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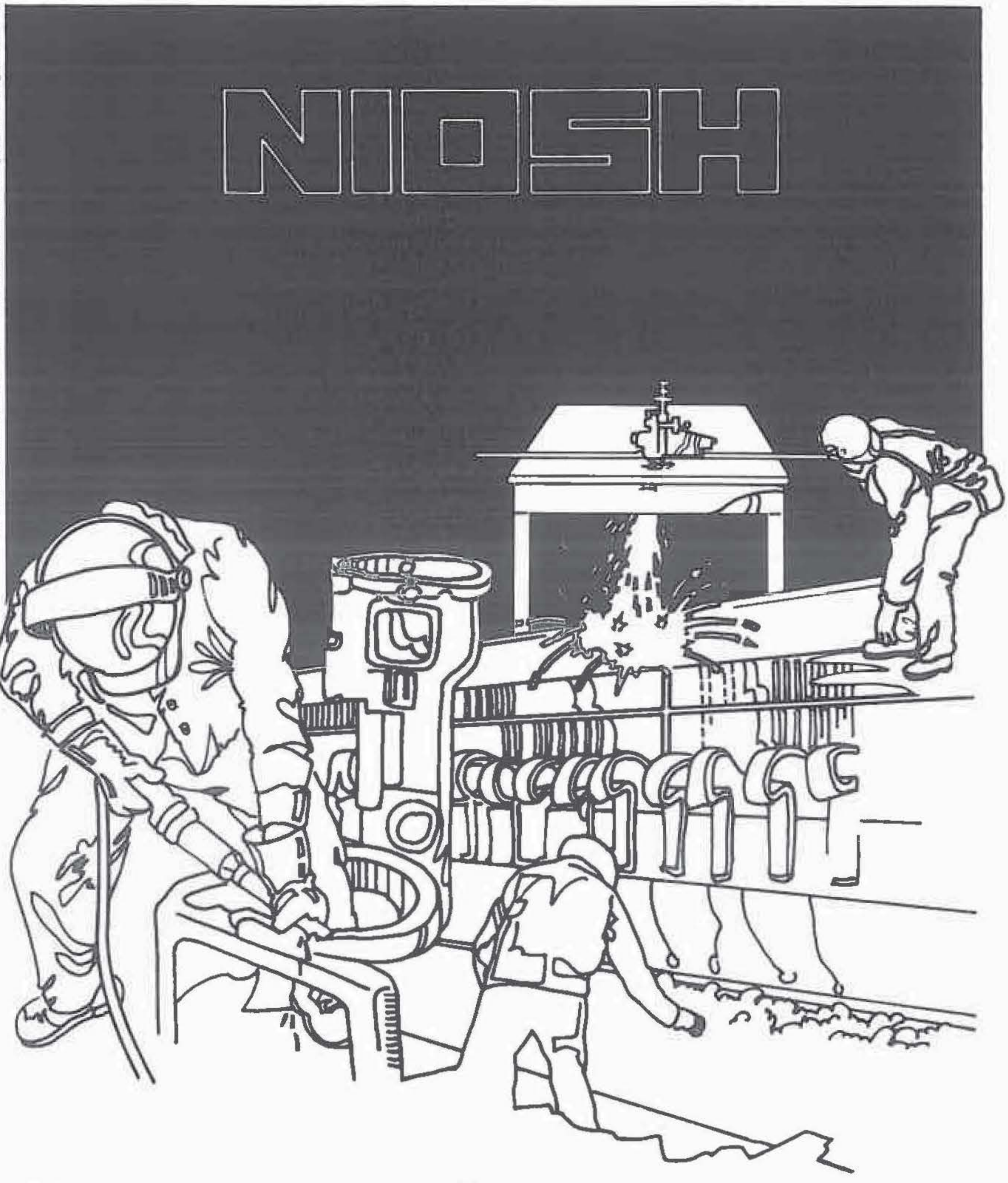

Health Hazard Evaluation Report

HHE 79-035-972
SIMPSON TIMBER COMPANY
SHELTON, WASHINGTON

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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NIOSH INVESTIGATORS:
A. APOL
T. WILCOX, M.D.
J. LYBARGER, M.D.

I SUMMARY

In October 1978, a representative of the International Woodworkers of America Local 3-38 requested the National Institute for Occupational Safety and Health (NIOSH) to evaluate the approximately 70 employees exposed to plywood veneer drying oven emissions at the Simpson Timber Company in Shelton, Washington.

An initial survey was made on December 4, 1978, and a combined environmental-medical survey was conducted on February 12-15 1979. The industrial hygiene survey revealed that the concentrations of the major constituents of veneer dryer emmissions (alpha and beta pinenes, and the abietic and pimaric acids), were in the same ranges as were the concentrations of these chemicals found in previous NIOSH surveys of plywood veneer drying oven operations.

The medical study was designed to detect any mucous membrane irritation and acute effects upon pulmonary function that might occur during the workshift. The production employees reported experiencing mucous membrane irritation (eg. eyes, nose, throat) with significantly greater frequency than did the office workers ($p=.0001$). When the production workers were considered as a whole, no significant lung function changes over the work shift were detected in either the smoking or non-smoking production employee groups. However, a subgroup of the production employees (18 workers) who reported occasionally experiencing shortness of breath while at work did have a slight but statistically significant decrease in their lung function over the workshift (approx. a 2% decrement in FEV and FEV_1), and some of these employees may be more sensitive to the irritating effects of the drying oven emmissions than are the majority of the production employees. No production employees had lung function measurements of FVC or FEV_1 below normal limits, but the long term (more than 8 years) production employees tended to have slightly lower FEV_1 results than did the office workers or the short term production employees. Linear regression analysis techniques also suggested that long term work exposure might have a slight detrimental effect of upon the FEV_1. However, these results could be caused by factors unrelated to work exposure and a long term study of comparable groups of production and non production employees would be needed to adequately assess the effects upon pulmonary function of long term exposure to the veneer drying oven emissions.

The available data, while not conclusively showing that a health hazard exists at the Simpson Timber Co., does indicate that the production employees experience work associated mucous membrane irritation far more frequently than do the office employees. Because of this irritation and the possibility that long term exposure to the veneer dryer oven emissions may cause lung function to decrease at a rate, slightly greater than the normal rate of decrease that occurs as people become older, it is advisable to continue efforts to decrease the concentration of the drying oven emissions in the plywood production area. Specific recomendations are contained in Section IX.

Keywords: SIC 2435 (Hardwood Veneer and Plywood) Plywood Veneer Drying Oven Emissions, Pinenes, Abietic & Pimaric Acids, Pulmonary Function.

II 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, and Human Services, 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.

NIOSH received such a request from the representative of the International Woodworkers of America Local 3-38 to evaluate potential exposure to plywood veneer dryer emissions at the Simpson Timber Co., Shelton, Washington.

III BACKGROUND

A. Plant Process

Simpson Timber Co. manufactures plywood. The veneer is peeled in an adjacent area of the plant. The veneer sheets are hand-fed into four continuous-feed, steam-heated veneer dryers which dry the veneer to a predetermined moisture content. As the dried veneer sheets exit from the dryer, they are removed by hand and graded. The veneer sheets are subsequently joined, patched, and assembled into panels which are then glued, pressed, trimmed, sanded, and graded. This request involves the veneer drying areas only.

This company has four steam-heated veneer dryers in operation. Veneer dryers are usually equipped to carry the stock through the dryer by a series of rolls. The rolls comprise a line with the dryers usually containing from four to eight lines. The lines are enclosed in a shell of sheet metal which is divided into sections. The shell also contains fans, ducts, and baffles for circulating and directing heat to the various lines. The temperatures used are usually less than 400°F. (Figure 1 is a schematic diagram of a typical dryer.)

As the water is given up by the heated veneer, it is converted to steam and when mixed with air makes an excellent drying medium. The amount of moisture in the dryer is controlled by dampers in the venting stacks which allow excess steam to escape into the atmosphere. The air-steam mixture is kept in constant circulation by the large fans in the dryer.

