. Application of strips to interior of enclosures (involves a lesser amount of resin and catalyst spraying) surface repair and cleaning, and final interior painting.
4. Sample had turbid appearance prior to analysis possibly due to entrainment of particulates in the impinger solution, reported result may be erroneously high.

Table V

Results of Personal Sampling to Determine Airborne MEKO Exposures

Warminster Fiberglass Company
Southampton, Pennsylvania

July 27, 1978

Sample No.	Location	Worker Activities (See Footnotes)	Sample Time (Hours:minutes)	MEKO Concentration (mg/M^3)
S-20	Booth 12/13	1	0:25	<0.3
S-21	Booth 12/13	1	0:19	<0.4
S-22	Booth 11	1, 3	0:19	2.2
S-24	Booth 11	2, 3	0:08	<0.9
S-25	Specialty Area	3, 4	0:15	<0.5
S-27	Booth 12/13	1	0:53	0.2
S-28	Booth 12/13	1	0:54	<0.1
S-29	Booth 12/13	1, 3	0:15	<0.5
Environmental Criteria - ACGIH TLV -				1.5

1. Application by spraying of polyester resin, MEKO catalyst and chopped fibrous glass roving. Resin and fibrous glass mat is compacted with hand rollers.
2. Application of reinforcement strips to interior of enclosures, requiring a lesser amount of resin and catalyst spraying than in 1 above.
3. Sample was obtained with an impinger held by the NIOSH investigator.
4. Hand lay-up fabrication technique was being used to form a "cherry picker" basket.

Table VI

Exposures to Airborne Organic Vapors

Warminster Fiberglass Company
Southampton, Pennsylvania

July 26 - 27, 1978

Sample No.	Date	Type[1] Sample	Sample Time Hr:Min	Location	Worker Activities	Contaminant Concentrations - ppm[2] Styrene-TWA	Styrene-Peak	Acetone
--	7/25	BZ	--	Parshall Flume Fabrication	Brushing, Rolling resin and catalyst	--	100 to 700 *	--
--	7/25	A	--	Parshall Flume Fabrication	After drying about 5 minutes		10 to 20 *	--
--	7/25	BZ	--	Booth 11	Applying resin to reinforcement strips	--	200 *	--
--	7/25	BZ	--	Booth 11	Rolling strips from above	--	20 to 250 *	--
--	7/25	BZ	--	Booth 11	Spraying resin & catalyst	--	200 to 600 *	--
CT2	7/25	BZ	2:05	Booth 3	5	42	--	22
CT5A	7/26	BZ	1:35	Booth 11	4	95	60 to 625 *	<1[9]
CT5B	7/26	BZ	1:52	Booth 11	6	102	--	60[9]
CT6A	7/26	BZ	1:24	Booth 11	4	68	200 to 625 *	36[9]
CT6B	7/26	BZ	1:59	Booth 11	5,6	200	--	88[9]
CT111	7/26	A	1:25	Booth 11	4	6	--	11
CT1A	7/26	BZ	2:19	Booths 12 & 13	5	60	20 to 360 *	30
CT1B	7/26	BZ	2:00	Booths 12 & 13	5,6	28	--	15
CT112	7/26	A	1:16	Booths 12 & 13	4	16	--	5
CT3A	7/26	BZ	2:20	Booths 12 & 13	5,6	27	20 to 360 *	19
CT3B	7/26	BZ	1:58	Booths 12 & 13	5,6	4	--	5
CT113	7/26	BZ	0:28	Booths 12 & 13	4	28	--	<3[9]
CT4A	7/26	BZ	1:59	Finishing Area	3	54	--	137[9]
CT4B	7/26	BZ	2:01	" "	3	8	--	16
CT4C	7/26	BZ	1:24	" "	3	5	--	55
CT20	7/27	BZ	:25	Booths 12 & 13	5	59	--	55
CT28	7/27	BZ	:50	Booths 12 & 13	5	24	--	19
CT21	7/27	BZ	:23	Booths 12 & 13	5	19	--	33
CT27	7/27	BZ	:50	Booths 12 & 13	5	27	--	13
CT25	7/27	BZ	1:55	Hand Fabrication Area	7	5	--	<1
DT1	7/28	BZ	--	Bracket Mfr.	8	--	50	--
DT2	7/28	BZ	--	Trim Panel Mfr.	8	--	10 to 15	--
DT3	7/28	BZ	--	Pier Panel Mfr.	8	--	<10	--
DT4	7/28	BZ	--	Instr.Panel Door Mfr.	8	--	30 to 50	--
Environmental Criteria						100	600	250

