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. 79-7-639

GREENHECK FAN CORPORATION
SCHOFIELD, WISCONSIN 54476

DECEMBER, 1979

## I. TOXICITY DETERMINATION

A health hazard evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) of powdered paint operations in Plants 1 and 2, Greenheck Fan Corporation, Schofield, Wisconsin, on November 7 and 8, 1978, and on March 6, 1979. The evaluation consisted of (a) medical interviews of employees in and around powder paint operations; (b) environmental sampling and laboratory analysis of air contaminants; (c) inspection of the work place.

Results of the hazard evaluation indicate the following:

A. The two powder paint spray operators in Plant 2 were exposed to excessive levels of airborne contaminants in powder paint spray operations. Maximum exposure was reported as 14.7 milligrams per cubic meter of air ($mg/M^3$) for total nuisance particulate matter (dust), which exceeded the ACGIH environmental criterion of 10 $mg/M^3$. The maximum exposures of the two spray operators to bisphenol A (BA) and to the diglycidyl ether of bisphenol A (DGEBA) were 1.063 $mg/M^3$ and 0.200 $mg/M^3$ respectively. These airborne levels of BA and DGEBA may be considered excessive and potentially toxic.

B. There was historical evidence of skin, eye, and mucous membrane irritation in several employees working in and around powder paint dipping and spraying operations. In addition, several employees were observed to have skin manifestations such as scattered, sparse, red papules (bumps) over the backs of the hands, slight erythema (redness) of the neck and exposed areas of the upper chest, and/or dry, peeling palms and slightly reddened eyes. In general, these signs and symptoms appeared to be mild.

   It was not considered feasible to determine the possible long-term effects of exposure to epoxy resins in this work force because of the limited number of "exposed" employees and their relatively brief exposure time.

C. Employees were not exposed to toxic concentrations of chromium, barium, lead, quartz, cristobalite, cadmium, epichlorohydrin, and trimellitic anhydride.

D. Employees were not exposed to toxic airborne toxic concentrations of the major organic solvents (i.e., mineral spirits, benzene, toluene, and xylene) considered at the time of this evaluation.

Recommendations are made on pp. 15 and 16 to minimize employee exposure to BA and DGEBA.

## II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request to 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 Publication office at the Cincinnati address.

Copies of this report have been sent to:

a) Greenheck Fan Corporation
b) Authorized Representative of the Sheet Metal Workers' International Association - Local No. 565, AFL-CIO
c) U.S. Department of Labor - Region V
d) NIOSH - Region V

For the purpose of informing the approximately 20 "affected employees", the employer shall promptly "post" for a period of 30 calendar days, this 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 received such a request from an authorized representative of the Local Union No. 565 - Sheet Metal Workers' International Association, AFL-CIO, concerning employees' complaints of eye irritation, foul taste, and skin irritation during powdered paint operations in plant 1 and 2.

## IV. HEALTH HAZARD EVALUATION

### A. Description of Process

The Greenheck Fan Corporation has 180 production employees and 100 administrative employees. It manufactures power roof ventilators, centrifugal fans, utility blowers, propeller fans, and similar equipment. Powder paint operations are conducted in plant 1 and plant 2.

Plant 1 involves the use of Product A (epoxy-based powder paint) in a fluidized bed (via air bubbles through membrane at bottom of vat). The top of the vat (4 feet by 6 feet by 6 feet) is at floor level and contains the fluidized powder paint between 70°F and 85°F. A walk-in type hood with no sash or doors is over the vat. An oven is over the hood and is maintained between 275°F and 375°F. A common conveyor chain services all three tier systems (below floor vat, floor level hood and overhead oven). The parts, primarily bird-screens, are placed on the conveyor chain which transfers the part to the oven for pre-heat. The part is then dipped in the fluidized powder paint and transferred to the oven for a cure time of 2 minutes. The chain is hit with a hammer prior to the oven in order to knock off any excess powder from the part. The entire process (placing part on conveyor, pre-heating, dipping, curing, and removing of part) takes about 3.0-3.5 minutes to complete. The operation is conducted by one employee during the day shift only. A few employees work in adjoining areas. The vat contains 1 inch slots at the top for ventilation. Paint spray operations using liquid paint are conducted in nearby spray booths.

Plant 2 involves Product B (epoxy-based powder paint) used in an electrostatic spraying operation ( conveyor belt part has positive charge and spray gun paint has negative charge). The spraying operations are conducted in a large spray booth (about 21 feet long, 10 feet wide, and 18 feet high) which is provided with baffled down draft ventilation. The ends of the spray booth have a two foot opening to provide for the moving conveyor belt with parts. Each side of the spray booth has an opening (spray operator stations) of about 4 feet at opposite sides of the spray booth. The two operator stations have two railed elevators (move up and down depending on part size, etc.). The part which is hung on the slow-moving conveyor line is spray painted on one side, top, and bottom at the first paint station and then painted on the other side (plus touch up top and bottom) at the second paint station as the part moves through the paint booth. The part then moves through a large enclosed oven (about 18 feet high, 50 feet long, and 12 feet wide) which is maintained around 300°F to 350°F. The curing time in the oven is around 20 minutes and the oven is ventilated. The part is then inspected, and if needed, a liquid spray paint is used to touch up that portion of

the part needing additional paint. A ventilated water fall paint spray booth is provided for this operation. The powder spray operation is operated by two spray painters and two material handlers. The operation is conducted during the day shift (5 days a week) and may be conducted a few hours on swing shift during the week. A few employees work in adjoining areas.