Since there are large fans circulating the air in the dryers, a portion of the air in the dryer is under negative pressure and a portion is under positive pressure. Air under positive pressure will seek out cracks and openings. Since a dryer has leaks around door seals, and also is open on both the feeding and grading ends of the dryer, the air escapes from the dryer into the surrounding room atmosphere. The air that escapes from the dryer will contain steam plus all the hydrocarbons that were volatilized from the wood. The hydrocarbons include alcohols, ketones, esters, aldehydes, terpenes, fatty acids and resin acids. The hydrocarbons can be divided into two categories--those that condense at ambient temperatures and those that remain volatile at ambient temperatures.

Douglas Fir was the wood species processed during this evaluation. The largest portion of the volatile hydrocarbons emitted during the drying of Douglas Fir consists of alpha and beta pinene and the majority of the condensed hydrocarbons are abietic and pimaric acids.

IV EVALUATION DESIGN AND PROGRESS

An initial survey was conducted on December 4, 1978, and the environmental-medical survey was conducted on February 12-15, 1979. The environmental evaluation consisted of measuring the employees exposure to the alpha and beta pinenes and the abietic and pimaric acids in the area of the feeders, graders, offbearers and pluggers.

V EVALUATION METHODS

A. Environmental

1. Total Acids - General area acid samples were collected using three Bendix Electrostatic Precipitator (ESP) units at 12,000 volts DC and at a flow rate of from 4.65 cfm to 8.55 cfm. (Each unit had a different flow rate. See Figure 2 for a diagram of the sampling train.) The collected material was analyzed for total acids.

2. Alpha and beta pinenes - General area samples were collected on charcoal tubes using personal sampling pumps at a flow rate of 1.0 liters per minute. The samples were collected in the exhaust of the ESP units as the acids, if not removed, would interfere with the adsorption of the pinenes on the charcoal. (See Figure 2 for a diagram of the sampling train.) The charcoal tubes were analyzed for total pinenes.

B. Medical

Data were collected from 109 Simpson Timber Company employees (75 out of a total 80 plywood production employees and 34 office employees who had no exposure to the plywood production area). A questionnaire was administered inquiring about work history, smoking history and respiratory and irritative symptoms. Physical examinations of the eyes, nose, throat, skin and lungs and pulmonary function tests, were performed pre- and post-shift. Informed consent was obtained from all participants prior to examination and testing. The 75 production employees received pulmonary function tests and were examined before shift and after at least six hours of work exposure on their first shift (Monday) and fourth work shift (Thursday) of the week. These employees did not have work exposure on the preceding Saturday or Sunday. The 34 office workers had pulmonary function tests and were examined near the begining and end of their Wednesday work shift.

1. Questionnaire

A modified version of the 1978 ATS-DLD[19] respiratory questionnaire was administered to each participant at the work site on the participant's first day of testing. This questionnaire was used to obtain basic information such as demographic data, occupational exposure history, smoking habits, and respiratory tract signs and symptoms such as chronic cough and sputum production which may indicate the presence of chronic bronchitis in the affected individual.

An abbreviated respiratory questionnaire was also administered before each pulmonary function test to determine the presence of acute symptoms, particularly any which might have developed over the work shift, and to ascertain any factors which might acutely affect pulmonary function results, such as recent cigarette smoking.

2. Pulmonary Function Tests

Pulmonary function tests were performed using a Vitalograph** single-breath, wedge-bellows spirometer. Spirometric tracings were corrected to BTPS (body temperature, standard pressure, saturated with water vapor).

The forced expiratory volume in one second (FEV_1), which is the maximum amount of air that a person can expel from his lungs in one second, and the forced vital capacity (FVC), which is the maximum amount of air that cam be expelled from the lungs after a maximal inspiration, were measured in each participant. The largest of three spirometric tracings was used for calculation. The ratio of FEV_1 to FVC,. expressed as a percentage (FEV_1/FVC), was calculated. In serial evaluations (pre- and post- shift tests), a decline in FVC or FEV_1 greater than 10% between test 1 and any of the 3 subsequent tests was considered significant.

The predicted values of FEV_1 and FVC were calculated using the Knudsen equations[10]. Knudsen obtained his equations by measuring the pulmonary function of 1,000 non-smoking caucasian men and women who had no identified respiratory abnormalities or diseases . These prediction equations are only approximate estimates of "Normal", but if a person's FEV_1 or FVC is less than 80% of the predicted value, the person is considered very likely to have abnormal pulmonary function.

If the FEV_1 is below the limits of normal (80% Of FEV_1 predicted) the person may have an obstructive lung problem that prevents the air from being expelled quickly from his lungs. People who suffer from asthma have episodes of air passage constriction that obstructs the air from leaving the lung, and these people can become quite short of breath during an asthma attack. People who have an FVC that is below the limits of normal may have an abnormality in the chest wall or lung, that restricts the lung from expanding normally. Persons that have had excessive exposure to silica dust or asbestos may develop "stiff" lungs and be unable to fully expand their lungs and thus have a decrease in their FVC.

Normally, taller people will have greater FEV_1 and FVC than will shorter people and the FEV_1 and FVC will decrease slowly with age even in non-smoking people who have not had exposure to noxious chemicals or dusts. If a person smokes or has occupational exposure to certain agents (eg. silica, asbestos, toluene diisocyanate, etc.); his FEV_1 and/or FVC may decrease at an accelerated rate.

It is most difficult to assess the effects of a long term environmental exposure upon a persons lung function unless serial measurements are taken on a periodic basis to quantitatively record any changes that may occur. If pulmonary function measurements are made only after several years of exposure have occurred one cannot determine what the persons lung function would have been had the exposure in question not occurred. The normal predicted values such as those derived by Dr. Knudsen are useful to provide a rough estimate of "normal" but the ranges of normal are quite wide because of the numerous factors besides the sex, race, height, and age that affect lung function parameters. These prediction equations are also useful to attempt to normalize pulmonary function data from people of differing age, race, sex, and height by calculating the ratio of the measured to the predicted value of FEV_1 or FVC, so that the lung functions of people with different levels of exposure can be compared on a group basis. However, when normalized pulmonary function data is used, the results of group comparisons can show small differences between the exposure groups because of factors of age, height and sex that differ between the groups and are not quite adequately corrected for by using the prediction equations. Therefore when data from only one point in time is available, estimates of possible lung effects secondary to environmental exposure can be obtained, but any findings that show only small differences between the groups (even if statistically significant) must be interpreted with caution since differences in age, height and sex between the exposure groups can slightly affect the results.

VI EVALUATION CRITERIA

A. Environmental Standards

Currently there are no Federal occupational health standards or any recommended levels for the pinenes, abietic or pimaric acids. The range and mean for levels found in previous veneer plant studies are presented below: (references 1-5)

	alpha and beta pinene mg/cu m		total organic acid mg/cu m	
	Range	Mean	Range	Mean
Plant 1	0.11-5.0	0.73	0.01-0.60	0.21
Plant 2	0.22-11.0	3.5	0.02-1.2	0.21
Plant 3	0.40-3.3	1.4	0.004-0.15	0.07
Plant 4	0.55-14.1	5.0	0.01-2.6	0.79
Plant 5	0.06-0.45	0.26	0.01-0.20	0.10
Plant 6*	0.50-5.14	1.55	0.02-0.35	0.13

*Plant #6 is this evaluation.

B. Toxicity

The information on pinenes and abietic and pimaric acids is scanty but a review of the current literature plus information on previously studied plywood veneer plants is given below:

1. Pinenes: The pinenes are colorless to yellow liquids with the odor of turpentine. They are the major constituents of oil of turpentine.

   The toxic properties of the pinenes include: a. inhalation - Among the effects observed in humans subjected to severe exposure were irritation of mucous membranes of nose and throat, cough, bronchial inflammation, salivation, headache, vertigo, and irritation of the bladder. It has been reported that continued inhalation of the vapor may cause chronic nephritis and predispose to pneumonia. In 1941 albuminuria and hematuria were reported in men exposed to turpentine vapor with subsequent recovery from such exposures[8], but there is little evidence to suggest that turpentine vapors at low levels are a chronic poison. There is scanty evidence to suggest that some individuals may develop a hypersensitivity to turpentine after prolonged, repeated exposures; b. skin contact - There is little doubt that turpentine is a skin irritant for normal persons if allowed to remain in contact with skin for a sufficient length of time. Some persons are so sensitive that even moderate exposure to vapors will cause a skin reaction. Most people do not develop a dermatitis from occasional contact[6,7,9]; and c. eye contact - A vapor concentration of 200 ppm is moderately irritating to the eyes.

