U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
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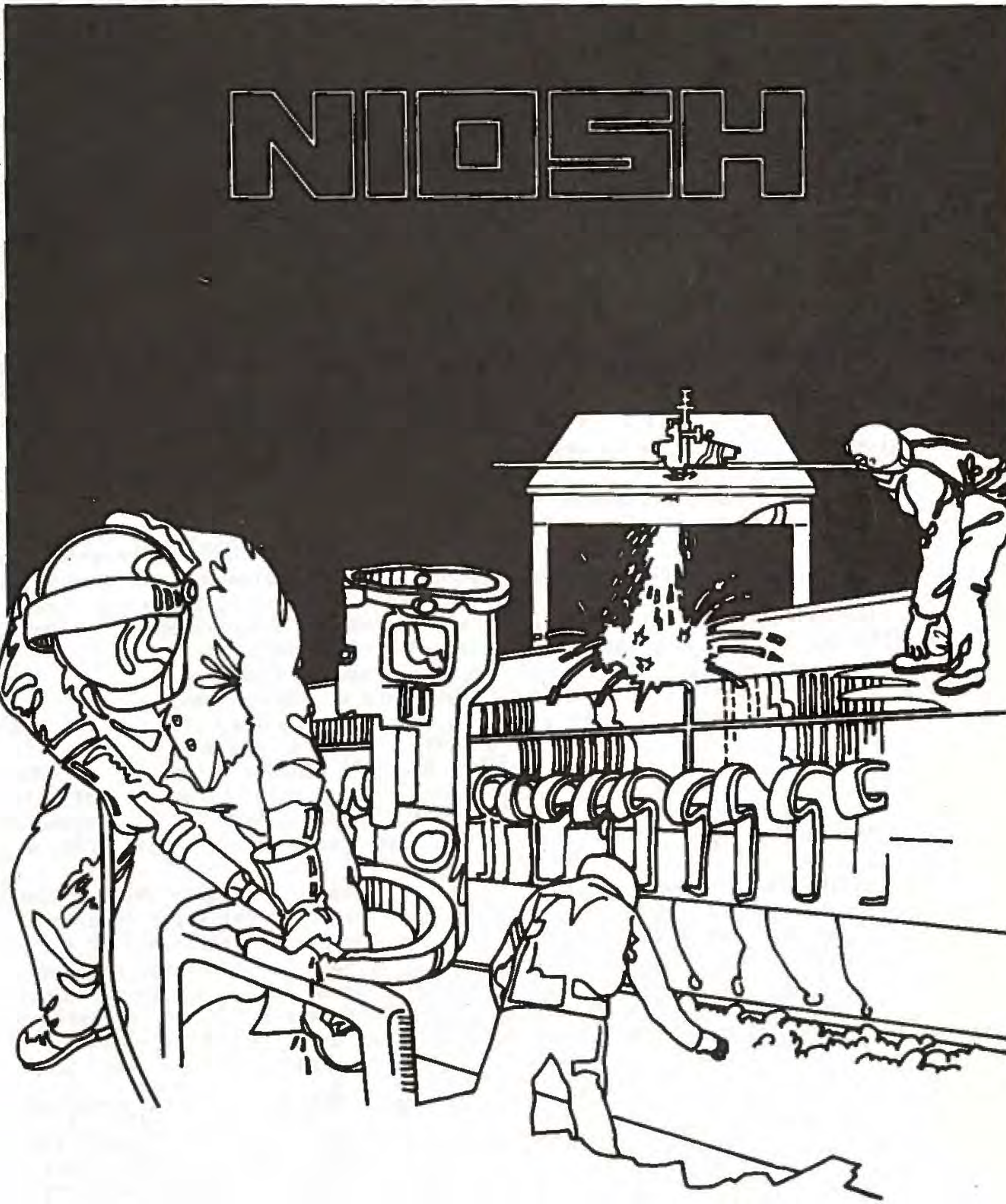

Health Hazard Evaluation Report

HETA 79-034-1440
INTEX PLASTICS
CORINTH, MISSISSIPPI

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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INTEX PLASTICS
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I. SUMMARY

In December 1978, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate complaints of health problems reported by production and maintenance workers of the Hatco Plastics Company (later to become Intex Plastics), Corinth, Mississippi. Workers had complained of respiratory problems from exposures to dusts and fumes in the Calender Department where vinyl chloride resins and other additives are mixed under heat and pressure and fabricated into sheets. Other exposures of concern were in the Color Department (lead chromate pigments, solvents), the Laminating and Print Departments (solvents), and the Maintenance Department (various exposures). NIOSH conducted an initial survey in March 1979 followed by environmental/medical investigations during the summer of 1979 and 1980. The Johns Hopkins Center of Occupational and Environmental Health (COEH) was contracted to perform pulmonary function testing and questionnaire studies of the workers.

Air sampling was performed in several departments to determine exposures to printing ink solvent vapors (methyl ethyl ketone [MEK], toluene, cyclohexanone, xylene, methyl isobutyl ketone [MIBK]), mineral spirits, methyl methacrylate, vinyl plastic dusts and fumes, lead, barium, cadmium, and other vinyl plastic additives (1,2-diethylhexyl phthalate [DEHP], 1,4-dioctyltera phthalate [DOTP], isodecyldiphenyl phosphate, antimony oxide), and residual vinyl chloride monomer. Except for MEK vapors, the majority of the airborne concentrations measured for these substances were quite low or not detected. All other solvent exposures were below the NIOSH health hazard evaluation criteria exposure limits. The departments with the highest levels of exposure to airborne contaminants were Print Service (36-229 ppm MEK), Laminating (74-105 ppm MEK), Printing (15-113 ppm MEK), Color (15-24 ppm MEK), (exposure criteria = 200 ppm MEK); Pre-mix (0.3-6.8 mg/M^3 total dust), Calender (0.1-0.6 mg/M^3 total dust), (exposure criteria = 10 mg/M^3 total dust). Phthalate exposures (DOTP) in the Calender Dept. ranged from 0.04-0.16 mg/M^3 (exposure criteria = 5 mg/M^3). No DEHP exposures were detected.

Questionnaire results indicated certain departments were associated with significant increases of particular respiratory symptoms (shortness of breath in Laminating, Printing, and Print Service; hoarseness in Shipping, Inspection and Materials Receiving). The prevalence of wheeze, chest tightness and occasional mucosal irritation seemed to be high in all departments, including the control department. Although workers reported a high frequency of respiratory symptoms, impaired pulmonary function could not be convincingly demonstrated.

Of all personal air samples collected, only the Old Ink Serviceman and the Barrel Washer were exposed to toxic substances (in this case solvent vapors) in excess of the evaluation criteria. Plastic fumes and vapors generated in the Calender Department were being adequately controlled by existing local exhaust systems. Dust levels were at the highest concentrations in the pre-mix penthouse. Although workers reported a high frequency of respiratory symptoms, there is no clinical evidence of any significant reduction in ventilatory function as indicated by the results of pulmonary function tests. Many of the recommendations made by NIOSH for reduction of solvent vapor exposures have now been implemented by the company.

KEYWORDS: SIC 3079 (Miscellaneous Plastic Products), MEK, phthalates, lead, isodecyldiphenyl-phosphate, DEHP, DOP, DOTP, solvents, respiratory, PVC, PFT

II. INTRODUCTION

On December 14, 1978 NIOSH received a request from the President of the United Rubber Workers, Local 759, for a NIOSH health hazard evaluation at the Hatco Plastics Division, (currently known as the Intex Plastics Company), in Corinth Mississippi. The requester reported that "numerous production and maintenance employees had been disabled from chemical poisoning and related illnesses" and that workers at the plant had a history of lung and liver problems which they suspected were work related. Efforts by NIOSH to obtain supporting documentation for these allegations were not sucessful. The requester was more concerned about the dusts and fumes in the Calender and Color Departments. Two employees who worked in the Color Dept. had been diagnosed by a local physician to have chemical bronchitis. Their symptoms included chest pains, shortness of breath, vomiting or coughing of blood, and proteinuria (the presence of excess serum proteins in the urine). The two workers were subsequently assigned to work in other departments. A complaint had been submitted to The Occupational Safety and Health Administration (OSHA) who then inspected the facility on October 4, 1978. OSHA had collected air samples for vinyl chloride, methyl ethyl ketone (MEK), xylene, toluene, lead, and chromium. No exposures above the OSHA permissible exposure limits (PELs) were detected, but airborne lead levels in the Color Dept. approached the 0.2 mg/M^3 limit during the mixing of lead chromate pigments. The company had planned to install a new ventilation system for this operation shortly after the OSHA inspection.

NIOSH conducted the initial environmental survey at the plant on February 20-23, 1979. The NIOSH investigator was accompanied by a representative from the Mississippi State Board of Health, Division of Occupational Safety and Health. An opening conference was held with company and union representatives to discuss the request and future plans for a NIOSH investigation. Following the opening conference, a walk-through tour of the production facility was conducted. Management representatives explained the various plant production processes. Information was provided concerning work practices, operating procedures, materials used, production schedules, and environmental control systems. NIOSH conducted confidential interviews with 12 current and former employees. The 12 people interviewed complained mostly of breathing difficulties and allergies. Several felt their symptoms were work related.

As requested by NIOSH, a physician with the Chronic Diseases Division, Bureau of Epidemiology, Center for Disease Control, Atlanta, conducted a preliminary medical survey at the plant on March 3, 1979. A questionnaire was administered to 50 employees who worked in exposed and unexposed areas of the plant. The workers were selected from seniority rosters in order to conduct interviews with those who had worked the longest in each department. The survey found significantly higher prevalences of eye, nose, and throat irritation, shortness of breath, cough, and skin rash among workers assigned to the Calender, Color, and

Laminating Departments than in workers from the non-exposed areas such as inspection, packing, shipping and receiving. Results of the initial environmental and medical survey were reported to company and union representatives on July 11, 1979.

A comprehensive environmental survey of worker exposures in the Pre-mix, Calender, Printing, and Laminating Departments was conducted by NIOSH industrial hygienists on June 11-13, 1980. The NIOSH investigators were accompanied by NIOSH Medical Service Contract investigators from the Johns Hopkins Center for Occupational and Environmental Health (COEH). COEH had been asked by NIOSH to conduct a preliminary medical walk-through evaluation to determine if a comprehensive medical investigation would be required. This follow-up survey was delayed while the NIOSH laboratory developed sampling and analytical methods for a chemical fire retardant (isodecyldiphenyl phosphate) used in the Pre-mix Department. Additional time was also required by the Medical Service Contractor to prepare the medical study protocol. After review of the COEH preliminary medical investigation report, NIOSH contracted with COEH to perform pulmonary function testing and questionnaire studies of the workforce. This investigation was conducted on September 22-26, 1980.

Because certain production processes involving the use of lead chromate pigments and fire retardants were not operated during the NIOSH survey conducted in June, additional follow-up surveys were required and conducted by NIOSH industrial hygienists on September 23-25, 1980, and April 28, 1981. The results of the environmental sampling conducted by NIOSH were forwarded in a report to company and union representatives on October 29, 1981.

III. BACKGROUND

Intex Plastics Company at Corinth, Mississippi is a polyvinyl chloride (PVC) fabrication plant engaged in the manufacture of decorative vinyl wall covering and vinyl sheeting used primarily as vinyl covered upholstery fabric. At the time of the initial NIOSH survey, the plant was operating three 8 hour shifts per day, five days per week, and employed approximately 375 production and maintenance personnel. The plant has 16 acres under roof, two-thirds of which is used for warehousing of in-process and finished goods. Prior to and during the initial NIOSH environmental and medical surveys conducted in February and March 1979, the plant production processes were organized in 6 primary departments: (1) Calender, (2) Color, (3) Print, (4) Laminating, (5) the oven line, and (6) Finishing. In July 1979, Hatco Plastics was purchased from W. R. Grace by the Intex Plastics Company. In the spring of 1980 the new owner stopped producing expanded vinyls and closed the oven line and Finishing Department. At this time Intex began producing non-woven fiber backing materials which had previously been purchased from an outside supplier.