B. Medical Facilities

Greenheck has 2 part-time registered nurses who provide coverage during the 1st and 2nd shifts, a total of 25 hours per week. Services provided by the health clinic include obtaining pre-employment health histories, treatment of minor job-related injuries, counseling, and a hypertension screening program. Pre-employment and periodic physical examinations are not done. A consultant physician is on call for emergencies.

C. Evaluation Progress and Methods

1. Progress

An initial NIOSH walk-through as well as an environmental/medical survey of powdered paint operations in Plant 1 and Plant 2 was conducted on November 7 through 8, 1979 by two industrial hygienists and a medical investigator. An exit interview was held with appropriate representatives of union and management to discuss any preliminary observations and findings, and to answer any questions concerning this evaluation and subsequent reports. An interim summary report of observations and preliminary findings was sent to management and union representatives on December 7, 1978. A follow-up environmental survey was conducted on March 6, 1979, by one of the industrial hygienists. It is noted that considerable time was necessary to develop new analytical procedures for the analysis of bisphenol A and diglycidyl ether of bisphenol A as there were no acceptable methods for analysis of these compounds at the time of the survey.

2. Environmental Design and Methods

Bulk samples of the powdered paints used in Plants 1 and 2 were obtained and submitted to the NIOSH laboratory in Cincinnati and analyzed for chromium, barium, lead, quartz, cristobalite, cadmium, epichlorohydrin, and trimellitic anhydride. These elements and/or compounds were either not detected or were found in such low trace amounts that they were not considered to represent a potential health hazard to employees and thus are not discussed further in this report. The manufacturer of the various products (e.g., two different powdered epoxy paints and liquid paint for touch-up) used in the operations were contacted to ascertain the specific chemicals in their products. Based on the information provided by the NIOSH laboratory and the manufacturer, it was concluded

that this evaluation should emphasize (1) environmental airborne concentrations of particulate dusts, bisphenol A (BA) and diglycidyl ether of bisphenol A (DGEBA) during powder paint operations and (2) environmental airborne concentrations of toluene, benzene, xylene, and mineral spirits during touch-up operations with liquid paint. Some employees expressed concern that the powder paints may contain epichlorohydrin and/or trimellitic anhydride. However, contact with the manufacturer as well as analysis of the bulk samples did not indicate the presence of these compounds.

Air samples via personal and area sampling apparatus were used to assess the potential exposure of employees to various contaminants. Charcoal tube samples were obtained using a Sipin Pump at 0.05 to 0.1 liters of air per minute (lpm). These samples were analyzed for toluene, benzene, xylene, and mineral spirits. FWSB or DM800 polyvinyl chloride filters in a two piece cassette were obtained using an MSA pump at a flow rate of 1.7 lpm or 1.5 lpm. Some respirable particulate samples were obtained using FWSB or DM800 filter samples with a 10 mm cyclone at a sampling rate 1.7 lpm. These samples were analyzed for nuisance particulates, BA, and DGEBA. Several GF glass fiber filters in a two piece cassette were obtained using a MSA pump at a flow rate of 1.5 lpm. These samples were analyzed for BA and DGEBA.

These samples were submitted to the NIOSH laboratory for gravimetric analysis of the filter samples and analysis of the charcoal tube samples via gas chromatographic procedures contained in the NIOSH Manual of Analytical Methods, HEW Publication No. (NIOSH) 77-157, Cincinnati, Ohio, 1977. Bisphenol A and the diglycidyl ether of bisphenol A were analyzed by High Performance Liquid Chromatography (HPLC) using a method developed by UBTL, for NIOSH (contact No. 210-78-0087). The HPLC method was a C-18 reverse phase column, and acetonitrile - water solvent gradient, and a UV spectrophotometer at 230 nm. Method details can be obtained from the Measurement Services Branch, Division of Physical Sciences and Engineering, NIOSH, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

Bendix and Draeger detector tube measurements for carbon monoxide were obtained in the powder paint areas of Plant 1 and 2. Results for carbon monoxide indicated a maximum level of 9 $mg/M^3$ (by oven in Plant 2) which is well below the NIOSH recommended level of 40 $mg/M^3$. Hence, carbon monoxide is not mentioned in other parts of this report as it is not a problem.

3. Medical Method of Evaluation

The NIOSH medical investigator conducted a walk-through evaluation of the medical clinic and of those areas of the plant involved in the powdered paint dipping and spraying operations. The plant nurse on duty that day was interviewed and the OSHA log reviewed. The NIOSH medical investigator interviewed all employees, present that day (from both plants) who worked in or around the powder paint dipping and spraying operations -

a total of 13. Questions were directed toward complaints of skin and mucous membrane irritation and any current, possibly work-related symptoms. A brief examination of exposed skin was made on those employees whose medical history suggested possible skin problems.

