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

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 76-60-398

HAYES-ALBION CORPORATION
WOLVERINE PLASTICS DIVISION
MILAN, MICHIGAN

JUNE 1977

I. TOXICITY DETERMINATION

A Health Hazard Evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) at the Hayes-Albion Corporation, Wolverine Plastics Division, May 5-7, August 17-18, and August 29 to September 2, 1976 regarding exposure of workers to organic solvents, isocyanates, and thermal degradation products from injection molding of thermoplastics. Methodology used in the evaluation included: (1) environmental sampling, (2) medical evaluation by interviews, (3) a follow-up with private physicians regarding health problems of interest, (4) review of company records, (5) laboratory investigation and literature search on thermal decomposition products of plastics, (6) inspection of the workplace and materials used, (7) evaluation of work practices, and (8) literature review on various processes and material used in the plant.

Results of the environmental sampling indicate that employees were not exposed to airborne contaminants at toxic concentrations during the investigation. Personal and area samples were collected over 8-hour work shifts to determine the airborne concentrations of acetone methyl ethyl ketone, benzene, methyl isobutyl ketone, methyl isobutyl carbinol, toluene, xylene, diisobutyl ketone, butyl cellosolve, tungsten, chromium, and nickel in the Decorating Department; toluene diisocyanate, methylene bisphenyl isocyanate, hydrogen cyanide, benzene, toluene, ethyl benzene, styrene, methyl styrene, phenol, and a qualitative and quantitative analyses for phthalates, aromatic amines, cresols, and organic vapors in the Finishing Department; and for formaldehyde, total aldehydes, phenol, hydrogen cyanide, ammonia, butyl-p-cresol, particulate weight determination, and a qualitative and quantitative analyses for phthalates, aliphatic and aromatic amines, cresols, organic vapors and heavy metals in the Molding Department. Short term samples were taken for phenol, hydrogen cyanide, formaldehyde, ammonia, styrene, benzene, acrylonitrile, nitrogen dioxide, triethylamine, dimethylformamide, vinyl chloride, ethyl acetate, methylene chloride, acetic acid, and carbon monoxide.

From data collected during the medical evaluation no basis could be found to relate the cases of thrombophlebitis and vocal cord modules to chemical exposures. The evaluation did reveal possible problems with contact dermatitis from organic solvents, plastics, and jewelry.

Other health problems mentioned during employee interviews included breathing difficulties from isocyanate paints (used in the past) and an obscure labarynthine disorder possibly related to ultrasonic welding exposures. A review of the literature and discussion with people knowledgeable in the field of ultrasound did indicate the possibility of problems with ultrasonic radiation. Although no reports were found associating thrombophlebitis with ultrasound, experimental results in chick embryos have shown alterations in blood flow which might predispose to clotting. Due to ultrasound being a physical agent, NIOSH was not authorized to investigate this energy source under the regulations governing the Health Hazard Evaluation.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio. 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati address. Copies of this report have been sent to:

a. Hayes-Albion Corporation, Milan, Michigan
b. United Rubber, Cork, Linoleum, and Plastic Workers of America, Local No. 552
c. U.S. Department of Labor - Region V
d. NIOSH - Region V

For the purpose of informing the approximately 200 "affected employees" the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

III. INTRODUCTION

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

The National Institute for Occupational Safety and Health received such a request from an authorized representative of employees regarding exposure of workers to organic solvents, isocyanates, and thermal degradation products from injection molding of thermoplastics. The request stated that some workers were developing nodes on their vocal cords, and that there have been a number of unexplained blood clots, and suggestion of tumors.

IV. HEALTH HAZARD EVALUATION

A. Conditions of Use

The work force at Hayes-Albion is composed of approximately 200 production and supervisory personnel in 3 shifts; the majority work during the day shift. The process is located in 112,000 square feet of building space, with a ceiling height which ranges from 15 to 30 feet. Equipment housed in the facility when visited included 17 injection molding presses, 2 metalizing evaporators, 21 spray painting booths, 3 ultrasonic welding units, and various equipment for woodgrain and hot-stamp-decorating.

This facility takes already formulated pelletized plastic, molds it in presses (utilizing heat and pressure) into selected shapes (mainly auto trim) and then spray paints the parts, stamps on metalized or other decorations, and/or deposits a metallic film using heat, static charge, and low pressure. The plastic is not intentionally heated to destruction.

B. Process Description

The process consisted basically of three phases: (1) injection molding, (2) decorating, and (3) finishing.

1. Injection Molding

At the time of the investigation, the plastics used for injection molding included acrylonitrile - butadiene - styrene copolymer (ABS material), polypropylene, cycoloy (one-half ABS and one-half polycarbonate), nylon (polyamides), and surlyn (ionomer resin). Other plastics used occasionally in the process were noryl (polyphenylene), polyethylene, and plexiglass (methyl methacrylate). These last three plastics accounted for less than six percent of the total production from January to July of 1976. The most frequently used plastic was ABS, which was used for more than 70 percent of the plastics molded.

The injection molding process consisted of plastic pellets being fed from a vacuum loading system into a heated cylinder where they were reduced to a molten state. Either virgin pellets or a combination of virgin material, reground scrap material, and/or reprocessed material were used for charging the presses. The temperature which the charged material was heated varied according to the item being molded and the type of plastic used. The approximate cylinder temperatures used for the various plastics were as follows: (1) nylon 470°F, (2) surlyn-380°F, (3) polypropylene-400°F, (4) cycoloy-470°F, and (5) ABS-400-580°F.

The operation was ventilated by the use of a general ventilation system and natural air movement through open doors.

2. Decorating

In the Decorating Department, various injection molded parts were painted or vacuum metalized. The painting process was done by compressed air atomization (spray painting) using manual or automatic equipment within the confines of a spray booth. The parts which were vacuum metalized had an aluminum coating deposited on them in a vacuum tank equipped with local exhaust. The process consisted of first applying a basecoat of a synthetic material, usually lacquer, to provide good adhesion, then drying the parts and placing them into a vacuum metalizing tank which was then pumped down to approximately one-millionth of normal atmospheric pressure. After the required vacuum level had been reached, aluminum filaments were heated by electric current to incandescence to melt the metal; the temperature was then quickly increased to cause metal vaporization. Upon completion of the process, the parts were spray painted with a protective coating.

3. Finishing

The two basic finishing operations were "Hot Stamping" and the placing of "Appliques". Hot stamping is the transfer of a bright aluminum finish onto a plastic molded part. This requires a combination of heat, dwell, and pressure. The part to be hot stamped comes in contact with an aluminum foil for 1 to 2 seconds at a temperature of approximately $300^{o}F$. Appliques require the removal of an adhesive backing and placing the applique on a finished part. Both operations were not mechanically ventilated.

C. Evaluation Design and Methods

The initial environmental and medical survey was conducted at Hayes-Albion from May 5-7, 1976. During this initial visit a walk-through survey of the facility was conducted, persons working in the plant were individually interviewed regarding possible health problems, air sampling was conducted, and bulk samples of various plastic materials were collected. From August 17-18, 1976, a follow-up medical evaluation to further investigate potential work-related health problems was performed. A final visit was made August 29 to September 2, 1976, to complete the environmental sampling.

1. Medical

Individual interviews of a sample of workers from all three shifts (see Table I for Characterization of the Work Force) were held, and permission was obtained to follow-up with private physicians concerning any medical problems of interest found in the interviews. The form used for the interviews is presented in Appendix A.

The sample to be interviewed was chosen to include all workers identified by management, the union president, or themselves as having medical problems, plus a random selection of workers. Sixty-five (65) workers were interviewed in person and 6 by telephone representing about 40% of the 176 person work force. The workers were predominantly white women. The sample included 61 women, with an average age of 43.1 years, a median age of 44 years, and a range of 24 to 64 years. There were 10 men included in the sample, with an average age of 33.6 years, a median age of 28.5 years, and a range of 18 to 65 years. Overall average of the workers in the sample was 41.8 years with a median age of 42 years.

A review of company records for the period of January through July, 1976, was made to determine which plastics were run in the molding department on each day and what jobs had been assigned to two molding operators who had recent phlebitis or thrombophlebitis (Table II and III). Results were reviewed to determine if any common factors were present.

2. Thermal Degradation Products

Bulk samples of the plastics in use at Hayes-Albion were collected and analyzed in the NIOSH laboratory to identify possible decomposition products evolved under normal operating conditions. Work was performed in three phases: (I) initial literature search. (II) monitoring with selected detector tubes, and (III) generation and analyses of solid sorbent samples. For the generation and monitoring steps, portions of the samples were heated in an enclosed furnace at their indicated injection molding temperatures. Air was passed over these heated samples and the effluent then passed into the solid sorbents. Refer to Tables IV and V for results of the analyses.

Phase I

Literature searches were conducted for the bulk plastics submitted and their decomposition products. Those compounds specifically searched for included acrylonitrile-butadiene-styrene (ABS) polymers, polycarbonates, polypropylene, polyolefin, methyl methacrylate, polyethylene and polyamides (nylon).

Phase II

Based on past experience and findings in the literature, the effluents evolved from the samples were monitored with an assortment of detector tubes to determine if certain decomposition products were present.

Phase III

At least three solid sorbent tubes were generated for each of the bulk samples--a charcoal tube (low boiling aliphatic and aromatic components), a silica gel tube (amines) and a fluorisil tube (high boiling components such as phthalates, and butyl-p-cresol. The solid sorbent tubes were desorbed and analyzed by gas chromatography (GC). A 12 foot, 1/4 inch glass column packed with 6% SP2100 was used for all the GC work. Charcoal tubes were desorbed with carbon disulfide, fluorisil with ethyl acetate, and the silica gel samples with methanol.

Representative samples with significant peaks were analyzed by GC/MS (gas chromatography/mass spectrometry) in an effort to identify as many of the compounds as possible. Chemical ionization (CI) mass spectrometry was also performed on some of the samples.

3. Air Sampling

Personal and area samples were used to evaluate employee exposure. The personal samplers were attached near the breathing zone of the employees to collect a representative sample of air. General area samples were positioned at specific locations in the working environment at a distance of 0.5 to 5 feet from the workers' breathing zones. Each of the sampling data tables (Tables VIII-XXI) includes information denoting the types of samples collected.

Organic vapors: Spray painting and oven line cleaning exposures from various organic vapors, including acetone, methyl ethyl ketone, benzene, methyl isobutyl ketone, methyl isobutyl carbinol, toluene, xylene, diisobutyl ketone, and butyl cellosolve were measured using tubes containing activated charcoal collecting media in conjunction with Sipin* pumps at a flow rate of approximately 50 milliliters (ml) per minute. The analysis was performed with carbon disulfide desorption and gas chromatography by the Utah Biomedical Test Laboratory.

Organic vapors: Exposures to organic vapors evolved from thermal decomposition products of plastics, were determined using the above mentioned sampling train. Qualitative and quantitative analyses (to identify both the contaminants present and their concentrations) were conducted with carbon disulfide desorption and gas chromatography/mass spectrometry at the NIOSH Laboratories in Cincinnati, Ohio.

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

Toluene diisocyanate (TDI) and Methylene Bisphenyl Isocyanate (MDI): The contaminants were collected by bubbling air through midget impingers containing 15 ml of absorbing solution using an MSA Model G pump at a flow rate of 1 liter per minute (lpm). The samples were analyzed colorimetrically at the Utah Biomedical Test Laboratory.

Chromium, Nickel, Copper, Zinc, Lead, and Tungsten: These metals were collected by drawing air through a 0.8 micron (u) AA filter at 1.5 lpm with a Model G pump. The determination consisted of ashing the filters with nitric acid and subsequent analyses by atomic absorption. For samples collected at the injection molding process, an additional analysis was requested in which an aliquot of the sample was analyzed for heavy metals by emission spectroscopy.

