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PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
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HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 77-51-502

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I. TOXICITY DETERMINATION

A walk-through survey and private interviews with exposed employees were conducted in the Automatic Soldering and Conformal Coating Room and in the Printed Circuit Detail Area of the Martin Marietta Aerospace - Orlando Division on April 25 and 26, 1977. Because several of the operations of interest were not being conducted on the day of the survey, and because many of the chemicals were identified by trade name only with composition unknown at that time, air sampling was not conducted.

The potential hazards of these exposures were judged by comparison with proper work practices and control measures recommended by NIOSH for these chemicals and operations. In the Conformal Coating Room,the controls and conditions of use of epoxy resins and perchloroethylene were found to be inconsistent with recommended standards or guidelines, and were thus considered to represent potential hazards. In the electroplating shop, the lack of use of personal protective equipment by an employee working at a tank labelled "HF acid" (hydrofluoric acid) was considered a definite hazard. Recommendations are offered in Section IV.E. of this report for improving the safety and protecting the health of exposed employees.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this 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 Services (NTIS), Springfield, Virginia. Information regarding its availability can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies have been sent to:

A. The employee representative who requested the investigation.
B. United Auto Workers Union, Local 788, Orlando, Florida.
C. United Auto Workers Union, National Office, Detroit, Michigan.
D. Martin Marietta Aerospace, Orlando, Florida.
E. NIOSH, Region IV
F. U.S. Department of Labor, OSHA, Region IV
G. Florida Department of Commerce, Division of Labor.

For the purpose of informing the approximately 50 "affected employees", the employer will promptly "post" this report for a period of 30 calendar days in prominent places near where affected 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 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.

This request for a NIOSH Health Hazard Evaluation was submitted by an authorized representative of employees regarding occupational exposure to numerous toxic substances, ultraviolet light, and several safety hazards. NIOSH was requested to assess the severity of these alleged hazards and to assist in the correction of several reported unhealthful conditions and work practices.

The findings of the plant survey conducted on April 25-26, 1977 were summarized in the SHEFS-1 report disseminated by NIOSH on May 2, 1977, to the plant management, local union, and employee requester.

The NIOSH investigator on this hazard evaluation is sorry for the long delay in completing this final report. NIOSH's Region IV (Atlanta) office has experienced a severe manpower shortage. The position of Regional Industrial Hygienist has been vacant and frozen by personnel ceilings imposed by the Center for Disease Control (CDC) since October 1977.

IV. HEALTH HAZARD EVALUATION

A. Plant Process - Conditions of Use

The Martin Marietta Aerospace - Orlando Division is a manufacturer of defense missiles. The plant has been in operation since 1957 and has approximately 4,300 employees. This particular NIOSH investigation was concerned with only a very small proportion of the plant's operations. Two areas were included in the hazard evaluation - the Automatic Soldering and Conformal Coating Room and the Printed Circuit

Detail area, both located within the main plant (MP) in the Electrical and Electronic Commodities Department. Most of the operations observed were involved with the production of printed circuit boards.

1. Automatic Soldering and Conformal Coating Room

All electronic conformal coating of electrical assemblies was performed in this room. A flow solder machine was used one day per week by one employee for soldering printed circuit boards. This machine utilized a rosin flux and a 60/40 tin-lead solder heated in an oil. The machine was equipped with a canopy-type local exhaust ventilation system. The use of smoke tubes for ventilation evaluation revealed that most fumes generated within the machine were retained inside and exhausted through the roof. However, the capture velocity was so low that fumes which may be swept out of the machine through opened window enclosures or by a draft created by manual adjustments may escape into the general workroom air.

Excess flux remaining from the operation was removed in an open tray of flux remover which consisted of a 80% perchloroethylene/20% amyl acetate mixture. Printed circuit boards were frequently cleaned in this manner. Drying was often accomplished by blowing the solvent off the board with an air gun at a laboratory-type hood.

