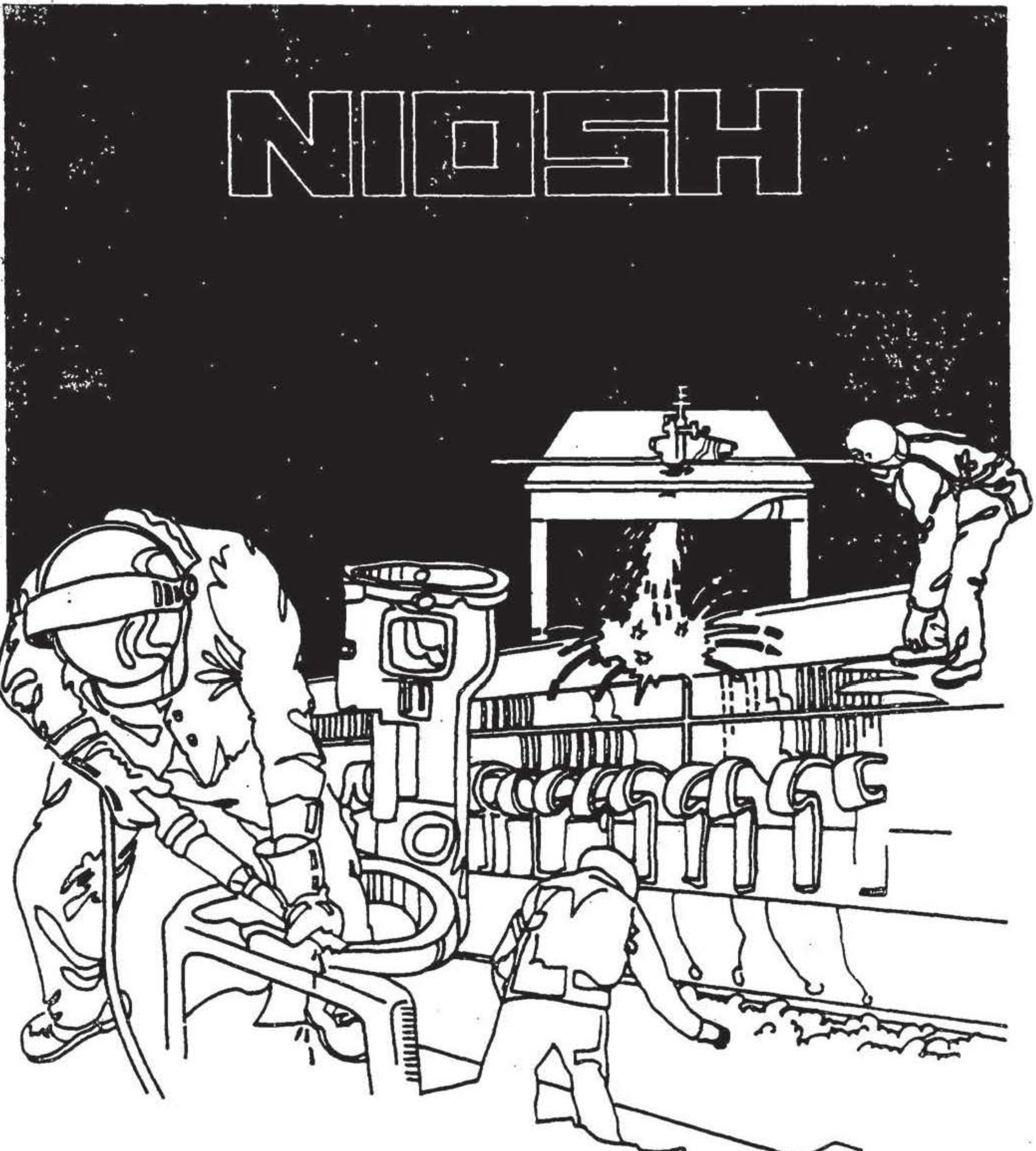
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 84-496-1766
APPLIED PLASTICS
SLOCUM, RHODE ISLAND

PREFACE

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

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

HETA 84-496-1766
JANUARY 1987
APPLIED PLASTICS
SLOCUM, RHODE ISLAND

NIOSH INVESTIGATORS:
Richard A. Keenlyside, M.D.
Louise A. House, BSN, RN
Marie Stoeckel, I.H.
Rhode Island Department of Health

I. SUMMARY

On August 24, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request from the owner of Applied Plastics Inc., in Slocum, Rhode Island, a company that manufactures machine parts from fluorocarbon polymers. For two months, workers in the molding and curing area had suffered from episodes of fever, chills, fatigue, shortness of breath, nausea, musculo-skeletal pain and headache. There was concern that they may be suffering from "polymer fume fever" following exposure to the heated product.

