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. 76-28-332

WELCH PLASTICS AND MANUFACTURING COMPANY
COLUMBUS, OHIO

SEPTEMBER 1976

I. TOXICITY DETERMINATION

Exposures of employees to chemical agents at a molding operation (Press #22) were not found to be toxic under the conditions observed by the NIOSH Hazard Evaluation personnel during the survey dates of March 25 and May 19, 1976. Worker exposures to benzene, bis-chloromethyl ether, 2,6-ditert-butyl-p-cresol (BHT), carbon monoxide, formaldehyde, hydrogen chloride, hydrogen cyanide, nuisance particulate, phthalates, styrene and vinyl chloride were determined by personal and area air sampling. Persons working at and around Press #22 have experienced mucous membrane (upper respiratory and eye) irritation associated with the use of a PVC-ABS material (a reground polyvinyl chloride and acrylonitrile-butadiene-polystyrene material). The use of this recycled material has been discontinued and should not be used unless emission control equipment is incorporated into these processes.

This determination is based upon medical evaluation by interview and brief physical examination, laboratory investigation of these materials thermal decomposition products, measurements of workplace concentrations of airborne chemicals, inspection of the work areas and materials used, and review of the current knowledge of the materials used.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Copies have been sent to:

a) Welch Plastics and Manufacturing Company, Columbus, Ohio
b) Authorized Representative of Employees
c) U. S. Department of Labor - Region V
d) NIOSH - Region V

For the purpose of informing the approximately twelve "affected employees", the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where affected 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 normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees regarding worker exposures at a plastic molding operation where employees had experienced eye irritation, headaches, and chest pains.

IV. HEALTH HAZARD EVALUATION

A. Description of Process - Conditions of Use

This facility is involved in the production of custom molded plastic products. A total of about 150 supervisory and production employees work three shifts, with most working during the day shift.

The operation of concern involves the production of an automobile dashboard part in molding room #2 (dimensions of about 100 by 20 feet with a 15-foot ceiling), at Press #22. Approximately 1,500 to 2,000 dashboard units were produced each day (as observed during the periods of this evaluation). A total of four employees per shift, three shifts per day are involved in the immediate area of Press #22. The backside operator places a piece of wood-grained vinyl plastic sheet on a "vacu-form" machine. The vacu-form heats (infra-red lamps) the vinyl plastic sheet and forms (by vacuum under the sheet) the dashboard features. This formed sheet is placed into the face of the mold with the aid of a "static electricity wand." Zinc stearate is applied to the mold face as a release aid. An acrylonitrile-butadiene-polystyrene copolymer (ABS material) is injection molded to this vinyl sheet to give the dashboard rigidity. The ABS material which is used at this operation is commonly a mixture of "virgin" ABS (Monsanto Lustran®) and reground scrap ABS materials. These reground materials are commonly the rejected dashboard parts (containing PVC and ABS material), and other non-ABS materials. The front side operator then removes the dashboard piece and trims off unwanted portions. A "cut-off" operator performs further trimming adjacent to Press #22. Another employee relieves the front and back operators during lunch and coffee breaks.

This operation is not ventilated with the exception of natural air movement through open doors. A space heater is located above Press #22.

This operation was to stop in June 1976 when the production contract for the dashboard expired.

B. Evaluation Design and Methods

NIOSH personnel visited this facility on three dates: March 25, May 12, and May 19, 1976. An initial environmental and medical survey was conducted on March 25. During this initial visit a walk-through survey of this facility was conducted, persons working in the area of Press #22 were evaluated by medical history and brief physical examination, air sampling was conducted, and bulk samples of various plastic materials were collected. An unannounced visit was made to this operation on May 12, 1976 for the purpose of confirming the conditions of operation and materials used, and to collect bulk samples of materials used. An unannounced follow-up environmental evaluation was conducted on May 19, 1976 and included air sampling and further investigation of work-related health problems.

1. Medical

On March 25, 1976 six persons (all female) working at and around Press #22 were interviewed regarding their occupational history, symptoms experienced on the job, and aggravating or alleviating factors. Brief physical examinations and chest ausculation (chest examinations using a stethoscope) were performed on several of the interviewees.

2. Thermal Degradation Products

Randomly selected bulk samples of plastic materials used at Press #22 were obtained and evaluated to determine which products are evolved under operating conditions. These materials were heated through a temperature range of 25-315^{o}C. with a Mettler DT-1 Thermo-analyzer and the weight losses were measured. Aliquots of these materials also were put into a small oven and heated to 410^{o}F. A steady stream of air was passed over the samples and the effluent vapors were analyzed for various contaminants: hydrogen chloride (using litmus paper in combination with chloride analysis by chloride specific ion electrode), butadiene-styrene (detector tube), formaldehyde (chromotrophic acid test), and hydrogen cyanide (detector tube). The effluent vapors also were collected using activated charcoal and fluorisil with subsequent analysis by linked gas chromatography/mass spectrophotometry.

