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I. SUMMARY

On May 2, 1986, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate employee exposures at Allen Industries, Inc., Herrin, Illinois (the name was subsequently changed to Sheller-Globe). The requestor was concerned with various chemicals used in the manufacture of acoustical resinated fiber insulation.

In June 1986, NIOSH investigators conducted an initial survey at the facility. In September 1986, an environmental survey was conducted during which personal breathing zone air, general area air, and bulk samples were collected for asbestos, phenol, ammonia, 1,1,1-trichloroethane, vinylidene chloride, carbon monoxide, hexamethylenetetramine, formaldehyde, total particulate, and respirable particulate. A follow-up environmental survey was conducted on April 8, 1987, during which personal and area air samples for toluene diisocyanate (TDI) were collected.

1,1,1-Trichloroethane was detected in two of eight samples collected at time-weighted average (TWA) concentrations of 0.32 and 0.63 parts of contaminant per million parts of air (ppm). These values were below the NIOSH Recommended Exposure Limit (REL) of 350 ppm as a 10 minute ceiling, and the Occupational Safety and Health (OSHA) Permissible Exposure Limit (PEL) of 350 ppm as an 8-hour TWA. No vinylidene chloride was detected in these samples above the limit of detection (LOD) of 0.01 microgram (ug) per sample. Formaldehyde was found to be below the limit of quantitation (LOQ) of 6 ug/tube in the five samples collected. Hexamethylenetetramine was detected in only one of five samples at a concentration of 0.044 ppm. There are currently no airborne criteria for hexamethylenetetramine.

Concentrations of ammonia in detector tube samples ranged from 3 ppm to 22 ppm, with a mean concentration of 11 ppm in five samples collected in the Airlay Department. Ammonia concentrations ranged from 2 ppm to 35 ppm, with a mean concentration of 13 ppm, in ten samples collected in the Hot Oil Department. All samples were below the NIOSH REL of 50 ppm as a ceiling concentration, and the OSHA PEL of 50 ppm as an 8-hour TWA. Detector tube samples for phenol collected at the Hot Oil presses were found to be less than the limit of quantitation of 5 ppm for the three samples collected. TWA concentrations of carbon monoxide measured directly outside of the ovens in the Airlay and Coating Departments were less than 1 ppm and 4 ppm, respectively. These values were below the NIOSH REL of 35 ppm, and the OSHA PEL of 50 ppm as a TWA exposure.

TWA concentrations of 8.72 and 13.78 mg/M^3 total particulate were found in personal samples collected in the New Compound Room, with TWA concentrations of 2.43 and 2.26 mg/M^3 total particulate in personal samples collected in the Old Compound Room. One of these samples exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) of 10 milligrams per cubic meter of air (mg/M^3), but was below the OSHA PEL of 15 mg/M^3 for total nuisance particulate. It should be noted that respiratory protection was required to be worn during the mixing operation. Bulk sample analysis of a resin powder containing talc showed no detectable quantities of asbestos.

Airborne concentrations of 2,4-TDI were found to be above the LOQ of 1 ug/tube in only two of the six personal samples collected (0.0036 and 0.0020 ppm). Airborne concentrations of total 2,6-TDI was found to be above the LOQ in one of six personal samples collected (0.0030 ppm). These concentrations were below the NIOSH REL and the OSHA PEL of 0.02 ppm as a ten-minute ceiling concentration.

On the basis of the data collected, the investigators concluded that a potential for overexposure to nuisance particulate above the ACGIH TLV existed in the New Compound Room at the time of this survey. Recommendations designed to reduce this and other exposures in the plant are contained in Section VIII of this report.

KEY WORDS: SIC 2295 (Resin Coated Fabrics), resin, formaldehyde, phenol,
nuisance particulate, hexamethylenetetramine, vinylidene
chloride, toluene diisocyanate, ammonia,
1,1,1-trichloroethane.

II. INTRODUCTION

On May 2, 1986, NIOSH received a request from an authorized representative of the Amalgamated Clothing and Textile Workers Union of America, Local 1374, for a health hazard evaluation at Allen Industries, Inc., Herrin, Illinois. The requester was concerned with employee exposures to the various chemicals used in the facility.

On June 13, 1986, NIOSH investigators conducted an initial survey at the facility. An opening conference was conducted with representatives of plant management and the local union, followed by a walk through survey of the areas of concern. Following this survey, records of recent OSHA inspections were obtained, and additional information was obtained from the manufacturers of materials used in the plant. On September 4, 1986, an environmental survey was conducted during which personal breathing zone, general area, and bulk samples were collected for asbestos, phenol, ammonia, 1,1,1-trichloroethane, vinylidene chloride, carbon monoxide, formaldehyde, hexamethylenetetramine, total particulate, and respirable particulate. In order to evaluate a process which was not operational during the environmental survey of September 4, a follow-up environmental survey was conducted on April 8, 1987, during which personal and area samples for toluene diisocyanate were collected. Preliminary results of the environmental survey were reported by phone on December 19, 1986, with final results being transmitted by letter on June 12, 1987.

