U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION REPORT 73-110-278
EVANS PRODUCTS COMPANY
MISSOULA, MONTANA

APRIL 1976

I. TOXICITY DETERMINATION

It has been determined that veneer dryer emissions which include principally abietic and pimaric acids (condensed hydrocarbons) and, α - and β- pinene (volatile hydrocarbons) present in the vicinity of the veneer dryer operations may produce, under usual working conditions, transient irritation of the mucous membranes of the eyes, nose, and throat as well as the lower respiratory tract producing cough and chest discomfort. Veneer dryer emissions may aggravate any pre-existing asthmatic or other chronic respiratory disease and may make hay fever symptomatically worse. On the day of the NIOSH investigation, five (19%) out of 27 persons reported acute development of symptoms: three reported eye irritation; one reported a stuffy nose. Pre- and post-shift chest auscultations were within normal limits in all cases and did not reveal the new development of rales, rhonchi, or wheezing over the shift.

Baseline pulmonary function tests were within normal limits for all but four persons (15%) tested. Comparison of pre- and post-shift pulmonary function test data revealed small but statistically significant decrements in expiratory flow rates ($FEV_{1.0}$ and MMEF 25%-75%) over the course of the shift. The relationship between these acute changes and any subsequent development of chronic respiratory disease is not known at present. Only a long-term survey with periodic (annual) pulmonary function testing would evaluate this matter completely. There is no evidence from this study to suggest that veneer dryer emissions cause allergic pulmonary disease or hay fever. This determination is based upon a thorough inspection of the veneer dryer operations, environmental measurements, medical interviews and physical examinations, and pulmonary function tests.

Detailed information concerning medical and environmental results of the determination are contained in the body of this report. Recommendations are included which are designed to keep the employee exposure to plywood veneer dryer emissions to a minimum.

II. DISTRIBUTION AND AVAILABILITY

Copies of this hazard evaluation determination report are available upon request from NIOSH, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Copies have been sent to:

(a) Evans Products Company
(b) Authorized Representative of Employees
(c) U.S. Department of Labor - Region VIII
(d) NIOSH - Region VIII

This report shall be posted for a period of approximately 30 days in a prominent place accessible to the 28 affected workers.

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.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from plant management of the Evans Products Company, Missoula, Montana, to evaluate potential exposure to plywood veneer dryer emissions.

IV. HEALTH HAZARD EVALUATION

A. Plant Process

Evans Products Company manufactures plywood. The veneer is peeled in an adjacent area of the plant. The veneer sheets are hand-fed into three 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 only the veneer drying areas.

This company has three steam-heated veneer dryers in operation at the present time. A fourth dryer was not operational. 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 end 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 colatilized from the wood. The hydrocarbons include alcohols, ketones, esters, aldehydes, terpenes, fatty acids and resin acids. These hydrocarbons can be divided into two categories--those that condense at ambient temperatures and those that remain volatile at ambient temperatures.

Previous studies indicate that in Douglas Fir the largest portion of the volatile hydrocarbons consist of α- and β-pinene; and the majority of the condensed hydrocarbons are abietic and pimaric acids.

The contents of the dryer emissions vary with the species of wood being dried; whether it is heartwood or sapwood; and with the percentage of redry veneer, operating temperatures, and operating speed. At the time of this evaluation, fir, larch and spruce were the major types of wood dried at Evans Products. Less than 1% of the wood dried was pine.

B. Evaluation Progress

On July 5, 1973, a health hazard evaluation request was received by the Hazard Evaluation Services Branch. On August 7, 1973, an initial environmental survey was conducted by the NIOSH Regional Industrial Hygienist. It was subsequently decided that a more detailed environmental and medical investigation was necessary.

A literature search and contacts with plywood associations, a plywood manufacturer, and government regulatory agencies revealed that sampling methods to characterize the plywood veneer dryer emissions in the workroom air were not available. It was not known if the existing analytical procedures used for stack sampling were sensitive enough to detect the low levels of hydrocarbons expected around the plywood veneer dryers. Air samples were collected in the plywood veneer dryer area of a similar plant in order to develop sampling and analytical methods. The pinenes

were collected on charcoal tubes, whereas abietic and pimaric acids were collected on fiberglass filters. Analysis of these samples indicated that either the sampling methods were not adequate, the analytical method not sensitive enough, or both. The University of Washington industrial hygiene group, under contract to NIOSH, embarked on a study to determine the optimum sampling and analytical methods. This period of research and development spanned two years--from 1973-75.