In response to the request, the Rhode Island Department of Health conducted site visits to the plant, on September 26, 1984, January 28, 1985, and February 7, 1985. During an initial walk-through inspection of the plant, work practices and working conditions were reviewed and employees in the molding room and adjacent machine shop were interviewed. Following this, recommendations were made to improve the ventilation of a compression process in the molding room, reduce exposure to the heated product, and to stop using an air hose to cool the teflon in heated molds.

During a follow-up visit, workers had pre- and post-shift pulmonary function tests (PFTs) and submitted urine specimens for fluoride analysis. Personal breathing zone and area air samples were obtained to measure exposure to polytetrafluoroethylene (PTFE), a pyrolysis product of heated teflon. Area levels of total dust, fluoride and hydrogen fluoride were also measured.

Three molding room workers who smoke reported symptoms of fever, chills, fatigue and shortness of breath that were consistent with fluorocarbon polymer exposure. Two other employees who occasionally worked in the area also had symptoms but these subsided when they stopped smoking.

The urinary concentrations of total fluorides in the three molding room workers ranged from 0.4 mg/g to 0.6 mg/g pre-shift to 0.3 mg/g to 1.0 mg/g post-shift (expressed per unit creatinine excretion); but all results were within the expected normal range. The same workers had a decrease of between 2.0% to 4.8% in FEV_1, and a 2.2% to 4.9% decrease in FVC between their pre- and post-shift pulmonary function tests. However, all tests were within normal limits.

Air samples contained low levels of total dust, toluene, fluoride and hydrogen fluoride, trace levels of hexane equivalents (aliphatic hydrocarbons within the range of 5-9 carbons). All levels were below OSHA permissible exposure limits and ACGIH threshold limit values.

We concluded that, despite low levels of environmental contamination that were within permissible limits and pulmonary function tests of workers that were within the normal range, the clinical presentation of illnesses in the five workers indicated that they had experienced symptoms which were consistent with polymer fume fever. Recommendations were made to control exposure to prevent recurrence of symptoms.

KEY WORDS: SIC 307.9, Polymer fume fever, teflon molding, Teflon PFA 350, urinary fluorides, pulmonary function testing.

II. INTRODUCTION

On August 24, 1984, NIOSH received a request for a health hazard evaluation from the owner of Applied Plastics, Inc. in Slocum, Rhode Island. The company manufactures machine parts from plastic polymers. During the previous two months, five employees who had worked in the plastics molding and curing room complained of respiratory problems with varying degrees of severity. The employer was concerned that these illnesses might be polymer fume fever and requested a health study.

III. BACKGROUND

Applied Plastics is a company (est. 1979) that produces solid teflon products such as ball valves, seals and electrical conductors by compressing heated teflon granules in molds. No teflon coating is carried out.

The plant is located in an unused aircraft hangar. It has an office/reception area, and a lunchroom where finished products are also packed. These lead to an open vestibule that has access to two adjacent rooms; the machine shop with five employees and the transfer molding room with four employees. See Figure 1.

One employee in the molding room carries out the transfer molding process and the other three operate presses that mold gaskets out of dry Teflon (Cold Automatic Molding). There are no windows in the area except for one in the lunchroom/packing area and two in the office area. Area ventilation is provided through open doors and a fan in the wall of the molding room. There is no cross ventilation between the machine shop and molding room. Smoking is not permitted in the plant except in the lunchroom during breaks. Cigarettes are not allowed in the transfer molding room and employees are requested to wash their hands before leaving that area.

The plant operates for 10 hours a day, four days per week and occasionally on weekends. The company employs 17 full time and a few part time workers. There had been a large worker turnover and some managerial changes recently.

<u>The Transfer Molding Process</u>

In the transfer molding process, dry teflon polymer is heated inside a tubular steel casting at 680^{o}F for 15 minutes. Castings are baked two at a time in one of two ovens (large and small) that are vented to the outside. After this, the hot casting is carried across the room to a wooden hood where the teflon is compressed under 2200 lbs. of pressure to form an inner lining. The hood is wooden and vented into the room. During the compression phase, holes in the side of the casting are covered to prevent escape of fumes. After compression, the casting is cooled with an air hose. Six to eight castings may be treated during a routine shift.

One employee, the "set-up man" carries out the molding process. Three other employees sit in the molding room close to the ovens. They operate automatic molding machine punch presses that compress cold powdered teflon into gaskets for unrelated products. These are processed further on lathes in the machine shop.

IV. THE INVESTIGATION

A. Walk through survey

On September 26, 1985, investigators from the Rhode Island Department of Health conducted a walk-through survey of the facility accompanied by NIOSH representatives from Cincinnati and Boston. At that time, there were four operators (2 male, 2 female) employed in the molding room. Three of these were available and interviewed about their symptoms during and after work. Employees working in the adjacent machine shop who were not directly exposed to heated teflon were also interviewed. Only those working in the molding room had complaints. See Figure 2.

Employee Complaints in the Molding Room

Employee A - The "set up man," a 25 year old white male, who had been working at the plant for one month, had the most striking symptoms.