III. BACKGROUND

Sheller-Globe, formerly Allen Industries, is located in Herrin, Illinois. The plant's primary product is acoustical resinated fiber insulation for automobile applications, produced at a rate of approximately 1,000 lbs/month. The plant has been at its present location since 1951, and has undergone 2 major structural additions since that time. The current facility encompasses 346 thousand square feet under roof, and employs 450 hourly and 70 salaried employees. Shift times are 7:00am - 3:00pm, 3:00pm - 11:00pm, and 11:00pm - 7:00am.

There are four major divisions within the plant; Raw Materials, Hot Oil, Air Molding, and Package Tray. The request encompassed the first three of these divisions. One area specified in the request, the "Hot Box", was no longer in operation at the time of the survey.

A. Raw Materials

At the time of the initial survey, this division employed 34 workers over 2 shifts. It included the two mixing areas, referred to as the Old Compound Room and New Compound Room, along with the Airlay Department, each of which is discussed separately below.

1. Old Compound Room

In this area, two different resin systems, a thermoplastic and a phenolic, are prepared for use in the Airlay Department. The resin systems are composed of Ionomer Resins (ethylene methacrylic acid and Ionomer Powder - including copolymer partial metal salt) and Phenolic Resin Powder (including hexamethylenetetramine and talc). Two compounders work in this area. Respirators are required to be worn during the actual compounding of the resin.

2. New Compound Room

In this area, barium sulfate, calcium carbonate, mixed alkyl phthalate esters, polyvinyl chloride homopolymer or copolymer, naptha, calcium oxide, and carbon black are blended to make the vinyl plastisol used in the Air Molding Department. Two compounders work in this area. Respirators are required to be worn during the actual compounding of the plastisol.

3. Airlay (Schirp) Department

The primary raw material used in this area is cotton shoddy which is supplied in large bales. The bales are composed of cotton denim and synthetic materials. The cotton material is first taken from the bales and placed into feed blend boxes. It is then formed into a continuous sheet material on a conveyor line. Next it is transported to one of the three Airlay lines. At the Airlay lines, one of the two resin materials prepared in the Old Compound Room is dispensed onto the cotton material as it passes along the conveyor system. The material then enters a curing oven (450° - 500° F), and is pressed and cut as it leaves the oven. There is one Airlay operator per line, and two to four "catchers" at the end of each line.

B. Hot Oil Department

In this area of the plant, partially cured blankets from the Airlay department are taken from pallets and placed in the hot oil presses for curing and forming to the desired shape under heat (300° - 450° F) and pressure. There are 16 hot oil presses in the area; however, due to limitations in heating capacity, only 50% to 75% of the presses may be operable at any one time. At some of the presses, a fiberglass pad is also placed in the press with the blanket. A vinyl acetate film on one side of the fiberglass pad causes it to adhere to the blanket when heated. Additionally, a mold release agent is used on the presses to prevent sticking. The release agent is composed primarily of 1,1,1-trichloroethane (methyl chloroform) with some Dow Corning 20 Release Coating (stoddard solvent and xylene). The release agent is sprayed onto the presses, as necessary, by the employees. One employee works on either side of each press placing new blankets in the press and removing them at the end of the press cycle. A third employee is sometimes present to trim the molded product. In some cases, one group of employees may work two presses. At the time of the survey, approximately 114 workers were employed in this area over the 3 shifts. In addition to the existing general ventilation, several air moving fans are used by the employees in this area. During the survey, company officials indicated that plans were underway to provide local exhaust ventilation for the presses in this area.

An EK Line is also present in this department. At this line, an employee applies a polyethylene trim adhesive to some of the formed blankets coming from the hot oil presses. However, this line was not operational during the period of the environmental survey.

C. Air Molding Department

In this department, the vinyl plastisol prepared in the New Compounding Room is automatically dispensed onto cotton blankets as they travel down a conveyor. The plastisol is then cured as the blankets are conveyed through the ovens located on each of the three coating lines. The fully cured blankets are then formed in a cold molding operation and placed in a press for final cutting. At one line, a flexible polyurethane pad is sometimes used in place of the cotton blanket. At the time of the survey, 70 workers were employed in the Air Molding Department over two shifts. The employee operating the cold mold press is located approximately 15 feet from the exit of the oven. Three employees rotate at this position on an hourly basis. Each of the ovens is equipped with local exhaust ventilation, in addition to the general ventilation in the area.

IV. MATERIALS AND METHODS

Prior to conducting the environmental survey, records of recent OSHA investigations at the plant were obtained and reviewed. Additionally, material safety data sheets (MSDS) for the major substances used in the plant were also obtained and reviewed. Based on the information obtained from these sources, a sampling and analytical protocol was designed to assess employee exposures to several of the substances used in the plant, as well as their possible reaction and decomposition products.

In order to assess employee exposures, personal samples were collected near the breathing zones of the employees. In addition, general area air samples were collected at select locations to provide additional information on contaminant concentrations at fixed locations. All TWA air samples were collected using battery-powered pumps operating at a specific flow rate attached via Tygon tubing to the appropriate collection media. A detailed discussion of the contaminants which were sampled for and the method of sample collection and analysis, and the rational for collection is provided below.

A. Asbestos

A review of the material safety data sheet for the phenolic resin powder used in the Old Compound Room indicated that talc was present in the powder. Since some forms of talc have been shown to contain appreciable amounts of asbestos, a bulk sample of this resin powder was obtained for asbestos analysis.[1] Analysis for amosite, chrysotile, crocidolite, actinolite/tremolite, and anthophyllite asbestos content was conducted using polarized light microscopy and dispersion staining techniques.