As a result, it was determined that the total acids could be collected with an electrostatic precipitator (ESP) and the pinenes could be collected on charcoal tubes after the acids had been removed by the ESP. It was determined that the pinenes could be desorbed from the charcoal tubes by using carbon disulfide and analyzed as turpentine by gas chromatography. The total acids could be removed from the ESP tubes with chloroform and analyzed by infrared techniques.[1,2] Difficulty was encountered in trying to analyze specifically for abietic or pimaric acids; however, it was possible to determine the total acids present. Since the bulk of the total acids are abietic and pimaric acids, it was decided to analyze for total acids and use the average molecular weight of these two acids in determining the concentration present.

C. Evaluation Methods

On November 3-6, 1975, a repeat environmental and medical survey was conducted.

1. Environmental Evaluation

This evaluation consisted of measuring the concentration of α- and β-pinene as turpentine and abietic and pimaric acids as total acids in the area of the plywood veneer dryer workers.

On November 4-5, 1975, samples were collected in the general work area of the plywood veneer feeders, graders and dryer tenders. "Area samples" rather than "personal samples" had to be collected because of the 110 volt AC power requirement for the ESP 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 from the dryer, and spend greater than 90% of their time in the immediate area of the dryer.

a. Total Acids - Fifteen general area acid samples were collected using four Bendix Electrostatic Precipitator 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 ESP tubes were forwarded to the NIOSH Cincinnati laboratory for total acid determination.

b. α- and β-pinenes - Fifteen general area samples were collected on charcoal tubes using MSA 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 by NIOSH for turpentine.

2. Medical Evaluation

On November 3-6, 1975, the medical evaluation was carried out. Since the health hazard evaluation specifically dealt with the veneer dryer emissions, those persons who worked in the areas of the veneer dryers were evaluated. The persons selected included all offbearers, feeders, graders, and dryer tender personnel on the day and evening shifts.

A nondirected and directed questionnaire was administered and focused on possible work-related illness, the acute and chronic symptoms associated with the inhalation of veneer dryer emissions, a short review of systems, a brief allergic history, a smoking history and a review of past medical illnesses. In addition, a short pre- and post-shift questionnaire was administered to evaluate the development of acute symptoms over the course of the shift, that is, those symptoms which were not present at the start of the shift. The pre- and post-shift questionnaires were administered in conjunction with chest auscultation, examination of the mucous membranes, and pulmonary function tests (PFT's). One person refused to participate in the pulmonary function studies.

The acute signs and symptoms of exposure to veneer dryer emissions that were sought included: irritation of the mucous membranes of the eyes, nose, and throat; headache; nausea and/or vomiting; shortness of breath; cough; wheezes and chest discomfort. The chronic symptoms and/or signs that were sought included: development of a new allergy specifically related to veneer dryer emissions; weakness, fatigue, weight loss; chronic cough, sputum production, chest discomfort, and chronic, persistent shortness of breath.

D. Evaluation Criteria

1. Environmental Standards

Currently there are no Federal occupational health standards or any recommended levels for α- or β-pinene, abietic or pimaric acids.

2. Medical Standards

The medical criteria used to determine a toxic response to veneer dryer emissions under investigation consist of the signs and symptoms associated with exposure to the major substances found in the veneer dryer emissions. The veneer dryer emissions consist basically of warm air, water vapor, a small amount of particulate matter, and hydrocarbons. The hydrocarbons consist of two components--those that condense readily on contact with the ambient air and those that remain volatile. Those that remain volatile are principally - and -pinene. Those that are condensed are principally abietic and pimaric acids.[6,7] The literature on these substances is scanty but a review of the current literature is given below:

a. Pinenes: The pinenes are colorless to yellow liquids with the odor of turpentine. They are the major constituents of oil of turpentine. Pinenes have the following physical properties: mol. wt., 136.2; melting point 55°C; flashpoint, 91°F; density, 0.8585 at the 20°C; vapor pressure, 10mm at 37.3°C; vapor density, 4.7. The following information has been obtained from the Hygienic Guide Series on Turpentine.

