U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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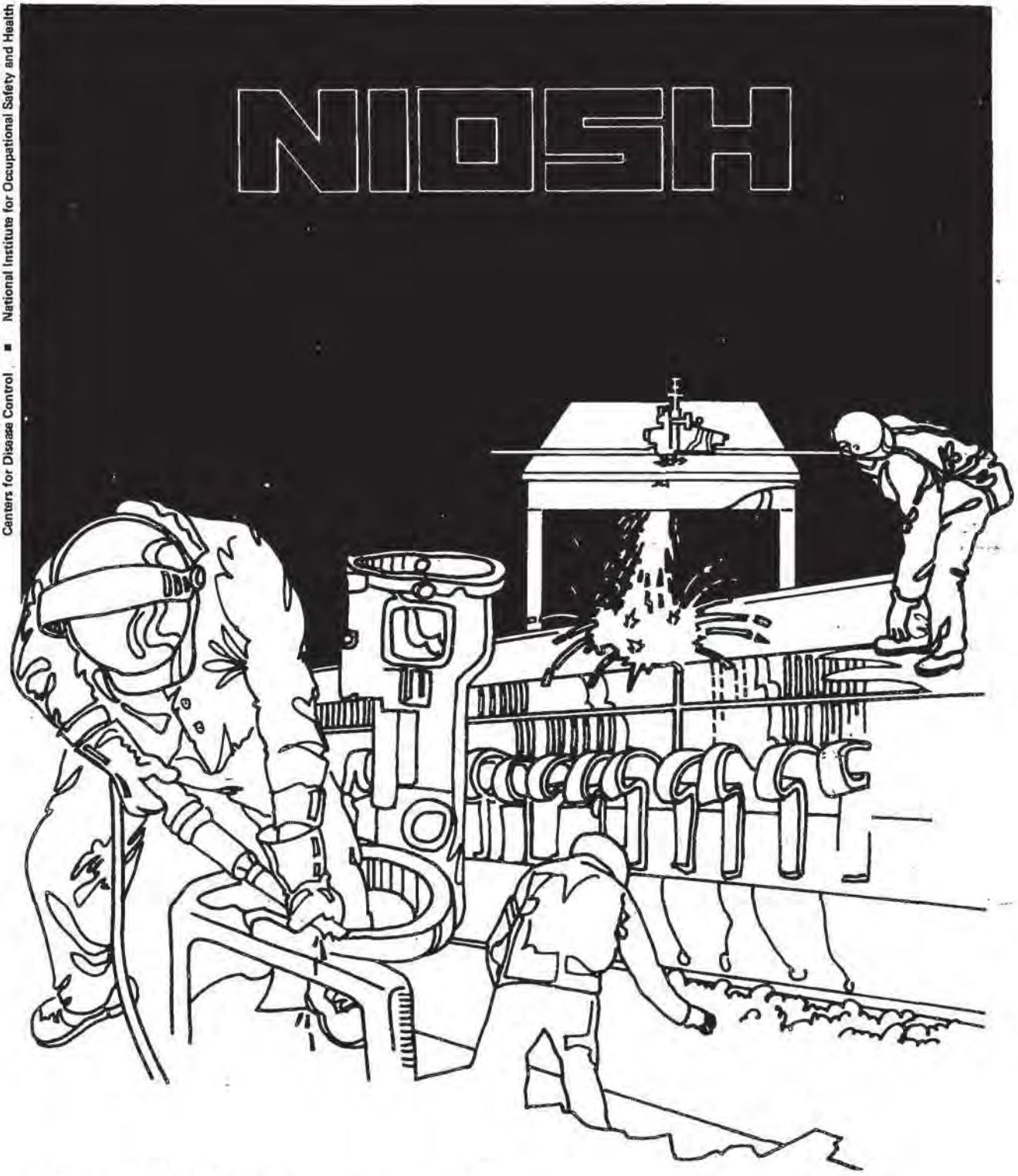
NIOSH



Health Hazard Evaluation Report

HETA 82-355-1375
R&S MANUFACTURING COMPANY
COLUMBIA, PENNSYLVANIA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 82-355-1375
September, 1983
R&S MANUFACTURING COMPANY
COLUMBIA, PENNSYLVANIA

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I. SUMMARY

On July 30, 1982, NIOSH received an employee request to evaluate adverse health effects following exposure to an epoxy resin dust at the R&S Manufacturing Company, Columbia, Pennsylvania, which produces fractional horsepower electric motors for oscillating electric fans. The request stated, "...that workers in close contact with epoxy resin dust experienced dizziness, severe chills, high fever, weakness in the joints, and lower back pain in the kidney area".

