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**LASKO METAL PARTS, INC.**
**R&S MANUFACTURING, INC.**
**COLUMBIA, PENNSYLVANIA**

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## I. SUMMARY

On March 30-31, 1993, investigators from the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) at R&S Manufacturing, Inc. in Columbia, Pennsylvania. R&S Manufacturing, Inc. is a division of Lasko Metal Parts, Inc. The HHE was conducted in response to a management request concerning operation changes in the Stator/Epoxy Department and employee exposures to epoxy powder.

R&S Manufacturing, Inc., produces electric motors for use in Lasko Galaxy oscillating fans. An epoxy powder is sprayed onto the stator, or motor, and heat cured. A recycling system has been added to the epoxy spray process and the epoxy powder has been reformulated. NIOSH investigators collected personal breathing zone (PBZ) air samples for $C_7$-$C_{11}$ naphthas and 1,1,1 trichloroethane (TCE); and general area (GA) air samples for fiber identification, respirable dust, and crystalline silica. Included in the investigation was a visual inspection of the local exhaust ventilation system in the epoxy room and a general walk-through survey of the entire facility.

The results of GA samples collected in the epoxy room on March 30, 1993, identified only trace concentrations of the fibrous material wollastonite (calcium silicate). Currently NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) do not have evaluation criteria specifically for wollastonite. The respirable dust GA samples collected in the epoxy room ranged from 0.20 to 0.24 milligrams per cubic meter (mg/m$^3$). The concentrations detected were less than 10% of the OSHA Permissible Exposure Limit (PEL) of 5.0 mg/m$^3$ for the respirable fraction of particulates not otherwise regulated or nuisance dust. However, since epoxy powders, or some components of epoxy powders can cause irritation and immunologic response in some individuals, the 5.0 mg/m$^3$ criteria may not be protective enough. Results of GA sampling for crystalline silica (quartz and cristobalite) were below the minimum detectable concentrations (MDC) of 0.016 mg/m$^3$ (quartz) and of 0.023 mg/m$^3$ (cristobalite) based on an air sampling volume of 630.7 liters.

The PBZ air samples for TCE were less than 1% of the NIOSH Recommended Exposure Limit (REL) and the ACGIH Threshold Limit Value (TLV) of 1,910 mg/m$^3$. The estimated 8-hour time weight average (TWA) for employees ranged from 0.2 to 1.0 mg/m$^3$. The PBZ air samples for $C_7$-$C_{11}$ naphthas were below the NIOSH REL and ACGIH TLV of 350 mg/m$^3$ and 1350 mg/m$^3$, respectively. The estimated 8-hour TWA for employees ranged from 10.0 to 19.0 mg/m$^3$.

Temperature and relative humidity measurements ranged from 98°F to 102°F and 20.0 to 21.0 percent relative humidity, respectively. A visual inspection of the local exhaust ventilation system and temperature measurements indicated deficiencies in the exhaust system; branched ducts entering the main duct at a 90° angle, inadequate hood designs that create unnecessary hood entry losses (loss in pressure caused by air flowing into the hood), and several feet of excess duct work. These deficiencies may have contributed to the minor symptoms of heat stress, such as feeling hot, increased sweating, and increased thirst which were reported by employees.

Observations made by NIOSH investigators during the walk-through survey identified potential lead exposures to employees working in the wire department because of inadequate exhaust hood design and poor work practices.  Further, welding fumes from the manual spot welding station between pillars F5 and F6 were being exhausted directly in the factory.

**Keywords**:  SIC 3634 (Housewares and Fans), epoxy powder, local exhaust systems, welding fumes, lead.

## II. INTRODUCTION

In August 1982, the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) at R&S Manufacturing, Inc. in Columbia, Pennsylvania.[1] R&S Manufacturing, Inc. is a division of Lasko Metal Parts, Inc. Employees were concerned about adverse health effects from exposures to epoxy powder.