The toxic properties of the pinenes include:

(1) 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 kidneys and bladder. It has been reported that continued inhalation of the vapor may cause chronic nephritis and predispose to pneumonia. Albuminuria and hematuria have been reported in men exposed to turpentine vapor with subsequent recovery from such exposures.[4] 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.

(2) 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.[3,6,7]

(3) Eye Contact: A vapor concentration of 200 ppm is moderately irritating to the eyes.

b. Abietic Acid: Abietic acid is a yellow powder with the following physical properties: mol. wt., 302-44, melting point, 137-166°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. [3]

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

E. Evaluation Results

1. Environmental Results

Fifteen area samples for total acids and for pinenes were collected at four sampling locations. The samples were collected from 7:00 a.m. until 11:00 p.m. on November 3-4, 1975. The individual sample results for the total acids and pinenes measured as turpentine are listed in Table I. The total acid concentrations ranged from 0.004 to 0.147 mg/M^3. The pinene concentrations (measured as turpentine) ranged from 0.4 to 3.3 mg/M^3.

Over 90% of the employee's time was spent in the general area of the plywood veneer dryers. Therefore, the area samples were considered to be representative of employee exposure to plywood veneer dryer emissions over the course of the work shift.

2. Medical Results

A total of 28 persons were interviewed over the course of two shifts. This group represents all offbearer, feeder, grader, and dryer tender personnel working in the areas of the veneer dryers. There were 23 men and five women evaluated. Table II summarizes the epidemiologic data of this group.

Analysis of the questionnaires revealed no clustering of symptoms, signs or medical illnesses to suggest that individuals working in any one area or operation are affected to a greater extent that individuals in any other area studied.

Table III summarizes that portion of the medical questionnaire pertaining to possible work-related complaints and/or illnesses.

Hay fever was noted by four persons but they did not relate this condition to veneer emissions. However, several noted that veneer dryer emissions would occasionally aggravate their hay fever symptoms. With regard to possible pulmonary allergy due to chronic exposure to veneer dryer emissions, no person reported the development of chest discomfort, wheezing, or shortness of breath while working around the dryers or after the shift upon returning home, either in the past or during the NIOSH study. Six persons noted that the drying of pine veneers was associated with a greater than usual amount of emissions and smoke. Table IV summarizes the employee's past history of mucous membrane irritation, cough, dyspnea, wheezing, and/or chest discomfort related to veneer dryer emissions.

The day of the NIOSH medical study was considered by employees and management to be an average work day. At that time five (19%) of 27 workers reported symptoms; three reported eye irritation; one headache; and one a stuffy nose. Physical examinations were all within normal limits and chest auscultation did not reveal the new development of rales, rhonchi or wheezing over the course of the shift.

Pre- and post-shift pulmonary function tests were carried out employing a Vitalograph spirometer. Five forced expiratory maneuvers were carried out and the "best" curve was chosen and analyzed for forced vital capacity (FVC), forced expiratory volume in one second ($FEV_{1.0}$), and maximal mid-expiratory flow rate (MMEF 25%-75%). These measurements were corrected to body temperature and standard barometric pressure of 760 mm Hg (BTPS). The predicted values for each person were calculated according to formulae that were derived from data obtained from a large group of Mormons and Seventh Day Adventists who resided in Oregon and who had "negative" smoking, pulmonary and occupational histories.[8] The results of these pulmonary function tests along with the predicted values for each subject are presented in Table V. (Note that only 26 subjects are listed since one subject's tracings were technically poor and could not be evaluated.)

The following criteria were used to determine if a significant acute obstructive change occurred over the course of the work shift: an acute decrease in MMEF and/or $FEV_{1.0}$ greater than 10% of the pre-shift value. There were three subjects (18, 24 and 26) whose $FEV_{1.0}$ declined 10% or more over the course of the shift. All were asymptomatic. There were six persons (3, 11, 13, 16, 18 and 22) whose MMEF declined 10% or more over the course of the work shift. None was symptomatic and none gave a history suggestive of acute or chronic lung disease. There was no correlation between the decrements in MMEF or $FEV_{1.0}$ with the number of cigarettes consumed or job location. These changes are difficult to interpret without a group of matched controls. However, there is evidence to suggest that nonspecific irritation may cause transient changes in peripheral airways which might account for these otherwise unaccountable changes in MMEF.

