U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT HE 77-80-620

GAF CORPORATION
WHITEHALL, PENNSYLVANIA

September 1979

I. TOXICITY DETERMINATION

A. Environmental

1. Environmental sample results indicated potentially hazardous exposure to airborne asbestos to employees working in the asbestos storage and hydropulper/mill. (Asbestos concentrations ranged from below detectable levels to 1.22 fibers/cc).

2. Employee exposures to air contaminants at the ink mixing and blending operations were found to be within recommended levels on the days of the NIOSH survey. Employees were exposed to high concentrations of dust for short periods of time during the dumping of pigments and filler materials when mixing ink. Exposures to solvent vapors were found to be within recommended levels but of significance was the presence of benzene. While the benzene concentrations were below permissible exposure limits, the benzene source should be identified and eliminated.

3. Solvent vapor concentrations at the 9 foot and 12 foot printers with "vinyl ink" did not exceed acceptable levels on the days of the NIOSH survey. However, review of solvent air sampling data performed by GAF and the Pennsylvania Bureau of Occupational Health showed excessive solvent exposures in the past. Solvent vapors when printing with "water-based inks" were well below acceptable exposure levels.

4. Employees exposures to air contaminants at the resin storage and mixing operations were found to be within current standards or criteria.

5. Area air sampling performed at the ovens for formaldehyde, acrolein, cyanide, isocyanates and hydrogen chloride showed no detectable levels. It was apparent, however, from employee interviews and symptoms noticed by the NIOSH investigators that there are substances emitted from the ovens which are irritating to the nose, throat, and eyes. Although the air contaminants responsible for the irritant effects were not identified, it is possible that these irritants are a potential health hazard, so exposure should be reduced.

B. Medical

1. Data from a limited number of death certificates of former employees did not substantiate initial reports of an unusual number of cancer deaths.

2. The annual blood counts on printing department employees revealed no evidence of chemical toxicity.

3. The company's annual chest X-ray reports revealed no statistically significant increased rate of cardiopulmonary abnormalities among employees with the highest exposure to asbestos. However, the inadequacy of the X-ray reports precludes a definite conclusion.

4. The company's annual pulmonary function tests revealed (a) no substantial difference in abnormality rates between jobs with high exposure and those with low exposure to organic chemicals, and (b) no substantial difference between asbestos-exposure categories in the rates of restrictive pulmonary dysfunction, a breathing abnormality characteristic of asbestosis. However, our study method had some deficiencies and may not have been sufficiently sensitive to detect such differences.

Recommendations concerning improvements of environmental control measures and medical surveillance are made.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

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

Copies of this report have been sent to:

(a) GAF Corporation, Whitehall, Pennsylvania
(b) GAF Corporation, Wayne, New Jersey
(c) United Paperworkers International Union, Jenkintown, Pennsylvania
(d) United Paperworkers International - Local 691, Allentown, Pennsylvania
(e) NIOSH, Region III
(f) U.S. Department of Labor, Region III

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees concerning employees exposures during floor covering manufacturing operations at the GAF Whitehall, Pennsylvania facility. The request alleged work related illnesses and deaths. Subsequent to receiving this request, OSHA requested that NIOSH perform a medical evaluation at this same facility. The OSHA request was prompted by: 1) the long history of high employee exposures to xylene, toluene, and 2-butanone; and 2) a list of 43 employees who had died or who had medical disorders thought to be related to exposures in the workplace (this list was compiled by Union Officials).

IV. HEALTH HAZARD EVALUATION

A. Evaluation Chronology

On August 10, 1977 a NIOSH investigative team (including an industrial hygienist, two medical officers, and an epidemiologist) visited the GAF facility to collect information relevant to the alleged health problems. The NIOSH industrial hygienist collected information concerning work activities and materials in use relative to health problems that employees reported. Operations with significant work exposure potential were identified and a protocol for air sampling of worker exposures was developed.

NIOSH industrial hygienists returned on September 14-15, 1977 to perform air sampling. The industrial hygienists briefly interviewed employees concerning work conditions and any health problems they might have experienced during the air sampling activities.

The NIOSH medical team surveyed all employees at work on September 14-15, 1977, recording age, sex, cigarette smoking behavior, and job history at the plant. The medical team also reviewed (1) personnel records (to verify job histories), and (2) medical records.

Preliminary findings were reported on August 16, 1977 (SHEFS I Report) and on December 1 and December 5, 1977 (letters to GAF and employee representatives). Medical findings were reported on September 22, 1978, to the union, company and OSHA.

B. Process Description

This facility is essentially devoted to the production of vinyl floor coverings. The finished end products vary in size, design patterns and finishes. An "inorganic felt" sheet is first produced by mixing water, wood pulp, asbestos, and a butadiene/styrene latex material. This "felt" is then coated with a PVC formulation, heat cured in an oven, and subsequently printed by the photogravure process to give the desired design. The printed rolls are then top coated with a heat curing polyurethane material. These finished rolls can then be embossed and/or a bottom layer of spongy foam can be applied ("soft-step" process). This facility, previously owned by different companies, has been involved in the production of vinyl floor coverning since 1948. Three shifts per day and six days a week are worked by a total of about 450 production employees.

Most of the production activities occur in a main building with various operations adjacent and separated by walls. The inspection and shipping operations are separated by as much as about 100 yards, while the oven and printing areas are adjacent to each other.

The various production locations and operations are discussed sequentially according to process and materials flow.

Felt Mill and Asbestos Warehouse

The felt sheet is produced from a slurry of water, wood pulp, asbestos fibers, Blancol N® (a wetting agent for the asbestos), and a butadiene/styrene latex (about 22 batches per shift are mixed in the hydropulper) which is spread on a large moving "conveyor screen" (by the "lead box"). Water is evaporated from this felt sheet and then rolled onto reels and transported for storage. The asbestos and wood pulp is stored in the raw materials warehouse. Bags or rolls of asbestos are unloaded about once a week from railcars adjacent to the asbestos warehouse. Employees working at the asbestos warehousing operation include the Material Handlers and Hydropulper Operators. The rolls of asbestos are warehoused in Stacks and covered with plastic. Handling of asbestos is accomplished with powered lift trucks. The asbestos mixing operations are designed to minimize asbestos dispersion. Bags of asbestos are fed by the lift truck into the hydropulper mixer and consumed, bag and all. Several workers are responsible for cleaning and vacuuming asbestos spills and contamination.

Resin Storage and Mixing

The vinyl plastic coatings are mixed in a building adjacent to the main production building. Bags of polyvinyl chloride resin stored here are transported by forklift, slit open, and dumped into ventilated mixing tanks, along with the liquid components which included dihexylphthalate, epoxidized soybean oil and other plasticizers. Specific formulations of these components are blended to meet the production needs. Other dry components added to this mixture can include titanium dioxide (pigment), and calcium carbonate. Approximately five employees per shift are involved in these activities.

Coating and 9' and 12' Ovens

The felt sheets are coated with various polyvinyl chloride (PVC) and urethane formulations: a PVC "basecoat" and either a PVC or polyurethane "topcoat". Each such coating must be oven cured at appropriate temperatures for a specific period of time. There is a curing oven each for the 9' and 12' wide sheets. The blade coater which applies the PVC or urethane coating is directly in-line with the entry to these ovens. The ovens are about 200' long and the sheet moves through at about 100' per minute (about 75' per minute for the urethane). The oven temperatures range from about 360°F to 390°F for the PVC coatings. A urethane "topcoat" is used on some products and is oven cured at about 300°F. The urethane topcoat is a two part system and has been in use for about 1 year. The urethane resin and catalyst is pumped and mixed from drum containers adjacent to the glade coater. A new urethane resin storage system located outside the building was near completion at the time of the September 1977 survey. The production schedule for the coating operations is typically arranged so that the base coat (for example) is applied to the warehoused felt sheets during the later part of the week and the topcoat is applied at the beginning of the week. The sheet is wound onto large rolls (as it exits the oven) and transported by lift truck to the warehouse until printed, embossed, or topcoated, whichever step is next in the process.

The 9' and 12' ovens are separated from each other by walls and involve essentially the same processes. The heat and combustion products from these curing ovens are exhaust ventilated at the oven entrances and exits as well in middle zones. A sliding exhaust hood is positioned at the entrance of the 9' oven during urethane coating. The exhaust from these ovens is scrubbed before release to the outside environment.

About 15 workers per shift are involved in various production activities at each of the ovens. About 10 workers are involved in making a "new splice" onto a roll. Several workers are present at all times at both the coating and exit ends of the ovens. Numerous other workers intermittently enter the oven areas to transport the rolls.

"Soft-Step"

About two employees per shift are involved in operating the blade coater and drying oven for the "soft-step" coat. Only certain floor covering products receive this spongy PVC bottom coating. This operation is located on a large platform and walkway adjacent and above the 12' oven. The PVC formulation is mechanically whipped before applied by the blade coater.

Ink Mixing and Blending

Both "vinyl" and "water-base" inks are used for printing patterns on the "base-coated" felt sheets. The "water-base" inks are bought and blended to the correct hue in a room adjacent and separate to the printing areas. The "vinyl" inks are mixed by two employees. The dry ingredients (including PVC powder, calcium carbonate, titanium doxide and other pigments) are hand carried and dumped into a tank in the charge ball mix room while the liquid ingredients (Solvent C and pthalate plasticizer) are piped to the tank and then transferred to the ball mill. (Solvent C is a mixture of 2-butanone, xylene and toluene.) After several hours of mixing in the ball mill the ink is transferred to 55 gallon drums. These drums of ink are stored in the ink blending room.

Two employees per shift are involved in blending these mixed inks to the correct color and hue. Buckets of mixed inks are hand carried and blended in mixing drums. The hue is matched by the gray bar scale method. About 150 drums (with loose fitting lids) are stored in this room.

9' and 12' Printers

The base coated sheets are printed with the desired pattern using either "vinyl" or "water-base" inks by the rotogravure process. There is a printing line for both the 9' and 12' wide rolls. The same printing machines are used for the vinyl and water-base inks. The printing heads are produced by about 15 employees (this operation was not evaluated). These printing machines are in use most of the time with vinyl inks generally used more than the water-base inks. Water-base inks were in use only on the 9' printer during the NIOSH visit in September of 1977. The number of printing heads in use normally ranges between three and five, depending on the type of printed pattern. The printing machines and cylinders are cleaned whenever a color or pattern change is made (varying from every shift to every other shift, etc.) Exhaust ventilation near the ink troughs operates to control Solvent C vapors. Supplied air respirators are used by the Printers and Printer Helpers at the 9' printer during cleanup. The printing cylinders and ink troughs are hand cleaned using rags soaked in Solvent C. Exhaust ventilation near the ink troughs operates to control the release of Solvent C vapors. There are about six workers (Printers and Printer Helpers) at each printing machine.

Warehousing - Inspection

There are about 25 workers per shift involved in warehousing, inspection, packaging and shipping of the finished vinyl floor coverings. These areas are separated from the main production areas and only the finished products are handled.

C. Evaluation Methods

1. Environmental

NIOSH industrial hygienists interviewed production and supervisory employees concerning the sources, nature, and extent of any air contaminants in relation to any health problems.

Worker exposures to asbestos fibers greater than 5 micrometers long were determined according to NIOSH Sampling Data Sheet No. 202. MSA Model G* pumps (attached to the workers belt) were used to draw air at 1.5 liters per minute through an 0.8 micrometer mixed cellulose membrane filter mounted in an open faced cassette. Analysis of these air samples for asbestos fibers was performed according to NIOSH method P&CAM 239.

