SUMMARY FOR WORKERS

NIOSH HEALTH HAZARD EVALUATION
REPORT NO. 75-171-448

OWENS-ILLINOIS GLASS PLANT
HAPEVILLE, GEORGIA

DECEMBER 1977

In October, 1975, NIOSH received a second formal request for a health hazard evaluation concerning occupational exposure of employees to sulfur dioxide, sulfur dioxide decay products, sodium sulfate and tin tetrachloride in the Forming and Selecting Departments of the Owens-Illinois Glass Container plant in Hapeville, Georgia. This request, submitted by the Glass Bottle Blowers Association Local 101, contended that the first NIOSH health hazard evaluation of the Forming and Selecting Departments, completed in April 1974, had considered sulfur dioxide exposure, but not sodium sulfate and other sulfur dioxide decay products. Furthermore, the union raised questions about the possibility of long-term lung damage resulting from airborne exposures of employees. It has taken a long time for NIOSH to complete this second evaluation due to the shortage of the extensive amount of medical manpower required to investigate the question of long-term lung damage.

During the week of March 14-18, 1977, a comprehensive environmental and medical survey was conducted of the Forming and Selecting Departments at the Owens-Illinois Glass Container Division plant in Hapeville, Georgia. The environmental investigation included measurements of air contaminants to which workers were exposed and a physical inspection of the working areas. Air samples were collected to measure airborne levels of sulfur dioxide, sulfates, tin compounds, chlorides, and respirable particulates. The medical investigation utilized private employee interviews, work histories, chest x-rays, and breathing tests.

The employee interviews were used to compare the percentage of workers having respiratory or other symptoms among the various production lines and departments. It was found that workers had about the same kind and frequency of symptoms whether they worked on sulfur lines, tin lines, or other departments in the plant with no detectable exposure to sulfur or tin compounds. The occurrence of symptoms among workers in the Forming and Selecting Departments was about the same as the occurrence of symptoms among employees in the Corrugating, Decorating, and Shipping Departments. Therefore, it does not appear that working in the Forming or Selecting Departments with sulfur and tin compounds causes any significant increase in symptoms from other departments.

No x-ray abnormalities associated with occupational exposure were detected during the medical tests.

Breathing tests were performed before and after the shift to detect short-term breathing reactions caused by exposures to airborne contaminants during the shift. Most of the results showed no change in lung functions during the work shift. The flow rate of air from the lung during the last stages of exhaling was slower after the work shift. This can be indicative of breathing resistance developing due to constriction of the bronchioles, possibly due to a reaction to some air contaminant. However, this reduced air flow rate from the lungs was similar in all three groups of workers - from the sulfur lines and tin lines in Forming and Selecting, and from unexposed workers in other departments who had no tin or sulfur exposure. Therefore, it does not appear that exposure to sulfur or tin compounds in Forming or Selecting causes any significant changes in lung function from other plant departments.

Air samples were taken to measure air concentrations and worker exposure to sulfur dioxide, sulfates, tin compounds, chlorides, and respirable particulates. Worker exposures were found to be within presently accepted levels which would not be believed to cause any adverse health effects to employees.

The NIOSH evaluation did not detect any increased risk of adverse symptoms or adverse health effects, including lung effects, due to exposure to airborne contaminants in the Forming or Selecting Departments.

U. S. Department of Health, Education, and Welfare
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
Cincinnati, Ohio 45226

Health Hazard Evaluation Determination
Report No. 75-171-448

Owens-Illinois Glass Container Division
Atlanta Plant
Hapeville, Georgia 30354

December 1977

I. TOXICITY DETERMINATION

During the week of March 14-18, 1977, a comprehensive environmental and medical survey was conducted of the Forming and Selecting Departments at the Owens-Illinois Glass Container Division plant in Hapeville, Georgia. The environmental investigation included measurements of air contaminants to which workers were exposed and a physical inspection of the working areas. Area and personal air samples were collected to measure airborne levels of sulfur dioxide, sulfates, tin compounds, chlorides, and respirable particulates. The medical investigation utilized private employee interviews, work histories, chest x-rays, and pulmonary function tests.

Analyses of medical tests indicated that no difference was observed between the prevalence of either acute or chronic irritation or respiratory symptoms in groups of workers on sulfur-treated bottle lines, tin-treated bottle lines, and workers from other departments in the plant with no detectable exposure to either tin or sulfur compounds.

Sulfur dioxide-exposed, tin-exposed, and unexposed (control) worker groups showed similar restriction in air flow rates from the lungs at low lung volumes. In the three worker groups studied at this plant, reductions during the shift in small airways function (FEF_{50} and FEF_{75}) are statistically significant. There was essentially no change in other pulmonary functions (FVC and FEV_1) during the work shift. There was no apparent association of respirable particulate with acute changes in pulmonary function. Employees' exposures to other air contaminants, including sulfur dioxide, sulfates, tin, and chlorides, were considered too low to produce adverse health effects.

There were no x-ray abnormalities associated with occupational exposure. Specifically, no cases of pneumoconiosis were detected.

In conclusion, the only significant abnormality detected was a reduction in air flow rates from the lungs at low lung volumes. This reduction was similar in sulfur-exposed, tin-exposed, and unexposed (control) worker groups. Therefore, no evidence was found to indicate that any toxic effects among the workers resulted from their exposures to airborne sulfur dioxide, sulfates, tin, chlorides, or respirable particulates.

I. DISTRIBUTION AND AVAILABILITY OF DETERMINATION 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 the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies have been sent to:

A. Owens-Illinois Glass Container Division, Hapeville, Georgia
B. Glass Bottle Blowers Association Local 101, East Point, Georgia
C. U. S. Department of Labor, OSHA, Region IV
D. NIOSH, Region IV
E. Georgia Department of Human Resources
F. Glass Bottle Blowers Association of the U.S. and Canada, Media, Pennsylvania

For the purpose of informing the approximately 500 "affected employees", the employer will promptly "post" this report for a period of 30 calendar days in prominent places 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 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.

In October, 1975, NIOSH received a second formal request for a health hazard evaluation concerning occupational exposure of employees to sulfur dioxide (SO_2), sulfur dioxide decay products, sodium sulfate and tin tetrachloride ($SnCl_4$) in the Forming and Selecting Departments of the Owens-Illinois Glass Container plant in Hapeville, Georgia. This request submitted by the Glass Bottle Blowers Association Local 101, contended that the first NIOSH health hazard evaluation of the Forming and Selecting Departments, completed in April 1974, had considered sulfur dioxide exposure, but not sodium sulfate and other sulfur dioxide decay products. Furthermore, the union raised questions about the possibility of chronic pulmonary damage resulting from airborne exposures of employees. It has taken a long time for NIOSH to complete this second evaluation due to the shortage of the extensive amount of medical manpower required to investigate the question of chronic pulmonary impairment.

IV. HEALTH HAZARD EVALUATION

A. Plant Process - Conditions of Use

This plant manufactures glass bottles for such products as beverages, pharmaceuticals, and biological fluids, and employs 1,080 employees. About half (573) are males, and 35 percent are blacks. Twenty-seven percent of the male employees and 45 percent (226) of female employees are black. There are four shifts working on a rotating basis.

The glass making process is outlined in Figure 1. The areas to be investigated are the Forming and Selecting Departments (processes 2 and 3). There are 13 bottle forming machines (1 operator/machine) in the Forming Department. Operators work in close proximity to the forming machines, making adjustments, rejecting imperfect bottles and applying "dope" to the molds. Dope may be applied 3-4 times per hour in order to maintain a constant mold temperature to prevent flaws in the glass. Elemental sulfur has been used in the past as dope, and is apparently still used by some operators, although graphite based dopes are more commonly used.

On two of the lines making bottles for parenternal fluids, gaseous SO_2 is injected to harden the interior bottle surface and prevent leaching of sodium and other ions from the glass into the contained fluids. On the other lines, the exterior surface is coated with a gaseous disperson of $SnCl_4$, providing a tough surface much less likely to scratch or adhere to another bottle. Both of these processes occur immediately prior to entering the lehrs, which are gas fired annealing ovens. These maintain the glass at 1200° F. for a specific time, and gradually cool it at a predetermined rate. This treatment removes internal strains and eliminates distortions and imperfections. Annealing is fully automated, does not require an operator, and conveys the bottle to the Selecting Department where 4 to 6 employees per line check, inspect, and box the bottles. The soft drink bottles go to the Decorating Department where they are decorated with ink or plastiseal and reboxed. Boxed bottles go to the Shipping Department.

B. Evaluation Design

Environmental investigations were conducted of the Forming and Selecting Departments during NIOSH's first hazard evaluation of the areas on June 13-14, 1973, and during NIOSH's initial environmental survey for this hazard evaluation on January 7, 1976. Both studies indicated that airborne exposures to sulfur dioxide, tin compounds, and total particulates were within levels considered to be of such a low magnitude that no health problems among exposed workers would be anticipated.

In order to determine the reaction or decomposition products of sulfur dioxide, Peter M. Eller, Ph.D., a NIOSH research analytical chemist from NIOSH's Cincinnati laboratories, conducted sampling at the plant site on January 12, 1977. Some samples were analyzed on the site, others taken back to Cincinnati for analysis. In order to identify the sulfur species involved, solutions of the powdery deposit in the 1-liter, SO_2-treated bottles were analyzed and found to contain sodium (3.2 mg/bottle) and sulfate (5.6 mg/bottle) in approximately correct proportions for sodium sulfate. Tests for ammonium and sulfite ions were both negative (less than 10 micrograms/bottle). In addition, one cubic meter of air was sampled at both the inlet and exit of the lehr with each of a variety of filter materials. Spherical particles containing appreciable amounts of sodium and sulfur and a smaller amount of tin were found by scanning electron microscopy with x-ray microanalysis. A number of other analytical techniques were applied to the samples. Sodium, sulfur, and tin were found to be the major components of the particles. A measurement for total particulate sulfate amounted to 0.11 mg of sulfate per cubic meter of air. All particulate sulfur was found to be in the +6 oxidation state. No sulfuric acid, ammonium, or free silica were detected (less than 10 micrograms/m^3 each). Dr. Eller's tests indicated that sulfate salts, particularly sodium sulfate, were the only significant sulfur dioxide decay products in this work environment.

In spite of the low levels of air contaminants found during every NIOSH environmental study, reports from the local union and from some of the employees who were interviewed continued to indicate that some workers may occasionally experience symptoms of skin, eye, and respiratory irritation. Concern among the workers and union about chronic effects persisted.

The second health hazard evaluation request from the local union referred to complaints of skin rash, dry throat, running nose, red eyes, hoarseness, and possibly bronchiectasis occurring as a result of sulfur and tin exposure. Sulfur oxides are known respiratory irritants. Tin tetrachloride is a strong acid that rapidly hydrolyzes to hydrogen chloride, which can produce symptoms similar to the sulfur oxides.

Therefore, NIOSH developed a joint environmental/medical study which was designed to answer the following questions:

1) Does exposure to the sulfur or tin compounds result in an increase in symptoms?

2) Does exposure to the sulfur or tin compounds result in acute changes in pulmonary function? If so, at what exposure level do the changes occur, i.e, what is the dose-response relation?

3) Are there chronic changes in pulmonary function or chest x-ray that are associated with exposure to the sulfur or tin compounds?

C. Evaluation Methods

1. Environmental Evaluation Methods

On those bottle lines employing sulfur dioxide treatment, area samples for SO_2 and particulate sulfate were collected on the catwalk above the bottle forming machines, near the SO_2 application at the lehr entrance, and near the lehr exit in the Selecting Department. A two-stage collection device was used to measure the sulfur species. A MSA Model G pump was used to draw air through a 0.8 micrometer pore size, cellulose membrane filter in a closed face 37 mm diameter cassette, to collect particulates and then through a midget impinger containing 0.3 N hydrogen peroxide collecting solution for SO_2. The air sampling rate was approximately one liter per minute.

From a study of the process and the analytical survey performed by Dr. Peter Eller of the NIOSH Division of Physical Sciences and Engineering, it is presumed that the sulfate detected on the filter is mainly sodium sulfate, and the sulfate found in the impinger solution is the result of SO_2 in the sampled environment travelling through the filter and collecting in the impinger solution. Both the impinger solution and the filters were analyzed for total sulfate content by the barium perchlorate titration method.[1] The limit of detection for particulate sulfate was 40 micrograms/filter; for SO_2 the limit of detection was 0.01 mg SO_2/ml of collecting solution.

On the bottle lines employing $SnCl_4$ treatment, at locations analogous to those described for the sulfur lines, samples were taken for filterable and non-filterable tin, and total chloride ion. A two stage sampling train consisting of a 0.8 micrometer pore size membrane filter followed by a midget impinger containing 0.01 N NaOH solution was utilized. Air was sampled through this system at a flow rate of one liter per minute. The filters were analyzed for tin, and the impinger solution was analyzed for both tin and total chloride ion The tin analysis was done by atomic absorption spectroscopy.[2] The chloride analysis was performed using a specific ion electrode.[3] Limits of detection for the chloride ion was 0.05 mg/ml of collecting solution, for filterable tin 10 micrograms/filter, and for nonfilterable tin 2 micrograms/ml solution. It is reported that stannic chloride reacts quickly in the presence of atmospheric moisture to form hydrochloric acid and tin oxide. The tin found on the filters was therefore presumed to be tin oxide. Tin found in the impinger solution was probably due to unreacted stannic chloride vapors passing through the filter and collecting in the impinger solution. The chloride in the impinger solution could be due to unreacted stannic chloride vapors and/or HCl from hydrolysis of stannic chloride in air.