In the past five years, R&S Manufacturing has moved to a new location, reformulated the epoxy powder, and introduced an epoxy powder recycling system. On November 20, 1992, NIOSH received a second request for a HHE at Lasko Metal Parts, Inc., R&S Manufacturing, Inc., to evaluate the new process and monitor employee exposures to epoxy powder. On March 30-31, 1993, NIOSH investigators conducted the evaluation. The request did not reflect concern about employee exposures to heat; however, during the survey, NIOSH investigators evaluated the local exhaust ventilation system because employees reported minor symptoms of heat stress.

## III. BACKGROUND

R&S Manufacturing produces approximately 13,000 - 15,000 electric motors per day for use in Lasko Galaxy oscillating fans. The plant is constructed of sheet metal and contains approximately 124,800 square feet ($ft^2$) of manufacturing area. The epoxy room, the powder room, the maintenance room, the tool room, and the compressor room are separated from the main manufacturing area by concrete block walls. The main focus of the HHE is the epoxy room of the Stator/Epoxy Department.

The Stator/Epoxy Department is a 6,000 $ft^2$ area divided into two spaces, the shave band/infrared oven area and the epoxy powder room. There are three shifts with a total of eight employees who work in the epoxy room; four on the first shift, and two on both the second and third shifts. Employees wear single use dust masks, safety glasses, and heat resistant gloves when working in the epoxy room. Employees are authorized to eat at their work stations (except for the employees who work in the epoxy room).

The first step of the motor production process is the application of an epoxy powder as an insulation material to the core of the stator, or the motor, in the Stator/Epoxy Department. The process begins in the shave band area where each stator is automatically wrapped with copper that is spot welded into place. The stator is placed on a hanger-like conveyor system which moves the stators through an infrared oven heating it to around 400°F. The conveyor system is enclosed in insulated duct work which runs along the west wall of the epoxy room. There are 2½ x 2½ foot, square openings in the duct work which allow employees access to the hot stators. Each opening has a local exhaust ventilation hood to control heat exposures. Employees remove stators from the conveyor system and place them on the arm of the epoxy spray and recycling system, located about three feet from the conveyor system. The epoxy powder is applied with pressurized air. The stator is then placed back on the conveyor system. Because the epoxy powder may build up on the arm of the epoxy spray and recycling system, a solvent spray containing 1,1,1 trichloroethane (TCE) is periodically used to clean it. The conveyor system exits the epoxy room back into the shave band/infrared oven area where another infrared oven cures the newly applied epoxy insulator. The conveyor system goes up to the ceiling where the stators cool and then returns to ground level. In addition to the process just described, there is another oven and epoxy spray and recycling system. The only difference with this unit is that it is one fourth of the size, it has a metal screen conveyor belt, and the epoxy powder formulation is not exactly the same. The slight difference in the two systems is required to achieve a variable thickness in the epoxy powder that is applied to the stator.

The epoxy spray and recycling systems have loading canisters in the powder room where virgin epoxy powder is added to each system. The epoxy powder is delivered to the epoxy room through hoses where it is first sifted and then sprayed onto the preheated stator with pressurized air. It is important to note that solvents are not used in the application of this epoxy powder. At the base of the epoxy spray and recycling system is a vacuum hose that collects the overspray and transports it to the loading canister in the powder room where it is recycled. Periodically, employees go into the powder room to add virgin powder to the loading canisters.

The epoxy resins form a class of cross-linked polyethers characterized as having excellent chemical resistance, adhesion to glass and metals, electrical insulating properties, and ease and precision of fabrication. In the preparation of a typical resin, a low-molecular-weight diepoxy compound is mixed with cross-linking agents, curing agents, fillers, and plasticizers and then allowed to cure either at room temperature or with the application of heat. The intermediate diepoxy compounds are condensation products of epichlorohydrin and aliphatic or aromatic diols. An example is the product of the reaction of epichlorohydrin with bisphenol A.[2] It is important to note that R&S Manufacturing does not mix any compounds to form the intermediate diepoxy compounds or the final product (epoxy powder). R&S Manufacturing purchases the epoxy powder as a complete product and applies it to the stators with pressurized air. Epichlorohydrin is probably not present during the subsequent polymerization steps. After polymerization, the resin is essentially inert and nontoxic.[3] The two epoxy powders used by R&S Manufacturing, Inc., are composed primarily of wollastonite (30-60%) and solid epoxy resins (20-30%). Wallastonite is a natural calcium silicate.