B. Formaldehyde

One of the major resin systems used by the company utilized a phenolic resin powder. During the reactions which take place during the processing of some phenolic resins, it is possible for formaldehyde to be evolved.[1] Therefore, personal and area air samples for formaldehyde were collected in the Old Compound Room, where the resin powder was mixed, as well as in the Airlay and Hot Oil Press Departments where formaldehyde might possibly be present from the volatilization and reaction of the resin as a result of the high temperatures of the ovens and presses. All samples were collected using Suppelco Inc. Orbo 22 sorbent tubes at a flow rate of approximately 50 cubic centimeters of air per minute (cc/min). Samples were analyzed by gas chromatography with a flame ionization detector in accordance with NIOSH method No. 2502 with modifications.[2] A complete listing of the sample times and locations is provided in Table 1.

C. Hexamethylenetetramine

A review of the material safety data sheets indicated that hexamethylenetetramine was also present as a component in the resin powders. Therefore, personal and area samples for hexamethylenetetramine were collected in the Old Compound Room, the Airlay Department, and in the Hot Oil Press Department. Samples were collected on 37 millimeter (mm) glass fiber filters followed in-line by Tenax sorbent tubes at a flow rate of 0.75 liters per minute (lpm). Samples were later desorbed with methanol, sonicated, and analyzed using gas chromatography with flame ionization detection. A complete listing of the sample locations and times is provided in Table 2.

D. Total and Respirable Particulate

In order to assess the concentrations of total particulate generated during resin compounding, personal and area air samples for total dust were collected in the Old and New Compound Rooms. Samples were collected at a flow rate of 2.0 lpm using sampling cassettes containing preweighed 37 mm polyvinyl chloride (PVC) filters. Samples were analyzed by gravimetric weighing, subtracting the previously determined tare weight of the filter. In addition, air samples for respirable particulate were collected in each of the compounding rooms using a 10 millimeter nylon cyclone containing a preweighed 37 mm PVC filter at a flow rate of 1.7 lpm. In order to determine the percentage of dust in the respirable fraction, these samples were collected side-by-side along with total particulate samples. A complete listing of information pertinent to sample collection is provided in Table 3.

E. 1,1,1-Trichloroethane and Vinylidene Chloride

The solvent mixture used as a release agent in the Hot Oil Press Department contained as its principal ingredient 1,1,1-trichloroethane. Therefore, air samples were collected to assess employee exposures to this substance. Additionally, since a recent laboratory study had revealed that vinylidene chloride is a primary product resulting from the thermal decomposition of 1,1,1-trichloroethane, samples were collected to assess exposure to this substance.[3] Samples for these substances were collected at a flow rate of approximately 50 cc/min using a charcoal tube collection media. Each sample tube was analyzed for 1,1,1-trichloroethane and vinylidene chloride by gas chromatography with a flame ionization detector in accordance with NIOSH Method No. 1003 with modifications.[2] A complete listing of sample times and locations is provided in Table 4.

F. Ammonia

During the curing of the thermosetting resin material, the reaction of the hexamethylenetetramine with the phenolic component of the resin can lead to the liberation of ammonia.[4,5] Air samples for ammonia were therefore collected using a Draeger hand pump and detector tubes in the Hot Oil Press Department during the operation of the presses, as well as in the Airlay Department at locations near the curing ovens.

G. Phenol

Phenol was also a substance that can be liberated from the phenolic based resins systems, particularly during the heating and curing processes.[4] A review of the OSHA records indicated that during an inspection on January 5, 1984, TWA concentrations of phenol in the press area ranged from 1.4 to 4.3 parts of phenol per million parts of air (ppm), with a mean of 2.7 ppm in seven sample collected. During a subsequent inspection on October 4, 1985, TWA concentrations of phenol ranged from 0.9 to 2.9 ppm, with a mean of 1.7 ppm in seven samples collected. In order to verify that current airborne concentrations of phenol were still of this magnitude, detector tube measurements for phenol were made in the Hot Oil Press Department using a Draeger hand pump and detector tubes.

H. Carbon Monoxide

Carbon monoxide can be evolved as a waste product of the incomplete combustion of carbonaceous fuel materials or the thermal decomposition of process materials. To assess this potential exposure, samples for carbon monoxide were obtained in the vicinity of ovens located in both the Airlay and the Coating Departments. Samples were collected using Draeger detector tubes attached to battery-powered sampling pumps operating at 20 cc/min.

I. Toluene Diisocyanate (TDI)

As previously discussed, a flexible polyurethane foam pad is sometimes used as the base material on one of the products made in the Coating Department. Polyurethane foams are usually produced from the reaction of isocyanates with polyether or polyester resins along with various other components. The isocyanate component in flexible polyurethane foams is generally toluene diisocyanate, with an 80/20 ratio of the 2,4- isomer to the 2,6- isomer.[6] Although the foam utilized in this process was delivered to the plant in a pre-manufactured state, the possibility that TDI might be given off as a result of either the release of residual monomer or the possible decomposition of the foam to the monomer during heating in the coating oven was evaluated. A review of the results of previous OSHA investigations had revealed three instances during which air sampling for toluene diisocyanate had been conducted. The first survey occurred on October 7, 1985, during which concentrations of 0.12, 0.07, and 0.12 mg/M^3 2,4-TDI, and 0.15, 0.076 and 0.15 mg/M^3 2,6-TDI, were found in three short-term samples. During an OSHA survey visit conducted on January 17, 1986, no 2,4-TDI or 2,6-TDI was detected in four samples collected. During a subsequent OSHA survey on January 23, 1986, 2,6-TDI was detected in one of four short-term samples at a concentration of 0.025 mg/M^3, and 2,4-TDI was detected in two of the four samples at concentrations of 0.02 and 0.01 mg/M^3.

