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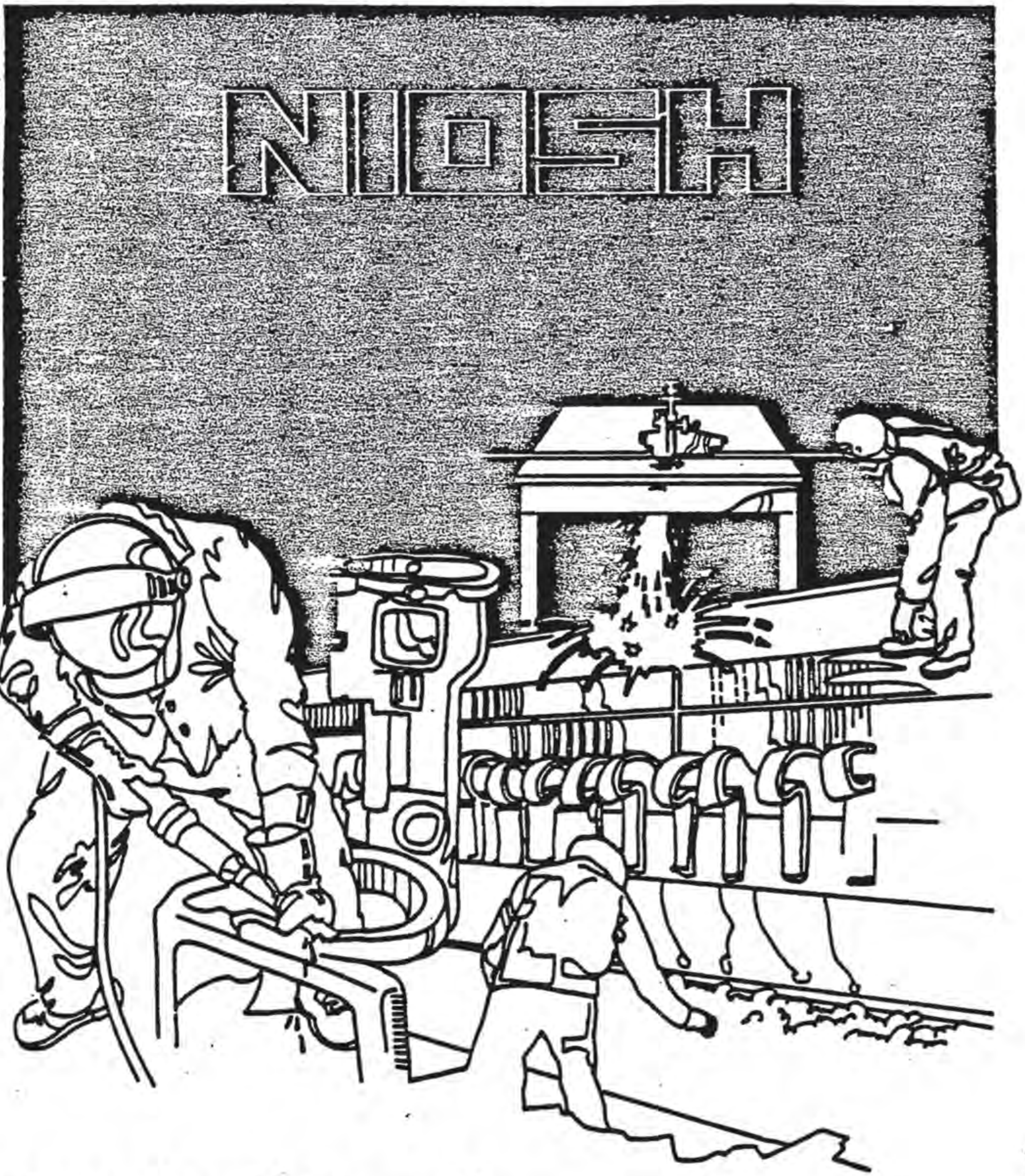

Health Hazard Evaluation Report

HETA 83-156-1622
LEON PLASTICS
GRAND RAPIDS, MICHIGAN

PREFACE

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

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

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LEON PLASTICS
GRAND RAPIDS, MICHIGAN

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I. SUMMARY

On February 17, 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation (HHE) at Leon Plastics in Grand Rapids, Michigan. The request was submitted jointly by the Michigan Department of Public Health, Local 19 of the United Auto Workers, and U.S. Senator Donald Reigle. The request expressed worker concerns about exposures to chemical substances and other contaminants. One area of particular concern was the injection molding department, where several workers complained of frequent respiratory problems and occasional skin irritations, believed to be a result of exposure to azodicarbonamide (ABFA), a chemical blowing agent.

NIOSH investigators conducted environmental surveys on March 24, 1983; May 2-6, 1983; and March 11-12, 1984, to evaluate personal exposures and area concentrations of ABFA, thermal decomposition products associated with polyphenylene oxide and ABFA, and to dust.

Worker exposures to contaminants monitored in May, 1983 identified median breathing zone ABFA level of 6.2 micrograms per meter cubed (ug/m^3) (range: none detectable or ND-280 ug/m^3); median area ABFA concentration of 0.6 ug/m^3 (ND-1800 ug m^3); and a median breathing zone exposure to total dust of 810 ug/m^3 (33-3000 ug/m^3). Ammonia, styrene, and triphenyl phosphate were identified as pyrolysis products in plumes above presses using ABFA. The median worker exposure to ABFA during the March 1984 survey was 25 ug/m^3 (trace-752 ug/m^3). Breathing zone exposures to selected pyrolysis products were ND for benzene, 0.1-0.3 parts per million (ppm) for styrene, and 0.003-0.1 (ppm) for toluene. No applicable evaluation criterion exists for ABFA and nuisance dust criteria was not applied due to the presence of a biologically active component. The evaluation criteria for benzene (NIOSH) is a 1 ppm ceiling; for styrene (NIOSH) is 50 ppm, and toluene (NIOSH) is 100 ppm. No overexposure to pyrolysis products was documented. Exposures to ABFA were observed to be higher during the March 1984 survey when compared to the May 1983 survey. This may have been due to equipment, production, and procedural changes.

NIOSH investigators conducted anecdotal interviews among 16 employees during the initial survey. Results of these interviews revealed a high degree of respiratory complaints and skin irritations in 14 of 16 employees interviewed. The occurrence of these symptoms was believed by the employees to be job-related.

A medical investigation conducted by the University of Michigan, under contract to Leon Plastics Division, included pulmonary symptom questionnaires and pulmonary function testing. Pulmonary function testing results were inconclusive in linking changes in pulmonmary function with exposure to ABFA. The questionnaire results indicated that symptoms of eye, nose and throat irritation, coughing and wheezing were strongly associated with work in injection molding.

Based on the industrial hygiene data and a review of the medical study, exposure to particulate azodicarbonamide is considered the probable cause for the reported symptoms. Based on these findings measures should be taken to reduce exposures to azodicarbonamide. Recommendations addressing ventilation, engineering controls, housekeeping, and work practices are presented in Section VIII.

KEYWORDS: SIC 3079 (Miscellaneous Plastic Products), injection molding, thermal decomposition products, azodicarbonamide (CAS # 123-77-3), benzene (CAS # 71-43-2), styrene (CAS # 100-42-5), toluene (CAS # 108-88-3), triphenyl phosphate (CAS # 115-86-6), irritation, asthma, pulmonary sensitization.

II. INTRODUCTION

On February 17, 1983, the National Institute for Occupational Safety and Health (NIOSH) received a joint request to conduct a health hazard evaluation (HHE) at Leon Plastics in Grand Rapids, Michigan. The request was submitted by the Michigan Department of Public Health and Local 19 of the United Auto Workers with the assistance of U.S. Senator Donald Reigle. The request expressed continuing worker concerns about exposures to workplace contaminants. One area of particular concern was the injection molding operation, where numerous worker complaints were reported about working conditions and odors and multiple workers compensation claims filed, alleging exposures to azodicarbonamide as the source of the problem.