3. Air Sampling

Benzene and Styrene - Worker exposures to benzene and styrene were estimated by area and personal air sampling. Benzene and styrene levels were measured by drawing air at 50 cc/minute through tubes containing activated charcoal collecting media. Analysis (carbon disulfide desorption and gas chromatography) was performed by NIOSH laboratories in Cincinnati, Ohio. Drager colorimetric gas detector units were also used to measure the benzene and styrene levels. The benzene gas detector units are NIOSH certified to have an accuracy of ±35 percent at one-half the exposure limit and an accuracy of ±25 percent at one to five times the exposure limit. The styrene gas detector units are not certified for accuracy.

B. Evaluation Design and Methods

NIOSH personnel visited this facility on three dates: March 25, May 12, and May 19, 1976. An initial environmental and medical survey was conducted on March 25. During this initial visit a walk-through survey of this facility was conducted, persons working in the area of Press #22 were evaluated by medical history and brief physical examination, air sampling was conducted, and bulk samples of various plastic materials were collected. An unannounced visit was made to this operation on May 12, 1976 for the purpose of confirming the conditions of operation and materials used, and to collect bulk samples of materials used. An unannounced follow-up environmental evaluation was conducted on May 19, 1976 and included air sampling and further investigation of work-related health problems.

1. Medical

On March 25, 1976 six persons (all female) working at and around Press #22 were interviewed regarding their occupational history, symptoms experienced on the job, and aggravating or alleviating factors. Brief physical examinations and chest ausculation (chest examinations using a stethoscope) were performed on several of the interviewees.

2. Thermal Degradation Products

Randomly selected bulk samples of plastic materials used at Press #22 were obtained and evaluated to determine which products are evolved under operating conditions. These materials were heated through a temperature range of 25-315^{o}C. with a Mettler DT-1 Thermo-analyzer and the weight losses were measured. Aliquots of these materials also were put into a small oven and heated to 410^{o}F. A steady stream of air was passed over the samples and the effluent vapors were analyzed for various contaminants: hydrogen chloride (using litmus paper in combination with chloride analysis by chloride specific ion electrode), butadiene-styrene (detector tube), formaldehyde (chromotrophic acid test), and hydrogen cyanide (detector tube). The effluent vapors also were collected using activated charcoal and fluorisil with subsequent analysis by linked gas chromatography/mass spectrophotometry.

3. Air Sampling

Benzene and Styrene - Worker exposures to benzene and styrene were estimated by area and personal air sampling. Benzene and styrene levels were measured by drawing air at 50 cc/minute through tubes containing activated charcoal collecting media. Analysis (carbon disulfide desorption and gas chromatography) was performed by NIOSH laboratories in Cincinnati, Ohio. Drager colorimetric gas detector units were also used to measure the benzene and styrene levels. The benzene gas detector units are NIOSH certified to have an accuracy of ±35 percent at one-half the exposure limit and an accuracy of ±25 percent at one to five times the exposure limit. The styrene gas detector units are not certified for accuracy.

Bis-chloromethyl Ether - Worker exposures to bis-chloromethyl ether were determined by area air sampling. Bis-chloromethyl ether levels were measured by drawing air at 200 cc/minute through Poro-pac Q collecting tubes with subsequent analysis (thermal elution into 2,4,6 trichlorophenol derivative solution with analysis of the derivative by gas chromatographic/ mass spectrophotometry) by the Bendix Launch Support Division in Coco Beach, Florida.

BHT and Phthalates - Worker exposures to butyl-p-cresol (BHT) and phthalates were determined by area air sampling. Air was drawn at 50 cc/minute through glass tubes containing fluorisil collecting media and subsequently analyzed (ethyl acetate desorption and gas chromatography) by NIOSH laboratories in Cincinnati, Ohio.

Carbon Monoxide - Worker exposures to carbon monoxide were determined by area air samples using Drager colorimetric gas detector units. These units are NIOSH certified to have an accuracy of ±35 percent at one-half the exposure limit and an accuracy of ±25 percent at one to five times the exposure limit.

Formaldehyde - Worker exposures to formaldehyde were determined by area air sampling. Formaldehyde levels were measured by drawing air at about 700 cc/minute through an impinger containing 1% sodium bisulfite collecting media with analysis performed by Utah Biomedical Test Laboratory under contract for NIOSH. Formaldehyde levels also were measured using Drager colorimetric gas detector units. These units are not certified for accuracy.