Footnotes

1. Type of Sample, BZ - sample obtained in the breathing zone of the worker, A-sample obtained in the general area of worker activity.
2. Parts of vapor per million parts of contaminated air by volume at 25°C and 760 mm. Hg. pressure.
3. Surface repair and cleaning of finished enclosure, application of interior reinforcement strips, and final interior painting.
4. Application by spraying of pigmented polyester resin (gel coat) and MEKO Catalyst.
5. Application by spraying of polyester resin, MEKO catalyst and chopped fibrous glass roving. Resin and fibrous glass mat is compacted with hand rollers.
6. Application of reinforcement strips to interior of enclosures, requiring a lesser amount of resin and catalyst spraying than in 5 above.
7. Hand lay-up fabrication technique was being used to form a "cherry picker" basket. The resin and MEKO catalyst are mixed together and applied with a brush to the mold.
8. Samples were obtained in the compression molding area of the plant with detecter tubes.
9. A significant amount of acetone was found on the reference portion of the charcoal tube and the result for acetone should not be considered quantitative.

* Direct reading instrument utilizing a photo ionization principle was used to obtain instantaneous measurements of styrene concentration; instrument was calibrated with styrene before use.

Table VII

Simultaneous Exposures to Airborne Organic Vapors and MEKO - Personal Samples

Warminster Fiberglass Company
Southampton, Pennsylvania

July 26, 27, 1978

Sample[1] Numbers	Date	Location	Worker Activities	Sample Times-Min Organic Vap.	Sample Times-Min MEKO	Contaminant Concentrations Styrene-ppm[2]	Acetone-ppm	MEKO-mg/M3[3]
S-8,CT5A	7/26	Booth 11	4	95	16	95[8]	<1	8.4[10]
S-13,S-15, CT5-B	7/26	Booth 11	5	112	25,17	102[9]	60	1.2, 2.0
CT6A,S-11	7/26	Booth 11	4	84	15	68[9]	36	13.
CT6B,S-12	7/26	Booth 11	5	119	12	200	88	1.3
CT1A,S-9	7/26	Booths 12 & 13	5	139	15	60	30	6.7[10]
CT113,S-18, S-19	7/26	Booths 12 & 13	4	28	28,15	28	<3	1.4, 0.3
S-10,CT4A	7/26	Finishing Area	6	119	15	54	137	0.6
CT20,S-20	7/27	Booths 12 & 13	5	25	25	59	55	<0.3
S-28,S-29, CT28	7/27	Booths 12 & 13	5	50	54,15	24	19	<0.1,<0.5
CT-21,S-21	7/27	Booths 12 & 13	5	23	19	19	33	<0.4
S-27,CT27	7/27	Booths 12 & 13	5	50	53	27	13	0.2
S-25,CT-25	7/27	Hand Fabrication Area	7	115	15	5	<1	<0.5
Environmental Criteria						100	250	1.5

1. Separate sampling trains for organic vapors and MEKO were utilized on the same worker at the same time during the shorter sampling time.
2. Parts of vapor per million parts of contaminated air by volume at 25°C and 760 mm. Hg.
3. Milligrams of substance per cubic meter of air.
4. Application by spraying of pigmented polyester resin (gel coat) and MEKO catalyst.
5. Application by spraying of polyester resin, MEKO catalyst and chopped fibrous glass roving. Resin and chopped fibrous glass mat is compacted with hand rollers.
6. Application of reinforcement strips to interior of enclosures, requiring a lesser amount of resin and catalyst spraying than in 5 above.
7. Hand lay-up fabrication technique was used. The resin and MEKO catalyst are mixed together and applied with a brush to the mold.
8. Peak measurement results during sampling period - 60 to 625 ppm of styrene.
9. Peak measurement results during sampling period - 200 to 625 ppm of styrene.
10. Sample may have had positive interference, result is probably erroneously high.

Table VIII

Detector Tube Measurements of Styrene Vapor in
Operator Breathing Zone - Compression Molding Area

Warminster Fiberglass Company
Southampton, Pennsylvania

July 28, 1978

Detector Tube No.	Time	Manufacturing Operation	Concentration (ppm)
1	10:57 am	Bracket	50
2	11:05 am	Trim Strip	10 to 15
3	11:10 am	Pier Panel	less than 10
4	11:15 am	Instrument Panel Door	30 to 50