NIOSH investigators conducted an initial survey at the plant March 24, 1983, followed by two industrial hygiene surveys in the injection molding department, May 2-6, 1983 and March 11-12, 1984. The March 1984 survey was conducted in conjunction with a medical study conducted by the University of Michigan's School of Public Health.

Interim reports were issued in July 1983 and June, 1984. The second report presented the industrial hygiene data from both follow-up surveys.

III. BACKGROUND

At the time of this investigation, Leon Plastics was a division of U.S. Industries involved in the manufacture of plastic parts for the automobile, computer, and other industries. Their work primarily involves custom molding (contract manufacturing). Leon Plastics specializes in insert molding, custom compounding of plastisols and polyvinyl chloride, structural foam parts, urethane foam molding, painting and finishing, blow molding, and assembly operations. The facility in Grand Rapids, Michigan serves as division headquarters while a sister plant of almost the same size is situated in Grand Island, Nebraska. The Grand Rapids facility, which consists of 185,000 square feet of manufacturing space, was completed and first occupied in 1979. Leon employs about 325 hourly workers at the Grand Rapids facility with about 130 in the Injection Molding Department. This 130 includes mold press operators and indirect labor (i.e., setup, material handler, utility, etc.).

A. Process Description:

The Injection Molding Department is primarily involved in the custom molding of thermoplastics. Parts are injection molded for the business machine, computer, communication, and automotive industries. Thermoplastic resins (both virgin and/or reground material) are fed into the injection mold machines from individual hoppers located at the machines. Some of the resins are used with a blowing agent (in the case of structural foam) which is mixed with the resin prior to being fed into the injection mold machine. Parts are removed from the machines by the mold press operators, inspected, and stacked. Structural foam parts are trimmed of flash and sprues by the operators upon removal of the part. Pneumatic sanders and cutters are used over portable downdraft tables located at the work station of the structural foam machines.

From this point parts may go to finishing, where articles are prepared for painting and where component assembly is completed.

Resins in use are a modified polyphenylene oxide (CAS # 52439-05-1), plasticized polyvinyl chloride, polycarbonate, polypropylene, acrylonitrile-butadiene-styrene, and nylon. The modified polyphenylene oxide is approximately 26% polystyrene and 74% polyphenylene oxide. Chemical blowing agents are added to the resins in use to produce structural foam items. Of the various resins used by the company, polyphenylene oxide and polycarbonate are the primary resins used with chemical blowing agents. The polyphenylene oxide is mixed with powdered azodicarbonamide (1,1-azobisformamide, hereafter referred to as ABFA (CAS #123-77-3) and a wax. Polycarbonate uses dust free pelletized blowing agent which is mixed in with the resin pellets.

Mixing of resins and chemical blowing agents is done in one of two large ribbon mixers in a corner of the Injection Molding Department.

B. Engineering Controls:

Work stations requiring the sanding of parts have portable downdraft tables to capture the plastic dust. Four large ceiling exhaust fans are located in the Department, and removable covers are available for the resin mixers. Additionally the company had recently (May 1983) installed a pneumatic resin handling system aimed at reducing the handling of resins and had indicated they would be switching to a liquid form of the ABFA blowing agent. Numerous pedestal fans are scattered throughout the department.

C. NIOSH Site Visits:

1. March 1983:

NIOSH investigators conducted an initial survey which began on March 23, 1983. After meetings with the Michigan Department of Public Health and represenitives from Senator Reigle's office, a site visit to the plant was conducted March 24, 1983. Initial survey activities included: an opening conference with labor and management representatives, a walk-through survey of the plant, and informal interviews conducted with Leon employees.

Discussions with Michigan Health Department investigators indicated that extensive non-routine (i.e. area and process samples rather than personal exposures for compliance determination) sampling had been done (in 1980 and 1981) to determine concentrations of possible decomposition products associated with injection molding. Contaminant concentrations were all below applicable Michigan Occupational Safety and Health Standards.

2. May 1883 Survey:

During the week of May 2-6, 1983, NIOSH conducted a follow-up survey. The primary purpose was to evaluate worker exposure to total dust and a powdered blowing agent (ABFA) prior to the conversion of the material handling system from the current manual system (i.e. individual hopper filling) to an enclosed pneumatic supply system.

Personal, process, and area samples for total dust and ABFA were collected during the first and second shift, May 3-5, 1983. Additionally, anecdotal interviews were conducted among 16 injection mold operators (with a focus on respiratory problems) to determine the type and extent of adverse health effects experienced by these employees.

3. March 1984 Survey:

A second follow-up industrial hygiene survey was conducted March 11 and 12, 1984, to coincide with a medical study conducted by the University of Michigan. Exposure monitoring for ABFA in the injection molding department was conducted during the first three workshifts of the week. Exposure data was obtained for all "exposed" employees in this department who were participating in the pre- and post-shift pulmonary function study. Worker exposure monitoring for styrene, toluene, and benzene (selected thermal decomposition products of polyphenylene oxide) was also conducted.

4. Consultant Surveys:

Past industrial hygiene studies have been conducted by National Loss Control Service Corporation (NATLSCO) addressing thermal decomposition products in injection molding, the use of nickel-containing paints, dermatitis causes and prevention, and an assessment of exhaust ventilation systems. Recommendations made by Natlsco in their three reports to the company included ventilation in all cases (local exhaust and/or general). One report also discussed the possibility of mass psychogenic illness (MPI) as being responsible for worker complaints about working conditions in the injection molding department. Despite two consultant reports subsequent to the initial one (which mentioned MPI as a possible cause of complaints) and recommendations to improve local exhaust ventilation and to consider the toxicity of substances used in the area, the company has continued to embrace the position that workplace complaints are largely due to MPI or "Group Depressive Psychosis" and thus exhibited resistance in considering the possibility that workplace conditions may require some modification.

IV. Methods and Materials

A. Industrial Hygiene:

The industrial hygiene evaluation consisted of personal and area monitoring for ABFA and personal exposure monitoring for polyphenylene oxide thermal decomposition products (styrene, benzene, and toluene). Qualitative analysis of bulk air samples obtained within the smoke plume above an injection mold machine using polyphenylene oxide and ABFA, and indicator tube sampling was conducted to determine the presence of several thermal decomposition products identified in previous NIOSH work addressing breakdown products given off by this polymer (1). These samples were also considered useful in trying to identify odorous contaminants present in the plume in higher concentrations.

1. Azodicarbonamide:

Sampling was conducted using FALP Fluoropore filters in two piece cassettes at a flow rate of two liters per minute (Lpm). These filters consist of polytetrafluoroethylene with a polyethylene backing and have a pore size of 1.0 micrometer (um).

The analytical procedure calls for desorption with 2 milliliters (ml) of dimethylsulfoxide (DMSO) and analysis by high performance liquid chromatography (HPLC). Separation is achieved on a 10 um silica Radial Compression Column in a Radial Compression Module. The mobile phase is 15 per cent DMSO/85 per cent methylene chloride isocratic (constant percentage mobile phase mixture). Detection and quantitation was achieved by using an ultraviolet detector at 276 um and a visible wavelength detector at 405 um in series.

The results of the ABFA analyses for all filters were quantitated at 276 nanometers (nm). A limit of quantitation (LOQ) of 5 micrograms (ug) per sample and a limit of detection (LOD) of 1 ug per sample was attained. If a sample concentration was large enough, quantitation at 405 nm was also obtained.