In view of these results, it was determined that additional sampling should be conducted to further explore the potential for TDI exposure in this area. Since the coating line which runs the flexible polyurethane foam was not operational during the first environmental survey, a follow-up survey was conducted on April 4, 1987. Personal samples for both isomers of TDI were collected for the cold mold press operator who worked in closest proximity to the oven and for whom previous sampling had indicated detectable levels of TDI. Since three employees rotated into the press operators job on an hourly basis, samples were collected consecutively for each employee while working in this position. In addition, area samples were collected at the exit to the coating oven where TDI concentrations might also be present. Samples were collected at a flow rate of 1.0 lpm using impregnated glass wool tubes as the collection media. Samples were shipped to the laboratory cold, and subsequently analyzed by high performance liquid chromatography in accordance with NIOSH method P&CAM 326 with modifications.[7] A complete listing of information pertinent to sample collection is included in Table 5.

V. EVALUATION CRITERIA

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

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

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations [Recommended Exposure Limits or REL's], 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) [Threshold Limit Values or TLV's], and 3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) occupational health standards [Permissible Exposure Limits or PEL's]. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 (29 USC 65l, et seq.) to meet those levels specified by an OSHA standard.

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

Following is a brief discussion of the toxicity of the major contaminants evaluated during this survey. The NIOSH, OSHA, AND ACGIH evaluation criteria for each of these substances is presented in Table 6.

A. Asbestos

Exposure to asbestos fibers may cause a lung disorder known as asbestosis which is characterized by a diffuse interstitial fibrosis. It is also capable of causing cancer of the lungs, digestive tract, and mesothelioma. Due to its carcinogenic nature, NIOSH recommends that employee exposures be reduced to the lowest feasible limit.

B. Formaldehyde

Formaldehyde concentrations in the range of 0.1 to 5 ppm can cause burning and tearing of the eyes, and general irritation to the upper respiratory passages. Dermatitis can also result from skin contact with formaldehyde and formaldehyde-containing resins. Following a few days of exposure, a worker may develop a sudden inflammatory (eczematous) reaction of the skin, although this reaction may also occur after several years of exposure. Animal studies have shown formaldehyde to be capable of causing mutatagenic activity in several test species, as well as a rare type of nasal cancer in different species of rats and mice. NIOSH recommends that formaldehyde be handled in the workplace as a potential carcinogen and exposure be reduced to the lowest feasible limit.[8]

C. Hexamethylenetetramine

Hexamethylenetetramine, also called "hexa", is used as a curing agent in thermosetting plastics. This substance is considered to be a skin irritant with no systemic effects from its' inhalation noted in the literature.[9] In general, it is not considered to be a major exposure problem in the plastics industry.[1]

D. Total and Respirable "Nuisance" Particulate

In contrast to fibrogenic dusts which cause scar tissue to be formed in the lungs when inhaled in excessive amounts, so-called "nuisance" dusts are stated to have little adverse effect on the lungs and do not produce significant organic disease or toxic effects when they are kept under reasonable control. Excessive concentrations of nuisance dusts may seriously reduce visibility, may cause unpleasant deposits in the eyes, ears, and nasal passages, or may cause injury to the skin or mucous membranes by chemical or mechanical action.[10]

E. 1,1,1-Trichloroethane and Vinylidene Chloride

1,1,1-Trichloroethane liquid or vapor may cause irritation to the eyes, and repeated contact with the skin may produce a dermatitis. Inhalation of sufficient amounts of the vapor may produce narcotic effects including dizziness, incoordination, and increased reaction time.[9]

Acute exposure to vinylidene chloride may cause eye and nose irritation as well as central nervous system depression. Chronic exposure may result in liver and kidney damage.[3] Animal studies have shown inhalation of vinylidene chloride can cause angiosarcoma at low exposure levels. NIOSH recommends that occupational exposure be reduced to the lowest feasible level.[11]

F. Ammonia

Ammonia is a severe irritant of the eyes, respiratory tract, and skin. It may cause burning and tearing of the eyes, runny nose, and coughing. Tolerance to usually irritating concentrations of ammonia may be acquired by adaptation.[12]

G. Phenol

Phenol vapor is an irritant to the eyes, mucous membranes, and skin. In animals, prolonged inhalation of the vapor at 30 to 60 ppm has induced respiratory difficulty, lung damage, and paralysis.[12]

H. Carbon Monoxide

Inhalation of carbon monoxide at sufficient concentrations can result in headache, nausea, dizziness, weakness, rapid breathing, unconsciousness, and death. Exposure to the gas may also aggravate heart and artery disease.[12]

I. Toluene Diisocyanate (TDI)

TDI can produce irritation of the respiratory tract at relatively high concentrations; such irritation has been reported in workers exposed to spills and other sources of high concentrations. In addition, workers may become sensitized to TDI, with subsequent exposures producing symptoms of asthma. Exposure to diisocyanates may also cause chronic respiratory effects measurable by long-term decrements in pulmonary function.[13]

VI. RESULTS

The results of the environmental surveys are presented in Tables 1 through 5. Table 1 shows the results of the environmental samples collected for formaldehyde. As evidenced by these data, formaldehyde was found to be below the limit of quantitation of 6 ug/tube in the five samples collected.