Worker exposures to hexavalent chromium were determined using MSA Model G pumps (attached to the workers belt) to draw air at 1.5 liters per minute through a pre-weighed PVC filters (Gelman VM-1®)* in a closed face cassette. The amount of total particulate collected was determined by weighing. The amount of hexavalent chromium was determined according to NIOSH Method P&CAM 169.

Vinyl chloride samples were obtained by drawing air at 50 cc per minute through two charcoal tubes in series. Analysis for vinyl chloride was performed by gas chromatography.

Personal and area air samples for 2-butanone, 2-hexanone, benzene, toluene, m-xylene, and light naptha were obtained using Sipin®* personal air sampling pumps to draw air at about 50 cc per minute through charcoal tubes (150 mg. tubes). Analysis for these hydrocarbons was performed by gas chromatographic methods.

Worker exposures to methyl alcohol, ethyl alcohol, and isopropyl alcohol were determined by personal air sampling using Sipin® personal sampling pumps (attached at the workers belt) to draw air at 50 cc per minute through a charcoal tube. Analysis of these samples for the alchohols was by a gas chromatographic method.

* Mention of commercial names or products does not constitute endorsement by NIOSH.

Area air samples at the 9' and 12' ovens were obtained to identify and quantitate volatile oven emissions. Sipin® personal sampling pumps (positioned at various locations around the ovens) were used to draw air at about 200 cc per minute through either activated charcoal or Florisil® sampling tubes. Bulk liquid samples of condensate from the oven scrubbers were collected to aid in analysis. The collecting media were extracted with carbon disulfide and analyzed by various methods to identify possible air contaminants: gas chromatography and chemical ionization mass spectrometry, Fiegl spot test, and Bielstein flame test (for halides).

Area air samples for formaldehyde were obtained by drawing air through midget impinger bubblers containing chromotropic acid. Analysis of the collecting media was on-site by NIOSH personnel according to Intersociety Method #110. Measurements for formaldehyde were also made using a Draeger* gas detector unit. Area air samples for acrolein were collected and analyzed on-site according to methods adopted from Intersociety Method #110.

An area air sample for cyanide particulate and gas was collected using a MSA® Model G pump to draw air at 600 cc per minute through an 0.8 micrometer mixed cellulose ester membrane filter backed up by a midget impinger containing 0.1 N NaOH. Analysis of the filter and liquid collecting media was by the cyanide ion specific electrode method.

Area air sampling for isocyanates was performed using the Minature Continuous Monitor Type 4000 (MDA Scientific, Inc.*) The tape samples obtained with the MCM were then analyzed using the Model 4100 MCM Integrating Reader/Recorder (MDA Scientific, Inc.). This sampling method has been investigated and is reported in a NIOSH Publication.

The resin used in the urethane coating operation was analyzed by a NIOSH contract laboratory for unreacted isocyanates. An aliquot of the bulk liquid resin sample was reacted with M-4-nitrobenzyl-N-N-propylamine and analyzed by liquid chromatrography (UV detection) for the chromophoric urea derivatives of MDI, 2,4-TDI, 2,6-TDI and HDI.

A Century Organic Vapor Analyzer* was used on September 14, 1977 to identify the sources of high hydrocarbon emissions. This instrument responds non-specifically to all hydrocarbons, and is calibrated to methane in parts per million. Unfortunately, this unit malfunctioned before all work areas were screened.

2. Medical

In 1976 the company initiated an annual medical monitoring program in which all workers are offered a chest X-ray and pulmonary function tests, and in addition, printing department employees are offered a complete blood count (CBC). Employee participation is voluntary.

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Since the company's medical monitoring data for 1976 and 1977 were available, since a large independent medical study (described on page 19) was done two years earlier, and since no specific medical problem had been identified NIOSH decided that the medical investigation, at least initially, should be directed at collecting and analyzing the available data.

The requester supplied a list of nine former employees who had died in the preceding 1½ years, six allegedly of cancer. There was also a list of 54 employees and former employees who reportedly had various medical disorders; the requester suspected that some or all of this morbidity was occupationally related. Since this latter list indicated no unusual distribution of disease, attention was directed to the nine deaths. NIOSH attempted to obtain all of the death certificates, even though important identifying information was unavailable in some cases.

All employees at work on September 14-15, 1977 were surveyed, recording age, sex, cigarette smoking behavior, and job history at the plant. The medical team also reviewed personnel records (to verify job histories), medical records and the company's Logs of Occupational Injuries and Illnesses (OSHA Forms 100-102). Recorded from the medical records were results of annual chest X-rays, pulmonary function tests, and - in the case of printing department employees - blood tests.

Attempts were made to obtain the results of a medical study of the plant's workers done in 1975 by the Mt. Sinai School of Medicine, New York. NIOSH requested the report of the study and the specific test results for those persons identified during NIOSH's survey as participants. (NIOSH obtained written consent from all participants for whom results were requested.) Tests performed in the study included a chest X-ray, pulmonary function tests, a CBC, and a biochemical profile (SMA-12).

D. Evaluation Criteria

1. Toxic Effects

Asbestos - Prolonged exposures to airborne asbestos fibers can result in a type of pneumoconiosis referred to as asbestosis. This is a fibrotic disease of the lungs which can impair the transfer of oxygen to the blood and result in respiratory insufficiency or cardiac failure. Studies have also shown that exposure to asbestos fibers causes cancer (pleural and pertioneal mesothiliomas and gastrointestinal cancers) in man. Among cigarette smokers the occurrence of lung cancer is greater in those occupationally exposed to asbestos fibers.

Benzene - Exposure to benzene liquid and vapor may produce primary irritation to skin, eyes and upper respiratory tract. Erythema, vesiculation and dry, scaly dermatitis may also develop from defatting of the skin. Acute exposure results in central nervous system depression. Headache, dizziness, nausea, convulsions, coma and death may result. Chronic exposure is well documented to cause blood changes. Recent epidemiologic studies along with case reports of benzene related blood dysrasias and chromosomal aberrations have led NIOSH to conclude that benzene can cause leukemia.

2-Butanone (MEK) - 2-Butanone may produce a dry, scaly and fissured dermatitis after repeated exposure. High vapor concentrations may irritate the conjunctiva and mucous membranes of the nose and throat, producing eye and throat symptoms. In high concentrations, narcosis is produced, with symptoms of headaches, nausea, light headedness, vomiting, dizziness, incoordination and unconsciousness.

Ethyl Alcohol - Mild irritation of eyes and nose occur at very high concentrations. Prolonged inhalation of high concentrations, besides the local effects on the eyes and upper respiratory tract, may produce headache, drowsiness, tremors and fatigue. The liquid can defat the skin, producing a dermatitis characterized by drying and fissuring.

2-Hexanone (Methyl n-butyl ketone) - Produces effects very similiar to 2-butanone.

Isopropyl Alcohol - Vapors are mildly irritating to the conjunctiva and mucous membranes of the upper respiratory tract. Isopropyl alcohol is also potentially narcotic at high concentrations.

Toluene - An 8-hour exposure to toluene at 50-100 ppm may produce slight drowsiness and possibly slight headache. At a level of 200 ppm unconditioned workers may complain of fatigue, muscular weakness, headache and nausea. At 200-500 ppm impairment of coordination, momentary loss of memory, and loss of appetite have been reported.

Xylene - Xylene vapor may cause irritation of the eyes, nose and throat. Repeated or prolonged skin contact with xylene may cause drying and defatting of the skin which may lead to dermatitis. Acute exposure to xylene vapor may cause central nervous system depression and minor reversible effects upon liver and kidneys. At high concentrations xylene vapor may cause dizziness, staggering, drowsiness and unconsiousness.

2. Environmental Evaluation Criteria

Airborne exposure limits intended to protect the health of workers have been recommended or promulgated by several sources. These limits are established at levels designed to protect workers occupationally exposed to a substance on an 8-hour per day, 40-hour per week basis over a normal working lifetime. For this investigation, the criteria used to assess the degree of health hazards to workers were selected from three sources:

a. NIOSH Recommended Standards - airborne exposure limits which NIOSH has recommended to OSHA for occupational health standards.

b. Threshold Limit Values (TLV's) - guidelines for airborne exposures recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) for 1979. These include 8-hour time weighted average (TWA) concentrations, ceiling concentrations, and Short Term Exposure Limits (TLV-STEL).

c. OSHA Standards - the air contaminant exposure standards enforced by the U.S. Department of Labor as found in 29 CFR 1910.1000.1028.

Environmental Criteria

Substance	NIOSH Recommended Level	ACGIH TLV	OSHA Standard
Acrolien		0.1 ppm	0.1 ppm
Asbestos	0.1 fibers/cc	2 fibers/cc	2 fibers/cc
Benzene	1 ppm	10 ppm	10 ppm
2-Butanone	200 ppm	200 ppm	200 ppm
Cyanide	5 mg/M^3	5 mg/M^3	5 mg/M^3
Ethyl Alcohol		1000 ppm	1000 ppm
Formaldehyde	1 ppm	2 ppm	3 ppm
2-Hexanone	1 ppm	25 ppm	100 ppm
Isopropyl Alcohol	400 ppm	400 ppm	400 ppm
Methyl Alcohol	200 ppm	200 ppm	200 ppm
Diphenylmethane diisocyanate (MDI)	0.05 mg/M^3	0.2 mg/M^3	0.2 mg/M^3
Naptha	350 mg/M^3		
Toluene	100 ppm	100 ppm	200 ppm
Vinyl Chloride	Minimum Detectable Level	No Exposure	1 ppm
Xylene	100 ppm	100 ppm	100 ppm

In addition to the recommended levels listed in the above table, special consideration should be given to the application of the TLV's in assessing the health hazards which may be associated with exposure to mixtures of two or more substances. When two or more hazardous substances are present, their combined effect, rather than any of the individual materials, should be given primary consideration. In the absence of information to the contrary, the effects of the different hazards should be considered as additive. This additive effect can be calculated. If the sum of the following fractions:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \ldots$$

exceeds unity, then the threshold limit of the mixture should be considered as being exceeded. C_n indicates the observed atmospheric concentration and T_n the corresponding threshold limit.

E. Results and Discussion

1. Environmental

a. Asbestos Handling and the Felt Mill

The hydropulper operators and material handlers have potential asbestos exposures during the unloading of asbestos. Table I summarizes personal air sampling results for asbestos fibers during the unloading operations.