2. Styrene, Toluene, Benzene:

Personal exposure monitoring of injection mold machine operators for styrene, toluene, and benzene was conducted using low flow sampling pumps pre-calibrated at 200 cubic centimeters (cc) per minute. Samples were collected on standard charcoal tubes (100 milligram (mg) of coconut shell charcoal-front section 50 mg-backup section). The samples were analyzed by gas chromatography according to NIOSH Method P&CAM 127(2) with the following modifications:

Desorption Process	: 30 minutes in 1.0 milliliter of carbon disulfide containing 1 microliter/milliliter of ethyl benzene as an internal standard.
Gas Chromatograph	: Hewlett-Packard Model 5711A equipped with a flame ionization detector
Column	: 30 meter x 0.315 millimeter fused silica capillary column coated internally with 0.25 micrometer of Durawax DX-4
Oven Coditions	: 110° C isothermal

The limits of detection are tabulated below:

Analyte	LOD (mg/sample)
Styrene	0.01
Toluene	0.01
Benzene	0.002

3. Indicator Tube Samples:

Indicator tubes for phenol, ammonia, styrene, carbon monoxide, and oxides of nitrogen were used to sample the smoke plumes above three injection mold presses. Two of the presses were running the polyphenylene oxide-ABFA mixtures and one acrylonitrile-butadiene-styrene polymer. The indicator tube readings were used primarily as a screening procedure for the presence or absence of the previously listed contaminants in the smoke discharge above the presses.

4. Characterization of Thermal Decomposition Products:

Four bulk air samples (two standard charcoal tubes, two standard silica gel tubes) were collected above a press running the polyphenylene oxide-ABFA mixture. Sampling rates were about two liters per minute, and sampling durations ranged from about four to seven and a half hours.

One charcoal tube sample was desorbed with one milliliter of carbon disulfide and a silica gel tube with one milliliter of ethanol. The samples were initially screened by gas chromatography (equipped with a flame ionization detector) using a 25 meter methyl silicone (1 micrometer film thickness) fused silica capillary column (splitless mode). Both samples were subsequently analyzed by gas chromotagraphy-mass spectroscopy (GC/MS) to identify peaks and later by gas chromatography with a nitrogen-phosphorus detector (GC-NPD) for nitrogen containing compounds.

Based upon a review of the GC/MS results by the NIOSH industrial hygienist and NIOSH chemist, the remaining charcoal tube and a blank were quantitated for several contaminants. The second silica gel sample was desorbed with two milliliters of one normal sulfuric acid for two hours (sonified). A 0.5 milliliter aliquot was then made basic with 1.1 normal sodium hydroxide and analyzed by GC-NPD for aliphatic amines.

B. Medical Study:

NIOSH conducted anecdotal interviews among 16 employees in injection molding on May 3-5, 1983, to determine the type and extent of health complaints associated with injection molding operations. Information gathered from these interviews was intended to guide further medical follow-up conducted by NIOSH. However, Leon Platics contracted with the University of Michigan to conduct a medical study, thus NIOSH, to avoid duplication of efforts, elected to postpone further medical follow-up pending the results of the University of Michigan's study.

The University of Michigan's medical survey was conducted December 11-15; 1983, February 2-3, 1984; and March 11-12, 1984. The survey consisted of cross-sectional pulmonary function tests, an adminstered pulmonary questionnaire and pre- and post- shift pulmonary function tests conducted on selected employees in the injection molding area.

V. Evaluation Criteria and Toxicity Discussion

A. Environmental Criteria:

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH investigators employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary source of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienist' (ACGIH) Threshold Limit Values (TLV's)®, and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's® are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's® usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In reviewing the exposure levels, and the recommendations for reducing those levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 to meet those levels specified by OSHA standards.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

The evaluation criteria used in this report are presented in Table I.

B. Azodicarbonamide:

Animal feeding studies addressing the safety of ABFA have been conducted to assess the compound's toxicity when used as a flour-maturing agent in baked goods(7). The use of ABFA in baked goods was authorized by the Food and Drug Administration in 1962. ABFA is hydrolyzed in the digestive system to an inert biurea. Azodicarbonamide, when ingested, has very low acute toxicity.

Toxicity studies addressing the health effects associated with the inhalation of ABFA are lacking. Two reports in the literature suggest the occurrence of occupational asthma among workers handling the powdered ABFA(8,9). and one discusses a decrease in pulmonary function(8). The exposure levels reported in these two articles ranged from 700 ug/m^3 to 5000 ug/m^3.

Slovak(9) reports that of the workers diagnosed as having asthma due to exposure to ABFA, none had had asthma or any other significant chest disease before exposure to the chemical. History of atopy (disease of an allergic nature) is not considered predictive of a predisposition to ABFA sensitivity. In the case of ABFA, the characteristic clinical presentation, as reported by Slovak, consists of a latent period preceeding onset followed by an abrupt onset and frequently rapid worsening of symptoms if exposures continue. He suggests that azodicarbonamide be considered a potent lung sensitizer of the small molecular weight type, the characteristics being a predominance of severe and worsening late onset asthamatic symptoms. The symptoms usually occur within the first year of exposure and have been associated with negative skin prick tests to the causative agent(9).

The National Toxicology Program (NTP) initiated the pre-chronic phase toxicity testing for ABFA in fiscal year 1984(10). Long-term toxicity testing was initiated in early 1985. An additional test species (guinea pigs) will be used in addressing the question of respiratory sensitivity associated with ABFA exposure. Invitro cytogenetic testing of ABFA was conducted during fiscal year 1984. The data from this study is currently undergoing statistical analysis.

Currently there is no environmental exposure criteria in any of the previously mentioned sources for ABFA. Extensive searches of both domestic and international literature, have revealed neither mandatory nor advisory limits for this compound. One approach has been to treat ABFA as a nuisance dust, thus applying a total dust TWA exposure limit over an eight hour workshift of 15 milligrams per cubic meter (mg/m^3) under the OSHA standard. The OSHA permissible exposure limit for respirable nuisance dust is a 5 mg/m^3 TWA. The ACGIH recommends nuisance dust exposures be kept below 10 mg/m^3 total and 5 mg/m^3 respirable dust over an eight-hour workshift.

Nuisance dust evaluation criteria was not applied to ABFA in this study because the compound in question did not meet the ACGIH definition of a nuisance particulate (dust), i.e. a dust that "has little adverse effect on lungs and does not produce significant organic disease or toxic effect when exposures are kept under reasonable control"(11). The ACGIH TLV documentation states that these (nuisance dust) limits do not apply to those substances which may cause physiologic impairment at lower concentrations, and for which threshold limits have not yet been recommended (11).

VI. RESULTS

A. Environmental

Results from the May 1983 survey for ABFA and total dust are presented in Table II.

NIOSH collected a total of 68 samples (breathing zone and area) for the powdered blowing agent azodicarbonamide (Celogen®). Forty-one samples were also analyzed gravimetrically for total dust. Airborne concentrations of azodicarbonamide in personal samples ranged from levels below the analytical limits of detection (LOD) to 280 micrograms per cubic meter (ug/m^3) with a median value of 6.2 ug/m^3 (geometric mean and standard deviation of 3.9 ug/m^3 and 6.3, respectively). Personal exposure values for this first survey are presented separately in Table III.

Concentrations of azodicarbonamide in area samples ranged from levels below the LOD to 1800 ug/m^3 with an estimated median value of 0.6 ug/m^3 (geometric mean and standard deviations of 1.7 ug/m^3 and 9.6 respectively). The calculated, volume-adjusted, lower limit of detection was 1 ug/m^3.

Total dust samples ranged from 33 ug/m^3 to 3000 ug/m^3 with a median value of 810 ug/m^3 (geometric mean and standard deviation of 620 ug/m^3 and 3.0 respectively).

Azodicarbonamide exposures during the March 1984 survey are presented in Table IV. These exposures coincided with pre- and post-shift pulmonary function testing conducted by the University of Michigan. A total of 32 samples were obtained for azodicarbonamide which included 16 samples for workers participating in the medical study. During this latter survey, concentrations of azodicarbonamide ranged from a trace amount (above detection limits, but below the quantifiable level) to 752 ug/m^3 with a median value of 25 ug/m^3 (geometric mean and standard deviation of 19.3 ug/m^3 and 6.5, respectively). No area or total dust samples were obtained.

Detector tube readings obtained for various compounds present as thermal decomposition products released from the machines were used primarily as indicators of the presence or absence of selected contaminants thought to be associated with the thermal decomposition of polyphenylene oxide resins. Ammonia, styrene, and carbon monoxide detector tubes produced color changes indicative of the presence of these compounds. The ammonia tube response was considered to be due to an unidentifiable interference since complete color change of the tube occurred with a partial pump stroke. No ammonia odor was noted by the investigators. Ammonia concentrations necessary for such a pronounced and complete color change would have exceeded the odor threshold.