2. Abietic Acid: Abietic acid is a yellow powder with the following physical properties: mol. wt., 302-44, melting point, 137-166^{0}C. There are scanty toxicological data available on this chemical. According to Patty, abietic acid has a low oral toxicity and is not a skin irritant. However, other sources claim that abietic acid is slightly toxic and slightly irritating to the skin and mucous membranes.[9].

3. Pimaric Acid: No information is available on this agent either in the standard references or in the current NIOSH Toxic Substance List.

Four prior studies determined that under normal working conditions veneer dryer emissions may produce transient irritation of the mucous membranes of the eyes, nose and throat, as well as the upper respiratory tract, producing cough and chest discomfort to workers in dryer operations. The emissions, which are principally abietic and pimaric acids (condensed hydrocarbons) and alpha and beta pinenes (volatile hydrocarbons), are most pronounced when Douglas and White Fir are being dried. Veneer dryer emissions as well as smoke from fires that occasionally break out in the dryers, may transiently aggravate any underlying asthmatic or other chronic respiratory condition and may make hay fever symptomatically worse.

Pulmonary function tests in two of the four plants studied revealed small decrements in forced expiratory flow and maximal midexpiration flow rates over the course of the usual work shift, but these findings were too inconsistent to make any firm conclusions. Periodic (annual) pulmonary function testing of exposed workers along with a control (unexposed) group would evaluate this matter completely. There is no evidence from the previous surveys to suggest that veneer dryer emissions cause allergic pulmonary disease or hay fever.

VII RESULTS AND DISCUSSION

A. Environmental Results

All the samples were collected in the general work area of the plywood veneer feeders, graders, offbearers and pluggers. Area samples rather than "personal samples" had to be collected because of the 110 volt AC power requirement for the electrostatic precipitator units. It was felt that these "area samples" would be representative of employee exposure to veneer dryer emissions since the persons involved in the dryer operations generally work 25 to 40 feet or more from the dryer, and spend greater than 90% of their time in the dryer area.

Thirty-six area samples were collected over 96 consecutive hours for the pinenes and acids in the following three areas: 8 in the feeder area, 16 in the offbearer and grader area, and 8 in the plugging area. The results are shown in tables 1 to 4 and Figures 3, 4 and 5 show the individual results by location. The summary of the results are shown below.

	pinenes mg/cu m		acids mg/cu m	
Location	range	mean	range	mean
feeder area	1.77-5.14	3.37	0.02-0.18	0.05
offbearing area	0.67-1.68	1.01	0.08-0.35	0.16
plugging area	0.50-1.45	0.78	0.07-0.16	0.12
All locations	0.50-5.14	1.54	0.02-0.35	0.13

The mean pinene concentration in the feeder area is significantly higher (probability 0.001) than those in the offbearing and plugger areas, while the reverse occurred for the acids. The mean acid concentrations in the feeder area is significantly less (probability 0.003) than in the offbearing and plugging area. The reason for this variation is not known.

Overall the mean pinene concentration was 1.55 mg/cu m and the mean acid concentration was 0.13 mg/cu m. These concentrations are within the range of those measured in five other plant studies involving veneer dryer emissions.

The ambient temperature varied from about 27° at night to a high of 50° during the day. Generally it was overcast with scattered showers during the four days of sampling. The concentrations of the acids and pinenes in each area (feeders, offbearers, pluggers) were about the same for each shift. No evaluation could be made between the air concentration and the outside weather condition.

There are 14 roof exhaust fans directly over the dryer. One fan was not working, 4 were operating at reduced RPM's due to belt slippage and 2 were vibrating excessively. There are seven additional ceiling exhaust fans over the dryer-plugging area. Of these one was not working and one had belt slippage.

There were numerous leaks in the dryers. Approximately 10% of the dryer door catches were broken thus preventing the doors from sealing properly.

B. Medical Results

1. Acute Effects

a. Mucous Membrane Irritation

During the initial interview the participants were asked if they experienced irritative symptoms of mucous membrane irritation such as eye irritation, nasal congestion or sore throat frequently while at work. Table 5 shows the number of employees (categorized as to present smoking and work exposure status) who reported experiencing these irritative symptoms with notable frequency while at work. The production employees who were not current cigarette smokers more frequently reported experiencing irritation than did the production employees who were current smokers. Clearly the entire group of production employees (both current smokers and current non-smokers) reported experiencing irritation at work with far greater frequency than did the office workers. When the production workers were compared to the office workers without regard to their current smoking status the differences in rates of nasal, throat, and eye irritation were significant at the $p=.0001$ level. Presumably, the subjective discomfort experienced by the production employees is related to the airborn pinenes, acids, dust, and smoke present in the production area.

During the pre-and post-shift examinations, participants were asked if they were presently experiencing eye irritation, nasal congestion or sore throat. The number of production employees with such complaints tended to increase from pre-shift to post-shift, and workers who who were not current cigarette smokers reported the development of such symptoms over the workshift more frequently than did production workers who were current smokers. However none of the increases over the shift in reports of mucus membrane irritation symptoms were statistically significant in the production workers. Reports of eye irritation, nasal congestion, or sorethroat did not increase from pre-to post-shift in the office workers.

The physical examinations of the lungs, eyes, nose and throat performed pre-and post-shift on the exposed population during both days of testing showed slight increases in the numbers of employees with evidence of eye or nose irritation following their work shift, but the increases did not approach statistical significance. No pre-to post-shift increase in the rate of lung abnormalities was noted.

b. Acute Pulmonary Function Effects

In order to study the acute effects of exposure to the plywood production area upon pulmonary function, the data for the participants was divided into production and control (office workers) groups. Each of these groups was further separated into presently non-smoking and presently smoking categories. The production employees performed pre-and post-shift pulmonary function tests on Monday (pre 1, post 2) and Thursday (pre 3, post 4) and the office workers (controls) performed tests at the beginning and near the end of shift only on Wednesday (pre 1, post 2). Table 6 shows the demographic characteristics of the groups catagorized by smoking and work status.

Table 6 also shows that when each member of each group was used as his own control (Paired T test) there was no statistically significant (at p=.05) difference between the initial pre-shift pulmonary function test (test 1) and any of the subsequent pulmonary function tests of the production or office workers. Seven production participants decreased by 10% and seven production employees increased by 10% their FEV_1 from tests Test 1 to Test 2, Test 3 or Test 4. These results imply that the changes were random in nature probably caused by variations in technician procedure, normal physiologic change and differing time intervals since the last cigarette smoked etc., rather than from work exposure. (Workers were requested to refrain from tobacco smoking for at least one hour prior to each pulmonary function test, but unfortunately an hour's abstinence from cigarette smoking was not present in each participant prior to each test. Mean interval from the last smoking of a cigarette was calculated for each group and did not differ significantly between the production and office groups for tests 1 and 2.)

Since the Industrial Hygiene measurements revealed that the employees working in the feeder area had a higher exposure to pinenes and the offbearers and pluggers had a higher exposure to abietic and pimaric acids, these two groups of employees were separately evaluated for changes in pulmonary function over the testing period. No consistent pattern of change was found in either group.

During the medical interviews 18 production employees stated that they occasionally experienced asthma-like symptoms such as shortness of breath or chest tightness or difficulty breathing while at work. To determine the acute pulmonary effects of work exposure on these 18 employees, the pulmonary function data for these employees was analyzed separately from the data of the remaining production workers, without respect to the employees present smoking status. There were 2 employees in the "Asthma" category with a greater than 10% decrease in FEV_1 and 1 with a 10% increase in FEV_1 between test 1 and one of the subsequent 3 tests. Table 7 contains the data comparing the production workers with asthma-like symptoms with the remaining production workers. The paired T Test results show that the group with asthma-like symptoms has consistent slight decreases in FEV_1 and FVC in tests 2, 3, and 4 as compared to test 1, while results for the other production workers do not show a consistent pattern. Note that several of the decreases in the asthmatic group were significant at the P=.05 level.

These decreases are very small in magnitude (a -2% change in FEV_1 is only about 80 cc's or approximately 5 tablespoonsful of air) and their physiologic significance is unclear. However the fact that the group with asthma like-symptoms shows statistically significant though slight decreases from their base line lung function in several subsequent pulmonary function tests suggests that there may be members of this group who are more sensitive than the majority of the employees in the production area to the airborne contaminants present in that area.