On August 19, 1982, NIOSH conducted environmental sampling for trimellitic anhydride (TMA), the curing agent contained in the epoxy resin. Breathing zone air samples collected for TMA showed concentrations ranging from 0.12 to 0.28 milligram per cubic meter (mg/m^3) which exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) upper limit of 0.04 mg/m^3. Due to trimellitic anhydride's extreme toxicity at low levels, NIOSH recommends that exposures should be kept at the lowest feasible limit.

A follow-up medical and environmental evaluation was conducted on September 29, 1982. Prior to the follow-up, the company changed to a non-trimellitic anhydride containing epoxy resin. Sampling was conducted for total dust and silica, a principle component of the new resin system. All of sixteen workers who had spent time in the epoxy room with the trimellitic anhydride were interviewed. Ten had experienced symptoms consistent with trimellitic anhydride exposure. The most common symptoms were of irritation. However, four workers had symptoms consistent with trimellitic anhydride immunologic syndromes. Nine of those reporting symptoms had a decrease or cessation of symptoms following removal from trimellitic anhydride exposure.

The brown resin without trimellitic anhydride, substitued for the original in mid-August, produced no respiratory symptoms but did cause irritation of the skin in 3 of 10 exposed workers. Several workers also reported coughing up brown, resin containing phlegm after working with the resin. Finally, NIOSH found a peripheral neuropathy in the dominant hand of three female workers, associated with the use of tongs to move hot stators, and multiple second degree burns on the forearms or hands of nine workers. The forearm burns were due to direct contact with hot stators, while the burns on the fingers were due to inadequate hand protection when handling hot stators.

Following engineering changes in the epoxy room, NIOSH conducted an environmental survey on November 19, 1982. Due to sampling problems encountered during this portion of the evaluation and the installation of additional engineering controls, environmental sampling was again conducted on June 9-10, 1983. Results of breathing zone samples collected over two shifts did not indicate the presence of respirable airborne free silica.

On the basis of these results, NIOSH determined that a health hazard existed in the past from overexposure to trimellitic anhydride at R&S. Following replacement of the epoxy resin, trimellitic anhydride exposure was eliminated. Possible health hazards exist from the use of improperly sized tongs used to move the hot stators, and from direct skin contact with the stators. Recommendations for eliminating these conditions are made in Section VII of this report.

KEYWORDS: SIC 3621 (Electrical Motors), epoxy resins, trimellitic anhydride, silica, epichlorohydrin, respiratory effects, chemically-induced immunologic syndromes, sore throat, cough, chest pain, shortness of breath, peripheral neuropathy, second degree burns.

II. INTRODUCTION

On July 30, 1982, NIOSH received a confidential employee request for a Health Hazard Evaluation to evaluate adverse health effects experienced following exposure to an epoxy resin dust at R&S Manufacturing Company, Columbia, Pennsylvania. The reported health effects included dizziness, severe chills, high fever, joint weakness, and lower back pain in the kidney area.

NIOSH personnel visited the plant on August 19, 1982, September 29, 1982, November 11, 1982, and June 9, 1983 and distributed interium reports in September 1982, following the initial visit to the plant, and on November 5, 1982, following the second visit.

III. BACKGROUND

At the time of the initial NIOSH visit, the R&S Manufacturing Company, Columbia, Pennsylvania, had manufactured fractional horsepower electric motors for oscillating electric fans for four years. The plant produces about 13,000 motors per day, and employ 190 people over three shifts; 160 of these are in production. The production area is a large open space which covers approximately one-half a city block.