Nuisance Particulate: Airborne particulate levels were measured by drawing air at 2.0 lpm through a pre-weighed 5u VM-1 filter with a Model G pump. A subsequent determination of the filter's weight gain was made at the Utah Biomedical Test Laboratory.

Aromatic Amines and Isomers of Cresol: Samples were collected by drawing air through silica gel tubes at 50 ml per minute with Sipin pumps. The analysis was conducted with methanol desorption and gas chromatography at the NIOSH Laboratories in Cincinnati, Ohio.

Aliphatic Amines: Samples were collected in the same manner as previously described for aromatic amines and isomers of cresol. The samples were analyzed colorimetrically at the NIOSH Laboratories.

Butyl-p-cresol (BHT) and Phthalates: Air was drawn through glass tubes containing fluorisil collecting media at 50 ml/minute with a Sipin pump. The samples were analyzed using ethyl acetate desorption and gas chromatography at the Utah Biomedical Test Laboratories.

Hydrogen Cyanide: Hydrogen cyanide was collected with a midget impinger containing 10 ml of 0.1 N sodium hydroxide using a Model G pump at 1.0 lpm. The samples were analyzed by the ion specific electrode method for CN-at the Utah Biomedical Test Laboratory. Hydrogen cyanide levels were also measured using Drager colorimetric gas detector units. These units are NIOSH certified to have an accuracy of ± 35% at one-half the exposure limit and an accuracy of ± 25% at one to five times the exposure limit.

Phenol: Phenol was collected with a midget impinger containing 15 ml of 0.1 N sodium hydrogen solution using Model G pumps at 1.0 lpm. The samples were analyzed by gas chromatography at the Utah Biomedical Test Laboratory. Drager colorimetric gas detector units were also used to measure levels of phenol. These units are not certified for accuracy.

Formaldehyde: Formaldehyde was collected with a midget impinger contaning 10 ml of sodium bisulfide solution using Model G pumps at 1.0 lpm. The concentrations of formaldehyde and total aldehydes (specifically C_2-C_5 which included acetaldehyde, propionaldehyde, butyraldehyde, isobutyraldehyde, crotonaldehyde, and valeraldehyde) were determined colorimetrically at the Utah Biomedical Test Laboratory. Formaldehyde levels were also measured using Drager colorimetric gas detector units. These units are not certified for accuracy.

Ammonia: Ammonia was collected with midget impingers using 10 ml of sulfuric acid solution at a flow rate of 1.0 lpm. The concentration of ammonia was determined by colorimetric analysis at the Utah Biomedical Test Laboratory. Ammonia levels were also measured using Drager colorimetric gas detector units. These units are NIOSH certified to have an accuracy of ± 35% at one-half the exposure limit and an accuracy of ± 25% at one to five times the exposure limit.

Carbon Monoxide: Carbon monoxide measurements were taken periodically throughout the work day at various work stations with an Ecolyzer.

Additional colorimetric gas detector units used during the survey included nitrogen dioxide and benzene which are NIOSH certified; and hydrogen cyanide, vinyl chloride, styrene, ethyl acetate, methylene chloride, acrylonitrile, triethylamine, dimethylformamide, and acetic acid which are not certified for accuracy.

D. Evaluation Criteria

1. Toxic Effects

a. The variety of plastics (Table II) used at Hayes-Albion are generally regarded as biologically inert.[1] As indicated in the literature, the major hazards associated with thermoplastics are from unreacted components used when manufacturing the polymers and from the effluent produced during thermal destruction of plastics. Hayes-Albion is not intentionally involved with either of these two processes. The most common health problems associated with injection molding operations include irritation of the eyes, nose, throat, and upper respiratory system from thermal decomposition of plastics, and skin irritation from use of hydrocarbon cleaning solvents. If plastic materials are excessively heated, such compounds as carbon monoxide, acrylonitrile, and hydrogen cyanide could be generated in significant concentrations.

Skin contact with the plastic might cause rashes if the person exposed were allergic to some constituent of the plastic, or, particularly in the case of fibrous glass filler, there might be a non-allergic irritation. Effects would generally be confined to the areas of skin contact.

b. The organic solvents employed in the plant are primarily narcotic in effect, tending to make workers drowsy. Some solvents are also irritating to the eyes, nose, and throat. Skin contact can defat the skin, and cause dermatitis.

c. The paint spraying operation is primarily a problem of solvent exposure. Of particular concern would be the use of urethane paint, as this is likely to contain free isocyanates. The isocyanates are irritating to the eyes, nose, throat, bronchi, and lungs, and can also cause a progressive sensitization of the respiratory tract and resulting asthma. The worst symptoms may be delayed in onset, not appearing until the evening following exposure. Once sensitization has occurred, a worker often cannot work with levels of isocyanate so low that there is no danger to unsensitized workers.[2]

d. The metalizing and hot stamping processes use aluminum which is not considered toxic[3] in solid metallic form. By nature of the metalizing operation, workers are not exposed to aluminum in vapor form. The aluminum coating is applied in a closed system equipped with local exhaust vented outside the work area.

2. Pathological Review

a. Thrombophlebitis is a clinical entity with many causes and/or predisposing factors.[4] The reason a particular person has an attack of thrombophlebitis at a particular time usually cannot be determined. Factors in thrombophlebitis can be roughly divided into four main categories: injury, stasis (slowed blood flow), hypercoagulability, and a variety of clinical conditions which work by relatively obscure mechanisms. (1) Injury to the vein wall can be caused by mechanical trauma, by infection, by chemical irritants injected into the vein, or by several disease states.

Strong sources of radiation also can cause localized vein injury[5] (2) Stasis can be caused by keeping the legs immobile for long periods of time, such as standing, sitting, or lying in one position. Other factors can include constriction, as tight garters, the hard edge of a chair or even sitting with the legs crossed for long periods of time. Varicose veins are a well known predisposing factor, as is pregnancy. Obesity can be a factor. According to the International Labor Office,[6] so can a hot environment. (3) Hypercoagulability states are not common, the more usual state is that seen in polycythemia, and a rather ill-defined condition found sometimes in persons with cancer (particularly pancreatic cancer). There are a number of usually congential abnormalities of the clotting mechanism which can also cause hypercoagulability. Two non-congenital causes may be a mental stress situation such as that experienced by tax accountants in the two weeks before the annual tax deadline[7] and total body radiation from a radar antenna at close range.[8] (4) Other conditions associated with thrombophlebitis include ulcerative collitis and the use of estrogens as in birth control pills. Much thrombophlibitis ends up being called idiopathic, meaning that no particular cause can be found.

b. Vocal (cord) nodules are the result of vocal trauma.[9] These are often called "singer's nodes" or "speaker's nodes" and sometimes in children they are best described as "screamer's nodes." They result from misuse of the voice, especially during a period of laryngitis. If they are not causing hoarseness (i.e., they are not painful), it is not necessary that they be removed. Treatment is to rest the voice and use it properly within one's normal voice range. Larger nodes may need to be removed surgically. A report from Sweden[10] discusses vocal and throat disorders due to talking in a noisy environment, and suggest that part of the problem results because a person unconsciously will change the pitch of his voice as well as its volume when talking over noise.

This is done in an attempt to find a frequency (pitch--soprano, bass, etc.) at which the noise from the surroundings least interferes with understanding. In the process, the pitch is moved away from the most efficient pitch for that particular individual and adds an element of strain to the vocal cords. Extensive talking in a noisy environment with possible irritants in the atmosphere might thus predispose to vocal nodules, particularly if practiced while the individual has a throat infection.

3. Environmental Evaluation Criteria

Airborne exposure limits intended to protect the health of workers have been recommended or promulgated by several sources. These limits represent conditions under which it is believed that nearly all workers may be repeatedly exposed to a substance on an 8-hour per day, 40-hour per week basis without adverse effects. For this investigation, the criteria used to assess the degree of health hazards to workers were selected from three sources: (1) airborne exposure limits which NIOSH has recommended to OSHA for occupational health standards, (2) Threshold Limit Values (TLV's) for 1976 and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), and (3) Occupational Health Standards as promulgated by the U.S. Department of Labor (Federal Register, 29CFR1910, pp. 506-509, January 1, 1976). The exposure limits applicable to the principal chemical substances of this evaluation are as follows:

Contaminant	Exposure Limits (mg/M^3)*		
	NIOSH	TLV's	OSHA
Acetone		2400	2400
Acrylonitrile		45	45
Ammonia		18	35
Benzene	3.2	80 (C)**	80
Butyl Cellosolve		240	240
Carbon Monoxide	40 (35 ppm)***	55 (50 ppm)	55 (50 ppm)
Chromium		0.5	1
Copper		1	1
Cumene		245	245
Diisobutyl Ketone		150	290
Ethyl Benzene		435	435
Formaldehyde	1.2 (C)	3 (C)	4
Hydrogen Cyanide	5 (C)	11	11
Lead	0.10	0.15	0.2
Methyl Ethyl Ketone		590	590
Methyl Isobutyl Carbinol		100	100
Methyl Isobutyl Ketone		410	410
Methyl Styrene		480 (C)	480 (C)
Methylene Bisphenyl Isocyanate		0.2 (C)	0.2 (C)
Nickel		0.1	1
Phenol	20	19	19
Styrene		420	420
Toluene	375	375	750
Toluene Diisocyanate	0.036	0.14 (C)	0.14 (C)
Xylene	435	435	435
Zinc Oxide Fume	5	5	5

*mg/M^3 - milligrams of contaminant per cubic meter of air.
**C - Ceiling concentration and should not be exceeded. All other values presented in the table are permissible exposure levels based on an 8-hour time weighted average.
***Is the equivalent value presented in ppm (parts of contaminant per million parts of air by volume).

The NIOSH Recommended Standards and the TLV's are given prominence in this evaluation since they are the most current criteria. If the three sources cite criteria values which differ for the same contaminant, the most stringent value will be used to assess the hazard. Federal standards are the legal standards and enforcement is a responsibility of the U.S. Department of Labor, OSHA.

Ventilation criteria applied in the evaluation were taken from the following: (1) Federal Register, 29 CFR1910, (2) Industrial Ventilation - A Manual of Recommended Practices[11] and (3) Recommended Industrial Ventilation Guidelines.[12]

E. Evaluation Results

1. Medical

a. Thrombophlebitis

Table II lists the thirteen cases of thrombophlebitis (or phlebitis) which were identified. The first six cases on the list were scattered over time and jobs. It is unlikely that they represent exposure to a toxic substance. Of concern were the seven cases identified between January and May, 1976. All were in the Molding Department and included three Inspectors, two Press Operators, a Janitor and a Finisher.

The first case (Case #7) was quite dramatic and ended in death. The worker had been employed by the company for 11 years, but had only been at his final job for approximately 3 months. The job primarily involved the cleaning of the presses (occasionally while still warm). His problem started as a migratory thrombophlebitis in his legs and feet. A medical work-up revealed a poorly differentiated adenocarcinoma (cancer) in his chest. Autopsy of the worker did not disclose the primary site of the cancer. It was noted that two-thirds of his stomach had been removed about 5 years ago. It was unlikely that his problems were job related for the following reasons:

1. Since cancer usually takes a minimum of 10 to 20 years to develop after exposure to a carcinogen (substance capable of causing cancer), the worker's exposure as a janitor was too short to account for the cancer. (Without information to the contrary one wonders if the primary cancer was removed with the stomach 5 years earlier.)

2. The migratory thrombophlebitis is most likely related to the cancer because there is a well known association between these two conditions.

Of the remaining six cases one could not be followed up. Three had predisposing factors identified and two had no predisposing factors. Of the last two, one seemed to be an infectious process, and only one thrombophlebitis case lacked some degree of explanation and could therefore, be classified as idiopathic.