A. Calender Department (pre-mix and calendering)

PVC resin powders, liquid plasticizer oils, e.g., diethylhexyl phthalate (DEHP), 1,4-dioctyltera phthalate (DOTP), and special additives, (e.g., liquid stabilizers, fire retardants, antimildew agents, etc.) are pre-mixed in large blenders until dried to a homogeneous, almost granular powder which looks much like table salt or sugar. This material is transported through a pneumatic system to one of two Banbury mixers located on the #1 and #2 calender line or to a Farrell continuous mixer on the #3 calender line. The material is then mixed with color pigments under heat and pressure into a warm pigmented vinyl dough. The dough is discharged from the Banbury or continuous mixer onto a conveyer belt which feeds the dough into a mill for more blending and mixing at approximately 325-370° F. A 2-3" strip of vinyl is then peeled off the mill roll and sent through an extruder/strainer machine to remove impurities. The extruded vinyl rope is then fed by conveyer to the top of a calender, consisting of two sets of large rollers, which apply more heat and pressure to form a thin (2-26 gage), 5 feet wide vinyl sheet. The sheet is threaded over and under a series of water-filled cooling drums and wound into rolls 500-700 yards in length.

Workers normally assigned each shift to the calender department include one pre-mix operator, two Banbury operators, three calender operators, three calender utility helpers, three mill men, three calender wind-up operators, two general helpers, and a chopper operator. The chief complaint from the calender department workers was the dust and smoke. During the initial survey, some dust fallout from overhead pneumatic systems was noted, especially on one occasion when make-up air systems had been turned off. At other times, airborne dust levels did not appear to be a problem. Workers mixing or adding materials to the pre-mix blenders had the dustiest jobs, but the exposures were infrequent and of short duration. All blender hatches used for adding bagged materials were local exhaust ventilated. Most of the smoke and mist from the hot vinyl on the calender lines is captured by local exhaust systems on the Banbury, milling, and calender machines. During the NIOSH surveys, a slight haze or blue-grey smoke was noted, but odors were not overpowering or objectionable.

B. Color Department

This department is a mixing area for solvent ink pigments, dull gloss concentrates, color paste dispersions, solvent-based top coatings and printing ink vehicles, and neutral and pigmented vinyl skin and foam plastisols used for the production of expanded vinyl upholstery materials. Normally four workers, known as color compounders, are assigned to this department each shift.

Three large ball mills are used for mixing chrome yellow, molybdate orange, and titanium dioxide ink pigment concentrates. Solvents used to disperse the pigments, e.g., methyl ethyl ketone

(MEK), methyl isobutyl ketone (MIBK), and xylene are mixed in the ball mills with vinyl chloride/vinyl acetate copolymer resins for 36-48 hours. After mixing, the color compounder drains the liquid ink concentrate into 55-gallon drums. The drums are then sent to the print service area for use in mixing vinyl printing inks. At the time of the initial NIOSH survey, yellow and orange pigment concentrates, containing lead chromate, were being mixed once each week on a variable schedule.

A fourth smaller ball mill is used for mixing dull gloss concentrates for clear top coatings. The dull gloss concentrate is a mixture of silica, vinyl resin, and MEK. The workers are required to wear disposable protective coveralls, dust caps, gloves, and respirators when compounding this material.

Solvent-based clear ink vehicle and top coat vehicle are also mixed in the color department. The top coat is a mixture of various resins and MEK. The clear ink vehicle is composed of vinyl resins, MEK, and toluene. The materials are dumped into a large rotary mixer, blended, and drained from the bottom of the mixer. Use of personal protective equipment, such as coveralls and respirators equipped with organic vapor cartridges and particle pre-filters, is required. These mixers had no local exhaust ventilation systems. Primary exposures were to solvents when compounders added materials into the top of the mixer.

General purpose vinyl adhesives, plastisol foams, and skins are formulated in other rotary mixers. The mixers were provided with a local exhaust dust collector system designed to capture dust created when workers dumped bagged materials into the top of the mixers. The exhaust air is filtered through a dust collector and recirculated back into the work area. The frequency at which the filters are changed or cleaned was not determined. Antimony oxide fire retardants are used in some plastisol formulations. However, plastisols contained mostly plasticizer oils and resins having a relatively low order to toxicity.

C. Laminating Department

This department contains five laminating machines which laminate layers of sheet vinyls and/or fabric support materials using vinyl adhesives, heat, and pressure. At the time of the initial survey, the only solvent used (for cleaning machinery) was 1,1,1-trichloroethane (methyl chloroform). After the company shut down the Finishing Department, two of the five laminating machines were modified to apply solvent based top coatings containing MEK, toluene, and xylene. During the follow-up environmental survey conducted by NIOSH in June 1980, NIOSH investigators found considerable leakage of solvent vapors from the top coater dryers. These dryers were equipped with push/pull local exhaust systems, but the air supplied and exhausted was not properly regulated. The condition was discussed with management and the systems were modified with side draft baffles and balanced. When

NIOSH returned to the plant in September 1980, a slight solvent vapor odor was noted, but solvent vapors were being adequately captured by the improved dryer exhaust system.

D. Print Department

Decorative printing of vinyl sheets using solvent-based inks is performed in this department. Each of the five print machines can apply up to five different colors. The department is well ventilated with both local capture and general dilution systems. Atmospheric sampling previously conducted by the company and OSHA found concentrations of MEK and toluene in this area below the current OSHA permissible exposure limits (PELs).

E. Print Service Department

Job classifications in this Dept. included the color shader ink serviceman, assistant color shader, and barrel washer. Workers assigned to this area are responsible for blending and shading various pigments to the desired color specification. Solvent vehicle is mixed with the selected color concentrate to prepare the inks used in the Print Department. Empty ink drums are cleaned with mineral spirits by the Barrel Washer working outside the plant on a loading dock.

General dilution ventilation was not adequate to control the strong and sometimes irritating solvent odor normally present during mixing of pigments and solvents. Organic vapor respirators were available but were not consistently used. Solvents, mostly MEK and toluene, are stored in two large cylindrical tanks mounted about 4 feet above the floor and open at the top. Solvents are dispensed from a tap at the bottom of the tank. The vapors released when filling ink drums was not adequately captured by the solvent tank exhaust system. Another more frequently used solvent tap near the shading booth had no local exhaust ventilation.

IV. EVALUATION METHODS

A. Environmental Evaluation

Based on the technical information provided by the plant chemist concerning the composition of the plastics formulated and the types of solvents and pigments used in mixing printing inks and vinyl top coatings; air sampling was conducted to characterize worker exposures in each department.

1. Solvent Vapor Sampling

On June 10-12, 1980, air samples were collected in the Print Department, Print Service Area, Color Department, and Laminating Department. Both personal breathing zone and general area samples were collected on organic vapor adsorbing charcoal tubes. A measured volume of air was pulled through the tubes using battery operated air sampling pumps set for a flow rate of 100 cc of air per minute. Personal exposure samples were determined by attaching the charcoal tube collector to the worker's shirt collar. The charcoal tubes were analyzed by the NIOSH laboratory for MEK, toluene, cyclohexanone, xylene, and MIBK by gas chromatography according to a modification of NIOSH P&CA Method 127.[1] The limit of detection for this method was 0.01 mg/sample for MEK, toluene, xylene, and MIBK; and for cyclohexanone, 0.02 mg/sample. The combined exposures to these solvents were calculated using the mixture formula recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).[2] Personal samples were collected from two Color Compounders who were using mineral spirits to clean a pigment mill and to wash out plastisol tubs. The Barrel Washer was also sampled for mineral spirits exposure since this solvent was used to clean out ink drums. One Color Compounder was sampled for possible exposure to methyl methacrylate during the mixing of clears and foams which may have contained this chemical in the formulation being mixed. The sampling locations are shown in Table 1.

Additional solvent vapor sampling for MEK, toluene, and xylene was conducted in the Print Service and Laminating Departments during a subsequent follow-up survey on Sept. 24-25, 1980. These areas had been identified as having the highest solvent vapor levels during the first environmental survey. The company had made several modifications to the ventilation system to control vapor levels in these departments. Air monitoring was performed to determine the effectiveness of these changes. The sampling locations are shown in Table 2.

In April 1981, NIOSH learned that the Occupational Safety and Health Administration (OSHA) had changed their method of sampling for MEK. OSHA had found that when MEK was collected on charcoal tubes, there was up to a 50% loss of sample when the tubes were stored at room temperature. The new OSHA sampling method called for collecting MEK on silica gel tubes at approximately 50-100 cc/min, with a maximum sampling volume of 3 liters. This new OSHA method was compared to the then current NIOSH method (S-3)[3] during side by side sampling in the Intex Print Service Department on April 28, 1981. However, only 3 samples were taken. The sampling locations are shown in Table 3.

2. Dust Sampling

Airborne dust concentrations in the Calender and Color Departments were measured by collecting personal and general area samples on pre-weighed membrane filters mounted in 3 piece plastic cassettes. Each cassette was connected with plastic tubing to a calibrated battery powered air sampling pump which pulled air through the filter at a flow rate of 1.5 liters of air per minute (Lpm). The total dust collected was determined by gravimetric (net increase in filter weight) analysis. Because organometallic salts of barium and cadmium were used as stabilizers in many of the plastic formulations, the filters were also analyzed by atomic absorption for barium and cadmium content according to NIOSH P&CA Method No. 173.[1] The sampling locations are shown in Table 4.

3. Lead Dust Sampling

Sampling for airborne lead exposure in the Color Department was scheduled for the follow-up survey on Sept. 24-25, 1980. A minor fire in the ball mill on Sept. 24th, prevented NIOSH from sampling during the job of loading sacks of lead based pigments into the mill. NIOSH did sample a color compounder mixing a "B Grind" plastisol. The formula called for 60 sacks (50 lbs. each) of lead chromate pigment to be dumped and mixed in a tub with resins and solvents. The worker adding these materials wore disposable coveralls, protective gloves, and a respirator. The tub was positioned under two local exhaust ducts to capture any dust released when dumping lead chromate into the tub. The air samples were collected on Millipore® type AA filters at a flow rate of 1.7 Lpm. The lead content collected on the filters was determined by atomic absorption analysis according to NIOSH P&CA Method No. S-341.[4] The sampling locations are shown on Table 5.

4. Plastic Fumes and Vapor Sampling

a. Qualitative Analyses

To identify and characterize the various organic fumes and vapors released in the Calender Department from hot vinyl plastics, on June 11, 1980, NIOSH collected several bulk air samples from various calender machines where visible plastic fumes and mist indicated airborne levels would be at their highest concentration. The samples were collected on Millipore® AA filters and/or Florisil tubes which were subsequently analyzed qualitatively by gas chromatography/mass spectrometry (GC/MS). A chunk of blended plastic discharged from a Banbury mixer was also submitted to the NIOSH laboratory for GC/MS analysis of any volatiles released when the sample was heated to 176° C (350° F) and 260° C (500° F).

Additional bulk air samples were collected on September 24, 1980, during a follow-up environmental survey. Samples were taken from inside the fume exhaust hood located directly above each calender machine. Air samples were collected on Millipore® AA filters backed up with organic vapor adsorbing charcoal tubes. The filters were analyzed by gas chromatography and the organic compounds collected were identified by GC/MS.

A bulk liquid urethane top coating used in the Laminating Department was also analyzed by the NIOSH laboratory using GC/MS to identify vapors likely to be released from this material. The urethane bulk liquid was put into a sealed vial and allowed to stand at room temperature for about a day. Using a gas tight syringe, a headspace sample was taken from this vial and injected into the GC/MS for analysis.

b. Quantitative Analysis

As identified on Intex mixing formulations and confirmed by NIOSH using GC/MS analyses of bulk air samples, the major component of the fumes and vapors released from the heated vinyl plastic processed in the Calender Dept. were phthalate esters (see Table 10). Company records indicated that three different phthalates were used interchangeably by Intex as "DOP" in the plastic formulations.