Area environmental samples were taken during the same shifts in which the medical data were collected. One sample for each contaminant (sulfate, sulfur dioxide, tin, and chloride ion) was taken at the shipping, decorating, and corrugating areas to verify that control workers from these areas were not exposed to these chemical species.

All workers medically tested (approximately 30 per shift) wore personal samplers for measurement of respirable particulate exposure during the shift of their test. Approximately ten workers from each of three exposure groups - tin lines, sulfur lines, and areas of the plant without significant sulfur, tin, or respirable dust exposure - were tested on each shift. Respirable dust was measured by drawing air at a rate of 1.7 liters per minute first through a 10-mm nylon cyclone to remove the larger, non-respirable particles prior to collection of the respirable particles on a pre-weighed, non hydroscopic, polyvinyl chloride membrane filter. After sampling the filters were reweighed to determine the amount of collected respirable dust. After reweighing, the filters were analyzed for either tin or sulfate content, depending on the exposure area in which the employee who wore the sampler was working.

Selected persons, primarily from the Forming and Selecting Departments, also wore a miniature sampling pump connected to a Drager long-term SO_2 detector tube to measure personal exposures to SO_2.

2. Medical Evaluation Methods

Shift work at this plant is conducted on a rotating, or swing-shift, schedule involving four complete shifts of workers. NIOSH evaluated workers from all four shifts. Three categories of workers were selected for study. All employees working on the two sulfur lines for all 4 shifts were asked to participate in the study (called the SO_2 group). They were age, sex, and race matched with employees working in the same departments, but on the tin lines rather than sulfur lines (called the tin group), and employees working in corrugating, decorating, and shipping departments who were not thought to be exposed to either tin or sulfur compounds (control group). Unfortunately, there were not enough control workers in these departments to match with those from the sulfur lines. Where unexposed controls were not available, individuals were selected from the tin group. Office workers were considered inappropriate as controls, since data indicate that socio-economic status is a variable associated with pulmonary function findings.

Each worker who was selected for the study from all three groups was subjected to the following medical study procedures:

1) A modified Medical Research Council (MRC) respiratory questionnaire was administered by trained interviewers. Height and weight were recorded after making appropriate adjustments for shoes and clothing.

2) Posterior/anterior (PA) and lateral chest x-rays were taken; these were read by three "B" readers following the International Labor Organization (ILO)/Union Internationale Contre Cancer (UICC) scheme for pneumoconiosis.

3) Pulmonary (lung) function tests were given during the first two hours of the shift, and then again during the last two hours of the shift, with an average of about 5 hours on the job between pulmonary function tests. The pulmonary function maneuvers were recorded on magnetic analog tape using an Ohio Med Science 800 rolling seal spirometer and consisted of a minimum of 5 forced exhalations breathing room air. A maximum envelope of the best curve was derived from all five blows. Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1) and flow rates at 25, 50 and 75% of exhaled FVC (FEF_{25}, FEF_{50}, (FEF_{75}) were selected for analysis. Acute changes in pulmonary function (ΔPF) were calculated in percentage changes (ΔPF%) by taking the difference of post and pre-shift values, dividing by the mean of pre and post-shift values, and multiplying by 100. Post-shift flow rates were determined by lining up the post-shift maximum envelope with pre-shift envelope at total lung capacity and measuring flow rates at 25, 50 and 75% of pre-shift exhaled FVC.

4) The complete work history of each participant was xeroxed from company records, coded by department, job and duration and merged with the environmental and medical data, for analysis of chronic effects.

D. Evaluation Criteria

Both environmental and medical criteria have been selected for assessing the degree of hazard posed by workplace exposures to the substances included in this evaluation. The environmental criteria generally consist of guidelines for airborne exposure which have been developed to protect workers from both acute and chronic health impairments, including transient irritation. Medical criteria consist of practical guidelines for interpretation of pulmonary and x-ray findings, and statistical tests for variances between comparison groups. The study was designed to evaluate the following acute and chronic effects of the substances under study.

Sulfur Dioxide

The acute (short-term) symptoms of low-level SO_2 exposure are primarily of irritancy nature. Exposure of less than an hour to SO_2 levels above 10 ppm is irritating to the nose and throat sometimes causing a choking sensation followed by a nasal discharge, sneezing, cough, and increased mucous secretion. Acute exposures to very elevated SO_2 levels may produce death, or result in chronic diseases such as chronic bronchitis, emphysema, and shortness of breath.

Chronic (long-term) exposure to low levels of SO_2 may produce chronic bronchitis and decrement of pulmonary function. There is evidence that 10 to 20% of people are especially susceptible to SO_2 effects.[4]

Inorganic Tin

In general the toxicity of inorganic tin salts is low. Acute exposure to low levels may cause irritation of the eyes, nose, throat, and skin. No significant effects are known from long-term exposure to most tin salts. Chronic inhalation of excessive levels of tin oxide may cause a benign pneumoconiosis (stannosis). Tin tetrachloride (stannic chloride) is considered a strong acid; the eye and skin irritation associated with this compound is presumably due to hydrochloric acid which is generated when the tin tetrachloride reacts with water.[5]

Sodium Sulfate

Sodium ions and sulfate ions apparently act independently. Both are extremely common in the natural environment, in food, and in water. These ions appear to be relatively innocuous when acting alone. Compounds of these ions appear to derive any toxicity from the other substances with which they are reacted. Inhalation or ingestion of low levels of sodium sulfate would probably not have any adverse effects on health. Since sodium sulfate is readily soluble in water, contact with skin may produce a drying effect, which could conceivably lead to dermatitis if the exposure is prolonged.

1. Environmental Criteria

The Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor has established standards for airborne exposure of workers to some of the chemical substances of concern in this study.[6] The National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH) have also recommended standards for some of these substances. These groups' recommendations are based on more recent health effects data than that on which the current OSHA standards are based.

Substance	Recommended Limit	Legal Limit
Respirable particulates (non-specific)	---	5 mg/M^3 (OSHA)
Sulfur dioxide	0.5ppm (NIOSH)[4]	5ppm (OSHA)
Hydrogen Chloride	---	C 7 mg/m^3 (OSHA)
Inorganic tin compounds (except tin oxide), as tin	---	2 mg/m^3 (OSHA)
Tin oxide (total)	10 mg/m^3 (ACGIH 1976)[7]	

mg/m3 = milligrams of particulate per cubic meter of air
ppm = parts of vapor or gas per million parts of air, by volume
C = ceiling concentration for short-term exposure, a maximum concentration level

se criteria are believed to represent the time-weighted average concentration .or a normal 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

There are no specific guidelines for airborne occupational exposure to non-specific inorganic sulfates or inorganic chlorides. These chemicals, as classes, are considered relatively innocuous.

2. Medical Criteria

This investigation was designed to determine whether statistically significant differences existed between sulfur, tin, and control groups of workers in the prevalence of irritancy symptoms, x-ray abnormalities, and pulmonary function parameters. Statistical tests were also used to determine whether any significant correlation existed between changes in pulmonary function parameters (ΔPF's) during the work shift and levels of airborne respirable particulate or years of work in the Forming and Selecting Departments.

Equations were used which predict "normal" values for pulmonary function parameters, accounting for age, height, sex, and race.[8,9] Significant decrements below predicted values, for example values less than 80% of predicted FEV_1, would be indicative of abnormalities.

E. Evaluation Results and Discussion

1. Environmental Sampling Results

Gravimetric analysis of personal samples for respirable, airborne particulates indicated that exposures were quite low. For the control group, twenty-six of the measured exposure levels were $\leq$ 0.4 mg/m^3, and one level was 0.6 mg/m^3. Respirable particulate exposure for the SO_2 group ranged from 0.02 to 1.7 mg/m^3, and for the tin group, from 0.04 to 1.2 mg/m^3.

In addition to gravimetric analysis for respirable dust, personal samples were also analyzed for either total tin or total sulfate, depending on whether the samples were taken on tin or sulfur dioxide line workers. Out of a total of 48 samples analyzed for total sulfate, sulfate (presumed to be sodium sulfate) was detected on six samples. These six samples were taken on workers in the Selecting Department on the sulfur treated lines. The highest sulfate value recorded was 1.1 mg/m^3; the average of the six was 0.30 mg/m^3. The analysis for tin also showed low concentrations. Of a total of 62 samples analyzed, tin was detected on only 4. These 4 samples were all on workers on tin lines in the Forming Department. The values ranged from 0.032 mg/m^3 to 0.092 mg/m^3 with the average being 0.055 mg/m^3.

Table #1 gives the results for area SO_2 and particulate sulfate samples. Relatively high levels of SO_2 (17, 14 and 11 PPM) were recorded from samples taken on the catwalk above the SO_2 lines. Concentrations of SO_2 from area samples taken on the main floor near SO_2 lines ranged from 0.40 PPM to 2.0 PPM, the average value being 0.96 PPM SO_2. As would be expected, the average SO_2 concentration was higher in the forming area (1.3 PPM) than it was in the Selecting area (0.68 PPM) of the SO_2 lines. As can be seen from the table, only 2 of the 20 samples analyzed resulted in any sulfate detection. These were the results of area samples taken on the catwalk above the SO_2 lines.

Filterable and non-filterable tin, as well as total chloride ion concentration are given in Table #2. Nine out of the 21 samples analyzed detected some amount of filterable tin. Concentrations were relatively low, ranging from 0.049 mg/m^3 to 0.95 mg/m^3. As can be seen from the table, non-filterable tin was detected in only one of the 20 samples analyzed. Chloride ion was detected in 6 of the 21 samples taken. One relatively high concentration of 11 mg/m^3 was recorded from a sample taken at the Selecting Department on line D-2. The fact that generally no tin was detected in the impinger solution tends to support the idea that the $SnCl_4$ is reacting to form hydrogen chloride and tin oxide.

Twenty workers from SO_2 lines in the Forming and Selecting Departments wore long term indicator tubes for determination of personal SO_2 exposure. The results are given in Table 3. The highest level recorded was 1.6 PPM. This sample was taken on a forming machine operator working around the B furnace where the sulfur lines are located. Other detected levels of SO_2 were below 0.52 PPM. Sixteen of the twenty samples failed to detect any SO_2.

2. Medical Evaluation Results

There were no cases of pneumoconiosis detected from the chest x-rays, and the x-ray findings are not analyzed further.

Table 4 summarizes the age and smoking distribution of the study population. About 1/4 (29) of the population are males. Of the males, 62% are smokers and about 1/4 ex-smokers, compared to 54% and 7% of the females. About 3/4 of the males and 66% of the females are 30-50 years of age. In the total study population, slightly over 60% are 30-50 years of age; 62% are smokers, 32% are non-smokers, 13% ex-smokers, and the proportion of smokers, ex-smokers and non-smokers is similar for all age groups. Of those who smoke, over 90% inhale and use filter cigarettes. Only 3/4 of the ex-smokers used filters, while 92% inhaled.

About 1/3 of the study population is black, with only one black male. Of the 75 whites, 63% are female. The percentage of smokers in the 2 races is the same (56%); 42% of the blacks are nonsmokers compared to 32% of the whites (Table 5).

Table 6 summarizes characteristics of the 3 exposure groups. The control and SO_2 groups both have about 1/3 males; the tin group is 1/5 males. The SO_2 and tin group are about 40% blacks, while the control group has about 20% blacks. The majority of workers in each group have a high school education, with about the same distribution in each exposure group. The slightly lower mean height and weight of the tin group is a reflection of the higher proportion of females in that group. The control group has a slightly higher proportion of heavy smokers than the SO_2 and tin groups, although the overall proportion of smokers is the same in each group. The tin group has a higher proportion of non-smokers and a lower proportion of ex-smokers than the SO_2 and control groups. The SO_2 and tin groups have about the same mean values for years worked in Forming and Selecting. The control group has considerably less years spent in these departments than either of the other groups.

Table 7 summarizes the prevalence of chronic symptoms by age, smoking, and exposure. The prevalence of cough and wheezing tends to increase with age, while other symptoms do not show an association with age. Smokers report an increased rate of cough, phlegm and wheezing, but the prevalence of other symptoms is not increased by smoking. Ex-smokers report a higher rate of Grade 2 and 3 dyspnea (difficulty in breathing) than both smokers and non-smokers. There is a slight trend for the controls to report more symptoms, particularly cough and phlegm. There is no consistent relationship between the prevalence of symptoms and the number of years of work experience in Forming and Selecting.

Table 8 summarizes the prevalence of acute symptoms for the total population. The worker was asked to estimate the approximate frequency of these symptoms over the past few weeks. There is no consistent difference in the prevalence of these symptoms when smoking and exposure groups are compared.

Table 9 summarizes the acute changes in pulmonary function by smoking category within each exposure group. Both smokers and non-smokers (combined ex-smokers and non-smokers) consistently show reductions in flow rates at low lung volumes. When smokers and non-smokers are combined, the acute reduction in flow rates at 50% and 75% of exhaled FVC is apparent. The reductions in FEF_{50} and FEF_{75} are statistically significant for the total workforce studied. The reduction in FEF_{50} is statistically significant for the total tin group. There is little difference in pre and post-shift pulmonary function between exposure groups and smoking categories.