Table III lists the types of plastics run over the 6 month period when most of these thrombophlebitis cases occurred. The table also shows which plastics each case was exposed to for a 2 week period prior to the onset of illness. No consistency could be observed. In the few cases where there was a high exposure for one case, other cases had a low exposure or no exposure to the plastic in question. For press operators, exposure was assumed to be to the material run on the particular press being operated. For inspectors, exposure was considered to be to the materials run on all the presses operating during the shifts.

Inspectors' exposure to a specific plastic was lower than that of press operators except for Surlyn which the inspectors periodically heat tested in an incubator type oven.

The oven used to heat the Surlyn was located in the main press room against the wall in the area where the inspectors conducted quality control checks. The Surlyn parts were placed in an unvented, electric oven for 1/2 hour at 195°F. The parts were then removed, allowed to cool, and checked to determine the degree of distortion. The inspectors also tested samples of the Surlyn for specific gravity in a bath of 73% water and 27% ethyl alcohol. Neither of these procedures would be expected to decompose the plastic, although the heating could conceivably drive off some chemicals. Other than local skin changes, when the protective gloves were not worn during the specific gravity test, the alcohol bath should not cause additional problems. It is unlikely that work with Surlyn was a factor in the thrombophlebitis as one inspector worked more than an average amount of time with it, one about average and one considerably less than average. The idiopathic case was the one working least with this substance.

A possible relationship between thrombophlebitis cases might exist if stress had made all the workers more susceptable to thrombosis (as suggested in Reference 7). The death in the department would be dramatic and make the workers more aware of the problem. Two more cases following soon thereafter could really set a person to wondering "who would be next".

Other than the possible relationship to stress, the cases in the Molding Department do not seem to be related. Birth control pills also were not a factor. No other unexpected tumors or cancers were found. One worker was found to have a lump in her breast which required further follow-up, but this óccurrence is not unusual in a predominantly female work force.

b. Vocal Nodules

Four workers interviewed had histories of vocal nodules. Three had had their vocal cords stripped; two with a microscopic diagnosis of Speaker's nodules, the other had insufficient tissue for a diagnosis. The fourth case had a history of recurrent tonsillitis and had to have a tonsillectomy and adenoidectomy prior to having the vocal cords stripped. At the time of the interview, the employee had not had the vocal cords stripped. Three of the four workers gave histories of chronic throat irritation. The last worker has had a hearing loss in one ear since infancy. Although it was not felt that noise per se was the problem, according to reference 10, one would not be surprised to find problems with both noise and irritation. The cases can not be considered job-caused as they are spread out over time and job, although the work environment might contribute to the problem.

c. Other Health Problems

As can be seen from Tables VI and VII there was a variety of other health problems mentioned during the employee interviews. Those deserving particular note involve the white paint used for the bumpers. This was an isocyanate paint which was said to be no longer in use. A couple of the breathing problems were severe, as might be expected if the urethane paint was not properly handled. These individuals may now be sensitized to isocyanates and may have recurring problems even when urethane paints are properly handled.

The other problems mentioned represent individaul variations, and probably a few sensitizations. If the hydrocarbon cleaning solvents were not handled properly, problems such as skin irritation could occur. Other complaints included histories of dermatitis from the use of nickel or the wearing of jewelry (probably sensitization to nickel), and tissue irritation from molding nylon and noryl plastics.

2. Environmental

a. Air Sampling

The processes in which environmental sampling was conducted included injection molding (press operators and purgers), parts inspection, spray painting, oven-line cleaning, paint mixing, hot stamping, placing of appliques, fastening plastics with a hot iron, metalizing, and custodial work. Results of the air sampling conducted May 5-7, and August 17-18, 1976 are presented in Tables VIII-XX. For comparison of the environmental results to the standards (exposure limits) applied in the Determination Report, the most stringent value cited for the respective contaminants should be used. These standards are listed in the Evaluation Criteria Section.

Results of the sampling indicated that employees were not exposed to chemical substances at toxic levels during the investigation. The individual results presented in Tables VIII-XX, as well as the equivalent additive exposures of mixtures (as applicable in Table VIII) were within the exposure limits. Therefore, those operations which manifested the higher contaminant levels will be discussed. Data pertaining to bulk sample analysis and to poor work practices observed during the survey are also included in this section.

Air sampling was performed at various presses during purging operations. Short term measurements using detector tubes were taken for hydrogen cyanide, formaldehyde, phenol, and ammonia at Presses 4,7,20, and 22; and long term measurements using charcoal tubes, silica gel tubes, and fluorisil tubes were taken for organics, phthalates, BHT, aromatic amines, and aliphatic amines at Presses 1,4,7,20,21,22,31 and 32. During times of purging a visible white/gray emission was observed. Detector tube measurements were taken in the most dense portion of the emissions, and the long term samples were taken at the breathing zone of the employee doing the purging. The concentrations of formaldehyde and hydrogen cyanide were determined to be in low quantities (Table XIV-XV). More significant levels of phenol and ammonia were found (Table XVI-XVII). The long term samples indicated only a trace of organic material which was identified as toluene (Table XVIII). Employees assigned to the purging operation were observed to have an infrequent exposure within the heavy emissions. Ten presses were purged during the 10 hour sampling period (0700-1700) on 8/31/76 with the time required to purge a press ranging from 1 to 10 minutes. If prolonged inhalation of the concentrated emissions is avoided, the present purging practices should not present a health hazard.

The only other appreciable level of contaminants present was from spray painting. The highest concentration monitored was at spray booth 16 (second shift), where the time weighted average exposure approached one-half the standard (Table VIII).

b. Ventilation Measurements

In conjunction with the air sampling, ventilation measurements were taken at the spray booths to further document their condition. As indicated in Table XXI, 5 booths, including booth 16, had face velocity determinations below 100 linear feet per minute (fpm). The air exhausted in the "Old Electrostatic Booth" was turbulent with poor distribution. Although the sampling data did not reveal a health hazard, the ventilation measurements did indicate a potential problem. As a minimum requirement, a face velocity of 100 fpm should be maintained in dry filter type booths. Also, the exhaust air should be uniformly distributed across the face of the booth. It was observed that a strong negative pressure existed in the Decorating Department which would reduce the efficiency of the exhaust system. Replacement air should almost equal the volume of air the ventilation system is designed to exhaust. If less air than the required volume is supplied the actual exhausted volume may be reduced.

c. Bulk Sample Analysis

Analysis was requested on bulk samples of the following materials: (1) asbestos and silica content of the molding powder, (2) benzene content in the mineral spirits, and (3) composition of metals present (i.e. nickel and chromium) in the aluminum strip (used for hot stamping). The analysis indicated that no asbestos or silica was present in the molding powder and that if any benzene was present in the mineral spirits, it was less than 0.01 percent. No other metals were detected in the aluminum strip which consisted of 99.99% aluminum.

d. Work Practices

During the survey several unacceptable work practices and ventilation deficiencies were noted:

1. Paint spray booths 4,8,12,15 and 16 had face velocity determinations below 100 fpm. The air in the "Old Electrostatic Booth" was turbulent with poor distribution.

2. The Decorating Area was under a strong negative pressure, thus reducing the efficiency of the ventilation system.

3. Areas around spray booths needed cleaning.

4. At some of the paint booths, the spray gun created a backlash effect which carried overspray and vapors into adjacent work areas.

5. In several areas of the plant, volatile paints were being sprayed within 20 feet of spark producing equipment (i.e. lighting).

6. An employee was observed wearing a cloth-type respirator while spray painting with paints containing organic solvents. This type of respirator does not provide protection against vapors released from the solvents.

7. Volatile materials were dispensed from 55 gallon drums without being properly grounded and bonded.

8. Frequently, containers of volatile materials (solvents) were not covered when not in use.

9. Employees were observed immersing their hands into containers of solvent.

10. The "Mask Solvent Wash" (tank containing methyl ethyl ketone, toluene, and acetone) in the Decorating Department, was not equipped with local ventilation. Access to the tank required the employee to position his head within the enclosure, thereby presenting a concentrated exposure to its contents. Potentially harmful exposure could occur if the tank were used frequently.

11. Hot plastic scrap extruded from the presses during purging was discarded onto the floor where it smoldered until cooled. This practice could produce needless contamination of the work environment.

12. The make-up air to the main press room was fed into an enclosed entrenchment (resembling a sump) which ran the length of the room. This entrenchment served not only as a plenum but also as a collection area for the oil and water which leaked from the presses. As the air moves through the plenum it interfaces with the drainage from the presses and causes potential contamination of the air.

13. Management was not well informed on the hazards of many of the formulations handled or their toxicity.

F. Conclusions and Summary

Personal and area samples were collected over 8-hour work shifts to determine the airborne concentrations of acetone, methyl ethyl ketone (MEK), benzene, methyl isobutyl ketone (MIBK), methyl isobutyl carbinol (MIBC), toluene, xylene, diisobutyl ketone (DIBK), butyl cellosolve, tungsten, chromium, and nickel in the Decorating Department; TDI, MDI, hydrogen cyanide, benzene, toluene, ethyl benzene, styrene, methyl styrene, phenol, and qualitative and quantitative analyses for phthalates, aromatic amines, cresols, and organic vapors in the Finishing Department; and for formaldehyde, total aldehydes, phenol, hydrogen cyanide, ammonia, BHT, particulate weight determination, and qualitative and quantitative analyses for phthalates, aliphatic and aromatic amines, cresols, organic vapors and heavy metals in the Molding Department. Short term samples were taken using indicator tubes for phenol, hydrogen cyanide, formaldehyde, ammonia, styrene, benzene, acrylonitrile, nitrogen dioxide, triethylamine, dimethylformamide, vinyl chloride, ethyl acetate, methylene chloride, acetic acid, and carbon monoxide. Measurements were also taken for carbon monoxide with an Ecolyzer. Results of the environmental sampling indicate that employees were not exposed to airborne contaminants at toxic concentrations during the investigation.

The environmental results depict the quality of the work area only under the conditions observed during the period of the Evaluation Surveys. It should be noted that alterations in the process could effect the environmental quality. To illustrate, if higher temperatures and longer hold times are used during injection molding, an increase in thermal decomposition will occur and may result in higher contaminant concentrations in the converting area.

The environmental sampling results do not consider the hazard of direct skin contact, such as dermatitis, from organic solvents. Although it was not a general problem, various workers did give histories of problems resulting from contact with warm plastics and solvents. During the investigation, it was observed that employees would occasionally submerge their hands in containers of solvent materials. This practice should be discontinued, as solvents can produce a dry, scaly, and fissured dermatitis.

Based on symptomatology derived through medical interviews, an over exposure to isocyanates might have occurred from a white urethane paint used for spraying. The manufacturer specified that the isocyanates contained in the paint and activator formulation were hexamethylene diisocyanate (HMDI) and the biuret compound of HMDI (trimolecular structure 1,3,5-tris (6-isocyanatohexyl) biuret (TICH-B)). The approximate percentages of HMDI and TICH-B in the formulation are less than (<) 0.5% and <2.0%, respectively. Exposure limits have not been established for HMDI and TICH-B, and little is known about their toxicity. Hexamethylene diisocyanate is as volatile as toluene diisocyanate (TDI) and strongly affects the skin and eyes. Some rare cases of respiratory irritation are known, and a possibility of sensitization also exists, although it is not well documented.[13] Since TICH-B has a lower vapor pressure and a diminished number of available isocyanate groups, it would be expected to have a lower level of toxicity than TDI. However, when sprayed during painting, higher air levels of TICH-B could occur than by evaporation. In a previous Hazard Evaluation done by NIOSH, urethane paint containing TICH-B was found to have health problem similar to those in this study, but of a lesser intensity.[14] It was not possible to take environmental samples at Hayes-Albion for HMDI and TICH-B because of the infrequent use of the paint. If painting is resumed, proper ventilation controls, protective clothing, and respiratory protection should be provided.