(1) Exon-Jaflex® (diisonylphthalate or DINP
(a mixture of phthalate esters, predominantly C_9)

(2) Kodeflex® DOP (1,2,-di-ethylhexyl phthalate or DEHP)

(3) Eastman DOTP (1,4-di-octylteraphthalate)

Although these phthalates all closely resemble dioctyl phthalate (DOP) in molecular weight and molecular structure, none of these are true DOP. The personal exposure and general area samples collected on June 10-12, 1980, were screened by GC/MS and found to contain both DOTP and DEHP. Each sample was collected on a Millipore® AA filter mounted with a steel backup pad in a three-piece plastic cassette followed by a two-piece Florisil tube which served as a back up collector for phthalates and other vapors not being trapped on the filter. The collection device was connected to a battery operated sampling pump, calibrated to provide a constant air flow of 1 Lpm through the filter and backup Florisil tube. The air samples were analyzed for DOTP and DEHP by gas chromatography according to a modified method of NIOSH Method S-40.[3] The samples collected in the Calender and Pre-mix Departments are identified on Table 6.

5. Vinyl Chloride Sampling

PVC resin being mixed with additives and plasticizers in blenders located in the pre-mix area was sampled for possible release of residual vinyl chloride monomer. Area samples were taken directly above open blender hatches and one personal exposure sample was collected for the pre-mix operator. The samples were collected on charcoal tubes at a flow rate of 1 Lpm, and analyzed by gas chromatograpy in accordance with NIOSH P&CAM No. 178.[1] The sample durations and locations are presented on Table 7.

6. Fire Retardants Sampling

The potential for exposure to fire retardants used in certain vinyl plastic formulations was investigated by collecting air samples in the Pre-mix and Calender Departments. The greatest use of fire retardants in these areas was during formulation of a plastic identified by Intex as "82F". This formulation contained 114 lbs. (5% of total formulation) of Monsanto Santicizer® 146 and 32 lbs. (1% of total formulation) of antimony oxide.

The major component of Santicizer® 146 was reported by Monsanto as isodecyldiphenyl phosphate (IDDP). Although IDDP has a low volatility, tests conducted by Monsanto demonstrated that if the compound is heated to 325° F the resulting vapors could represent a hazard for exposed workers. To evaluate the potential for exposure to IDDP, the NIOSH laboratory developed a sampling and analytical method for identifying and quantitating IDDP vapor concentrations in the workplace. The samples were collected at 1 Lpm on Millipore® AA filters, backed up with silica gel tubes to capture any break-through vapors. The samples (filters and silica gel tubes) were desorbed with ethanol and the desorbed samples were analyzed by gas chromatography using a flame photometric detector. IDDP samples were collected on September 28, 1981 during the formulation of plastic 82F. The specific locations of the samples taken and the sampling durations are presented in Table 8.

Antimony oxide samples were collected on Millipore® AA type filters at 1.5 Lpm. The samples were analyzed for antimony according to NIOSH method P&CAM No. 261.[5] Sample locations and durations are presented in Table 9.

B. Medical Evaluation

1. Employee Interviews

After obtaining the workers' informed consent, participants were stratified (by department and by work shift) and randomly allocated to be tested over the five days of the study. Individuals were requested to appear for testing 1 to 1-1/2 hours prior to beginning their shift. Testing was initiated by administering a standardized respiratory questionnaire.[6] Interviewers administered the American Thoracic Society (ATS) respiratory symptom questionnaire plus additional questions concerning upper airway and mucous membrane irritation. Interviewing was conducted in a NIOSH trailer adjacent to the Plant. Interviewers were supervised during the course of the study to assure consistency of technique.

The standardized ATS questionnaire elicits symptoms related to the lower respiratory tract, including cough and chronic cough, phlegm and chronic phlegm, chronic wheeze, wheeze with shortness of breath, three grades of shortness of breath, and chest tightness. However, since the preliminary surveys of the work force suggested a high frequency of upper respiratory symptoms, the ATS questionnaire was supplemented to elicit upper respiratory tract symptoms, including sore throat and chronic sore throat, hoarseness and chronic hoarseness, rhinitis, and chronic rhinitis and conjunctivitis.

2. Pulmonary Function Testing

Respiratory technicians who had completed a NIOSH-approved training course administered pre- and post-shift spirometry to each worker within one and one-half hours of starting and ending his work shift. Three Stead-Wells spirometers (W.E. Collins Company, Braintree, Massachusetts) were shipped from the COEH to Corinth, Mississippi and established in an airconditioned room at the work site.[7] Spirometers were calibrated prior to testing each shift. Spirometry was administered in accordance with the ATS Snowbird Conference criteria [8]. Pre-shift spirometric measurements of Forced Vital Capacity (FVC) and the one-second Forced Expiratory Volume (FEV_1) were compared with the predicted values of Morris.[9] Pre-shift spirometric values were used for all comparisons. The magnitude and direction of work shift change in spirometric function were examined separately.

3. Analyses of Data

Complete work history records were obtained from the company Personnel Office. These records provided the calendar dates and duration of employment (exposure) in each of the departments under study. Exposure groups were compiled from the current department of employment and the total duration of employment in each department. All data was subjected to computer analysis. Discreet variables, such as respiratory symptomatology, were analyzed by multiple contingency tables, combined when appropriate, by the Mantel-Haenzel procedure.[10] Continuous variables, such as timed forced expiration were analyzed by the Abbey-Tonascia modification of the Feldstein linear regression technique (7). Multiple adjustments for significant confounding variables including age, height and cigarette smoking were carried out with the Feldstein procedure.

V. EVALUATION CRITERIA

A. Environmental 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, 2. the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's),[2] and 3. the U.S. Department of Labor (OSHA) occupational safety and health standards.[11] 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 standards, by contrast, are based solely 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 legally required to meet only those levels specified by an OSHA standard.

For those compounds with established occupational exposure limits, the various criteria proposed by OSHA, ACGIH, and NIOSH for airborne concentrations of the chemical substances measured in this evaluation are listed in Table 11 of this report. For the purposes of this evaluation, the NIOSH recommended standard or the most stringent value is the criterion used. Table 11 also lists the major health effects or sites of action of those chemicals. 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) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures. At the present time there are no established criteria for isodecyldiphenyl phosphate.

A further discussion of the toxicity for certain compounds detected in the work environment of Intex Plastics are presented below:

1. Solvents

METHYL ETHYL KETONE--is an irritant of the eyes, mucous membranes, and skin. At high concentrations it causes narcosis in animals, and it is expected that severe exposure in humans will produce the same effect. In humans, short-term exposure to 300 ppm was "objectionable," causing headache and throat irritation; 200 ppm caused mild irritation of the eyes; 100 ppm caused slight nose and throat irritation. MEK can be recognized at 25 ppm by its odor, which is similar to acetone but more irritating. The TLV recommended by the ACGIH (200 ppm) was established at a level to prevent injurious effects and minimize complaints about odor and irritation.[12] NIOSH also recommends a 200 ppm TWA exposure limit for exposure durations up to 10 hours.[13]

TOLUENE--is a colorless liquid with an odor threshold reported to be 2.5 ppm. It is used as a solvent in many paints and coatings. Occupational exposures to toluene are normally through inhalation of toluene vapors and skin absorption of toluene liquid. Chronic exposure to toluene does not produce the severe injury to the bone marrow, characteristic of benzene poisoning. As a result, toluene has been widely substituted for benzene in many products and industrial processes. The predominant effect from exposure to toluene is depression of the central nervous system. Controlled exposures of human subjects to 200 ppm toluene for 8 hours has produced mild fatigue, weakness, confusion, watery eyes, and a tingling sensation of the skin.[12] Prolonged reaction times, decreased pulse rates, and decreases in systolic blood pressure have been detected among human subjects exposed to 200 ppm for 7 hours.[14] At higher concentrations, effects include nervousness, muscle fatigue, and insomnia.[12] Workers exposed to less than 200 ppm have complained of headaches, lassitude, and nausea.[14] In 1973 NIOSH recommended the occupational exposure limit be reduced to 100 ppm as an 8-hour TWA.[15] Repeated or prolonged skin contact with liquid toluene has a defatting action, causing drying, fissuring, and dermatitis. Toluene causes some irritation to the eyes at 300-400 ppm.[16]

METHYL ISOBUTYL KETONE--has a camphor-like odor detectable at 100 ppm. In humans, at levels of 400 ppm it is quite objectionable causing eye and nasal irritation. Eye irritation is noted at a level of 200 ppm. Workers exposed to about 100 ppm complained of nausea and headache, but developed a tolerance after several days of repeated exposure. The OSHA standard of 100 ppm was set at a level believed to prevent eye irritation.[12] NIOSH believes the current standard is not adequate and has recommended the level be lowered to 50 ppm.[13]

MINERAL SPIRITS--are clear colorless liquids with a pleasant sweetish odor. They are commonly used as a general-purpose industrial solvent and as a thinner in paints and varnishes. Prolonged or repeated contact with the skin can cause moderate skin irritation or dermatitis. Ingestion of mineral spirits can cause gastrointestinal irritation, nausea, vomiting, and diarrhea. If swallowed, aspiration into the lungs causes chemical pneumonitis which can be fatal. Airborne concentrations of mineral spirits above 2,500 mg/M^3 have been shown to cause nausea and vertigo in humans.[17] Inhalation of mineral spirits vapors can irritate the upper respiratory tract and will depress the central nervous system resulting in dizziness, weakness, fatigue, nausea, headache, and under conditions of severe exposure, unconsciousness and possible asphyxiation. The 10-hour TWA exposure limit recommended by NIOSH is 350 mg/M^3 with a ceiling limit of 500 mg/M^3. These limits were established to prevent the symptoms of central nervous system depression, upper respiratory irritation, and chronic responses based on the projected toxicities of the major aliphatic (70-90%) and aromatic (10-30%) components of mineral spirits.[12]

2. Dusts

POLYVINYL CHLORIDE--dust exposures have been associated with slight impairment of pulmonary function and pneumoconiosis (dust in the lungs detectable on chest x-rays) on two separate epidemiological studies conducted outside the United States which involved a total of 1549 workers. Many other studies pertaining to PVC exposures have also reported respiratory effects in exposed workers, but in these studies exposure to vinyl chloride monomer was thought to be a contributing factor.[18] Biological affects from exposures to polymer dusts is more the result of physical size and form of the particles inhaled into the lungs, and is often the result of gross over exposures in excess of 10 mg/M^3 (as total dust). Occupational exposure limits for the airborne dust of specific polymers or their decomposition products have been defined or evaluated in only a relatively few cases. Where no specific exposure limit exists, the ACGIH TLV for nuisance dust (10mg/M^3, as total dust) is considered to be the only, and also the most lenient, exposure limit applicable to PVC dust exposure.

3. Lead Chromate Pigments

LEAD--exposure, through inhalation (breathing) of dust and fume, is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once adsorbed, lead is excreted from the body very slowly. Adsorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/deciliter whole blood are considered to be normal levels which may result from daily environmental exposure. The new Occupational Safety and Health Administration (OSHA) standard for lead in air is 50 ug/M^3 calculated as an 8-hour time-weighted average for daily exposure.[19] The standard also dictates that workers with blood lead levels greater than 60 ug/deciliter must be immediately removed from further lead exposure and, in some circumstances, workers with lead levels of less than 60 ug/deciliter must also be removed. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels decline to below 50 ug/deciliter and they can return to lead exposure areas.

4. Vinyl Plastic Compounds and Additives

PHTHALATE ESTERS--plasticizers including di-2-ethylhexylphthalate (DEHP), diisonylphthalate (DINP), and dioctylteraphthalate (DOTP) were used interchangeably as the "DOP" (dioctyl phthalate) component of the vinyl plastics formulated by Intex. Second only to the PVC resin, the "DOP" additive was the principal component. Typical formulations contained from 10-30% "DOP" plasticizer. These compounds were also found to be the major component of the plastic fumes and vapors sampled in the Intex Calender Department.