The following criteria were used to diagnose chronic obstructive airways disease: $FEV_{1.0}$ less than 70% of predicted value with normal FVC; and/or MMEF less than 75% of predicted with a normal FVC. Four persons (5, 6, 17 and 21) all long-time, active cigarette smokers without any history of symptoms of chronic bronchitis or emphysema fulfilled these criteria. These persons ranged in age from 30 to 47 years and have been employed at Evans Products from 6 months to 12 years. It is believed that these findings are probably related to chronic cigarette smoking. There were no cases of restrictive lung disease in this population.

Statistical analyses using the paired t-test of mean pre- and post-shift FVC, $FEV_{1.0}$, and MMEF by work shift and smoking habits (Table VI) reveals small but significant decrements in expiratory flow rates over the shift.

V. SUMMARY OF INVESTIGATION AND CONCLUSIONS

A medical and environmental investigation to evaluate the possible relationship of illness and occupational exposure to veneer dryer emissions was carried out. Analysis of the questionnaires revealed that exposure to veneer dryer emissions was frequently associated with mucous membrane irritation as well as a mild but definite increase in airways symptomatology (cough, chest discomfort, shortness of breath, and wheezing). Underlying hay fever and asthma have been exacerbated on occasion by veneer dryer emissions. There is no question that veneer dryer emissions and/or smoke from fires that occasionally break out in the dryers are irritating, depending on the degree of emission intensity. The degree of emission intensity in the area of the dryers is dependent on several environmental factors which include: (1) season of the year--the smoke is reported to be most intense from the end of November to the beginning of March; (2) daily weather conditions--the smoke intensity is greater when the air is heavily laden with moisture, little wind velocity is present, or a temperature inversion occurs; (3) time of day--the smoke intensity is greater in the evening than in the morning; (4) type of wood being dried--certain types of wood contain a lot of pitch, especially pine, and (5) dryer operational procedures--dryer temperature, speed, damper setting, etc.

On the day of the NIOSH study, five persons (19%) out of 27 reported symptoms: three reported eye irritation; one reported a headache; and one reported a stuffy nose. Pre- and post-shift chest auscultations were within normal limits.

Baseline pulmonary function tests were within normal limits for all but four (15%) of the 27 persons tested. These four persons fulfilled the study criteria for chronic obstructive lung disease. Comparison of pre- and post-shift pulmonary function tests revealed small but statistically significant decrements in expiratory flow rates over the course of the shift.

Based on a thorough inspection of the veneer drying operation, medical questionnaires, physical examinations and pulmonary function tests, it is concluded that occupational exposure to veneer dryer emissions under usual working conditions and at the levels found by the NIOSH investigation is associated with transient irritation of the eyes, nose, and throat as well as the upper respiratory tract, producing cough and chest discomfort. Veneer dryer emissions, as well as smoke from fires that occasionally break out in the dryers, may aggravate any underlying asthmatic or other chronic respiratory condition and may make hay fever symptomatically worse. Small but statistically significant decrements in expiratory flow rates ($FEV_{1.0}$ and MMEF 25%-75%), as well as a mild but definite increase in airway symptomatology were associated with exposure to veneer dryer emissions. The relationship between these acute changes and any subsequent development of chronic respiratory disease is not known at present. Only a long-term survey with appropriate, periodic (annual) pulmonary function studies would evaluate this matter completely. It is recommended that NIOSH conduct such a study. There is no evidence from this survey to suggest that veneer dryer emissions cause allergic pulmonary disease or hay fever.

VI. RECOMMENDATIONS:

1. We strongly recommend that the Evans Products Company continue its efforts in improving ventilation control systems in order to reduce employee exposure to veneer dryer emissions.

2. The dryer tender should diligently maintain proper operating conditions (e.g. temperatures,..) of the dryers. Frequent removal of wood splinters and chips would aid in eliminating fires at the dryers.

3. When leaks develop in the dryers, they should be repaired as soon as is practical.

4. Supply (makeup air) should be provided in strategic locations to replace the air being exhausted. Proper placement of the supply air will aid in sweeping the emissions from the work area.