## IV. MATERIALS AND METHODS

On March 30, 1993, two general area (GA), full-shift, air samples were collected in the epoxy room. Sample locations are shown in Figure 1. In order to identify airborne fibers, air samples were collected on 25-millimeter (mm) diameter, 0.45- to 1.2-micron (µm) pore size cellulose ester membrane filters using battery-powered sampling pumps calibrated at a flow rate of 2 liters per minute (Lpm). The filters were analyzed according to the NIOSH Analytical Method 7402.[4] Respirable dust air samples were collected on tared 37-mm diameter, 5.0 µm polyvinyl chloride membrane filters through a 10-mm Dorr-Oliver nylon cyclone. The battery-powered sampling pumps were calibrated at a flow rate of 1.7 Lpm. The samples were prepared and analyzed according to the NIOSH Analytical Method 0600.[4] To assess possible silica exposure, air samples were collected on 37-mm diameter, 5.0 µm polyvinyl chloride membrane filters through a 10-mm Dorr-Oliver nylon cyclone. The battery-powered sampling pumps were calibrated at a flow rate of 1.7 Lpm. The samples were analyzed according to NIOSH Analytical Method 7500[4] for quartz and cristobalite.

In addition to the air sampling noted above, two GA and six personal breathing zone (PBZ) samples were collected for volatile organic compounds (VOCs). Air samples were collected on charcoal tubes using battery-powered sampling pumps calibrated at a flow rate of 100-milliliters per minute (mL/min). The two GA samples were qualitatively analyzed for VOCs by gas chromatography-mass spectrometry (GC-MS). Based on these results, the six PBZ samples were quantitatively analyzed for $C_7$-$C_{11}$ naphthas (concentrations were quantified using n-decane as the standard), and TCE according to NIOSH Analytical

Methods 1003 and 1550.[4]

The NIOSH investigation also included a walk-through survey of the facility and visualization of air flow through exhaust ducts using chemical smoke. Finally, temperature and relative humidity were measured using a Vaisala HM 34 humidity and temperature meter.

## V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the 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 from eight to ten hours a day, forty hours a week, for a working lifetime without experiencing adverse health effects. However, it is 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 to the level set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, thus potentially increasing 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 Recommended Exposure Limits (RELs), 2) the United States Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs), and 3) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs).[5,6,7] The OSHA PELs may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; in contrast, the NIOSH recommended exposure limits are primarily based upon the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing those levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

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

Epoxy Resin

Evaluation criteria do not exist for epoxy resins or epoxy powders. However, according to material safety data sheets (MSDS), the epoxy powders used at R&S Manufacturing, Inc. are considered nuisance dusts. The OSHA PEL for nuisance dust or the respirable fraction of particulates not otherwise regulated is 5.0 mg/m$^3$. But, since epoxy resins are known to cause irritation and possible immunologic response in some hypersensitive individuals, exposures should be minimized to the extent feasible. Further, by assessing exposure to the various individual components of the epoxy product (curing agents, fillers, or cross-linking agents), it is possible to report health effects from the individual components. It is important to note that this approach does not take into consideration the possible additive or synergistic affects from combinations of the components.

1,1,1 Trichloroethane

Human subjects exposed to 4,910 to 5,456 mg/m$^3$ for 20 minutes experienced light-headedness, incoordination, and impaired equilibrium; transient eye irritation also has been reported at similar concentrations. Impairments in psychomotor task performance have been demonstrated at levels around 1,910 mg/m$^3$.[3] The NIOSH REL for TCE is 1,910 mg/m$^3$.[3]

Naphtha $C_7$-$C_{11}$ hydrocarbons

The NIOSH REL for varnish makers' and printers' (VM&P) naphtha is 350 mg/m$^3$.[5] The ACGIH TLV for VM&P naphtha is 1,350 mg/m$^3$.[7] Naphtha vapor is a central nervous system depressant and a mild irritant of the eyes and upper respiratory tract. In human tests, exposures to 4,100 mg/m$^3$ for 15 minutes resulted in eye and throat irritation with olfactory fatigue.[3]