B. Chronic Effects

To assess the possible effects of long-term employment in the plywood production area, participating workers were divided into three response groups. The office control workers (exposure = none), production employees with less than 8 years employment at Simpon (exposure = short) and production employees with more than 8 years employment at Simpson (exposure = long). These three groups were each categorized by smoking history; people who had never smoked, former smokers, and present smokers. The results are summarized in Table 8.

Factors which influence pulmonary function (sex, age and total cigarette consumption) are included in Table 8 to judge the comparability of the groups. Women comprise a significant proportion of the office and short exposure groups but there are no women in the long exposure category. Since the pulmonary prediction equations account for sex this difference should not greatly affect the comparison of pulmonary function results.

The mean ages of the exposure groups in each smoking catagory are roughly comparable except that the production employees with less than 8 years of employment who had never smoked or who were active smokers were considerably younger than the comparable office workers or long-term exposed employees.

It can be seen that in the long-term exposed employee groups, most (20) were present smokers. Only 5 were past smokers and 3 had never smoked. However in the office groups only 9 employees were presently smoking cigarettes, while 13 were former smokers and 12 had never smoked.

The mean pack years of cigarette smoking is roughly comparable among the 3 exposure groups in each smoking category except that the presently smoking short-term exposed employees had only 12.5 pack years while the other 2 presently smoking exposed groups each had over 30 pack years.

Clearly the categories are not perfectly comparable in the characteristics of age, sex and total cigarette consumption and the number of long term exposed workers in the never smoked and past smoking categories is small, but the groups appear sufficiently similar so that the respiratory symptoms present in each group and the pulmonary function parameters of each group should hopefully yield an indication if prolonged exposure to the veneer drying emissions may effect the respiratory system.

Table 8 also shows the number of people in each smoking and exposure catagory who report the symptoms of chronic bronchitis. If a person smokes cigarettes or is chronically exposed to substances that irritate the lung he may be at increased risk of developing chronic bronchitis, which is defined for epidemiologic purposes as the production of sputum from the chest for four or more days a week for three months a year for 2 consecutive years. The presence of bronchitic symptoms appears to be most strongly influenced by currently smoking cigarettes, but the fact that 6 currently non-smoking production employees (3 former smokers and 3 who had never smoked) reported symptoms of chronic bronchitis, while no presently non-smoking office employees reported symptoms of bronchitis, suggests that exposure to the production environment may have some influence on the development of bronchitis.

Table 8 also shows that all the mean values for the pulmonary function parameters FEV and FEV_1 are above 90% of the predicted values except for the 5 former smokers in the long exposure category, and that the values for the employees with long exposure are consistently the lowest in each smoking category. The numbers in each group are small and no difference was statistically significant at the $p=.05$ level but the consistent pattern suggests the possibility that long-term exposure to the plywood production area may slightly accelerate the normal rate of decrease of pulmonary function that occurs with advancing age.

To further evaluate the relation of exposure to the plywood production area to changes in lung function, stepwise linear regression analysis was performed on the differences between the measured and predicted values of FEV_1 (FEV_1 measured - FEV_1 predicted) and FVC (FVC measured - FVC predicted). The analyses were performed using the length of time worked in the plywood production area (Years Exposed), the years of cigarette smoking multiplied by the average number of cigarette packs smoked per day (Pack Years), the age, and the height of the employee as the independant variables.

For FEV_1 most of the difference (85%) between the measured and actual values was not accounted for by the 4 independent variables being considered and age and height did not have an appreciable effect on this difference. A regression equation containing Years Exposed and Pack Years did account for about 15% of the variation ($R^2=.147$).

FEV_1 measured-FEV_1 predicted = 0.221 -.0047*Pack Years -.0275*Years Exposed
(p=.055)
(p=.003)

Thus while work exposure and to a lesser extent cigarette smoking, may account for a small amount of the decrement between predicted and measured FEV_1, the majority of the difference appears to be due to causes other than smoking and work exposure.

For FVC even more of the difference between the measured and predicted values appeared to be random in nature. The employee's pack years of cigarette smoking and height did not have appreciable effects and the regression equation using age and years of exposure could account for only about 8% of the variation (R^2=.082).

FVC Measured - FVC predicted = 0.151 - 0.00655*Age - 0.0197*Years Exposed (p=0.086) (p=0.048)

Although the coefficients of variation of the differences between measured and expected values of FEV_1 and FVC are significantly different from zero at the p=0.05 level (0.003 and 0.048 respectively), the regression equations can account for only a small amount of the variation seen in the lung function parameters of the Simpson employees and the observed relations could easily be due to other factors. However these relations do suggest a potential relation and may warrant further study. The pulmonary effects of long term employment in the production area could best be investigated by conducting a long term study that measured the pulmonary function of the production workers and a comparable control group of non-production employees on an annual basis, using instruments and procedures recommended by the American Thoracic Society so that comparability of pulmonary function results from year to year would be maintained.

VIII SUMMARY AND CONCLUSIONS

The industrial hygiene measurements showed that the concentrations of pinenes and abietic and pimaric acids were well within the ranges of the concentrations for these substances found at 5 other plywood manufacturing facilities surveyed by NIOSH . The medical interview showed that the production employees reported experiencing mucous membrane irritation while at work much more frequently than did the office employees. The production employees when considered in smoking and non smoking groups did not show significant pre-shift to post-shift changes in their pulmonary function parameters. However a group of 18 production employees who reported at least occasionally experiencing symptoms of shortness of breath while at work, did show slight but statistically significant decreases in their pulmonary fuction parameters over the work shift, and some of these employees may be more sensitive to the irritating effects of the veneer drying oven emissions than are the majority of the production employees.

Although it is usually not possible to conclusively determine the potential chronic effects of work expossure on lung function using pulmonary function data acquired at only one point in time, the pulmonary function data obtained was compared to predicted normal values for standard lung function parameters in order to get a rough estimate of possible chronic pulmonary effects. No production employees had lung function measurements of FVC or FEV_1 below normal limits. However the long term (more than 8 years) production employees tended to have proportionately lower FEV_1 results than did the office workers or the short term production employees and linear regression analysis techniques also suggested that long term work exposure might have a slight detrimental effect of upon the FEV_1. These effects could be caused by factors unrelated to work exposure. A long term study of comparable groups of production and non-production employees would be needed to conclusively determine the pulmonary effects of exposure to the veneer drying oven emissions.

IX. RECOMMENDATIONS

1. All the ceiling exhaust fans have to be maintained on a scheduled basis.

2. Remove the screens on the ceiling exhaust fans. Some have screens and some do not. The exhausted material builds up on the screen and restricts the exhaust air flow.

3. Clean the build up off the fan blades - this condition reduces the exhaust air volume and if a portion breaks loose, causes a fan vibration.

4. Add more ceiling exhaust fans if possible.

5. Repair all broken dryer door catches as soon as possible after they are broken or damaged.

6. Find and repair all dryer leaks.

7. Extend the existing shrouding around the dryers closer to the floor. This would aid in containing the emission to the immediate area around the dryer and make the exhaust fans over the dryer more effective as the air velocity under the shrouding toward the dryers would be increased. The shrouded area should have a negative pressure to surroundings.

8. Medical monitoring and education is recommended for all workers assigned to dryer operations:

    a. These workers should be made aware to the irritant effects produced by veneer dryer emissions.
    b. Pre-assignment histories and physical examinations should be carried out on all employees, and periodically repeated.

c. Pre-assignment and subsequent periodic (annual) pulmonary function testing (to include FVC, $FEV_{1.0}$, and MMEF 25-75%) should be considered for employees in veneer dryer operations to determine if long term employees experience an accelerated decrement in pulmonary function.

d. Individuals with a history of asthma or other chronic respiratory condition which is reported or detected by pulmonary function testing should be advised that their condition may be made symptomatically worse by working in close proximity to the veneer dryers.