D. Evaluation Criteria

1. Environmental Criteria

The three primary sources of environmental evaluation criteria considered in this report are: (a) NIOSH Criteria Documents with recommended standards for occupational exposure; (b) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's) with supporting documentation; and (c) Federal Occupational Health Standards as promulgated by the Occupational Safety and Health Administration, U. S. Department of Labor (29 CFR 1910.1000). For the substances evaluated during this study, the primary environmental criteria considered most appropriate are

TABLE OF ENVIRONMENTAL CRITERIA

| SUBSTANCE | STANDARD OR GUIDE $mg/M^3$* |
|---|---|
| Mineral Spirits (e.g., stoddard solvent, etc.) | 350 (a)** (maximum concentration of 1,800 $mg/M^3$ for 15 minute sampling period) |
| Toluene | 375 (a,b)*** (750 $mg/M^3$ for 10 minute sampling period) |
| Benzene | 3.2 (a)**** |
| Xylene | 434 (a,b,c) |
| Total Nuisance Particulates (Dusts) | 10 (b) |
| Respirable Nuisance Particulates (Dusts) | 5 (b) |

*Approximate milligrams (mg) of substance per cubic meter ($M^3$) of air sampled.

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

***In case of mixture of air contaminants particularly with organic solvents, the overall effects are considered as additive. An employer shall compute the equivalent exposure as follows:

$$Em = \frac{C_1}{L_1} + \frac{C_2}{L_2} \ldots \frac{C_n}{L_n}$$ The value of Em shall not exceed unity.

Where:

Em is the equivalent exposure for the mixture,
C is the concentration of a particular contaminant,
L is the exposure criteria for that contaminant.

****The current ACGIH-TLV for benzene is 30 mg/M$^3$ with a reference that benzene is a chemical substance associated with industrial processes which are suspect of inducing cancer in man. However, recent studies from clinical as well as from epidemiological data are conclusive at this time that benzene is leukemogenic because it produces progressive, malignant disease of the blood-forming organs. Based on this more recent data, NIOSH recommended to OSHA that an emergency standard for benzene be 3.2 mg/M$^3$. OSHA has recently published an emergency standard for benzene of 3.2 mg/M$^3$.

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.

There are no established standards or criteria for bisphenol A or diglycidyl ether of bisphenol A. At present there is insufficient data available to suggest a standard for these compounds.

2. Biological Criteria

Nuisance Particulates[1]

"Nuisance" dusts, in contrast to fibrogenic or scar-tissue forming dusts, are reported to have relatively little harmful effect on the lung provided exposures are kept within reasonable limits. These dusts are also called (biologically) inert dusts, a term which is inappropriate to the extent that any inhaled dust (reaching alveoli or air sacs) will induce some cellular response. High concentrations of such dust may cause skin and mucous membrane irritation, bronchitis, and safety hazards such as decreased visibility.

Epoxy Resin Systems-bisphenol A Type/DGEBA/BA[2-13,15]

The bisphenol A type epoxy resin system is the most commonly used commercially and is produced by reacting epichlorhydrin (ECH) and bisphenol A (BA) in varying proportions. This reaction, in the presence of an alkaline catalyst, produces the diglycidyl ether of bisphenol A (DGEBA),

the simplest epoxy resin or monomer. Using various manipulations it is then possible to make resins of increasing molecular weight. As the molecular weight increases, there is a transition from a relatively low-viscosity liquid to a high-viscosity liquid and finally to a solid material. In general, toxicity and irritancy decrease as the molecular weight increases.

The uncured epoxy resin system used in the two powdered paint operations covered by this evaluation are essentially identical chemically and therefore will be considered together. The basic uncured resin consists of a high-molecular weight, partially polymerized resin, bisphenol A type, the diglycidyl ether of bisphenol A (DGEBA), bisphenol A (BA) plus fillers and additives such as pigment, curing agents (hardeners), reactive diluents and materials necessary to obtain desired characteristics such as flow.

The high molecular weight resin system such as used in Plants 1 and 2 are reported to be relatively weak skin irritants and sensitizers. If left in contact with the skin for prolonged periods of time they may cause contact dermatitis. The material may also be transferred, for example by the hands, to more sensitive areas of the body such as the eyes resulting in irritation. Skin reaction may be delayed and may not develop for several weeks or months after onset of exposure. A small percentage of individuals will be unusually sensitive to the resin and will respond to even trace amounts of the material.

DGEBA has been found to be mutagenic in bacteria. The implication of this for humans, as observed by Andersen et al,[3] is that it is an indication of a genetic hazard, including a cancer risk, for individuals exposed to these compounds. It was pointed out that "The fact that epoxy resins can be metabolized to mutagenic active compounds enhances the genitic risk from aromatic epoxy resins. Man is exposed to the resins during the manufacture and use either by skin contact with the compound or inhalation of air contaminated with droplets or powder particles of epoxy resin." (P.392) The investigators further noted that for the immediate future it is not feasible to identify the genetic or carcinogenetic hazards of aromatic epoxy resins by epidemiological means. In humans there is a long latent period for genetic damage in most cancers and widespread commercial use of epoxy resins did not begin until the early 1960's. They suggested that in order to prevent cancer and genetic damage in humans it is necessary to "minimize the exposure to substances such as aromatic epoxy resins which have been shown to be mutagenic in bacteria, and thus must be considered as potential mutagens and carcinogens in human beings." (P. 392)

In addition to the major components of the epoxy resins described above, they also contain such materials as fillers, pigment, curing agents (hardeners) and/or catalyzing agents, reactive diluents, and materials needed to obtain desired characteristics of the uncured resins such as flow. These additives, particularly the curing agents, can present a

health hazard, e.g., moderate to severe skin irritation, eye irritation, and skin sensitization in susceptible individuals. Communication with the manufacturers of the chemicals used in the formulation of the products used in Plants 1 and 2 indicated that the hazard associated with the use of the materials is low with an oral LD 50 (rat) in excess of 200 mg/KG. It was further stressed that eye contact with the material may cause minor irritation but no corneal injury, skin contact would not likely result in skin absorption of toxic amounts but that weak sensitization or allergenic response may result. The dusts are reported to be low in hazard by inhalation.