Table 2 shows the results of the samples collected for hexamethylenetetramine. This substance was detected in only one of the five samples at a concentration of 0.044 ppm. However, it was noted in the analysis that some breakthrough on the sampling tube may have occurred; therefore, the actual concentrations may have been somewhat higher than reported. There are currently no airborne criteria for hexamethylenetetramine; but in view of the limited toxicity of this substance, the concentration found would not appear to present a health hazard.

Table 3 shows the results of the samples collected for total and respirable particulate. TWA concentrations of 8.72 and 13.78 mg/M^3 total particulate were found in personal samples collected for the two mixers in the New Compound Room. One of these samples exceeded the ACGIH TLV of 10 mg/M^3, but was below the OSHA PEL of 15 mg/M^3 for total nuisance particulate. A comparison of side-by-side samples collected for total and respirable particulate revealed the dust was approximately 18% respirable particulate by weight. In the Old Compound Room, TWA concentrations of 2.43 and 2.26 mg/M^3 total particulate were found in personal samples collected for the two mixers. Both samples were below the ACGIH TLV and OSHA PEL for total nuisance particulate. A comparison of side-by-side samples collected for total and respirable particulate revealed the dust was approximately 8% respirable particulate by weight.

Table 4 shows the results of the samples collected for 1,1,1-trichloroethane and vinylidene chloride. 1,1,1-Trichloroethane was detected in only two of the eight samples collected at TWA concentrations of 0.32 and 0.63 ppm. These values were well below the NIOSH REL of 350 ppm as a 10 min ceiling, and the OSHA PEL of 350 ppm as an 8-hour TWA. No vinylidene chloride was detected in these samples above the limit of detection of 0.01 ug/tube.

The results of detector tube samples for ammonia collected in the Airlay Department revealed instantaneous concentrations ranging from 3 ppm to 22 ppm, with mean concentration of 11 ppm in the five samples collected. The results of the detector tube samples collected in the vicinity of the Hot Oil presses revealed instantaneous concentrations of ammonia ranging from 2 ppm to 35 ppm, with a mean concentration of 13 ppm in the ten samples collected. All samples were below the NIOSH REL of 50 ppm as a ceiling concentration, and the OSHA PEL of 50 ppm as an 8-hour TWA. It should be noted that the majority of these samples were "instantaneous" type readings taken when the presses were first opened, thereby reflecting "worst case" conditions when the highest ammonia concentrations would be expected. When the presses were closed, concentrations were much lower (maximum of 4 ppm). Therefore the average concentrations to which employees are exposed would also be below the ACGIH TLV of 25 ppm as a TWA, and 35 ppm as an STEL.

Detector tube concentrations of phenol collected at the Hot Oil presses were found to be less than 5 ppm in the three samples collected. These results were in agreement with the findings of the previous OSHA surveys indicating that all concentrations were below the NIOSH REL and the OSHA PEL of approximately 5 ppm for phenol.

TWA concentrations of carbon monoxide collected directly outside of the ovens in the Airlay and Coating Departments were less than 1 ppm and 4 ppm, respectively. These values were below the NIOSH REL of 35 ppm, and the OSHA PEL of 50 ppm as a TWA exposure.

Table 5 shows the results of the samples collected for toluene diisocyanate. Airborne concentrations of 2,4-toluene diisocyanate were found to be above the limit of quantitation of 1 ug/tube in only two of the six personal samples collected (0.0036 and 0.0020 ppm). Airborne concentrations of total 2,6-TDI was found to be above the limit of quantitation in only one of the six personal samples collected (0.0030 ppm). Since samples were collected for approximately one hour during which each operator worked at the cold mold press location, the results shown should be compared to ceiling criteria, as opposed to TWA criteria. Therefore, these concentrations were below the NIOSH REL (for both isomers) and the OSHA PEL (for the 2,4- isomer only) of 0.02 ppm as a ten-minute ceiling concentration. The actual TWA concentration for these employees would be much lower due to the averaging of these exposures with the other jobs performed during the day where TDI exposure would not be expected. No quantifiable amounts of either of the isocyanate isomers were found in the area samples collected at the exit from the oven.

The bulk sample of the Durite powder showed no detectable quantities of any of the five asbestos fiber types for which it was analyzed.

VII. DISCUSSION AND CONCLUSIONS

A. Compounding Areas

As evidenced by the results of the environmental surveys, the only area where an exposure above the environmental criteria was found, was in a personal sample collected in the New Compound Room. This sample exceeded the ACGIH TLV for nuisance particulate, but was below the corresponding OSHA PEL.