3. Correlation Between Exposure Levels and Pulmonary Effects

Figures 2 through 7 display dose-response relations of respirable particulate collected on each individual worker and flow rates at low lung volumes. The only statistically significant relation is in the Control group for FEF_{50} and FEF_{75}. The significance of this relation is reduced by the limited range of exposure to respirable particulate. Twenty-six of the exposure levels are ≤ 0.4 mg/m^3, with the one remaining respirable particulate level at 0.6 mg/m^3 which is undoubtedly producing the negative slope. The range of exposure for SO_2 and tin is broader (0.02 - 1.7 and 0.04 - 1.2 respectively), but there are no significant dose-response relations in these groups. When all exposure groups are combined, there is no effect of particulate exposure on changes in pulmonary function (see Figures 6 and 7 for changes in FEF_{50} and FEF_{75}). Table 6 provides average values and the range of values of respirable particulate taken by personal samples in each exposure group.

The levels of particular chemical species to which workers were exposed were below detectable levels in many instances. These exposures were thought to be too low to be significant, and correlation with pulmonary effects was not feasible.

4. Significance of Medical Results in Terms of Chronic Exposure Effects

It was not possible to determine chronic effects of exposure to SO_2 and tin separately, since workers frequently move back and forth between the SO_2 and tin lines. An attempt was made to assess chronic effects of exposure by comparing the years spent in the Forming and Selecting Departments with expected pulmonary function from a non-smoking healthy population[8] with calculated expected pulmonary function adjusted for race.[9]

The association between pulmonary function and years of work in the Forming and Selecting Departments is presented in Table 10 and Figures 8 and 9. Mean percent predicted FEV_1 and FVC are in general greater than 90% of predicted values. Mean percent predicted FEV_1 is statistically less than 100 for smoking females, but the values are well above 80% of predicted, a commonly used cutoff of abnormality for individuals. For flow rates at low lung volumes mean predicted values are clearly reduced. The comparison population used for developing "practical values". was healthy and non-smoking and lived in an area relatively free from air pollution. No data from the same study are available for expected flow rates of smoking and non-smoking males and females, making interpretation of flow rates difficult. The predicted values are, therefore, artificially high, so the low mean values for percent predicted FEF_{50} and FEF_{75} can only be used for comparing smoking and exposure categories, and cannot be used for an evaluation of overall abnormality or disease. For females (and in particular non-smoking females), the reduction in expired flow rates are associated with years worked in forming and selecting (Table 10, Figures 8 and 9).

Any study of the effects of occupational exposure on the respiratory system must attempt to control for the potentially confounding effects of difference in age, height, sex, race and smoking. In this study age, sex, and race were partially controlled for in matching on these variable in the plant population selected for study. The three exposure groups are comparable for these variables, and also similar in height and smoking, although the tin group has a slightly higher proportion of non-smokers. Where appropriate and possible, all of the variables are also controlled for in the analysis. Social status has been shown in other studies to be associated with differences in pulmonary function and symptomatology. Educational status is used as an indicator of social status, but the small differences in educational status between exposure groups appears unlikely to result in any significant differences.

The effects of age and smoking on chronic respiratory symptoms is not inconsistent with findings in other studies. There is no marked difference between exposure groups in reported symptoms, although the control group tends to have a higher prevalence. It has been suggested that finding increased symptomatology in an unexposed group may be due to selection out of the exposed areas. The higher rate of dyspnea among ex-smokers when compared to smokers is suggestive that this symptom is affecting smoking habits. The proportion of ex-smokers is the same in the control and sulfur dioxide groups, and about twice that found in the tin group. The proportion of smokers is the same in all three groups. There is a higher proportion of blacks in the control group than in the tin and sulfur groups, which might account for the control group's higher prevalence of symptoms. The overall prevalence of cough, phlegm, and shortness of breath is in general slightly lower than male asbestos workers[10] and roughly comparable to synthetic textile workers[11], as measured in previous studies in these industries.

There is no apparent difference between the three exposure groups and between the various smoking groups in reporting of acute symptoms. In a study of male rubber workers where some of the same questions were asked, smokers had a higher prevalence of wheeze and cough.[12] A comparison of overall prevalence is presented in Table 11. Rubber workers report a higher prevalence of itch, cough, and dry sore throat, while the glass workers in this study report more rash, chest tightness, wheeze, burning eyes, running nose, hoarseness and burning sensation in the heart region. The interpretation of these findings is difficult because there is no good comparison group (these are the only two studies available which report acute symptoms), and because the chronic and acute symptoms do not correlate well with acute changes in pulmonary function. The prevalence of reported symptoms is quite high, although the lack of correlation with exposure at work suggests that not all of the symptoms are work-related.

All three exposure groups show a similar acute pulmonary function response, a response not related to respirable particulate levels. There is no evidence of large airways response nor change in lung volume over the work shift, i.e., FEV_1, FEF_{25}, FVC are not reduced over the shift. There is, however, a small, but significant, reduction in flow rate at low lung volumes. Although smokers have a greater reduction over the shift in FEF_{50} and FEF_{75} than do non-smokers, the differences generally are small.

Changes in pulmonary function over the shift were similar among the three exposure groups. Some comparisons with other industrial populations are noted in Table 12. A population exposed to no air contaminants will be expected, in general, to show a slight diurnal improvement in function during the day shift. The working populations exposed to air contaminants show a decrement in lung function. The percentage reduction (and increase) is greatest for flow rates at low lung volumes (FEF_{50}, and FEV_{75}). Percent changes in lung function over a shift are influenced by mean values; therefore, the lower mean values for flow at low lung values in part accounts for the greater percentage change. The average reductions in flows at 75% of exhaled FVC of the glass workers in this study are similar in magnitude to rubber workers and TDI workers, but less than coal miners and cotton textile workers. Flow reductions at 50% of exhaled FVC in these glass workers are similar to rubber workers and coal miners, but less than TDI and cotton textile workers. There is, however, a wide variation in individual response. Of the exposed worker populations, only the glass and rubber workers have a slight increase in mean FEV and FVC.

The significance of acute changes over a work shift are not clear, as only in TDI workers is there adequate data suggesting that those with acute reductions in FEV are more likely to experience cumulative changes in FEV.[13] The cumulative or chronic effects of work exposure to cotton dust, and coal mine dust are well documented.[14,15] The acute reduction in FEF_{50} is also similar in magnitude to smoking a single cigarette.[16] Although there is no proven connection between reversible acute effects on lung function and irreversible chronic effects, it is often assumed that those individuals with the greatest reduction over the shift are more susceptible to the long-term effects of toxic inhalants. This hypothesis is unproven; it assumes that acute changes in lung function indicate something of the hazard of the job and the prognosis for continued well-being, and it is biased in favor of protecting the worker's health. It is also known that when workers exposed to TDI, cotton dust, and coal dust are followed for longer periods of time, the annual decline in pulmonary function is excessive, regardless of acute response.

The reason for a small airways response (reduction in FEF_{50} and FEF_{75}) in the absence of large airways response (ΔFEV) is conjectural. It is known that if different individuals are exposed to the same pollutant (e.g. hemp dust), one individual may display a flow rate response (small airway constriction) or a conductance response (large airways constriction).[17] It seems unlikely, however, that there would be any selection for small airway reactors. There are irritant receptors located in the lower respiratory tract that stimulate bronchoconstriction. Irritants less than 5μ in size (e.g., cigarette smoke or other airborne particulates) are preferentially deposited in small airways and theoretically could produce bronchoconstriction, and may thereby explain a differential airways response. It is possible that there were additional air contaminants present at this plant which were not detected and measured.

F. Conclusions

1. There were no observed differences between the tin, SO_2 and control groups in acute or chronic symptoms.

2. There were similar reductions in flow rates over the shift at low lung volumes (FEF_{50} and FEF_{75}) in the SO_2, tin and control groups. In the total study population, reductions in small airways function are statistically significant and comparable to other dust-exposed industrial populations. Unlike most other industrial populations, there was essentially no change in FEV and FVC over the shift. There was no apparent association of respirable particulate with acute changes in pulmonary function. The detected levels of other air contaminants (e.g., SO_2, $SnCl_4$) are thought too low to be significant.

3. There were no x-ray abnormalities associated with occupational exposure. Baseline pulmonary function as measured by FEV and FVC are in the normal range and are not associated with exposure. Reduced flow rates at low lung volumes (FEF_{50}, FEF_{75}) were associated with years worked on the sulfur and tin lines.

4. Occupational exposures to airborne contaminants such as sulfur dioxide, sulfates, tin compounds, chlorides, and respirable particulates (non-specific) were within recommended exposure limits and were not thought to be of a magnitude which could cause adverse health effects.

G. Recommendations

1. During the six site visits to this plant by NIOSH during the course of this hazard evaluation, the NIOSH industrial hygienists observed several deficiencies in the ventilation system used for local exhaust of sulfur dioxide and stannic chloride from the application stations in the Forming Department. Although employees were not directly exposed to high concentrations during the NIOSH surveys, high concentrations of sulfur dioxide were measured on catwalks above the forming machines and, at times, near the point of SO_2 injection into the bottles. Sometimes visible emissions could be observed from the stannic chloride hoods. This was evidence that some

sulfur dioxide and stannic chloride were escaping into the room and that the collection systems were not working as well as they perhaps ought. The NIOSH industrial hygienists felt that the company could do a better job of maintenance of these systems by implementing the following recommendations:

a. Ventilation ducts which are not being used should be closed off and capped so that the efficiency of the hoods in use will be improved.

b. A pressure gauge should be installed at each hood outlet and checked daily to insure that the airflow through each exhaust system is kept up to par.

c. Sections of horizontal duct work should be inspected periodically and accumulations of dust removed so that air flow through the duct will not be restricted.

2. Because large quantities of sulfur dioxide are stored in large cylinders between the Forming and Selecting Departments, and because cylinders of stannic chloride are also present and exposed to high temperatures, emergency procedures should be developed in case of massive accidental release of the gases into the workroom. Copies of the emergency procedures should be posted in prominent areas in the departments, and employees should be trained in these procedures. An evacuation plan should be established, and appropriate respirators should be available for wear during such emergencies.

3. The NIOSH criteria document for sulfur dioxide should be used as a guideline for establishing medical surveillance, exposure monitoring, and proper work practices regarding occupational exposure to sulfur dioxide.[4,18]

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TABLE

RESULTS OF AREA SAMPLING

AIRBORNE SULFUR CONTAMINANTS

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

MARCH 14-18, 1977

Sample #	Date Sample Collected	Sampling Location	Sample Volume (Liters)	Sampling Period	SO_2 Concentration (PPM)	Total Particulate Sulfate Concentration mg/m³
1	3-14-77	Selecting B-4	289	9:06 a.m.-1:47 p.m.	1.6	ND
2	3-14-77	Selecting B-3	280	9:08 a.m.-1:45 p.m.	.62	ND
4	3-14-77	Forming B-4	173	9:32 a.m.-12:23 p.m.	lost	ND
5	3-14-77	Shipping	222	10:07 a.m.-1:47 p.m.	ND	ND
13	3-15-77	Forming B-3	294	3:17 p.m.-8:14 p.m.	2.0	ND
14	3-15-77	Forming B-4	297	3:20 p.m.-8:14 p.m.	1.5	ND
15	3-15-77	Catwalk B-3 - B-4	286	3:24 p.m.-8:16 p.m.	17	ND
16	3-15-77	Selecting B-3	289	3:12 p.m.-8:04 p.m.	.56	ND
17	3-15-77	Decorating	285	3:08 p.m.-7:59 p.m.	ND	not analyzed
18	3-15-77	Selecting B-4	289	3:14 p.m.-8:06 p.m.	.68	ND
31	3-16-77	Selecting B-3	323	10:48 p.m.-4:08 a.m.	.40	ND
32	3-16-77	Selecting B-4	316	10:54 p.m.-4:10 a.m.	.54	ND
34	3-16-77	Catwalk B-3 - B-4	312	11:17 p.m.-4:20 a.m.	11	.14
35	3-16-77	Forming B-3	307	11:14 p.m.-4:18 a.m.	.44	ND
36	3-16-77	Forming B-4	304	11:11 p.m.-4:18 a.m.	1.1	ND
37	3-18-77	Catwalk B-3 - B-4	231	7:12 a.m.-11:08 p.m.	14	.20

TABLE 1
(Continued)

Sample #	Date Sample Collected	Sampling Location	Sample Volume (Liters)	Sampling Period	SO_2 Concentration (PPM)	Total Particulate Sulfate Concentration mg/m^3
38	3-18-77	Forming B-3	237	7:10 a.m.-11:05 p.m.	1.1	ND
39	3-18-77	Forming B-4	234	7:08 a.m.-11:04 p.m.	1.9	ND
41	3-18-77	Selecting B-3	339	6:51 a.m.-12:20 p.m.	.45	ND
42	3-18-77	Selecting B-4	312	6:53 a.m.-12:21 p.m.	.55	ND
40	3-18-77	Corrugating	324	7:00 a.m.-12:24 p.m.	not analyzed	ND