During the first two weeks of his employment, he noted increasing shortness of breath, wheezing, musculoskeletal pain and fatigue. This was associated with chills and fever of 103^{o} on one day. Symptoms began toward the end of the work shift and continued after work. The fatigue became so severe at home that he had difficulty climbing the stairs and would have to rest afterwards. He usually felt better by the following morning and the cycle then repeated itself. He was noticeably better on weekends. After 2 weeks of recurrent illness he visited a local hospital emergency room where he had a chest x-ray and was treated for bronchitis.

Following his illness, the process was shut down during the week and only operated at weekends. The production was resumed a month later for one half day a week because of an increased demand for the product, but the evening fatigue and muscle pain returned with this exposure. He had smoked 1 1/2 packs of cigarettes a day for several years, and denied smoking on the job. There was no history of allergy or previous respiratory illness. He left the company after the initial visit and was not interviewed during the follow up study.

During the investigation we learned that an employee who had worked as the "set up man" for a year and a half before the present one had no respiratory symptoms while working in the molding room. He was a non-smoker.

Employee B - A 23 year old white female automatic molding machine punch operator reported a single episode of dyspnea on effort, choking, coughing, nausea and tearing of the eyes during the same time period as Employee A. The symptoms occurred after work and were much improved after two hours rest. She did not seek medical attention. She smoked 1/2 pack of cigarettes a day and had no previous medical history of allergies or respiratory illness.

Employee C - A 28 year old white female who worked for a short time as a molding machine punch operator also experienced symptoms. Approximately three times per week towards the end of the day, she experienced extreme fatigue, tightness in chest, fever, cough, aching limbs and severe headaches. On several occasions she left work early because of shortness of breath and had difficulty walking 75 feet from her car to her house after work. She smoked a 1/2 pack of cigarettes a day. She did not seek medical attention for her symptoms, but was transferred to the clerical staff of the plant after the walk through visit.

Two management representatives, who carried out the transfer molding on weekends had similar symptoms on several occasions. These usually resolved within 24 hours and did not warrant medical attention. Both were smokers at the time. They have since stopped smoking and continue to work in the molding room on occasions with no recurrence of symptoms.

Pre-employment physical examinations were not required for new employees, but all were informed of the possibility of "polymer fume fever" syndrome. No protective clothing or respiratory equipment was issued to employees. However, a dusty canister type respirator was observed hanging on the wall in the molding room. We were told no one ever uses it.

The exhaust ventilation systems of both ovens and the hood over the compression area were evaluated during the walk through. Both were found to be operating under positive pressure and the hood over the compression process was vented into the room. Recommendations were made during the survey to rectify these problems. To reduce exposures, suggestions were made to limit the number of items produced on each shift and to discontinue the use of the air hose for cooling the castings.

B. Follow-up Investigation

Follow up medical and industrial hygiene studies were carried out at the plant on January 28, 1985. By this time the two most severely affected employees were no longer working in the molding room and had been replaced.

All available employees were interviewed and given pre- and post-shift urine samples for measurement of urinary fluoride levels. For technical reasons pulmonary function tests could not be carried out during the visit and had to be postponed until later.

V. METHODS

1. Medical

Questionnaires were administered to 14 employees who were present that day. (Three from the molding room and 11 from the machine shop and other areas.) Information was obtained about symptoms experienced at work, previous occupations, family history, smoking history and past history of allergy and respiratory illness.

Pre- and post-shift urine samples were obtained from 14 employees. The fluoride levels were measured according to the guidelines of the National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods #8303. The results were corrected for degree of dilution and expressed as units of creatinine excretion.(1)

Urinary fluoride levels were measured as an index of Polytetrafluoroethylene (PTFE) exposure, since carbonyl fluoride, a pyrolysis product of PTFE, is metabolized and excreted as an organic fluoride ion.(2) Virtually all food stuffs (e.g., fish, vegetables, tea, public water supplies) contain traces of fluorine and fluoride dental treatment is common. These are also metabolized to organic fluoride and excreted in the urine. According to the World Health Organization, a dietary intake of fluoride for adults may range between 0.2 - 3.1 mg/day.(3)

Pre- and post-shift pulmonary function test measurements were obtained from 13 employees on February 7, 1985. One subject was not available for repeat testing. A positive displacement, waterless spirometer was used. Workers were asked to refrain from smoking for one hour before the test, but compliance was poor. Tests were performed with the subject in standing position without a nose clip.(4) A minimum of three acceptable forced expiratory maneuvers was obtained from each according to American Thoracic Society (ATS) guidelines for spirometry standards.(5)

The parameters used in the screening were Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), Forced Expiratory Volume in One Second as a percentage of Forced Vital Capacity (FEV_1/FVC %), and Forced Mid-Expiratory Flow Rate ($FEF_{25-75\%}$).(6) Results were derived from Knudson's standards and adjusted for age, height and sex. The largest recorded values for FEV_1 and FVC obtained from each employee were used in the analysis.(4)

2. Environmental

Total dust, hydrocarbons, hydrogen fluoride and fluorides were measured in personal breathing zone samples obtained from the "set-up man" and in area samples obtained at the compression molding unit, adjacent to the ovens.(7,8) Total hydrocarbons were also measured adjacent to the hood during two fifteen minute sequences of the pressure process. Sampling periods were approximately 2 hours. Sampling was split to measure exposures from the smaller oven in the morning and the larger oven in the afternoon since exposures may vary according to this size of oven in use.