The first step in the motor production is the application of an insulator to the core of the motor, the stator. In late June 1982, the company installed the semi-automated resin spray operation which applied an epoxy resin to pre-heated electric motor stators to act as an electrical insulator. Previously, preformed plastic insulators had been used. A small section of the building was walled off to form an area for spraying the epoxy on the stators. Prior to spraying, the metal stator is passed through a gas-fired furnace (operated at 350°F) via conveyor belt which runs between the main production area and the epoxy room. Employees grasp the stator with either a glove covered hand or a pair of metal tongs and place it on a holder in a semi-automatic spray machine. The machine, which has its own recirculating ventilation system, applies an epoxy resin powder to the stator. The epoxy powder is melted by the hot metal and polymerizes to form a stable, hard coating. The stator is removed from the machine by hand or with the use of tongs and returned to a conveyor belt hook. After passing through the oven in the opposite direction, the stator is removed from the belt hook outside the epoxy room and proceeds through the assembly process.

Prior to the NIOSH environmental evaluation in June, 1983, the epoxy coating room was remodeled. The two fluidizers were isolated via a block wall, which eliminated the potential for recirculated air contaminating the work area with resin dust. The fluidizers draw over-spray from the three resin coating machines. This action produces local exhaust ventilation for the applicators, by drawing work-room air through the system along with the resin over-spray. Fabric collectors,

internal to the fluidizers, filter the air and collect the resin for re-use. Prior to isolation of the fluidizers, tears or other malfunctions would release resin dust into the work area.

Three people per shift work in the epoxy room: a substitute relieves them during breaks and meals.

Three epoxy resins, all fine powders, have been used at the plant. The first, colored blue and containing 6% trimellitic anhydride as a curing agent, was used only from late June until mid August, 1982. A green resin, deemed unsatisfactory for the application, was used for two days following discontinuation of the blue resin. At present, the company is using a brown resin containing an amide curing agent and silica (57% according to the product's Material Safety Data Sheet and 17 to 74% according to NIOSH analysis of bulk samples).

Shortly after the epoxy operation commenced in late June 1982, several employees began experiencing adverse health effects, necessitating visits to their physicians. The plant closed for vacation for the first two weeks in August. Upon returning to work, the employees again experienced adverse health effects.

A chronology of these events and the subsequent evaluations follows:

Date	Event
Late June, 1982	Epoxy resin spraying (Blue - 6% TMA) starts
Early-mid July, 1982	First health problems
30 July, 1982	HHE request
1-15 August, 1982	Plant closed for 2 week vacation
16 August, 1982	Vacation ends; symptoms recur
19 August, 1982	Initial NIOSH environmental survey
20 August, 1982	Switch to green resin - found to be unsatisfactory
22 August, 1982	Switch to brown resin - amide curing; 74% silica
September, 1982	First NIOSH interim report
29 September, 1982	Medical survey and environmental follow-up
September - November	Institution of engineering controls
5 November, 1982	Second NIOSH interim report
11 November, 1982	Third environmental survey
February - March	Remodeling of epoxy room
9 June, 1983	Fourth environmental survey

IV. EVALUATION DESIGN AND METHODS

A. Environmental

1. Trimellitic Anhydride (TMA)

During the August 1982 environmental survey, personal breathing zone samples were collected on 0.8 um polyvinyl chloride

filters with MSA model "G" pumps operating at 2 liters per minute (lpm). These samples were analyzed by gas chromatography using NIOSH Method P&CAM #322 (1), with the following modification:

Trimellitic anhydride was derivatized to its trimethyl ester according to NIOSH Method P&CAM #322, and then the boron trifluoride complex was precipitated by adding 100 microliter (ul) of diethyl ether, 100ul of pentane, and 500ul of pyridine mixture.

2. Silica

During the September and November 1982 environmental surveys, breathing zone samples for respirable dust were collected with MSA model "G" pumps operating at 2 lpm and closed-faced cassettes containing 0.8um polyvinyl chloride filters preceded by a nylon cyclone. These samples were subsequently analyzed gravimetrically. Samples of total dust were collected appproximately 3 feet from the breathing zone of the employees as above, except that no cyclone was used. These samples were also analyzed gravimetrically.