ND - None Detected

TABLE 2

RESULTS OF AREA SAMPL...G

AIRBORNE TIN AND CHLORIDE CONTAMINANTS

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

MARCH 14-18, 1977

Sample #	Date Sample Collected	Sampling Location	Sample Volume (Liters)	Sampling Period	Filterable Tin mg/m^3	Non-Filterable Tin mg/m^3	Total Chloride Ion mg/m^3
7	3-14-77	Shipping	213	10:12 AM-1:47 PM	ND	ND	ND
9	3-14-77	Selecting A-1	200	10:56 AM-2:10 PM	ND	.20	ND
10	3-14-77	Selecting D-2	194	10:52 AM-2:10 PM	ND	ND	5.2
12	3-14-77	Forming A-1	191	10:34 AM-1:55 PM	.15	ND	4.6
19	3-15-77	Selecting B-1	264	3:41 PM-8:02 PM	ND	ND	ND
20	3-15-77	Decorating	291	3:08 PM-7:59 PM	ND	ND	ND
21	3-15-77	Selecting D-2	281	3:34 PM-8:07 PM	ND	ND	11
22	3-15-77	Forming D-2	246	3:30 PM-8:09 PM	.049	ND	2.7
23	3-15-77	Forming B-1	270	3:40 PM-8:17 PM	.13	ND	ND
24	3-15-77	Catwalk D-2	280	3:31 PM-8:11 PM	.13	ND	ND
25	3-16-77	Selecting E-1	311	11:01 PM-4:12 PM	ND	ND	2.6
26	3-16-77	Selecting E-2	306	11:00 PM-4:13 PM	ND	ND	ND
28	3-16-77	Catwalk E-1 - E-2	306	11:06 PM-4:15 PM	.078	ND	ND
29	3-16-77	Forming E-2	303	11:05 PM-4:14 PM	.14	ND	ND
30	3-16-77	Forming E-1	319	11:04 PM-4:14 PM	ND	ND	ND

TABLE 2
(Continued)

Sample #	Date Sample Collected	Sampling Location	Sample Volume (Liters)	Sampling Period	Filterable Tin mg/m3	Non-Filterable Tin mg/m3	Total Chloride Ion mg/m3
43	3-18-77	Catwalk A-2	313	7:17 AM-12:33 PM	.077	ND	ND
44	3-18-77	Forming A-2	316	7:16 AM-12:32 PM	ND	ND	ND
45	3-18-77	Forming D-1	316	7:06 AM-12:28 PM	.95	ND	ND
46	3-18-77	Selecting D-1	326	7:04 AM-12:27 PM	.058	ND	ND
47	3-18-77	Corrogating	323	6:58 AM-12:24 PM	ND	Lost	Lost
48	3-18-77	Selecting A-2	343	6:45 AM-12:18 PM	ND	ND	2.8

ND - None Detected

TABLE 3

SO_2 PERSONAL SAMPLING DATA

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

MARCH 14-18, 1977

Dept.	Line #	Start Time	End Time	Conc. PPM
March 14				
Forming	B-furnice	8:06 a.m.	12:07 p.m.	1.6
Forming	B-4	8:21 a.m.	12:05 p.m.	ND
Cavity Checker	B-3,B-4	8:23 a.m.	12:25 p.m.	ND
Selector	B-4	8:33 a.m.	12:11 p.m.	ND
Forming Operator	B-3	8:50 a.m.	12:05 p.m.	ND
March 15				
Decorating		3:44 p.m.	7:05 p.m.	ND
Selecting	B-4	4:02 p.m.	7:40 p.m.	ND
Selecting	B-2,3	4:53 p.m.	8:34 p.m.	.40
Selecting	B-4	4:59 p.m.	8:36 p.m.	ND
Forming	B-3,4,5	6:30 p.m.	9:13 p.m.	.50
March 16				
Forming	B-tank	11:43 p.m.	3:23 a.m.	ND
Selecting	B-3	11:56 p.m.	3:28 a.m.	.28
Selecting	B-4	12:59 a.m.	4:54 a.m.	ND
Selecting	B-4	1:05 a.m.	4:52 a.m.	ND
Cavity Checker	G-4	1:52 a.m.	4:57 a.m.	ND
Forming	B-tank	1:55 a.m.	4:48 a.m.	ND
March 18				
Selecting	B-2,3	7:51 a.m.	11:38 a.m.	.29
Selecting	B-4	7:59 a.m.	11:50 a.m.	.52
Forming	B-4,5	8:08 a.m.	11:40 a.m.	ND
Selecting	B-4	8:52 a.m.	11:43 a.m.	ND

TABLE 4

AGE, SEX, AND SMOKING DISTRIBUTION
OF STUDY POPULATION

OWENS-ILLINOIS GLASS PLANT
HAPEVILLE, GEORGIA

MARCH 14-18, 1977

		AGE ≤ 29 n (%)	30 - 39 n (%)	40 - 49 n (%)	50 - 59 n (%)	≥ 60 n (%)	TOTAL
MALE	Nonsmoker	2 (50)	2 (17)	- (--)	- (--)	- (--)	4 (14)
	Exsmoker	1 (25)	1 (8)	4 (40)	1 (33)	- (--)	7 (24)
	Smoker	1 (25)	9 (75)	6 (60)	2 (67)	- (--)	18 (62)
	N	4 (14)	12 (41)	10 (34)	3 (10)	- (--)	29 (26)
FEMALE	Nonsmoker	4 (33)	9 (38)	13 (43)	6 (40)	- (--)	32 (39)
	Exsmoker	- (--)	2 (8)	2 (7)	2 (13)	- (--)	6 (7)
	Smoker	8 (67)	13 (54)	15 (50)	7 (47)	1 (100)	44 (54)
	N	12 (15)	24 (29)	30 (37)	15 (18)	1 (1)	82 (74)
TOTAL	Nonsmoker	6 (38)	11 (31)	13 (33)	6 (33)	- (--)	36 (32)
	Exsmoker	1 (6)	3 (8)	6 (15)	3 (17)	- (--)	13 (12)
	Smoker	9 (56)	22 (61)	21 (53)	9 (50)	1 (100)	62 (56)
	ALL	16 (14)	36 (32)	40 (36)	17 (16)	1 (1)	111

PERCENTAGES IN EACH CELL ARE COLUMN PERCENTAGES.
PERCENTAGES IN MARGINALS ARE PERCENT OF THE TOTAL.

TABLE 5

RACE, SEX, AND SMOKING DISTRIBUTION OF STUDY POPULATION

OWENS-ILLINOIS GLASS PLANT HAPEVILLE, GEORGIA

MARCH 14-18, 1977

		SMOKING STATUS			
RACE	SEX	n (%) NONSMOKERS	n (%) EXSMOKERS	n (%) SMOKERS	TOTAL
	Male	1 (7)	- (--)	- (--)	1 (1)
BLACK	Female	14 (93)	1 (100)	20 (100)	35 (32)
	All	15 (42)	1 (3)	20 (56)	36 (32)
	Male	3 (14)	7 (58)	18 (43)	28 (25)
'TE	Female	18 (86)	5 (42)	24 (57)	47 (42)
	All	21 (28)	12 (16)	42 (56)	75 (68)
	TOTAL	36 (32)	13 (12)	62 (56)	111

PERCENTAGES IN THE CELLS ARE COLUMN PERCENTAGES. PERCENTAGES FOR ALL ARE ROW PERCENTAGES. PERCENTAGES FOR MARGINALS (TOTAL) ARE PERCENTAGES OF THE TOTAL.

TABLE 6

CHARACTERISTICS OF THE EXPOSURE GROUPS

OWENS-ILLINOIS GLASS PLANT
HAPEVILLE, GEORGIA

MARCH 14-18, 1977

		CONTROLS n (%)	SO_2 n (%)	TIN n (%)	ALL n (%)
	MALE	10 (32)	9 (31)	10 (20)	29 (26)
SEX	FEMALE	21 (68)	20 (69)	41 (80)	82 (74)
	BLACK	6 (19)	11 (38)	19 (37)	36 (32)
RACE	WHITE	25 (81)	17 (62)	32 (63)	75 (68)
	0-8	1 (3)	2 (7)	3 (6)	5 (5)
EDUCATION	9-11	16 (52)	9 (31)	17 (33)	42 (38)
(grades)	12	13 (42)	16 (55)	28 (55)	57 (51)
	≥13	1 (3)	2 (7)	3 (6)	6 (5)
NON-SMOKERS		9 (29)	8 (28)	19 (37)	36 (32)
EX-SMOKERS		5 (16)	4 (14)	4 (8)	13 (12)
	SMOKERS	17 (55)	17 (59)	27 (56)	61 (55)
≤ 15 CIGARETTES/DAY		4 (13)	8 (28)	15 (29)	27 (24)
16-24 CIGARETTES/DAY		8 (26)	7 (24)	9 (18)	24 (22)
≥ 25 CIGARETTES/DAY		5 (16)	2 (7)	3 (6)	10 (9)

PERCENTAGES IN CELLS ARE COLUMN PERCENTAGES. PERCENTAGES IN MARGINALS ARE PERCENT OF TOTAL.

	CONTROLS	SO_2	TIN	ALL
AGE (yrs, S.E.)	37.7 (1.6)	41.4 (1.8)	41.7 (1.3)	40.5 (1.9)
HEIGHT (cm., S.E.)	170.0 (1.4)	169.1 (1.3)	166.8 (1.0)	168.3 (0.7)
WEIGHT (kg., S.E.)	74.5 (2.2)	71.6 (3.5)	67.9 (1.8)	70.7 (1.4)
MEAN YRS FORMING DPT	0.06 (.06)	3.6 (1.2)	2.4 (.80)	2.1 (.50)
MEAN YRS SELECTING	4.5 (1.0)	8.2 (1.3)	8.3 (.96)	7.2 (.64)
RESP. PARTICULATE mg/m^3				
MEAN (S.E.)	0.15 (.02)	0.35 (.07)	0.29 (.04)	0.27 (.03)
RANGE	.04 - 0.63	.02 - 1.7	.04 -1.21	.02 - 1.7

STANDARD ERROR OF THE MEAN IS IN PARENTHESIS.

TABLE 7

PREVALENCE OF CHRONIC SYMPTOMS
BY AGE, SMOKING HABITS, AND EXPOSURE GROUP

PERCENTAGE OF TESTED WORKERS
EXHIBITING THE SYMPTOM

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

MARCH 14-18, 1977

AGE	N	COUGH (%)	PHLEGM (%)	DYSPNEA GR 1 (%)	DYSPNEA GR 2&3 (%)	WHEEZING GR 1&2 (%)	NASAL DRAINAGE GR 1 (%)	NASAL DRAINAGE GR 2 (%)
≤ 29	16	6	19	38	6	13	31	25
30-39	36	22	19	33	14	22	22	25
40-49	40	20	13	28	23	33	20	40
≥ 50	19	32	21	42	11	32	11	28
ALL	111	21	17	33	15	26	26	25
SMOKING STATUS								
NONSMOKER	36	8	6	31	14	8	22	19
EXSMOKER	13	15	15	8	31	8	8	31
SMOKER	62	29	24	40	13	40	23	27
EXPOSURE GROUP								
CONTROLS	31	29	32	36	23	32	23	29
SO_2	29	17	10	38	7	21	17	17
TIN	51	18	12	29	16	26	22	28

TABLE 7A

RELATIONSHIP BETWEEN OCCURRENCE OF SYMPTOMS AND YEARS OF EXPOSURE

MEAN YEARS OF EXPOSURE OF ALL WORKERS EXHIBITING THE SYMPTOM

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

MARCH 14-18, 1977

	SYMPTOMS						
MEAN YEARS EXPOSED	COUGH	PHLEGM	DYSPNEA GR 1	DYSPNEA GR 2 & 3	WHEEZING GR 1 & 2	NASAL DRAINAGE GR 1	NASAL DRAINAGE GR 2
IN FORMING DEPT.							
with symptom	8.2	4.1	8.2	7.8	7.2	6.2	7.5
without symptom	6.9	7.8	6.4	6.4	7.2	7.5	7.5
IN SELECTING DEPT.							
with symptom	1.7	3.2	2.3	1.2	7.4	1.4	1.9
without symptom	2.2	1.8	2.2	2.2	2.0	2.4	2.4

TABLE 8

PREVALENCE OF ACUTE SYMPTOMS

PERCENTAGE OF TESTED WORKERS EXPERIENCING
THE SYMPTOM DURING THE PAST FEW WEEKS
BEFORE THE MARCH 1977 NIOSH SURVEY

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

SYMPTOM	FREQUENCY (PERCENT) RARELY OR SOMETIMES	FAIRLY OFTEN VERY OFTEN
DRY NOSE OR THROAT	9	--
COUGH	4	1
NOSEBLEED	51	17
NOSE TICKLED OR IRRITATED	50	14
SNEEZE	11	4
MUCUS DISCHARGE OR DRIPPING FROM NOSE	34	14
EYES ITCH, BURN, OR WATER	50	15
HEADACHES	25	11
DIFFICULT OR LABORED BREATHING	36	21
TIGHT OR CONSTRICTED FEELING IN CHEST	45	20
FEELING AS IF GOING TO SUFFOCATE	25	5
SPIT UP BLOOD	23	7
TINGLING OR NUMBNESS IN LEGS	17	2
DIZZINESS	2	--
NAUSEA	26	6
RED INFLAMED SKIN	24	4
DRY SCALING SKIN	19	4
ITCHING SKIN	12	1
RASH	24	16
PAIN IN HEART OR CHEST REGION	28	11
STUFFED UP NOSE	17	3
WHEEZE	27	5
HEART RACE LIKE MAD	33	19
HOARSENESS	19	5

TABLE

ACUTE CHANGES IN PULMONARY FUNCTION
BY EXPOSURE GROUP AND SMOKING STATUS

MEAN PERCENTAGE CHANGES IN PULMONARY FUNCTION

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

Note: Percent change in pulmonary function (Δ PF%) is calculated as post-shift PF minus pre-shift PF divided by the mean of pre and post-shift PF x 100