IX. REFERENCES

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X. DISTRIBUTION AND AVAILABILITY

Copies of this determination report are currently available upon request from the National Institute for Occupational Safety and Health (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 of this report have been sent to:

1. Simpson Timber Co., Shelton, Washington
2. International Woodworkers of America Local 3-38 Shelton, Washington
3. International Woodworkers of America Western States Regional Council No. 111, Gladstone, Oregon
4. Washington Industrial Safety and Health Agency (WISHA), Olympia, Washington
5. U. S. Department of Labor, Occupational Safety and Health Agency (OSHA), Region X, Seattle, Washington

For the purpose of informing the approximately 200 affected workers, a copy of this report shall be posted in a prominent place accessible to the employees for a period of 30 calendar days.

XI ACKNOWLEDGMENTS

Report prepared and survey conducted by:

Arvin G. Apol
Industrial Hygienist
Region X/NIOSH
Seattle, Washington

Thomas Wilcox, M.D.
Medical Officer
NIOSH
Cincinnati, Ohio

Jeffrey Lybarger, M.D.
Medical Officer
NIOSH
Cincinnati, Ohio

Originating Office:

Hazard Evaluation and Technical
Assistance Branch
DSHEFS/NIOSH
Cincinnati, Ohio

TABLE 1

ALPHA AND BETA PINENE AND TOTAL ACID AIR CONCENTRATIONS

SIMPSON TIMBER CO.
SHELTON WASHINGTON

HHE 79-35

LOCATION	DATE	SAMPLE PERIOD	SAMPLE TIME MINS.	SAMPLE NUMBER	TOTAL ACIDS SAMPLE VOL. cu m	TOTAL ACIDS CONCENTRATION mg/ cu m	ALPHA & BETA PINENES SAMPLE VOL. LITERS	ALPHA & BETA PINENES CONCENTRATION PPM	ALPHA & BETA PINENES CONCENTRATION mg/m^3
Between Pluggers 2 & 3	2/12/79	12:00 - 7:55 A	475	1	106.9	0.13	475	0.09	0.53
#1 Dryer by Offbearers	2/12/79	12:00 - 3:00 A 5:20 A - 8:00 A	340	2 + 4	94.4	0.09	340	0.15	.85
Between Dryers 3 & 4 by Feeders	2/12/79	12:00 - 8:05 A	485	3	128.4	0.04	485	0.31	1.77
Between Pluggers 4 & 5	2/12/79	7:55 A- 3:50 P	475	5	106.9	0.13	475	0.11	.61
Between #3 & 4 Offbearing lines	2/12/79	8:05A - 3:55 A	470	6	130.4	0.18	470	0.13	.72
Between Dryers 1 & 2 By Feeders	2/12/79	8:15A - 4:00 P	465	7	123.1	0.02	465	0.90	4.99
By #1 Plugger	2/12/79	3:55P -11:45 P	460	8	103.5	0.07	460	0.10	.54
By #2 Dryer Grader	2/12/79	4:00P -11:50 P	470	9	130.4	0.20	470	0.19	1.04
By #1 Dryer Offbearers	2/12/79	4:50P -11:55 P	425	10	112.5	0.12	425	0.16	.87

TABLE 2

ALPHA AND BETA OINENE AND TOTAL ACID AIR CONCENTRATIONS

SIMPSON TIMBER CO.
SHELTON WASHINGTON

HHE 79-35

LOCATION	DATE	SAMPLE PERIOD	SAMPLE TIME MINS.	SAMPLE NUMBER	TOTAL ACIDS		ALPHA & BETA PINENES		
					SAMPLE VOL. cu m	CONCENTRATION mg/ cu m	SAMPLE VOL. LITERS	CONCENTRATION PPM	mg/m^3
By #3 Dryer Grader	2/13/79	11:50P - 7:25A	455	11	102.4	0.13	455	0.23	1.30
By #2 Dryer Grader	2/13/79	11:55P - 7:40A	465	12	129.0	0.08	465	0.24	1.31
Between Dryers 1&2 By Feeders	2/13/79	12:00P - 7:50A	470	13	124.5	0.03	470	0.60	3.32
Between Dryers 3&4 By Feeders	2/13/79	7:30A - 4:40P	510	14	135.0	0.06	510	0.45	2.53
By # 1&2 Dryer Graders	2/13/79	7:45A - 3:55P	490	15	135.6	0.17	490	0.18	1.00
Between Pluggers 4 & 5	2/13/79	7:55A - 3:50P	475	16	106.9	0.13	475	0.12	.69
By #1 Plugger	2/13/79	3:50P - 11:50P	480	17	108.0	0.08	480	0.17	.99
By #2 Dryer Grader	2/13/79	3:55 - 11:40P	465	18	129.0	0.16	465	0.17	.97
Between Dryers 1&2 by Feeders	2/13/79	4:00P - 11:25P	445	19	117.8	0.18	445	0.94	2.11

TABLE 3

ALPHA AND BETA PINENE AND TOTAL ACID AIR CONCENTRATIONS

SIMPSON TIMBER CO.
SHELTON WASHINGTON

HHE 79-35

LOCATION	DATE	SAMPLE PERIOD	SAMPLE TIME MINS.	SAMPLE NUMBER	TOTAL ACIDS		ALPHA & BETA PINENES		
					SAMPLE VOL. cu m	CONCENTRATION mg/ cu m	SAMPLE VOL. LITERS	CONCENTRATION PPM	mg/m^3
By #4 Dryer Grader	2/14/79	11:55 - 7:50A	475	20	106.9	0.08	475	0.12	.69
Between #2 & 3 Offbearers	2/14/79	11:55 - 8:05A	490	21	136.0	0.22	490	0.19	1.06
By #1 Dryer Offbearers	2/14/79	11:30 - 8:10	520	22	137.7	0.11	520	0.15	.85
Between #3&4 Dryer Dry Chains	2/14/79	8:00A - 4:10P	490	23	110.3	0.21	490	0.16	.90
By #2 Dryer Grader	2/14/79	8:10A - 4:05P	475	24	131.2	0.15	475	0.17	.93
Between Dryers 3&4 By Feeder	2/14/79	8:15A - 4:00P	465	25	123.1	0.02	465	0.57	3.18
Between Pluggers # 2 & 3	2/14/79	4:15 P _ 11:40P	445	26	123.5	0.13	465	0.15	.84
Between Dry Chain of #3&4 Dryers	2/14/79	4:15P - 11:50P	455	27	102.4	0.17	455	0.20	1.10
Between # 1&2 Dryers Offbearers	2/14/79	4:05 - 11:25P	440	28	116.5	0.16	440	0.28	1.55

TABLE 4

ALPHA AND BETA PINENE AND TOTAL ACID AIR CONCENTRATIONS

SIMPSON TIMBER CO.
SHELTON WASHINGTON

HHE 79-35

LOCATION	DATE	SAMPLE PERIOD	SAMPLE TIME MINS.	SAMPLE NUMBER	TOTAL ACIDS SAMPLE VOL. cu m	TOTAL ACIDS CONCENTRATION mg/ cu m	ALPHA & BETA PINENES SAMPLE VOL. LITERS	ALPHA & BETA PINENES CONCENTRATION PPM	ALPHA & BETA PINENES CONCENTRATION mg/m^3
Between #4 & 5 Pluggers	2/15/79	11:45P - 7:55A	490	29	136.0	0.13	490	0.14	.76
By #3 Grader	2/15/79	11:55P - 8:00A	485	30	109.2	0.35	485	0.24	1.34
Between #1&2 Dryer Feeders	2/15/79	11:30P - 8:05A	515	31	136.4	0.02	515	0.75	4.17
By #1 & 2 Pluggers	2/15/79	8:00A - 3:35P	455	32	126.3	0.16	455	0.26	1.43
Between #2 & 3 Dry chains	2/15/79	8:05A - 3:50 P	465	33	104.7	0.12	465	0.32	1.76
By #1 Grader	2/15/79	8:10A - 3:25P	435	34	115.2	0.22	435	0.30	1.66
By #4 Grader and Offbearers	2/15/79	3:40P - 11:05	445	35	123.5	0.15	445	0.24	1.35
Between #3&4 Dryer Feeders	2/15/79	3:30P - 11:05P	455	36	120.5	0.06	455	0.70	3.91
By #2 Dryer Offbearers & Grader	2/15/79	3:55P - 11:15P	440	37	99.0	0.27	440	0.30	1.45

TABLE 5

SUMMARY OF INFORMATION ON EMPLOYEES WHO REPORTED EXPERIENCING SYMPTOMS OF MUCOUS MEMBRANE IRRITATION WITH NOTICEABLE FREQUENCY WHILE AT WORK