Following isolation of the resin fluidizers, environmental monitoring was conducted to determine employee exposures to free silica on June 9-10, 1983. Two environmental conditions exist in the resin coating room; one under summer conditions, where the resin room doors are opened and a 48 inch exhaust fan located in an external wall is operated, and winter conditions where the doors are closed and the fan is off. Sampling was conducted for one shift under both conditions. Breathing zone samples were collected from each of the three employees, and three general area samples were also collected. The sampling units consisted of 10 mm nylon cyclones and 37 mm, 5 um pore size pre-weighed polyvinyl chloride membrane filters, operated at 1.7 lpm. High volume area samples were collected using 0.5 inch HASL® cyclones and 37 mm, 5 um pore size polyvinyl chloride filters, collected at 9 lpm for the duration of the work shift. Material bulk samples and settled dust samples were also collected.

Free silica samples were analyzed utilizing NIOSH Method P&CAM 259(2) with the following modifications: (1) Filters were dissolved in tetrahydrofuran rather than ashed in a furnace. (2) Standards and samples were run concurrently and an external calibration curve was prepared from the integrated intensities rather than from the suggested normalization prodedure.

3. Epichlorohydrin

During the August 1982 environmental survey, breathing zone samples were collected on standard 150-mg charcoal tubes with sampling pumps operating at 0.2 lpm. The samples were analyzed for epichlorohydrin by a variation of Method S-118 (3). The A and B sections of the charcoal tubes were separately desorbed in 1 milliter (ml) of carbon disulfide. The analyses were performed on a Tracor 560 gas chromatograph equipped with a Hall detector in the halogen mode. A 10° X 1/8" glass column packed with 0.2% Carbowax 1500 on Carbopack C was used isothermally at 100°C.

B. Medical

All workers who had worked in the epoxy room were interviewed. A medical, occupational, and exposure history was taken with special emphasis on the period of work with the blue epoxy resin powder. Since all of the workers had worked with another resin, had been on vacation, and/or had terminated exposure to the blue resin, they served as their own controls. Exposure information was based on time worked in the epoxy room. Physical examination of the hands and arms was done when the history suggested a peripheral neuropathy or burns.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure.

Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

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

B. Epoxy Resins

An epoxy resin system (4) is composed of the following two (or more) reactive components: (1)the curing agent (also referred to as the hardener, catalyst, accelerator, activator, or setting agent), and (2) the resin, which, in turn, is usually a long-chained prepolymer composed of previously reacted epichlorohydrin and glycidyl ethers. Epoxy resins may be modified with "fillers", such as mica, asbestos, diatomaceous earth, and silica flour.

1. Curing Agents

Several classes of chemicals have been used as curing agents. These include anhydrides, aromatic or aliphatic amines, and amides. Trimellitic anhydride (TMA), the curing agent in the blue resin, is a very reactive, low molecular weight chemical. Four clinical syndromes (5) are now recognized as being caused by the inhalation of trimellitic anhydride dust or fumes (The first three immunologic syndromes have a latent period of exposure before the onset of symptoms).

The first is an immediate-type airway response, asthma-rhinitis, which is mediated by IgE antibody directed against trimellityl conjugated human respiratory tract proteins.

The second, the late respiratory systemic syndrome, is characterized by cough, wheezing, dyspnea, mucus production, and systemic symptoms of malaise, chills, myalgias, and arthralgias occurring 4 to 12 hours after exposure. This syndrome is accompanied by substantial levels of serum antibody directed against trimellityl-substituted human proteins.

The third syndrome, developed by workers in several plants in the United States and Canada, is a pulmonary disease characterized by hemoptysis, dyspnea, pulmonary infiltrates, restrictive lung disease, and anemia designated the "pulmonary disease-anemia syndrome". This illness develops with high-dose exposure to fumes when heated metal surfaces are sprayed with materials containing trimellitic anhydride to make them resistant to corrosion. High levels of antibody to trimellityl human proteins and red blood cells have been found in these patients.