CONTROLS	N	Δ FVC (%)	Δ FEV (%)	Δ FEF_{25} (%)	Δ FEF_{50} (%)	Δ FEF_{75} (%)
COMBINED NONSMOKERS	14	2.0 (1.6)	0.5 (1.6)	1.6 (1.7)	-0.3 (2.6)	- 6.8 (7.3)
SMOKERS	17	2.0 (1.4)	0.8 (1.2)	1.7 (3.6)	-2.8 (4.6)	-15.6 (8.6)
ALL	31	2.0 (1.0)	0.67 (.96)	1.7 (2.1)	-1.2 (2.8)	-11.6 (5.7)
SO_2						
COMBINED NONSMOKERS	12	3.0 (1.7)	2.6 (1.7)	14.1 (7.6)	0.2 (5.2)	-13.8 (8.6)
SMOKERS	17	0.18 (1.4)	-0.19 (1.4)	2.2 (3.0)	-3.7 (3.9)	- 7.7 (6.6)
ALL	29	1.3 (1.1)	1.0 (1.1)	7.1 (3.7)	-2.1 (3.1)	-10.2 (5.2)
TIN						
COMBINED NONSMOKERS	23	0.35 (1.0)	0.26 (.74)	-0.14 (2.7)	-4.4 (2.9)	- 3.6 (5.2)
SMOKERS	28	0.28 (1.6)	-0.24 (1.2)	3.6 (2.1)	-5.3 (3.4)	-12.5 (7.4)
ALL	51	0.31 (1.0)	-0.02 (.75)	1.9 (1.7)	-4.9 (2.3)*	- 8.5 (4.7)
TOTAL	111	1.1 (0.6)	0.4 (.52)	3.2 (1.4)**	-3.1 (1.5)*	- 9.8 (3.0)***

S.E. IN PARENTHESES. THE STATISTICAL TEST OF SIGNIFICANCE IS THE ONE-SIDED TEST WITH THE HYPOTHESIS THAT THERE WAS NO SIGNIFICANT CHANGE IN PULMONARY FUNCTION. (H: Δ PF = 0).

* $p < 0.05$
** $p < 0.025$
*** $p < 0.005$

TABLE 10

MEAN VALUES OF PERCENT OF PREDICTED PULMONARY FUNCTION AND MEAN % CHANGE PER YEAR OF WORK IN FORMING AND SELECTING

(CLASSIFIED BY SEX AND SMOKING STATUS)

OWENS-ILLINOIS GLASS COMPANY HAPEVILLE, GEORGIA

Notes: Mean % predicted pulmonary function = $\frac{\text{observed PF}}{\text{predicted PF}} \times 100$

Percent change in predicted PF per year of work is calculated from a linear regression analysis of % predicted PF vs. years of work.

A. BY SMOKING

	NONSMOKER		EXSMOKER		SMOKER	
N	36		13		62	
Mean % predicted FEV	95.5	(2.8)	96.9	(3.9)	89.1	(2.2)***
% change/years worked	- 0.33	(.5)	- 0.64	(0.5)	- 0.03	(.3)
Mean % predicted FVC	104.8	(2.9)	108.1	(2.4)*	100.8	(2.1)
% change/years worked	- 0.06	(.5)	- 0.47	(.3)	+ 0.38	(.3)
Mean % predicted FEF_{50}	75.0	(3.7)***	74.0	(7.5)*	67.4	(3.1)***
% change/years worked	- 1.1	(.6)	- 0.19	(1.0)	- 0.9	(.5)
Mean % predicted FEF_{75}	48.5	(3.0)***	43.3	(5.8)***	42.5	(3.2)***
% change/years worked	- 1.2	(.5)*	- 1.5	(0.8)	- 0.6	(.5)

B. BY SEX

	FEMALE		MALE		TOTAL	
N	82		29		111	
Mean % predicted FEV	91.6	(1.9)***	93.3	(3.2)	92.1	(1.6)***
% change/years worked	- 0.5	(.3)	+ 0.3	(.4)	- 0.2	(.2)
Mean % predicted FVC	102.5	(1.8)	104.2	(2.9)	103.0	(1.5)
% change/years worked	- 0.2	(.3)	+ 0.7	(.4)	+ 0.1	(.2)
Mean % predicted FEF_{50}	71.7	(2.6)***	66.6	(4.8)***	70.4	(2.3)***
% change/years worked	- 1.1	(.4)**	- 0.3	(.7)	- 0.9	(.3)*
Mean % predicted FEF_{75}	45.8	(2.6)***	41.9	(3.7)***	44.6	(2.1)***
% change/years worked	- 1.2	(.4)**	- 0.5	(.5)	- 1.0	(.3)**

C. BY SEX AND SMOKING

	FEMALE				MALE			
	NONSMOKER		SMOKER		NONSMOKER		SMOKER	
N	32		44		4		18	
Mean % predicted FEV	95.5	(3.0)	87.5	(2.5)***	95.1		92.9	(4.6)
% change/years worked	-0.45	(.5)	-0.38	(.4)	+1.4	(1.4)	+0.51	(.6)
Mean % predicted FVC	105.0	(3.2)	99.6	(2.4)	102.8	(7.8)	103.7	(4.0)
% change/years worked	-0.23	(.5)	-0.07	(.4)	+2.3	(1.7)	+1.08	(.5)
Mean % predicted FEF_{50}	76.2	(4.0)	67.2	(3.6)***	64.8	(3.5)*	67.9	(6.4)***
% change/years worked	-1.3	(.6)*	-0.94	(.6)	-0.25	(.8)	-0.78	(.8)
Mean % predicted FEF_{75}	48.7	(3.3)***	42.9	(4.0)***	47.5	(4.2)*	41.8	(5.4)***
% change/years worked	-1.3	(.5)*	-0.8	(.6)	-0.58	(.9)	-0.36	(.7)

S.E. IS IN PARENTHESES

* $p \leq 0.05$

** $p \leq 0.005$

*** $p \leq 0.0005$

TABLE 11

COMPARISON OF PREVALENCE OF ACUTE SYMPTOMS
IN GLASS WORKERS AND RUBBER WORKERS (from ref. 10)

GLASS WORKERS OF OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

MARCH 1977

	PREVALENCE (%)	
SYMPTOM	GLASS	RUBBER
N (Number of workers studied)	111	152
ITCH	13	26
RASH	40	16
COUGH	5	20
CHEST TIGHTNESS	65	19
WHEEZE	32	12
BURNING EYES	65	33
RUNNING NOSE	48	20
DRY, SORE THROAT	9	18
HOARSENESS	24	9
BURNING SENSATION IN HEART REGION	39	10

TABLE 12

COMPARISON OF ACUTE PULMONARY EFFECTS
IN SEVERAL INDUSTRIES

WORKER POPULATION	N	ΔFEV%	ΔFVC%	$\Delta FEF_{50}\%$	$\Delta FEF_{75}\%$
THIS STUDY	111	+0.4	+1.1	-3.1	-9.8
RUBBER WORKERS[12]	54	+0.2	+0.9	-3.4	-8.4
COAL MINERS[19]	93	-2.9	-2.5	-4.8	-16.7
NONCOAL MINER CONTROLS[19]	42	+3.8	+1.5	+6.6	+4.2
TDI WORKERS[13]	38	-4*	-4	-10.1	-8.1
COTTON TEXTILE WORKERS[20]	12	-6	-3	-18	-20
COTTON TEXTILE WORKERS-UNEXPOSED[20]	12	+0.02	0	-0.002	-0.03
THIS STUDY - NONSMOKERS	49	+0.9	+1.5	-2.1	-7.0
THIS STUDY - SMOKERS	62	+.06	+.72	-4.2	-12.0