Other Chemicals

Although the results of the environmental sampling did not detect exposure to toxic airborne concentrations of the major organic solvents, information on their toxicity is included here for general information purposes.

Toluene

At high concentrations toluene is a central nervous system depressant. Repeated or prolonged skin contact with liquid toluene cause drying, fissuring and dermatitis. If the liquid is splashed into the eyes it can cause a transient corneal damage and conjunctival irritation. The TLV was set at a level to prevent systemic effects.

Xylene

Locally xylene vapor has an irritant effect on the eyes, mucous membranes, and skin. Systemically, acute exposure to the vapor can cause central nervous system depression and minor reversible effects upon the liver and kidneys. At high concentrations it causes narcosis.

Mineral Spirits

Mineral spirits is a commonly used organic solvent which upon repeated or prolonged skin contact may lead to dermatitis. Solvents alter the protective barrier of the skin resulting in redness, drying, and cracking of the skin. Once this barrier is broken an individual is more susceptible to infection and absorption of chemicals through the affected areas is facilitated. The major toxic effects from mineral spirits and other solvents are skin, eyes, and mucous membrane irritation plus central nervous system effects resulting in such symptoms as light-headedness, headache, incoordination, and a feeling of sleepiness.

Benzene

Acute exposure causes central nervous system depression; chronic exposure results in depression of the hematopoietic (blood-forming) system and is associated with an increased risk of leukemia.

E. Evaluation Results and Discussion

1. Environmental Results and Discussion

Tables I and III show the concentrations of organic solvents obtained from personal and area samples obtained during touch-up liquid spray painting operations in the area or adjacent areas in Plant 1 and 2. Considering the results for toluene, benzene, xylene, and mineral spirits by themselves as well as the combined effects ($Em = \frac{C_1}{L_1} + \frac{C_2}{L_2} \cdot \cdot \frac{C_n}{L_n} = 1$) of all the organic solvents covered by this evaluation, employee exposure would be less than 1 (Em = 0.01) percent of the environmental criteria of Em = 1. Hence, employees were not exposed to airborne concentrations of organic solvents considered toxic or even potentially toxic or excessive at the time of this evaluation.

Table II shows the results of three personal and four area samples obtained during normal fluidized-bed, powder paint operations in Plant 1. The maximum result on the personal samples was 1.3 mg/M$^3$ for total nuisance particulates which is well below the environmental criterion of 10 mg/M$^3$ for total nuisance particulates. The maximum sample result for BA and DGEBA were reported as 0.006 mg/M$^3$and 0.008 mg/M$^3$ respectively. The concentrations found for BA and DGEBA are not considered excessive or toxic. However, it is noted that the area sample result of 1.6 mg/M$^3$ for total nuisance dusts is indicative of airborne dusts outside of the walk-in hood which was designed to contain such dusts. Also, operations (e.g., changing of fluidized-bed, maintenance, etc.) which may generate excessive dusts were not conducted during the evaluation and hence, may present a problem.

Table IV shows the results of 15 personal and six area samples obtained during normal spray powder paint operations in Plant 2. Six out of the 21 samples obtained are considered as the most significant from an environmental standpoint and are underlined. The six personal samples were for total dust and represent exposure confined to employees who were spray paint operators at the two paint stations of the booth. Four of the six selected samples were analyzed for total nuisance particulates with results varying from 4.3 to 14.7 mg/M$^3$ with two samples exceeding the environmental criteria of 10 mg/M$^3$ for total nuisance particulates. The other two samples (Sample Nos. PGF-3 and PGF-10) were not analyzed for total particulate samples, although, it may be concluded that these samples would exceed the environmental criteria of 10 mg/M$^3$ for total nuisance particulates considering the results of BA slightly in excess of 1 mg/M$^3$ when considering all the analytical results of the samples. Hence, it is felt that four out of the six samples probably exceeded the environmental criteria of 10 mg/M$^3$ for total nuisance dusts. The results of these six samples for BA varied from 0.173 to 1.063 mg/M$^3$. The results of these six samples for DGEBA varied from 0.087 to 0.200 mg/M$^3$. No definitive conclusions could be made as to whether these concentrations

were toxic or not toxic, although the levels for BA and DGEBA may be considered excessive and potentially toxic. Results of dust samples indicated that an average of 16% of the total dust was of the respirable size. These results are of concern regarding potential inhalation exposure. Samples obtained from the two material handlers (one of which is also a touch-up painter using liquid spray paint) and area samples did not show airborne concentrations of total nuisance dusts, BA, or DGEBA which are considered toxic. Therefore, the two employees at the two painting stations at the spray booth represent the workers with the most exposure to total nuisance dusts, BA, and DGEBA. Employees in areas adjacent to the spray booth have less exposure. Operations such as cleaning of the bag filter and box, and maintenance, which may generate excessive dust, were not performed during the evaluation and may present an exposure problem.