The fourth syndrome, the irritant syndrome, occurs on the first high-dose exposure to trimellitic anhydride dust or fumes and is related to the chemical irritant properties of the anhydride.

In view of this toxicity, NIOSH (6) recommends that trimellitic anhydride be handled as an extremely toxic agent in the workplace. The ACGIH (12) recommends an upper exposure limit of 0.04 mg/m^3.

2. Epichlorohydrin

Epichlorohydrin (7,8) is highly irritating to eyes, skin, and respiratory tract. Skin contact may result in delayed blistering and deepseated pain. Allergic eczematous contact dermatitis occurs occasionally in exposed workers. NIOSH considers epichlorohydrin to be a suspect human carcinogen. This is based primarily on two recent studies: a long term epidemiologic study showing a significant increase in respiratory cancer deaths of exposed workers, and an inhalation study showing an increae in nasal carcinomas in rats. In addition, cytogenetic studies of human peripheral lymphocytes have shown a highly significant increase in chromosomal abnormalities in exposed workers. Thus, NIOSH recommends that exposures to epichlorohydrin should be maintained at the lowest feasible limit. The current OSHA standard is 19 mg/m^3.

C. Silica

Silicosis (9,10) is a debilitating respiratory disease caused by inhalation of fine crystalline silica dust that is retained in the lungs. The amount of dust inhaled, the percentage of free or uncombined silica in the dust, the size of the dust particles, and the length of exposure all affect the onset of silicosis. The inhaled dust deposited in the small airways and air sacs (alveoli) of the lungs reacts within the lung tissue to cause a fibrotic response and the production of silicotic nodules. The earliest symptom of silicosis is shortness of breath. As the disease progresses, the silicotic nodules coalesce and form a continuous mass of fibrotic tissue, called progressive massive fibrosis.

Silicosis appears in different ways depending on exposure conditions and individual variations. Researchers have described three forms of the disease. They differ primarily in the length of exposure before the onset of symptoms of the disease and the rate at which the disease then progresses. The common or simple form of silicosis has been recognized as an occupational disease since antiquity. It may take 20 or more years of exposure before a chest X-ray is positive for silicosis. Usually there is little or no problem with breathing in the early stages of simple silicosis. The silica content of the dust to which workers developing simple silicosis are exposed is often less than 30%.

Accelerated and acute silicosis develop after shorter exposure to respirable silica dust at high concentrations. Accelerated silicosis differs from simple silicosis mainly in the time from first exposure to silica dust until silicotic nodules appear on a chest X-ray. In accelerated silicosis the exposure varies between 5-15 years, the progression of disease is faster and often there is progressive massive fibrosis.

Acute silicosis, also termed silicoproteinosis, develops after 1-3 years of exposure and progresses even faster than accelerated silicosis. There is a rapid loss of pulmonary function, invariably followed by death. A distinctive feature in acute silicosis is the presence of a surfactant-like liquid in the alveoli. On a chest X-Ray there are few silicotic nodules, and they are rather diffuse. No effective medical treatment is available for silicosis. Thus, prevention of exposure to silica is of paramount importance.

NIOSH recommends that respirable free silica exposure should not exceed 0.05 mg/m^3, for a ten-hour time-weighted average (TWA).

The Occupational Safety and Health Administration°s standard (11) for crystalline silica (SiO_2) for an eight-hour workshift is calculated by dividing 10 mg/m^3 by (% SiO_2 + 2) for respirable

dust with more than 5% SiO_2, or 5 mg/m^3 for respirable dust with 5% or less SiO_2.

VI. Results and Discussion

A. Environmental

1. Trimellitic Anhydride

The concentrations of trimellitic anhydride in two breathing zone samples of the epoxy resin powder sprayers were 0.14 and 0.28 mg/m^3. Both of these exposures exceeded the ACGIH TLV (12) of 0.04 mg/m^3. Another sample taken at the stack of the recirculation filter system to check its effectiveness was 0.12 mg/m^3.

2. Epichlorohydrin

All samples were less than 0.01 mg/m^3, which is the lower volume adjusted limit of detection.