Thirteen cases of thrombophlebitis/phlebitis were identified, of which the first six cases were scattered over time and job. Of concern were the remaining seven cases which occurred within the same time interval (January to May, 1976) and in the same area of the plant (Molding Department). In the medical evaluation, one of the seven cases could not be followed up, several cases were identified to have predisposing factors, and only one case lacked some degree of explanation. A review of the materials handled in the area, and the toxicology of these materials did not reveal causes for the thrombophlebitis. The medical evaluation found no unique exposure or contributing factors which would account for the seven cases. Similarly, the air sampling conducted during use of ABS, polypropylene, cycoloy (1/2 ABS and 1/2 polycarbonate), nylon and suryln was no more revealing. The only samples which approached or exceeded the exposure limits were two detector tube measurements collected for phenol and ammonia in the dense emissions released during purging. These two samples, however, were not representative of breathing zone exposure. It was observed that contact with the dense emissions occurred only occasionally during the purging procedures. With the exception of these two detector tube measurements, all personal and area samples taken for airborne contaminants in the Molding Department were less than one-half the allowable exposure limits. In conclusion, no basis could be found to relate the cases of thrombophlebitis to occupational chemical exposures.

During the survey several poor work practices and ventilation deficiencies were noted. These practices are listed in the Evaluation Results Section of the report.

G. Unresolved Question

The three ultrasonic welding machines in the plant should be studied as a possible cause of the thrombophlebitis cases. A study also should be conducted to determine if the ultrasonic radiation emitted from these machines may result in other ill effects. A review of the literature and discussion with persons knowledgeable in the field of ultrasound indicate the following effects might be expected at the 20KHz these machines use:

1. Airborne Ultrasound

a. For some people, particularly younger women, these machines produce sound at the upper limits of hearing. When workers have been able to hear the "ultrasound," there have been problems with headache, fatigue, nausea, dizziness, and occasional labarynthine problems with loss of balance.

b. At higher levels of airborne ultrasonic radiation, heating of body surfaces may occur. It is unlikely these machines give off radiation of this intensity.

The general consensus of opinion is that airborne radiation poses little hazard, as the ultrasound does not cross the boundary between air and skin easily. A few workers mentioned complaints which suggested there might be problems such as were mentioned under point 1a. This included an obscure labarynthine disorder.

2. Solid, or Liquid Coupled Ultrasound

a. Good coupling, such as hand contact with solid parts of the vibrating portions of the machine, can transmit considerable energy to the body. Direct contact can cause pain, and continuing exposure leads to heating and to tissue and cellular disruption. This has been more commonly noted in cases where workers place their hands in ultrasonic cleaning baths.

b. If a liquid is involved, the ultrasound may set up standing waves in the longitudinal axis of the wave. In the case of blood vessels, this can lead to a clumping of red cells and platelets at the nodes of the standing waves.[15] These clumps disperse over time after the ultrasound exposure stops.

An important question to be answered is "Do workers get sufficient exposure of ultrasonic energy to their legs to cause problems?" The airborne route should not be a problem. This suggests the floor as the only route of transmission. Ultrasound is quite directional so one would have to postulate good coupling between the machine and the floor and good reflection of the waves from the concrete-dirt interface beneath the floor. Concentric rings of high and low energy would then be expected on the surface of the floor. If safety shoes form a good coupling, there could be ultrasound introduced into the longitudinal axis of the long veins in the legs.

Due to ultrasound being a physical agent, NIOSH was unable to investigate this energy source under the Health Hazard Evaluation Program. The regulations as outlined under Title 42, Part 85 limit the investigative activities to chemical and biological agents.

V. RECOMMENDATIONS

1. Hot plastic scrap extruded from the presses during purging should be properly disposed of and not discarded onto the floor.

2. The practice of continuously heating the barrel of the press when not in use should be minimized. Not only might emissions be released during this process, but, when purged, greater quantities of decomposition products would result from the continuous heating of the barrel contents.

3. Inhalation of the concentrated emissions released during purging should be avoided. If the frequency of purging increases, emission control measures such as local exhaust should be used.

4. Ensure proper temperatures and hold times are maintained during injection molding. Thermal decomposition of plastics increases rapidly with elevated temperatures and extended hold times. Without adequate ventilation, these gases could reach toxic levels in the converting area. An audible alarm or warning device should be used to indicate overheating.

5. Whenever flammable liquids are transferred from one container to another, both containers should be bonded and grounded to prevent discharge sparks of static electricity.

6. Open vessels containing volatile substances constitute both a fire and health hazard and should therefore be kept covered when not in use.

7. Ensure that no open flames or spark producing equipment are located within 20 feet of a spraying area.

8. Maintain a clean area around the spray booths. A clear space of not less than 3 feet should be kept free from storage and combustible construction.

9. Prevent overspray from entering the work area. Too high an air pressure in the spray gun could create a backlash that can carry overspray and vapors into adjacent work areas.

10. Dry filtered spray booths should have an even flow of air maintained across the face of the booth at a minimum velocity of 100 feet per minute.

11. Ensure a sufficient volume of make-up air is supplied in the plant to prevent a reduction in the efficiency of the exhaust system.

12. Workers should be periodically instructed in the proper handling and use of solvents.

13. Avoid prolonged or repeated skin contact with solvents.

14. Workers needing to avoid skin contact with a particular material should use proper protective clothing. The clothing should be impervious to the material and provided in a variety of sizes.

15. If spray painting with polyurethane coatings is resumed, care must be taken to avoid undue exposure to isocyanates. It is recommended that environmental measurements be taken for isocyanates and that proper protection is provided through the use of ventilation controls, protective clothing, and respiratory protection. It may prove necessary to transfer those workers experiencing problems with urethane paint out of the area whenever the paint is used.

16. A respirator program should be established by the company in the event that respiratory protection is to be used. Minimum procedures such as those outlined in the Occupational Safety and Health Standards, 29CFR 1910.134 (b) (1)-(11), should be followed. All respirators used must be of the NIOSH-certified type.

17. Workers should avoid voice strain, particularly when their throats are irritated or infected.

18. Local ventilation should be considered for the "Mask Solvent Wash" tank. Access to the tank required the employee to position his head within the enclosure, thereby exposing the employee to concentrated vapors.

19. The air supplied to the main press room should not come into contact with potential contaminants such as oil drainage from the presses.

20. A noise survey should be conducted in the plant. A considerable amount of noise is produced in the press room from the injection molding equipment and regrind machines.

21. The company should strive to compile as many "Material Safety Data Sheets" or their equivalent as possible. By understanding the toxicity of and hazards associated with materials handled, the company will be able to provide useful instructions to employees on good work practices. The end result would be the development of respect for all materials, leading to a more healthful and a safer work environment.

22. A survey should be conducted to evaluate the amount of ultrasonic energy radiated in the work environment from the ultrasonic welding machines.

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TABLE I
CHARACTERIZATION OF WORK FORCE AND WORKERS INTERVIEWED

HAYES-ALBION CORPORATION, MILAN, MICHIGAN

DEPARTMENT AND JOB	STUDY GROUP Total Seen Shift 1st	2nd	3rd	Total	Phone	Total	Total on Duty* Total	Shift 1st	2nd	3rd
Molding Department										
Press Operators	4	3	3	9	2	11	25	10	10	25
Relief Press Operators	1	2	1	4	0	4	5	2	2	1
Inspectors	2	2	1	5	1	6	6	3	2	1
Set-Up	0	1	1	2	0	2	3	1	1	1
Machine Tenders	1	0	0	1	0	1	5	2	2	1
Material Handlers	1	0	0	1	0	1	4	2	1	1
Utility	1	0	1	2	0	2	3	2	0	1
Janitors	1	0	0	1	0	1	2	1	0	1
Finishers	11	2	3	16	1	17	45	28	12	5
Maintenance	1	1	0	2	0	2	4	3	1	0
Tool Repair	0	0	0	0	0	0	1	1	0	0
Packer	0	0	0	0	0	0	1	0	1	0
Receiving Clerk	0	0	0	0	0	0	1	1	0	0
Shipping	0	0	0	0	0	0	6	6	0	0
Truck Drivers	0	0	0	0	0	0	2	2	0	0
Total Molding	23	11	9	43	4	47	113	64	32	17
Decorating Department										
Spray Painters	4	4	1	9	1	10	34	17	16	1
Set-Up	1	1	0	2	0	2	2	1	1	0
Inspectors	2	0	0	2	0	2	0	0	0	0
Evaporator Operators	2	1	0	3	0	3	7	4	3	0
Finishers	4	2	0	6	1	7	14	7	7	0
Material Handlers	0	0	0	0	0	0	4	2	2	0
Mask Repair	0	0	0	0	0	0	1	1	0	0
Janitor	0	0	0	0	0	0	1	0	0	1
Total Decorating	13	8	1	22	2	24	63	32	29	2
Total for Plant	36	19	10	65	6	71	176	96	61	19

*The total on duty was taken from the roster for the week of May 3, 1976. Two names were added to the list. A couple of workers were not doing the job the list indicated. No attempt was made to correct duty assignments as shown on the duty roster.

TABLE II
IDENTIFIED CASES OF THROMBOPHLEBITIS OR PHLEBITIS

HAYES-ALBION CORPORATION, MILAN, MICHIGAN

CASE #	PROBABLE DIANGOSIS	DATE OF ONSET	PREDISPOSING FACTORS PRESENT	DEPARTMENT	JOB
1	Thrombophlebitis	1972	None known*	Molding	Press Op.
2	Thrombophlebitis	1973	Yes	Molding	Press Op.
3	Thrombophlebitis	About 1974	Yes	Molding	Finishing
4	Thrombophlebitis	1974	Yes	Decorating	Spray Painter
5	Thrombophlebitis	1974	None Known	Decorating	Finishing
6	Thrombophlebitis	1975, Spring	Yes#	Molding	Inspector
7	Poorly differentiated adenocarcinoma and migratory thrombophlebitis	1-5-76	Yes	Molding	Janitor
8	Phlebitis(infection)	Feb. 1976	None Known	Molding	Press Op.
9	Thrombophlebitis	3-15-76	Yes	Molding	Inspector
10	Thrombophlebitis with embolism	4-26-76	None Known	Molding	Inspector
11	Thrombophlebitis	5-19-76	Yes#	Molding	Inspector
12	Thrombophlebitis	5-28-76	Yes*	Molding	Press Op.
13	Thrombophlebitis	May 1976	Unknown	Molding	Finisher

*This worker had two episodes of thrombophlebitis. Although no predisposing factors were known for the first episode, the first episode would be classified as a predisposing factor for the second episode.

#This worker had two episodes of thrombophlebitis.