A cursory ventilation survey was made of the powder paint operation in Plants 1 and 2 using velometer and smoke tubes. The velometer did not indicate any flow of air into the hood over the vat in Plant 1 and no flow of air into the slots of the vat. Smoke tubes indicated some flow of air into the back slot of the vat. Air flow in the hood indicated some flow at floor level into the hood over the vat with upward currents moving back out of the hood at the 5 or 6 foot or breathing zone level of the operator. Fine particles of the powder paint were noticed immeditely outside of the hood at the breathing zone of the operator when the hammer hit the conveyor chain to knock off the excess powder. Openings into the spray booth (powder spray painting) showed air flow into the booth of 100 feet per minute (fpm) at the conveyor belt entrance and exit and around the breathing zone of both operators at the spray station. The flow of air into the spray booth (e.g., used for liquid paint touch-up) was 100 fpm at the intended point of operation. However, the actual point of operation was too far away from the spray booth to provide for any effective ventilation for the material handler who occasionally has to spray or touch-up parts.

2. Medical Results and Discussion

The NIOSH medical investigator interviewed all employees present that day who worked in and around the powder paint dipping and spraying operations. Five employees reported no work-related health problems. Eight (8/13) had signs and/or symptoms which were possibly work-related. Included were eye irritation, itching and/or redness (3); nasal "sores" (1); sore throat (1); burning tongue (1); "dusty" taste in the mouth (1); occasional episodes of breathing difficulty with wheezing (1); and skin irritation, rash, peeling and/or erythema (redness) (3). The skin problems tended to be worse when perspiring heavily. Several workers were observed to have skin manifestations such as erythema of the neck and exposed area of the upper chest (2), scattered red papules (bumps) sparsely distributed over the backs of the hands (1); peeling skin on the palms of the hands (1); and signs of eye irritation (reddened conjunctiva) (1). The signs and symptoms appeared to be mild in nature.

In discussions with the plant nurse on duty that day it was apparent that she was unaware of the then current skin and mucous membrane complaints as reported to NIOSH investigators. Review of the OSHA log did not reveal any unusual patterns of illness pertinent to this evaluation.

## V. SUMMARY OF OBSERVATIONS AND FINDINGS

Environmental/Medical

Results of Environmental sampling indicated excessive exposure to airborne contaminants in the two powder spray paint operations in Plant 2. The powder spray operators' exposure to airborne levels of total nuisance particulate dusts exceeded the environmental criteria of 10 $mg/M^3$. The environmental/medical results further indicated that the spray operators were exposed to potentially toxic airborne levels of epoxy resin constituents, specifically BA and DGEBA.

The dip operation in Plant 1 is also an area of concern. Although excessive levels of airborne contaminants were not detected during this survey, it is noted that the operator was visibly contaminated with powder. Also, the environmental samples obtained during this survey were not taken during operations which were likely to generate excessive dust such as during the addition of the uncured resin to the vat. The necessity for improving engineering controls such as ventilation and for the use of protective clothing as indicated.

During the survey, it was noted that the skin and clothing of several employees, particularly dip and spray painters, were contaminated with visible amounts of uncured resin. While air sampling is the only readily quantifiable measure of exposure, air sampling alone will not adequately measure occupational exposure to various chemicals. Other routes such as ingestion and skin absorption need to be considered.

It is noted that the company has well-designed facilities for the use of epoxy resins in Plants 1 and 2. It appears that there is a problem, however, with insuring that engineering design parameters are implemented and maintained. Although present housekeeping procedures are above average considering the type of process involved, they could be improved. Meticulous housekeeping must be maintained to minimize contamination.

Several work practices which need correction or improvement include, 1) inadequate emergency eye wash or emergency showers; 2) inadequate ventilation, e.g., none at dip operations (150 fpm needed at openings to spray booth); 3) inadequate respiratory protection program (e.g., beards on faces of employees, face fit, etc.); 4) visible contamination of skin and clothing of employees with powdered paint; 5) visible powdered paint on surfaces in areas adjacent to dipping and spraying operations; and 6) periodic

ventilation changes in certain areas of Plant 2 that cause a "rain" of particulate matter. (This condition was not observed during the survey.) The last item, No. 6, was discussed with management and union and both agreed that it may or may not be a valid complaint and that if any employee(s) complains of the "rain" that both union and management will evaluate the situation and take appropriate action on the matter.

There are several operations, which may create airborne dust problems such as maintenance, cleanup of bag filters, addition of resin to the system, and changing of resin in the fluidized-bed, which were not performed at the time of the survey and, hence, were not evaluated or included as part of this report. It must be emphasized that uncured epoxy resins should not be considered "nuisance" particulate. Aromatic epoxy resins have been shown to be mutagenic in bacteria and may represent a cancer risk in humans. They contain additives (catalysts, curing agents, etc.) other than bisphenol A (BA) and DGEBA which were not covered in this evaluation due to inadequate information and/or lack of necessary or sufficiently sensitive analytical procedures for their detection. Although such additives represent a very small percentage of the overall formulation, they may contribute significantly to the overall toxicological considerations of the total resin system. The glycidyl ethers are highly reactive both chemically and biologically. Cytotoxic effects and mutagenicity in bacteria and other test systems has been demonstrated. It is recommended [(NIOSH) criteria document, Occupational Exposure to Glycidyl Ethers.[17]] that because of the evidence that some "glycidyl ethers have the potential to produce tumorigenic, mutagenic, or reproductive effects, and because few have been adequately tested for such effects, occupational exposure to glycidyl ethers is defined (in this document) as work in any area where these substances are manufactured, stored, used, or handled". (p.11) It is further recommended that "work practices appropriate for handling glycidyl ethers should be adhered to in processes involving an uncured epoxy resin system". (p.27)

There is historical evidence of irritation of the skin, eyes, and mucous membranes of the respiratory tract in several employees working in and around powder paint dipping and spraying operations. In addition, several employees were observed to have skin manifestations such as sparse, scattered red papules (bumps) over the back of the hands, slight erythema (redness) of the neck and exposed areas of the upper chest, and/or dry, peeling palms and slightly reddened eyes. The signs and symptoms appeared to be mild in nature.