*n - 34

FIGURE 1

SCHEMATIC DIAGRAM OF GLASS
BOTTLE PRODUCTION PROGRESS

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

MARCH 14-18, 1977

FIGURE 1

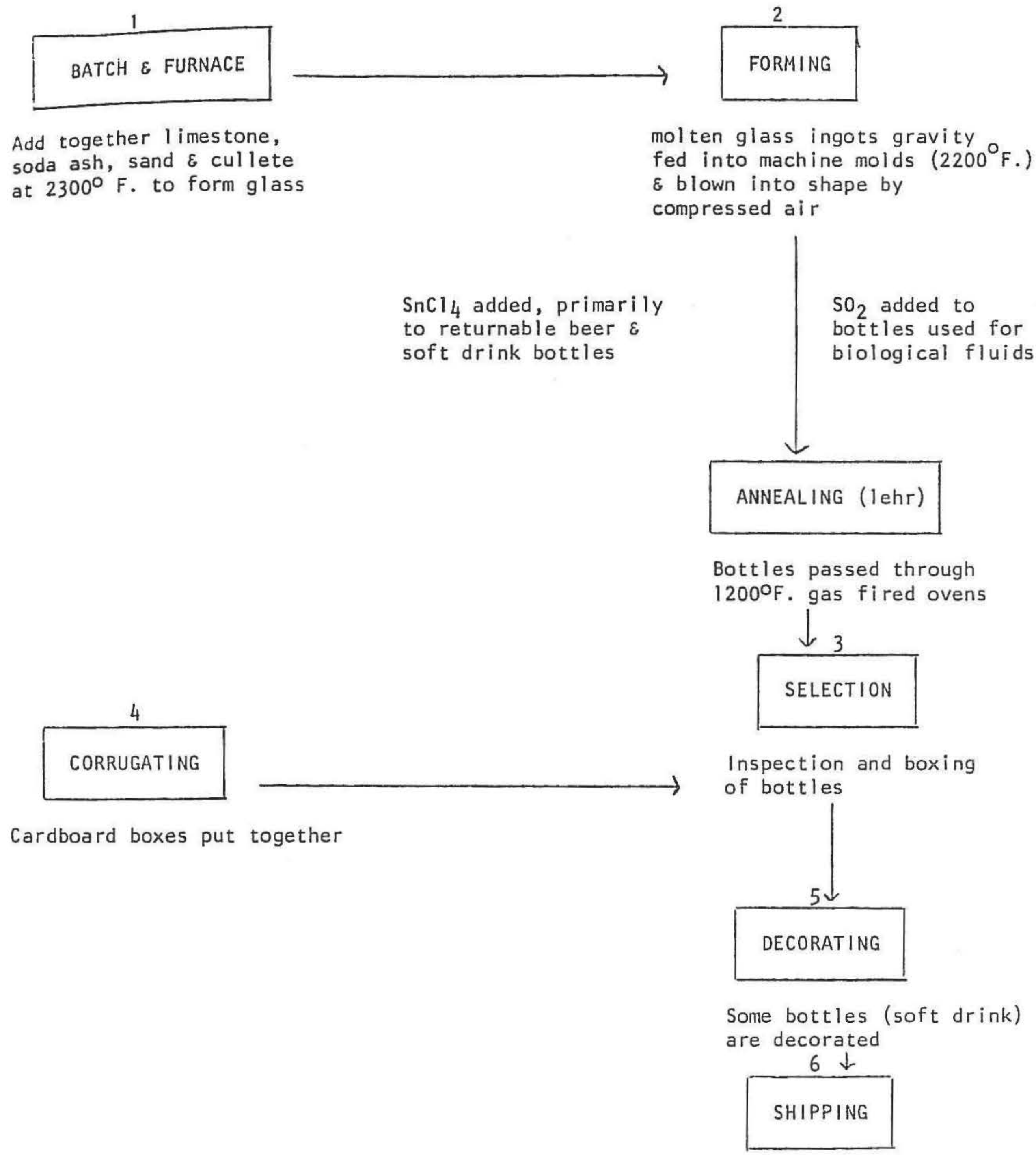

FIGURE 2: DOSE-RESF RELATIONSHIP
BETWEEN ∆ F_{50}% AND RESPIRABLE
PARTICULATE IN CONTROLS

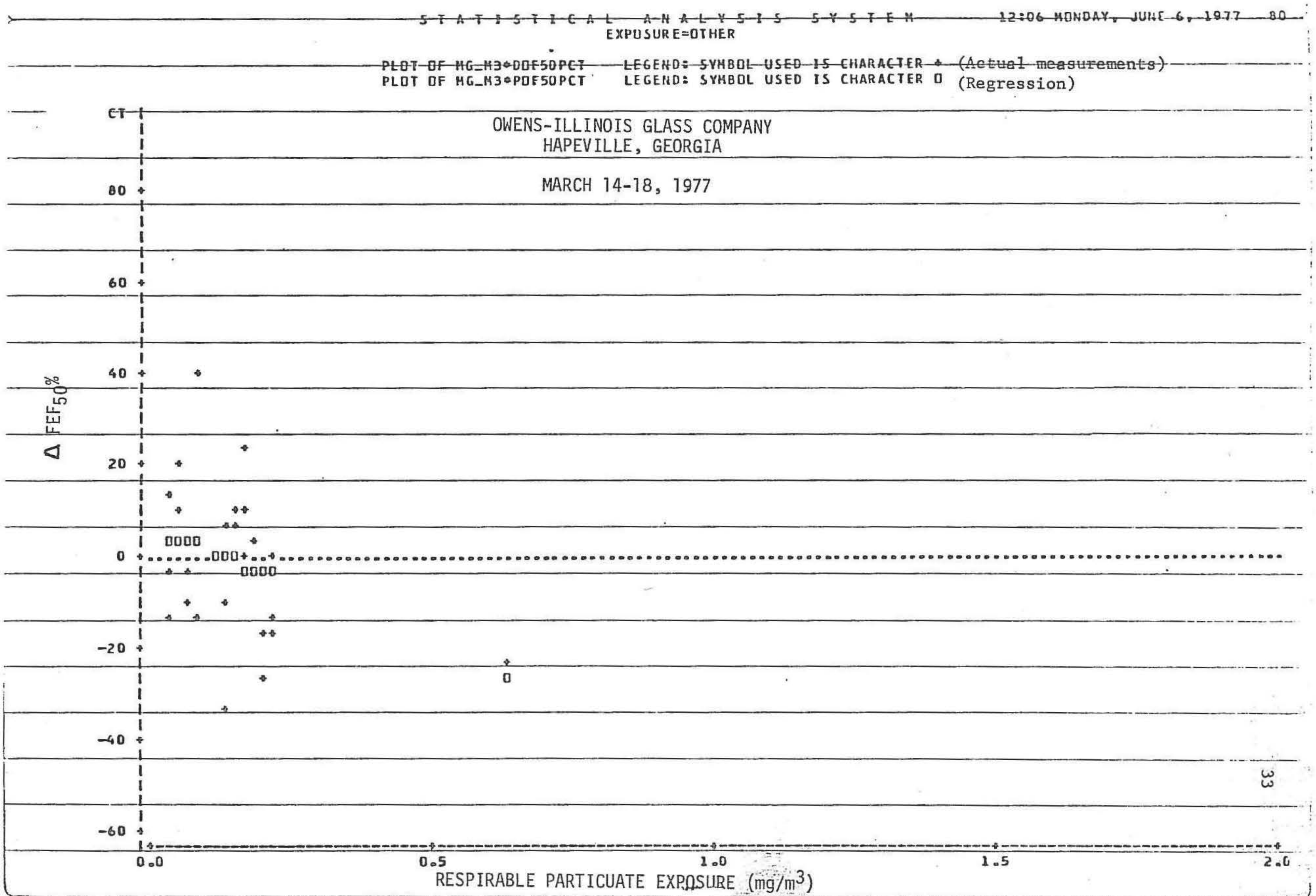

FIGURE 3: DOSE-RESPON LATIONSHIP BETWEEN Δ FE ,5% RESPIRABLE PARTICULATE IN CONTROLS

EXPOSURE=OTHER

PLOT OF MG_M3*DOF75PCT   LEGEND: SYMBOL USED IS CHARACTER * (Actual measurements)
PLOT OF MG_M3*POF75PCT   LEGEND: SYMBOL USED IS CHARACTER O (Predicted by regression)