TABLE III
TYPES OF PLASTICS USED IN MOLDING DEPARTMENT OVER
24 WEEKS DURING JANUARY 19 THROUGH JULY 10, 1976

HAYES-ALBION CORPORATION, MILAN, MICHIGAN

Molding Department as a Whole	ABS	Type of Poly-Propylene	Plastic Surlyn 80/20	Plexiglass Clear	Noryl	Nylon	Other	Total
Total Shifts	2,842	555.5	336	146	101	28.5	22	4,031
Percent	70.5	13.8	8.3	3.6	2.5	0.7	0.5	100
% Run for the 14 days prior to the onset of thrombophlebitis in an inspector during the shift the inspector worked								
Case #9 (3rd Shift)	67.7	18.9	8.1	0	6.3	0	0	(111)*
Case #10 (2nd Shift)	79.8	14.6	1.1	4.5	0	0	0	(89)
Case #11 (1st Shift)	72.7	9.8	12.9	2.3	0	2.3	0	(132)
Experience of molders developing thrombophlebitis or phelbitis								
Case #8 - Total Experience								
Percent	67.0	11.3	8.6	1.0	11.1	1.0	0	(99)
For 14 days prior to onset of phlebitis (estimated as at most only 1 day lost time)								
Percent	33	27	15	0	25	0	0	(10)
Case #13 - Total Experience								
Percent	48.9	46.8	1.6	1.1	1.6	0	0	(95)
For 14 days prior to onset of thrombophlebitis								
Percent	100	0	0	0	0	0	0	(8)

*Total Shifts = 100%

Table IV
Analysis of Bulk Plastic Materials Collected at
Hayes-Albion Corporation, Milan, Michigan

Material	Temperature Material Heated To (°F)	Compounds Identified On The Charcoal Tube Samples With GC/MS*
Lustran-ABS	440	Styrene, ethyl benzene, cumene, butyl-p-cresol (BHT), Terpenes (a and y-terpinene), t-butyl benzene, dimethyl styrene, octadecanol, possibly substituted cresols (similar to BHT).
Cycolac-ABS	440	Vinyl cyclohexane, ethyl benzene, styrene cumene, substituted benzenes, a-methyl styrene, BHT, acetophenone, possibly a, a dimethylbenzyl alcohol or hydroperoxide octadecanol, possibly substituted cresols (similar to BHT).
Cycoloy-½ABS-½ Polycarbonate	470	Styrene, substituted benzenes, t-butyl benzene, acetophenone.
Polypropylene	400	Series of aliphatic-type hydrocarbons.
Surlyn-Ionomer Resin	500	No major GC peaks
Noryl-Polyphenylene Oxide	510	Toluene, ethyl benzene, styrene, BHT
Nylon	500	No major GC peaks
Plexiglas-Methyl Methacrylate	440	Methyl methacrylate
Polyolefin	400	No major GC peaks
Polyethylene	400	No major GC peaks
Cycolac-ABS	440	Styrene, ethyl benzene, cumene, BHT a-methyl styrene, substituted ethyl benzenes.
Cycolac-ABS	440	Styrene, cumene, ethyl benzene, BHT, substituted ethyl benzenes, possible alpha, alpha dimethyl benzyl alcohol or hydroperoxide.

*Since chromatograms from the silica gel tubes were identical to the charcoal tubes (no additional peaks) and all peaks idenified on fluorisil were also found on the charcoal tubes, only the charcoal tube results are reported.

Table V
Analysis of Bulk Plastic Materials
Hayes-Albion Corporation, Milan, Michigan

Detector Tube:	Amine/NH_3 (1)	Phenol	Formaldehyde
Color Change:	Yellow Grey Blue	White Blue	White Pink
Material		Observed Color	
Lustran-ABS	Yellow Grey	Bluish Grey	Yellow Brown
Cycolac-ABS	Yellow Grey	Bluish Grey	Dark Yellow Brown
Cycoloy-½ ABS, ½ Polycarbonate	Yellow Grey	Bluish Grey	Yellow
Polypropylene	Yellow Grey	Bluish Purple	White
Surlyn-Ionomer resin	Yellow Grey	Bluish Grey	Yellowish Pink/Brown
Noryl-Polyphenylene oxide	Greenish	Bluish Grey	Dark Yellow Brown
Nylon	Blue	Blue-Black	Yellow Brown
Plexiglas-Methyl Methacrylate	--------	Bluish Grey	------------
Polyolefin	Yellow Grey	Bluish Grey	Pale Yellow
Polyethylene	Yellow Grey	Bluish Grey	Pale Yellow

	NO/NO_2	HCN	Acrylonitrile (3)
	Pale Grey Bluish Grey	Yellow Red	Yellow Red
Lustran	Pale Grey	Red	Red
Cycolac	Pale Grey	Red	Red
Cycoloy	Pale Grey	Red	Red
Noryl	Yellowish Grey	---	---
Nylon	Bluish Grey	Red	---
Plexiglas	Trace of Blue	Yellow	---

	Hcl	H_2S	Posgene
	Blue Yellow Gray	White Brown	Yellow Bluish Green
Lustran	Blue	-----	---
Plexiglas	----	White	---
Cycolac	Blue	-----	---
Cycoloy	Blue	-----	Yellow

(1) Ammonia is an interfenence for the amine detector tube.
(2) Acetaldehyde, acrolein, furfuryl alcohol and styrene turn indicating layer yellow to brown.
(3) Free HCN acid interferes with acrylonitrile detector tube.

NOTE: In the presence of the contaminant being monitored, the indicating layer of the detector tube changes to the color listed in the table.
IE: In the presence of amines/NH_3, the color changes from yellow grey to blue.

TABLE VI
MEDICAL PROBLEMS AS OBTAINED BY EMPLOYEE INTERVIEWS

HAYES-ALBION CORPORATION, MILAN, MICHIGAN

Department and Jobs	Number	No Problems	Thrombo-phlebitis Phlebitis	Vocal Cord Nodules	Other Possibly Job Related	Other Not Job Related
Molding Department	47	11	9	1	22	32
Percent	100	23	19	2	47	68
Press Operators & Relief Operators	15	4	3	1	7	9
Finishers	16	3	2	0	11	13
Others	15	4	4	0	4	10
Decorating Department	24	2	2	3	13	16
Percent	100	8	8	12	54	67
Painters	10	2	1	0	5	6
Finishers	8	0	1	1	4	4
Others	7	0	0	2	4	6
Total	71	13	11	4	35	48
Percent	100	18	15	6	49	68

TABLE VII
POSSIBLY JOB RELATED MEDICAL PROBLEMS AS
OBTAINED BY EMPLOYEE INTERVIEWS

HAYES-ALBION CORPORATION, MILAN, MICHIGAN

Problems	Workers Mentioning Problem	
Problems with White Paint on Bumpers	6	
Eye Irritation		1
Canker Sores		1
Throat Irritation		4
Breathing Difficulties		3
Vomiting		1
Problems with "A" Posts (Noryl)	4	
Breaking Out		3
Throat Irritation		1
Breathing Difficulty		2
Feeling Sick		1
Paints and Solvents		
Nasal Irritation	1	
Throat Irritation	1	
Skin Problems	4	
Headaches, Dizziness, Tiredness	4	
Chest Discomfort	1	
Molding Operations		
Eye Irritation	2	
Nasal Irritation	1	
Breaking Out	3	
Nausea or Indigestion	2	
Headaches	2	
Purging Bothers	1	
Other and More General Complaints		
Injuries	5	
Sinus Problems	5	
Throat Irritation	3	
Dermatitis or Itching	5	
Plastics		3
Rubber		1
Dust		1
Hearing Loss	1	
Heat from Ovens (Decorating)	1	
Anxiety or Nerves	3	

TABLE VIII

SUMMARY OF AIR SAMPLES FOR ORGANIC VAPORS AT
HAYES - ALBION CORPORATION, MILAN, MICHIGAN

MAY 6, 1976

Operation or Location	Spray Booth No.	Sample Type	Sample Time	Concentration (mg/M³) 1-A	2-MEK	3-B	4-MIBK	5-MIBC	6-T	7-X	8-DIBK	9-BC	Percent of Standard[1]
Spray Painting	15	P	0707 - 1047	N.D.	N.D.	N.D.	10	2	13	5	6	N.D.	9
			1047 - 1440	N.D.	N.D.	N.D.	9	1	13	4	3	N.D.	7
"	13	P	0707 - 1038	N.D.	N.D.	N.D.	1	N.D.	3	N.D.	N.D.	N.D.	1
			1038 - 1448	N.D.	N.D.	N.D.	4	N.D.	8	3	N.D.	N.D.	3
"	16	P	0712 - 1040	38	20	N.D.	19	3	28	7	6	N.D.	20
			1040 - 1440	70	44	N.D.	34	6	49	12	8	N.D.	32
"	17	P	0714 - 1043	N.D.	N.D.	N.D.	6	2	10	3	2	N.D.	6
			1043 - 1440*	N.D.	N.D.	N.D.	5	N.D.	66	3	N.D.	N.D.	11
"	19	P	0716 - 1045	N.D.	N.D.	N.D.	N.D.	N.D.	24	N.D.	N.D.	N.D.	3
			1045 - 1440	N.D.	N.D.	N.D.	1	N.D.	44	N.D.	N.D.	N.D.	6
"	1	P	0719 - 1050	N.D.	N.D.	N.D.	9	1	15	4	2	N.D.	7
			1050 - 1440	N.D.	N.D.	N.D.	5	1	10	2	2	N.D.	5
"	3	P	0722 - 1053	N.D.	N.D.	N.D.	13	2	22	6	4	N.D.	11
			1053 - 1440	N.D.	12	N.D.	10	2	18	5	3	N.D.	9
"	5	P	0724 - 1056	N.D.	N.D.	N.D.	5	2	10	3	3	N.D.	6
"	6	P	0726 - 1056	N.D.	N.D.	N.D.	6	N.D.	35	1	N.D.	N.D.	6
			1056 - 1440	N.D.	N.D.	N.D.	N.D.	N.D.	4	N.D.	N.D.	N.D.	1
"	12	P	0728 - 1057	56	N.D.	N.D.	4	N.D.	9	2	N.D.	N.D.	5
			1057 - 1440	N.D.	N.D.	N.D.	7	2	10	3	4	N.D.	7

*At approximately 1100 the employee moved to the Press Room Truck Line spray booth.

Table VIII (Continued)

Operation or Location	Spray Booth No.	Sample Type	Sample Time	Concentration (mg/M^3) 1-A	2-MEK	3-B	4-MIBK	5-MIBC	6-T	7-X	8-DIBK	9-BC	Percent of Standard
Spray Painting	4	P	1535 - 1845	N.D.	N.D.	N.D.	2	N.D.	12	N.D.	N.D.	N.D.	2
			1845 - 2233	N.D.	N.D.	N.D.	2	N.D.	13	N.D.	N.D.	N.D.	2
"	5	P	1536 - 1848	N.D.	8	N.D.	12	3	20	5	5	N.D.	13
			1848 - 2234	44	10	N.D.	9	1	16	4	3	N.D.	19
"	13	P	1542 - 1852	N.D.	N.D.	N.D.	7	1	13	4	1	N.D.	6
			1855 - 2240	N.D.	N.D.	N.D.	11	2	19	4	3	N.D.	9
"	15	P	1544 - 1856	N.D.	13	N.D.	17	3	26	7	5	N.D.	16
			1856 - 2240	52	27	N.D.	28	5	41	10	7	N.D.	29
"	16	P	1545 - 1856	99	58	N.D.	51	9	76	17	11	N.D.	53
			1856 - 2240	37	18	N.D.	19	4	29	7	5	N.D.	20
"	17	P	1546 - 1900	N.D.	N.D.	N.D.	2	N.D.	6	1	N.D.	N.D.	2
			1900 - 2242	N.D.	N.D.	N.D.	6	N.D.	11	3	N.D.	N.D.	4
"	18	P	1549 - 1901	N.D.	N.D.	N.D.	N.D.	N.D.	5	N.D.	N.D.	N.D.	1
			1901 - 2245	N.D.	N.D.	N.D.	N.D.	N.D.	6	N.D.	N.D.	N.D.	1
"	19	P	1615 - 1902	N.D.	N.D.	N.D.	N.D.	N.D.	69	N.D.	N.D.	N.D.	9
			1902 - 2242	N.D.	N.D.	N.D.	1	N.D.	53	N.D.	N.D.	N.D.	7
Oven Line Cleaning	--	A	1904 - 2245	N.D.	N.D.	N.D.	N.D.	N.D.	4	N.D.	N.D.	N.D.	1
Spray Painting	11	P	0731 - 1100	--	N.D.	N.D.	--	--	N.D.	--	--	N.D.	<1
			1100 - 1440	--	N.D.	N.D.	--	--	4	--	--	N.D.	<1
			1540 - 1850	--	N.D.	N.D.	--	--	2	--	--	N.D.	<1
			1850 - 2236	--	N.D.	N.D.	--	--	2	--	--	N.D.	<1

Table VII. (Continued)