Further cleaning may be accomplished in a vapor degreaser employing freon® products assumed to consist of a mixture of ethanol and 1,2,2,-trichloro-1,1,2-trifluoroethane.

Epoxy resins were used for the conformal coatings. Most of the resins used a hardener consisting of a polysulfide resin and 40% methyl isobutyl ketone (MIBK). A second type of resin used rather infrequently and in small quantities contained diethylene triamine as a hardener. The epoxy resin systems were normally mixed on a table or work bench without local exhaust ventilation. The conformal coating was normally applied by spraying the resins onto the circuit boards at a laboratory-type hood. The face velocity of this hood was inadequate for this kind of operation and was measured by a velometer between 50 and 100 feet per minute (fpm).

One employee worked approximately 6 hours per day with a black light and applied resins using a brush applicator with no local exhaust ventilation. The employee's eyes were not directly in the path of the light, and the skin of her hands and arms was shielded from the light by gloves and long-sleeved garments.

2. Printed Circuit Detail Area

The basic circuit boards were manufactured in this area. There were roughly four sub-areas - shearing of the boards, electroplating, printing, and assembly.

B. Evaluation Methods

A site visit to the plant was conducted on April 25 and 26, 1977, by a NIOSH industrial hygienist for the Region IV (Atlanta) office. A walk-through examination of the two areas was conducted. Information was collected regarding the conditions, frequency, identity, and quantity of the usage of various chemicals. Control devices were observed, and a brief examination of potential safety hazards was made. Evening shift employees were privately interviewed on April 25, day shift employees on April 26. Verbal consultation and recommendations were made to the plant safety and health staff during the walk-through survey and at a closing conference.

C. Evaluation Criteria

The criteria used for assessing the potential health hazards of the chemical and physical exposures of employees in this study were the recommended work practices and control measures given in various NIOSH publications or other published sources which are available to the public and frequently used by industrial health professionals. Since the operations of chief concern in the Conformal Coating room were not being conducted during the NIOSH site visit, sampling for airborne exposure was not possible.

Perchloroethylene

Perchloroethylene (synonym: tetrachloroethylene) is a toxic substance regulated by OSHA. Current OSHA standards limit employee airborne exposure to 100 ppm as an 8-hour time-weighted average, with an acceptable ceiling concentration of 200 ppm for a short duration. OSHA's standard is based on ANSI Z37.22-1967 and was designed to protect against short-term narcotic effects and long-term damage to the liver and central nervous system.[1,2]

In July 1976 NIOSH transmitted a criteria document to OSHA recommending a new standard for perchloroethylene to limit worker exposure to 50 ppm as a time-weighted average, with a ceiling concentration of 100 ppm for intervals of 15 minutes or less. NIOSH's recommendations were based upon its thorough evaluation and review of available information, and were designed to prevent harmful effects of perchloroethylene on the nervous system, eyes, skin, respiratory tract, and liver.[3]

In January 1978 NIOSH issued a current intelligence bulletin on perchloroethylene recommending that it is prudent to handle

perchloroethylene in the workplace as if it were a human carcinogen. This recommendation was based on a study by the National Cancer Institute indicating that perchloroethylene causes liver cancer in laboratory mice. NIOSH recommended that occupational exposure be minimized.[4]

Epoxy Resins

The primary health hazards associated with epoxy resins are dermatitis and skin sensitization. Therefore, good personal hygiene and good housekeeping are prerequisites for controlling hazardous exposure. Impervious gloves should be used, and skin contact avoided in all operations. Mixing of volatile materials should always be done in a well-ventilated area, and precautions should be taken to avoid splashing of materials on hands and face. Splashes in the eye may cause serious injury to the eye. In the event of eye splashes, thorough flushing with water should be carried out immediately and the individual then referred to a physician for observation and further treatment, if necessary.[5]