Employee exposures to asbestos (greater than 5 microns in length) were found to range from below detectable levels to 1.22 fibers per cubic centimeter of air (f/cc). Workers were observed to be wearing NIOSH tested and certified disposable dust respirators so that actual exposures were probably below these measured levels. (The NIOSH recommended standard for worker exposures to airborne asbestos fibers whose length is greater than 5 microns in length is 0.1 fibers per cubic centimeter of air on an 8-hour time weighted average basis with peak concentrations not exceeding 0.5 fibers per cubic centimeter of air on a 15-minute sample period. The OSHA standard is 2.0 fibers per cubic centimeter for an 8-hour time weighted average exposure). Stacks of asbestos were observed to be covered with plastic and it appeared that housekeeping measures to minimize asbestos release were practiced. The transport and dumping of asbestos at the hydropulper utilized an automated process which was ventilated and consumes the entire bag of asbestos. These asbestos handling procedures had been instituted during the past several years. Review of asbestos air sampling results provided by GAF for the period of 1972-1977 confirmed that workers at these operations have had asbestos exposures in the ranges measured by NIOSH industrial hygienists. The air sampling results provided by GAF provided no information concerning production conditions, but it is apparent that employees are exposed to highly variable concentrations of asbestos. Of the 87 measurement results provided to NIOSH by GAF, nine of the measured concentrations were at or above the OSHA permissible limit of 2.0 f/cc. Eighty of the 87 measurements were at or above the NIOSH recommended limit of 0.1 f/cc. Evaluation of this GAF data showed a general trend toward reduced employee exposures to asbestos.

b. Resin Storage and Mixing

Evaluation of the resin mixing operations did not identify hazardous worker exposures to dusts, gases or vapors during the NIOSH visits. The mixing activities are widely varied and involve many different components. Exhaust ventilation had recently been installed at the mixing tanks and appeared to provide some control of vapors and dust during the mixing of base coat plastisols. Workers generally stated during interview that dust and vapor exposures were not bothersome and that conditions had improved with the new ventilation system. A personal air sample for vinyl chloride was obtained on a Mixing Helper during the mixing of three batches of base coat on September 14, 1977 and no vinyl chloride (less than 0.02 ppm) was detected on the sample. The OSHA exposure limit for vinyl chloride is 1 ppm for the 8-hour workday. This indicated that no residual vinyl chloride monomer was present in the polyvinyl chloride powder. Exposure to polyvinyl chloride dust at this kind of operation is not considered to be a health problem unless a dense irritating cloud is encountered.

c. Ink Mixing and Blending

The workers involved at the vinyl ink mixing operations have potential exposures to Solvent C vapors (MEK, xylene, and toluene) and to airborne dusts. Table II summarizes personal sampling for airborne particulate and hexavalent chromium during the dumping and mixing of vinyl ink components at the charge ball mix room. Workers were observed to wear disposable dust respirators during the pouring of bagged polyvinyl chloride and pigments. Total airborne particulate exposures were 0.1 and 24.6 mg/M^3 (OSHA Standard - 15 mg/M^3 for an 8-hour time weighted average exposure). No hexavalent chromium was detected on the samples (less than 4 micrograms per cubic meter of air).

Employees working at the ink mixing operation reported that Solvent C vapors were very noticeable in the mill room when Solvent C is added to the ball mill. Table III contains a summary of personal air sampling by NIOSH for solvent vapors at the ink mixing operations on September 14, 1977. Air sampling by NIOSH found the highest exposure to solvent vapors among the Ink Mixers and helpers at 27% of the calculated "combined exposure" permissible limit. The locations and activities of the Mixing Leader and Mixing Helpers was not observed during the entire air sampling period and it appears that work activities and exposures to Solvent C vapors range widely. No air sampling data was provided by GAF regarding employee exposures at the ink mixing and ball mill operation.

The results of personal air sampling of the Ink Blenders exposure to Solvent C vapor are summarized in Table III. Their combined exposures ranged from 13-24% of the calculated TLV. One of the four breathing zone samples found 0.8 ppm of benzene. The GAF Corporation made available the results of personal air sampling for the Ink Blenders. Their exposures to Solvent C vapors were reported to be of the same range as NIOSH measured. Benzene was not measured by the company.

d. 9' and 12' Printers

The results of NIOSH personal air sampling for Solvent C vapors at the "vinyl" printing operations is summarized in Table III. Worker exposures at the 12' printer on September 14-15, 1977, to Solvent C vapors was found to range from 1-42% of the maximum permissible combined exposure limit. Personal air sampling of the Printer Helpers on September 15, 1977, found Solvent C exposures to be 1-2% of the maximum permissible combined exposure limit. These two samples also revealed benzene levels of 0.9 ppm, 3.0 ppm and 0.94 ppm. One of six personal air samples of operators at the 12' printer for solvent vapors found benzene at 0.8 ppm.

Table IV summarizes personal air sampling for methanol, ethanol, and isopropanol vapors at the 9' printing operation on September 14, 1977, during the printing with "water-base" inks. Exposures to these alcohol vapors were less than 10% of the OSHA standard.

Work activities were reported by employees to be generally typical during the sampling periods. Three to six heads per printer were used during this sampling. The GAF Corporation made available to NIOSH personal air sampling data from 1975-1976 of Solvent C exposures at the 9' and 12' printers. Workers exposures to solvent vapors (naptha, 2-butanone, 2-hexanone, xylene, and toluene) were reported to approach or exceed exposure limits on occasion.

The Pennsylvania Bureau of Occupational Health conducted surveys of worker exposures to solvent vapors at the printing operations from 1964-1970. These survey results show that workers at the 9' and 12' printing operations commonly had exposures exceeding the calculated threshold limit values (TLV's). Measurements were made with a Davis* vapotester. The highest worker exposures occurred during the washup of the print heads.

e. Coating Operations - 9' and 12' Ovens and Soft-Step

Employee exposures to air contaminants at these operations were thought to be due to (1) volatile components in the PVC and urethane resins prior to and during application to the sheets, and (2) oven emissions including the volatile and gaseous products of the curing resins and oven combustion products. During the NIOSH survey period the oven areas were observed to fill with a noticeable blue/gray haze which NIOSH investigators noted to be moderately irritating to the eyes, nose and throat. Workers generally stated during informal interviews that the irritating oven emissions are commonly noted and apparent. It appeared that there is considerable variability in the amount of oven emissions depending on production conditions. Emissions from the open ends of the ovens are controlled by two means: (1) maintaining proper oven flue exhaust volumes, and (2) operation of attached canopy exhaust hoods at the ends of the ovens. Oven emissions were reported to be most apparent when inadequate oven exhaust volumes are maintained, and on occasions such as during the repair work when the oven is shut down and the oven exhaust fans are not kept on.

Employee exposures to resin vapor components at the coater were found to be insignificant except for the urethane coating operation. Table V presents the results of testing for "relative hydrocarbon concentrations." The urethane resin material was found to have a significant volatile hydrocarbon emission, while the base coat and softstep resin material showed a much lower response with the organic vapor analyzer testing.

The charcoal tube air sample obtained at the operators work location of the urethane coater found only 8% of the permissible solvent exposure concentration (Table III). The charcoal tube air sample located directly above the urethane resin in the coating trough revealed the presence of benzene.

* Mention of commercial names or products does not constitute endorsement by NIOSH.

F. Coating Operations - 9' and 12' Ovens and Soft-Step

Employee exposures to air contaminants were found to be within acceptable levels at these operations as determined by air sampling. Prior to baking, only the urethane resin was found to have appreciable volatile organic components. Benzene was detected in the air immediately above the resin trough while coating with urethane. Air sampling was performed to identify possible emission products from the baking processes. Four area air samples (by impinger method) for formaldehyde and acrolein were obtained near the various oven operations and were analyzed on-site by NIOSH personnel. Sample analysis failed to detect either formaldehyde or acrolein at levels near the OSHA standard (formaldehyde 3 ppm; acrolein, 0.1 ppm). Formaldehyde measurements were also made at two times on September 14, 1977 using Drager gas detector units. Both of these detector tube samples failed to indicate the presence of formaldehyde or other aldehydes. Air sampling for cyanide gas and particulate at the 12' oven during urethane coating operations on September 14, 1977 failed to detect any (the analytic lower limit of detection is three microgram per sample and the sample volume was 204 liters). Air sampling using activated charcoal and Florisil^{R} collecting media (a total of ten samples) was performed by placing the samplers directly over the coated sheets of flooring as they exited the ovens (in the most concentrated portions of the oven emissions) and in work areas adjacent to these ovens. Bulk liquid samples were obtained from the oven exhaust scrubbers and used as an aid in analysis. Gas chromatography of the liquid showed three major peaks (possibly chlorophenyl butyrate, phenyl chlorobutyrate, or chlorophenyl chlorobutyrate) and numerous small peaks. Analysis of the charcoal tube and Florisil^{R} samples detected these three major components (as identified from the analysis of the bulk liquid). The semiquantitative anlysis found as high as about 50 mg/M^{3} of the three major components (possibly chlorophenyl butyrate, phenyl chlorobutyrate, or chlorophenyl chlorobutyrate) on air samples taken in the concentrated emission plume. An area air sample obtained in the general work area at the soft-step operation showed about 6 mg/M^{3} of these three major components. The five Florisil^{R} samples were analyzed for pthalates and only the sample taken under the exhaust hood at the nine foot oven (during base coating) detected any, with a concentration of 3 mg/M^{3}. The health consequences of exposure to these levels of oven emissions is unknown. It was apparent from employee interviews and symptoms noticed by NIOSH investigators that there are oven combusion products and votatile coating materials emitted from the ovens which are irritating to the nose and throat. Although the air contaminant(s) responsible for the irritant effects were not specifically identified, it is the judgement of the NIOSH investigator that the irritant air contaminants are a potential hazard and that measures should be taken to further reduce exposures.

G. Warehousing, Inspection, and Shopping

The walk-through industrial hygiene survey of these areas and operations indicated little or no potential employee exposures to volatile or dusty materials since work activities mainly involve the handling of the finished products. No air sampling was performed at these work operations. Employees who work at the warehousing and inspection operations are likely to be exposed to air contaminants only when they enter the printing, coating or other areas which have appreciable air contamination.

2. Medical

A. Review of Death Certificates

Five death certificates were obtained, three of them for cases that were reported by the requester as cancer. In only one of these was cancer (of the pancreas) mentioned as an immediate or contributing cause of death. In the other two cases the causes of death were: (1) myocardial infarction, and (2) subarachnoid and intra-cerebral hemorrhage from a ruptured berry aneurysm. In the two cases not reported by the requester as cancer, the causes of death were myocardial infarction and arteriosclerotic heart disease.

B. Company Records of Occupational Illness

The Logs of Occupational Injuries and Illnesses from mid-1971 to mid-1977 revealed an increasing number of injuries annually (22 in 1972 to 169 in 1976) but infrequent reports of other health problems; there was one report of illness in 1972, three reports of problems due to physical agents (one in 1972, two in 1976), and three reports of skin problems (two in 1976, one in 1977).

The absence of reports of occupational illnesses from these logs, particularly chronic illness, is common in industry and is not necessarily evidence of the lack of such illnesses.

C. Medical Survey

1. Extent of Survey

Of the 443 non-supervisory production employees, 390 (88%) agreed to participate in the survey; the 53 non-participants included 13 workers who refused and 40 who were on vacation, absent from work, or inadvertently not contacted during the survey. (Supervisory employees were offered the opportunity to participate in the survey, but none did.)

Since it was apparent from the survey data that most employees tended to remain in one department for a number of years, and since the company's medical screening program was two years old, excluded from further analysis were the 20 participants who had changed departments within the preceding two years. (These 20, on the average, were younger and had less seniority than the other 370. In two cases there were one or more abnormalities found during the medical monitoring that might have been responsible for the job change; in the other 18 cases there was no apparent reason to suspect that the job changes were for medical reasons.) Thus, the 370 employees included in the subsequent analyses represent 95% of the participants and 84% of all non-supervisory production employees. Age and seniority of the study participants are shown in Table VI.

In order to simplify the analysis of the chest X-ray and pulmonary function data, some departments were grouped according to toxic substance exposure. This was determined by the nature of the job, the location of the worksite, and/or environmental sampling data. The eight job categories thus derived are shown in Table VII.

2. Blood Tests

Of the 42 printing department employees included in the analyses, 37 had a CBC at least once. In 22 cases, all test results would be considered normal by at least one of two authoritative sources,[1,2] and six had a minor abnormality in 1976 that was not present in 1977. In five cases there was a minor abnormality (both years or one year with no subsequent test) that was probably not of medical consequence: (1) one case of minimally decreased values for hematocrit, hemoglobin, and red blood cell count in 1976, with no test in 1977, (2) one case of a minimally decreased hematocrit in 1976, with a normal hemoglobin and red blood cell count and no test in 1977, (3) three cases of a slightly increased number of neutrophils both years (one of these also had a minimally decreased red blood cell count both years, with the hemoglobin and hematocrit normal both years and stable). In three cases there was an elevated white blood cell count in the last year tested (one of these also had a slightly decreased red blood cell count both years, with the hemoglobin and hematocrit normal both years and stable); in two of these cases the elevation was due to an increase in segmented neutrophils, and in the other it was due to an increase in lymphocytes. Finally, there was one case of a normal white blood cell count in which the proportion of lymphocytes was higher than "normal" because of a low - though still "normal" - number of neutrophils.