Operation or Location	Spray Booth No.	Sample Type	Sample Time	Concentration (mg/M^3) 1-A	2-MEK	3-B	4-MIBK	5-MIBC	6-T	7-X	8-DIBK	9-BC	Percent of Standard
Oven Line Cleaning	--	A	0735 - 1118	N.D.	N.D.	N.D.	N.D.	N.D.	5	N.D.	N.D.	N.D.	1
			1118 - 1440	N.D.	N.D.	N.D.	N.D.	N.D.	4	N.D.	N.D.	N.D.	1
Paint Locker	--	P	0742 - 1104	N.D.	29	N.D.	2	18	1	N.D.	N.D.	N.D.	24
			1104 - 1440	N.D.	27	N.D.	2	N.D.	16	N.D.	N.D.	N.D.	7
Base Coat	24	P	0745 - 1033	N.D.	N.D.	N.D.	8	N.D.	3	3	N.D.	N.D.	3
			1105 - 1440	N.D.	N.D.	N.D.	15	N.D.	4	4	1	N.D.	5
Top Coat	23	P	0747 - 1032	N.D.	N.D.	N.D.	6	1	6	4	6	N.D.	6
			1115 - 1440	N.D.	N.D.	N.D.	5	1	6	4	5	N.D.	6
Spray Painting	17	P	1115 - 1440	N.D.	17	N.D.	15	2	23	6	5	N.D.	15
Base Coat	24	P	1525 - 1840	N.D.	N.D.	N.D.	6	N.D.	3	3	N.D.	N.D.	3
			1840 - 2230	N.D.	N.D.	N.D.	14	N.D.	4	4	N.D.	N.D.	5
Top Coat	23	P	1525 - 1840	N.D.	N.D.	N.D.	17	3	12	12	12	N.D.	16
			1840 - 2230	N.D.	N.D.	N.D.	7	2	8	7	10	N.D.	10
Paint Locker	--	P	1528 - 1853	N.D.	19	N.D.	3	N.D.	16	N.D.	N.D.	N.D.	6
			1853 - 2231	N.D.	N.D.	N.D.	2	N.D.	8	N.D.	N.D.	N.D.	2
Spray Painting	1	P	1530 - 1845	N.D.	20	N.D.	20	3	32	7	5	N.D.	19
			1845 - 2238	N.D.	16	N.D.	17	2	28	6	6	N.D.	16
"	3	P	1532 - 1840	N.D.	14	N.D.	16	2	27	6	4	N.D.	15
			1840 - 2232	N.D.	12	N.D.	11	2	21	5	4	N.D.	12
"	6	P	1851 - 2235	N.D.	N.D.	N.D.	3	N.D.	27	N.D.	N.D.	N.D.	4

TABLE VIII (Continued)

Operation or Location	Spray Booth No.	Sample Type	Sample Time	Concentration (mg/M³) 1-A	2-MEK	3-B	4-MIBK	5-MIBC	6-T	7-X	8-DIBK	9-BC	Percent of Standard
Spray Painting	9	P	0733 - 1052	--	N.D.	N.D.	--	--	N.D.	--	--	N.D.	<1
			1052 - 1440	--	N.D.	N.D.	--	--	2	--	--	N.D.	<1
Press Room	Spray Booth on Truck Line	P	0805 - 1115	--	3	N.D.	--	--	30	--	--	N.D.	1
Spray Painting	24	P	1505 - 1909 (8/31/76)									1	<1
			1911 - 2245									1	<1

P - Personal sample collected in breathing zone of employee.
A - Area sample.
N.D. - (None Detected). The lower limit of detection for all compounds is 0.01 mg per sample.
mg/M³ - Approximate milligrams of contaminant per cubic meter of air.

OSHA Standard for 8-hour time weighted average exposures.

	mg/M³		mg/M³
1. A/Acetone	2400	6. T/Toluene	750
2. MEK/Methyl Ethyl Ketone	590	7. X/Xylene	434
3. B/Benzene	80	8. DIBK/Diisobutyl Ketone	290
4. MIBK/Methyl Isobutyl Ketone	410	9. BC/Butyl Cellosolve	240
5. MIBC/Methyl Isobutyl Carbinol	100		

1. Since similar organic solvents are present simultaneously in the work environment, their combined effects should be considered as additive. The value provided in the column is the percent of permissible exposure.

TABLE IX

SUMMARY OF AREA SAMPLES* COLLECTED FOR TOLUENE DIISOCYANATE (TDI)
AND METHYLENE BISPHENYL ISOCYANATE (MDI) AT HAYES - ALBION CORPORATION, MILAN, MICHIGAN
MAY 7, 1976

Location	Operation	Sample Time	Concentration TDI	Concentration MDI
Truck Line - Kensol Rotating Press	Hot Stamping Truck Panels with Metal Foil	0735 - 1119	ND	ND
Truck Line - Kensol Rotating Press	Hot Stamping Truck Panels with Metal Foil	1119 - 1435	ND	ND
Finishing Dept - Pontiac G Body Machine	Applying Wash-Wiper - Light Piece to Panel. Pressing Wood Grain Covering onto Dash	0740 - 1125	ND	ND
Finishing Dept - Pontiac G Body Machine	Applying Wash-Wiper - Light Piece to Panel. Pressing Wood Grain Covering onto Dash	1125 - 1435	ND	ND
Finishing Dept - Carrier Rotary Machine	Applying Metal Foil	0745 - 1125	ND	ND
Finishing Dept - Carrier Rotary Machine	Applying Metal Foil	0917 - 0924	ND	ND
Finishing Dept - Carrier Rotary Machine	Applying Metal Foil	1125 - 1420	ND	ND
Finishing Dept - Franklin Imprinting Machine	Applying Metal Foil to F Body	0750 - 1123	ND	ND

TABLE IX (Continued)

Location	Operation	Sample Time	Concentration TDI	MDI
Finishing Dept - Frankling Imprinting Machine	Applying Metal Foil to F Body	1123 - 1430	ND	ND
Finishing Dept - Hot Iron	Hand Application of Metalic Trim with Hot Iron	0845 - 0900	ND	ND

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* Area samples were collected at a distance of .5 - 5 feet from worker's breathing zone. The collection media was positioned near the point of maximum contaminant release.

ND - (None Detected). Lower limit of detection for TDI and MDI is 0.001 mg per sample.

TABLE X

RESULTS OF ORGANIC VAPOR SAMPLING WITH CHARCOAL TUBES
MAY 6, 1976

Location	Operation	Type of Sample	Sample Time	Concentration (mg/M^3) 1-B	2-T	3-EB	4-S	5-MS
Imperial Line (Finishing Dept.)	Fastening ABS and acrylic plastics with soldering iron	P	0820 - 1106	N.D.	N.D.	N.D.	N.D.	N.D.
			1106 - 1440	N.D.	N.D.	N.D.	N.D.	N.D.

P - Personal sample collected in breathing zone of employee.
mg/M^3) Approximate milligrams of contaminant per cubic meter of air.
N.D. (None Detected) The lower limit of detection for all compounds is 0.01 mg per sample.

1. B/Benzene
2. T/Toluene
3. ET/Ethyl Benzene
4. S/Styrene
5. MS/Methyl Styrene

TABLE XI

SUMMARY OF ENVIRONMENTAL SAMPLING FOR VARIOUS METALS
AT HAYES - ALBION CORPORATION, MILAN, MICHIGAN
MAY 6, 1976

Operation or Location	Sample Type	Sample Time	Concentration Tungsten	Chromium	Nickel
Metalizing	P	0805 - 1440	ND	--	--
Metalizing	P	0810 - 1440	ND	--	--
Metalizing	P	0814 - 1440	ND	--	--
Molding Dept - Hot Stamping	A	0840 - 1705	--	ND	ND
Finishing Dept - Above Chevy Carrier Press	A	0820 - 1455	--	ND	ND
Finishing Dept - Near East Wall	A	0825 - 1455	--	ND	ND

P - Personal sample collected in breathing zone of employee
A - General area sample
ND- None detected
Limit of Detection:

Tungsten - 0.1 mg per sample
Chromium - 0.001 mg per sample
Nickel - 0.001 mg per sample

TABLE XII

Summary of Air Sampling for Carbon Monoxide at
Hayes-Albion Corporation, Milan, Michigan
8/30/76 - 9/1/76

Date	Sample Location	Sample Period	Concentration of Carbon Monoxide (ppm)*
8-30-76	Press 30	1710	<10**
	11	1844	<10**
	26	2130	<10**
8-31-76	4	0930	<10**
	31	1200	<10**
	11	2200	3
	32	2203	3
	30	2206	2
	31	2209	3
	29	2212	1
	24	2215	1
	21	2218	1
	26	2221	1
	7	2224	1
	4	2227	4
	Oven 3 (Decorating Dept.)	2230	3
	4	2233	2
9-1-76	3	1030	3
	4	1033	2
	5	1036	2
	6	1039	4
	Decorating Dept.	1042	1-4
	Metalizing Room	1050	2-4
	Press 1	1100	3
	7	1103	2
	26	1106	2
	21	1109	5
	24	1112	3
	31	1130	5
	28	1133	5
	29	1136	3
	30	1140	3
	11	1143	3

*OSHA Standard - 50 parts of carbon monoxide per million parts of air by volume (50ppm).

**Measurements taken with colorimetric indicator tubes. All other measurements were made using an Ecolyzer.

TABLE XIII

Summary of Air Sampling* for Total Particulates at
Hayes - Albion Corporation, Milan, Michigan
8/31/76

Press Number	Sample Period	Type of Plastic	Concentrations of Airborne Particulate (mg/M^3)**
26	0747-1500	80% Surlyn	0.12
30	0725-1447	ABS Color Regrind	0.17
31	0800-1500	Polypropylene	0.16
32	1636-2300	Virgin ABS	<0.1

*Sampling Media was worn by the employee.

**OSHA Standard - 15 milligrams of nuisance particulate per cubic meter of air (15 mg/M^3).

TABLE XIV

Summary of Air Sampling for Formaldehyde and Total Aldehydes* at Hayes - Albion Corporation, Milan, Michigan
8/30/76-9/1/76

Date	Press Number or Location	Sample Type	Sample Period	Type of Plastic	Press Temperature	Concentration (mg/M^3)** Formaldehyde	Total Aldehydes
8/30/76	30	A	1555-1625	ABS Color Regrind	450°F/232°C	N.D.	N.D.
			1647-1717			N.D.	N.D.
			1745-1815			N.D.	N.D.
			1916-2005			N.D.	N.D.
			2030-2117			N.D.	N.D.
			2159-2230			N.D.	N.D.
	1	A	1614-1649	ABS Color Regrind	580°F/304°C	N.D.	N.D.
			1718-1748			N.D.	N.D.
			1819-1920			N.D.	N.D.
			2000-2050			N.D.	N.D.
	4	A	2119-2149	Nylon (1700-2200)	460-480°F/238-249°C	N.D.	N.D.
	26	A	2227-2300	Surlyn (2200-2300)	380-400°F/193-204°C	N.D.	N.D.
	11	A	1540-1615	1/3 ABS Reprocessed	400°F/204°C	N.D.	N.D.
			1644-1717	1/3 ABS Color Regrind		N.D.	N.D.
			1745-1815	1/3 ABS Virgin		N.D.	N.D.
			1916-2010			N.D.	N.D.
			2030-2117			N.D.	N.D.
			2157-2230			N.D.	N.D.
8/31/76	21	P	0733-0803	Cycoloy	450-480°F/232-249°C	N.D.	N.D.
			0833-0903			N.D.	N.D.
			0937-1007			N.D.	N.D.
			1039-1109			N.D.	N.D.
			1142-1212			N.D.	N.D.
			1340-1410			N.D.	N.D.
			1421-1451			N.D.	N.D.
	32	A	1636-1706	ABS Virgin	470°F/243°C	N.D.	N.D.
			1708-1738			N.D.	N.D.
			1740-1810			N.D.	N.D.
			1830-1900			0.3	N.D.
			1915-1945			N.D.	N.D.
			2106-2136			N.D.	N.D.
			2202-2232			1.0	N.D.
	7***		1945-1950	40% Reprocessed ABS 60% Virgin ABS	Purging	N.D.	
9/1	20***		2235-2240	ABS	Purging	1-2	
	22***		2315-2320	ABS	Purging	N.D.	