Heat Stress

There are a number of heat stress guidelines that are available to protect against heat-related illnesses such as heat stroke, heat exhaustion, heat syncope, and heat cramps. These include, but are not limited to, the wet bulb globe temperature (WBGT), Belding-Hatch heat stress index (HSI), and effective temperature (ET).[9,10,11] The underlying objective of these guidelines is to prevent a worker's core body temperature from rising excessively. The World Health Organization has concluded that "it is inadvisable for deep body temperature to exceed 38ºC (100.4ºF) in prolonged daily exposure to heavy work."[12] Many of the available heat stress guidelines, including those proposed by NIOSH and the ACGIH, also use a maximum core body temperature of 38ºC as the basis for the environmental criterion.[13,14]

Both NIOSH and ACGIH recommend the use of the WBGT index to measure environmental factors because of its simplicity and suitability in regards to heat stress. The International Organization for Standardization (ISO), the American Industrial Hygiene Association (AIHA), and the U.S. Armed Services have published heat stress guidelines which also utilize the WBGT index.[15,16,17] Overall, there is general similarity of the various guidelines; hence, the WBGT index has become the standard technique for assessment of environmental conditions in regards to occupational heat stress.

The WBGT index takes into account environmental conditions such as air velocity, vapor pressure due to atmospheric water vapor (humidity), radiant heat, and air temperature, and is expressed in terms of degrees Fahrenheit (or degrees Celsius). Measurement of WBGT is accomplished using an ordinary dry bulb (DB) temperature , a natural (unaspirated) wet bulb (WB) temperature, and a black globe temperature (GT) as follows:

$WBGT_{in}$ = 0.7 (WB) + 0.3 (GT)
for inside or outside without solar load,

Or

$WBGT_{out}$ = 0.7 (WB) + 0.2 (GT) + 0.1 (DB)
for outside with solar load.

Originally, NIOSH defined excessively hot environmental conditions as any combination of air temperature, humidity, radiation, and air velocity that produced an average WBGT of 79°F (26°C) for unprotected workers.[18] However, in the revised criteria for occupational exposure to hot environments, NIOSH provides diagrams showing work-rest cycles and metabolic heat versus WBGT exposures which should not be exceeded.[13] NIOSH has developed two sets of recommended limits: one for acclimatized workers (recommended exposure limit [REL]), and one for unacclimatized workers (recommended alert limit [RAL]).

Similarly, ACGIH recommends a TLV for environmental heat exposure permissible for different work-rest regimens and work loads.[14] The NIOSH REL and ACGIH TLV criteria assume that the workers are heat acclimatized, are fully clothed in summer-weight clothing, are physically fit, have good nutrition, and have adequate salt and water intake. Additionally, they should not have a pre-existing medical condition that may impair the body's thermoregulatory mechanisms. For example, alcohol use and certain therapeutic and social drugs may interfere with the body's ability to tolerate heat.

Modifications of the NIOSH and ACGIH evaluation criteria should be made if the worker or conditions do not meet the previously defined assumptions. The following modifications have been suggested:[19]

1. Unacclimatized or physically unconditioned - subtract 4°F (2°C) from the permissible WBGT value for acclimatized workers.

2. Increased air velocity (above 1.5 meters per second or 300 feet per minute) - add 4°F (2°C). This adjustment can not be used for DB air temperatures in excess of 90-95°F (32-35°C). This correction does not apply if impervious clothing is worn.

3. Impervious clothing which interferes with evaporation:

   a. Body armor, impermeable jackets - subtract 4°F (2°C).
   b. Raincoats, turnout coats, full-length coats - subtract 7°F (4°C).
   c. Fully encapsulated suits - subtract 9°F (5°C).