Hydrogen Chloride - Worker exposures to hydrochloric acid mist were measured by bubbling air at 650 cc/minute through an impinger containing 0.5 N sodium acetate collecting media. The amount of hydrochloric acid was determined by the turbidimetric method. Drager colorimetric gas detector units also were used to measure levels of hydrochloric acid gas. These units are not certified for accuracy.

Hydrogen Cyanide - Worker exposures to hydrogen cyanide were measured by bubbling air at 700 cc/minute through an impinger containing 0.1 N sodium hydroxide collecting media with analysis performed by Utah Biomedical Test Laboratory under contract for NIOSH. Hydrogen cyanide levels also were measured using Drager colorimetric gas detector units. These units are NIOSH certified to have an accuracy of ±35 percent at one-half the exposure limit and an accuracy of ±25 percent at one to five times the exposure limit.

Nuisance Particulate - Worker exposures to airborne nuisance particulate were determined by area air sampling. Airborne particulate levels were measured by drawing air at 2.0 liters per minute through a pre-weighed VM-1 filter with subsequent determination of the filter's weight gain.

Vinyl Chloride - Worker exposures to vinyl chloride monomer were determined by personal air sampling. Vinyl chloride levels were measured by drawing air at 50 cc/minute through tubes containing activated charcoal collecting media with analysis (carbon disulfide desorption of the activated charcoal and gas chromatography) performed by Utah Biomedical Test Laboratory under contract for NIOSH.

The worker's thermal environment was evaluated by obtaining the wet bulb, dry bulb, and globe temperatures.

C. Evaluation Criteria

1. Toxic Effects

A review of the literature on health hazards associated with plastic molding of thermoplastic materials (plastic materials which are capable of being softened by increase of temperature and hardened by decrease of temperature) found few reports of health hazards. The most common health problems at these operations are upper respiratory irritation due to thermal decomposition of the plastics, and skin irritation from the use of hydrocarbon cleaning solvents. Volatile emissions from thermoplastic molding operations are usually not a problem since the molding materials would have altered properties at temperatures resulting in decomposition and emission of volatiles. Volatile emissions are dependent on the components of the material and temperatures reached during the melting stage. The operation of concern uses a polyvinyl chloride sheet and an acrylonitrile-butadiene-styrene copolymer.

The emissions from heating or combustion of PVC materials is dependent on the components of the formulation and the temperatures which are reached. Laboratory analysis by NIOSH of the volatile products at operating temperatures indicated the presence of benzene, 2-octene, 1-chloroheptane, 1-chloro-2-ethylhexane, BHT, and phthalates. Laboratory studies of pure PVC resin pyrolysis indicate that hydrogen chloride and benzene are the main volatile products.[1,2] Most PVC formulations are blended with plasticizers and stabilizers to give the PVC flexibility and inhibit thermal degradation. On thermal degradation, this PVC sheet would first emit the volatile plasticizers (phthalates) with subsequent emission of hydrogen chloride and hydrocarbons, predominantly benzene. In most cases, employee exposures to benzene from PVC degradation would be controlled by the irritating hydrogen chloride emissions. Studies in the meat wrapping industry[3,4,5] on the pyrolysis products of PVC film suggest that the emitted smoke is primarily plasticizers with only minimal amounts of hydrogen chloride and other decomposition products of the PVC.

Much attention has recently been directed toward vinyl chloride in the work environment. Vinyl chloride exposures occur primarily in the production of vinyl chloride, in polymerization of vinyl chloride, and the handling of freshly manufactured resin powder containing residual vinyl chloride. Trace concentrations of free vinyl chloride have been found at extrustion and molding operations during NIOSH studies at other plants utilizing PVC formulations.[6,7,8] Vinyl chloride (the monomer from which PVC is made) is a carcinogenic agent. It is an etiological agent in the development of angiosarcoma of the liver (a rare form of liver cancer).

As stated in NIOSH's Recommended Standard for Occupational Exposure to Vinyl Chloride,[9] "there is probably no threshold for carcinogenesis although it is possible that with very low concentrations, the latency period might be extended beyond the life expectancy." In view of these considerations and NIOSH's inability to describe a safe exposure level as required in Section 20(a)(3) of the Occupational Safety and Health Act, the concept of a threshold limit for vinyl chloride gas in the atmosphere was rejected. As a result, the NIOSH recommended Standard for Occupational Exposure to Vinyl Chloride states that exposure to vinyl chloride monomer should not exceed levels that are detectable by the recommended methods of sampling and analysis.