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

MARCH 14-18, 1977

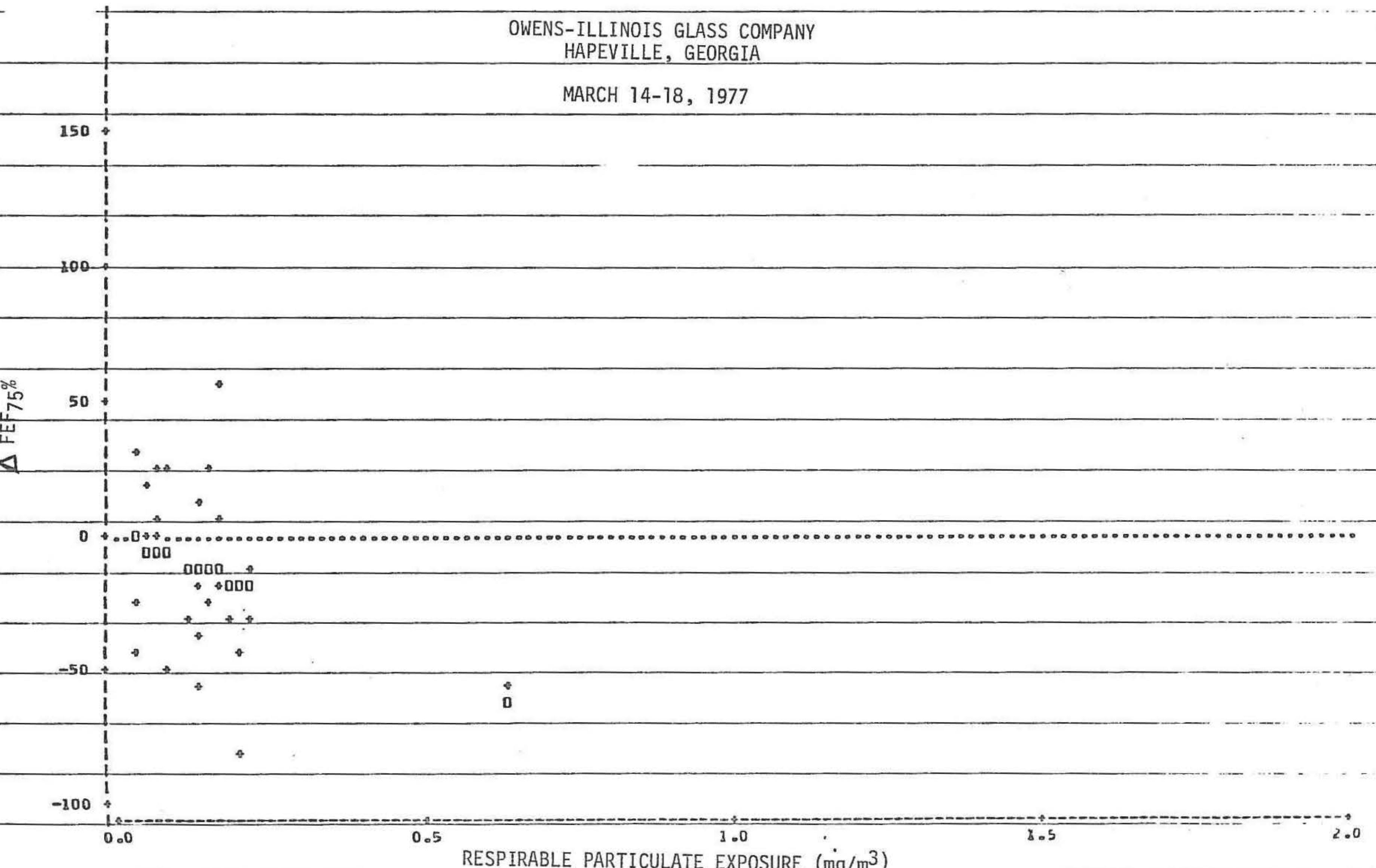

FIGURE 4: DOSE-RESPC ELATIONSHIP
BETWEEN Δ 75% AND RESPIRABLE
PARTICULATE IN SO_2 GROUP

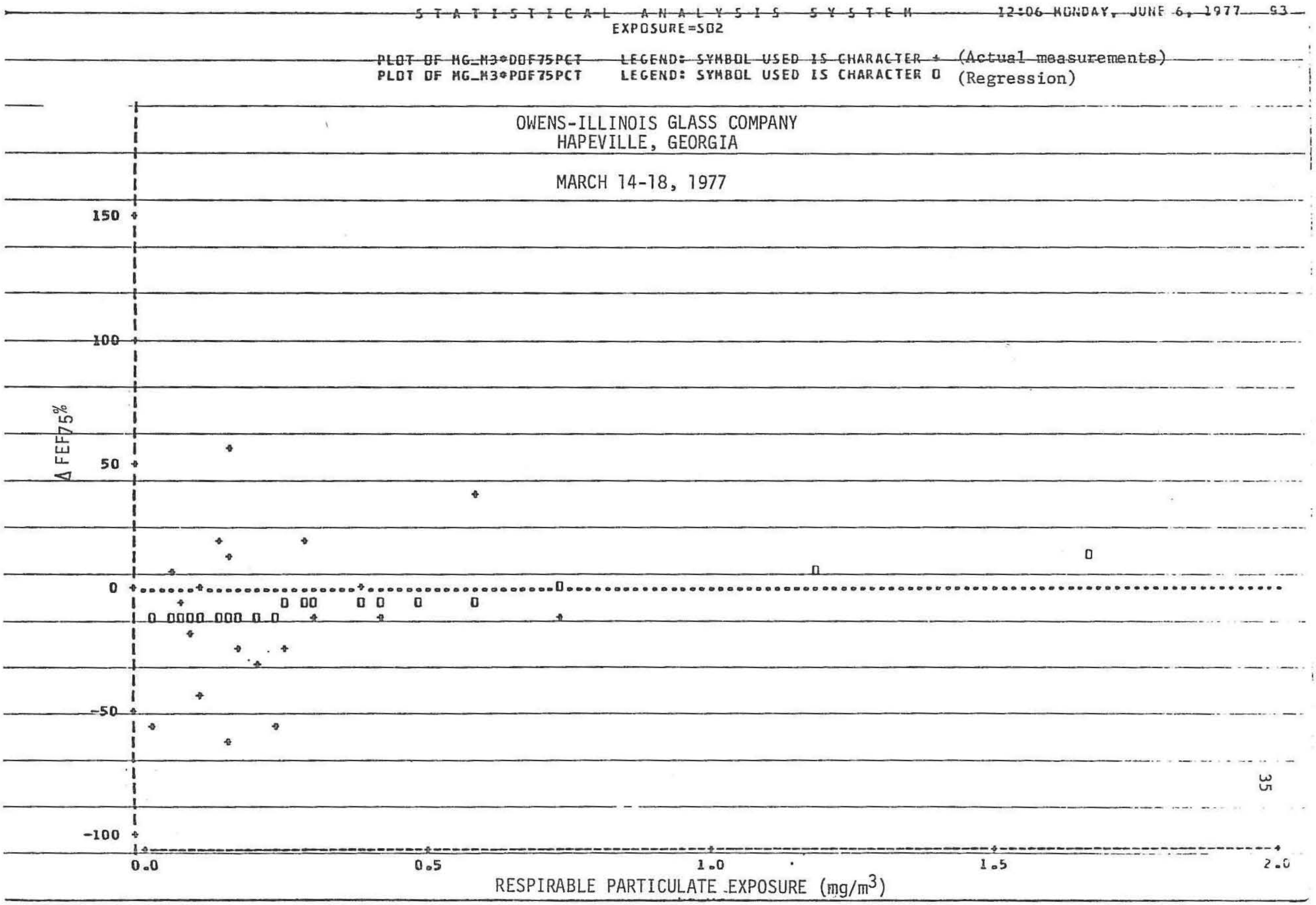

FIGURE 5: DOSE-RESPO .ELATIONSHIP BETWEEN Δ FEF75% AND RESPIRABLE PARTICULATE IN THE TIN GROUP

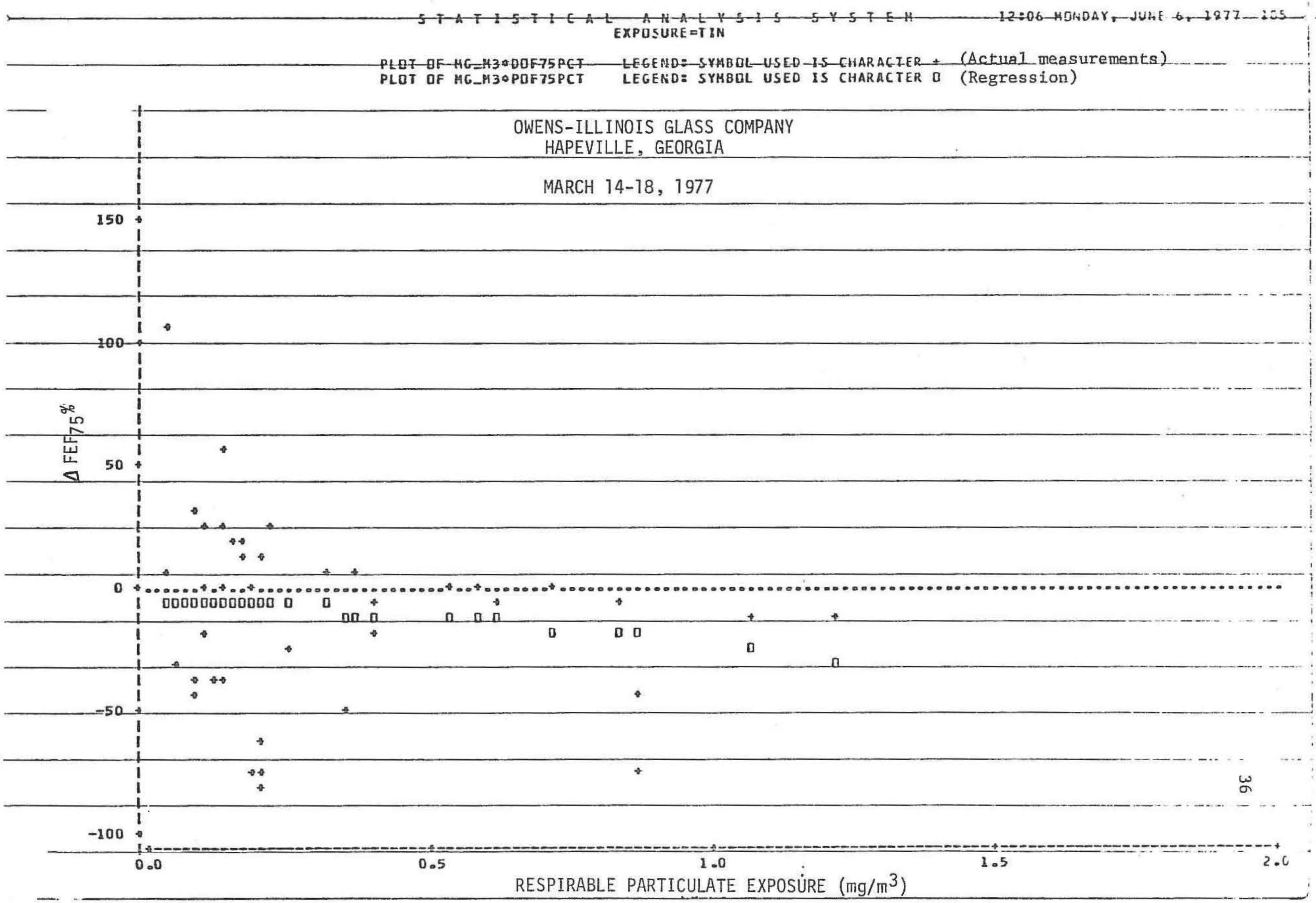

FIGURE 6: DOSE-RESPC :ELATIONSHIP
BETWEEN Δ FE,$_{50}$% AND RESPIRABLE
PARTICULATE IN THE TOTAL TEST POPULATION

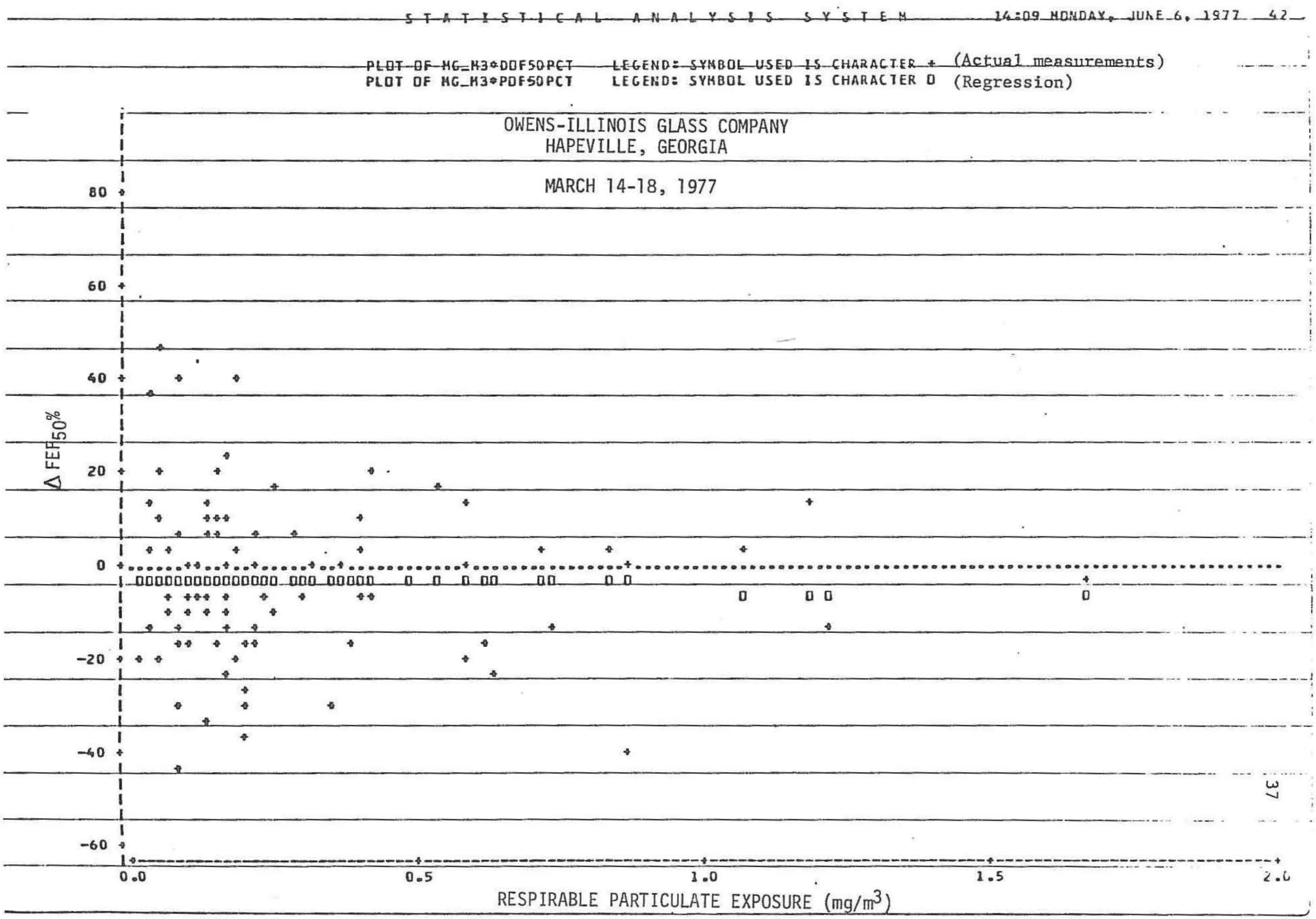

FIGURE 7: DOSE-RESPON LATIONSHIP BETWEEN
Δ FEF$_{75\%}$ A ESPIRABLE PARTICULATE
IN THE TOTAL TEST POPULATION

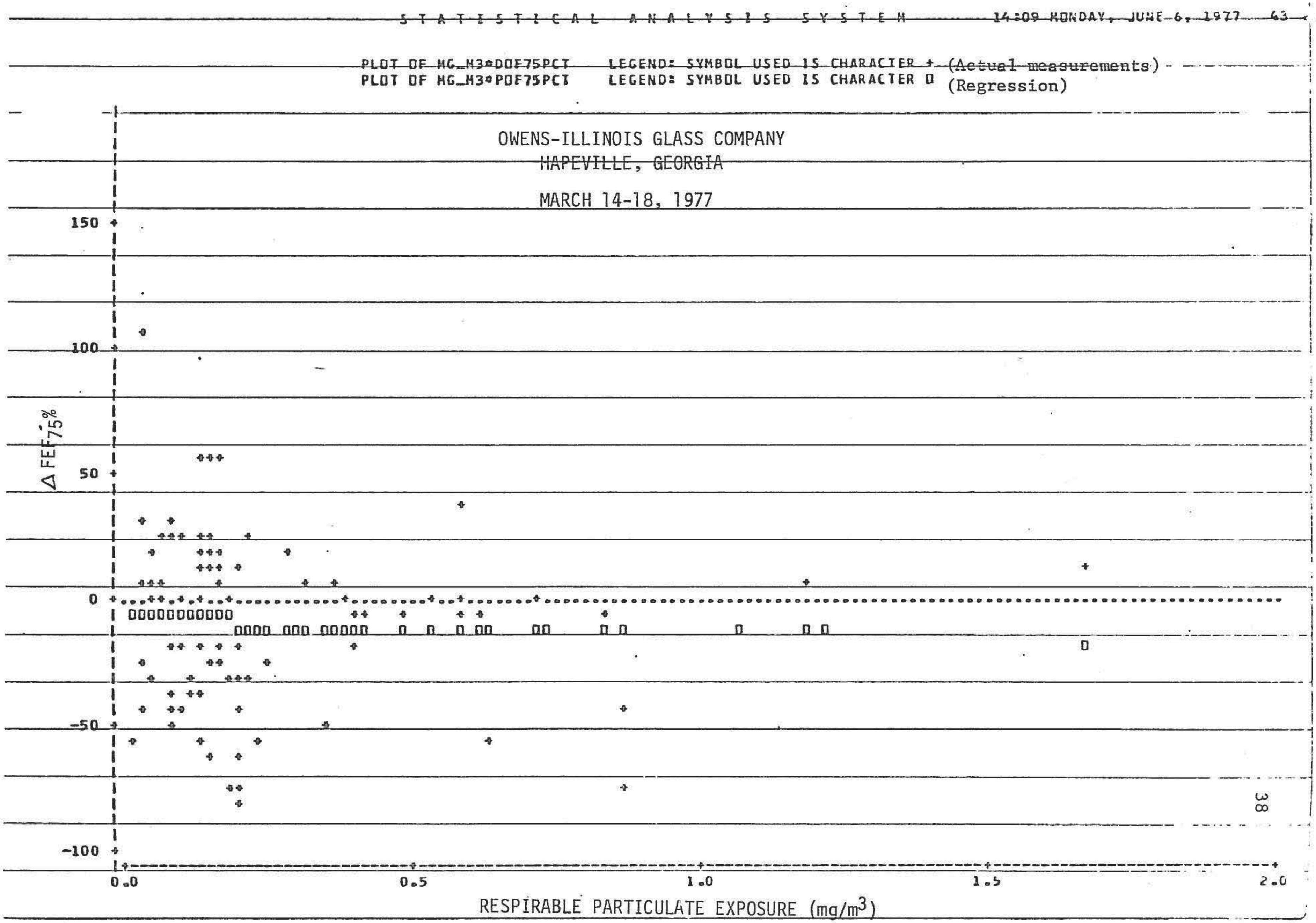

FIGURE 8A: ASSOCIAT' 'ETWEEN YEARS WORKED
AND % PR ED FEF_{75}, NON-SMOKING WORKERS

STATISTICAL ANALYSIS SYSTEM 9:04 THURSDAY, JUNE 23, 1977
STATUS=NEVER

~~PLOT OF YRS_WORK*DF75 LEGEND: SYMBOL USED IS CHARACTER + (Actual measurements)~~
PLOT OF YRS_WORK*P_DF75 LEGEND: SYMBOL USED IS CHARACTER O (Predicted values)

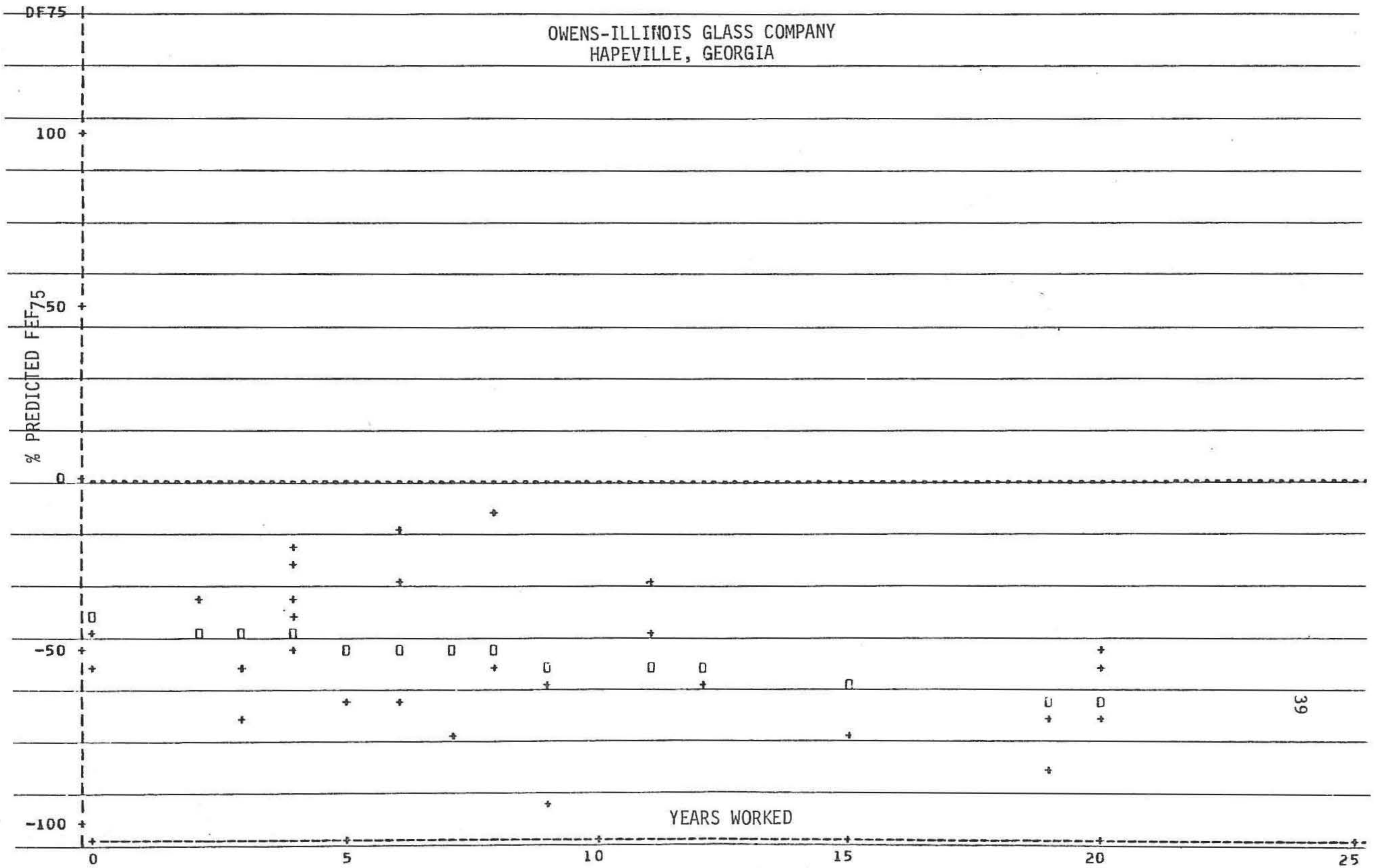

FIGURE 8B: ASSOCIATIO WEEN YEARS WORKED
AND %PREDICTED FEF$_{75}$, SMOKING WORKERS

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M   9:04 THURSDAY, JUNE 23, 1977