Qualitative and limited quantitative analyses of air samples obtained near the smoke discharge above the machines indicated the presence of toluene, styrene, phenols, and triphenyl phosphate as major constituents in the smoke. In addition, there were a variety of other organic compounds present as minor contaminants which could not be positively identified. Evaluation of a silica gel tube for aliphatic amines, an interference of ammonia detector tubes and suspected as a possible explanation for the total color change seen on the detector tubes, was unproductive. A 530 liter air sample collected on a charcoal tube obtained at the same location as the other thermal decomposition product air samples on Press No. 2 provided the following contaminant concentrations:

benzene	0.02 mg/m^3	(0.006 ppm)
styrene	0.9 mg/m^3	(0.2 ppm)
toluene	1.5 mg/m^3	(0.4 ppm)

xylene 0.3 mg/m^3 (0.07 ppm)
phenol* 0.5 - 1.9 mg/m^3
triphenyl phosphate* 0.4 - 1.1 mg/m^3

*Ranges given for these two compounds represent approximations due to poor desorption efficiency of these materials from the sampling media used.

These initial thermal decomposition product air samples were obtained during the May 1983 survey above a press using polyphenylene oxide resin and the azodicarbonamide blowing agent. None of these samples were obtained in what could be considered a worker's breathing zone. Figure I presents the reconstructed total ion chromatograms for the bulk air charcoal tube. Each peak indicated different compound(s) and an indication of the compound's identity is given.

During the follow-up survey, (March 1984), personal exposure monitoring of injection mold operators was conducted for benzene, styrene, and toluene. No benzene exposures were identified. Styrene and toluene exposures are presented in Table V. Styrene exposures ranged from 0.1 to 0.3 parts per million. Toluene exposures ranged from 0.03 to 0.1 parts per million.

B. Medical:

Results of anecdotal interviews conducted by NIOSH investigators during the initial survey revealed a high rate of respiratory complaints (wheezing, coughing, stuffy nose, sinus etc.) and skin irritations (persistant rashes, burning, itching skin, etc.) in 14 of 16 employees interviewed. Headaches, nausea (associated with dust and fumes) and other associated respiratory symptoms were also reported. The occurrence of individuals symptoms was believed to be job-related.

Two hundred twenty-seven employees participated in the University of Michigan's study. Of these, 223 received pulmonary function tests, and subsequently 17 injection molding operators, on the first shift of a work week received pre- and post- shift pulmonary function tests.

Results of both the cross-sectional and pre- and post-shift pulmonary function tests were unable to link decreases in pulmonary function associated with working in injection molding(14).

Results of the pulmonary questionnaires revealed that eye, nose and throat irritation along with cough and wheezing were strongly associated with working in injection molding(14).

VII. DISCUSSION

Comparison of exposure data to ABFA from the two surveys indicates a higher exposure level during the March 1984 survey. The mean (geometric) breathing zone exposures to ABFA obtained from sampling conducted over four workshifts in May 1983 was 3.9 ug/m^3 with a median value of 6.2 ug/m^3 whereas the mean (geometric) breathing zone exposure for workers obtained over three shifts in March of 1984 was 19.3 ug/m^3 with a median value of 25 ug/m^3. This increase appears even though the company began using a pneumatic resin handling system following the May 1983 survey. This system eliminated most of the manual handling and transferring in the injection molding department of the resins mixed with ABFA.

Additionally, the number of presses in operation during the two surveys that were using ABFA was essentially the same; three during the May 1983 survey and during the March 1984 survey - one on the first shift (11-7), three with a fourth in start-up on the 7-3 shift, and four on the third or 11-7 shift.

Mixing of ABFA with the resins was done only on the day shift during both surveys. In the case of the March 1984 survey conducted the first workshifts of the week, no mixing of ABFA was reported to have been done over the weekend.

Although about twice the number of batches containing resin and ABFA were mixed on March 12, 1984 when compared to May 4 and 5, 1983, the mean (geometric) exposure level for the workshift preceeding mixing was higher (8.68 ug/m^3, median 10 ug/m^3, GSD 1.54) for the 11-7 shift, March 11, 1984 than the mean (geometric) for all personal exposures obtained during the May 1983 survey (3.9 ug/m^3, median 6.2 ug/m^3, GSD 6.3).

During the May 1983 survey, 36 percent (10 of 28) personal exposures to ABFA were below detectable limits and this included all mold press operators running presses using ABFA. The follow-up survey conducted in conjunction with pulmonary function testing demonstrated that 100 percent of the personal exposures (32 of 32) were above detectable limits and this included workers not operating presses using ABFA. Note that the analytical limit of detection and quantitation was the same for both sets of samples.

Complaints expressed by workers regarding an odor associated with running presses using polyphenylene oxide resin and ABFA is substantiated by the fact that all operators monitored for exposure to selected thermal decomposition products had styrene exposures above the odor threshold of 0.08 ppm (12). Many of the workers monitored had levels which exceeded the 50 percent odor recognition level of 0.15 ppm (13).

The odor of styrene is described by Hellman and Small(13) as having a sharp/sweet odor quality and a hedonic tone (an approximate indication of the pleasure or displeasure associated with the odor quality) of unpleasant. Although the odor may be objectionable, and most likely there are other odorous compounds contributing to what workers perceive, the styrene exposure levels are well below those representing a health risk. The NIOSH recommended 8-10 hour time-weighted average exposure limit for styrene is 50 ppm (4).

The identification of low levels of various organic compounds associated with the vapor and smoke discharged above an injection mold machine using ABFA and polyphenylene oxide resin does not support managment's position that the visible plume is simply water vapor and carbon dioxide.

Inspection of breathing zone exposure data in Tables III and IV. During the May, 1983 survey Material Handlers generally had the higher exposures to ABFA. At that time these workers were involved with directly transporting and handling resins mixed with ABFA for each machine using this blowing agent. Examination of breathing zone exposures to ABFA during the March 1983 survey (Table IV) reveals the highest values to be occurring in the area of the resin mixing operation (Presses 26, 27, and 28). One also notices that worker exposures to ABFA on presses 26, 27, and 28 are much lower during the shifts preceding (11-7) and following (3-11) the day shift (7-3). The mixing of ABFA with resins was limited exclusively to the day shift on March 12, 1984.

The current handling practices of the powdered ABFA contribute to worker exposures. Examples observed by the investigators were the open boxes of azodicarbonamide and spillage in the resin blending area, observation of visible dust escaping from the ribbon blenders during initial mixing (although use of the blender covers and on oily mold lubricant did reduce visible emissions), and the location of a pedestal fan in this area which had the effect of blowing ABFA out into the mold press areas. This effect is noted by the fact that the injection mold operator at Press #28, directly across from the resin blending area (where ABFA is handled during mixing) had the highest ABFA exposure of all injection mold operators. This also held true when one compared other injection mold operator exposures using the same raw materials as those on Press #28.

An interesting finding is that worker exposures to ABFA during the March 1984 survey are higher than exposure levels seen in the May 1983 survey. This is seen in spite of reduced usage of ABFA and the implementation of the pneumatic resin handling system. One possible explanation may be that the use of the pedestal fan in the resin blending area along with spillage and dust releases during measurement of the blowing agent is resulting in distribution of ABFA throughout the injection mold department. A second question may be whether the new resin handling system is in some manner contributing to the dispersion and elevated environmental level of ABFA throughout the injection molding department. A third possibility, although considered much less plausible in light of production activity differences between the first and second follow-up surveys, is the release of untreated ABFA during the sanding of parts. Finally, the release of ABFA from some source in addition to the bulk powdered form may have been introduced or its usage increased since the May 1983 survey.

Past consultant work done for the company addressing concerns in the Injection Mold Department included evaluations of the local exhaust and ventilation systems, evaluation of decomposition products associated with ABFA and discussions of complaints of irritation and dermatitis associated with mixing resins with powdered ABFA and loading it into presses. Out of the March 1981 consultant survey came a suggestion that the ABFA powder itself, rather than decomposition products from the molding process alone, may be associated with the complaints of irritation.