Normally, a hardener is mixed into an epoxy resin system prior to application of the resin in order to promote the curing of the resin. All the hardeners should be regarded as irritant to any body surface with which they come in contact, either as liquids or vapors. Many are sensitizers, and after a period of use or previous irritation from the hardener, certain individuals become hypersensitive. In this event, with minimal further contact with the liquid hardener or its vapor, an acute skin reaction may result. The face and eyelids may become involved. Some persons may develop asthma from spray droplets or vapor. Since all the various components used in the mixing and application of epoxy resin systems are potential irritants, safety and health measures should be directed at the process as a whole and not purely at the hardener. Consequently, it is necessary to install local exhaust systems and general ventilation, and to provide workers with hand, arm, eye, and face protection. Respiratory protection may be necessary where resin systems are applied in confined spaces or where the capture and control of spray droplets and vapors is not feasible.[5]

Resin systems also normally contain an organic solvent of some sort. Suitable measures must be taken to control skin and eye contact and solvent vapor inhalation. Consideration must also be given to controlling the flammable or explosive properties of the solvent.

Hydrofluoric Acid

In March 1976 NIOSH transmitted to OSHA a criteria document on hydrogen fluoride recommending that the current OSHA limit for airborne exposure of 3 ppm, as a time-weighted average, be maintained. NIOSH also

recommended the adoption of a ceiling limit of 6 ppm for exposures of 15 minutes or less. The basis for the recommended environmental limits is the prevention of irritation of the skin, eyes, and respiratory tract and the prevention of excessive deposition of fluoride in bone. If excessive fluoride is deposited in bone, an increase in bone density with calcification of ligaments may result in reduced mobility in the hips, spine, shoulders, and other joints.[6]

NIOSH also recommends that when direct contact with hydrogen fluoride (HF) or its aqueous solution, hydrofluoric acid (HF acid), may occur, impervious personal protective clothing should be worn. Unless eye protection is afforded by a respiratory hood or facepiece, chemical goggles and face shields should be worn. These precautions are necessary because skin contact may cause painful burns and tissue destruction, and eye contact may cause intense pain, tissue destruction, and corneal scarring.[7]

D. Evaluation Findings

The findings of the plant survey conducted on April 25-26, 1977 were summarized in the SHEFS-1 report disseminated by NIOSH on May 2, 1977, to the plant management, local union, and employee requester. Since many of the substances under evaluation were identified by trade, or brand name, only, it was necessary for the NIOSH industrial hygienist to contact each manufacturer of these substances individually to obtain the chemical composition and identity of hazardous ingredients. The information was finally obtained, summarized, and transmitted to the plant management and employee requester on August 24, 1977. On the basis of this information coupled with the quantities and conditions of use, it was not deemed necessary to make a return visit to the plant to measure airborne exposure, since recommendations for improvements were quite obvious, and since usage quantities, especially in Conformal Coating, were quite small. The primary findings are summarized below for each area.

1. Automatic Soldering and Conformal Coating Room

   a. Flow Solder Machine. This machine was equipped with a canopy-type hood and was enclosed on two sides. There were openings on each end of the machine through which circuit boards were conveyed in and out. The use of smoke tubes for ventilation evaluation revealed that most fumes generated within the machine will be retained inside and exhausted through the roof. However, the capture velocity is so low that fumes which may be swept out of the machine through opened window enclosures or by a draft created by manual adjustments may escape into the general workroom air. Therefore, there is a possibility of occasional exposure of the operator to lead fumes from the solder and

isopropyl alcohol and rosin decomposition vapors from the flux. Since this machine was not in operation at the time of the visit, it was not possible to measure airborne concentrations. Since the machine was only used one day per week, cumulative average exposures are greatly reduced.