The criteria for "nuisance particulate" was used in this instance because the primary components of the resin mixture are either directly classified as nuisance dusts, have the same TLV's as nuisance dust, or generally exhibit a low order of toxicity. A major component of the resin mixture, barium sulfate, has its own ACGIH TLV of 10 mg/M^3 which is the same as that for nuisance particulate. Another component, calcium carbonate, is classified as a nuisance particulate by the ACGIH. Other lesser ingredients, such as mixed alkyl phthalate esters, are generally recognized as having a very low order of toxicity, with the exception of di-2-ethylhexyl phthalate (widely used in the past as a quantitative respirator fit testing agent) which a recent study has shown to cause cancer in rodents.[14] The polyvinyl chloride homopolymer, also appears to have a low order of toxicity. Since occupational exposure limits do not exist for the airborne dust of specific polymers, unless otherwise specified, the guidelines for exposure to nuisance dust are generally used.[1] The manufacturer of this product states in their material safety data sheet that their testing indicates that there is virtually no exposure to vinyl chloride monomer above the OSHA action level of 0.5 ppm during use of the material, and recommends dust exposure be controlled within the ACGIH nuisance dust guidelines. While some of the minor ingredients of the resin mixture (naptha, calcium oxide, and carbon black) do have more restrictive exposure criteria, since they together comprise a small percentage of the mixture, they would not be expected to present a hazard when the overall dust is controlled within the ACGIH guideline. Therefore, attempts should be made to maintain the dust levels in this area, at a minimum, within the ACGIH TLV of 10 mg/M^3. While the respirators currently used should substantially reduce the employees actual exposure, engineering controls supplemented with good work practices would be a more acceptable means of exposure control.

In the Old Compound Room, no exposures above the evaluation criteria were found for formaldehyde, hexamethylenetetramine, asbestos, or total or respirable particulate. However, a review of the literature does reveal some association between exposure to the dust and fumes from phenol-formaldehyde resins and lung function, eye irritation, cough, and skin rash.[4] Therefore, the ongoing emphasis should also be on controlling dust in this area.

Although it was not evaluated in this survey, significant exposure to the resin dust is also a possibility in the bag house located adjacent to the Airlay Department. Since activities associated with the maintenance of this equipment can often lead to substantial contact with the dust, it is important that the employees carrying out these tasks be provided with the proper respiratory and skin protection. Observations of one employee working in this area revealed dermatitis on his hands and forearms. Since a medical evaluation was not conducted, the etiology of the dermatitis could not be positively identified. However, based on the potential for these substances to elicit this effect, it is possible that this condition could have resulted from skin contact with the resin dust. This indicates a need not only for ensuring that proper protective equipment is readily available and properly used, but also that any potentially work-related problems are promptly reported, evaluated by qualified medical personnel, and corrective actions taken.

B. Airlay and Hot Oil Press Departments

In the Airlay and Hot Oil Press areas, no over-exposures to any of the resin components, their reaction products, or the release agents used on the presses were found. However, while no specific evaluation criteria were exceeded, the emissions from the hot oil presses were noticeably irritating during the brief period immediately following the opening of the press. During this time, instantaneous concentrations of ammonia were found to be as high as 37 ppm, as compared to 4 ppm with the presses closed. While several of the potential contaminants from the presses were evaluated during this survey (formaldehyde, phenol, hexamethylenetetramine, 1,1,1-trichloroethane, vinylidene chloride), there are numerous other possible contaminants which were not addressed. Traditionally, emissions from presses have been difficult to characterize due to the wide variety of contaminants which can be present at relatively low concentrations. The chemistry surrounding the reactions of phenol-formaldehyde resins are complex, and even today, not completely understood.[5] Contaminants can not only evolve from the resin material and release agents used at the presses, but also from the oils and other contaminants present in the cotton blanket which may vary from batch to batch. The combined effects from exposure to low concentrations of these substances is extremely difficult to assess. Therefore, the company's plans to install local exhaust ventilation in the Hot Oil Press Department is a prudent step in reducing employee exposures, despite the lack of data indicating that any occupational standards for airborne emissions are exceeded. Although the degree of direct worker contact with the heated process materials is not as great in the Airlay Department, many of the contaminants evolving from the ovens would be similar to those from the presses. Therefore, ongoing emphasis should be placed on insuring that the oven ventilation continues to work properly, thereby reducing the chance of exposures out in the work areas.

C. Coating Department

While both the 2,4- and the 2,6- isomers of toluene diisocyanate were detected in samples collected in the Coating Department (and the previous OSHA surveys), the concentrations were below the NIOSH, OSHA and ACGIH evaluation criteria. Since TDI is not a component of the plastisol mixture, the most likely source of the emissions would be from the liberation of uncured TDI monomer from the flexible foam during heating in the coating line oven. Although quantifiable levels of TDI were not found in the area sample collected directly outside of the coating oven, this would not be considered unusual since this sample location would be likely to reflect the flow of air into the oven from the surrounding work area, as opposed to the air inside of the oven itself. The fact that the highest concentrations of TDI were found at the Cold Mold Press located down the conveyor line from the oven might be explained by the liberation of the heated residual monomer vapors during the pressing operation. Discrepancies in the detection of TDI between consecutive samples (and between surveys in the case of the OSHA investigations) may possibly be due to minor variations during the manufacturing of the different batches of the flexible foam.