P - Personal sample collected in breathing zone of employee.
A - Area sample
N.D. (None Detected) **The lower limit of detection for formaldehyde is 0.001 mg per milliliter of collecting media, and for total aldehydes is 0.01 mg per sample. The collecting media volumes ranged from 7 to 10 milliliters.**

*An analysis was conducted for total aldehydes (specifically C_2-C_5) which included acetaldehyde, propionaldehyde, butyraldehyde , isobulyraldehyde, crotonaldehyde, and valeraldehyde.

**OSHA Standard - 4 milligrams of formaldehyde per cubic meter of air (4 mg/M^3) as measured by an 8-hour time weighted average exposure. No airborne exposure limit has been set for total aldehydes.

***Indicator tube sample collected in smoke plume during purging operation.

TABLE XV

SUMMARY OF AIR SAMPLING FOR HYDROGEN CYANIDE
AT HAYES - ALBION CORPORATION, MILAN, MICHIGAN
8/30/76 - 9/1/76

Date	Press Number or Location	Sample Type	Sample Period	Type of Plastic	Press Temperature	Concentration (mg/M^3)*
8/31/76	24	P	0749-1140 1209-1451	1/3 Reprocessed ABS 1/3 Color Regrind ABS 1/3 Virgin ABS	500°F/260°C	N.D. N.D.
	30	P	0750-1134 1135-1447	ABS Color Regrind	430-450°F/221-232°C	N.D. N.D.
	1	P	0721-1127 1127-1445	ABS Regrind	580°F/304°C	N.D. N.D.
	4	P	0815-1025 1030-1450	Nylon	460-480°F/238-249°C	N.D. N.D.
	32	A	1636-1936 1940-2300	ABS Virgin	470°F/243°C	N.D. N.D.
	7	P	1518-1918 1924-2257	40% Reprocessed ABS 60% Virgin ABS	420-440°F/216-227°C	N.D. N.D.
	4 26	P	1550-1925 1930-2245	Nylon (1700-2100) Surlyn (2100-2300)	460-480°F/238-249°C 380-400°F/193-204°C	N.D. N.D.
9/1/76	21	P	0712-1112 1114-1451	Cycolov	460°F/238°C	N.D. N.D.
	31	P	0710-1112 1113-1452	Polypropylene	390-430°F/199-221°C	N.D. N.D.
	Imperial Line	P	0710-1050 1050-1450	Fastening ABS to Methyl Methacrylate with a hot iron		N.D. N.D.
8/30/76	4**		1738-1742 1745-1750	Nylon	purging	N.D. N.D.
8/31/76	4**		0930-0935	Nylon	purging	N.D.
	7**		1945-1950	40% Reprocessed ABS 60% Virgin ABS	purging	N.D.
9/1/76	20**		2235-2240	ABS	purging	1-2
	22**		2315-2320	ABS	purging	1-2

P - Personal sample collected in breathing zone of employee.
A - Area Sample
N.D. (None Detected) The lower limit of detection for hydrogen cyanide is 0.0001 mg per milliliter of collecting media, the collecting media volumes ranged from 4 to 9 milliliters.

*OSHA Standard - 11 milligrams of hydrogen cyanide per cubic meter of air (11 mg/M^3).

**Indicator tube sample collected in smoke plume during purging operation.

TABLE XVI

Summary of Air Sampling for Phenol at
Hayes - Albion Corporation, Milan, Michigan
8/30 - 9/1/76

Date	Press Number or Location	Sample Type	Sample Period	Type of Plastic	Press Temperature	Concentration (mg/M^3)*
8/30/76	30	P	1555-1922 2005-2255	ABS Color Regrind	450°F/232°C	N.D. N.D.
	1	A	1614-1920	ABS Regrind	580°F/304°C	N.D.
	4 26	A	2000-2300	Nylon (1700-2200) Surlyn (2200-2300)	460-480°F/238-249°C 380-400°F/193-204°C	N.D.
	11	P	1535-1916 2013-2240	1/3 Reprocessed ABS 1/3 Color Regrind ABS 1/3 Virgin ABS	400°F/204°C	N.D. N.D.
	7	P	1533-1933 1935-2300	40% Reprocessed ABS 60% Virgin ABS	410-430°F/210-221°C	N.D. N.D.
8/31/76	26	P	0744-1144 1145-1456	80% Surlyn 20% Black Concentration	390°F/199°C	N.D. N.D.
	31	P	0800-1115 1120-1500	Polypropylene	430°F/221°C	N.D. N.D.
	32	A	1636-1936 1940-2300	Virgin ABS	470°F/243°C	N.D. N.D.
	4 26	P	1550-1930 1931-2245	Nylon (1500-2100) Surlyn (2100-2300)	460-480°F/238-249°C 380-400°F/193-204°C	N.D. N.D.
9/1/76	21	P	0716-1116 1121-1452	Cycoloy	460°F/238°C	N.D. N.D.
	Parts Inspection Table**	P	0720-1130 1132-1445	Surlyn		N.D.
	On Top of Oven	A	0715-1130 1130-1458	Surlyn		N.D. N.D.
	31	P	0710-1114 1116-1452	Polypropylene	390-430°F/199-221°C	N.D. N.D.
8/31/76	7***		1945-1950	40% Reprocessed ABS 60% Virgin ABS	Purging	N.D.
9/1/76	20***		2235-2240	ABS	Purging	N.D.
	22***		2315-2320	ABS	Purging	19
	Imperial Line		1000-1010	Fastening ABS to Methyl Methacrylate with a hot iron.		N.D.

P - Personal sample collected in breathing zone of employee.
A - Area Sample
N.D. (None Detected) The lower limit of detection for phenol is 0.03 mg per milliliter of collecting media, the collecting media volumes ranged from 9 to 18 milliliters.

*OSHA Standard - 19 milligrams of phenol per cubic meter of air (19 mg/M^3).

**Employee works at the Parts Inspection Table adjacent to oven used to heat Surlyn.

***Indicator tube sample collected in smoke plume during purging operation.

TABLE XVII

Summary of Air Sampling for Ammonia at
Hayes - Albion Corporation, Milan, Michigan
8/30/76 - 9/1/76

Date	Press Number or Location	Sample Type	Sample Period	Type of Plastic	Press Temperature	Concentration (mg/M^3)*
8/31/76	24	Personal	0751-0821	1/3 Reprocessed ABS	500°F/260°C	0.1
			0824-0829	1/3 Color Regrind ABS		N.D.
			0846-0913	1/3 Virgin ABS		0.1
			0929-0934			0.2
			0946-1015			N.D.
			1017-1022			0.1
			1046-1116			N.D.
			1117-1122			0.1
			1340-1410			0.2
			1411-1436			0.2
			1436-1456			0.2
	4	Personal	0745-0815	Nylon	460-480°F/238-249°C	N.D.
			0915-0920			N.D.
			0925-0955			N.D.
			1000-1030			0.1
			1154-1224			N.D.
			1220-1225			N.D.
			1400-1430			<0.1
			1435-1440			N.D.
8/30/76	4**		1730-1735	Nylon	Purging	N.D.
			1735-1740			N.D.
			1750-1755			N.D.
8/31/76	4**		0930-0935	Nylon	Purging	N.D.
	7**		1945-1950	40% Reprocessed ABS 60% Virgin ABS	Purging	4
9/1/76	20**		2235-2240	ABS	Purging	42
	22**		2315-2320	ABS	Purging	14

N.D. (None Detected) The lower limit of detection for ammonia is 0.001 mg per sample. The collecting media volumes ranged from 8 to 11 milliliters.

*OSHA Standard - 35 milligrams of ammonia per cubic meter of air (35 mg/M^3).

**Indicator tube sample collected in smoke plume during purging operation.

TABLE XVIII

Summary of Air Sampling[1] for Aliphatic Amines, Aromatic Amines, Cresols, Butyl-p-cresol (BHT), Phthalates, and Organics at Hayes-Albion Corporation, Milan, Michigan
August 30, 1976 - September 1, 1976

Date	Press Number or Operation	Sample Period	Type of Plastic	Press Temperature	Concentration (mg/M^3) Aliphatic Amines	Aromatic Amines and Cresols	BHT and Phthalates	Organics[2] (Toluene)
8-30-76	30	1550-1930	ABS Colors Regrind	450°F/232°C			N.D.[3]	
		2005-2255					N.D.	
		1550-1925				N.D.		
		1920-2255				N.D.		
		1550-1922						<1
		1923-2255						<1
	1	1610-1935	ABS Regrind (1600-1700)	580°F/304°C			N.D.	
	4	2000-2300	Nylon (1700-2200)	460-480°F/238-249°C			N.D.	
	6	1611-1935	Surlyn (2200-2300)	380-400°F/193-204°C		N.D.		
		1920-2300)				N.D.		
		1612-1935						<2
		1935-2300						<2
	11	1550-1918	1/3 Reprocessed ABS	400°F/204°C			N.D.	
		2013-2255	1/3 Colors Regrind ABS				N.D.	
		1530-1917	1/3 Virgin ABS			N.D.		
		1920-2255				N.D.		
		1530-1920						<1
		1920-2255						<1
	Parts Inspector	1649-1951					N.D.	
		1954-2257					N.D.	
		1649-2257				N.D.		
		1649-1953						<2
		1954-2257						<2
	7	1541-1941	40% Reprocessed ABS	410-430°F/210-221°C			N.D.	
		1942-2300	60% Virgin ABS				N.D.	
		1547-2300				N.D.		
		1536-1936						<1
		1938-2300						<2

TABLE XVIII (Continued)

Date	Press Number or Operation	Sample Period	Type of Plastic	Press Temperature	Concentration (mg/M^3) Aliphatic Amines	Aromatic Amines and Cresols	BHT and Phthalates	Organics (Toluene)
8-31-76	7	1523-2300	40% Reprocessed ABS 60% Virgin ABS	420-440°F/216-227°C	N.D.			
	4	1505-2245 1540-2245	Nylon (1500-2100) Surlyn (2100-2300)	460-480°F/238-249°C 380°F/193°C	N.D.	N.D.		
9-1-76	21	0717-1117 1122-1453	Cycology	460°F/238°C				<1 <1
	Parts Inspector	0720-1445			N.D.	N.D.		<1
	31	0710-1450	Polypropylene	390-400°F/199-204°C	N.D.	N.D.		
	Imperial Line	0710-1450	Fastening a piece of methyl methacrylate to to ABS with a hot iron			N.D.	N.D.	<1
	Maintenance[6]	2135-0108			N.D.	N.D.	N.D.	N.D.

1. Air sampling media was worn by the employee

2. With the exception of the sample collected on the Janitor, the only component detected and identified by GC/MS for the other samples was a trace of toluene. The concentration of toluene was generally less than 10 micrograms per sample. The sample collected on the Janitor contained mineral spirits

3. N.D. (None Detected) The lower limit of detection for organics, cresols, and aromatic amines is 0.01 mg per sample, for aliphatic amines is 0.007 mg per sample and for BHT and phthalates is 0.005 mg per sample. Air sample volumes ranged from 9.4 to 26.5 liters (ℓ) for aliphatic amines, 4.7 to 26.7 for aromatic amimes and cresols, 7.4 to 27.6ℓ for organics, and 6.1 to 26ℓ for BHT and phthalates.

4. Maintenance employee purged 4 presses containing ABS, 4 presses with nylon, and two presses with cycoloy during the sampling period.