The information obtained during the course of this investigation does not refute the possibility that ABFA may pose a significant health hazard, necessitating concern greater than what would be associated with a material considered to be a nuisance dust.

VIII. Recommendations

1. Local exhaust ventilation is advised in the resin mixing areas - specifically where the handling of ABFA is concerned. The use of a pedestal fan to blow the dust away from the blending area and out into the injection mold area should be discontinued.

2. Lids on top of the ribbon blenders should be modified to assure a good seal of the mixing chamber, preventing the escape of dry contents during initial blending. Additionally, the attachment of an exhaust system to the blending units could be used at the end of mixing procedures to remove any residual dust suspended inside the blender prior to opening the unit.

3. Inspection of the pneumatic resin handling system for leaks, open drop locations, and escape of material from feed hoppers is suggested to help reduce any potential leakage of dusty materials from the system.

4. Storage of the bulk ABFA should be changed. Replacement of the open free standing box adjacent to general traffic paths with closed containers in a designated area of the resin mixing location is suggested. The implementation of using a pre-measured metal sleeve and plastic bags is a good start in reducing the open

handling of ABFA, but work practices and control of the fugitive dust generated during this process needs further evaluation and modification.

5. Care should be taken when handling powdered ABFA. Dry sweeping of spilled material should not be permitted. Vacuuming (equipped with a high efficiency particulate air filter) or wet cleanup should be done at the time the material is spilled.

6 Enclosure of the resin blending area from the rest of the injection molding department may assist in reduction of raw material escape from blending procedures and possibly facilitate better control of materials such as ABFA at the source of contaminant release.

7. Hoppers of ABFA and resin mixtures in holding or material handling system feed areas should be covered.

8. Downdraft tables located at injection mold operator work stations should be on a routine maintenance schedule to assure their performance within design specifications. Worker education concerning the proper use of these units as well as their limitations will enhance their utility.

9. Procedures should be established informing workers of the hazards associated with materials used in the process. This may also encourage proper work practices since workers would have more information on the rationale behind engineering controls, personal protective equipment, and the work practices themselves.

10. The disposable nuisance dust respirator currently used by the material handler mixing ABFA with resins should be replaced with a half mask respirator equipped with high-efficiency particulate air cartridges. This type of respirator would provide better protection than the disposable dust mask. Uncertainty regarding the biological activity of ABFA through inhalation exposure supports this recommendation.

11. In order to minimize exposure due to contamination of regular work clothes, and to reduce direct contact with ABFA, workers should use gloves and disposable coveralls when directly handling this compound.

IX. References

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1. United Auto Workers Local 19
2. Leon Plastics
3. U.S. Senator Donald Riegle
4. Michigan Department of Public Health
5. International United Auto Workers
6. NIOSH, Region V
7. OSHA, Region V

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

Table I

Air Contaminant Evaluation Criteria

Leon Plastics
Grand Rapids, Michigan
HETA 83-156

Contaminant*	Recommended TWA Exposure Limit mg/m^3 (ppm)**	Source+	OSHA++ 8 hr TWA PEL mg/m^3 (ppm)	Symptoms+	Target Organs+
Benzene	3.2 (1)	NIOSH	32(10)	Irritation eyes, nose, respiratory system; giddy; headache, nausea, staggered gait; fatigue, anorexia, eyes, lassitude; dermatitis; bone marrow depression; abdominal pain.	Blood, central nervous system, skin, bone marrow (leukemogen), respiratory system.
Phenol - (skin)	20(52)	NIOSH	19(5)	Irritation eyes, nose, throat; anorexia, weight loss; weakness, muscle ache, pain; dark urine; cyanosis; liver, kidney damage; skin burns; dermatitis; ochronosis; tremor, convulsions; twitch.	Liver, kidneys, skin.
Styrene	212(50)	NIOSH	424(100)	Irritation eyes, nose; drowsy, weak, unsteady gait; narcosis; defatting dermatitis.	Central nervous system, respiratory system, lungs, eyes, skin.
Toluene	375(100)	NIOSH	751(200)	Fatigue, weakness confusion, euphoria, dizziness, headache; dilated pupils, lacrimation; nervousness muscle fatigue, insomnia; paresthesias, dermatitis, photophobia.	Central nervous system, liver, kidneys, skin.
Triphenyl phosphate - (skin)	3	ACGIH	3	Minor changes in blood enzymes; in animals: muscular weakness, paralysis.	Blood
Xylene	435(100)	NIOSH	435(100)	Dizziness, excitement, drowsiness, incoordination, staggering gait; irritation eyes, nose, throat; corneal vacuolization, anorexia, nausea, vomiting, abdominal pain, dermatitis.	Central nervous system, eyes, gastrointestinal tract, blood, liver, kidneys, skin.

* "Skin" notation refers to potential contribution to the overall exposure by the cutaneous route including mucous membranes and eye, either by airborne, or more particularly, by direct contact with the substance.

** Values given in milligrams per meter cubed (mg/m^3) with parts per million (ppm) in parentheses.

\+ Source: NIOSH Pocket Guide to Chemical Hazards (reference 3). This reference also used for Symptoms and Target Organs.

NIOSH Criteria for a recommended standard... occupational exposure to styrene (reference 4). ACGIH Threshold Limit Values for 1984-85 (reference 5).

++ OSHA eight hour time-weighted average permissible exposure limit. General Industry Standards (reference 6).

TABLE II

Azodicarbonamide and Total Dust Sampling Results
Leon Plastic
Grand Rapids, Michigan

HETA 83-156

May 3-5, 1983

Sample Description							Concentration in micrograms per cubic meter (ug/m3)**	
Date	Workshift	Press No.	Location or Job Title	Materials	Type (A or BZ)	Duration (min)	Azodicarbonamide	Total Dust
5/3	Second	2	Injection Mold Operator	PPO Mix.	BZ	460	ND	629
5/3	Second	2	Injection Mold Operator	PPO Mix	BZ	460	7.4	458
5/3	Second	2	Over sanding table	PPO Mix	A	468	Trace	-
5/3	Second	2	Edge of resin feed hopper	PPO Mix	A	463	ND	33.2
5/3	Second	2	Edge of resin feed hopper	PPO Mix	A	463	ND	-
5/3	Second	8	Injection Mold Operator	PPO Mix	BZ	458	ND	760
5/3	Second	8	Injection Mold Operator	PPO Mix	BZ	465	Note 1	Note 1
5/3	Second	8	Over sanding table	PPO Mix	A	472	ND	-
5/3	Second	8	Above resin feed hopper	PPO Mix	A	486	ND	51.5
5/3	Second	8	Above resin feed hopper	PPO Mix	A	486	ND	-
5/3	Second	10	Injection Mold Operator	PPO Mix	BZ	465	ND	1300
5/3	Second	10	Over sanding table	PPO Mix	A	465	ND	-
5/3	Second	10	Edge of resin feed hopper	PPO Mix	A	465	ND	247
5/3	Second	10	Edge of resin feed hopper	PPO Mix	A	465	ND	-
5/3	Second	11	Injection Mold Operator	PPO&L	BZ	456	ND	2220
5/3	Second	11	Over sanding table	PPO&L	A	452	ND	-
5/3	Second	11	Above resin feed hopper	PPO&L	A	454	ND	54.9
5/3	Second	11	Above resin feed hopper	PPO&L	A	454	ND	-
5/3	Second	-	Material Handler	Varied	BZ	449	8.9	578
5/4	First	2	Injection Mold Operator	PPO Mix	BZ	466	10.1	1240
5/4	First	2	Injection Mold Operator	PPO Mix	BZ	462	9.6	812
5/4	First	2	Over sanding table	PPO Mix	A	455	ND	-
5/4	First	2	Edge of resin feed hopper	PPO Mix	A	456	ND	528
5/4	First	2	Edge of resin feed hopper	PPO Mix	A	456	Trace	-
5/4	First	8	Injection Mold Operator	PPO Mix	BZ	459	ND	2420
5/4	First	8	Injection Mold Operator	PPO Mix	BZ	290*	ND	2520
5/4	First	8	Over sanding table	PPO Mix	A	434	ND	-
5/4	First	10	Injection Mold Operator	PPO Mix	BZ	468	6.2	85.1
5/4	First	10	Over sanding table	PPO Mix	A	442	ND	-
5/4	First	11	Injection Mold Operator	UPPO&L	BZ	466	6.3	891
5/4	First	11	Over sanding table	UPPO&L	A	441	ND	-
5/4	First	11	Edge of resin feed hopper	UPPO&L	A	430	ND	419
5/4	First	11	Edge of resin feed hopper	UPPO&L	A	430	ND	279
5/4	First	-	Material Handler	Varied	BZ	460	8.4	698
5/4	First	-	Material Handler/Mixer	Varied	BZ	460	128	352
5/4	First	-	Above resin mixer	Varied	A	435	217	-
5/4	Second	2	Injection Mold Operator	PPO Mix	BZ	453	ND	1660
5/4	Second	2	Injection Mold Operator	PPO Mix	BZ	453	ND	828
5/4	Second	2	Over sanding table	PPO Mix	A	436	ND	-
5/4	Second	2	Edge of resin feed hopper	PPO Mix	A	450	ND	817
5/4	Second	2	Edge of resin feed hopper	PPO Mix	A	434	ND	-
5/4	Second	8	Injection Mold Operator	PPO Mix	BZ	452	ND	2800