3. Silica

The concentrations of silica in all samples collected for free silica during the June 9-10 environmental survey were below the analytical limit of detection of 0.03 milligrams per sample for both silica polymorphs (quartz and cristobalite). This corresponds to airborne concentrations of generally less than 0.04 mg/m^3 (Table I). The two high volume samples collected for respirable silica were also reported at less than the limit of detection, which correlates to less than 0.009 mg/m^3. The high-volume samples for total dust (non-respirable plus respirable) were reported as having a free silica content of 0.97 and 0.43 mg., or 0.225 and 0.106 mg/m^3, respectively. In comparing the high volume area samples (respirable vs. total), it appears that the airborne free silica in the resin room is non-respirable, and therefore does not pose a silicosis health threat to the employees in this area.

A material bulk sample was obtained and analyzed for free silica content, with analytical results showing a quartz content of 17%, and a cristobalite content of less than 1.5%. A settled dust sample showed a silica content of 37% quartz, and less than 1.5% cristobalite. The material bulk was microscopically analyzed to determine the physical nature of the silica. The supplier of the resin material reported that the silica was coated with resin and therefore did not pose a significant health threat to exposed persons. However, microscopic analysis indicated resin granules coated with

smaller silica particles. However, as demonstrated through environmental sampling of respirable exposures these particles were in the non-respirable range.

B. Medical

Sixteen workers had been exposed to the trimellitic anhydride containing resins for periods ranging from 1 day to 5 weeks with a mean exposure of 3 weeks. Of these 16 workers, there were 10 females and 6 males. The average age was 30.1 years (range 21-51). The mean duration of employment at R&S was 3 years (range 1-7years). Fourteen of the exposed workers smoked. Three of the 16 reported a history of allergies, and the remaining ten had no known allergies.

Ten of the 16 exposed workers (63%) reported symptoms temporarily related to TMA exposures. The most common symptoms were cough and nose, throat, and/or eye irritation temporaly related to TMA exposure. Of these ten workers, four reported symptoms consistent with the irritant syndrome, three consistent with late respiratory-systemic syndrome, one consistent with both an irritational and late respiratory-systemic syndrome, and one consistent with the asthma-rhinitis syndrome. Six reported no symptoms. Of the ten with symptoms nine noted a marked reduction or complete cessation of symptoms following removal from exposure to the trimellitic anhydride resin or switch to a non-trimellitic anhydride containing resin. The mean duration of exposure to the trimellitic anhydride resin in those reporting symptoms was 3.4 weeks, vs. 2 weeks in those without symptoms.

In addition to health effects related directly to the epoxy resin powders, NIOSH observed two significant sources of work related injury in the epoxy room at R&S:

1. Peripheral neuropathy in the dominant hand of three female workers, associated with the use of tongs to move hot stators. From physical examination and the workers history, the NIOSH medical officer determined that the tongs were poorly designed and sized for female workers. This produced compression of tissue, including nerves at the base of the palm of the workers' hands, leading to a peripheral neuropathy.

2. Multiple recent and partially healed second degree burns on the forearms or hands of nine workers. The forearm burns were due to direct contact with hot stators, while the burns on the hands were due to inadequate hand protection when handling hot stators.

The results clearly show an abundance of symptoms following exposure to trimellitic anhydride, which were similar to those reported in the literature. In contrast to a previous report (5), though, symptoms appeared somewhat sooner in this group of workers. This may be due to higher exposures than observed in some other groups.

An alternative explanation for the reported symptoms would have been widespread upper respiratory tract illness among those in the epoxy room. Although this cannot be totally excluded, the good correlation between symptoms and exposure, the disappearance of symptoms following termination of exposure, and the reappearance of symptoms in several workers following return from a two week vacation argue strongly in favor of trimellitic anhydride exposure as the causative factor in the workers symptoms. A possible limitation of this study is its retrospective nature, i.e., workers' recall being biased by their knowledge of a problem and the apparent role of the blue epoxy resin.