It was not considered feasible to try to determine the possible long-term effects of exposure to epoxy resins in this work-force because of the limited number of "exposed" employees and their relatively brief exposure time.

## VI. RECOMMENDATIONS

In view of the above information as well as the lack of toxicological information on various chemicals, particularly BA AND DGEBA, etc., it is prudent to minimize exposure. The following recommendations are offered to provide a safer and more healthful working environment for all personnel:

1. Review, evaluate, and make appropriate modifications to the current engineering controls (e.g., ventilation, enclosures, hoods, etc.) to assure that the engineering controls are adequate, operational, and properly used. This should include periodic checking, cleaning and maintenance of equipment and engineering controls such as hoods, booth, vats, and filter bags. Improved engineering controls and maintenance programs would preclude the possible airborne contamination and accumulation of dusts outside of the vat hood in Plant 1 and spray booth in Plant 2. Maximum ventilation should be maintained to minimize all exposures.

2. An improved continuing education program to ensure that employees are made aware of the potential health hazards associated with and the precautions to be observed in the safe handling of epoxy materials. Good work practices and good personal hygiene should be stressed with the goal of preventing or minimizing inhalation, ingestion, skin and eye contact with these materials. Included in this program should be 1) thorough and frequent hand-washing, especially before eating, drinking, smoking or going to the lavatory; 2) no eating, drinking or smoking at work stations or areas involved with the powder paint operations; 3) use of protective clothing for operators directly involved in dipping or spraying operations with daily change of contaminated work clothes. The recommendations outlined in the NIOSH criteria document on Glycidyl Ethers[17] should be implemented where appropriate. Illnesses should be reported to the plant nurse(s) particularly cases of skin, eye and mucous membrane irritation.

3. The company should evaluate and modify the respiratory protection program to ensure that it is in compliance with requirements (e.g., training, face fit, etc.) described (outlined as 11 criteria for a "minimal acceptable program") in the Occupational Safety and Health Administration Standard, Title 29 of the Code of Federal Regulations, Part 1910, Section 134.

4. Adequate protective clothing should be provided for employees where operations which generate dust or involve direct contact with the uncured resin. Contamination of personal clothing or the body with the powder should be avoided. The two spray operators and the vat operator in particular, should be provided with adequate protective clothing, such as hoods, gloves that have no gauntlets or cuffs and are tight at wrists, cuffless pants or coveralls, long sleeve shirts.

5. As a minimum, an emergency dual water stream eye wash basin, preferably with an overhead shower, should be easily accessible to employees in both powder paint areas.

6. Good housekeeping practices are mandatory for safe handling of epoxy resin systems. Powdered epoxy resins are prone to dust freely. These dusts, suspended in air, represent not only a health hazard, for example from inhalation, but a fire and explosion hazard as well if dusts are permitted to reach explosive levels. Dust accumulation (in ducts, bins, filters and such) should not be permitted. Dust collectors should be vented outdoors. Vacuuming and/or wet cleanup procedures for floor or other areas should be used in lieu of dry sweeping or similar cleanup procedures. Contamination outside of the powder paint hood in Plant 1 and spray booth in Plant 2 should be kept to a minimum.

7. The plant should have a medical monitoring program as described in the NIOSH Criteria Document on Occupational Exposure to Glycidyl Ethers, DHEW (NIOSH) Publication No. 78-166 (1978).[17]

8. All cases of irritation of the skin, eyes and mucous membrane should be reported to the plant nurse.

9. Emergency procedures should be re-evaluated and revised for the two paint areas in Plants 1 and 2. Employees shall be instructed in and follow proper emergency procedures in the event of fire or explosion. These procedures shall include prearranged plans for (a) medical care and transportation of injured; (b) firefighting procedures; (c) fire protection in accordance with the requirements of 29 CFR 1910.156 and 1910.65; (d) proper shutoff procedures; (e) cleanup and decontamination procedures including use of protective clothing during emergencies; (f) evacuation of non-essential employees; roping off, posting, and securing of perimeters of hazardous areas from entry until the employee indicates it is safe to enter the area; and (g) warning or alarm systems for alerting workers to possible concentrations of flammable dust, liquids or vapors.

10. As described in the NIOSH criteria document on glycidyl ethers,[17] "During examinations, applicants or employees found to have medical conditions, such as neurodermatitis, dyshydrosis, or atopy (an inherited predisposition to allergy), that would be directly or indirectly aggravated by exposure to glycidyl ethers shall be counseled on the increased risk of impairment of their health from working with these substances."

5. As a minimum, an emergency dual water stream eye wash basin, preferably with an overhead shower, should be easily accessible to employees in both powder paint areas.

6. Good housekeeping practices are mandatory for safe handling of epoxy resin systems. Powdered epoxy resins are prone to dust freely. These dusts, suspended in air, represent not only a health hazard, for example from inhalation, but a fire and explosion hazard as well if dusts are permitted to reach explosive levels. Dust accumulation (in ducts, bins, filters and such) should not be permitted. Dust collectors should be vented outdoors. Vacuuming and/or wet cleanup procedures for floor or other areas should be used in lieu of dry sweeping or similar cleanup procedures. Contamination outside of the powder paint hood in Plant 1 and spray booth in Plant 2 should be kept to a minimum.