Samples were collected on charcoal tubes using Dupont P200 sampling pumps calibrated at approximately 50 cubic centimeters per minute for long-term samples and 200 cc per minute for short-term samples. The activated charcoal samples were desorbed with carbon disulfide and injected into a Hewlett-Packard gas chromatograph equipped with flame ionization detectors.

Since thermal decomposition of fluorocarbon polymers results in a wide range of oxidized products, the American Conference of Government Industrial Hygienists (ACGIH) TLV Booklet for 1984-85 and the National Institute for Occupational Safety and Health (NIOSH) 1977 Criteria Document suggest monitoring for air levels of inorganic fluorides and hydrogen fluoride as indicators of PTFE exposure.

Each sample was collected through an impinger containing 10 ml. 0.1 N sodium hydroxide with a 0.45 micron polyvinyl chloride prefilter using a Dupont P2500 sampling pump. The pumps were calibrated before, during and after use at a flow of approximately 0.5 liter per minute.

Preweighed filters were extracted with water, added to an equal volume of ionic strength buffer, and the concentration of the fluoride ion was determined with an orion ion sensitive fluoride electrode. Aliquots of the impinger samples were analyzed for hydrogen fluoride as stated above. All samples were analyzed at the University of Wisconsin Occupational Health Laboratory.

VI. RESULTS

1. Symptoms

All of the workers in the molding room and 3 of the 11 non-exposed workers in the adjacent machine shop and office areas were smokers. Among the molding room workers, the recently employed set-up man complained of pain and tightness in the chest, shortness of breath, shivering, fever, cough, fatigue and headache. The automatic machine operator had experienced difficulty breathing, sore throats and increased perspiration on several occasions. The most recent employee who had been working half time for less than one month complained of an occasional cough. The non-exposed workers had no complaints.

2. Urine Testing for Fluorides

Levels of urinary fluoride measured in 14 pre-shift samples ranged from 0.3 mg/g to 1.5 mg/g and from 0.2 mg/g to 1.0 mg/g in post-shift samples. The levels measured were similar among exposed and non-exposed and there was no trend for an increase in levels over the shift. (See Table 1.)

3. Pulmonary Function Testing

Table 2 gives the results of pulmonary function testing of the 13 employees. The mean pre- and post-shift measurements were similar for all parameters used, i.e. FVC - 4.77 vs. 4.68; FEV_1 - 3.98 vs. 3.88 ; FEV_1/FVC% - 83.4% vs. 82.9%; $FEF_{25-75\%}$ - 4.45 ml/sec vs. 4.27 ml/sec. Only one individual had a significant decrease in lung function over the shift.(19) He was a machinist who had a 23% loss of FEV_1. He was exposed to cutting oils during his work which may have contributed to this change. Among the others tested there were no changes and no differences between exposed and unexposed groups. All tests were within expected limits when adjusted for age, sex and height.

4. Industrial Hygiene Studies

Table 3 summarizes results of testing for total dust, fluoride and hydrogen fluoride in a personal breathing zone sample obtained from the set up man and in an area sample which was taken close to the compression unit and the ovens.(20) Time weighted average exposures (TWA) and permissible exposure limits (PEL) are given.

Low levels of total dust, fluoride and hydrogen fluoride were detected in all samples. Table 4 summarizes the results of testing for hydrocarbons at the same sampling points. The samples contained low levels of toluene and most had a trace amount of hexane equivalents (aliphatic hydrocarbons within the range of 5 to 9 carbons). There was no difference in air levels when the larger oven was in use. All levels of the toxic substances measured were very low and well below OSHA permissible exposure limits and ACGIH threshold limit values.

VII. EVALUATION CRITERIA

Teflon is a trade name for fluorocarbon resins obtained by the fluorination of unsaturated low molecular weight hydrocarbons.(9) One type used extensively in industry is obtained by the polymerization of tetrafluoroethylene-polytetrafluorethylene (PTFE).(8)

The toxicity of PTFE depends upon its physical state. If it is heated in the absence of air, more than 95% of the decomposition product is the monomer tetra-fluoroethylene (TFE). If heating occurs above 300^{o}C. in the presence of air, small amounts of other fluorocarbon gases and particulates may also be produced. It is these products that are thought to cause the symptoms of polymer fume fever (PFF). Little is known about their chemical structure or the pathogenesis of the syndrome. It occurs without previous exposure and cannot be reproduced in animals.(10,11)

The health effects of exposure to heated teflon polymers were first described by Harris in 1951.(12)

Symptoms may begin several hours after exposure and commonly resolve within 24-48 hours.