The emissions from heating or combustion of acrylonitrile-butadiene-polystyrenes (ABS) copolymers is dependent on the components of the formulation and the temperatures which are reached. Laboratory analysis by NIOSH of the volatile products resulting from operating temperatures achieved with ABS material indicated the presence of hydrogen cyanide, styrene, BHT, and a terpene. Other laboratory studies of ABS and similar polymer pyrolysis indicate that styrene, benzene, toluene, d-methylstyrene, hydrogen cyanide, ammonia and 1,3-butadiene are possible volatile products.[2,10,11,12]

Information on the resulting pyrolysis products of combined ABS and PVC materials is not available in the literature. Laboratory analysis by NIOSH indicates that these materials when combined and heated to operating temperatures have a greater volatile emission than the individual materials (See Table I). The significance of this is unknown as the qualitative analysis indicated essentially the same emissions from the pure materials and when mixed, and this analysis was not quantitative.

Bis-chloromethyl ether (BCME) is recognized as a carcinogenic agent for animals and humans. Epidemiologic studies of workers occupationally exposed to BCME have shown these persons to be at an increased risk of developing lung cancer.[13,14] It has been reported that the formation of BCME can occur from the reaction of formaldehyde and ionic chloride compounds.[15] Studies by NIOSH have found BCME to occur spontaneously in concentrations of parts per billion in the textile industry where both formaldehyde and the chloride ion are present.[16]

2. Environmental Evaluation Criteria

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

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

b. Threshold Limit Values (TLV's) - guidelines for airborne exposures recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) for 1976.

c. OSHA Standards - the air contaminant standards enforced by the U.S. Department of Labor as found in Federal Register, Vol. 39, 23540-23543, June 27, 1974.

The criteria used in this investigation to assess potential health hazards from airborne exposures are listed below:

Source	Substance	8-hour Time Weighted Average Concentrations
NIOSH Criteria Document	Benzene	30 mg/M^3*
NIOSH Criteria Document	Carbon Monoxide	35 ppm
1976 TLV	2,6-Ditert-butyl-p-cresol (BHT)	10 mg/M^3
1976 TLV	Formaldehyde	3 mg/M^3
OSHA Standard	Hydrogen Chloride	7 mg/M^3
OSHA Standard	Hydrogen Cyanide	11 mg/M^3
1976 TLV	Nuisance Particulate	10 mg/M^3
OSHA Standard	Styrene	420 mg/M^3

* - approximate milligrams of contaminant per cubic meter of air.

NIOSH is unable to describe a safe exposure level for the carcinogens vinyl chloride and bis-chloromethyl ether. Levels of vinyl chloride and bis-chloromethyl ether should not exceed levels that are detectable by the recommended methods of sampling and analysis.

NIOSH Recommended Standards and TLV's are only recommended exposure limits whereas the OSHA Standards are those promulgated and enforced by the U.S. Department of Labor.

D. Evaluation Results

1. Medical

Table II summarizes the pertinent points of the employee interviews. The work related health complaints were mainly mucous membrane irritation associated with working around Press #22 while the reground PVC-ABS material was being used. All but one press operator admitted experiencing increased symptoms associated with a foul odor on March 22, 1976, a day when the reground PVC-ABS material apparently was used in high concentrations for molding. The reground PVC-ABS material was not normally used in such high concentrations and when the irritating emissions were noted the operation was stopped and the press was purged of the remaining molding material. Workers present during this incident admitted to having the worst symptoms at this time. At other times complaints consisted of dry mouth, sore throat, and occasional headaches. One worker complained of burning eyes, cough and wheeze, but these symptoms only occurred on March 22, 1976. Two workers complained of occasional mild to moderate severe chest pains in the anterior chest. These pains were rather vague and only associated with work, never occurring at home. It was thought that these pains might be caused by the constant stretching required by the work.

Brief physical exams consisting of throat examinations and chest ausculation were performed. Pulmonary findings were consistent with a history of smoking, and one patient had evidence of a recent pharyngitis. The skin rash reported by one worker was resolved at the time of this evaluation. While consistent complaints of respiratory irritation were reported to be associated with work at Press #22 while using the reground PVC-ABS material no evidence exists to indicate that a permanent health effect has resulted from these work exposures.

2. Environmental

Both on-site air sampling and laboratory analysis of these materials thermal decomposition products was conducted in an attempt to determine the airborne contaminants that workers were exposed to during normal operating conditions and during the incident on March 22, 1976. Following the initial visit of March 25, 1976, several unannounced visits were made to this facility to determine if the reground PVC-ABS material was still being used. At these times only virgin and recycled ABS material was used.