b. Use of Flux Remover. It was reported by employees that quantities up to one gallon at a time of flux remover (80% perchloroethylene/ 20% amyl acetate) may be used in open containers without local exhaust ventilation to clean circuit boards. Such containers of solvents were left in the room up to 5 or 6 hours on some days. The use of these solvents in such quantities and for such time periods is obviously inconsistent with good industrial hygiene practices. This flux cleaner was not used in this manner during the NIOSH visit, and thus airborne measurements could not be made.

c. Vapor degreaser. The vapor degreaser employing 1,2,2-trichloro-1,1,2-trifluorethane and ethanol appeared to be operating properly and adequately controlled. Employees expressed no particular complaints about this degreaser, and no air samples were collected in the area.

d. Epoxy resins systems were mixed and manually applied on bench or table tops without local exhaust ventilation. Epoxy resins were sprayed on circuit boards inside laboratory hoods which had insufficient capture velocities for this type of operation.

e. One employee worked approximately six hours per day with a black light inspecting and applying epoxy resins to circuit boards. The employee's eyes were not directly in the path of the light, and the skin of her hands and arms was shielded from the light by gloves and long-sleeved garments. According to information supplied by the manufacturer of the black light, the particular model in use emits ultraviolet (UV) light with primary wavelengths ranging from 3200 to 4100 angstroms (320 - 410 nm), with energy densities ranging from 1.6 mw/cm^2 to 8.7mw/cm^2 at a distance of 18 inches from the bulb.

f. Several suspected violations of OSHA safety standards were observed These included improper storage, handling, disposal, and labelling of flammable and combustible materials, and insufficient ventilation rates for laboratory hoods or spray booths.

g. Because most operations were performed infrequently in this area and for short time durations, it is very doubtful that time-weighted average exposures to airborne contaminants would be excessive. Short-term exposures to solvent vapors might occasionally exceed recommended values. No such operations were being performed during the NIOSH visit to this area, so on-site evaluation was not possible.

2. Printed Circuit Detail Area

Several suspected violations of OSHA safety standards were observed in the electroplating shop. The one eye wash and emergency shower was not readily accessible to the entire area where employees might be exposed to accidental splashes or spills of acids. Smoking was observed in the area of the vapor degreaser. An employee working at a hydrofluoric acid tank was not properly equipped with personal protective equipment for his skin and eyes.

Most operations in the Printed Circuit Detail Area were equipped with effective control devices to prevent excessive employee exposures to airborne contaminants. There did not appear to be any operations requiring environmental sampling.

Five employees of this area were privately interviewed by the NIOSH industrial hygienist to inquire about any health problems the employees were experiencing which might be associated with their work exposure. Two of the employees had no health complaints related to their jobs, except that one felt her sinus problem was irritated by exposure to plating solution fumes. One employee avoided methyl ethyl ketone (MEK) vapors which he found irritating. One employee had pulled some vertebrae in his back, and one was a diabetic.

Since the employees expressed no strong complaints about their working conditions, and since a walk-through inspection of the area revealed conditions with no apparent significant, airborne exposures, no air sampling was conducted in this area.

E. Recommendations

1. Automatic Soldering and Conformal Coating Room

a. Although it is not thought that employee exposure to emissions from the flow solder machine is likely to be excessive, it is recommended that the plant's own industrial hygienist consult with the machine operator about peak exposure periods and make measurements of airborne exposures of the operator to lead, isopropanol, and aldehyde decomposition products of rosin flux. Because this machine is not operated on a regular schedule, it is difficult to schedule air sampling measurements except on very short notice.

b. The flux remover should be kept in closed containers except when boards are being put in or taken out of the container. The remover should be stored and used under well-ventilated conditions.