The typical illness is characterized by increasing malaise, dry cough, fever with shaking chills, joint pains and tightness in the chest. This may progress in rare cases to more severe pulmonary symptoms with pulmonary edema.(13,14,15) The findings or physical examination of the lungs are usually unremarkable. There may be some scattered crepitations and the chest x-ray is usually clear.(16)

The illness is thought by many to be a benign transient disorder and is frequently misdiagnosed as influenza. However, studies by Evans(13) and Williams et al.(10) suggest that employees who have experienced several bouts of polymer fume fever may develop chronic pulmonary fibrosis that requires aggressive investigation and treatment with steroids.

Cigarette smoking greatly increases the risk of polymer fume fever in persons working with teflon polymer.(17) Cigarettes may be contaminated with PTFE from the air or the hands of the workers. A lighted cigarette may heat PTFE to temperatures sufficient to convert it to its irritant breakdown products. Control of polymer fume fever is best accomplished by limiting exposure to heated polymer through good work practices, appropriate ventilation, ensuring a strict non-smoking policy and good hygiene (especially hand washing) among workers.

Urinary Fluoride Testing

Urine concentrations of fluorides in normal non-occupationally exposed workers are reported to range from 0.2-3.2 mg/g of creatinine depending on dietary intake. Pre-shift levels of less than 4 mg/g creatinine and post shift levels of less than 7 mg/g creatinine appears to protect against bony fluorosis. NIOSH has recommended that pre-shift urine specimens should not exceed 4 mg/litre (corrected to a specific gravity of 1.024) and post-shift should not exceed 7 mg/litre.

There are no recommended threshold limit values for exposure to the decomposition products of PTFE since they are diverse and the irritant agent has not been identified. The primary sources of environmental evaluation criteria for the investigation are: 1) NIOSH criteria documents and recommendations, 2) The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's), and 3) the United States Department of Labor (OSHA) occupational health standards.

VIII. Discussion

This investigation revealed that at least seven persons who were at some time exposed to fluorocarbon polymer fumes in the molding room at Applied Plastics developed an illness that was consistent with the symptoms of polymer fume fever. The set up man who handled heated polymer had the most severe symptoms with incapacitating fatigue, myalgia, and respiratory symptoms. The others had illnesses with varying degrees of severity depending upon proximity to the production process and time in the molding room. As would be expected, smokers fared worse than non-smokers with more fatigue, myalgia, and fever.(18) Employees in other areas, most of whom did not smoke, had no symptoms. Evaluation of the environment in the molding room during the walk through survey revealed a number of problems that could have resulted in excessive exposure. These were inadequate ventilation of the compression process, unprotected exposure of employees to fumes and lack of protective clothing.

Humidity may also have an effect on the composition of pyrolysis products of PTFE. The most severe cases of polymer fume fever occurred in July when the high relative humidity (around 80%) may have exacerbated symptoms.(5)

Some of the identified problems had been corrected at the time of the follow up medical and industrial hygiene survey. However, at that time, production was slowed and the most severely affected employees were no longer working in the area.

These factors may have contributed to our inability to document exposure to polymer fumes or adverse health effects by medical and environmental testing during the follow up investigation.

Unfortunately for technical reasons the pulmonary function tests were not carried out on the same day as the environmental survey. It is, therefore, difficult to correlate the results with measures of exposure. Employees complained of symptoms at the time of the second visit but all had test results that were within normal limits.19,21

The one employee who had been severely affected previously had no apparent reduction in function on retesting.

The biologically active constituents of fluoropolymer fumes have not been identified. We, therefore, used levels of fluoride and hydrocarbon in the air as surrogate estimates of environmental polymer fume levels.

For the same reasons urinary fluoride levels were measured in workers' pre- and post-shift to estimate absorption of fumes. Environmental exposures were low at the time of the study and urine concentrations were within the normal limits expected from intake of fluorine in medications, water and a normal diet. Our conclusion is that urinary fluoride balance is not a sensitive measure of polymer fume exposure since we had no way of estimating the fluorine intake of the subjects from these confounding exposures. All values were less than levels at which systemic effects might be expected.

IX. CONCLUSION

As a result of our investigation we concluded that employees at Applied Plastics exposed to heated fluoropolymers were experiencing symptoms of polymer fume fever. This was made worse by cigarette smoking. Environmental and medical studies did not demonstrate high levels of exposure or absorption of fumes by workers but workers continued to have incapacitating symptoms. Changes in work practices, improved ventilation, closer attention to no smoking policies and improved personal hygiene should reduce exposure and the likelihood of illness.

X. RECOMMENDATIONS

1. Smoking materials should be banned from areas where fluorocarbon polymers are handled and used.

2. All employees who are exposed to fluorocarbon polymer should be instructed to wash their hands thoroughly before eating, smoking or handling smoking materials.