Results of air sampling on March 25 and May 20, 1975 are presented in Tables III-XI. These results do not indicate that employees were exposed to chemical substances at toxic levels during the time and conditions of air sampling. Symptoms were not experienced or were minimal on the days of air sampling such that these air sampling results provide little information to aid in determining the causative agent(s) of employee complaints.

Air sampling was performed at Press #10 and #22 during purging operations where ABS material was being used. At these times a visible white/gray emission was observed and the samples were obtained in the most dense portion of the emissions. Detector tube samples for benzene, hydrogen cyanide and formaldehyde showed no or only trace quantities of these contaminants. Detector tube samples for styrene showed a concentration of about 100 ppm. Charcoal and fluorisil tube samples at Press #22 (Tables III and V) during purging showed BHT to be present but no phtalates, benzene or styrene. The present purging practices should not present a health hazard to employees as long as inhalation of the concentrated emissions is avoided.

One of thirteen air samples for vinyl chloride showed detectable levels. The analytic lower limit of detection for vinyl chloride is 0.001 mg per charcoal tube sample. The one sample with detectable quantities showed 0.002 mg and a blind blank sample (a charcoal tube which had no air drawn through it but was identified to the laboratory as an actual sample) showed 0.001 mg. Based on the results showing only one sample to have vinyl chloride quantities only slightly greater than the lower limit of detection, and the low probability of residual monomer being present in such a highly processed vinyl product (wood grain vinyl sheet), it is the investigator's opinion that measurable worker exposures to vinyl chloride did not occur on the days of investigation.

Psychrometric measurements were obtained to determine if the heat/humidity environment could be a contributing or causitive factor of the employee complaints of dry throat, etc. (Table XII). These results indicate a low relative humidity which may contribute to the workers complaints of dry throat.

E. Conclusions

Employees have consistently complained of upper respiratory and mucous membrane irritation associated with the use of the reground PVC-ABS material (scrap Cadillac regrind) at Press #22 molding operations. Medical interview and brief physical examination of those persons working at and around Press #22 failed to find residual health effects from exposure to emissions from these operations. The intensity of symptoms appears to increase as the amount of reground PVC-ABS material is increased. Review of the literature, and laboratory analysis of the materials used at this operation, suggests that thermal decomposition of a PVC-ABS material would result in irritating emission such as hydrogen chloride, styrene, phthalates, ammonia and BHT. The use of the PVC-ABS material (scrap Cadillac regrind) had been discontinued and was not in use during periods of air sampling and consequently no estimation of worker exposures to airborne contaminants from these materials could be made. Air sampling was performed during the use of virgin ABS material and found that worker exposures to carbon monoxide, airborne particulate, hydrogen chloride, BHT, phthalates, bis-chloromethyl ether, benzene, styrene, formaldehyde, hydrogen cyanide and vinyl chloride were within acceptable exposure limits. While some workers complained of objectionable odors and minor respiratory irritation during the purging of ABS material from the presses, no adverse health effect is expected to result if inhalation of the concentrated emission is avoided.

V. RECOMMENDATIONS

1. Reground PVC-ABS materials should not be used in place of ABS materials under operating conditions observed at Press #22.

2. Plastic materials purged from molding presses should not contact hot surfaces. A collecting device for the purged material, or the shielding of hot surfaces may be appropriate for this purpose.

3. Future use of reground PVC-ABS materials at molding operations should be performed with emission control measures such as local exhaust ventilation. Information sources exist which provide ventilation design and performance criteria.[17]

VI. REFERENCES

1. E.A. Boettner, et. al. "Analysis of the Volatile Combustion Products of Vinyl Plastics." Journal of Applied Polymer Science 13, 377-91, 1969.

2. S.L. Madorsky, Thermal Degradation of Organic Polymers. Interscience Publishers, N.Y., 1963.

3. Vandervort, R., Brooks, S., Health Hazard Evaluation Report 74-24, 92,95-246, December, 1976.

4. Van Houten, R.W., Cudworth, A.I., Irvine, C.H., "Evaluation and Reduction of Air Contaminants Produced by Thermal Cutting and Sealing of PVC Packaging Film." Am. Ind. Hyg. Assoc. J. 35:218-222 (April 1974).

5. Jaeger, R.J., Hites, R. A. "Pyrolytic Evaporation of the Plasticizer from Polyvinyl Chloride Meat Wrapping Film," Bulletin of Environmental Contamination and Toxicology 11:45-48 (1974).