The skin irritation and sensitization from TDI noted in the literature are associated with contact directly with the isocyanate or uncured resin, and generally not with the completely cured foam.[4] However, since TDI is a potent respiratory sensitizer, steps should be taken to ensure that any exposure to this substance is minimized as much as possible. The rotation of employees in this area, although not conducted for this purpose, serves as an administrative control in reducing the potential exposure of any single employee. However, a more prudent means of control would be to ensure that the flexible foam product used in this process has as little residual monomer as possible - assuming that this is the source of the TDI.

VIII. RECOMMENDATIONS

In order to minimize the potential for work-related health problems from occupational exposure to the materials used in the plant, the following recommendations are provided:

1. Increased emphasis should be placed on reducing dust exposure in the New Compounding Room through engineering controls and work practices.

2. The company should proceed with the current plans for the addition of local exhaust ventilation in the Hot Oil Press Department. Care should be taken to ensure that any air moving fans used in this area do not interfere with the effectiveness of the local exhaust ventilation.

3. Further investigation of the source of the TDI in the Coating Department, possibly in conjunction with the manufacturer of the flexible polyurethane foam product, might provide additional information which would further reduce or eliminate this exposure.

4. All incidences of dermatitis or other health problems which might possibly be work-related should be immediately reported to supervisory personnel. A prompt evaluation of the problem should be carried out by qualified personnel, with consideration of the potential exposures of the affected individual. Based on the findings, appropriate treatment, corrective actions (i.e., personal protective equipment), or removal from the area should be carried out as appropriate.

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 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 through NTIS can be obtained from the NIOSH publications office at the Cincinnati, address. Copies of this report have been sent to the following:

A. Sheller-Globe, Herrin Illinois
B. Amalgamated Clothing and Textile Workers Union, Local 1374
C. U. S. Department of Labor, OSHA - Region V
D. NIOSH Regional Offices/Divisions

TABLE 1
RESULTS OF PERSONAL AND AREA AIR SAMPLES COLLECTED FOR FORMALDEHYDE

Allen Industries, Herrin, IL
September 4, 1986

Sample Type	Sample Location	Sample Time (min.)	Sample Volume (liters)	TWA Concentration Formaldehyde (ppm)
Personal	Hot Oil Operator Press # 1002-1003	391	18.3	< LOQ
Personal	Hot Oil Operator Press # 1009	385	16.8	< LOD
Area	Exit from Oven Line 3	298	14.9	< LOQ
Personal	Oven Operator Line 3	310	14.7	< LOQ
Area	On Pump Frame Old Mixing Room	334	16.6	< LOD

< LOD - Less than the limit of detection of 2 micrograms per tube
< LOQ - Less than the limit of quantitation of 6 micrograms/tube. (Substance was detected, but not in high enough concentrations to quantitate.)

EVALUATION CRITERIA : Formaldehyde
NIOSH REL - Lowest feasible limit (suspect carcinogen)
OSHA PEL - 3 ppm as an 8-hour TWA, 5 ppm ceiling, 10 ppm peak
ACGIH TLV - 1 ppm as an 8-hour TWA, 2 ppm STEL (15-min) (suspect carcinogen)

TABLE 2
RESULTS OF PERSONAL AND AREA AIR SAMPLES COLLECTED FOR HEXAMETHYLENETETRAMINE

Allen Industries, Herrin, IL
September 4, 1986

Sample Type	Sample Location	Sample Time (min.)	Sample Volume (liters)	TWA Concentration Hexamethylenetetramine (ppm)
Personal	Hot Oil Operator Press # 1010	259	194	< LOQ
Personal	Hot Oil Operator Press # 1002	257	193	< LOQ
Area	Exit from Oven Line 3	192	144	< LOQ
Personal	Die Cut Operator Line 3	186	140	< LOQ
Area	On Pump Frame Old Mixing Room	228	171	0.044

< LOQ - Less than the limit of quantitation of 20 micrograms per filter and 5 micrograms per Tenax tube. (Substance was detected, but not in high enough concentrations to quantitate.)

EVALUATION CRITERIA : Hexamethylenetetramine
There are currently no NIOSH REL's, OSHA PEL's, or ACGIH TLV's for airbome exposure to hexamethylenetetramine

TABLE 3

RESULTS OF PERSONAL AND AREA AIR SAMPLES COLLECTED FOR TOTAL AND RESPIRABLE PARTICULATE

Allen Industries, Herrin, IL
September 4, 1986

Sample Type	Sample Location	Sample Time (min.)	Sample Volume (liters)	TWA Concentration Particulate (mg/M3)
Personal	Mixer - New Compounding Room	345	690	8.72 (Total Dust)
Personal	Mixer - New Compounding Room	343	686	13.78 (Total Dust)
Area	On mixer column New Compd. Room	329	658	14.59 (Total Dust)
Area*	On mixer column New Compd. Room	340	578	2.60 (Respirable)
Personal	Mixer - Old Compounding Room	327	654	2.43 (Total Dust)
Personal	Mixer - Old Compounding Room	330	660	2.26 (Total Dust)
Area	Near Mixer in Old Compd. Room	332	664	4.01 (Total Dust)
Area*	Near Mixer in Old Compd. Room	332	564	0.32 (Respirable)