TABLE II
(Continued)

Date	Workshift	Press No.	Location or Job Title	Materials	Type (A or BZ)	Duration (min)	Concentration in micrograms per cubic meter (ug/m³)** Azodicarbonamide	Total Dust
5/4	Second	8	Injection Mold Operator	PPO Mix	BZ	452	6.1	2290
5/4	Second	8	Over sanding table	PPO Mix	A	435	ND	-
5/4	Second	10	Injection Mold Operator	PPO Mix	BZ	466	ND	880
5/4	Second	10	Over sanding table	PPO Mix	A	433	ND	-
5/4	Second	11	Injection Mold Operator	PPO&L	BZ	468	6.3	3000
5/4	Second	11	Oversanding table	PPO&L	A	435	ND	-
5/4	Second	11	Edge of resin feed hopper	PPO&L	A	464	ND	453
5/4	Second	11	Edge of resin feed hopper	PPO&L	A	435	ND	-
5/4	Second	-	Material Handler	Varied	BZ	462	9.1	1070
5/5	First	2	Injection Mold Operator	PPO Mix	BZ	474	ND	222
5/5	First	2	Injection Mold Operator	PPO Mix	BZ	476	6.1	1240
5/5	First	2	Over sanding table	PPO Mix	A	476	Trace	-
5/5	First	2	Edge of resin feed hopper	PPO Mix	A	477	9.9	189
5/5	First	2	Edge of resin feed hopper	PPO Mix	A	477	Trace	-
5/5	First	6	Injection Mold Operator	PPRO&C	BZ	283*	13.6	230
5/5	First	6	Edge of resin feed hopper	PPRO&C	A	318***	1430	1620
5/5	First	6	Edge of resin feed hopper	PPRO&C	A	318***	1800	-
5/5	First	8	Injection Mold Operator	PPO Mix	BZ	417	9.8	1090
5/5	First	8	Injection MOld Operator	PPO Mix	BZ	462	6.6	1940
5/5	First	8	Over sanding table	PPO Mix	A	456	6	-
5/5	First	11	Injection Mold Operator	PPO&L	BZ	460	Trace	946
5/5	First	11	Over sanding table	PPO&L	A	463	ND	-
5/5	First	11	Edge of resin feed hopper	PPO&L	A	458	ND	-
5/5	First	-	Material Handler	Varied	BZ	445	185	404
5/5	First	-	Material Handler/Mixer	Varied	BZ	457	283	952
5/5	First	-	Resin mixer area	Varied	A	475	110	516
5/5	First	-	Resin mixer area	Varied	A	475	117	-

PPO Mix = virgin and/or reground polyphenylene oxide resin mixed with azodicarbonamide and a lubricant.
PPO&L = machine running virgin polyphenylene oxide and a liquid blowing agent is injected into the system.
Varied = workers supply the various resins and resin mixes to all the presses on a continuing basis.
PPRO&C = Polypropylene and azodicarbonamide (Celogen™), no lubricant.
BZ = breathing zone sample (personal exposure)
A = area sample
**ND = indicates concentration of material in sample was below the analytical limits of detection. This calculated out for the ND's to be an environmental value less than about 1.1 ug/m³.
Trace = indicates that concentration is detectable but falls between the limit of detection and the limit of quantitation.
Note 1: Indicated sample discarded due to evidence of tampering (i.e. loose material present in cassette, not observed in any other samples of same type for same job title, job tasks, part produced, and materials used.)
*Cassette changed midshift. Original cassette cracked, air flow not drawn through filter.
*** Process did not start until about midshift.

Table III

Breathing Zone Azodicarbonamide and Total Dust Sampling Results

Leon Plastic
Grand Rapids, Michigan

HETA 83-156

May 3-5, 1983

Sample Description						Concentration in micrograms per cubic meter (ug/m3)**	
Date	Workshift	Press No.	Location or Job Title	Materials	Duration (min)	Azodicarbonamide	Total Dust
5/3	Second	2	Injection Mold Operator	PPO Mix	460	ND	629
5/3	Second	2	Injection Mold Operator	PPO Mix	460	7.4	458
5/3	Second	8	Injection Mold Operator	PPO Mix	458	ND	760
5/3	Second	8	Injection Mold Operator	PPO Mix	465	Note 1	Note 1
5/3	Second	10	Injection Mold Operator	PPO Mix	465	ND	1300
5/3	Second	11	Injection Mold Operator	PPO&L	456	ND	2220
5/3	Second	-	Material Handler	Varied	449	8.9	578
5/4	First	2	Injection Mold Operator	PPO Mix	466	10.1	1240
5/4	First	2	Injection Mold Operator	PPO Mix	462	9.6	812
5/4	First	8	Injection Mold Operator	PPO Mix	459	ND	2420
5/4	First	8	Injection Mold Operator	PPO Mix	290*	ND	2520
5/4	First	10	Injection Mold Operator	PPO Mix	468	6.2	85.1
5/4	First	11	Injection Mold Operator	UPPO&L	466	6.3	891
5/4	First	-	Material Handler	Varied	460	8.4	698
5/4	First	-	Material Handler/Mixer	Varied	460	128	352
5/4	Second	2	Injection Mold Operator	PPO Mix	453	ND	1660
5/4	Second	2	Injection Mold Operator	PPO Mix	453	ND	828
5/4	Second	8	Injection Mold Operator	PPO Mix	452	ND	2800
5/4	Second	8	Injection Mold Operator	PPO Mix	452	6.1	2290
5/4	Second	10	Injection Mold Operator	PPO Mix	466	ND	880
5/4	Second	11	Injection Mold Operator	PPO&L	468	6.3	3000
5/4	Second	-	Material Handler	Varied	462	9.1	1070
5/5	First	2	Injection Mold Operator	PPO Mix	474	ND	222
5/5	First	2	Injection Mold Operator	PPO Mix	476	6.1	1240
5/5	First	6	Injection Mold Operator	PPRO&C	283*	13.6	230
5/5	First	8	Injection Mold Operator	PPO Mix	417	9.8	1090
5/5	First	8	Injection Mold Operator	PPO Mix	462	6.6	1940
5/5	First	11	Injection Mold Operator	PPO&L	460	Trace	946
5/5	First	-	Material Handler	Varied	445	185	404
5/5	First	-	Material Handler/Mixer	Varied	457	283	952

PPO Mix = virgin and/or reground polyphenylene oxide resin mixed with azodicarbonamide and a lubricant.
PPO&L = machine running virgin polyphenylene oxide and a liquid blowing agent is injected into the system.
Varied = workers supply the various resins and resin mixes to all the presses on a continuing basis.
PPRO&C = Polypropylene and azodicarbonamide (Celogen™), no lubricant.
**ND = indicates concentration of material in sample was below the analytical limits of detection. This calculated out for the ND's to be an environmental value less than about 1.1 ug/m^3.
Trace = indicates that concentration is detectable but falls between the limit of detection and the limit of quantitation.
Note 1: Indicated sample discarded due to evidence of tampering (i.e. loose material present in cassette, not observed in any other samples of same type for same job title, job tasks, part produced, and materials used.)
*Cassette changed midshift. Original cassette cracked, air flow not drawn through filter.
*** Process did not start until about midshift.