7. The plant should have a medical monitoring program using the NIOSH Criteria Document on Occupational Exposure to Glycidyl Ethers, DHEW (NIOSH) Publication No. 78-166 (1978)[17] as a guide.

8. Emergency procedures should be re-evaluated and revised for the two paint areas in Plants 1 and 2. Employees shall be instructed in and follow proper emergency procedures in the event of fire or explosion. These procedures shall include prearranged plans for (a) medical care and transportation of injured; (b) firefighting procedures; (c) fire protection in accordance with the requirements of 29 CFR 1910.156 and 1910.65; (d) proper shutoff procedures; (e) cleanup and decontamination procedures including use of protective clothing during emergencies; (f) evacuation of non-essential employees; roping off, posting, and securing of perimeters of hazardous areas from entry until the employee indicates it is safe to enter the area; and (g) warning or alarm systems for alerting workers to possible concentrations of flammable dust, liquids or vapors.

9. As described in the NIOSH criteria document on glycidyl ethers,[17] "During examinations, applicants or employees found to have medical conditions, such as neurodermatitis, dyshydrosis, or atopy (an inherited predisposition to allergy), that would be directly or indirectly aggravated by exposure to glycidyl ethers shall be counseled on the increased risk of impairment of their health from working with these substances."

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Table I

Concentrations of Organic Solvents of Area (A) and Personal (P) Charcoal Tube Samples Obtained in Plant 1 During Normal Production Operations at the Greenheck Fan Corporation, Schofield, Wisconsin

| Date | Job and/or Area Classification | Sample Number | Time of Sample | Toluene mg/M$^{3*}$ | Benzene mg/M$^{3*}$ | Xylene mg/M$^{3*}$ | Mineral Spirits mg/M$^{3*}$ |
|---|---|---|---|---|---|---|---|
| 11/8/78 | Dip Painter A | P-10 | 0752-1417 | 0.4 | ND** | 0.4 | 1.6 |
| 11/8/78 | Area Sample on Parts Dipper Hanager | A-11 | 0757-1417 | ND | ND | 0.5 | ND |
| 11/8/78 | Area Sample on Parts Dipper Hanger | A-12 | 0757-1417 | 0.7 | ND | 0.5 | 1.1 |
| Environmental Criteria for 40-hour workweek | | | | 375 | 3.2 | 434 | 350 |

*mg/M$^3$--approximate milligrams of substance per cubic meter of air.

**ND----ND-none detected or value was less than the limit of detection of 0.02 mg per charcoal tubes

Table II

Environmental Results of Personal (P) and General Area (A) Filter Samples
(GF--Glass Fiber, Filters; FW and DM--are Polyvinyl Filters)
Obtained in Plant 1 During Normal Production Operations at the
Greenheck Fan Corporation, Schofield, Wisconsin

| Date | Job and/or Area Classification | Sample Number | Time of Sample | Type of Sample | Nuisance Particulates | Bisphenol A $mg/M^{3*}$ | Diglycidyl Ether of Bisphenol A $mg/M^{3*}$ |
|---|---|---|---|---|---|---|---|
| 11/8/78 | Dip Painter A | PGF-12 | 0752-1417 | Total Dust | NA | 0.005 | 0.008 |
| 11/8/78 | Area Sample on Parts Dipper Hanger | AGF-7 | 0804-1417 | Total Dust | NA | 0.006 | 0.004 |
| 11/8/78 | Area Sample on Parts Dipper Hanger | AFW-3336 | 0804-1417 | Total Dust | 0.3 | 0.005 | 0.004 |
| 11/8/78 | Area Sample on Parts Dipper Hanger | AFW-3334 | 0804-1417 | Respirable Dust | 0.1 | 0.005 | 0.001 |
| 03/6/79 | Dip Painter A | PD8-1568 | 0800-1505 | Total Dust | 1.3 | 0.004 | 0.007 |
| 03/6/79 | Dip Painter A | PD8-1574 | 0800-1505 | Respirable Dust | 0.2 | 0.005 | ND |
| 03/6/79 | Area Sample on Parts Dipper Hanger | AD8-1591 | 0804-1505 | Total Dust | 1.6 | 0.005 | 0.002 |
| Environmental Criteria for 40-hour workweek | | | | Total Dust<br>Respirable Dust | 10.0<br>5.0 | --** | --** |

*$mg/M^3$--approximate milligrams of substance per cubic meter of air.

--**----No environmental criteria or standards were suggested for Bisphenol A and Diglycidyl Ether of Bisphenol A. Refer to body of report for further information.

ND------None detected or value was less than the limit of detection of 0.0005 mg per filter for Bisphenol A and 0.0007 mg per filter for Diglycidyl Ether of Bisphenol A.

NA------Sample not analyzed for nuisance particulates.