With the possible exception of this last case, there is no evidence of bone marrow depression, which is a possible toxic effect of benzene[3] (and conceivably other aromatic compounds found in the printing department). This case of relative neutropenia and lymphocytosis, however, is not necessarily explained by chemical toxicity; it could, for example, have occurred as a result of a viral infection.

3. Chest X-rays

The chest X-rays findings were reported using descriptive, clinical terminology rather than a standardized, quantitative method such as the UICC/Cincinnati system.[4] Furthermore, the reports gave no indication that the 1977 X-rays were compared to the corresponding 1976 X-rays. Thus, we had no way of assessing the occurrence of progressive changes.

The frequency of abnormalities was determined for those who had an X-ray in 1976, in 1977, and in both years. In the last group (hereafter referred to as 1976/77), an abnormality reported in either year was considered the same as one that was reported both years. An "abnormality" was defined an any thoracic finding noted by the radiologist as abnormal, excluding arterial calcifications and findings limited to the vertebral column and/or other bones. The vast majority of abnormalities thus defined were pulmonary or pleural, with most of the rest being cardiomegaly.

In the only job categories with frequent, appreciable asbestos exposure - felt, and possibly maintenance/janitorial - the abnormality rates appeared to be the highest of all categories in 1977 and 1976/77 (but not in 1976), and the 1977 and 1976/77 differences seemed more pronounced in smokers (Table VIII). However, none of these differences was statistically significant (felt and maintenance/janitorial combined vs. all other job categories combined: 1977 smokers - $X^2 = 2.36$, $p>0.1$; all 1977 employees - $X^2 = 1.55$, $p>0.2$; 1976/77 smokers - $X^2 = 2.38$, $p>0.1$; all 1976/77 employees - $X^2 = 2.47$, $p>0.1$). On the other hand, in 1977 and 1976/77 there were substantial differences in abnormality rates between smokers and non-smokers (1976 - $X^2 = 2.50$, $p>0.1$; 1977 - $X^2 = 5.13$, $0.05>p>0.02$; 1976/77 - $X^2 = 6.69$, $0.02\geq p>0.01$). The abnormality rate generally increased with age (1976 - $X^2 = 155$, $p<<0.001$, d.f. = 2; 1977 - $X^2 = 54$, $p<0.001$, d.f. = 2; 1976/77 - $X^2 = 172$, $p<<0.001$, d.f. = 2 (Table IX), as might be expected. There were no statiscally significant differences in X-ray abnormalities between the felt and maintenance/janitorial categories combined and all other categories combined even when adjustments were made for differences in age distribution (1976 age-adjusted rates: 10% for each of the two groupings; 1977: 20% for felt + maintenance/janitorial, 17% for others, $X^2 = 0.05$, $p>0.5$; 1976/77: 26% and 19%, $X^2 = 1.06$, $p>0.2$).

4. Pulmonary Function Tests

Pulmonary function results were recorded qualitatively rather than quantitatively; that is, instead of recording numerical values, we recorded the test results as normal, restrictive, or obstructive, and the latter two as minimal, moderate, or severe. The individual test reports used these terms, so we did not define them ourselves. (In retrospect, had we recorded the numerical test results and the predicted normal values we would have had a more sensitive method of comparing test results.) As with the chest X-rays, we analyzed the pulmonary function data by calculating abnormality rates for 1976, 1977, and 1976/77. Obstructive and restrictive abnormality rates were calculated independently. In calculating these rates, the severity of the abnormality was not taken into account.

a. Obstructive Abnormalities

In 1977 and 1976/77 the highest rate of obstructive abnormalities occurred in the felt category (Table X), but compared to all other job categories combined the differences were not statistically significant (1977 - $X^2 = 2.39$, $p>0.1$; 1976/77 - $X^2 = 1.67$, $p>0.1$). The difference seemed more pronounced in the oldest age group, and in this age group also seemed to be present in 1976, but again, with the possible exception of 1976/77 ($p = 0.03$, Fisher's exact test, 2-tailed), the differences were not statistically significant (in both 1976 and 1977: $p>0.1$, Fisher's exact test, 2-tailed). Among smokers (Table XI), this job category and the maintenance/janitorial category had a combined rate greater than the other job categories combined ($X^2 = 4.72$, $0.05>p>0.02$) in 1977 but not in 1976/77 ($X^2 = 2.00$, $p>0.1$) or 1976. In 1976, the highest rate was in the warehouse/etc. category, but compared to the combined rate for all other categories the difference was not statistically significant ($X^2 = 1.73$, $p>0.1$).

The rate of obstructive abnormalities consistently increases with age (comparing the totals in the three age groups by X^2, d.f. = 2: 1976 - $X^2 = 6.95$, $0.05>p>0.02$; 1977 - $X^2 = 10.82$, $0.01>p>0.001$; 1976/77 - $X^2 = 13.18$, $0.01>p>0.001$) (Table X). This may seem unexpected since the calculation used to predict an individual's "expected" pulmonary function (which is used to interpret the test results) takes age into account. However, this association is consistently strong only in smokers (1976 - $X^2 = 25.01$, $p<0.001$; 1977 - $X^2 = 56.39$, $p<0.001$; 1976/77 - $X^2 = 23.84$, $p<0.001$) (Table XI) and not seen to a statistically significant degree in former smokers (Table XII) or non-smokers (Table XIII). (For these latter two sets of analyses, the two youngest age groups were combined in each case because the relatively small numbers and low abnormality rates rendered the regular 2 X 3 chi-squared analyses unusable. For both former smokers and non-smokers: $p>0.1$ each year, Fisher's exact test, 2-tailed). The association is therefore likely attributable to the cumulative amount of exposure to cigarette smoke and/or recent exposure to cigarette smoke rather than to age itself. To the extent that the job categories involving asbestos exposure contributed to the overall abnormality rates, the combined effect of cigarette smoke and asbestos might also be a factor in the observed association. In non-smokers there is no substantial effect of age on the rate of obstructive abnormalities (Table XIII).

The apparent absence of an association between obstructive abnormalities and high asbestos exposure is not surprising since asbestosis results in restrictive, rather than obstructive, changes.[5]

b. Restrictive Abnormalities

Restrictive pulmonary abnormalities were reported in no more than 8% of workers tested (Table XIV), only half as frequently as obstructive abnormalities. Overall, there was no job category that had an unusually high rate. The mixing category appeared to have the highest abnormality rate each year, but compared to all other job categories combined the differences were not statistically signigicant ($p>0.1$ each year, Fisher's exact test, 2-tailed). (Of the four felt category workers that had a restrictive abnormality, one was minimal in 1976 and normal in 1977, two were normal in 1976 and minimal in 1977 [both had minimal obstructive changes both years], and one was minimal in 1976 and not tested in 1977.) Among non-smokers (Table XVII) the oldest age group had abnormality rates higher than the other two age groups combined in both 1977 and 1976/77 ($p = 0.04$ and 0.02, respectively, Fisher's exact test, 2-tailed); this was true for former smokers (Table XVI) in 1977 only ($p = 0.04$). No such phenomenon occurred among smokers in any year (Table XV).

As with obstructive abnormalities, the rate of restrictive abnormalities should be independent of age if expected pulmonary function is calculated properly. The observed associations with age, in the absence of any association with job category, are unexplained.

5. Limitations of X-ray and Pulmonary Function Data Analysis

In 1976, 88% of the workers participated in the medical monitoring program; in 1977, 81% participated. This decrease was due, in part, to the effect of having an abnormality reported in 1976. Of those with normal test results in 1976, 11% did not participate in 1977, whereas 34% of those who had an abnormality in 1976 didn't participate in 1977. (We can speculate, but have no data to document, that since workers with abnormalities were referred to their personal physicians they got subsequent testing from them rather than from the company.) It is possible that this phenomenon may selectively remove workers with occupational diseases from the population medically monitored by the company and may thus obscure evidence of adverse health effects.

Smoking behavior was not recorded quantitatively, and this may have resulted in (1) failure to detect the more subtle effects of smoking on the X-ray and pulmonary function test results, and/or (2) the occurrence of spurious associations.

No attempt was made to analyze abnormality rates according to seniority because the amount of time spent at previous job assignments at the company or at jobs at other companies was not recorded, so there was no way of calculating total time spent in the job categories used for the analyses. Furthermore, it would have been difficult to separate the effects of seniority from age, and the latter seemed to be a more accurate number to work with.

D. Results of Mt. Sinai Study

Among the survey participants, 111 said that they participated in Mt. Sinai study; 109 authorized NIOSH to obtain their test results. Despite multiple requests for these results and a report of the study, we received no information other than a verbal comment that the blood tests and X-rays yielded no significant findings and that the pulmonary function tests revealed some restrictive abnormalities of uncertain significance (Alf Fischbein, M.D., personal communication, September 2, 1977).

E. Conclusions

1. Environmental

a. Asbestos Handling and the Felt Mill - Employees working in the area of asbestos storage and the hydropulper/felt mill have potential over exposure to airborne asbestos. Potentially hazardous exposure to other air contaminants were not identified at these operations during the survey visit. Employees working in the following job categories have potential exposures to asbestos: material handler, tow motor operator, material handler helper, assistant hydropulper, yard and scrap sweep operator, and mechanic room helper. Air sampling by NIOSH did not find employee asbestos exposures that exceeded OSHA limits but the assistant hydropulper operator, hydropulper operator, and material handler helper were exposed to asbestos levels exceeding the NIOSH recommended 8-hour TWA exposure limit. Respirators were worn by workers during the unloading of asbestos from box cars and/or semi-trailers. Respirators are available and were observed to be generally worn by the sweeper operator and other exposed workers.

It appears that airborne asbestos is generated during the unloading of box cars, during the transport or handling of bags of asbestos, during sweeping of the asbestos storage area, possibly during the addition of asbestos to the hydropulper, and in areas where asbestos has been spilled or sedimented on the floor and subsequently made airborne by foot or motor traffic. NIOSH tested and certified respirators for protection against asbestos should be worn at these operations unless air sampling and analysis determines that exposures are below 0.1 fibers/cc. Because workers at these operations have had exposures which exceeded the NIOSH recommended exposure limits, asbestos exposed employees should be provided with medical testing and surveillance as discussed below (page 25).

Present work practices and housekeeping procedures appear to be partially effective in preventing asbestos exposures. Because of the large amounts of asbestos stored and handled, employees will continue to have exposure. The Company and employees should continue their efforts to keep employee exposures as low as possible through improved process controls and work procedures.

b. Resin Storage and Mixing - Employee exposures to air contaminants at these operations appear to be within currently acceptable limits. Extensive air sampling at these operations was not performed because of the difficulty in obtaining proprietary component information for many of the products mixed. Use of powdered or pellet polyvinyl chloride formulations minimizes the likelihood of exposures to vinyl chloride monomer. Air contamination with vinyl chloride monomer was not detected on the days of the NIOSH survey. Exposure to volatile components of the plastisol solvent mixes at these operations is relatively low since the plastisol is not heated until later stages of the flooring manufacturing process at other plant locations (at the ovens). The company should continue close surveillance of these resin mixing operations and perform air sampling if new materials are introduced.

c. Ink Mixing and Blending - Employee exposures to air contaminants at the ink mixing and blending operations were found to be within recommended levels on the NIOSH survey days. Employees are potentially exposed to high concentrations of dust for short periods of time during the dumping of pigment and filler materials when mixing the inks. Charging of the ball mill with Solvent C potentially exposes employees to high solvent levels for short periods of time. Employees should continue to use NIOSH tested and certified respirators during these high exposure periods.