5. Janitor cleaned presses with a solution of mineral spirits. The sample displayed a series of peaks which mass spectorscopy identified as mainly aliphatic type hydrocarbons (alkanes) and possibly some cumene. The concentration of mineral spirits was approximately 45 mg/M^3. (A GC analysis on a bulk sample of the mineral spirits did not detect any benzene).

6. Maintenance employee purged two presses containing ABS and 1 press with polypropylene.

OSHA Standards: Toluene - 750 milligrams per cubic meter (750 mg/M^3).
Cumune - 245 mg/M^3.
Mineral Spirits - No airborne exposure limit has been established.

TABLE XVIII (Continued)

Date	Press Number or Operation	Sample Period	Type of Plastic	Press Temperature	Concentration (mg/M^3)			
					Aliphatic Amines	Aromatic Amines and Cresols	BHT and Phthalates	Organics (Toluene)
8-31-76	24	0750-1141	1/3 Reprocessed ABS	500°F/260°C	N.D.			
		1141-1452	1/3 Colors Regrind ABS		N.D.			
			1/3 Virgin ABS					
	30	0725-1134	ABS Colors Regrind	430-450°F/221-232°C	N.D.			
		1137-1447			N.D.			
	1	0719-1127	ABS Regrind	580°F/304°C	N.D.			
		1129-1445			N.D.			
	Maintenence[4]	0710-1100				N.D.	N.D.	<2
		1110-1650				N.D.	N.D.	<1
	26	0751-1501	80% Surlyn					
			20% Black Concentrate	390°F/199°C				<1
	21	0727-1453	Cycoloy	450-480°F/232-249°C			N.D.	
		0725-1125				N.D.		
		1128-1452				N.D.		
	31	0720-1115	Polypropylene	430°F/221°C			N.D.	4
		1120-1500					N.D.	<1
	4	0708-1030	Nylon	460-480°F/238-249°C	N.D.		N.D.	
		1035-1445			N.D.		N.D.	
		0708-1445						<1
	32	1636-2300	Virgin ABS	470°F/243°C	N.D.	N.D.	N.D.	<1
	Janitor[5]	1534-2252			N.D.	N.D.	N.D.	45

TABLE XIX

Summary of Air Sampling* for Metals at
Hayes - Albion Corporation, Milan, Michigan
8/30/76 - 8/31/76

Date	Press Number or Operation	Sample Period	Type of Plastic	Concentration (mg/M^3)** Copper	Lead	Zinc
8/30/76	Parts Inspector	1649-2257		<0.01	<0.01	<0.01
8/31/76	1	0719-1445	ABS Regrind	<0.01	<0.01	0.01
	26	0749-1459	80% Surlyn 20% Black Concentrate	<0.01	<0.01	<0.01
	21	0730-1454	Cycoloy	<0.01	<0.01	<0.01
	31	0720-1500	Polypropylene	<0.01	<0.01	<0.01
	32	1636-2300	Virgin ABS	<0.01	<0.01	<0.01
	7	1525-2258	40% Reprocessed ABS 60% Virgin ABS	<0.01	<0.01	<0.01
	4	1506-2245	Nylon (1500-2100) Surlyn (2100-2300)	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01

*Sampling media was worn by the employee

**OSHA STANDARD: Copper dust - 1 milligram of contaminant per cubic meter of air (1 mg/M^3).
Lead - 0.2 mg/M^3
Zinc - 5 mg/M^3

Note: No additional heavy metals were found when analyzed by emission spectroscopy.

TABLE XX

Summary of Additional Measurements taken for Various Chemical Substances with Drager Indicator Tubes at

Hayes-Albion Corporation
Milan, Michigan

Date	Location	Sample Type	Time of Day	Type of Plastic	Press Temperature	Contaminant	Tube Reading
5/7/76	Press 20	A	1030	Cycoloy		Hydrogen Cyanide	None
		A	1035			Acrylonitrile	None
		A	1040			Benzene	None
		A	1045			Styrene	None
		A	1049			Formaldehyde	None
	Press 7	A	1100	ABS		Hydrogen Cyanide	None
		A	1105			Formaldehyde	None
		A	1115			Styrene	None
		A	1122			Acrylonitrile	None
		A	1140			Benzene	None
	Press 11	A	1420	ABS		Hydrogen Cyanide	None
		A	1430			Styrene	None
		A	1434			Formaldehyde	None
		A	1455			Benzene	None
		A	1520			Acrylonitrile	None
	Press 20	SP		Cycoloy	Purging	Hydrogen Cyanide	2 ppm
8/30/76	Press 30	BZ	1710	ABS Regrind	450°F/232°C	Styrene	None
		BZ	1741			Carbon Monoxide	None
		BZ	1809			Acrylonitrile	None
		BZ	1812			Phenol	None
		BZ	1815			Nitrogen Dioxide	None
		BZ	1824			Hydrogen Cyanide	None
		BZ	2220			Dimethylformamide	None

Table XX (Continued)

Date	Location	Sample Type	Time of Day	Type of Plastic	Press Temperature	Contaminant	Tube Reading
8/30/76	Press 11	BZ	1830	1/3 Reprocessed ABS	400°F/204°C	Hydrogen Cyanide	None
		BZ	1835	1/3 Color Regrind ABS		Phenol	None
		BZ	1840	1/3 Virgin ABS		Acrylonitrile	None
		BZ	1844			Carbon Monoxide	None
		BZ	1849			Nitrogen Dioxide	None
		BZ	1855			Dimethylformamide	None
	Press 26	BZ	2130	Surlyn	380-400°F	Carbon Monoxide	Trace (<10 ppm)
		BZ	2140		193-204°C	Nitrogen Dioxide	None
		BZ	2145			Acrylonitrile	None
		BZ	2149			Hydrogen Cyanide	None
		BZ	2151			Styrene	None
		BZ	2209			Phenol	None
		BZ	2273			Dimethylformamide	None
8/31/76	Press 24	BZ	0938	1/3 Reprocessed ABS	500°F/260°C	Benzene	None
		BZ	0948	1/3 Color Regrind ABS		Vinyl Chloride	None
		BZ	0955	1/3 Virgin ABS		Ethyl Acetate	None
		BZ	1005			Methylene Chloride	Trace (<100ppm)
	Press 4	BZ	0930	Nylon	460-480°F	Carbon Monoxide	None
		BZ	0930		238-249°C	Ammonia	None
		BZ	0930			Nitrogen Dioxide	None
	Press 31	A	1200	Polypropylene	430°F/221°C	Phenol	None
		A	1210			Carbon Monoxide	None
		A	1214			Hydrogen Cyanide	None
	Press 7	SP	1945	40% Reprocessed ABS	Purging	Styrene	None
		SP	1945	60% Virgin ABS		Carbon Monoxide	Trace (<5 ppm)
	Press 32	BZ		Virgin ABS	470°F/243°C	Hydrogen Cyanide	None
		BZ				Phenol	None
		BZ				Formaldehyde	None
		BZ				Carbon Monoxide	None
		BZ				Benzene	None
		BZ				Ammonia	None

Table XX (Continued)

Date	Location	Sample Type	Time of Day	Type of Plastic	Press Temperature	Contaminant	Tube Reading
9/1/76	Press 32	SP	0930	Virgin ABS	Purging	Triethylamine	5 ppm
	Press 20	SP	2235	ABS	Purging	Styrene	None
	Press 22	SP	2315	ABS	Purging	Carbon Monoxide	5 ppm
	Imperial Line	SP	1025	Fastening ABS to		Acrylonitrile	None
		SP	1010	Methyl Methacrylate		Vinyl Chloride	None
		SP	1040	with a hot iron		Acetic Acid	None
		SP	1049			Styrene	None

A - Area Sample
SP - Sample collected in smoke plume during purging
BZ - Sample collected in breathing zone of employee
ppm - Parts of contaminant per million parts of air by volume

Contaminant	OSHA Standard	Lower Range of Measurement for Indicator Tube
Hydrogen Cyanide	10 ppm	2 ppm
Acrylonitrile	20 ppm	5 ppm
Benzene	10 ppm	5 ppm
Styrene	100 ppm	50 ppm
Formaldehyde	3 ppm	0.5 ppm
Carbon Monoxide	50 ppm	5 ppm
Phenol	5 ppm	5 ppm
Nitrogen Dioxide	5 ppm	5 ppm
Dimethylformamide	10 ppm	10 ppm
Vinyl Chloride	1 ppm	1 ppm
Ethyl Acetate	400 ppm	200 ppm
Methylene Chloride	500 ppm	100 ppm
Ammonia	50 ppm	5 ppm
Triethylamine	25 ppm	5 ppm
Acetic Acid	10 ppm	5 ppm

TABLE XXI

FACE VELOCITY DETERMINATIONS OF SPRAY BOOTHS IN OPERATION
AT HAYES - ALBION CORPORATION, MILAN, MICHIGAN
MAY 6, 1976

Location	Booth Number	Linear Feet Per Minute*
Decorating Area	1	115
" "	3	180
" "	4	80
" "	5	110
" "	6	155
" "	8	75
" "	9	155
" "	10	140
" "	11	140
" "	12	90
" "	13	120
" "	15	90
" "	16	80
" "	17	130
" "	18	160
" "	19	185
Truck Line	--	140
Base and Top Coat Line	Top Coat Booth (23)	230
Base and Top Coat Line	Booth Opposite 23	285
Base and Top Coat Line	Base Coat Booth (24)	110
Base and Top Coat Line	Booth Opposite 24	300
Old Electrostatic Booth	--	105**

* Data have been rounded off to nearest 5 linear feet per minute. A minimum of 9 readings (traverse points) were used to determine the individual averages.

** Air in booth turbulent with poor distribution.

RHHE No. ____________
Date ____________
NIOSH Investigator:
____

Appendix 1
HEALTH HAZARD EVALUATION INITIAL SURVEY
EMPLOYEE INTERVIEW
(Confidential)

1. Employee Name ____
   (First) (Middle) (Last)
   Job Title ______________________________ Shift ____________
   Description of Work Duties ______________________________
   Address ____
   (Street) (City/State/Zip Code)
   Age ________ Sex ____________ Telephone ____________

2. Occupational Work History (Start with Present Job):

Company	Job Description	Month/Year Began	Month/Year Ended

3. Do you have any health problems at work or you feel might be related to your work? If so, list symptoms, describe how and when they occur, when they go away, and how long you have had them. What do you think they are caused by?

   ____
   ____
   ____
   ____

4. When was the last time you had this problem? ____________
   Are you symptomatic or have this problem today? ____________

5. Do you have any other health problems? If so, list symptoms, describe how and when they occur, when they go away, and how long you have had them, and the last time you had them. What do you think they are caused by?

   ____
   ____
   ____
   ____

6. Do you smoke? ________ Type? ________ How long? ________ How much? ________
   ____

7. Attempt to find out names of workers who have or had health problems, who are absent because of sickness, have been discharged or transferred to other areas for health reasons, and workers who are deceased. For these workers attempt to find out diagnoses, symptoms, when they became ill and suspected relationship to work, if any. (use reverse side for listing of names, etc.)

- over -

PROJECT APPROVED
OMB No. 68-R1236

Listing of other workers who reportedly have or have had health problems which may be related to their work.

Name	Job/Location	Health Problem (if known)

8. REQUEST AND AUTHORIZATION FOR RELEASE OF MEDICAL INFORMATION

I, ______________________________ hereby request and
Patient Name

authorize ______________________________
(Personal and/or Company Physician)

____
Address

to release to the National Institute for Occupational Safety and Health (NIOSH) such of my medical records as are requested by NIOSH as a part of Health Hazard Evaluation Number __________.

DATE ____________________ SIGNATURE OF WORKER ____________________

WITNESS: ____________________

9. Space for additional comments (attach other pages as necessary).