STATUS=SMOKER

~~PLOT OF YRS_WORK*DF75   LEGEND: SYMBOL USED IS CHARACTER +~~ (Actual measurements)

PLOT OF YRS_WORK*P_DF75   LEGEND: SYMBOL USED IS CHARACTER O (Predicted values)

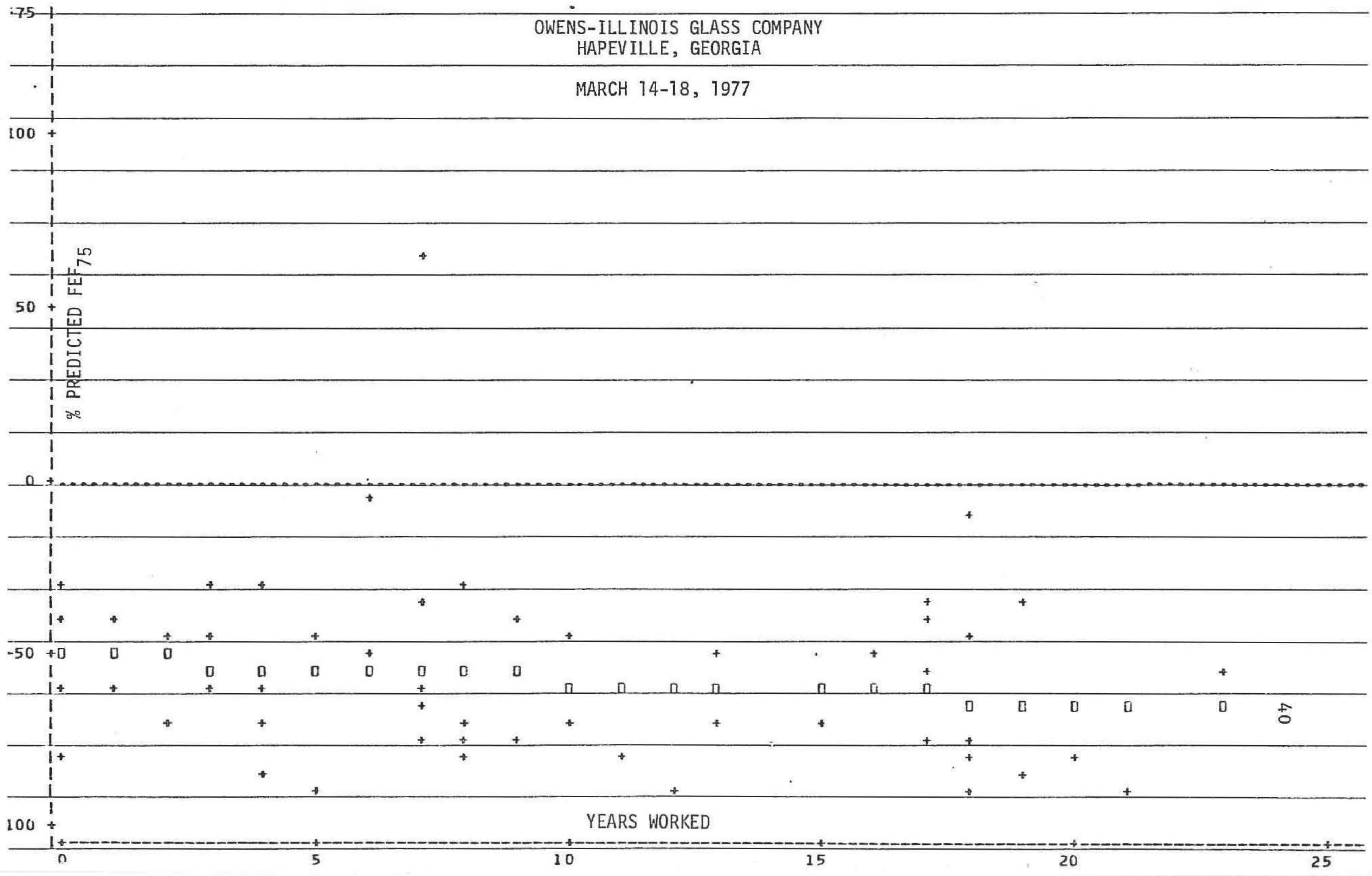

FIGURE 9A: ASSOCIATION 'EEN YEARS WORKED
AND % PREDI FEF75, FEMALE WORKERS

S T A T I S T I C A L A N A L Y S I S S Y S T E M 12:53 MONDAY, JUNE 20, 1977
SEX=FEMALE

PLOT OF YRS_WORK*DF75 LEGEND: SYMBOL USED IS CHARACTER + (Actual measurements)
PLOT OF YRS_WORK*P_DF75 LEGEND: SYMBOL USED IS CHARACTER O (Predicted values)

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

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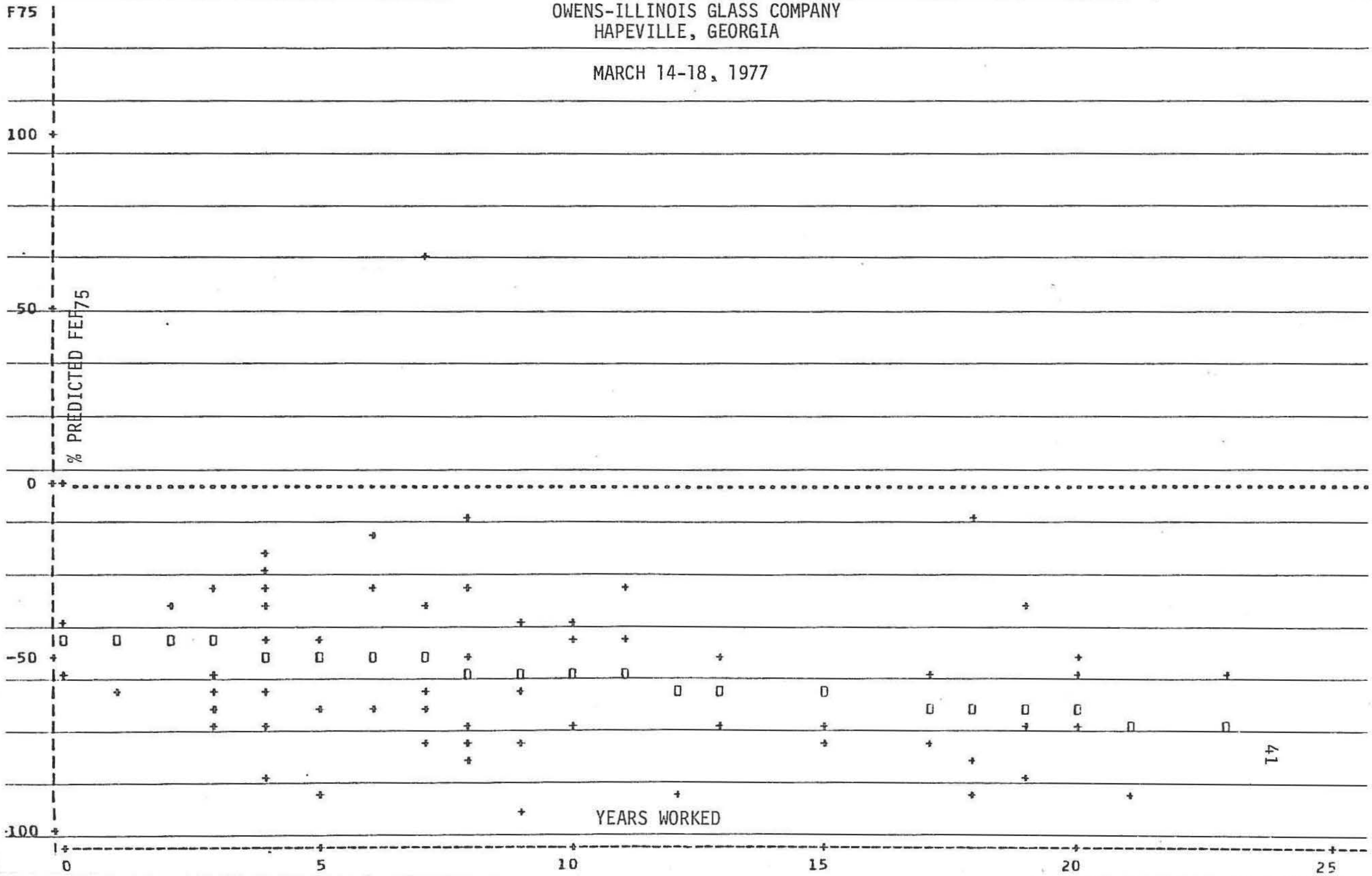

FIGURE 9B: ASSOCIATION 'EN YEARS WORKED
AND % PREDIC ·EF75, MALE WORKERS

S T A T I S T I C A L A N A L Y S I S S Y S T E M 12:53 MONDAY, JUNE 20, 1977 3
SEX=MALE

PLOT OF YRS_WORK*DF75 LEGEND: SYMBOL USED IS CHARACTER + (Actual measurements)
PLOT OF YRS_WORK*P_DF75 LEGEND: SYMBOL USED IS CHARACTER O (Predicted values)

OWENS-ILLINOIS GLASS COMPANY
HAPEVILLE, GEORGIA

MARCH 14-18, 1977

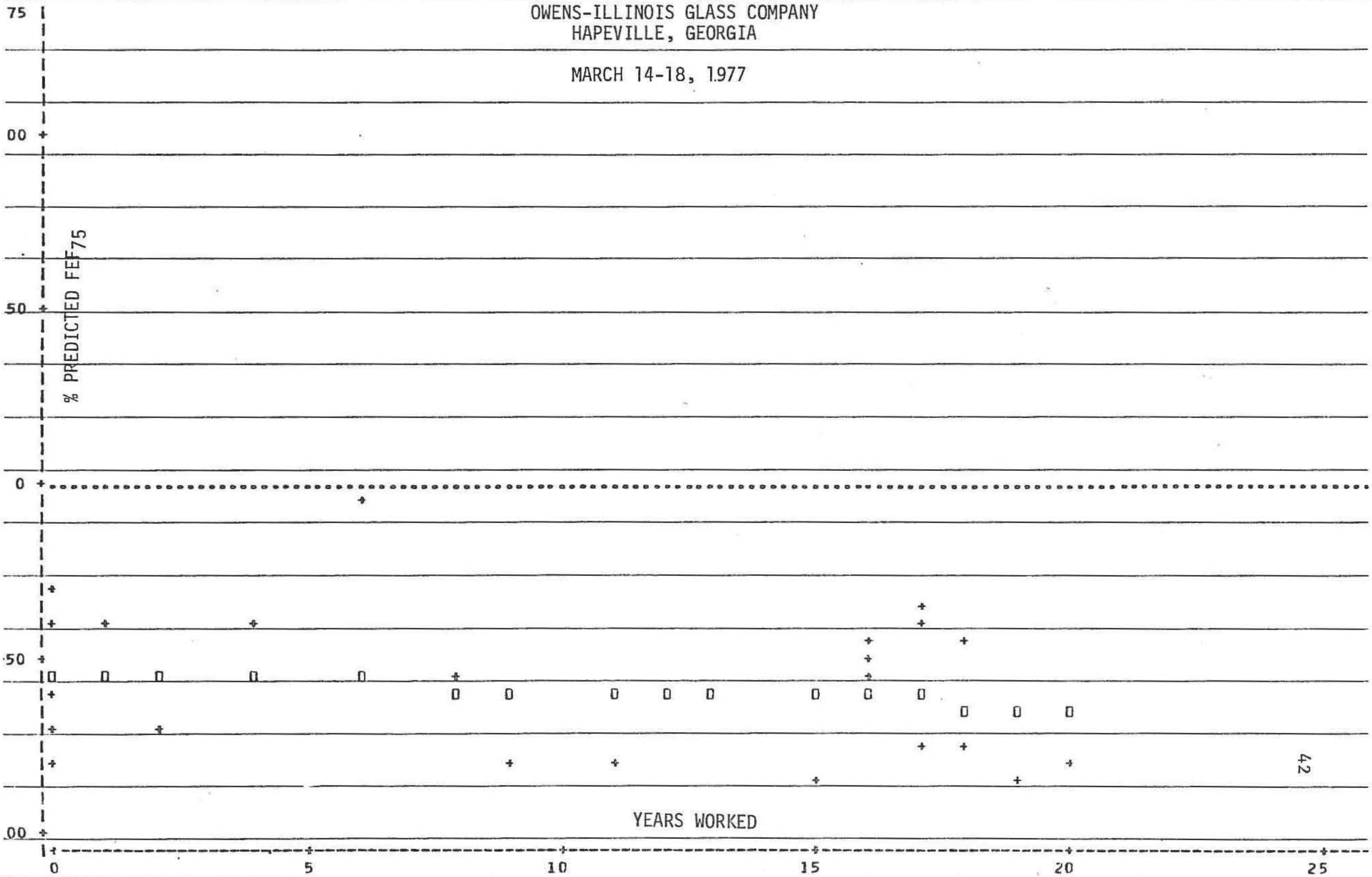

FIGURE 10: ASSOCIATION BETWEEN YEARS WORKED AND % PREDICTED FEF_{75}, NON-SMOKING FEMALE WORKERS