3. Employees should be encouraged to stop smoking by offering incentives and/or by identifying smoking cessation groups in the community where employees could get support and encouragement.

4. Workers should be supplied with protective clothing and personal protective equipment, i.e., gloves, coveralls, respirator (1/2 mask equipped with combination acid/gas organic vapor sorbet increase efficiency filter cartridge).

5. Both ovens should be operated at negative pressure in relation to the room with an exhaust velocity of 100 foot per minute. An automatic temperature cutout may help prevent heating of the polymer above the manufacturer's recommended temperature.

6. The hood over the compression area should be further enclosed and the duct work placed under negative pressure by installation of a fan to the outside.

7. Relocation of the ovens to another room may reduce the exposure of co-workers in the area.

8. The Molding Room should be provided with a fresh air intake to provide for the ventilation systems on the ovens and hood and provide general dilution.

XI. REFERENCES

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XII. AUTHORSHIP/ACKNOWLEDGEMENTS

Evaluation Conducted and Report prepared by:

Richard A. Keenlyside, MD
Chief of Epidemiology
Division of Disease Control
Rhode Island Department of Health

Louise A. House, BSN, RN, COHN
Occupational/Environmental Epidemiology
Division of Disease Control
Rhode Island Department of Health

Marie Stoekel, IH
Industrial Hygienist
Occupational Health and Radiation Control
Rhode Island Department of Health

Jeanne M. Durand
Principal Clerk
Division of Disease Control
Rhode Island Department of Health

XIII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available, upon request, from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of this report have been sent to:

1. Applied Plastics, Bristol, RI
2. Requestors of this study.
3. NIOSH Region I
4. U.S. Department of Labor, OSHA, Region I

For the purpose of informing the affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calender days.

Table 1
Urine Fluoride Analyses
Expressed in mg/g Creatinine

Applied Plastics
Slocum, Rhode Island

Job Description	Age	Sex	Pre-Shift (mg/g)	Post-Shift (mg/g)
molder*	42	M	0.4	0.2
molder*	24	F	0.2	1.0
molder (5 hr. shift)*	32	M	0.4	0.3
machinist	25	M	0.4	1.0
management	31	M	0.3	0.3
machinist/molder	30	M	0.4	0.3
machinist	32	M	0.4	0.5
pack/receiving	52	F	0.6	0.4
secretary	28	F	0.7	0.3
management/bookkeeper**	50	F	1.5	---
secretary**	39	F	0.4	---
machinist	32	M	1.3	0.5
machinist	20	M	0.3	0.4
management/sales	25	M	0.9	1.0

*exposed.
**no post-shift urine obtained. Went home sick shortly after arriving at work.

Method #8308 NIOSH Manual of Analytical Methods. Third Edition, U.S. Dept. of Health and Human Services, Feb. 1984.

Table 2
Summary of
Pulmonary Function Testing
Applied Plastics, Slocum, RI
(Pre/Post-Shift)

Age	Sex	Race	Smoking Status	Job Description	Pre-Shift $FEV_1(\ell)$	Post-Shift $FEV_1(\ell)$	Pre-Shift $FVC(\ell)$	Post-Shift $FVC(\ell)$	Pre-Shift FEV/FVC%	Post-Shift FEV/FVC%	Pre-Shift FEF(ml/sec)	Post-Shift FEF(ml/se
*42	M	W	Current	Molder	4.17	3.98	4.90	4.66	85.1	85.4	4.80	4.95
*32	M	W	Current	Molder	4.95	4.85	6.49	6.35	76.3	76.4	4.12	4.07
*24	F	W	Current	Molder	3.88	3.69	4.22	4.05	91.9	91.1	4.91	4.61
52	F	W	Current	Ship/Receive	2.14	2.63	3.56	3.54	60.1	74.3	1.69	2.03
32	M	W	Current	Machinist	4.69	4.59	5.62	5.56	83.5	82.6	5.05	4.71
28	F	W	Current	Clerical	2.76	2.73	3.45	3.21	80.0	85.0	2.54	2.86
25	M	W	Current	Machinist	4.49	4.48	5.04	4.93	89.0	90.9	6.30	6.67
31	M	W	Former	Management	3.65	3.71	4.39	4.37	83.4	84.9	3.78	3.90
30	M	W	Former	Machinist	5.01	4.86	6.39	6.32	78.4	76.9	4.31	3.80
25	M	W	Former	Management	4.57	4.47	5.27	5.13	86.7	87.1	4.39	4.57
50	F	W	Non-Smoker	Management	2.43	2.46	2.79	2.86	87.1	86.0	3.41	3.24
32	M	W	Non-Smoker	Machinist	4.18	4.25	4.42	4.75	94.6	89.5	6.69	6.98
20	M	W	Non-Smoker	Machinist	4.93	3.75	5.53	5.50	89.2	68.2	5.88	3.12
				Mean	4.77	4.68	3.98	3.88	83.4	82.9	4.45	4.27

*Exposed

Results derived from Knudson, R.J., American Review of Respiratory Disease, Vol. 113 1976.