Table III

Concentrations of Organic Solvents of Area (A) and Personal (P) Charcoal Tube Samples
Obtained in Plant 1 During Normal Production Operations at the
Greenheck Fan Corporation, Schofield, Wisconsin

| Date | Job and/or Area Classification | Sample Number | Time of Sample | Toluene $mg/M^{3*}$ | Benzene $mg/M^{3*}$ | Xylene $mg/M^{3*}$ | Mineral Spirits $mg/M^{3*}$ |
|---|---|---|---|---|---|---|---|
| 11/8/78 | Spray Painter A | CT-1 | 0708-1512 | ND** | ND | 0.5 | 1.5 |
| 11/8/78 | Spray Painter C | CT-2 | 0711-1510 | ND | ND | ND | ND |
| 11/8/78 | Material Handler E | CT-3 | 0705-1516 | ND | ND | 1.0 | 1.7 |
| 11/8/78 | Material Handler F (Touch-Up Painter) | CT-4 | 0715-1516 | ND | ND | ND | 1.6 |
| 11/8/78 | Wheel Balancing Area | CT-5 | 0722-1441 | ND | ND | ND | ND |
| 11/8/78 | Area Sample Stations F | CT-6 | 0832-1240 | ND | ND | 0.4 | 1.2 |
| 11/8/78 | Area Sample Stations D | CT-7 | 0832-1449 | ND | ND | 0.3 | 1.3 |
| Environmental Criteria for 40-hour workweek---------- | | | | 375---------- | 3.2---------- | 434---------- | 350 |

*$mg/M^3$--approximate milligrams of substance per cubic meter of air.

**ND----ND-none detected or value was less than the limit of detection of 0.02 mg per charcoal tubes

Table IV

Environmental Results of Personal (P) and General Area (A) Filter Samples
(GF--Glass Fiber, Filters; FW and DM-are Polyvinyl Filters)
Obtained in Plant 2 During Normal Production Operations at the
Greenheck Fan Corporation, Schofield, Wisconsin

| Date | Job and/or Area Classification | Sample Number | Time of Sample | Type of Sample | Nuisance Particulates | Bisphenol A mg/M$^3$* | Diglycidyl Ether of Bisphenol A mg/M$^3$* |
|---|---|---|---|---|---|---|---|
| 11/8/78 | Spray Painter D | PGF-3 | 0708-1512 | Total Dust | NA | 1.039 | 0.181 |
| 11/8/78 | Spray Painter C | PGF-10 | 0711-1510 | Total Dust | NA | 1.063 | 0.200 |
| 11/8/78 | Material Handler E | PGF-13 | 0705-1516 | Total Dust | NA | 0.003 | ND |
| 11/8/78 | Material Handler F | PGF-15 | 0715-1516 | Total Dust | NA | 0.004 | ND |
| 11/8/78 | Wheel Balancing | AGF-16 | 0722-1441 | Total Dust | NA | 0.001 | ND |
| 11/8/78 | Area Sample Outside Station D | AGF-17 | 0832-1449 | Total Dust | NA | 0.042 | 0.008 |
| 11/8/78 | Area Sample Outside Station C | AGF-24 | 0835-1446 | Total Dust | NA | 0.011 | 0.002 |
| 11/8/78 | Spray Painter C | PFW-3332 | 1055-1510 | Respirable Dust | 2.2 | 0.008 | 0.021 |
| 11/8/78 | Area Sample Outside Station C | AFW-3330 | 0828-1449 | Total Dust | 0.3 | 0.007 | 0.002 |
| 11/8/78 | Area Sample Outside Station C | AFW-3347 | 0828-1449 | Respirable Dust | 0.1 | 0.002 | 0.002 |
| 11/8/78 | Spray Painter A | PFW-3328 | 1539-1730 | Respirable Dust | 2.0 | 0.101 | 0.043 |
| 11/8/78 | Spray Painter A | PFW-3349 | 1539-1730 | Total Dust | 14.5 | 0.503 | 0.117 |
| 11/8/78 | Spray Painter B | PFW-3350 | 1539-1730 | Total Dust | 5.5 | 0.243 | 0.117 |
| 11/8/78 | Spray Painter B | PFW-3338 | 1539-1730 | Respirable Dust | 0.4 | 0.026 | 0.005 |
| 03/6/79 | Spray Panter A | PDB-1633 | 0730-1520 | Total Dust | 14.7 | 0.259 | 0.114 |
| 03/6/79 | Spray Painter A | PDB-1643 | 0730-1520 | Respirable Dust | 2.7 | 0.131 | 0.058 |
| 03/6/79 | Spray Painter B | PDB-1659 | 0738-1520 | Total Dust | 4.3 | 0.173 | 0.087 |
| 03/6/79 | Spray Painter B | PDB-1626 | 0738-1520 | Respirable Dust | 0.9 | 0.052 | 0.022 |
| 03/6/79 | Touch-Up Painter C | PDB-1583 | 0711-1520 | Total Dust | 0.5 | 0.007 | 0.003 |
| 03/6/79 | Touch-Up Painter C | PDB-1636 | 0713-1520 | Respirable Dust | 0.4 | 0.003 | ND |
| 03/6/79 | Wheel Balancing Area | ADB-1638 | 0741-1520 | Total Dust | 0.2 | 0.004 | 0.004 |

NOTE: Underlined samples are considered significant. Refer to text of report for explanation.

| | | | | |
|---|---|---|---|---|
| Environmental Criteria for 40-hour workweek---------- | Total Dust | 10.0 | --** | --** |
| | Respirable Dust | 5.0 | | |

*mg/M$^3$--approximate milligrams of substance per cubic meter of air

--**----No environmental criteria or standards were suggested for Bisphenol A and Diglycidyl Ether of Bisphenol A. Refer to body of report for further information.

ND------None detected or value was less than the limit of detection of 0.0005 mg per filter for Bisphenol A and 0.0007 mg per filter for Diglycidyl Ether of Bisphenol A.

NA------Sample not analyzed for nuisance particulates.