DOP and DEHP are similar in their physical and toxicological properties. DEHP is the most widely used plasticizer and has therefore been studied extensively by many investigators. Although different phthalate esters have been found to exhibit varying degrees of biologic effects, DEHP has previously been considered to to have a very low order of toxicity, especially through oral ingestion. The lethal dose (LD-50) is about 30-34 grams/kilograms for the rat. Human volunteers have ingested 5 and 10 grams of DEHP without serious adverse effects. Also patch tests on human subjects showed no irritation or sensitization to the skin.[20] Vapor and mist generated by bubbling air through plasticizer heated to 348° F could be tolerated by rats exposed up to 2 hours. However, after 4 hours exposure, all rats succumbed. On the bases of these experiments a determination was made that the hazard of industrial exposure to DEHP would be minimal under normal industrial process conditions.[14]

The continued interest in the toxicity of several phthalates and their extensive commercial applications prompted the National Toxicology Program (NTP) to conduct chronic bioassay testing of DEHP and other phthalic acid esters for possible carcinogenicity. Using the NTP bioassay test protocol, groups of rats and mice were fed DEHP in their diets for a period of 103 weeks. In 1982 the NTP reported that under the conditions of the test, DEHP was found to cause liver cancer in both sexes of mice and in female rats. The data further suggests that the incidence of liver neoplasms was dose related. Based on the NTP bioassay test results, NIOSH has concluded that DEHP should be considered to have carcinogenic potential. However, no evidence of DEHP carcinogenicity in humans has been reported.[27] The current OSHA permissible exposure limit is still 5mg/M^3, as is the ACGIH TLV.

Teraphthalates and nonyl phthalates are also reported to present a relatively low order of oral toxicity. They are not absorbed through the skin and do not cause skin irritation.[20] No evidence exists to indicate these compounds are either more or less toxic than DEHP. The carcinogenic effects of these compounds have not been fully studied.

RESIDUAL VINYL CHLORIDE MONOMER--is now being removed from PVC resins by means of more effective stripping methods employed by the PVC manufacturer. Vinyl chloride is a gas which is absorbed by the body through inhalation. Vinyl chloride is regarded as a human carcinogen, and can cause angiosarcoma, a rare form of liver cancer. Excess cancer of the lung and the lymphatic and nervous systems has also been reported. The OSHA permissible exposure limit is 1 ppm for an 8 hour time weighted average and a ceiling limit not to exceed 5 ppm over a 15 minute exposure period.[21]

ISODECYLDIPHENYL PHOSPHATE (IDDP)--the major component of the Monsanto Santicizer® 146 fire retardant additive, is a relatively non-volatile organophosphate compound that may be transported by air in both production and utilization facilities. Although information about the chronic toxicity of this and other organophosphates is limited, several are known to be delayed neurotoxins.[22] When heated to 325° F, IDDP induced mortalities in rats exposed for six hours to the vapors released. Monsanto has advised that "precautions should be observed to avoid inhalation of increased vapor concentrations which may occur if Santicizer® is used at elevated temperatures." The temperature for the vinyl plastic being processed through the Calender Dept. was approximately 325-370° F. There is currently no recommended occupational exposure limit for IDDP.[23]

ANTIMONY OXIDE--is another commonly used fire retardant. Antimony and its compounds are generally regarded as primary skin irritants. Exposure to airborne dusts and fumes also irritate the eyes, nose, and throat. Antimony oxide causes a dermatitis known as "antimony spots". This form of dermatitis results in intense itching followed by skin eruptions. Lesions occur in hot weather and are due to dust accumulating on exposed areas of the skin that are moist due to sweating.[21] The OSHA permissible exposure limit for antimony is 0.5 mg/M^3, which is also the current NIOSH recommended limit.

VI. RESULTS AND DISCUSSION

A. Environmental

1. Solvent Vapor Exposures

The results obtained for the organic vapor samples collected during June, 1980 are presented in Table 1. Of the compounds sampled, MEK and toluene were the predominant contaminants in areas where printing inks and other solvent based materials were used. Of the areas sampled, the Print Service Department and the top coater machine in the Laminating Department presented the greatest risk of solvent vapor exposure. Personal exposure to MEK in the Print Service area ranged from 36 ppm for a second shift Color Shader up to 229 ppm for the Old Ink Serviceman working the first shift. In fact, the two highest exposures detected for MEK were obtained from the Old Ink Serviceman on two consecutive days of sampling.

The average MEK concentrations detected, by department, for personal exposures and area levels was: 110 ppm in the Laminating Department, 104 ppm in the Print Service Area, 48 ppm in the Print Department, and 20 ppm for the Color Department. The average personal exposure to MEK for the Barrel Washer was 149 ppm.

Exposures to a mixture of solvents having similar toxic effects were considered to be additive. As recommended by ACGIH, a formula was used (shown at the bottom of Table 1) to determine if the these exposures exceeded the ACGIH TLV. When calculating the combined personal exposures to the mixture of all solvent vapors sampled (MEK, toluene, cyclohexanone, xylene, and MIBK), as shown at the bottom of Table 1, the results from this formula found the Old Ink Serviceman and Barrel Washer exposed above the ACGIH TLV for mixtures (a result greater than 1).

A follow-up environmental survey conducted in September 1980, revealed that the additional equipment provided by Intex for increased ventilation in the Print Service Area, as well as the modifications made on the push/pull local exhaust hoods for the top coater machines in the Laminating Department, were effective in reducing solvent vapor concentrations. Average MEK levels measured in the Print Service area were 92 ppm; in the Laminating Department, concentrations were reduced to an average of 45 ppm. Results of all personal and area samples taken during the September survey are presented in Table 2.

Results of side-by-side sampling for MEK, comparing the NIOSH S-3 method with the revised OSHA method, are presented in Table 3. As the results indicate, the OSHA method detected MEK concentrations 23-30% higher than the levels measured using the NIOSH method. Although only three comparison samples were collected, it seems reasonable to conclude that the MEK sampling results from the previous NIOSH surveys may have been lower than the actual MEK concentrations present.

2. Dust Sampling Results

Airborne dusts, as total dust, detected in the Pre-mix area and Calender Department are presented in Table 4. Personal exposures to dust in the Pre-mix area ranged from 0.3 to 6.8 mg/M^3. Exposures in the Calender were from 0.1 to 0.6 mg/M^3. None of the exposures exceeded 10 mg/M^3, the evaluation criteria for nuisance dust. The highest dust levels, 9.2 and 5.9 mg/M^3, were found during first shift in the penthouse area on two consecutive days of sampling. The relatively high dust exposure for the second shift Pre-mix Operator (6.8 mg/M^3), detected on June 10th was much higher than the exposure monitored for the first shift Pre-mix operator (0.9 mg/M^3) on June 11th and 12th. This difference could be the result of additional tasks assigned to the second shift operator requiring a greater amount of time to be spent in the penthouse dumping sacks of dusty materials into the blenders. Barium and cadmium organometallic stabilizers were not detected on any of the air samples, indicating the only risk of exposure to these substances is through direct skin contact.

3. Lead Sampling Results

Airborne lead exposure detected when adding lead chromate pigment to a "B-grind" formulation was 156 ug/M^3 for the duration (approximately one hour) of the job. The worker was wearing protective clothing and a respirator at the time. This worker was not exposed to lead for the remainder of the 8-hour work shift resulting in an 8-hour time weighted average exposure of 25 ug/M^3, a level below the current OSHA permissible exposure limit of 50 ug/M^3. The use of lead chromate pigments was intermittent at Intex. Improved ventilation and short exposure durations indicate that lead exposures in the color department were not a significant problem. Lead sampling results for the "B-grind" mixing and other areas sampled in the Color Department are presented in Table 5.

4. Plastic Fume and Vapor Sampling

a. Qualitative Analyses

When AA pre-filters were used during sample collection on June 11, 1980, essentially all phthalates were trapped on the filter. and lower molecular weight compounds were found in the back-up Florisil tubes. Two samples collected without pre-filters contained both phthalates and lower weight compounds. One of these tubes was analyzed by GC/MS to identify compounds present. The compounds identified are listed with the first sample presented on Table 10. The major component found had the same mass spectra as the "DOP" bulk liquid obtained from INTEX during the NIOSH survey. This "DOP" liquid was also analyzed by GC/MS and found to be a mixture of mostly 1,4-di-octyltera phthalate (Eastman DOTP) with a small amount of DEHP (Kodeflex® DOP). Neither the bulk air samples or "DOP" liquid contained authentic 1,2-di-n-octyl phthalate, the true chemical name for DOP.

In the NIOSH laboratory, a chunk of plastic material taken from the No. 1 Banbury mixer was heated to approximately 176° C (350° F) and to 260° C (500° F) in a microfurnace. The fumes and vapors released were trapped with charcoal tubes, desorbed with carbon disulfide, and analyzed by GC/MS to identify the various detected components. The results of these analyses are presented in the second sample shown in Table 10. Essentially, no major compounds were detected from the sample generated at the lower temperature. At the higher temperature, among the major components identified were benzene, acetone, numerous aliphatics, nonylphenol isomers and some high boiling compounds later identified as phthalate esters. The largest component detected was 1,4,-di-octyltera phthalate (DOTP).

a. Quantitative Analysis

Verification was obtained from the NIOSH contract laboratory, through further GC/MS analyses, that air samples collected in the Calender Department on June 10-12, 1980, contained both DOTP and DEHP. The samples were subsequently analyzed for these two compounds by gas chromatography. The results of these analyses of both personal and general area samples are presented in Table 6. Very little DEHP was detected and only in areas where fumes and vapors were known to be highly concentrated, i.e. under the calender exhaust hood. This is consistent with the GC/MS results which indicated that DEHP was not the major phthalate present in the samples. DOTP concentrations in area samples ranged from 0.05 to 6.8 mg/M^3 with an averaged concentration of 2.85 mg/M^3. The levels were much higher during the first shift sampling than during second shift. As expected, area samples detected DOTP at much higher levels than were found for personal samples. Personal exposures to DOTP ranged from 0.04 to 0.16 mg/M^3 with an average exposure level of 0.07 mg/M^3. These exposures are well below the evaluation criteria of 5 mg/M^3.

c. Subsequent Qualitative Sampling

The results obtained from GC/MS analyses of bulk air samples collected in the Calender Department on September 24, 1980, are presented on Page 2 of Table 10. During this survey the major component detected in the fumes and vapors was diisonyl phthalate (Exon-Jaflex DINP). Trace amounts of DOTP were also found in samples taken from Calender No. 1 and No. 3. No DEHP was detectable during this follow-up survey. Low molecular weight compounds identified on charcoal back-up tubes included toluene and trichloroethane with lesser amounts of methyl ethyl ketone, a mixture of 120 molecular weight aromatics, and a series of alkanes in the C_9-C_{16} range.

As shown on Table 10, the vapors released from the urethane liquid top coating applied to sheet vinyls in the Laminating Department were identified by GC/MS analysis as isopropanol, MEK, toluene, and xylene.

5. Vinyl Chloride Sampling Results

Residual vinyl chloride monomer was released from a batch of vinyl plastic (formula 209-F) being blended in the penthouse on the morning of June 12, 1980. Vinyl chloride concentrations ranged from 0.3 to 2.0 ppm as measured directly above the blender hatch. Based on the results of the personal sample taken that day, the pre-mix operator assigned during this shift was not exposed. No personal sample was taken for the Pre-mix Helper. Vinyl chloride was not detected in the Pre-mix Control Room. Vinyl chloride monomer sampling results are presented on Table 7.

6. Fire Retardants Sampling Results

The results obtained from air samples taken to determine the levels of exposure to fire retardants used during the processing of vinyl plastic formulation 82F are presented in Tables 8 and 9.

Isodecyldiphenyl phosphate (IDDP) was detected in only one of eight samples collected, and only inside the exhaust hood of a calender machine. As reported by the manufacturer, IDDP has a low volatility which would indicate that airborne vapors would not be expected in industrial work environments unless the material was used at elevated temperatures. Although some IDDP vapors are released during calendering of formulation 82F, all vapors were being effectively captured by the calender machine's local exhaust system.

Antimony oxide levels monitored in the Pre-mix and Calender areas were all well below the environmental criteria for antimony of 0.5 mg/M^3. The concentrations measured during the survey were from 0.0003 to 0.064 mg/M^3. The highest personal exposure detected was only 0.0006 mg/M^3. The low levels found may be explained by the fact that the 82F formulation contains only 1% antimony oxide. Also, laboratory tests by NIOSH found the antimony oxide fire retardant used by Intex contained only 8% antimony, by weight. Pure antimony oxide contains 41.7% antimony, by weight.