Employee exposures to solvent vapors at the ink blending operations were found to be within recommended levels on the days of the survey. The sources of solvent vapor air contamination are stored drums of ink which are left open or not tightly sealed, solvent evaporation during ink blend mixing and less so during the conduct of the "graybar scale test." Of significance is that on September 15, 1977, an employee (ink blender) was exposed to 0.8 ppm of benzene. While this level is below the NIOSH recommended exposure limit for benzene (1 ppm), certain conditions may exist that expose the employees at the ink blending operations to higher levels. The source of benzene air contamination should be identified and eliminated to further reduce possible benzene exposures. Evaluation of the ventilation system in the ink blending room by the use of smoke tubes, and personal air samples, showed dilution ventilation to be adequate to maintain employee exposures within acceptable levels. Exhaust ventilation at the ink blenders is provided by floor level vents. This location of the exhaust vents is effective in removing vapors for explosion/fire control when ink is spilled on the floor, but does not effectively capture ink solvent vapors as they are evolved from the operating of the ink mix tank during normal blending activities. It is likely that a lateral exhaust hood location at the back lip of the blending mixer would further reduce employee exposures.

d. 9' and 12' Printers - Employee exposures to solvent vapors at the 9' and 12' printers with "vinyl ink" did not exceed acceptable levels during the survey dates. Employee exposures to solvent vapors when printing with "waterbased inks" were well below acceptable exposure levels. Evaluation of solvent vapor air sampling data submitted by GAF Corporation and the Pennsylvania Bureau of Occupational Health indicates that in the past employee exposures to Solvent C vapors exceeded currently recommended levels. Employee exposures to solvent vapors results from the evaporation of the ink solvent in the ink troughs, on the printing heads, on the printed flooring and during clean-up procedures using Solvent C. Clean-up procedures result in the highest momentary exposures to Solvent C vapor. Employee exposures appeared to increase with an increase in the number of printing heads. Three of four personal air samples of the printer operators on Setpember 15, 1977, found detectable levels of benzene.

Local exhaust ventilation at the ink troughs appeared to be partially effective in capturing evaporating vapors from the troughs as determined by smoke tube testing. It appears that dilution ventilation will be effective in controlling vapors released at the printing heads and on the printed sheets.

Efforts to reduce employee exposures at the printing operation should be directed toward increased ventilation exhaust volumes in close proximity to the solvent evaporation points, increased room air changes, use of "water-based inks," and the use of NIOSH tested and certified respirators at high exposure operations such as head cleaning. The source of benzene exposure should be identified and eliminated.

e. Coating Operations - Although the air contaminant(s) responsible for the irritant effects in this area were not identified, it is the judgement of the NIOSH investigator that the irritant source is a potential health hazard and that exposures in the area should be reduced. Measures such as larger flue exhaust volumes on the bake oven, local exhaust ventilation hoods at the oven openings, and maintenance of seals on the oven access doors should be employed to reduce the irritating oven emissions which enter the general workroom air.

2. Medical

a. Data from a limited number of death certificates of former employees did not substantiate initial reports of an unusual number of cancer deaths.

b. No evidence was found of hematologic toxicity in printing department workers.

c. No association was found between pulmonary function abnormalities and exposure to organic chemicals. However, the study method was not capable of detecting toluene diisocyanate-related asthma.

d. No statistically significant association was found between pulmonary function abnormalities and asbestos exposure.

e. No statistically significant increased rate of X-ray abnormalities was found among those workers with highest exposure to asbestos. However, the inadequacy of the X-ray reports precludes a definite conclusion.

f. The data collected for this study were not sufficient to determine the presence or absence of various potential health hazards conceiveably associated with the numerous substances present at the plant. In the absence of evidence of a specific problem not already discussed, such potential problems would be difficult to detect by a routine medical study and, in any case, are best avoided through control of hazardous substances and good industrial hygiene practices.

g. In this study, cigarette smoking was found to have had a greater adverse health effect than the occupational exposures.

V. RECOMMENDATIONS

A. Environmental

The following recommendations, arranged according to the applicable production operation, are made to further ensure that employees are not exposed to unhealthful conditions.

1. Asbestos Handling and Felt Mill - The following measures should be implemented to insure that employees are not over exposed to asbestos:

a. The handling, processing, and storage of the asbestos should continue to be done in a manner which minimizes any release of asbestos into the air. The asbestos should be kept in a closed container until mixed with other felt components. Since airborne asbestos exposures are minimal once it has been wetted, the ultimate solution to controlling airborne asbestos exposures might involve receiving the asbestos in a wet slurry.

b. Any spills of asbestos should be immediately cleaned-up in a manner which minimizes exposure to the employee who is performing the clean-up.

c. Continued employee exposure monitoring should be performed of all employee operations where asbestos exposure could occur. The job categories of hydropulper operator and assistant, material handler helper, and any others as indicated by past high exposure monitoring results should be sampled more frequently than low exposed employees.

d. Employees should continue to use NIOSH Tested and Certified respirators for protection against airborne asbestos fibers. The use of respirators by employees should be in conformance with all parts of the OSHA Standard 29 CFR 1910.1001(d).

e. Employees in the job categories of hydropulper operator and assistant, material handler and other employees exposed above 0.1 fibers/cc should receive medical surveillance as recommended by the NIOSH Asbestos Criteria Document.[6]

2. Resin Storage and Mixing - Employee exposure monitoring should be performed if production conditions substantially change or if a new component material is introduced which could result in the release of an air contaminant.

3. Ink Mixing and Blending

a. Employees should continue to utilize proper respiratory protection when charging the ball mill with solvent or during other high solvent vapor exposure operations. The use of respirators by employees should be in conformance with all parts of the OSHA Standard 29 CFR 1910.134.

b. Continuing efforts should be made to further reduce employee exposures to ink solvent vapors in the ink blending room. Any container with ink solvent in it should be kept covered whenever possible to minimize the emission of vapors. It is also recommended that the ink blending units be provided with local exhaust ventilation by relocating the existing floor level exhaust ducts at the edge position of the blending units. Enclosed are some ventilation design guidelines (Figures 4-15, 4-10, 4-11, 4-9, US-504, VS-503) ACGIH Vent. Manual 13th Edition.

c. Employees exposures to solvent vapors should be monitored with analysis for benzene included. The component(s) contaminated with benzene should be identified and replaced with a benzene-free material.

4. 9' and 12' Printers

a. Employee exposure monitoring for ink solvent vapors (including benzene) should be identified and eliminated by using a benzene-free material.

b. Employees should continue to utilize appropriate respiratory protection during clean-up of the printing heads with Solvent C or during other high solvent vapor exposure operations. The use of respirators by employees should be in conformance with all parts of the OSHA Standard 29 CFR 1910.134.

5. Coating Operations

a. Employee exposures to airborne isocyanates should be evaluated by GAF because of the serious health consequences of allergic sensitization to many isocyanates. Employee exposures to benzene at urethane coating operations should also be monitored periodically.

b. Operation of the bake ovens should be such to minimize oven emissions to the inside work areas. Measures such as larger flue exhaust volumes on the bake oven, local exhaust ventilation hoods at the oven openings, and maintenance of seals on the oven access doors will help to control oven emissions into the work areas.

B. Medical

1. It is recommended that all workers exposed to asbestos continue to have pre-employemnt and periodic chest X-rays and pulmonary function tests[6] and that all workers have pre-employment pulmonary function tests. Routine periodic chest X-rays for workers not exposed to fibrogenic substances are not recommended.

Any worker exhibiting evidence of asbestosis should be removed from further exposure to asbestos.[7]

2. It is recommended that chest X-rays be interpreted according to the UICC/Cincinnati system[3] by a qualified reader.

Pulmonary function test reports should include (a) the percentage of predicted normal for forced vital capacity (FVC) and one-second forced expiratory volume (FEV_1), and (b) the FEV_1/FVC ratio.

X-ray and pulmonary function results should be evaluated with respect to an individual's previous test results. This can be facilitated by the medical consultant noting on the report any significant changes from previous findings. Additionally, a flow-sheet type of record for each employee would permit a more efficient evaluation of that employee's test results.

3. All workers exposed to benzene should be monitored for urinary phenol, as well as for hematologic changes.[8]

4. Employees should have access to the specific results of their tests.

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TABLE I

SUMMARY OF PERSONAL AIR SAMPLING RESULTS FOR ASBESTOS FIBERS*

GAF CORPORATION
WHITEHALL, PENNSYLVANIA

September 14, 1977

Employee Sampled	Work Activities while sampled	Sample Period	Asbestos Concentration f/cc**
Asst. Hydropulper Operator	Operated the fork lift to unload the asbestos	7:26 - 8:28 a.m. 8:45 - 9:56 a.m.	1.15
Hydropulper Operator	At hydropulper controls (upper level)	7:31 - 9:58 a.m.	1.22
Material Handler Helper	Truck unloading and hammer stays for rolls of asbestos	7:19 - 9:45 a.m.	1.17
Hydropulper Helper	Operated forklift	7:33 - 8:24 a.m.	N.D.[a]
Material Handler	Truck loading and hammer stays for rolls of asbestos	8:45 - 9:45 a.m.	N.D.

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* NIOSH Standard for asbestos fibers greater than 5 micrometers in length - 0.1 f/cc.

** f/cc - fibers of asbestos per cubic centimeter of air.

a - N.D., none detected where the analytic, lower limit of detection was 4.400 fibers per sample and sample volumes ranged from 77 to 221 liters.

TABLE II

SUMMARY OF AIR SAMPLING RESULTS FOR

AIRBORNE PARTICULATE* AND HEXAVALENT CHROMIUM**

CHARGE BALL MIX ROOM
GAF CORPORATION
WHITEHALL, PENNSYLVANIA

September 14, 1977

		Concentrations of	
Operator	Sample Period	Total Airborne Particulate mg/M^3 [a]	Hexavalent Chromium
#1	11:00 - 11:33 a.m.	24.6	N.D.[b]
#2	10:53 - 11:34	0.1	N.D.

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* NIOSH Standard - 8-hour time weighted average exposure of 10 mg/M^3.

** NIOSH Standard - 1 ug/M^3.

a Milligrams of airborne contaminant per cubic meter of air.

b N.D. - None detected where the analytic lower limit of detection was 0.2 micrograms per sample and sample volumes were 49.5 and 69.7 liters.