SIMPSON TIMBER COMPANY
Shelton, Washington
HHE 79-35

	Participants Who Do Not Curently Smoke Cigarettes		Participants Who Curently Smoke Cigarettes	
	Control	Production	Control	Production
SYMPTOMS EXPERIENCED				
EYE IRRITATION DURING WORKSHIFT				
Yes	0	24	1	20
No	25	10	8	21
NOSE IRRITATION DURING WORKSHIFT				
Yes	0	23	1	21
No	25	11	8	20
THROAT IRRITATION DURING WORKSHIFT				
Yes	0	15	1	15
No	25	11	8	26

TABLE 6

SUMMARY OF ACUTE CHANGES IN PULMONARY FUNCTION PARAMETERS

SIMPSON TIMBER COMPANY
Shelton, Washington
HHE 79-35

	Participants Who Do Not Presently Smoke Cigarettes		Participants Who Presently Smoke Cigarettes	
	Office	Production	Office	Production
Age (yr)	46.1	37.9	47.3	39.6
Height (in)	67.8	68.5	68.19	69.2
Male/Female	18/7	26/8	6/3	37/4
No. Never Smoked	15	17	0	0
No. Past Smokers	10	17	0	0
Mean Years Since Smoked	9.1	8.29	0	0
Mean Percentage Chg.VC				
Test 1 to Test 2	1.27	-0.24	-1.43	-0.13
" 3		-1.25		-1.09
" 4		-0.81		-1.28
Mean % Chg. FEV 1				
Test 1 to Test 2	0.3	0.60	-2.20	-0.54
" 3		-0.50		-0.85
" 4		-0.52		-1.28

TABLE 7

SUMMARY OF INFORMATION ON LUNG FUNCTION CHANGES IN PRODUCTION WORKERS

SIMPSON TIMBER COMPANY
Shelton, Washington
HHE 79-35

	Production Employees with Occasional symptoms of Asthma	P	Other Production Employees	P
Mean Percentage Change VC				
Test 1 to Test 2	-1.99	.05	0.45	.54
3	-3.98	.0008	-0.18	.80
4	-3.51	.007	-0.25	.77
Mean Percentage Change FEV_1				
Test 1 to Test 2	-1.85	.02	0.63	.44
3	-1.63	.16	-0.36	.64
4	-2.50	.06	0.18	.85

TABLE 8

SUMMARY OF DATA ON PARTICIPANTS GROUPED TO SHOW CHRONIC EFFECTS

SIMPSON TIMBER COMPANY
Shelton, Washington
HHE 79-35

		Participants Never smoked			Participants Former smokers			Participants Presently smoking		
Plywood Drying Oven Exposure		none	short	long	none	short	long	none	short	long
Mean months of Exposure		0	15	142	0	37	156	0	27.0	154
Number of Participants		12	12	3	13	14	5	9	21	20
Number	Men	8	6	3	10	12	5	6	17	20
	Women	4	6	0	3	2	0	3	4	0
Race	White	12	12	3	13	14	5	9	18	19
	other races	0	0	0	0	0	0	0	3	1
Mean	Age (yrs)	43.8	27.9	36.9	48.2	43.2	47.4	47.3	31.6	48.0
Mean cigarette pack years		0	0	0	20.1	21.7	29.4	37.8	12.5	31.0
Mean years since smoked		-	-	-	9.5	7.5	10.7	-	-	-
No. reporting symptoms of chronic bronchitis	yes	0	1	2	0	3	0	4	8	4
	no	12	11	1	13	11	5	5	13	16
Mean ratio of vital capacity to predicted vital capacity		.99	.99	.97	.98	.98	.88	.93	.96	.92
Mean of Ratio of Forced Exp. volume/sec. to predicted force of Exp. volume		1.1	1.04	1.03	1.06	1.01	.91	.99	1.01	.92
Mean of Ratio of Forced Exp. Volume 1 sec to measured vital capacity		.85	.83	.82	.80	.79	.77	.79	.82	.75

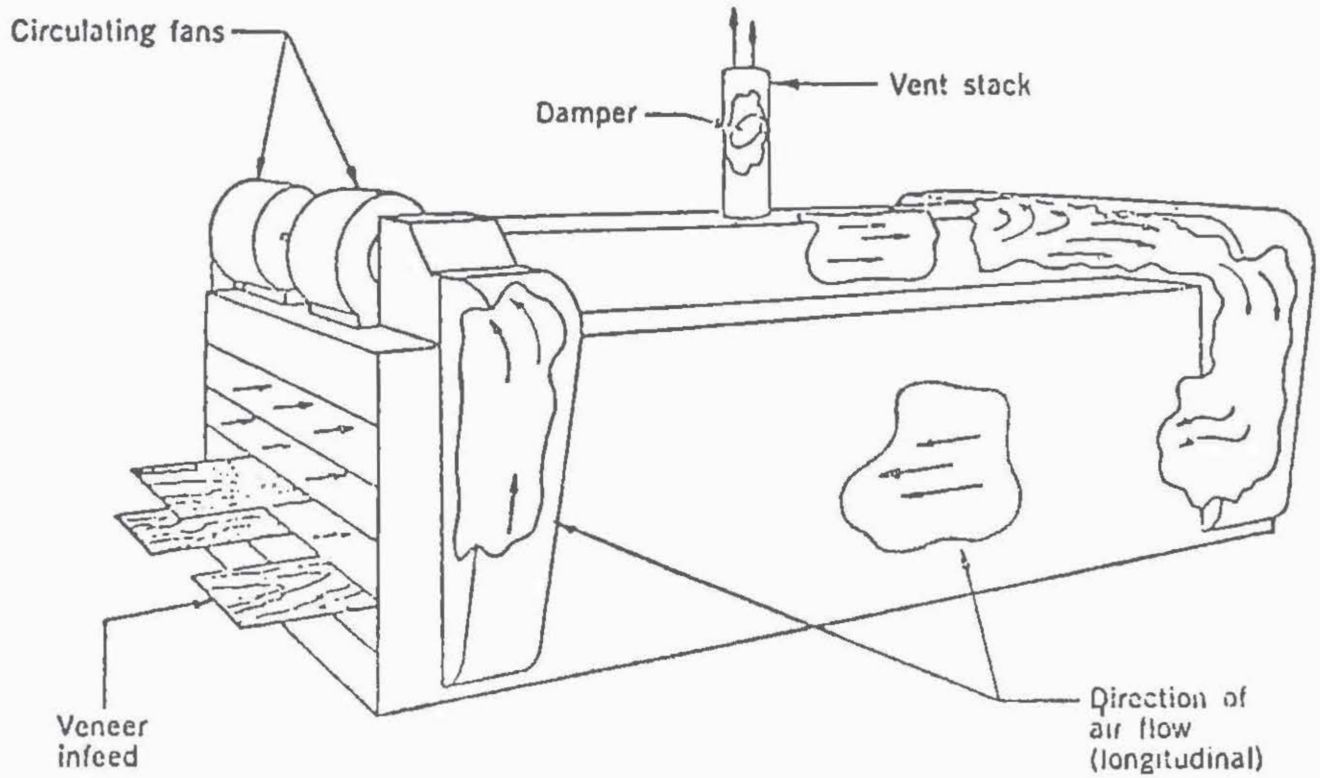


Figure 1 / Veneer Dryer (Single Zone)