6. Okawa, M., HHE Report No. 74-96-173, NIOSH, February, 1975.

7. Straub, W., HHE Report No. 74-85-185, NIOSH, April, 1975.

8. Okawa, M., HHE Report No. 75-1-194, NIOSH, May, 1975.

9. NIOSH Recommended Standard for Occupational Exposure to Vinyl Chloride, with excerpts from a March 11, 1974 memorandum from Marcus M. Key, Director, National Institute for Occupational Safety and Health to John H. Stender, Assistant Secretary of Labor, Occupational Safety and Health Administration.

10. Shirokor, Yu.G., Dzhezhev, A.M. "Experimental Studies of the Liberation of Volatiles by Plastics on Heating." Gigiena I Sanitariya, 33, 102-4, 1968.

11. Iglauer, N., Bentley, F.F. "Pyrolysis GLC for the Rapid Identification of Organic Polymers." J. of Chromatographis Science 12, 23, 1974.

12. Howe, R.H., Ed. Progress in Hazardous Chemicals Handling and Disposal. Institute of Advanced Sanitation Research, International Noyes Data Corp., Park Ridge, N.J., 1972. pp. 239-241.

13. Lemen, Richard A., et.al. "Cytologic Observations and Cancer Incidence Following Exposure to BCME." N.Y. Academy of Sciences, 271, 71-80, 1976.

14. DeFonso, L.R., Kelton, S.C. "Lung Cancer Following Exposure to Chloromethyl Methyl Ether." Archives of Environmental Health, June 1976 pp. 125-130.

15. Frankel, L.S., et.al. "Formation of Bis (chloromethyl) Ether from Formaldehyde and Hydrogen Chloride." Environmental Science and Technology 8, 356-9, 1974.

16. Marceleno, T., et.al. 1974. A preliminary report on the formation and detection of bis (chloromethyl) ether in the industrial and medical environments. A NIOSH paper presented at the AIHA conference in Miami, Florida.

17. American Conference of Governmental Industrial Hygienists "Industrial Ventilation. A Manual of Recommended Practice." 14th Ed. (1976).

VII. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared By:

Jack O. Geissert
Industrial Hygienist
Hazard Evaluation and
Technical Assistance Branch
Cincinnati, Ohio

John Herbert, M.D.
Cancer and Birth Defects Division
Center for Disease Control
Atlanta, Georgia

Originating Office:

Jerome P. Flesch, Acting Chief
Hazard Evaluation and
Technical Assistance Branch
Cincinnati, Ohio

Acknowledgments

Environmental Evaluation:

William A. Evans
Industrial Hygienist
Hazard Evaluation and
Technical Assistance Branch
Cincinnati, Ohio

Laboratory Analysis:

Ardith A. Grote
Peter M. Eller
R. W. Kurimo
Division of Physical Sciences
and Engineering
Cincinnati, Ohio

Steven Hudson
F. D. Pierce
Utah Biomedical Test Laboratory
Salt Lake City, Utah

Table I

Weight Loss of Plastic Materials
(Collected at Welch Plastics and Manufacturing Company, Columbus, Ohio on March 25, 1976)
as a Result of Heating

Material	% Weight Loss			
	25°C (77°C)	200°C (392°F)	240°C (464°F)	290°C (554°F)
Black ABS*	0	0.4	0.5	1.0
White ABS*	0	0.3	0.5	1.1
PVC Sheet	0	0.5	2.0	41.3
Reground PVC-ABS*	0	1.1	1.2	5.7

* These materials are heated to about 350°F-410°F during the injection molding step.

Table II

Summary of Health Complaints Reported
at Welch Plastics and Manufacturing Company, Columbus, Ohio

March 25, 1976

Case Number	Job Description	Symptoms	Comments
1	Press #22 Operator (2 months), other operations (2 years)	Rash following pruritus of wrists, neck, face (relieved by washing). Sore throat, dry mouth (relieved by drinking).	Worse symptoms on March 22, 1976
2	Press #22 Operator (7 months), other operations (10 years)	Sore, dry throat (decreased with lozenges).	
3	Press #22 Operator (6 months), other operations (2 years)	Headache, dizziness, dry throat and lips, weakness (all on March 22, 1976).	No symptoms prior to March 22, 1976
4	Press #22 Operator (6 months), other operations (2 years)	Eye and nose irritation, and headache for two days following March 22, 1976. Dry mouth, cough, wheeze.	No symptoms until March 22, 1976
5	Press #22 Operator and trimming (1 month), other operations (3 years)	Occasional chest pains (no pattern).	Absent March 22, 1976
6	Relief operator (3 days)	None.	Noted bad smell from Press #22