4. Obese or elderly - subtract 2-4°F (1-2°C).

5. Female - subtract 1.8°F (1°C). This adjustment, which is based on a supposedly lower sweat rate for females, is questionable since the thermoregulatory differences

between the sexes in groups that normally work in hot environments are complex.[20] Seasonal and work rate considerations enter into determining which sex is better adapted to work in hot environments.[21]

Selection of a protective NIOSH WBGT exposure limit is contingent upon identifying the appropriate work-rest schedule and the metabolic heat produced by the work. The work-rest schedule is characterized by estimating the amount of time the employees work to the nearest 25%. The most accurate assessment of metabolic heat production is to actually measure it via calorimetry. However, this is impractical in industrial work settings. An estimate of the metabolic heat load can be accomplished by dividing the work activity into component tasks and adding the time-weighted energy rates for each component. Because of the error associated with estimating metabolic heat, NIOSH recommends using the upper value of the energy expenditure range to allow a margin of safety.[13]

The ACGIH heat exposure TLVs are published for light, moderate and heavy work load categories. The work load categories are described by the following energy expenditure rates:[14]

1. Light work - up to 200 kcal/hr,

2. Moderate work - 200 to 350 kcal/hr,

3. Heavy work - 350 to 500 kcal/hr.

## VI. RESULTS

The results of GA samples collected in the epoxy room identified only trace concentrations of fibrous material. The concentrations were between the minimum detectable concentration (MDC) of .0005 fibers per cubic centimeter (f/cc) and the minimum quantifiable concentration (MQC) of .0521 f/cc assuming an average sample volume of 738 liters. Wollastonite was the major component in both the fibrous and non-fibrous (dust) materials. GA samples for respirable particulates ranged from 0.20 to 0.24 $mg/m^3$ in the epoxy room. The concentrations are well below the OSHA PEL of 5.0 $mg/m^3$ for the respirable fraction of particulates not otherwise regulated or nuisance dust.[6] Once again, the 5.0 $mg/m^3$ may not be protective enough because epoxy resins are known to cause irritation and possible immunologic response in some hypersensitive individuals. The sample concentrations for crystalline silica were below the MDC of 0.016 $mg/m^3$ for quartz and 0.023 $mg/m^3$ for cristobalite based on an air sampling volume of 630.7 liters, and therefore, below all relevant criteria.

Results from the qualitative analysis of the area VOC samples indicate that the major compounds detected were branched aliphatic hydrocarbons in the $C_{10}$-$C_{12}$ range (organic compounds having a backbone of ten to twelve carbons), aliphatic hydrocarbons in the $C_6$-$C_9$ range, TCE, acetone, and toluene. Based on these results, the PBZ samples were quantitatively analyzed for TCE and naphtha $C_7$-$C_{11}$. Naphtha $C_7$-$C_{11}$ was chosen as the evaluation criteria because a majority of the aliphatic hydrocarbons fell into this group. TCE concentrations were below the evaluation criteria. Employees exposures ranged from 0.2 to 1.0 $mg/m^3$ for TCE. Naphtha $C_7$-$C_{11}$ concentrations were below the NIOSH REL and ACGIH TLV of 350 $mg/m^3$ and 1,350 $mg/m^3$, respectively. The employees' exposures ranged from 10.0 to 19.0 $mg/m^3$.

The local exhaust ventilation hoods in the epoxy room did not adequately control thermal drafts in the conveyor system. Several deficiencies were identified by visual observation of the local exhaust system including: branched ducts entering the main duct at a 90° angle; inadequate hood designs that create unnecessary hood entry losses (loss in pressure caused by air flowing into the hood); and several feet of excess duct work. Temperature and relative humidity measurements ranged from 98°F to 102°F and 20.0 to 21.0 percent, respectively. At these temperatures, heat cramps and heat exhaustion are important concerns when employees are exposed for extended periods of time. Employees reported minor symptoms of heat stress, such as feeling hot, increased sweating, and increased thirst. In an attempt to make the work environment cooler, employees put small oscillating fans at each station near the epoxy spray and recycling systems. However, when the fan was turned on, the settled powder near the fan was blown into the air.

In general, epoxy powder dust was found throughout the epoxy room, especially near the sifters where damaged hoses were discovered that had been repaired with duct tape. Employees used industrial vacuum cleaners to clean the epoxy powder from the floors and equipment in the epoxy room. Evidence of epoxy powder was found on shelves and boxes just outside the south doors of the epoxy room. The epoxy room is generally under negative pressure; however, because of various air currents, such as fans and hot air drafts from the conveyor system, epoxy powder was able to migrate out of the epoxy room. Employees who worked in the epoxy room do not vacuum themselves off before leaving which also may contribute to the epoxy powder found outside of the room.