TABLE III

SUMMARY OF AIR SAMPLING RESULTS FOR SOLVENT VAPORS

GAF CORPORATION
WHITEHALL, PENNSYLVANIA

September 14-15, 1977

Person or Location Sampled (Work Location of Operator)	Sample Period	Concentrations						
		2 Butanone (ppm)	2 Hexanone (ppm)	Benzene (ppm)	Toluene (ppm)	m-xylene (ppm)	Light Naptha (mg/M^3)	Combined Exposure**
			9/14/77					
12' Coater with Urethane Resin	8:45 - 13:50	2.1	N.D.*	N.D.	1.8	5.3	N.D.	0.08
Printer Helper at 12' Printer	8:25 - 9:30	1.4	N.D.	N.D.	0.5	0.4	N.D.	0.01
Printer at 12' Printer	7:30 - 9:35	24.4	N.D.	N.D.	9.9	5.4	N.D.	0.27
Printer Helper at 12' Printer	7:33 - 9:30	25.3	16.9	N.D.	12.8	N.D.	N.D.	0.42
Printer Helper at 12' Printer	7:36 - 9:30	11.6	N.D.	N.D.	5.8	4.3	N.D.	0.16
Mixing Leader in Charging Area	7:51 - 13:39	N.D.	N.D.	N.D.	N.D.	1.7	N.D.	0.02
Mixing Helper	7:47 - 13:37	N.D.	N.D.	N.D.	N.D.	1.9	N.D.	0.02
Mixing Helper	7:50 - 13:39	49.2	N.D.	N.D.	N.D.	3.1	N.D.	0.27
Ink Blender	7:42 - 14:06	15.0	4.1	N.D.	3.5	N.D.	N.D.	0.15
Ink Blender Helper	8:40 - 14:07	14.3	3.3	N.D.	2.7	N.D.	N.D.	0.13
Above Trough on 12' Urethane Coater	14:04 - 14:48	N.D.	N.D.	1.4	1.5	5.2	N.D.	-
			9/15/77					
Printer at 12' Printer	8:05 - 12:55	3.5	N.D.	0.8	2.1	1.5	3.9	0.86***
Printer Helper at 12' Printer	8:06 - 11:45	2.7	N.D.	N.D.	4.2	1.5	7.8	0.09
Ink Blender	8:10 - 12:56	17.0	N.D.	0.8	4.2	2.4	N.D.	0.95***
Printer Helper at 9' Printer	8:21 - 11:52	4.7	N.D.	0.9	N.D.	N.D.	N.D.	0.92***
Printer Helper at 9' Printer	8:25 - 11:51	N.D.	N.D.	0.9	0.4	0.2	4.3	0.91***
Ink Blender Helper	9:51 - 10:06	17.0	N.D.	N.D.	9.8	6.2	N.D.	0.24

* N.D. - None detected where the analytical lower limits of detection for all of these substances is 0.01 milligrams per sample and sample volumes ranged from 4.8 to 17.9 liters.

** Calculated combined exposure to mixtures.

*** Combined exposures calculated using the benzene standard of 1 ppm.

TABLE IV

SUMMARY OF AIR SAMPLING RESULTS FOR ALCOHOL VAPORS*
DURING "WATER-BASED INK" PRINTING

GAF CORPORATION
WHITEHALL, PENNSYLVANIA

September 14, 1977

Person Sampled	Sample Period	Concentration of Methanol ppm**	Ethanol ppm	Isopropanol ppm
Printer Helper #1 at 9' Print Operation	8:15 a.m. - 2:13 p.m.	N.D.[a]	1.3	8.0
Printer Helper #2 at 9' Print Operation	8:18 a.m. - 2:15 p.m.	N.D.	0.6	3.0
Printer Helper #1 at 12' Print Operation	9:30 a.m. - 2:04 p.m.	N.D.	0.3	2.1
Printer Helper #2 at 12' Print Operation	9:30 a.m. - 2:04 p.m.	N.D.	N.D.	2.4

* NIOSH Standard - Methanol, 200 ppm; Isopropanol, 400 ppm.
TLV Methanol, 200 ppm; Ethanol, 1000 ppm; Isopropanol, 400 ppm.

** ppm - parts per million

a - N.D., None detected where the analytic lower limit of detection is 0.01 milligram per sample for these substances and sample volumes ranged from 13.9 to 19.6 liters.

TABLE V

Summary of Spot-Measurements for Organic Vapors (Using the Century Organic Vapor Analyzer) at the GAF Corporation in Whitehall, Pennsylvania, on September 14, 1977, at about 1:00 p.m.

Area Sampled	Meter Reading*
Outside Building - Ambient Air	9
At area of 12' embosser	10
In exhaust hood at exit end of 12' oven	40
Adjacent to exhaust hood at exist end of 12' oven	10
On catwalk by softstep oven	11
At exit end of soft-step oven	12
At application blade of soft-step coater	17
At control panel of soft-step coater	10
At 12' coater in isleway during urethane coating	20-40
About 1 inch above urethane in 12' coater	350
Inside hood above 12' coater	100
In ball mill room	19-30
Charging floor at ball mill	7
About 1 inch above freshly mixed plastisol base coat	8
In walkway near 9' coater during base coating	15
12' printer area during printing with water-base ink	19

*The Century Organic Vapor Analyzer is calibrated to read in ppm for methane. These readings reflect relative concentrations of hydrocarbons.

TABLE VI

Characteristics of vinyl floor covering manufacturing workers according to department

Allentown, Pennsylvania, 1977

Department	Total Employees	Survey participants	Employees Studied (see text)					
			Number	% of Participants	% of Total	Mean age (years)	Mean Seniority (years) Department	Plant
Printing	51	46	42	91	82	35	9	9
Coating	39	32	32	100	82	36	7	10
Foam Coating	6	6	6	100	100	39	4	14
Mixing	16	15	15	100	94	37	9	10
Material handling - Felt mill	14	13	13	100	93	43	11	16
Material handling - Yard and scrap	6	3	3	100	50	52	10[A]	18[A]
Maintenance	59	52	52	100	88	43	9[B]	17[B]
Inspection	85	79	78	99	92	39	11[A]	12[A]
Labor pool	39	31	24	77	62	24	3	4
Samples & Advertising	26	25	25	100	96	39	6	10
Warehouse	22	21	20	95	91	44	7[A]	13[A]
Janitors	9	6	5	83	56	42	6[A]	16[A]
Shipping	31	25	25	100	81	42	13[A]	19[A]
Felt mill	34	31	26	84	76	39	5	13
Outside Warehouse	6	5	4	80	67	46	3	25
Total	443	390	370	95	84	39	8	12

A - Seniority unknown in 1 case
B - Seniority unknown in 2 cases

TABLE VII

Categorization (see text) of job departments
at a vinyl floor covering manufacturing plant

Allentown, Pennsylvania, 1977

Job Category	Department's included
1. Printing	Printing
2. Coating/foam	Coating Foam Coating
3. Mixing	Mixing
4. Felt	Felt mill Material handling -felt mill
5. Warehouse/etc.	Warehouse Outside warehouse Samples and advertising Material handling - yard and scrap Shipping
6. Maintenance/janitorial	Maintenance Janitors
7. Inspection	Inspection
8. Labor pool	Labor pool

TABLE VI..

Chest x-ray abnormalities among vinyl floor covering manufacturing workers according to cigarette-smoking behavior and job category

Allentown, Pennsylvannia, 1977

Year	Job category (see Table 2)	Employees with abnormal chest x-ray/employees tested (%)			
		Smokers	Former smokers	Non-smokers	All employees tested
1976	Printing	2/26 (8)	1/4 (25)	0/9 (0)	3/39 (8)
	Coat/foam	2/22 (9)	0/5 (0)	0/9 (0)	3/39 (6)
	Mixing	0/6 (0)	0/3 (0)	1/6 (17)	1/15 (7)
	Felt	3/26 (12)	0/7 (0)	0/2 (0)	3/35 (9)
	Ware/etc.	6/37 (16)	3/16(19)	0/10(0)	9/63 (14)
	Maint/jan	4/26 (15)	2/18(11)	1/9 (11)	7/53 (13)
	Inspection	3/26 (12)	3/21(14)	0/17(0)	6/64 (9)
	Labor pool	1/12 (8)	0/2 (0)	0/7 (0)	1/21 (5)
	Total	21/181(12)	9/76(12)	2/69(3)	32/326(10)
1977	Printing	4/24 (17)	1/4 (25)	1/11(9)	6/39 (15)
	Coat/foam	4/20 (20)	0/5 (0)	0/10(0)	4/35 (11)
	Mixing	0/5 (0)	0/2 (0)	0/5 (0)	0/12 (0)
	Felt	8/24 (33)	0/8 (0)	0/3 (0)	8/35 (23)
	Ware/etc.	7/27 (26)	3/13(23)	0/9 (0)	11/49 (22)
	Maint/jan	6/24 (25)	4/16(25)	1/8 (13)	11/48 (23)
	Inspection	4/23 (17)	6/18(33)	2/15(13)	12/56 (21)
	Labor pool	0/13 (0)	0/3 (0)	1/7 (14)	1/23 (4)
	Total	33/160(21)	14/69(20)	5/68(7)	53/297(18)
1976/77 (see text)	Printing	4/23 (17)	1/4 (25)	1/9 (11)	6/36 (17)
	Coat/foam	5/19 (26)	0/5 (0)	0/9 (0)	5/33 (15)
	Mixing	0/5 (0)	0/2 (0)	1/5 (20)	1/12 (8)
	Felt	8/24 (33)	0/7 (0)	0/2 (0)	8/33 (24)
	Ware/etc.	7/25 (28)	2/10(20)	0/7 (0)	9/42 (21)
	Maint/jan	7/22 (32)	5/16(31)	1/8 (13)	13/46 (28)
	Inspection	3/19 (16)	7/16(44)	1/13(8)	11/48 (23)
	Labor pool	1/12 (8)	0/2 (0)	0/6 (0)	1/20 (5)
	Total	35/149(23)	15/62(24)	4/59(7)	54/270(20)

TABLE IX

Chest x-ray abnormalities among vinyl floor covering manufacturing workers according to age and job category

Allentown, Pennsylvania, 1977

Year	Job category (see Table 2)	Employees with abnormal chest x-ray/employees tested (%)			
		<30	31-45	>45	All employees tested
1976	Printing	1/22 (5)	1/7 (14)	1/10 (10)	3/39 (8)
	Coat/foam	0/16 (0)	0/9 (0)	2/11 (18)	2/36 (6)
	Mixing	0/5 (0)	1/7 (14)	0/3 (0)	1/15 (7)
	Felt	0/10 (0)	1/13 (8)	2/12 (17)	3/35 (9)
	Ware/etc.	0/14 (0)	3/24 (13)	6/25 (24)	9/63 (14)
	Maint/jan	0/6 (0)	1/27 (4)	6/20 (30)	7/53 (13)
	Inspection	0/21 (0)	2/21 (10)	4/22 (18)	6/64 (9)
	Labor pool	0/17 (0)	1/4 (25)	0/0 (--)	1/21 (5)
	Total	1/111(1)	10/112(9)	21/103(21)	32/326(10)
1977	Printing	1/22 (5)	3/7 (43)	2/10 (20)	6/39 (15)
	Coat/foam	0/14 (0)	0/11 (0)	4/10 (40)	4/35 (11)
	Mixing	0/3 (0)	0/7 (0)	0/2 (0)	0/12 (0)
	Felt	1/10 (10)	3/13 (23)	4/12 (33)	8/35 (23)
	Ware/etc.	0/14 (0)	2/19 (11)	9/16 (56)	11/49 (22)
	Maint/jan	0/5 (0)	4/26 (15)	7/17 (41)	11/48 (23)
	Inspection	2/21 (10)	6/16 (38)	4/19 (21)	12/56 (21)
	Labor pool	1/19 (5)	0/4 (0)	0/0 (--)	1/23 (4)
	Total	5/108(5)	18/103(17)	30/86 (35)	53/297(18)
1976/77 (See text)	Printing	1/20 (5)	3/7 (43)	2/9 (22)	6/36 (17)
	Coat/foam	0/14 (0)	0/9 (0)	5/10 (50)	5/33 (15)
	Mixing	0/3 (0)	1/7 (14)	0/2 (0)	1/12 (8)
	Felt	1/10 (10)	3/12 (25)	4/11 (36)	8/33 (24)
	Ware/etc.	0/12 (0)	2/17 (12)	7/13 (54)	9/42 (21)
	Maint/jan	0/5 (0)	5/25 (20)	8/16 (50)	13/46 (28)
	Inspection	0/17 (0)	3/14 (21)	8/17 (47)	11/48 (23)
	Labor pool	0/16 (0)	1/4 (25)	0/0 (--)	1/20 (5)
	Total	2/97 (2)	18/95 (19)	34/78 (44)	54/270(20)