* Sample was collected side-by-side with the previously listed sample

EVALUATION CRITERIA : Nuisance Particulate
OSHA PEL - 15 mg/M3 as an 8-hour TWA for Total Dust
5 mg/M3 as an 8-hour TWA for Respirable Dust
ACGIH TLV - 10 mg/M3 as an 8-hour TWA for Total Dust

TABLE 4

RESULTS OF PERSONAL SAMPLES COLLECTED FOR 1,1,1-TRICHLOROETHANE and VINYLIDENE CHLORIDE

Hot Oil Press Department
Allen Industries, Herrin, IL
September 4, 1986

Sample Location (press #)	Sample Time (min.)	Sample Volume (liters)	TWA Concentration 1,1,1-Trichloroethane (ppm)	TWA Concentration Vinylidene Chloride (ppm)
1002-1003	246	12.1	< LOD	< LOD
1002-1003*	159	7.70	< LOD	< LOD
1011	243	11.6	0.32	< LOD
1011*	155	7.55	< LOD	< LOD
1010	238	13.4	< LOD	< LOD
1010*	158	9.12	< LOD	< LOD
1001	239	11.7	0.63	< LOD
1001*	155	7.57	< LOD	< LOD

* Indicates sample was collected in sequence to the previous sample

< LOD - Less than the limit of detection of 0.01 mg per tube

EVALUATION CRITERIA : 1,1,1-trichloroethane
NIOSH REL - 350 ppm as a 15-minute ceiling
OSHA PEL - 350 ppm as an 8-hour TWA
ACGIH TLV - 350 ppm as an 8-hour TWA, 450 ppm STEL (15-min)

TABLE 5
RESULTS OF PERSONAL AND AREA AIR SAMPLES COLLECTED FOR TOLUENE DIISOCYANATE (TDI)

Coating Department
Sheller-Globe, Herrin, IL
April 8, 1987

Sample Time (Start-Stop)	Sample Volume (liters)	Concentration 2,4-TDI (ppm)	Concentration 2,6-TDI (ppm)	Concentration Total TDI (ppm)
Personal Samples Collected at the Cold Mold Press*				
0710 - 0801	51	0.0036	0.0030	0.0066
0802 - 0902	60	< LOD	< LOD	< LOD
0923 - 1022	59	< LOQ	< LOQ	< LOQ
1021 - 1104	43	< LOQ	< LOQ	< LOQ
1128 - 1228	60	< LOQ	< LOQ	< LOQ
1343 - 1451	687	0.0020	< LOQ	0.0020
Area Samples Collected at the Exit to the Oven				
0804 - 0903	59	< LOD	< LOQ	< LOQ
1023 - 1104	41	< LOD	< LOD	< LOD
1131 - 1229	58	< LOD	< LOQ	< LOQ
1343 - 1451	68	< LOD	< LOQ	< LOQ

* Consecutive samples were collected (excluding breaks and lunch) from three employees who rotated approximately every hour onto this job.

< LOD - Less than the limit of detection of 0.3 ug/sample
< LOQ - Less than the limit of quantitation of 1.0 ug/sample. (Substance was detected, but not in high enough concentrations to quantitate.)

EVALUATION CRITERIA : TDI
NIOSH REL - 0.005 ppm TWA, 0.02 ppm as a 10-minute ceiling both types TDI
OSHA PEL - 0.02 ppm ceiling for 2,4-TDI
ACGIH TLV - 0.005 ppm as an 8-hour TWA, 0.02 ppm STEL (15-min) for 2,4-TDI

TABLE 6
ENVIRONMENTAL EVALUATION CRITERIA[15,16,17]

SUBSTANCE	NIOSH REL	OSHA PEL	ACGIH TLV
Asbestos	LFL	0.2 fibers/cc TWA	varies w/type
Formaldehyde	LFL	3 ppm TWA 5 ppm (10 min) 10 ppm (peak)	1 ppm TWA 2 ppm (STEL)
Hexamethylenetetramine	NA	NA	NA
Nuisance Particulates:			
Total Dust	NA	15 mg/M^3 TWA	10 mg/M^3 TWA
Respirable Dust	NA	5 mg/M^3 TWA	NA
1,1,1-Trichloroethane	350 ppm (15 min)	350 ppm TWA	350 ppm TWA 450 ppm STEL
Vinylidine Chloride	LFL	NA	5 ppm TWA 20 ppm STEL
Ammonia	50 ppm (5 min)	50 ppm TWA	25 ppm TWA 35 ppm STEL
Phenol	5.2 ppm TWA 15.6 ppm (15 min)	5 ppm TWA	5 ppm TWA 10 ppm STEL
Carbon Monoxide	35 ppm TWA 200 ppm ceiling	50 ppm TWA	50 ppm TWA 400 ppm STEL
Toluene Diisocyanate	0.005 ppm TWA 0.020 ppm (10 min) (all isomers)	0.02 ppm (10 min) (2,4- isomer)	0.005 ppm TWA 0.020 ppm STEL (2,4- isomer)

All evaluation criteria followed by "TWA" are expressed as 8-hour (OSHA, ACGIH) or 10-hour (NIOSH) time-weighted averages. Short-term criteria such as ceiling's or STEL's should not be exceeded during any fifteen minute sampling period or other time-limit specied.. Those criteria followed by "peak" should not be exceeded at any time during the workshift. Due to their potential for carcinogenicity, exposures to substances noted with "LFL" should be reduced to the lowest feasible limit.