Table III

Summary of Air Sampling for Benzene* and Styrene
at Welch Plastics and Manufacturing Company, Columbus, Ohio

May 20, 1976

Person or Location Sampled	Sample Period	Concentration of Benzene (mg/M^3)**	Concentration of Styrene (mg/M^3)**
Back Side Operator Press #22	1505-1913	N.D.***	N.D.
Front Side Operator Press #22	1508-1923	N.D.	N.D.
Cutoff Operator	1517-1931	N.D.	N.D.
Back Side Operator Press #22	1921-2250	N.D.	N.D.
Front Side Operator	1925-2250	N.D.	N.D.
Cutoff Operator	1934-2244	N.D.	N.D.
Purging of Press #22	2125-2130	N.D.	N.D.

* OSHA Standard - 32 mg/M^3 for benzene and 420 mg/M^3 as measured by an 8-hour time weighted average exposure.

** Approximate milligrams of contaminant per cubic meter of air.

***N.D. - None detected where the analytic lower limit of detection is 0.01 mg of styrene and benzene per sample. Air sample volumes ranged from 3.0 to 13.1 liters.

Table IV

Summary of Air Sampling for bis-Chloromethyl Ether*
at Welch Plastics and Manufacturing Company, Columbus, Ohio

May 20, 1976

Sample Location	Sample Period	Concentration of bis-Chloromethyl Ether
Front Side of Press #22	1541-2230	N.D.**
Above Press #22	1526-2229	N.D.
Back Side of Press #22	1533-2226	N.D.
Cutoff Area	1544-2231	N.D.

* OSHA Standard - Employee exposures are controlled by work practices and personal protective devices. No airborne exposure limit has been established.

** N.D. - None detected where the measurement lower limit of detection is approximately one part of bis-chloromethyl ether per billion parts of contaminated air by volume.

Table V

Summary of Air Sampling for Butyl-p-cresol (BHT) and Phthalates* at Welch Plastics and Manufacturing Company, Columbus, Ohio

May 20, 1976

Location Sampled	Sample Period	Concentration of BHT (mg/M^3)**	Concentration of Phthlates (mg/M^3)**
Above Press #22	1513-1716	N.D.***	N.D.
Back Side of Press #22	1536-1738	N.D.	N.D.
Front Side of Press #22	1537-1734	N.D.	N.D.
Above Press #22	1718-2213	N.D.	N.D.
Front Side of Press #22	1736-1945	N.D.	N.D.
Back Side of Press #22	1738-1945	N.D.	N.D.
Front Side of Press #22	1949-2213	N.D.	N.D.
Back Side of Press #22	1951-2217	N.D.	N.D.
Purging of Press #22	2125-2130	6.6	N.D.

* OSHA Standard - No standard has been set for BHT or the general class of phthalates.

** Approximate milligrams of contaminant per cubic meter of air.

***N.D. - None detected where the analytic lower limit of detection for BHT and phthalates is 0.02 mg per sample, and air sample volumes ranged from 3.0 to 14.3 liters.

Table VI

Summary of Air Sampling for Carbon Monoxide*
at Welch Plastics and Manufacturing Company, Columbus, Ohio

May 20, 1976

Sample Location	Sample Period	Concentration of Carbon Monoxide (ppm)**
Back Side of Press #22	1332	10
Front Side of Press #22	1336	10
Back Side of Press #22	2031	10
Front Side of Press #22	2036	10

* OSHA Standard - 50 ppm

** Parts of carbon monoxide per million parts of contaminated air by volume.

Table VII

Summary of Air Sampling for Formaldehyde*
at Welch Plastics and Manufacturing Company, Columbus, Ohio

May 20, 1976

Sample Location	Sample Period	Concentration of Formaldehyde* (mg/M^3)**
Top of Press #22	1513-1910	.51
Back Side of Press #22	1525-1927	N.D.***
Front Side of Press #22	1533-1920	N.D.
Top of Press #22	1917-2228	N.D.
Back Side of Press #22	1934-2214	N.D.
Front Side of Press #22	1932-2222	.44

* OSHA Standard - 4.5 mg/M^3 as measured by an 8-hour time weighted average exposure.

** Approximate milligrams of contaminant per cubic meter of air.

***N.D. - None detected where the analytic lower limit of detection is 0.0002 mg per mililiter of collecting media, the collecting media volumes ranged from 11 to 13 mililiters, and sample volumes ranged from 0.10 to 0.17 cubic meters.