TA[illegible]

Obstructive pulmonary abnormalities among vinyl floor covering manufacturing workers according to age and job category

Allentown, Pennsylvania, 1977

Year	Job category (see Table 2)	Employees with obstructive abnormality/employees tested (%)			
		<30	31-45	>45	All employees tested
1976	Printing	1/22 (5)	2/7 (28)	3/10 (30)	6/39 (15)
	Coat/foam	2/16 (13)	0/9 (0)	2/11 (18)	4/36 (11)
	Mixing	2/9 (40)	1/7 (14)	0/3 (0)	3/15 (20)
	Felt	0/10 (0)	1/13 (8)	5/12 (42)	6/35 (17)
	Ware/etc.	1/13 (8)	4/25 (16)	7/25 (28)	12/63 (19)
	Maint/jan	0/6 (0)	3/27 (11)	3/20 (15)	6/53 (11)
	Inspection	3/22 (14)	3/22 (14)	5/21 (24)	11/65 (17)
	Labor pool	4/17 (24)	1/4 (25)	0/0 (--)	5/21 (24)
	Total	13/111 (12)	15/114(13)	25/102(25)	53/327 (16)
1977	Printing	1/22 (5)	1/7 (14)	2/10 (20)	4/39 (10)
	Coat/foam	0/14 (0)	1/11 (9)	3/10 (30)	4/35 (11)
	Mixing	0/3 (0)	1/7 (14)	0/2 (0)	1/12 (8)
	Felt	1/11 (9)	2/12 (17)	5/12 (42)	8/35 (23)
	Ware/etc.	1/13 (8)	2/20 (10)	1/16 (6)	4/49 (8)
	Maint/jan	1/5 (20)	2/26 (8)	4/17 (24)	7/48 (15)
	Inspection	3/21 (14)	2/16 (13)	5/19 (26)	10/56 (18)
	Labor pool	1/19 (5)	0/4 (0)	0/0 (--)	1/23 (4)
	Total	8/108 (7)	11/103(11)	20/86 (23)	39/297 (13)
1976/77 (see text)	Printing	1/20 (5)	2/7 (28)	3/9 (33)	6/36 (17)
	Coat/foam	1/14 (7)	1/9 (11)	4/10 (40)	6/33 (18)
	Mixing	1/3 (33)	1/7 (14)	0/2 (0)	2/12 (17)
	Felt	0/10 (0)	2/12 (17)	7/11 (64)	9/33 (27)
	Ware/etc.	0/11 (0)	2/18 (11)	2/13 (16)	4/42 (10)
	Maint/jan	1/5 (20)	3/25 (12)	4/16 (25)	8/46 (17)
	Inspection	3/18 (17)	3/15 (13)	4/16 (25)	9/49 (18)
	Labor pool	3/16 (19)	1/4 (25)	0/0 (--)	4/20 (20)
	Total	10/97 (10)	14/97 (14)	24/77 (31)	48/271 (18)

TABLE XI

Obstructive pulmonary abnormalities among cigarette-smoking vinyl floor covering manufacturing workers according to age and job category

Allentown, Pennsylvania, 1977

Year	Job category (see Table 2)	Employees with obstructive abnormality/employees tested (%) <30	31-45	>45	All smokers tested
1976	Printing	1/15 (7)	2/6 (33)	1/5 (20)	4/26 (15)
	Coat/foam	2/9 (22)	0/5 (0)	2/8 (9)	4/22 (18)
	Mixing	0/1 (0)	1/4 (25)	0/1 (0)	1/6 (17)
	Felt	0/7 (0)	1/11 (9)	2/8 (25)	3/26 (12)
	Ware/etc.	1/9 (11)	4/15 (27)	5/13 (38)	10/37 (27)
	Maint/jan	0/2 (0)	3/16 (19)	2/8 (25)	5/26 (19)
	Inspection	0/7 (0)	1/9 (11)	3/10 (30)	4/26 (15)
	Labor pool	1/10 (10)	1/2 (50)	0/0 (--)	2/12 (17)
	Total	5/60 (8)	13/68 (19)	15/53 (28)	33/181(18)
1977	Printing	1/13 (8)	1/6 (17)	0/5 (0)	2/24 (8)
	Coat/foam	0/7 (7)	0/6 (0)	3/7 (43)	3/20 (15)
	Mixing	0/1 (0)	1/4 (25)	0/0 (--)	1/5 (20)
	Felt	0/7 (0)	2/10 (20)	4/7 (57)	6/24 (25)
	Ware/etc.	0/7 (0)	2/10 (20)	1/10 (10)	3/27 (11)
	Maint/jan	1/2 (50)	2/16 (13)	4/6 (67)	7/24 (29)
	Inspection	0/6 (0)	2/9 (22)	2/7 (29)	4/22 (18)
	Labor pool	0/11 (0)	0/2 (0)	0/0 (--)	0/13 (0)
	Total	2/54 (4)	10/63 (16)	14/42 (33)	26/159(16)
1976/77 (see text)	Printing	1/13 (8)	2/6 (33)	1/4 (25)	4/23 (17)
	Coat/foam	1/7 (14)	0/5 (0)	4/7 (57)	5/19 (26)
	Mixing	0/1 (0)	1/4 (25)	0/0 (--)	1/5 (20)
	Felt	0/7 (0)	2/10 (20)	4/7 (57)	6/24 (25)
	Ware/etc.	0/7 (0)	2/10 (20)	2/8 (25)	4/25 (16)
	Maint/jan	1/2 (50)	3/15 (20)	4/5 (80)	8/22 (36)
	Inspection	0/5 (0)	1/8 (13)	2/6 (33)	3/19 (16)
	Labor pool	1/10 (10)	1/2 (50)	0/0 (--)	2/12 (17)
	Total	4/52 (8)	12/60 (20)	17/37 (46)	33/149(22)

TAL 1

Obstructive pulmonary abnormalities among formerly cigarette-smoking vinyl floor covering manufacturing workers according to age and job category

Allentown, Pennsylvannia, 1977

Year	Job category (see Table 2)	Employees with obstructive abnormality/employees tested (%) <30	31-45	>45	All former smokers tested
1976	Printing	0/2 (0)	0/1 (0)	1/1 (100)	1/4 (25)
	Coat/foam	0/2 (0)	0/1 (0)	0/2 (0)	0/5 (0)
	Mixing	1/1 (100)	0/0 (--)	0/2 (0)	1/3 (33)
	Felt	0/3 (0)	0/1 (0)	2/3 (67)	2/7 (10)
	Ware/etc.	0/3 (0)	0/3 (0)	2/10 (20)	2/16 (13)
	Maint/jan	0/1 (0)	0/10 (0)	1/7 (14)	1/18 (6)
	Inspection	0/3 (0)	2/9 (22)	0/9 (0)	2/21 (10)
	Labor pool	0/0 (--)	0/2 (0)	0/0 (---)	0/2 (0)
	Total	1/15 (7)	2/27 (7)	6/34 (18)	9/76 (12)
1977	Printing	0/2 (0)	0/1 (0)	1/1 (100)	1/4 (25)
	Coat/foam	0/2 (0)	1/1 (100)	0/2 (0)	1/5 (20)
	Mixing	0/0 (--)	0/0 (--)	0/2 (0)	0/2 (0)
	Felt	1/4 (25)	0/1 (0)	0/3 (0)	1/8 (13)
	Ware/etc.	0/3 (0)	0/4 (0)	0/6 (0)	0/13 (0)
	Maint/jan	0/1 (0)	0/9 (0)	0/6 (0)	0/16 (0)
	Inspection	0/2 (0)	0/5 (0)	2/11 (18)	2/18 (9)
	Labor pool	0/1 (0)	0/2 (0)	0/0 (---)	0/2 (0)
	Total	1/15 (7)	1/23 (4)	3/31 (10)	5/69 (7)
1976/77 (see text)	Printing	0/2 (0)	0/1 (0)	1/1 (100)	1/4 (25)
	Coat/foam	0/2 (0)	1/1 (100)	0/2 (0)	1/5 (20)
	Mixing	0/0 (--)	0/0 (--)	0/2 (0)	0/2 (0)
	Felt	0/3 (0)	0/1 (0)	2/3 (67)	2/7 (28)
	Ware/etc.	0/3 (0)	0/2 (0)	0/5 (0)	0/10 (0)
	Maint/jan	0/1 (0)	0/9 (0)	0/6 (0)	0/16 (0)
	Inspection	0/2 (0)	1/5 (20)	1/9 (11)	2/16 (13)
	Labor pool	0/0 (--)	0/2 (0)	0/0 (---)	0/2 (0)
	Total	0/13 (0)	2/21 (10)	4/28 (14)	6/62 (10)

TAb. .III

Obstructive pulmonary abnormalities among non-cigarette-smoking vinyl floor covering manufacturing workers according to age and job category

Allentown, Pennsylvania, 1977

Year	Job category (see Table 2)	Employees with obstructive abnormality/employees tested (%)			
		<30	31-45	>45	All non-smokers tested
1976	Printing	0/5 (0)	0/0 (--)	1/4 (25)	1/9 (11)
	Coat/foam	0/4 (0)	0/3 (0)	0/2 (0)	0/9 (0)
	Mixing	1/3 (33)	0/3 (0)	0/0 (---)	1/6 (17)
	Felt	0/0 (--)	0/1 (0)	1/1 (100)	1/2 (50)
	Ware/etc.	0/3 (0)	0/5 (0)	0/2 (0)	0/10 (0)
	Maint/jan	0/3 (0)	0/1 (0)	0/5 (0)	0/9 (0)
	Inspection	3/12 (25)	0/4 (0)	2/2 (100)	5/18 (28)
	Labor pool	3/7 (43)	0/0 (--)	0/0 (---)	3/7 (43)
	Total	7/37 (19)	0/17 (0)	4/16 (25)	11/70 (16)
1977	Printing	0/7 (0)	0/0 (--)	1/4 (25)	1/11 (9)
	Coat/foam	0/4 (0)	0/4 (0)	0/2 (0)	0/10 (0)
	Mixing	0/2 (0)	0/3 (0)	0/0 (---)	0/5 (0)
	Felt	0/0 (--)	0/1 (0)	1/2 (50)	1/3 (33)
	Ware/etc.	1/5 (20)	0/3 (0)	0/1 (0)	1/9 (11)
	Maint/jan	0/2 (0)	0/1 (0)	0/5 (0)	0/8 (0)
	Inspection	3/13 (23)	0/2 (0)	1/1 (100)	4/16 (25)
	Labor pool	1/7 (14)	0/0 (--)	0/0 (---)	1/7 (14)
	Total	5/40 (13)	0/14 (0)	3/15 (20)	8/69 (12)
1976/77 (see text)	Printing	0/5 (0)	0/0 (--)	1/4 (25)	1/9 (11)
	Coat/foam	0/4 (0)	0/3 (0)	0/2 (0)	0/9 (0)
	Mixing	1/2 (50)	0/3 (0)	0/0 (---)	1/5 (20)
	Felt	0/0 (--)	0/1 (0)	1/1 (100)	1/2 (50)
	Ware/etc.	0/3 (0)	0/3 (0)	0/1 (0)	0/7 (0)
	Maint/jan	0/2 (0)	0/1 (0)	0/5 (0)	0/8 (0)
	Inspection	3/11 (27)	0/2 (0)	1/1 (100)	4/14 (29)
	Labor pool	2/6 (33)	0/0 (--)	0/0 (---)	2/6 (33)
	Total	6/33 (18)	0/13 (0)	3/14 (21)	9/60 (15)