c. Skin contact with epoxy resins should be prevented because these resins may produce dermatitis and allergic sensitization

reactions in exposed individuals. Clean protective clothing and good personal hygiene are important control methods in minimizing skin contact. These resins should be mixed and applied only under well-ventilated conditions, primarily because of the solvent vapors which become airborne from the use of these materials.[5,8]

d. Exposure of employees to ultraviolet light should be controlled and minimized. Exposure to the UV radiation emitted by black light sources may cause temporary blurring of vision, eye fatigue, and headaches. Although no permanent damage is known to result from black light sources in particular, exposure to ultrviolet radiation in general may be hazardous, the organs primarily affected being the skin and eyes. Although exposed skin and eyes may not be in the direct path of the primary UV light source, the UV radiation may be scattered and reflected from surfaces and be secondarily directed on exposed skin or eyes. Skin should be protected by suitable clothing or barriers. Eye protection, in the form of face shield or UV-filtering lenses, may be advisable. (See NIOSH Publication 77-138: Ultraviolet Radiation and the Work Environment)[9]

e. Where epoxies are sprayed onto cirbuit boards, a hood with suitable capture velocity and designed for this type application should be used. Protective clothing should be worn by the worker.

f. The use of an air gun for drying residual solvent from circuit boards should be discontinued. A low-velocity hot air blower might be substituted. It will probably be necessary to continue the drying operation in a hood to prevent the buildup of toxic vapor concentrations.

g. The mixing of batches of resins should be performed inside a hood. Impervious protective gloves should be worn to prevent skin contact.

h. The number of former employees of the area who wished to speak to the NIOSH industrial hygienist about concerns and complaints of past chemical exposures in the area indicates that past exposures were probably much higher and that the employees need training and counselling about the health hazards of their work.

i. Combustible waste material should be stored in covered metal receptacles and disposed of daily. Flammable liquids should be stored in approved safety cans or other approved containers.[10] Areas for flammables should be posted as "No Smoking" areas.

j. NIOSH recommends that perchloroethylene be handled in the work-place as if it were a human carcinogen, and that occupational exposure be minimized.[4]

2. Printed Circuit Detail Area

Recommendations for this area concern safety improvements in the electroplating shop:

a. Eye washes and emergency showers should be accessible to the entire area where employees may be exposed to highly corrosive liquids.

b. Smoking should be prohibited in the area of the vapor degreaser.

c. Eye and face protection and protective clothing impervious to hydrogen fluoride should be worn when direct contact with HF acid may occur.[7]

V. REFERENCES

1. OSHA Standards for Toxic and Hazardous Substances - Air Contaminants (29 CFR 1910.1000), General Industry Standards, OSHA Publication No. 2206, OSHA, 1976.

2. Documentation of the Threshold Limit Values for Substances in Workroom Air. Third Edition, American Conference of Governmental Industrial Hygienists, 1971.

3. Memorandum of July 2, 1976, from the Director of NIOSH to the Assistant Secretary (of DHEW) for Health, "Criteria Document: Recommendations for an Occupational Exposure Standard for Tetrachloroethylene - INFORMATION".

4. "Current Intelligence Bulletin 20, Tetrachloroethylene (Perchloroethylene)," NIOSH, January 20, 1978.

5. Encyclopaedia of Occupational Health and Safety, Vol. 1, International Labour Office (ILO), pp. 467-469 and 643-645, McGraw-Hill Book Co., New York, N.Y., 1972.

6. Memorandum of March 2, 1976, from the Director of NIOSH to the Assistant Secretary (of DHEW) for Health, "Criteria Document: Recommendations for an Occupational Exposure Standard for Hydrogen Fluoride - Information".

7. "Criteria for a Recommended Standard....Occupational Exposure to Hydrogen Fluoride", NIOSH Publication No. 76-143, NIOSH, 1976.

8. "Epoxy Wise is Health Wise", NIOSH Publications No. 76-152, NIOSH, 1976.

9. "Ultraviolet Radiation and the Work Environment", NIOSH Publication No. 77-138, 1977.

10. OSHA Standards for Hazardous Materials - Flammable and Combustible Liquids (29 CFR 1910.106), General Industry Standards, OSHA Publication No. 2206, OSHA, 1976..

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