Table VIII

Summary of Air Sampling for Hydrogen Chloride*
at Welch Plastics and Manufacturing Company, Columbus, Ohio

March 25, 1976

Sample Location	Sample Period	Sample Method	Concentrations of Hydrochloric Acid (mg/M^3)**
Front Side of Press #22	2015	Detector Tube	N.D.***
Front Side of Press #22	2121	Detector Tube	N.D.
Back Side of Press #22	2025	Detector Tube	N.D.
Back Side of Press #22	2030	Detector Tube	N.D.

May 20, 1976

Top of Press #22	1513-1919	Impinger	N.D.
Back Side of Press #22	1522-1927	Impinger	N.D.
Front Side of Press #22	1533-1920	Impinger	N.D.
Top of Press #22	1917-2228	Impinger	N.D.
Back Side of Press #22	1934-2214	Impinger	N.D.
Front Side of Press #22	1932-2222	Impinger	N.D.

* OSHA Standard - 7 mg/M^3 as measured by an 8-hour time weighted average exposure.

** Approximate milligrams of contaminant per cubic meter of air.

*** N.D. - None detected where the analytic lower limit of detection is 0.001 mg per mililiter of collecting solution, the collecting media volume ranged from 11 to 14 mililiters, and air sample volumes ranged from 0.10 to 0.17 cubic meters (impinger method). The lower limit of detection by the detector tube method is 1.5 mg/M^3.

Table IX

Summary of Air Sampling for Hydrogen Cyanide*
at Welch Plastics and Manufacturing Company, Columbus, Ohio

May 20, 1976

Sample Location	Sample Period	Concentration of Hydrogen Cyanide (mg/M^3)**
Top of Press #22	1513-1910	N.D.***
Back Side of Press #22	1525-1927	N.D.
Front Side of Press #22	1533-1920	N.D.
Top of Press #22	1917-2228	N.D.
Back Side of Press #22	1934-2214	N.D.
Front Side of Press #22	1932-2222	N.D.

* OSHA Standard - 11 mg/M^3 as measured by an 8-hour time weighted average exposure
** Approximate milligrams of contaminant per cubic meter of air.
***N.D. - None detected where the analytic lower limit of detection is 0.00002 mg per mililiter of collecting media, and the volume of collecting media ranged from 12 to 14 mililiters, and air sample volumes ranged from 0.11 to 0.19 cubic meters.

Table X

Summary of Air Sampling for Nuisance Particulate*
at Welch Plastics and Manufacturing Company, Columbus, Ohio

March 25, 1976

Sample Location	Sample Period	Concentration of Airborne Particulate (mg/M3)**
Back Side of Press #22	1549-2230	0.16
Front Side of Press #22	1549-2230	0.17

* OSHA Standard - 15 mg/M^3.

** Approximate milligrams of contaminant per cubic meter of air.

Table XI

Summary of Air Sampling for Vinyl Chloride*
at Welch Plastics and Manufacturing Company, Columbus, Ohio

Person or Location Sampled	Sample Period	Concentration of Vinyl Chloride (mg/M^3)**
	March 25, 1976	
Back Side Operator - Press #22	1531-2230	N.D.***
Front Side Operator - Press #22	1527-2230	0.15
Back Side Operator - Press #22	1530-2230	N.D.
Front Side Operator - Press #22	1626-2230	N.D.
	May 20, 1976	
Back Side Operator - Press #22	1505-1913	N.D.
Front Side Operator - Press #22	1508-1923	N.D.
Cutoff Operator	1517-1931	N.D.
Front Side of Press #22	1723-2236	N.D.
Back Side of Press #22	1727-2250	N.D.
Above Press #22	1752-2239	N.D.
Back Side Operator - Press #22	1921-2250	N.D.
Front Side Operator - Press #22	1929-2250	N.D.
Cutoff Operator	1938-2245	N.D.

* OSHA Standard - No employee may be exposed to vinyl chloride at concentrations over 2.55 milligrams of contaminant per cubic meter of air, averaged over any 8-hour period.

** Approximate milligrams of contaminant per cubic meter of air.

***N.D. - None detected where the analytic lower limit of detection is 0.001 mg per sample, and air sample volumes ranged from 5.9 to 25.1 liters.

Table XII

Summary of Psychrometric Measurements
at Welch Plastics and Manufacturing Company, Columbus, Ohio

May 20, 1976

Location	Time	Dry Bulb Temperature (°F)	Globe Temperature (°F)	Wet Bulb Temperature (°F)	Relative Humidity
Front Side Press #22	1651	77	79	55	25%
Front Side Press #22	1731	75	77	55	25%
Back Side Press #22	1753	81	84	55	10%
Front Side Press #22	2126	78	79	58	30%
Back Side Press #22	2220	82	83	59	25%