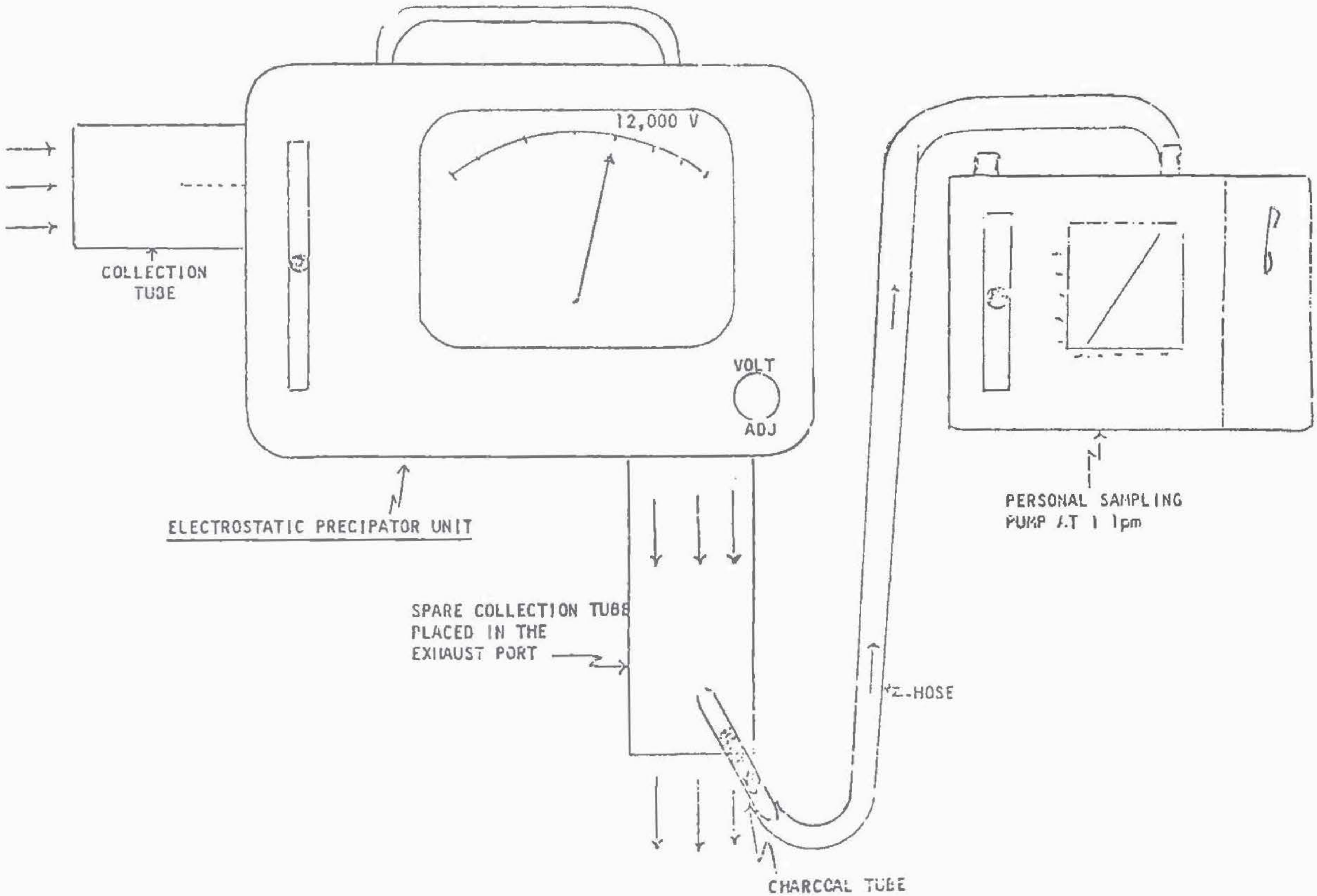


FIGURE 2. SAMPLING SCHEMATIC DIAGRAM

FIGURE 3

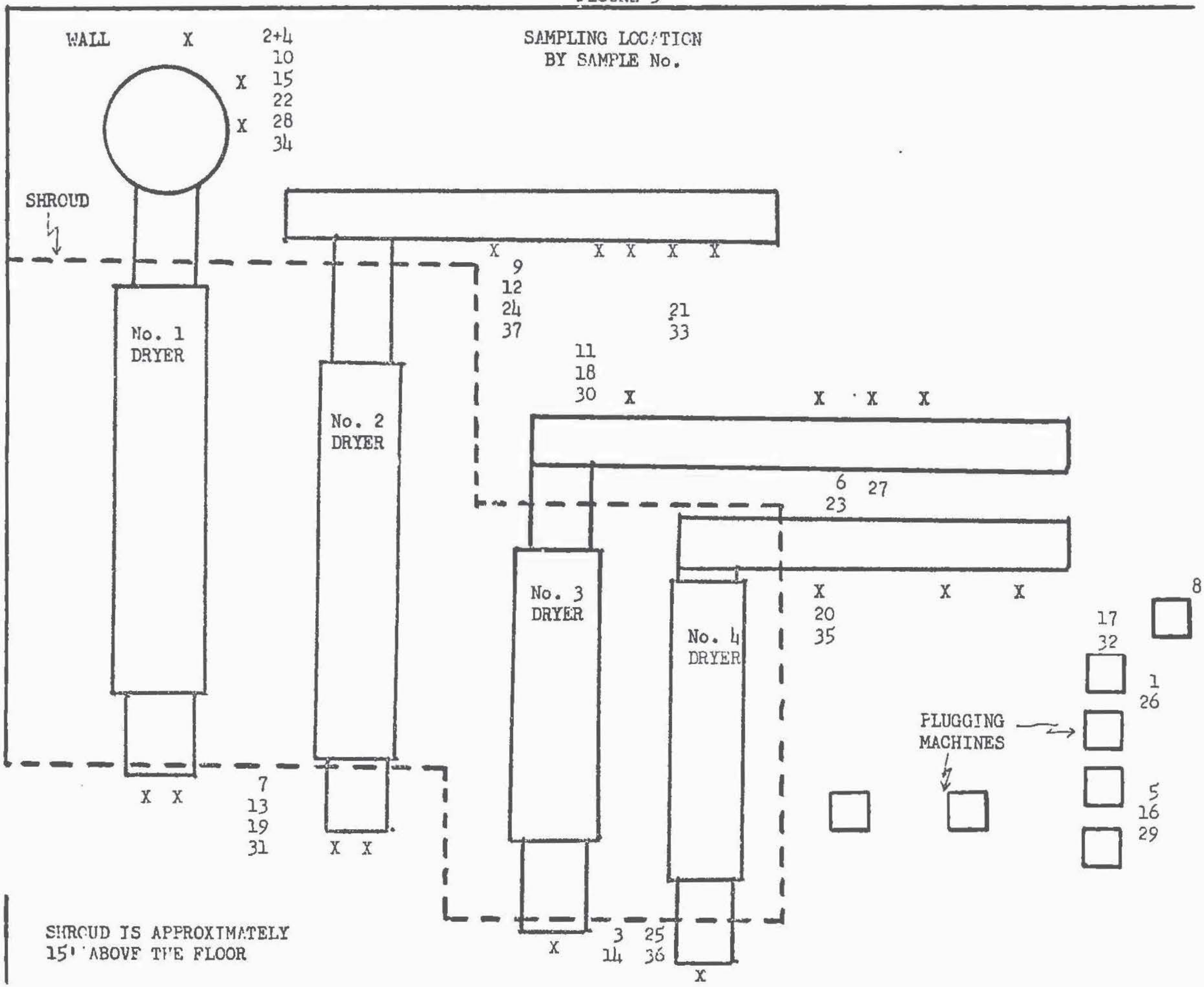

SAMPLING LOCATION
BY SAMPLE No.
WALL
2+4
10
15
22
28
34
SHROUD
No. 1
DRYER
No. 2
DRYER
No. 3
DRYER
No. 4
DRYER
9
12
24
37
21
33
11
18
30
6
23
27
20
35
8
17
32
1
26
5
16
29
PLUGGING
MACHINES
7
13
19
31
3
14
25
36
SHROUD IS APPROXIMATELY
15' ABOVE THE FLOOR