B. Medical

1. Demographic Characteristics of Study Population

The population for the on-site study was limited to the current active work force of the plastics plant. Of 360 total production line workers, 274 (76%) were white males (Table 12). Blacks and females were not selected for study due to their small numbers. Among the white males, 202 of 274 (74%) were considered eligible for participation since at the time of the study they were working either in departments with potential exposures (Calender, Color, Laminating and Print, and Maintenance) or in control departments which were subjectively free from fume and odor (Shipping, Inspection, and Receiving Materials). Of the 202 eligible workers, 174 (86%) actually participated in the interview, 170 (84%) had acceptable pre-shift spirometry in addition to an interview, 165 (82%) had an interview plus acceptable pre- and post-shift spirometry, while 163 (81%) had an interview, acceptable pre- and post-shift spirometry plus a work history available from the Personnel Office. There are no significant differences between departments in the proportion of tests successfully administered or completed (Table 12).

Characteristics of the 174 eligible white males who participated in the study were compared to the 28 (14%) who did not participate (Table 13). Only age, current department and duration of employment were available for this latter group. The small observed differences between eligibles studied and eligibles not studied with respect to age and duration of employment are not significant. A comparison of participation by current department shows that significantly more of the members of Department A (Calender) participated (97%) than did those of the control department Department F (Shipping, Inspection, and Materials), with 82% participation. Participation of Department B (Laminating), Department C (Print and Print Services), Department D (Color), and Department E (Maintenance) showed no differences from the control department.

The characteristics of the 174 white male members of the study population are presented in Table 14. Forty-one (24%) of the 174 are currently employed in Department A, 23 (13%) in Department B, 38 (22%) in Department C, 6 (3%) in Department D, 25 (14%) in Department E, and 41 (24%) in the unexposed control department, Department F. The mean age of the calender workers (37.7 years) is significantly lower (by 6.3 years) than the mean age of the control, Department F (44.0 years) and, in fact, is significantly younger (by 5.3 years) than the average age of all non-calender workers. At 14.2 years, the duration of employment among the control department, Department F, significantly exceeds that of Departments A (10.6 years), C (11.5 years), D (8.2 years) and E (10.8 years), There are no significant differences in mean height or in the distribution of smoking states by department.

The department of current employment reflects only part of the occupational exposure sustained by the study population, since transfers between jobs are common at the plastics plant (Table 15). The percent of total employment spent in the current department rises from a low of 59% (Department F), to a high of 82% (Department B). However, it is reassuring that 88% of the total duration of study population employment at the plastics plant was spent among one or more of the departments under study (A through F). Along the diagonal of Table 15, it may be seen that the duration of employment (in years) spent in their current department is significantly greater than the duration spent by study participants in any other department.

2. Respiratory Symptomatology

Workers at the plastics plant have several characteristics which are known to affect symptom frequency. For example, both age and cigarette smoking are known to have an effect on the prevalence of reported respiratory symptoms. Therefore, the population was divided into two age groups (less than 40 years and 40 years or older) plus three smoking groups (never smokers, previous smokers, and current smokers). When the symptom responses which correspond to these age and smoking categories are entered into the Feldstein linear regression model, it becomes possible to determine both the crude (observed) symptom frequency, as well as the frequency of symptoms expected (adjusted symptom frequency) if all characteristics other than the one under study were equally distributed. For example, the frequency of symptoms among those who have never smoked is given a relative risk (R.R.) of 1.00. The adjusted frequency of symptoms among the other classes ("Previous" and "Current") of this characteristic ("Smoking Status") are then compared to that of the Never smokers. The adjusted frequency of cough among never smokers was 11.5%. This "normal" frequency is given a relative risk of 1.00. Previous smokers have an adjusted frequency of cough of 19.7%. If 19.7% were divided by 11.5%, one would arrive at the relative risk of 1.71. This means that if all other characteristics were equal among the smoking groups, a history of previous smoking is associated with an excess risk of cough of 71%. Nevertheless, this excess risk of cough is not statistically significant. Current smokers have a relative risk for cough of 2.46. Current smokers are thus 2-1/2 times more likely to report cough than are never smokers. This excess is statistically significant.

This method of analysis is also useful for evaluating whether or not certain characteristics (for example, those associated with occupational exposure) may have an effect on symptom frequency. Occupational characteristics to be evaluated for their effect upon symptom frequency include workshift, test day, current department and duration in current department. A summary of the significant characteristic effects upon lower airway symptom frequency is shown in Table 16. From this summary, it may be seen that the frequency of cough, chronic cough, chronic phlegm and chronic wheeze are all reported with a significantly greater frequency in the subjects tested on Mondays. In addition, the frequencies of chronic cough and chronic phlegm are significantly greater among those employees who have worked in their current department more than six months. This significant effect of employment duration was evaluated by adjusting for department. Small numbers did not permit evaluation of employment duration within specific departments. Specific departmental exposures may be associated with grade three (moderate to severe) dyspnea which is reported in significant excess by employees of Department B (Laminating) and C (Print and Print Services).

Although not significantly associated with one department, particularly high frequencies of certain respiratory symptoms were noted when compared with community surveys in the literature (8-10). Nearly half of those working in the color department (Department D) report chronic cough (41%), chronic phlegm production (48%), and chronic wheeze (47%). Chronic wheeze (42%) and mild shortness of breath (60%) were reported by employees in the Calender (A) Department. A similar proportion (47%) of those in the Laminating Department (B) report chronic wheeze. In the Print and Print Services Department (C) more than 47% report mild shortness of breath. It is particularly striking that every production department (A-E) reports a high frequency (40% or more) of chest tightness and even the "control" department (F) reports a 39% frequency of chest tightness.

The summary of upper airways symptoms (Table 16) shows that the night shift is associated with a significantly greater frequency of hoarseness and chronic hoarseness. This hoarseness occurs primarily in Departments B (Laminating), E (Maintenance), and F (Shipping, Inspection and Materials). The day shift is associated with a significant excess of rhinitis and sore throat. Those employees who have worked in their current department for more than six months report an excess of chronic sore throat and chronic hoarseness although no specific departmental association has been identified.

3. Pre-Shift Pulmonary Function

A similar analysis has been used to examine the effects of demographic and occupational characteristics upon the crude and adjusted mean values for pre-shift spirometry. For greater precision in the evaluation of pulmonary function, age was divided into four classes (less than 30 years, 30 to 39 years, 40 to 49 years and 50 years or older). A summary of the significant characteristic effects (including age, height, smoking status, workshift, test day, current department and duration in current department) upon pre-shift spirometry (FEV_1, FVC, FEV_1/FVC, and FEV_3/FEV_6) is shown in Table 6. From this summary, it may be seen that pre-shift pulmonary function is primarily determined by age, height and cigarette smoking status. The only occupational association with pre-shift spirometry is a slight, but significant reduction in FVC observed on Wednesdays. There is no single department associated with lowered pre-shift spirometry.

An evaluation of the pre-shift FVC as a percent of predicted showed that the mean adjusted FVC of each department exceeded 100% of the predicted. To minimize the potential that selection for healthy workers might have biased this result, further analyses of the spirometry were undertaken using an internal control as the standard of comparison for pulmonary function. The adjusted FEV_1 and FVC (adjusted for age, height, smoking status, shift, test day and duration in department) of each department was compared to that of Department F. The smallest adjusted mean FEV_1, 93% of predicted, and the smallest adjusted mean FVC, 96% of predicted, (both in Department D) were nevertheless within the normal range (greater than 80% of predicted).

4. Cross-Shift Change in Pulmonary Function

Since each worker serves as his own control (thereby eliminating between individual variation), cross-shift pulmonary function change provides a sensitive index of acute respiratory response to exposures sustained during a workshift. The cross-shift change (post-shift minus pre-shift) is expressed as a percent of the initial (pre-shift) value. A summary of the significant characteristic effects upon cross-shift spirometric change is shown in Table 18. This summary demonstrates several associations of pulmonary function change with exposure over a workshift. A fall in FEV_1/FVC was noted only across the second shift. Other significant workshift changes were actually improvements in function from pre-shift to post-shift. Cross-Shift FVC improvement was noted among those tested on Fridays. A slight improvement in FEV_1/FVC was observed among workers who have been employed in their current department more than six months. However, this cross-shift improvement was significantly less than that observed among employees who had less than six months exposure in their current department. Finally, the FEV_3/FEV_6, a measure which emphasizes the "tail" of the spirogram (and possibly small airways function) showed a modest improvement in Department D.

5. Discussion

In response to reports of respiratory irritation among the Intex workers, 86% of the eligible workforce were tested with spirometry and the standardized ATS respiratory symptom questionnaire. Certain respiratory symptoms were significantly associated with current employment in particular departments. Grade 3 (moderate to severe) dyspnea is reported in significant excess by employees of Departments B (Laminating) and C (Print and Print Services). Other respiratory complaints were more widely distributed. It is particularly striking that every production department reports a high frequency of chest tightness (A, Calender-43%; B, Laminating-60%; C, Print and Print Services-55%; D, Color-46%; E, Maintenance-40%), and even the "unexposed" control department (F, Shipping, Inspection, and Receiving Materials) has 39% of its workforce reporting this symptom. Nearly half of those working in the Color Department (Department D) report chronic cough (41%), chronic phlegm production (48%), and chronic wheeze (47%). Chronic wheeze (42%) and mild shortness of breath (60%) were reported by the employees in the Calender (A) Department. A similar proportion (47%) of those in the Laminating Department (B) report chronic wheeze. High rates of respiratory symptom complaints persist after adjustment for age, height, smoking status, shift, rest day, and duration in current department. This high prevalence of wheeze and chest tightness has not been reported in community surveys even among heavy smokers.[24-26] However, it should be noted that the ATS questionnaire does elicit a higher frequency of wheeze than other standardized respiratory symptom questionnaires.[26]

Although the employees of the plastics fabricating plant reported a high frequency of respiratory symptoms, impaired pulmonary function could not be convincingly demonstrated. There was no evidence of FEV_1, FVC, FEV_1/FVC, or FEV_3/FEV_6 impairment in workers currently exposed in particular departments. This lack of impairment was seen when the pre-shift spirometric values were compared to an external control (the predicted values of Morris), or when the adjusted mean values of Department F were used as an internal control. There was also no evidence of any department-related pulmonary change over a work shift. Further analyses of the spirometry data failed to show any statistical significance to the small decline in FEV_1 or FVC associated with prolonged employment.

VII. CONCLUSIONS

A. Environmental

Out of all personal air samples collected by NIOSH during this investigation, only the samples for the Old Ink Serviceman and the Barrel Washer detected exposures to toxic substances (in this case solvent vapors) in excess of the evaluation criteria. The level of exposure to MEK may have been higher than sample results had indicated (due to possible loss of MEK collected on the charcoal tubes). However, follow-up survey results demonstrated a measurable reduction in solvent vapor exposures in both the Print Service Department and the Laminating Department which reflects the efforts made by the company to improve ventilation in these departments.

Plastic fumes and vapors generated in the Calender Department were being adequately controlled by existing local exhaust systems. Based on qualitative analysis of these fumes and vapors, the major component was the so-called DOP plasticizer. The average level of exposure (0.07 mg/M^3) to these phthalate esters is not considered excessive based on the current occupational exposure criteria (5mg/M^3). However, recent reports by the National Toxicology Program that DEHP can cause liver cancer in laboratory animals has increased our concern regarding the potential for adverse health effects for workers who have experienced long term exposures to DEHP and other related phthalate esters such as DOTP and DINP.

Dust levels were at the highest concentrations above and near the pre-mix blenders. This was especially true for the blenders located in the penthouse. Although these blenders were equipped with local exhaust systems, hatch covers on unused blenders were frequently left open which reduced the capture velocity for all blender exhaust hoods. Maintaining adequate air flow on blender exhausts is not only necessary to control dusts but also to capture any residual vinyl chloride monomer which may occasionally be released when blending PVC resin with plasticizers and other vinyl plastic additives.

B. Medical

In summary, certain departments of the plastics fabricating plant have been associated with significant increases of particular respiratory symptoms. Grade 3 (moderate to severe) shortness of breath has been reported with significant excess in Departments B (Laminating) and C (Print and Print Services). Hoarseness has been reported with significant excess in Department F (Shipping, Inspection and materials Receiving). The prevalence of certain symptoms was higher than might have been expected by community surveys in the literature.[24-26] The prevalence of wheeze, chest tightness and occasional mucosal irritation seemed to be high in all departments, including the control department. The reasons for this apparently high symptom prevalence in all departments is unexplained and cannot be further defined by this study. There is no clinical evidence of any significant reduction in ventilatory function as indicated by the results of pulmonary function tests.