Table 3
Rhode Island Safety/Health
Consultation Services
Sampling Results

Applied Plastics
Slocum, Rhode Island

Date	Employee	Job & Location	Contaminant	Sample Number	Time (Min)	Conc. (mg/m^3)	TWA (mg/m^3)	PEL (mg/m^3)	TWA/PEL
1/28/85	Personal Sample	Set-up Man	Fluoride	23666 23667	110 112	0.016 0.012	0.006	2.5	<0.01
			Hydrogen Fluoride	23672 23673	110 112	0.020 0.037	0.013	2.5	<0.01
			Total Dust	23666 23667	110 112	0.80 0.73	0.35	15	0.02
1/28/85	Area	Near Compression Molding Unit	Fluoride	23668 23669	107 115	0.026 N.D.	0.006	2.5	<0.01
			Hydrogen Fluoride	23674 23675	107 115	0.051 0.012	0.014	2.5	<0.01
			Total Dust	23668 23669	107 115	0.48 N.D.	0.11	15	<0.01

Table 4
Rhode Island Safety/Health
Consultation Services
Sampling Results

Applied Plastics
Slocum, Rhode Island

Date	Employee	Job & Location	Contaminant	Sample Number	Time (Min)	Conc. (ppm)	TWA (ppm)	PEL (ppm)	TWA/PEL
1/28/85	Personal Sample	Set-up Man	Toluene	23659 23660	109 112	12 N.D.*	3	200	0.01
			Hexane	23659 23660	109 112	<1 <1	<1	500	<0.01
1/28/85	Area	Near Compression Molding Unit	Toluene	23661 23662	109 115	N.D. 1	<1	200	<0.01
			Hexane Equiv.	23661 23662	109 115	N.D. 1	<1	500	<0.01