Table IV

Azodicarbonamide Sampling Results
Leon Plastics
Grand Rapids, Michigan
HETA 83-156
March 11-12, 1984

Sample Description*							
Date	Workshift	Press No.	Job Title	Materials	Duration (min)	Notes	Azodicarbonamide Concentration in ug/m3**
3/11	11-7	3	Injection Mold Operator	PPRO&C&F	451		Trace
3/11	11-7	6	Injection Mold Operator	PPO Mix	447	A	14
3/11	11-7	7	Injection Mold Operator	PVC	415		10
3/11	11-7	9	Injection Mold Operator	PVC	428		13
3/11	11-7	10	Injection Mold Operator	PPRO&C	449	B	10
3/11	11-7	11	Injection Mold Operator	PPRO&F	424		11
3/11	11-7	25	Injection Mold Operator	PPRO&F	420		6
3/11	11-7	26	Injection Mold Operator	PC	448	C	8
3/11	11-7	27	Injection Mold Operator	PC	445		6
3/11	11-7	--	Material Handler	Varied	468		12
3/12	7-3	3	Injection Mold Operator	PPRO&C&F	444		26
3/12	7-3	4	Injection Mold Operator	PPRO&F	442		22
3/12	7-3	6	Injection Mold Operator	PPO Mix	442	D,E	24
3/12	7-3	7	Injection Mold Operator	PVC	412		34
3/12	7-3	24	Injection Mold Operator	PPRO&C	392		27
3/12	7-3	25	Injection Mold Operator	PPRO&F	422		36
3/12	7-3	26	Injection Mold Operator	PC	420	E	48
3/12	7-3	27	Injection Mold Operator	PC	430	E	57
3/12	7-3	28	Injection Mold Operator	PPO Mix	445	F,E	368
3/12	7-3	--	Material Handler	Varied	445	G	752
3/12	7-3	--	Injection Mold Operator	Varied	440	H	33

(Continued)

Tab e IV

Azodicarbonamide Sampling Results

(Continued)

Sample Description*							
Date	Workshift	Press No.	Job Title	Materials	Duration (min)	Notes	Azodicarbonamide Concentration in ug/m³**
3/12	3-11	3	Injection Mold Operator	PPRO&C&F	457		12
3/12	3-11	4	Injection Mold Operator	PPRO&F	427	I	27
3/12	3-11	6	Injection Mold Operator	PPO Mix	455	E	30
3/12	3-11	7	Injection Mold Operator	PVC	85	J	47
3/12	3-11	10	Injection Mold Operator	PPO Mix	455	E	45
3/12	3-11	11	Injection Mold Operator	PPRO&F	452	E	48
3/12	3-11	24	Injection Mold Operator	PC	434		43
3/12	3-11	26	Injection Mold Operator	PC	437	E	9
3/12	3-11	27	Injection Mold Operator	PC	452	E	8
3/12	3-11	28	Injection Mold Operator	PPO Mix	447	E	24
3/12	3-11	--	Material Handler	Varied	436		57

Analytical Limits in Micrograms of Azodicarbonamide Per Sample Are: Limit of Detection: 1 Limit of Quantitation: 5

*Sample Description and Notes:
- PPRO&C&F = polypropylene, azodicarbonamide, and fibrous glass
- PPO Mix = virgin and/or reground polyphenylene oxide resin mixed with azodicarbonamide
- PVC = polyvinylchloride resin
- PPRO&C = polypropylene and azodicarbonamide
- PPRO&F = polypropylene and fibrous glass
- PC = pelletized polycarbonate resin system

Duration Given In Minutes

Notes:
- A Swept floors all evening, press not running
- B Press did not operate during shift, worker ran relief throughout the department
- C Press did not start up until about 1:20
- D Press in start-up entire shift, no parts run, worker sanded structural foam doors produced 2/24/84
- E Sanding of parts performed at work station
- F Work station located across from the resin mixing area
- G Worker did mixing of azodicarbonamide with resins
- H Worker ground scrap entire shift except for brief operation of press during relief period
- I Worker moved to press number 13 at 7:30p.m. Resin used PPRO&C
- J Sample terminated early due to employee's refusal to continue wearing sampling pump

**ug/m³ = micrograms per meter cubed

Trace denotes a sample in which contaminant concentration in the sample fell between the given analytical limits

Table V

Styrene and Toluene Sampling Results
Leon Plastics
Grand Rapids, Michigan
HETA 83-156
March 11-12, 1984

Sample Description*							Contaminant Concentration in mg/m3**	
Date	Workshift	Press No.	Job Title	Materials	Duration (min)	Volume (L)	Styrene	Toluene
3/11	11-7	3	Injection Mold Operator	PPRO&C&F	452	87	0.5 (0.1)	0.2 (0.06)
3/11	11-7	6	Injection Mold Operator	PPO Mix	449	82	0.6 (0.1)	0.1 (0.03)
3/11	11-7	26	Injection Mold Operator	PC	447	88	0.7 (0.2)	0.2 (0.06)
3/12	7-3	3	Injection Mold Operator	PPRO&C&F	444	84	1.0 (0.2)	0.4 (0.1)
3/12	7-3	6	Injection Mold Operator	PPO Mix	442	81	0.7 (0.2)	0.4 (0.1)
3/12	7-3	24	Injection Mold Operator	PPRO&C	435	82	1.0 (0.2)	0.2 (0.07)
3/12	7-3	28	Injection Mold Operator	PPO Mix	445	85	1.3 (0.3)	0.5 (0.1)
3/12	7-3	Note A	Injection Mold Operator	Note A	422	78	1.0 (0.2)	0.4 (0.1)
3/12	3-11	3	Injection Mold Operator	PPRO&C&F	457	85	0.8 (0.2)	0.4 (0.09)
3/12	3-11	6	Injection Mold Operator	PPO Mix	455	105	0.8 (0.2)	0.5 (0.1)
3/12	3-11	10	Injection Mold Operator	PPO Mix	455	86	0.9 (0.2)	0.5 (0.1)
3/12	3-11	28	Injection Mold Operator	PPO Mix	447.	82	1.1 (0.3)	0.5 (0.1)
Analytical Limit of Detection in Milligrams Per Sample:							0.01	0.01
Evaluation Criteria+:	OSHA						424 (100)	751 (200)
	NIOSH						212 (50)	375 (100)
Odor Threshold++:							0.34 (0.08)	38 (10) - 56 (15)

*Sample Description:
Materials Run On Presses: PPRO&C&F = polpropylene with azodicarbonamide and fibrous glass
PPO Mix = virgin and/or reground polyphenylene oxide resin mixed with azodicarbonamide
PC = pelletized polycarbonate resin system
PPRO&C = polypropylene and azodicarbonamide

Duration Given In Minutes (min)
Volume Given In Liters (L)

**Concentrations are given in milligrams per cubic meter (mg/m^3) with parts per million (ppm) in parentheses

Note A: Worker normally on Press 5, press was down 3/12/84. Worker swept floors throughout department during workshift.