In the wire department, electrical wires for the oscillating fans were dipped in heated solder, which, according to the safety officer, contains 40 percent lead. A hood had been constructed from a small bench with corner supports holding a high efficiency particulate air (HEPA) filter and plastic flaps to contain the solder fumes. During the wire dipping process, employees would lift all flaps on one side of the bench and turn on a small fan inside the hood which was directed up towards the HEPA filter. The HEPA filter was also equipped with its own fan. The wire ends were dipped into the solder, pulled out, and then hit on a trash can located outside of the hood. This procedure caused small bits of lead solder to splatter on the benches and tables in that area. The small fan directed up at the HEPA filter blew the solder fumes out of the hood. Employees may have lead exposure through the solder fumes or the small bits of solder on the benches and tables. As mentioned before, employees are authorized to eat at their work stations which could also contribute to lead exposure through ingestion. When asked by NIOSH investigators, the employees did not know that the solder contained lead.

Between pillars F5 and F6 near the wire department, there was a manual spot- welding station. The station was enclosed in a metal exhaust hood with one side open for employee access. Fumes from this spot welding station were exhausted directly into the factory space.

## VII. CONCLUSION

The visual inspection as well as the temperature and relative humidity measurements indicate deficiencies in the local exhaust ventilation system. Employees working in the epoxy room described symptoms consistent with minor heat stress. The general air and personal breathing zone air sampling results indicate that exposures to respirable dust, crystalline silica (quarts and cristobalite), naphtha $C_7$-$C_{11}$, and TCE were below all relevant criteria. The composition of fiber and dust samples collected in the epoxy room was identified as wollastonite. The wollastonite was measured at trace concentration levels. Finally, observations made during the survey identified potential lead exposures to employees working in the wire department because of inadequate local exhaust ventilation hood design and poor work practices.

## VIII. RECOMMENDATIONS

The NIOSH evaluation identified some deficiencies in the epoxy room and wire department at R&S Manufacturing, Inc. Based on the results and observations of the survey, the following recommendations are offered to correct those deficiencies.

1. The local exhaust ventilation system in the epoxy room should be evaluated by a qualified industrial ventilation company that specializes in hot processes. Also, the exhaust hood for the manual spot welding station between pillar F5 and F6 should be included in this evaluation.
2. A comprehensive heat stress evaluation involving work-related estimations and WBGT measurements should be conducted. Recommendations for engineering controls which may be adapted to processes and equipment at R&S Manufacturing, Inc., as well as other methods of controlling heat exposure are described in the NIOSH Criteria for a Recommended Standard: Occupational Exposure to Hot Environments.[13] A copy of this document has been provided to the company.

3. Improved housekeeping practices should help to minimize employee exposures and prevent the epoxy powder from migrating out of the epoxy room when employees enter and exit. Because epoxy powders may cause irritation and possible immunologic response in some hypersensitive individuals, employee exposures should be minimized. The following recommendations are provided to minimize employee exposures to epoxy powder.

    A. The epoxy room should be cleaned on a daily basis. Employees should use vacuum cleaners equipped with HEPA filters when cleaning the epoxy room. Employees should avoid using pressurized air to blow debris or dry sweeping. Employees should clean large spills immediately.

    B. Employees should be required to use the vacuum cleaner to remove excess powder from their clothing prior to leaving the epoxy room. Consideration should be given to supplying employees with light weight disposable or washable coveralls. If washable coveralls are chosen, R&S Manufacturing should be responsible for laundering.

    C. The small oscillating fans should not be used in the epoxy room. The fans can increase airborne concentrations of epoxy powder by re-entraining the settled dust into the air.

    D. Damaged hoses on the epoxy spray and recycling system should be replaced. A more permanent solution than duct tape should be used in the repair.