VIII. RECOMMENDATIONS

1. As indicated on GC/MS analysis, thermal decomposition of vinyl plastics will generate numerous and potentially highly toxic substances. When vinyl plastics are heated in excess of 500° F or are allowed to burn as may occur during equipment malfunctions, dangerous fumes and gases are produced. It is therefore essential that workers who must occasionally repair or correct equipment malfunctions which involve removal or cleaning of overheated or burning plastic materials be required to wear NIOSH approved self contained breathing apparatus.

2. Blender hatch covers should be kept closed except when materials are being manually dumped into the blenders.

3. The company should continue to periodically monitor the Print Service and Laminating areas to insure the effectiveness of existing ventilation systems to adequately control ink solvent vapor exposures.

4. The significance of the symptomatic abnormalities experienced by the workers is unknown. It is recommended, therefore, that a worker health surveillance program be instituted. This program should include documentation of individual exposures by combining personnel assignment records with a record of agent usage. Annual respiratory symptom questionnaires should be administered, and pulmonary function should be retested with spirometry at 3 to 5 year intervals.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After ninety (90) days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati, Ohio address.

Copies of this report have been sent to:

1. Intex Plastics
2. Local 759, United Rubber Workers
3. United Rubber Workers International
4. U.S. Department of Labor (OSHA), Region IV
5. NIOSH Region IV
6. Designated State Agencies

For the purpose of informing the approximately 375 "affected employees", the employer will promptly "post" this report for a period of thirty (30) calendar days in a prominent place(s) near where the affected employees work.

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TABLE 1

INTEX PLASTICS
CORINTH, MISSISSIPPI
HE 79-34

SOLVENT VAPOR CONCENTRATIONS

Job Classification	Type of Sample	Sampling Time	Concentration in ppm MEK	Toluene	Cyclohexanone	Xylene	MIBK	Combined Exposure Value
			June 10, 1980 (second shift)					
Print Department								
Printer, mch. 6	personal	3:48pm-9:24pm	39.0	8.8	ND	ND	<0.1	0.3
Print Tender, mch. 6	personal	3:49pm-9:24pm	17.8	6.7	ND	ND	ND	0.2
Printer, mch. 5	personal	3:53pm-9:31pm	113.2	12.9	0.2	ND	2.0	0.7
Print Tender, mch. 5	personal	3:55pm-9:30pm	33.0	6.4	ND	ND	0.3	0.2
Printer, mch. 4	personal	3:59pm-9:25pm	14.7	4.3	ND	ND	<0.1	0.1
Print Tender, mch. 4	personal	4:06pm-9:27pm	20.9	6.0	ND	ND	<0.1	0.2
Print Service								
Color Shader	personal	4:02pm-9:28pm	36.2	6.4	ND	ND	0.7	0.3
Color Shader	personal	4:04pm-9:28pm	40.4	8.3	ND	ND	0.3	0.3
On fire blanket box	area	4:40pm-9:26pm	112.1	8.7	ND	ND	2.2	0.5
Laminating Dept.								
Top Coater, mch. 3	personal	4:27pm-9:35pm	105.2	25.1	0.2	ND	<0.1	0.8
Top Coater, mch. 5	personal	4:32pm-9:41pm	105.1	26.2	0.3	ND	ND	0.8
On elec. box by mch. 3	area	4:34pm-9:38pm	174.4	45.0	0.2	ND	<0.1	1.3
Environmental Criteria			200*	100*	25**	100*	50**	1.0***

Mixture formula

$$\frac{exp}{200} + \frac{exp}{100} + \frac{exp}{25} + \frac{exp}{100} + \frac{exp}{50} = \text{Exposure Value}$$

TABLE 1

SOLVENT VAPOR CONCENTRATIONS

Job Classification	Type of Sample	Sampling Time	Concentration in ppm: MEK	Toluene	Cyclohexanone	Xylene	MIBK	Combined Exposure Value
		June 11, 1980 (first shift)						
Print Department								
Printer, mch. 5	personal	7:20am-2:42pm	76.1	16.0	ND	ND	<0.1	0.2
Print Tender, mch. 5	personal	7:21am-2:45pm	23.1	5.4	ND	ND	ND	0.2
Printer, mch. 4	personal	7:29am-2:43pm	33.6	5.9	ND	ND	0.1	0.2
Print Tender, mch. 4	personal	7:32am-2:49pm	28.0	5.9	ND	ND	<0.1	0.2
Print Tender, mch. 4	personal	7:34am-2:40pm	21.5	5.2	ND	ND	<0.1	0.2
Printer, mch. 2	personal	7:37am-2:44pm	38.2	5.1	ND	ND	<0.1	0.2
Print Tender, mch. 2	personal	7:36am-2:45pm	30.9	5.5	ND	ND	0.1	0.2
Printer, Relief Man	personal	7:41am-2:45pm	62.8	9.7	0.1	ND	0.1	0.4
Pit btw. mch. 4 and 5	area	7:46am-2:50pm	193.3	30.0	ND	ND	0.4	1.3
Pit near mch. 1	area	7:49am-2:47pm	16.6	3.3	ND	ND	ND	0.1
Print Service								
Old Ink Service Man	personal	7:53am-2:35pm	228.8	17.2	ND	ND	1.3	1.3
Color Shader	personal	7:56am-2:35pm	130.6	10.8	ND	ND	1.4	0.8
Color Shader	personal	7:58am-2:39pm	50.4	6.8	ND	ND	0.5	0.3
On fire blanket box	area	8:08am-2:37pm	207.1	15.5	0.3	ND	2.9	1.3
Color Shader	personal	8:02am-4:39pm	62.4	7.3	ND	ND	0.5	0.4
Outside Plant								
Barrel Washer	personal[1]	8:04am-2:22pm	139.0	18.7	ND	ND	0.6	0.9
Still Operator	personal[1]	8:17am-2:27pm	32.4	3.8	0.2	ND	0.1	0.2
Color Department								
Color Compounder	personal[2]	8:35am-2:20pm	21.2	4.2	ND	ND	ND	0.1
Environmental Criteria			200*	100*	25**	100*	50**	1.0***

Mixture formula

$$\frac{exp}{200} + \frac{exp}{100} + \frac{exp}{25} + \frac{exp}{100} + \frac{exp}{50} = \text{Exposure Value}$$

TABLE 1

SOLVENT VAPOR CONCENTRATIONS

Job Classification	Type of Sample	Sampling Time	Concentration in ppm MEK	Toluene	Cyclohexanone	Xylene	MIBK	Combined Exposure Value
		June 12, 1980 (first shift)						
Print Service								
Color Shader	personal	7:26am-2:32pm	61.2	6.1	0.2	ND	0.4	0.4
Color Shader	personal	7:29am-2:34pm	97.7	6.3	0.2	ND	0.8	0.6
Color Shader	personal	7:35am-2:32pm	36.7	3.3	ND	<0.1	0.2	0.2
Old Ink Service Man	personal	7:34am-2:32pm	181.3	16.1	0.2	<0.1	0.7	1.1
Color Department								
Color Compounder	personal[3]	7:41am-2:38pm	24.4	4.7	1.0	<0.1	1.1	0.2
Color Compounder	personal[1]	7:51am-2:39pm	15.1	3.9	ND	ND	0.1	0.1
Laminating Dept.								
Top Coater, mch. 5	personal	8:04am-2:40pm	73.8	19.5	ND	ND	ND	0.6
Top Coater, mch. 3	personal	1:18am-2:47pm	89.8	18.9	ND	ND	0.3	0.6
Outside Plant								
Barrel Washer	personal[1]	7:31am-2:31pm	156.6	25.2	0.4	0.1	0.7	1.1
Still	area	10:53am-2:42pm	34.4	5.6	0.3	ND	0.3	0.2
Environmental Criteria			200*	100*	25**	100*	50**	1.0***

Mixture formula $\frac{exp}{200} + \frac{exp}{100} + \frac{exp}{25} + \frac{exp}{100} + \frac{exp}{50} = \text{Exposure Value}$

* American Conference of Governmental Industrial Hygienists - Recommended TLV's for 1981

** NIOSH Criteria for a Recommended Standard - Occupational Exposure to Ketones

*** If combined exposure value is less than 1.0, environmental criteria is not exceeded

< = Less than value indicated

ND = Not Detected

Notes: 1. This person was also exposed to mineral spirits at a concentration of less than 20mg/M^3.

2. This person was also sampled for methyl methacrylate but no exposure was detected.

3. During the cleaning of plastisol tubs, this person was also exposed to mineral spirits vapors at a concentration of 115 mg/M^3, the NIOSH recommended limit for mineral spirits is 350 mg/M^3.

TABLE 2

INTEX PLASTICS
CORINTH, MISSISSIPPI
HE 79-34

SOLVENT VAPOR CONCENTRATIONS
September 24-25, 1980 (first shift)

Job Classification	Type of Sample	Sampling Time	Concentration in ppm MEK	Concentration in ppm Toluene	Concentration in ppm Xylene	Combined Exposure Value
Print Service						
(Sept. 24)						
Old Ink Service Man	personal	8:34am-2:10pm	127	12	ND	0.8
On fire blanket box	area	8:36am-2:12pm	85	13	ND	0.6
(Sept. 25)						
On fire blanket box	area	7:32am-12:50pm	64	7	ND	0.4
Print Department						
(Sept. 24)						
Printer, mch. 5	personal	8:44am-2:46pm	40	8	ND	0.3
Pit btw. mch. 4 and 5	area	8:51am-2:48pm	96	15	ND	0.6
(Sept. 25)						
Pit btw. mch. 4 and 5	area	7:30am-2:52pm	41	2	ND	0.2
Outside Plant						
(Sept. 24)						
Barrel Washer	personal	8:47am-2:11pm	76	13	ND	0.5
Laminating Dept.						
(Sept. 24)						
On elec. box by mch. 3	area	8:56am-2:51pm	48	25	0.2	0.5
Top Coater	personal	9:15am-2:52pm	22	15	0.1	0.3
On elec. box by mch. 5	area	9:21am-2;52pm	28	26	0.7	0.4
(Sept. 25)						
On elec. box by mch. 3	area	7:52am-2:53pm	52	12	ND	0.4
Top Coater	personal	7:59am-2:52pm	63	11	ND	0.4
On elec. box by mch. 5	area	8:00am-2:52pm	59	14	ND	0.4
Environmental Criteria			200*	100*	100*	1.0**

Mixture formula $\frac{exp}{200} + \frac{exp}{100} + \frac{exp}{25} =$ Exposure Value

* American Conference of Governmental Industrial Hygienists - Recommended TLV's for 1981
** If combined exposure value is less than 1.0, environmental criteria is not exceeded
ND = Not Detected

TABLE 3

INTEX PLASTICS
CORINTH, MISSISSIPPI
HE 79-34

COMPARISON OF SAMPLING AND ANALYTICAL METHODS FOR
METHYL ETHYL KETONE (MEK)

April 28, 1981 (second shift)

Job Classification	Type of Sample	Sampling Time	Concentration Detected		% Increase
			NIOSH Method*	OSHA Method**	
Print Service					
Asst Shader	personal	7:09pm-10:23pm	110.0	135.3	23
Color Shader	personal	7:12pm-10:20pm	33.3	43.3	30
On fire blanket box	area	7:16pm-10:26pm	141.3	174.6	24
Environmental Criteria (ACGIH Recommended TLV for 1981)			200	200	

* NIOSH Method S-3 - Samples collected on charcoal tubes at 200 cc/min.
** OSHA Method No. 16 - Samples collected on silica gel tubes at 20 cc/min. Maximum air sample volume recommended was 3 liters.