Figure 1
Overview of Factory

Applied Plastics
Slocum, Rhode Island

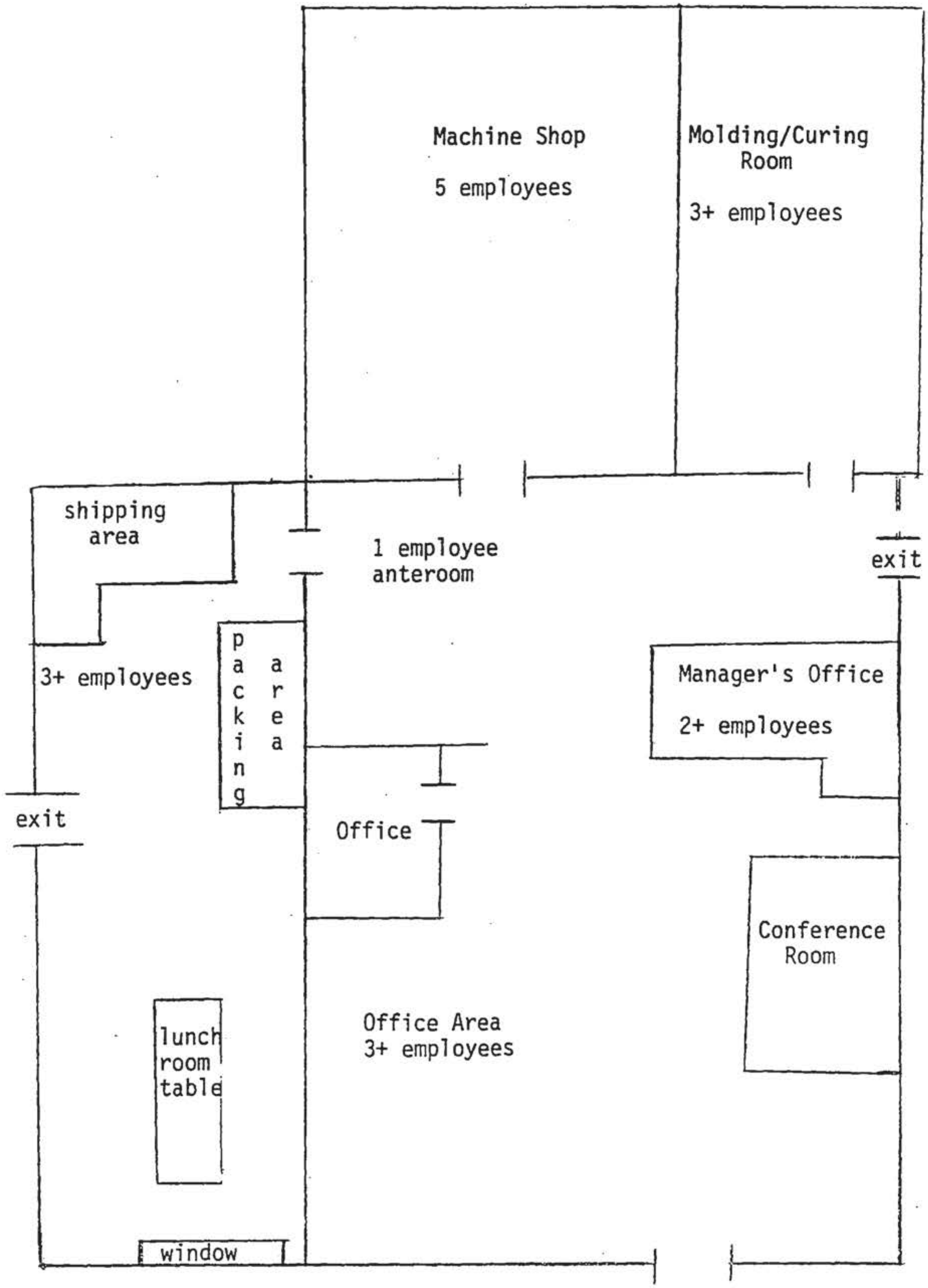
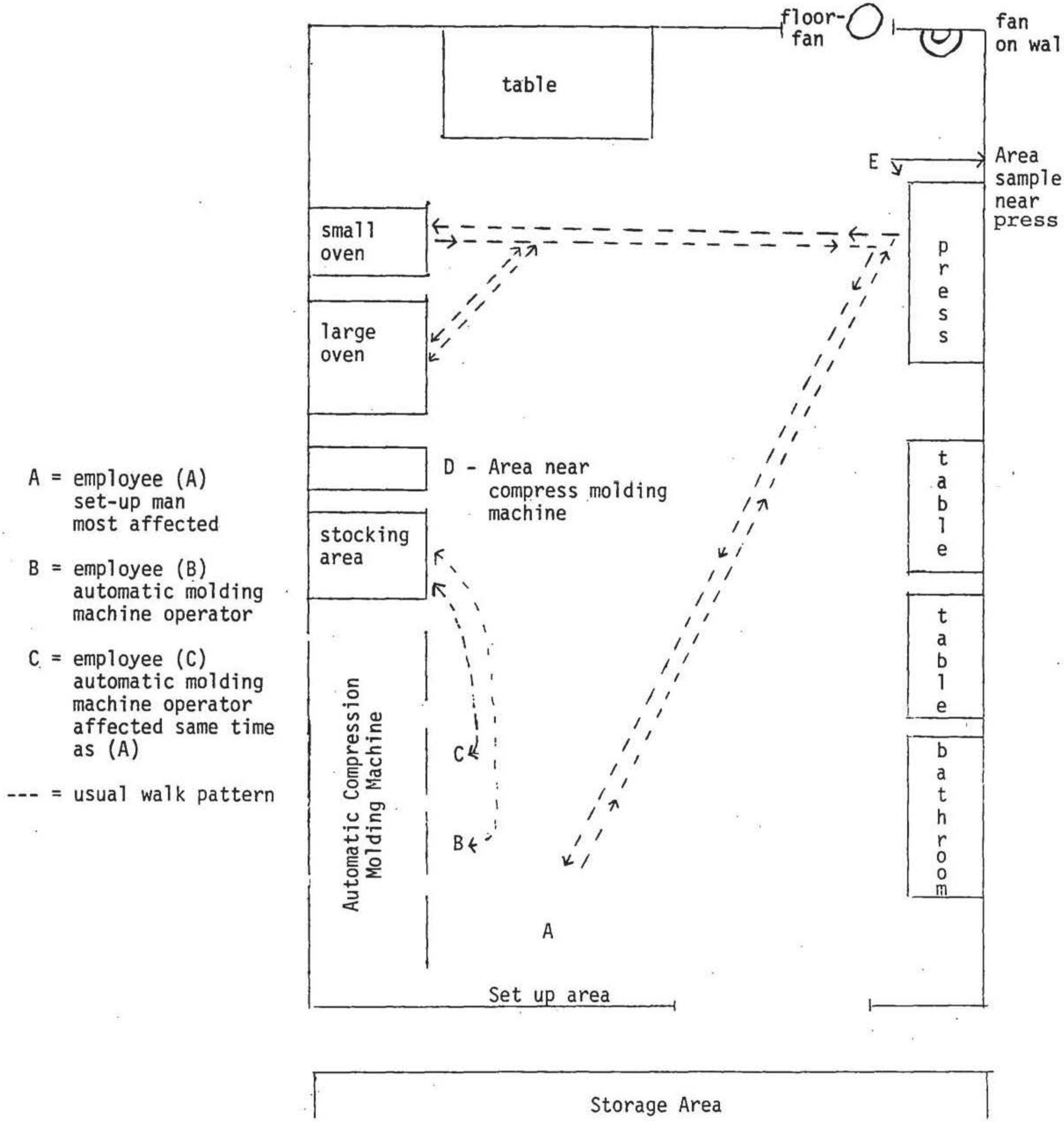


Figure 2

Approximate Overview of Molding Room



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PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
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