FIGURE 4

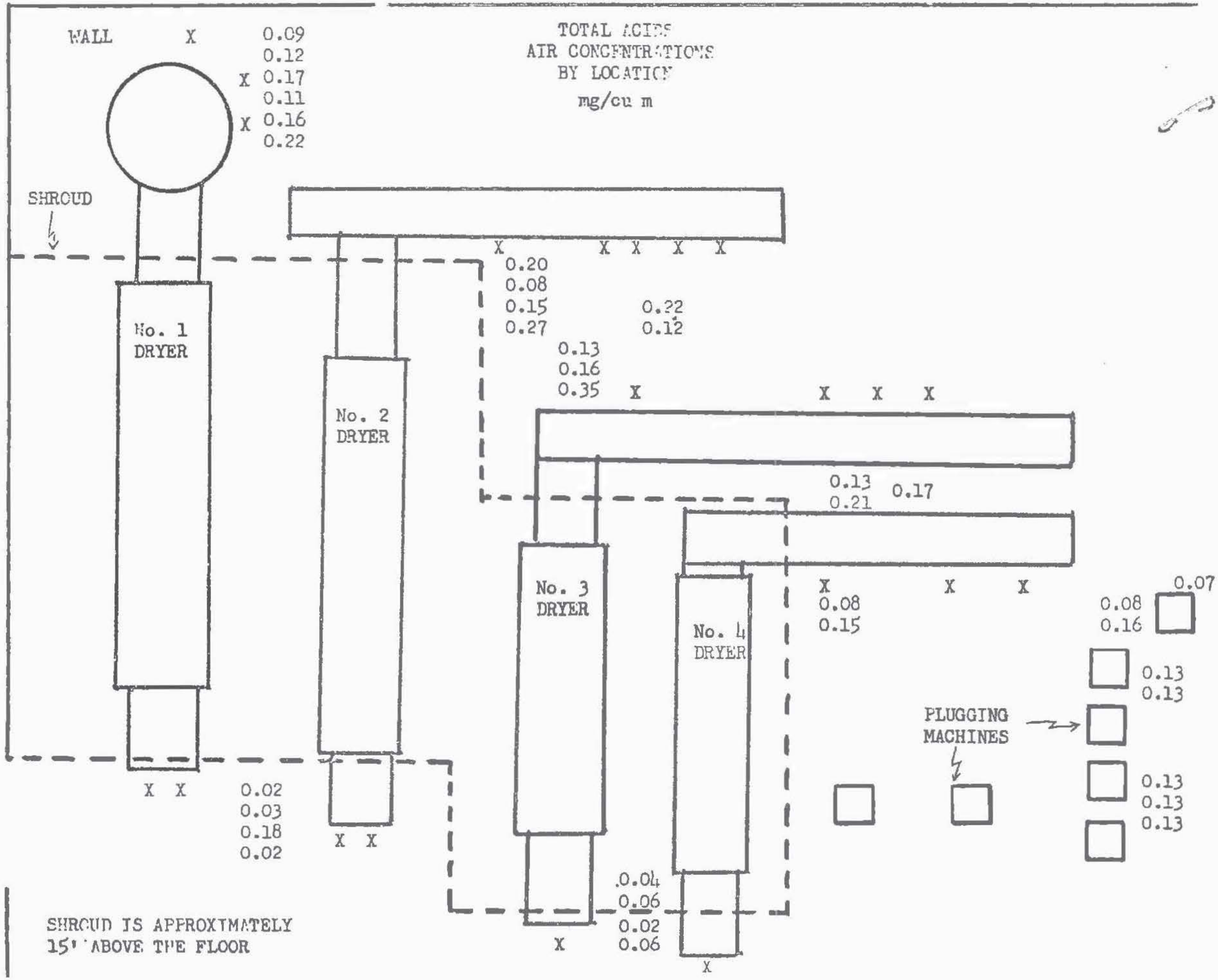
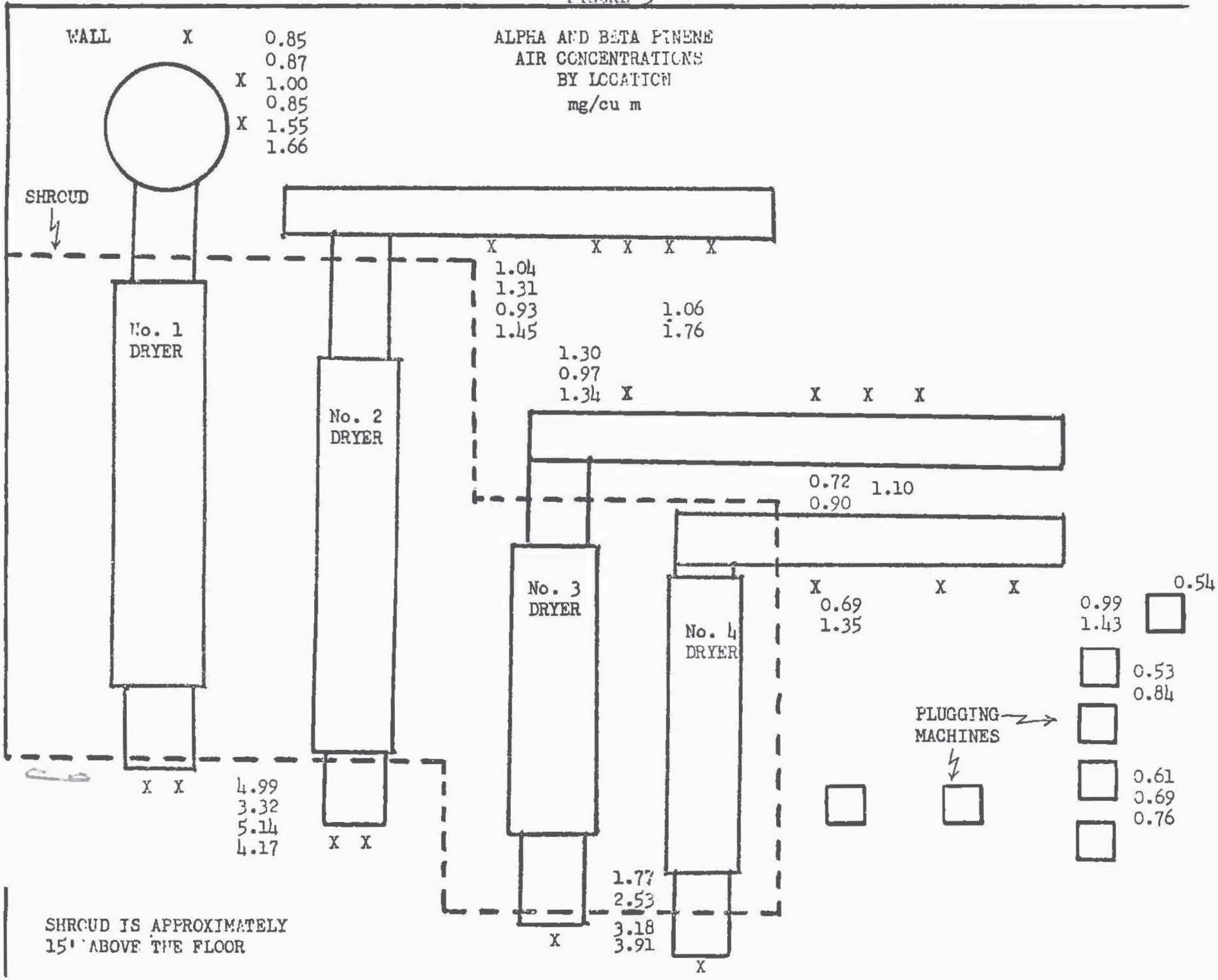

TOTAL ACIDS
AIR CONCENTRATIONS
BY LOCATION
mg/cu m
WALL
X
X
X
0.09
0.12
0.17
0.11
0.16
0.22
SHROUD
X X X X X
0.20
0.08
0.15
0.27
0.22
0.12
0.13
0.16
0.35
X X X X
No. 1
DRYER
No. 2
DRYER
No. 3
DRYER
No. 4
DRYER
0.13
0.21
0.17
X X X
0.08
0.15
0.07
0.08
0.16
0.13
0.13
PLUGGING
MACHINES
0.13
0.13
0.13
X X
0.02
0.03
0.18
0.02
X X
0.04
0.06
0.02
0.06
X
X
SHROUD IS APPROXIMATELY
15' ABOVE THE FLOOR

FIGURE 5


ALPHA AND BETA PINENE
AIR CONCENTRATIONS
BY LOCATION
mg/cu m
WALL
X
0.85
0.87
X 1.00
0.85
X 1.55
1.66
SHROUD
No. 1
DRYER
No. 2
DRYER
No. 3
DRYER
No. 4
DRYER
X X X X X
1.04
1.31
0.93
1.45
1.06
1.76
1.30
0.97
1.34 X
X X X
0.72
0.90
1.10
X X X
0.69
1.35
0.54
0.99
1.43
0.53
0.84
PLUGGING
MACHINES
0.61
0.69
0.76
X X
4.99
3.32
5.14
4.17
X X
1.77
2.53
3.18
3.91
X
X
SHROUD IS APPROXIMATELY
15' ABOVE THE FLOOR