TABLE 4

INTEX PLASTICS
CORINTH, MISSISSIPPI
HE 79-34

CALENDER AND COLOR DEPARTMENT
AIRBORNE DUST CONCENTRATION

Job Classification	Type of Sample	Sampling Time	Concentration in mg/M^3 Total Dust	Barium	Cadmium
Pre-mix Area					
		June 10, 1980 (second shift)			
Pre-mix Operator	personal	3:46pm-10:18pm	6.8	ND	ND
		June 11, 1980 (first shift)			
Pre-mix Operator	personal	7:20am-2:42pm	0.9	0.01	0.004
Control Room	area	7:57am-2:40pm	ND	ND	ND
Penthouse	area	7:58am-2:45pm	5.9	0.02	0.01
		June 12, 1980 (first shift)			
Penthouse	area	7:25am-2:38pm	9.2	0.02	0.01
Helper	personal	7:33am-2:36pm	0.3	ND	ND
Pre-mix Operator	personal	7:25am-2:42pm	0.9	ND	ND
Calender Department					
		June 10, 1980 (second shift)			
No. 3 Windup Man	personal	4:08pm-10:06pm	ND	ND	ND
Helper	personal	4:11pm-10:16pm	0.6	ND	ND
No. 3 Continuous Mix	area	4:18pm-10:09pm	0.8	ND	ND
No. 1 Utility Man	personal	3:35pm-10:07pm	0.3	ND	ND
No. 2 Banbury Opr.	personal	3:49pm-10:10pm	0.1	ND	ND
No. 2 Mill Man	personal	3:52pm-10:13pm	0.1	ND	ND
No. 3 Calender Opr.	personal	4:02pm-10:19pm	0.2	ND	ND
No. 3 Mill Man	personal	4:08pm-10:08pm	0.4	ND	ND
No. 1 Extruder, Maint.	personal	3:58pm-10:13pm	0.1	ND	ND
No. 1 Calender Opr.	personal	5:44pm-10:13pm	ND	ND	ND
Evaluation Criteria:			10.0*	0.5*	0.04**

* ACGIH recommended TLV's for 1983-84
** NIOSH criteria for a recommended standard - Occupational Exposure to Cadmium

TABLE 4

CALENDER AND COLOR DEPARTMENT
AIRBORNE DUST CONCENTRATION

Job Classification	Type of Sample	Sampling Time	Concentration in mg/M^3 Total Dust	Barium	Cadmium
Calender Dept.					
		June 11, 1980 (first shift)			
No. 2 Mill Man	personal	7:35am-2:38pm	0.3	ND	ND
No. 3 Calender Opr.	personal	7:08am-2:31pm	0.2	ND	ND
No. 3 Mill Man	personal	7:16am-2:33pm	0.2	ND	ND
No. 3 Windup Man	personal	7:10am-2:31pm	0.1	ND	ND
Utility Man	personal	7:11am-2:35pm	0.2	ND	ND
No. 1 Calender Opr.	personal	7:43am-2:35pm	0.2	ND	ND
Helper	personal	7:32am-2:36pm	0.1	ND	ND
No. 2 Banbury Opr.	personal	7:37am-2:35pm	0.1	ND	ND
No. 1 Windup Man	personal	7:40am-2:38pm	0.02	ND	ND
		June 12, 1980 (first shift)			
No. 2 Banbury Opr.	personal	7:47am-2:39pm	0.5	ND	ND
Color Department					
		June 10, 1980 (second shift)			
Compounder, mix skins	personal	6:00pm-8:33pm	ND	ND	ND
No. 1 Skin Tank	area	6:04pm-9:22pm	---	ND	ND
		June 11, 1980 (first shift)			
Comp. mix foams/clears	personal	8:38am-2:18pm	3.1	ND	ND
B-grind mixers	area	8:45am-2:43pm	0.004	ND	ND
		June 12, 1980 (first shift)			
Comp. mixing foams	personal	7:50am-2:39pm	4.4	ND	ND
Evaluation Criteria:			10.0*	0.5*	0.04**

* ACGIH recommended TLV's for 1981
** NIOSH criteria for a recommended standard - Occupational Exposure to Cadmium

ND = None Detected
Note: Air samples were also analyzed for zinc compoounds but no zinc was detected on any of the samples.

TABLE 5

INTEX PLASTICS
CORINTH, MISSISSIPPI
HE 79-34

COLOR DEPARTMENT
AIRBORNE LEAD CONCENTRATION

September 25, 1980

Job Classification	Type of Sample	Sampling Time	Concentration in µg/M³
Color Compounders:			
B-Grinding	personal	7:42am-8:50am	156
rest of shift	personal	8:50am-2:48pm	ND
Total Exposure	TWA	7:42am-2:48pm	25
Making skins	personal	7:43am-2:48pm	ND
Making foams	personal	7:45am-2:48pm	ND
Area Samples			
Mixing Room	area	7:52am-2:49pm	ND
Near B-Grind Mixer	area	7:48am-2:50pm	97
Evaluation Criteria:			
OSHA Standard as 8-hour time weighted average (TWA)			50

ND = None Detected
µg/M³ = micrograms of lead per cubic meter of air

TABLE 6

INTEX PLASTICS
CORRINTH, MISSISSIPPI
HE 79-34

"DOP" CONCENTRATIONS
CALENDER DEPARTMENT

June 10-12. 1980

Job/Location	Sampling Period	Sample Volume (liters)	DOTP* (mg/M^3)	DEHP** (mg/M^3)
June 10, 1980				
No. 3 Calender Oper.	5:27pm-10:19pm	292	ND	ND
No. 2 Calender Oper.	5:32pm-10:10pm	287	0.07	ND
No. 1 Calender Oper.	5:42pm-10:13pm	271	0.04	ND
Above No. 3 Calender (area)	5:50pm-9:15pm	154	0.05	ND
Above No. 1 Calender (area)	5:42pm-10:17pm	275	0.11	ND
Above Extruder (area)	5:35pm-10:12pm	277	ND	ND
June 11, 1980				
Near No. 2 Extruder (area)	7:51am-2:39pm	408	3.92	0.12
Above No. 1 Calender (area)	7:50am-2:41pm	411	6.08	0.24
No. 3 Calender Oper.	7:07am-2:31pm	444	0.14	ND
No. 3 Mill Man	7:15am-2:33pm	438	0.16	ND
Above No. 3 Calender (area)	7:51am-2:54pm	423	4.73	ND
No. 1 Calender Oper.	7:43am-2:35pm	412	0.05	ND
No. 2 Banbury Oper.	7:37am-2:35pm	418	0.12	ND
June 12, 1980				
No. 1 Calender Oper.	7:47am-2:42pm	415	0.10	ND
No. 3 Calender Oper.	7:17am-2:33pm	436	0.09	ND
No. 3 Calender (area)	7:15am-2:34pm	439	2.20	0.68
(No 3 Calender not operating from 1030-1330)				
Evaluation Criteria:				
OSHA permissible exposure limit as 8-hour TWA			None	5.0
Limits of Detection:			0.01mg	0.01mg

* DOTP = 1,4-dioctyltera phthalate
** DEHP = 1,2-diethylhexyl phthalate
(di-sec, octyl phthalate)

mg/M^3 = milligrams of phthalate per cubic meter of air

TABLE 7

INTEX PLASTICS
CORINTH, MISSISSIPPI
HE 79-34

VINYL CHLORIDE MONITORING
PRE-MIX AREA

June 12, 1980

Location	Type of Sample	Sampling Time	Vinyl Chloride Concentration in ppm
Penthouse			
Above Blender	area	7:25am-8:55am	2.0
(mixing formula 209-F)	area	8:55am-10:30am	0.3
	area	10:30am-11:58am	0.7
	area	11:58am-1:20pm	ND
	area	1:20am-2:38pm	ND
Control Room			
Above Blender No. 2	bulk air	7:20am-2:35pm	ND
(mixing formula 0010A)	area	7:30am-8:55am	ND
	area	8:55am-10:30am	ND
	area	10:30am-11:58am	ND
	area	11:58am-1:20pm	ND
	area	1:20pm-2:35pm	ND
Pre-Mix Operator			
	personal	7:25am-8:55am	ND
	personal	8:55am-10:30am	ND
	personal	10:30am-11:58am	ND
	personal	11:58am-1:20pm	ND
	personal	1:20pm-2:42pm	ND
Evaluation Criteria: (OSHA Standard as 8-hour time weighted average)			1.0

ND = None Detected

TABLE 8

INTEX PLASTICS
CORINTH, MISSISSIPPI
HE 79-34

CALENDER DEPARTMENT

(SANTICIZER 146)tn CONCENTRATION
isodecyldiphenyl phosphate (IDDP)

April 28, 1981
(second shift)

Job Classification	Type of Sample	Sampling Time	Concentration in mg/M^3
No. 3 Calender Opr.	personal	6:18pm-10:40pm	ND
No. 3 Mill Man	personal	6:22pm-10:42pm	ND
Above Calender No. 3	area	6:30pm-10:53pm	3.7
No. 1 Banbury Opr.	personal	6:35pm-10:48pm	ND
No. 1 Mill Man	personal	6:38pm-10:50pm	ND
Above Mill No. 1	area	6:38pm-10:50pm	ND
Penthouse	area	5:55pm-10:49pm	ND
Pre-Mix Opr. Helper	personal	6:01pm-10:46pm	ND

Minimum level of detection = .5mg/sample or approximately 1.8 mg/M^3 for the air sample volume collected.

No environmental criteria or OSHA standards have been established for IDDP.

ND = None Detected

TABLE 9

INTEX PLASTICS
CORINTH, MISSISSIPPI
HE 79-34

CALENDER DEPARTMENT

ANTIMONY OXIDE CONCENTRATION

April 28, 1981
(second shift)

Job Classification	Type of Sample	Sampling Time	Concentration in mg/M³ (as antimony)
Pre-Mix Area			
Pre-mix Operator	personal	6:06pm-10:45pm	0.0003
Pre-mix Opr. Helper	personal	6:00pm-10:46pm	0.0006
Penthouse			
Above blender No. 6	area	6:14pm-10-55pm	0.064
Near blender No. 5	area	6:14pm=10:55pm	0.016
Calender Area			
No. 3 Calender Opr.	personal	6:21pm-10:40pm	0.0005
No. 3 Mill Man	personal	6:23pm-10:42pm	0.0003

Environmental Criteria: (as 8-hour time weighted average - as antimony)	
NIOSH Recommended Standard for Antimony Oxide	0.5
ACGIH Recommended TLV	0.5
Current OSHA Standard	0.5

Note: Bulk sample analysis of antimony oxide compound in use at the time of this survey was found to contain only 8% antimony. Pure antimony oxide (Sb_2O_3) would contain 41.7% antimony.