TABLE IV

Restrictive pulmonary abnormalities among vinyl floor covering manufacturing workers according to cigarette-smoking behavior and job category

Allentown, Pennsylvania, 1977

Year	Job category (see Table 2)	Employees with restrictive abnormality/employees tested (%)			
		Smokers	Former smokers	Non-smokers	All employees tested
1976	Printing	1/26 (4)	1/4 (25)	1/9 (11)	3/39 (8)
	Coat/foam	1/22 (5)	0/5 (0)	0/9 (0)	1/36 (3)
	Mixing	1/6 (17)	0/3 (0)	1/6 (17)	2/15 (13)
	Felt	2/26 (8)	0/7 (0)	0/2 (0)	2/35 (6)
	Ware/etc.	6/37 (16)	0/16 (0)	0/10 (0)	6/63 (10)
	Maint/jan	3/26 (12)	1/18 (6)	0/9 (0)	4/53 (8)
	Inspection	3/26 (12)	1/21 (5)	4/18 (22)	8/65 (12)
	Labor pool	0/12 (0)	0/2 (0)	1/7 (14)	1/21 (5)
	Total	17/181 (9)	3/76 (4)	7/70 (10)	27/327 (8)
1977	Printing	1/24 (4)	1/4 (25)	1/11 (9)	3/39 (8)
	Coat/foam	2/20 (10)	0/5 (0)	0/10 (0)	2/35 (6)
	Mixing	1/5 (20)	0/2 (0)	1/5 (20)	2/12 (17)
	Felt	1/24 (4)	0/8 (0)	1/3 (33)	2/35 (6)
	Ware/etc.	1/27 (4)	1/13 (8)	1/9 (11)	3/49 (6)
	Maint/jan	3/24 (13)	0/16 (0)	1/8 (13)	4/48 (8)
	Inspection	1/22 (5)	2/18 (11)	2/16 (13)	5/56 (9)
	Labor pool	0/13 (0)	0/3 (0)	0/7 (0)	0/23 (0)
	Total	10/159 (6)	4/69 (6)	7/69 (10)	21/297 (7)
1976/77 (see text)	Printing	2/23 (9)	1/4 (25)	1/9 (11)	4/36 (11)
	Coat/foam	1/19 (5)	0/5 (0)	0/9 (0)	1/33 (3)
	Mixing	1/5 (20)	0/2 (0)	1/5 (20)	2/12 (17)
	Felt	2/24 (8)	0/7 (0)	1/2 (50)	3/33 (9)
	Ware/etc.	1/25 (4)	0/10 (0)	0/7 (0)	1/42 (2)
	Maint/jan	4/22 (18)	0/16 (0)	1/8 (13)	5/46 (11)
	Inspection	1/19 (5)	2/16 (13)	2/14 (14)	5/49 (10)
	Labor pool	0/12 (0)	0/2 (0)	0/6 (0)	0/20 (0)
	Total	12/149 (8)	3/62 (5)	6/60 (10)	21/271 (8)

TA. V

Restrictive pulmonary abnormalities among cigarette-smoking vinyl floor covering manufacturing workers according to age and job category

Allentown, Pennsylvania, 1977

Year	Job category (see Table 2)	Employees with restrictive abnormality/employees tested (%) <30	31-45	>45	All smokers tested
1976	Printing	1/15 (7)	0/6 (0)	0/5 (0)	1/26 (4)
	Coat/foam	0/9 (0)	0/5 (0)	1/8 (13)	1/22 (5)
	Mixing	0/1 (0)	1/4 (25)	0/1 (0)	1/6 (17)
	Felt	1/7 (14)	1/11 (9)	0/8 (0)	2/26 (8)
	Ware/etc.	1/9 (11)	2/15 (13)	3/13 (23)	6/37 (16)
	Maint/jan	0/2 (0)	1/16 (6)	2/8 (13)	3/26 (12)
	Inspection	0/7 (0)	1/9 (11)	2/10 (20)	3/26 (12)
	Labor pool	0/10 (0)	0/2 (0)	0/0 (0)	0/12 (0)
	Total	3/60 (5)	6/68 (9)	8/53 (15)	17/181(9)
1977	Printing	1/13 (8)	0/6 (0)	0/5 (0)	1/24 (4)
	Coat/foam	1/7 (14)	0/6 (0)	1/7 (14)	2/20 (10)
	Mixing	0/1 (0)	1/4 (25)	0/0 (0)	1/5 (20)
	Felt	0/7 (0)	0/10 (0)	1/7 (14)	1/24 (4)
	Ware/etc.	0/7 (0)	0/10 (0)	1/10 (10)	1/27 (4)
	Maint/jan	0/2 (0)	1/16 (6)	2/6 (33)	3/24 (13)
	Inspection	0/6 (0)	1/9 (11)	0/7 (0)	1/22 (5)
	Labor pool	0/11 (0)	0/2 (0)	0/0 (0)	0/13 (0)
	Total	2/54 (4)	3/63 (5)	5/42 (12)	10/159(6)
1976/77 (see text)	Printing	1/13 (8)	0/6 (0)	1/4 (25)	2/23 (9)
	Coat/foam	1/7 (14)	0/5 (0)	0/7 (0)	1/19 (5)
	Mixing	0/1 (0)	1/4 (25)	0/0 (0)	1/5 (20)
	Felt	1/7 (14)	0/10 (0)	1/7 (14)	2/24 (8)
	Ware/etc.	0/7 (0)	0/10 (0)	1/8 (13)	1/25 (4)
	Maint/jan	0/2 (0)	2/15 (13)	2/5 (40)	4/22 (18)
	Inspection	0/5 (0)	1/8 (13)	0/6 (0)	1/19 (5)
	Labor pool	0/10 (0)	0/2 (0)	0/0 (0)	0/12 (0)
	Total	3/52 (6)	4/60 (7)	5/37 (14)	12/149(8)

TABLE XV1

Restrictive pulmonary abnormalities among formerly cigarette-smoking vinyl floor covering manufacturing workers according to age and job category

Allentown, Pennsylvania, 1977

Year	Job category (see Table 2)	Employees with restrictive abnormality/employees tested (%)			
		<30	31-45	>45	All former smokers tested
1976	Printing	0/2 (0)	0/1 (0)	1/1 (100)	1/4 (25)
	Coat/foam	0/2 (0)	0/1 (0)	0/2 (0)	0/5 (0)
	Mixing	0/1 (0)	0/0 (--)	0/2 (0)	0/3 (0)
	Felt	0/3 (0)	0/1 (0)	0/3 (0)	0/7 (0)
	Ware/etc.	0/3 (0)	0/3 (0)	0/10 (0)	0/16 (0)
	Maint/jan	0/1 (0)	0/10 (0)	1/7 (14)	1/18 (6)
	Inspection	0/3 (0)	0/9 (0)	1/9 (11)	1/21 (5)
	Labor pool	0/0 (--)	0/2 (0)	0/0 (---)	0/2 (0)
	Total	0/15 (0)	0/27 (0)	3/34 (9)	3/76 (4)
1977	Printing	0/2 (0)	0/1 (0)	1/1 (100)	1/4 (25)
	Coat/foam	0/2 (0)	0/1 (0)	0/2 (0)	0/5 (0)
	Mixing	0/0 (--)	0/0 (--)	0/2 (0)	0/2 (0)
	Felt	0/4 (0)	0/1 (0)	0/3 (0)	0/8 (0)
	Ware/etc.	0/3 (0)	0/4 (0)	1/6 (17)	1/13 (8)
	Maint/jan	0/1 (0)	0/9 (0)	0/6 (0)	0/16 (0)
	Inspection	0/2 (0)	0/5 (0)	2/11 (18)	2/18 (11)
	Labor pool	0/1 (0)	0/2 (0)	0/0 (---)	0/3 (0)
	Total	0/15 (0)	0/23 (0)	4/31 (13)	4/69 (6)
1976/77 (see text)	Printing	0/2 (0)	0/1 (0)	1/1 (100)	1/4 (25)
	Coat/foam	0/2 (0)	0/1 (0)	0/2 (0)	0/5 (0)
	Mixing	0/0 (--)	0/0 (--)	0/2 (0)	0/2 (0)
	Felt	0/3 (0)	0/1 (0)	0/3 (0)	0/7 (0)
	Ware/etc.	0/3 (0)	0/2 (0)	0/5 (0)	0/10 (0)
	Maint/jan	0/1 (0)	0/9 (0)	0/6 (0)	0/16 (0)
	Inspection	0/2 (0)	0/5 (0)	2/9 (22)	2/16 (13)
	Labor pool	0/0 (--)	0/2 (0)	0/0 (---)	0/2 (0)
	Total	0/13 (0)	0/21 (0)	3/28 (11)	3/62 (5)

TABLE XVII

Restrictive pulmonary abnormalities among non-cigarette-smoking vinyl floor covering manufacturing workers according to age and job category

Allentown, Pennsylvania, 1977

Year	Job category (see Table 2)	Employees with restrictive abnormality/employees tested (%) <30	31-45	>45	All non-smokers tested
1976	Printing	0/5 (0)	0/0 (-)	1/4 (25)	1/9 (11)
	Coat/foam	0/4 (0)	0/3 (0)	0/2 (0)	0/9 (0)
	Mixing	1/3 (33)	0/3 (0)	0/0 (-)	1/6 (17)
	Felt	0/0 (-)	0/1 (0)	0/1 (0)	0/2 (0)
	Ware/etc.	0/3 (0)	0/5 (0)	0/2 (0)	0/10 (0)
	Maint/jan	0/3 (0)	0/1 (0)	0/5 (0)	0/9 (0)
	Inspection	2/12 (17)	0/4 (0)	2/2 (100)	4/18 (22)
	Labor pool	1/7 (14)	0/0 (-)	0/0 (-)	1/7 (14)
	Total	4/37 (11)	0/17 (0)	3/16 (19)	7/70 (10)
1977	Printing	0/7 (0)	0/0 (-)	1/4 (25)	1/11 (9)
	Coat/foam	0/4 (0)	0/4 (0)	0/2 (0)	0/10 (0)
	Mixing	1/2 (50)	0/3 (0)	0/0 (-)	1/5 (20)
	Felt	0/0 (-)	0/1 (0)	1/2 (50)	1/3 (33)
	Ware/etc.	1/5 (20)	0/3 (0)	0/1 (0)	1/9 (11)
	Maint/jan	0/2 (0)	0/1 (0)	1/5 (20)	1/8 (13)
	Inspection	1/13 (8)	0/2 (0)	1/1 (100)	2/16 (13)
	Labor pool	0/7 (0)	0/0 (-)	0/0 (-)	0/7 (0)
	Total	3/40 (8)	0/14 (0)	4/15 (27)	7/69 (10)
1976/77 (see text)	Printing	0/5 (0)	0/0 (-)	1/4 (25)	1/9 (11)
	Coat/foam	0/4 (0)	0/3 (0)	0/2 (0)	0/9 (0)
	Mixing	1/2 (50)	0/3 (0)	0/0 (-)	1/5 (20)
	Felt	0/0 (-)	0/1 (0)	1/1 (100)	1/2 (50)
	Ware/etc.	0/3 (0)	0/3 (0)	0/1 (0)	0/7 (0)
	Maint/jan	0/2 (0)	0/1 (0)	1/5 (20)	1/8 (13)
	Inspection	1/11 (9)	0/2 (0)	1/1 (100)	2/14 (14)
	Labor pool	0/6 (0)	0/0 (-)	0/0 (-)	0/6 (0)
	Total	2/33 (6)	0/13 (0)	4/14 (29)	6/60 (10)