4. Employees should continue to wear dust mask respirators while working in the epoxy room. Respiratory protection must only be used in conjunction with a comprehensive respiratory protection program as outlined in the OSHA respiratory protection standard, 29 CFR 1910.134.[22]

5. The hood in the wire department where wire dipping is done should be evaluated. Additionally, personal air monitoring for inorganic lead should be done. Employee exposures at or above the OSHA action limit of 0.030 mg/m$^3$, require compliance with the OSHA general industry lead standard (29CFR 1910.1025). This involves medical monitoring for employees and routine air sampling. An education program should be formulated by R&S Manufacturing, Inc., to educated employees about the hazards of inorganic lead, potential routes of exposure, and precautions for minimizing exposures. Employees should not be authorized to eat at their workstations throughout the plant in order to reduce the possibility of ingestion of toxic materials.

## IX. REFERENCES


1. NIOSH [1982]. Hazard evaluation and technical assistance report: R&S Manufacturing Company, Columbia, Pennsylvania. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 82-355-1375.

2. Mcgraw-Hill [1992]. Mcgraw-Hill Encyclopedia of Science and Technology: Polyether resins. 7th ed. Vol. 14. New York, NY: Mcgraw-Hill Publishers, p. 143.

3. Procter N, Hughes J, Fischman M [1991]. Chemical hazards of the workplace. 3rd ed. New York, NY: Van Nostrand Reinhold Company

4. NIOSH [1989]. Eller PM, ed. NIOSH manual of analytical methods. 3rd. rev. ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) publication No. 84-100.

5. CDC [1992]. NIOSH recommendations for occupational safety and health standards 1992. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention; National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

6. Code of Federal Regulations [1989]. 29CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

7. ACGIH [1994]. Threshold limit values and biological exposure indices for 1993-1994. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

8. Bardana E, Mantanaro A, O'halloran M [1992]. Asthma associated with amine-based epoxy resins, latex, reactive dyes, and miscellaneous chemicals. Occupational Asthma. St. Louis, MO: Mosley Inc.

9. Yaglou C, Minard D [1957]. Control of heat casualties at military training centers. Arch Indust Health 16:302-316.

10. Belding H, Hatch T [1955]. Index for evaluating heat stress in terms of resulting physiological strain. Heat Pip Air Condit 27:129.

11. Houghton F, Yaglou C [1923]. Determining lines of equal comfort. J Am Soc Heat and Vent Engrs 29:165-176.

12. WHO [1969]. Health factors involved in working under conditions of heat stress. Geneva, Switzerland: World Health Organization. Technical Report Series No. 412.

13. NIOSH [1986]. Criteria for a recommended standard: occupational exposure to hot environments, revised criteria. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113.

14. ACGIH [1990]. Threshold limit values and biological exposure indices for 1990-1991. Cincinnati, OH: American Conference of Governmental Industrial Hygienist

15. ISO [1982]. Hot environments: estimation of heat stress on working man based on the WBGT index. Geneva, Switzerland: International Standards Organization. ISO No. 7243-1982.

16. AIHA [1975]. Heat exchange and human tolerance limits, heating and cooling for man in industry, 2nd ed. Akron, OH: American Industrial Hygiene Association, pp 5-28.

17. U.S. Department of Defense [1980]. Occupational and environmental health: prevention, treatment and control of heat injuries. Washington, DC: Headquarters, Departments of the Army, Navy, and Air Force, TB MED 507, NAVMED P-5052-5, AFP 160-1.

18. NIOSH [1972]. Criteria for a recommended standard: occupational exposure to hot environments. Cincinnati, OH: U.S. Department of Health, Education and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 72-10269.

19. Ramsey JD [1978]. Abbreviated guidelines for heat stress exposure. AIHAJ 39:491-495.

20. Kenney WL [1985]. A review of comparative responses of men and women to heat stress. Environ Res 37:1-11.

21. NIOSH [1977]. Assessment of deep body temperatures of women in hot jobs. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-215.

22. Code of Federal Regulations [1990]. 29 CFR 1910.134. Washington, D.C.: U.S. Government Printing Office, Federal Register.

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Evaluations, and Field Studies

## XI. DISTRIBUTION AND AVAILABILITY

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