+ = Evaluation-Criteria given are for a full workshift (8 hours for OSHA; 8-10 hours, 40 hour week for NIOSH). Full shift exposure criteria are considered applicable

++ = Reference: NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards (reference 12)

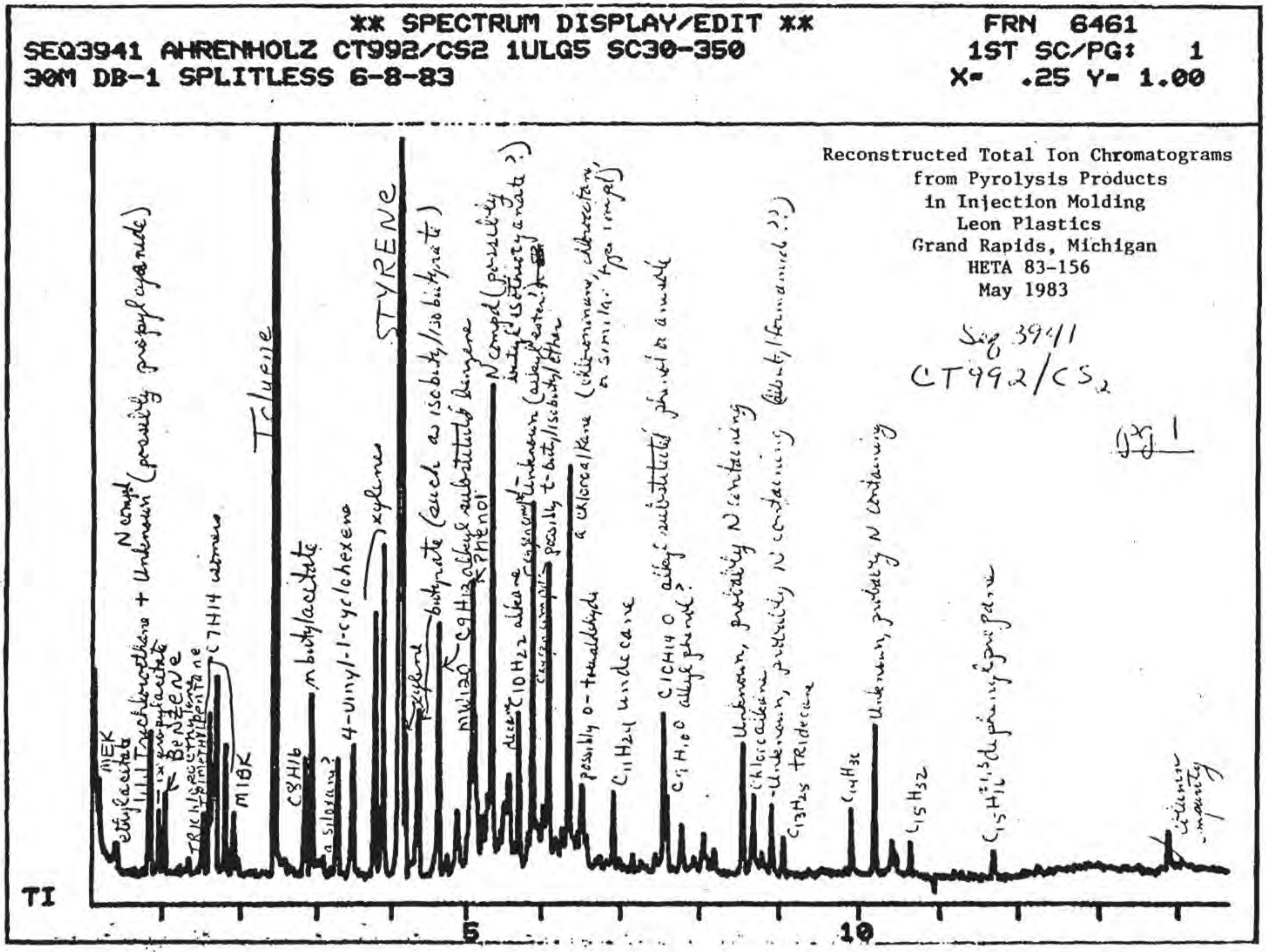
** SPECTRUM DISPLAY/EDIT **
FRN 6461
SEQ3941 AHRENHOLZ CT992/CS2 1ULG5 SC30-350
1ST SC/PG: 1
30M DB-1 SPLITLESS 6-8-83
X= .25 Y= 1.00
Reconstructed Total Ion Chromatograms
from Pyrolysis Products
in Injection Molding
Leon Plastics
Grand Rapids, Michigan
HETA 83-156
May 1983
TI
5
10

Figure I

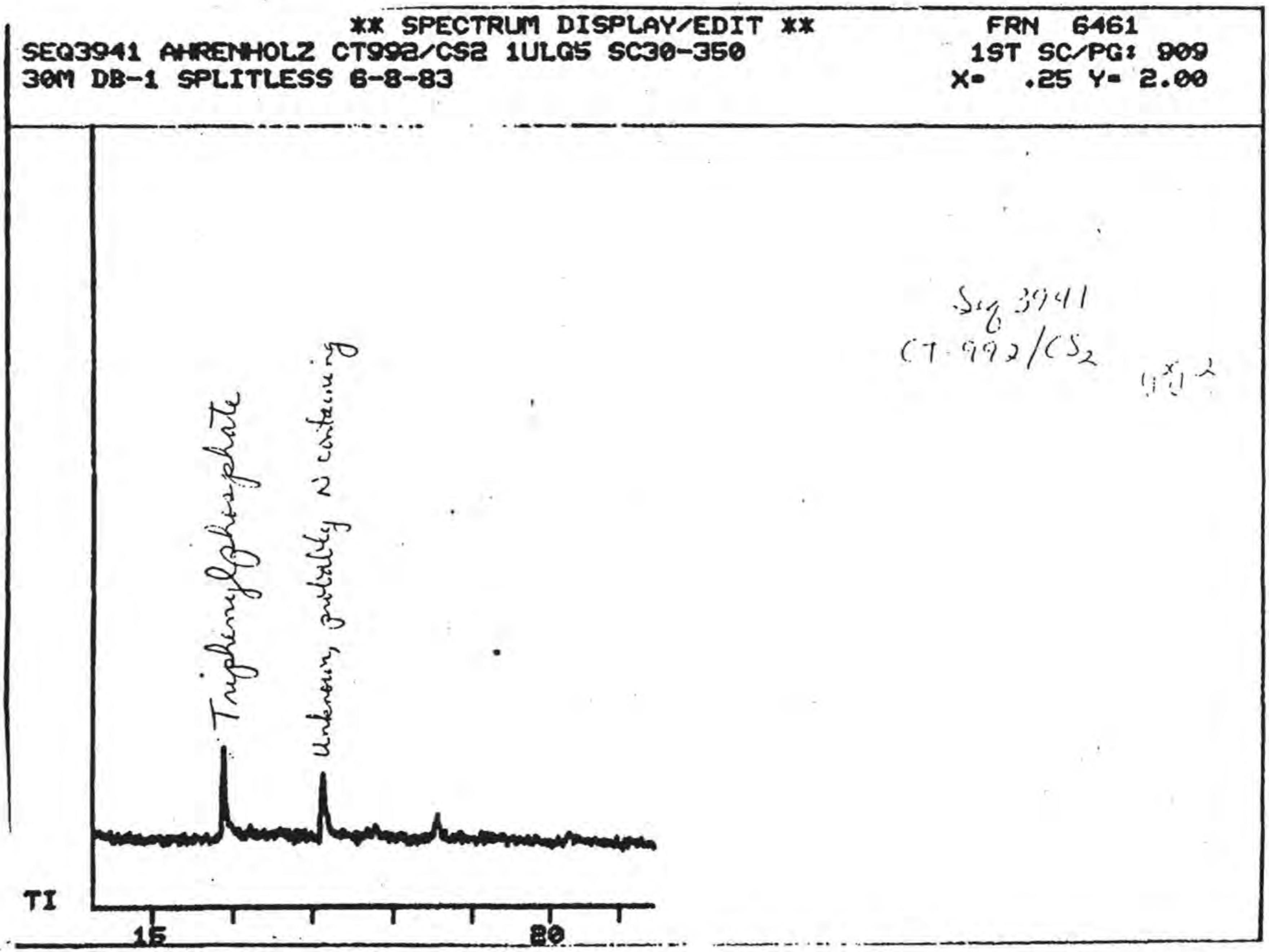

Figure I continued

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
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