TABLE 10

INTEX PLASTICS
CORINTH, MISSISSIPPI
HE 79-34

GAS CHROMATOGRAPHY/MASS SPECTROMETRY ANALYSIS RESULTS
PLASTIC FUMES AND VAPORS

Date Collected	Type Sample	Location	Formula No.	Sample Collection Media	Substances Identified
June 11, 1980	bulk air	No. 1 Calender	207A+0007A	Florisil tube (no prefilter)	Major Component: 1,4-di-octyltera phthalate (Eastman DOTP) Other Components: -mixture of aliphatic hydrocarbons -methyl phthalate isomer -ethoxypropoxy propanol
June 11, 1980	bulk plastic heated to: 500-536° F	No. 1 Banbury discharge	0007A	Generated sample (heated plastic)	Major Component: 1,4-di-octyltera phthalate (Eastman DOTP) Other Components: -benzene -acetone -mixture of aliphatic hydrocarbons -nonylphenol isomers -phthalate esters
"	320-356° F	"	"	"	No volatiles detected

TABL[illegible]

GAS CHROMATOGRAPHY/MASS SPECTROMETRY ANALYSIS RESULTS
PLASTIC FUMES AND VAPORS

Date Collected	Type Sample	Location	Formula No.	Sample Collection Media	Substances Identified
Sept 24, 1980	bulk air*	Calender 1 and 3	189F	AA pre-filter**	Major Component: diisonyl phthalate (Jaflex DINP) Other Components: -1,4-di-octyltera phthalate (Eastman DOTP) -nonyl phenol isomers -tripropylene glycol -phenol
Sept 24, 1980	bulk air	Calender 2	159A	AA pre-filter**	Major Component: diisonyl phthalate (Jaflex DINP) Other Components: -other phthalates
Sept. 24, 1980	bulk air	Calender 1-3		charcoal tube	Major Components: toluene and trichloroethane Other Components: -mixture of 120 MW aromatics -methyl ethyl, trimentyl benzenes -C_9-C_{16} alkanes -xylene -methyl ethyl ketone (MEK)
Sept 24, 1980	bulk liquid	Laminating Dept.	QF 4344-36 (Urethane)	N/A	Major Component (as vapor): toluene Other Components: -isopropanol -methyl ethyl ketone (MEK) -xylene

* Analyses of filters on calender 1 and 3 gave same mass spectrum patterns
** Millipore AA type filter with steel back-up pad

TABLE 11

SUMMARY OF EXPOSURE LIMITS* and HEALTH EFFECTS
for SUBSTANCES MEASURED at INTEX PLASTICS
CORINTH, MISSISSIPPI

HE 79-34

SUBSTANCE	OSHA PEL**	ACGIH TLV***	NIOSH RECOMMENDATION	HEALTH EFFECTS CONSIDERED	REFERENCE
Methyl Ethyl Ketone (MEK) [CAS 79-93-3]	200 ppm	200 ppm 300 ppm STEL	200 ppm	Irritation; liver, kidney and nervous system effects	13
Cyclohexanone [CAS 108-94-1]	50 ppm	25 ppm 100 ppm STEL	25 ppm	"	13
Methyl isobutyl ketone [CAS 108-10-1]	100 ppm	50 ppm 75 ppm STEL	50 ppm	"	13
Toluene [CAS 108-88-3]	200 ppm 300 ppm ceiling 500 ppm max.	100 ppm 150 ppm STEL	100 ppm 200 ppm/10 min	Central nervous system depressant	15
Xylene [CAS 1330-20-7]	100 ppm	100 ppm 150 ppm STEL	100 ppm 200 ppm/10 min	Central nervous system depressant; respiratory irritation	16
Mineral Spirits	2950 mg/M^3 (for Stoddard solvent)	525 mg/M^3 1050 mg/M^3 STEL	350 mg/M^3	Central nervous system depressant	17
PVC Dust [CAS 9002-86-2]	15 mg/M^3	10 mg/M^3	--	Reduced visibility, eye irritation; upper respiratory congestion	
Vinyl chloride monomer [CAS 75-01-4]	1 ppm 5 ppm ceiling	5 ppm	minimum detectable	Liver cancer	21

TABLE 11

SUMMARY OF EXPOSURE LIMITS* and HEALTH EFFECTS
for SUBSTANCES MEASURED at INTEX PLASTICS

SUBSTANCE	OSHA PEL**	ACGIH TLV***	NIOSH RECOMMENDATION	HEALTH EFFECTS CONSIDERED	REFERENCE
Lead [CAS 7439-92-1]	0.05 mg/M^3	0.15 mg/M^3 0.45 mg/M^3 STEL	<0.1mg/M^3	Kidney, blood, and nervous system effects	19
Barium [CAS 7440-39-3]	0.5 mg/M^3	0.05 mg/M^3	--	Skin, eye, and upper respiratory irritation	14
Cadmium [CAS 7440-43-9]	0.2 mg/M^3 0.6 mg/M_3 (ceiling)	0.05 mg/M^3 0.2 mg/M^3 STEL	0.04 mg/M^3 0.2 mg/M^3 (ceiling)	Lung and kidney effects	16
di-sec-Octyl phthalate (DEHP) [CAS 117-81-7]	5 mg/M^3	5 mg/M^3	--	mild eye irritation	14
Antimony oxide [CAS 1309-64-4]	0.5 mg/M^3	0.5 mg/M^3	0.5 mg/M^3	Irritation; heart and lung effects	14

* Limits are 8-hour time-weighted averages (TWA) unless otherwise stated.
** For OSHA standards, see Reference No. 11
*** For ACGIH TLV's, see Reference No. 2

ppm = parts per million parts of air
mg/M^3 = milligrams per cubic meter of air

TABLE 12

INTEX PLASTICS
CORINTH, MISSISSIPPI
HE 79-34

TESTS ADMINISTERED, BY CURRENT DEPARTMENT

Current Dept.	Total in Dept.	Total WM	Total* Eligible	Administered Questionnaire	Acceptable Pre-shift Spirometry	Acceptable Post-shift Spirometry	Work History Available
A	64	43	42	41	40	39	38
B	41	25	25	23	22	21	21
C	55	46	42	38	38	38	37
D	9	6	6	6	6	6	6
E	41	37	37	25	23	22	22
F	70	50	50	41	41	39	[illegible]
OTHER	80	61	0	0	0	0	0
TOTAL	360	274	202	174 Study Population	170	165	163

*Eligibles: White males working in depts. A-F during week of study, e.g.,

Not sick or laid-off

TABLE 13

INTEX PLASTICS
CORINTH MISSISSIPPI
HE 79-34

CHARACTERISTICS OF ELIBIBLE WORKERS STUDIED AND NOT STUDIED

CHARACTERISTIC		ELIGIBLES NOT STUDIED	ELIGIBLES STUDIED
Age ($\overline{x}$ ± S.D.)		43.7 ± 8.5	41.8 ± 10.3
Duration of employment ($\overline{x}$ ± S.D.)		13.3 ± 4.9	12.1 ± 5.2
			(Percent of total in dept.)
Department	A	1	41 (97.6)
	B	2	23 (92.0)
	C	4	38 (90.5)
	D	0	6 (100.0)
	E	12	25 (67.6)
	F	9	41 (82.0)
TOTAL		28	174 (86.1)

TABLE 14

INTEX PLASTICS
CORINTH MISSISSIPPI
HE 79-34

DEMOGRAPHIC CHARACTERISTICS OF STUDY POPULATION, BY CURRENT DEPARTMENT

Characteristic		Current Department						
		A	B	C	D	E	F	TOTAL
N		41	23	38	6	25	41	174
Height (inches) ($\bar{x}$±S.D.)		70.2 ±3.3	70.4 ±2.9	69.1 ±2.5	69.1 ±0.9	70.6 ±2.6	69.6 ±2.1	70.1 ±2.7
Duration of total employment (yrs.)($\bar{X}$±S.D.)		10.6 ±5.2	15.0 ±3.8	11.5 ±5.6	8.2 ±5.8	10.8 ±5.8	14.2 ±3.7	12.2 ±5.2
Age (yrs.)	<30	13	1	2	2	1	3	22
	30-39	10	2	19	0	8	14	55
	40-49	12	9	10	1	12	9	56
	50+	6	11	7	3	4	15	47
	$\bar{X}$±S.D.	37.7 ±9.9	47.3 ±9.0	39.8 ±9.7	43.7 ±18.7	42.2 ±7.5	44.0 ±10.7	41.8 ±10.1
Smoking status								
Non-smoker		18	10	13	2	11	18	75
Ex-smoker		4	4	5	2	3	7	25
Current, <1 pk/day		4	3	4	1	1	2	15
Current, ≥1 pk/day		15	6	16	1	10	14	65

TAB[illegible]5

INTEX PLASTICS
CORINTH MISSISSIPPI
HE 79-34

DURATION IN DEPARTMENTS BY CURRENT DEPARTMENT

Current Dept.	N	Ever in Department A (N=86)	B (N=88)	C (N=83)	D (N=37)	E (N=31)	F (N=86)	OTHER (N=45)	Percent of total duration of employment spent in current department
A	41	6.64 (±6.39)	0.68 (±1.99)	0.37 (±0.87)	0.19 (±0.76)	0.00 (±0.00)	0.32 (±1.83)	1.91 (±2.21)	62.6
B	23	0.21 (±0.46)	12.32 (±6.05)	0.77 (±3.25)	0.02 (±0.07)	0.00 (±0.00	0.54 (±1.58)	1.14 (±1.61)	82.1
C	38	0.11 (±0.27)	1.15 (±2.47)	8.36 (±5.77)	0.60 (±1.46)	0.00 (±0.01)	0.21 (±0.65)	1.07 (±1.43)	72.7
D	6	0.02 (±0.03)	0.07 (±0.16)	1.66 (±2.58)	5.21 (±5.71)	0.00 (±0.00	0.02 (±0.02	1.18 (±2.15	63.8
E	25	0.19 (±0.57)	0.23 (±0.73)	0.38 (±1.08)	0.13 (±0.50)	7.51 (±5.69)	0.72 (±2.14)	1.63 (±2.93)	69.6
F	41	1.73 (±2.60)	0.30 (±0.97)	1.06 ±2.08)	0.11 (±0.42)	0.17 (±1.10)	8.40 (±4.42)	2.49 (±2.69)	58.6
TOTAL	174								

Mean percent of total duration of employment of study population spent in any of the studied departments = 87.6

TABLE 16

INTEX PLASTICS
CORINTH MISSISSIPPI
HE 79-34

SUMMARY OF SIGNIFICANT DIFFERENCES IN ADJUSTED RATES OF RESPIRATORY SYMPTOMATOLOGY, BY CHARACTERISTICS

	CHARACTERISTIC						
SYMPTOM	AGE	HEIGHT	SMOKING	SHIFT	DAY OF WEEK	DURATION IN CURRENT DEPARTMENT	CURRENT DEPARTMENT
COUGH			Current>Never[2]		Mon>Wed[2]		
CHRONIC COUGH			Current>Never[1]		Mon>Wed[1]	(≥.5) > (<.5)[1]	
PHELGM							
CHRONIC PHELGM		(<67) (67-71)[1]			Mon>Wed[1]	(≥.5) > (<.5)[1]	
CHRONIC WHEEZE			Never>Previous[1]		Mon>Wed[2]		
SOB and WHEEZE							
SOB 1							
SOB 2							B>F[2]
SOB 3							C>F[1]
CHEST TIGHTNESS,							
SORE THROAT				1>2[2]			
CHRONIC SORE THROAT						(≥.5) < (<.5)[1]	
HOARSENESS				3>1[4]			F>A[3]
CHRONIC HOARSENESS				3>1[3]		(≥.5) > (<.5)[1]	
CONJUNCTIVITIS							
RHINITIS				1>3[2]			
CHRONIC RHINITIS							

1 = p .05
2 = p .02
3 = p .01
4 = p .001

TABLE 17

INTEX PLASTICS
CORINTH MISSISSIPPI
HE 79-34

SUMMARY OF SIGNIFICANT DIFFERENCES IN ADJUSTED PRE-SHIFT PULMONARY FUNCTION, BY CHARACTERISTICS

PULMONARY FUNCION	CHARACTERISTIC AGE	HEIGHT	SMOKING	SHIFT	DAY OF WEEK	DURATION IN CURRENT DEPARTMENT	CURRENT DEPARTMENT
FEV_1	(30-39)<(<30)[2] (40-49)<(<30)[4] (50+) < (<30)[4]	(71+)>(67-71)[4]	Current-never[3]				
FVC	(49-49)<(<30)[3]	(71+)>(67-71)[4]			Weds<Mon[1]		
FEV_1/FVC	(30-39)<(<30)[1] (40-49)<(<30)[2] (50+) < (<30)[4]		Current<never[3]				
FEV_3FEV_6	(30-39)<(<30)[3] (40-49)<(<30)[4] (50+) < (<30)[4]						

1 = p <.05
2 = p <.02
3 = p <.01
4 = p <.001

TABLE 18

INTEX PLASTICS
CORINTH MISSISSIPPI
HE 79-34

SUMMARY OF SIGNIFICANT DIFFERENCES IN ADJUSTED CROSS-SHIFT CHANGE* IN PULMONARY FUNCTION, BY CHARACTERISTICS

	CHARACTERISTIC						
PULMONARY FUNCION	AGE	HEIGHT	SMOKING	SHIFT	DAY OF WEEK	DURATION IN CURRENT DEPARTMENT	CURRENT DEPARTMENT
ΔFEV_1							
ΔFVC					Fri>Mon[1]		
$\Delta FEV_1/FVC$				2<1[1]		$(<.5)>(\geq.5)$[2]	
$\Delta FEV_3/FEV_6$	(40-49)>(<30)[1]	(>71)>(67-71)[1]					D>F[1]

1 $p = <.05$
1 $p = <.01$

*Cross shift change = $\frac{(\text{Post-pre})}{\text{pre}} \times 100$

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