Although symptoms abated when R&S switched to the non-trimellitic anhydride resin, health concerns among employees continued in light of the high silica content of the brown resin. However, these concerns should be mitigated as a result of the June 1983 environmental survey, which demonstrated exposures to respirable free silica below the NIOSH recommended standard. These lowered exposures are probably a direct result of remodeling the resin room. However, the long-term effects of the inhalation of epoxy powders are not known. This lack of information should dictate caution and a continued effort to reduce exposures to the lowest possible levels.

VII. RECOMMENDATIONS

1. Good housekeeping practices should be maintained. Cleaning should be done with wet or vacuum methods. Air guns should not be used.

2. For moving hot stators, R&S should obtain tongs that are the right size and weight for those using them. In addition some padding on the handles of the tongs should reduce the local pressure at the base of the hand, thereby eliminating nerve compression.

3. Showers should be provided at work so that workers may remove any residual epoxy resin.
4. Workers should be informed of hazards of epoxy resins and methods of controlling those hazards by posting notices on both doors entering the epoxy room, through distribution of copies of this report, and through other educational programs.

5. No smoking should be allowed in the epoxy room due to the potential explosion hazard. (A sign is already in place on the door).

6. No eating, drinking, or personal objects should be allowed in the epoxy room (A sign is already in place on the door).

7. The resin spraying machines should be placed so that workers do not bump into each other while moving or handling the hot stators. Gloves which will provide adequate thermal insulation should be utilized. These measures should prevent burns in the future.

VIII. REFERENCES

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. 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:

1. R & S Manufacturing Company
2. Employee Representative
3. Requestor
4. NIOSH, Region III
5. OSHA, Region III

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE I

AIRBORNE CONCENTRATIONS; RESPIRABLE QUARTZ, CRISTOBALITE, PARTICULATE

R&S MANUFACTURING
COLUMBIA, PENNSYLVANIA

JUNE 8-9, 1983
HETA 82-355

Date	Type	Duration	Location	Concentration (mg/m^3)		
				Quartz	Cristobalite	Particulate
6-8-83 183	BZ-R[1]	07:28-15:21	Operator	<0.042	<0.042	0.014
6-8-83 174	BZ-R	07:25-12:35[2]	Operator	<0.059	<0.059	0.195
6-8-83 176	BZ-R	13:05-15:24[2]	Operator	<0.135	<0.135	0.584
6-8-83 175	BZ-R	07:22-15:18	Operator	<0.042	<0.042	0.180
6-8-83 182	Area-R[3]	07:31-15:16	#2 Epoxy Machine	<0.038	<0.038	0.139
6-8-83 181	Area-R	07:41-15:10	Fluidizer Room	<0.039	<0.039	0.118
6-8-83 180	Area-R	07:36-15:14	Central Work Area	<0.039	<0.039	0.064
6-8-83 178	Hi-vol-R[4]	07:55-15:04	#1 Epoxy Machine	<0.009	<0.009	0.174
6-8-83 185	Hi-vol-T[5]	07:55-15:04	#1 Epoxy Machine	0.106	<0.007	0.341
6-9-83 164	BZ-R	07:09-15:13	Operator	<0.041	<0.041	0.705
6-9-83 163	BZ-R	07:13-15:16	Operator	<0.040	<0.040	0.537
6-9-83 169	BZ-R	07:11-15:15	Operator	<0.041	<0.041	0.517
6-9-83 168	Area-R	07:19-15:08	Fluidizer Room	<0.038	<0.038	0.063
6-9-83 171	Area-R	07:17-15:12	#2 Epoxy Machine	<0.037	<0.037	0.533
6-9-83 162	Area-R	07:15-15:10	Central Work Area	<0.037	<0.037	0.421
6-9-83 172	Hi-vol-R	07:25-15:02	#1 Epoxy Machine	<0.007	<0.007	0.545
6-9-83 170	Hi-vol-T	07:25-15:02	#1 Epoxy Machine	0.225	<0.007	0.504

1 Breathing zone sample; respirable fraction
2 Hole discovered in tygon tubing during shift; necessitated replacement of filter
3 General area sample; respirable fraction
4 General area high volume sample; respirable fraction
5 General area high volume sample; total dust