5. It is recommended that a pre-employment history and physical examination be carried out on all new employees assigned to the veneer drying operations. In addition, it is recommended that pre-employment and subsequent periodic (annual) pulmonary function testing (to include FVC, $FEV_{1.0}$, and MMEF 25%-75%) be carried out on all new employees assigned to the veneer dryer operations as well as on the current dryer feeders, off-bearers, and dryer tenders. Individuals with a history of asthma or other chronic respiratory condition should be advised that their underlying respiratory condition or hay fever may be made symptomatically worse by working in close proximity to the veneer dryers.

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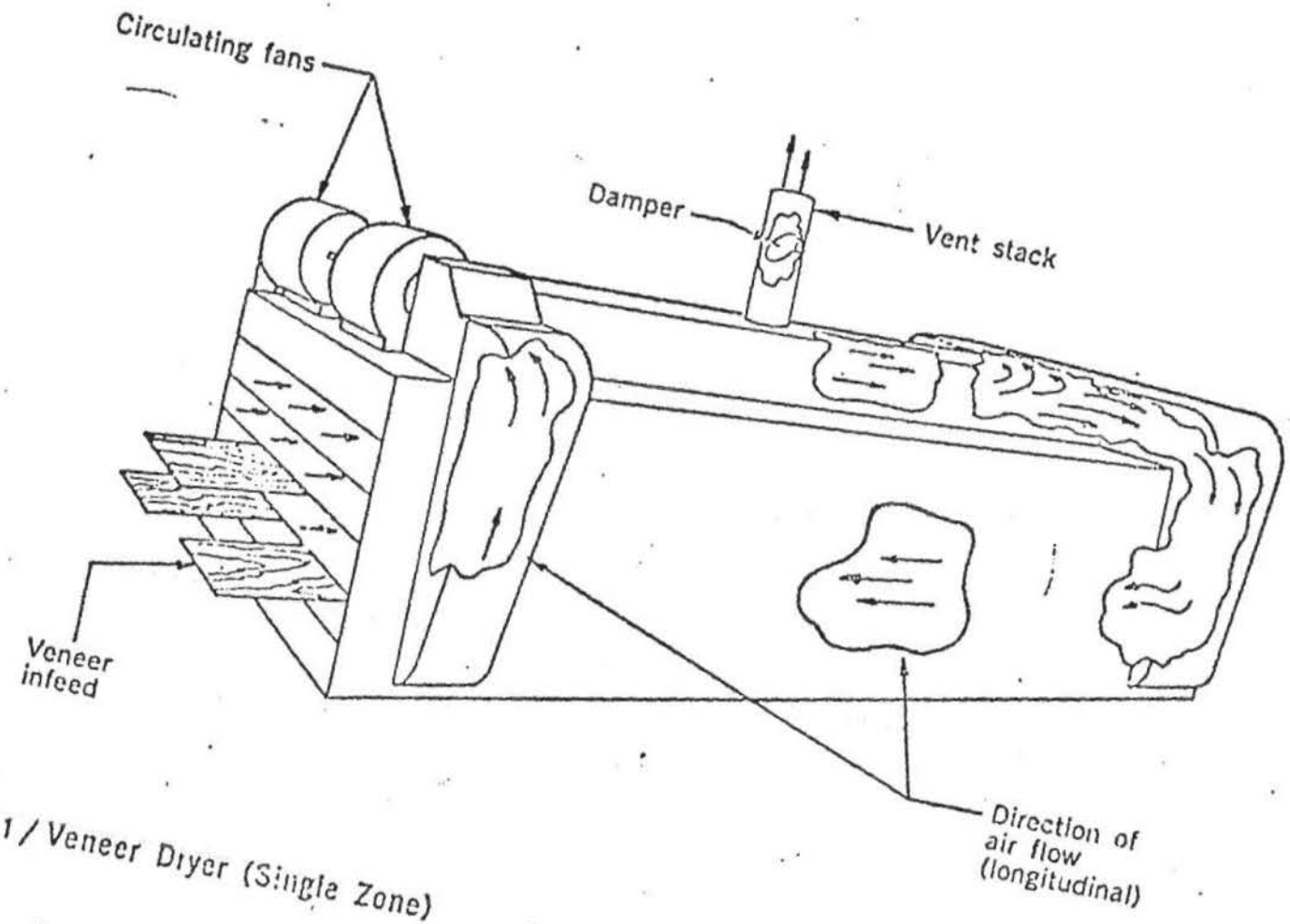

Figure 1 / Veneer Dryer (Single Zone)

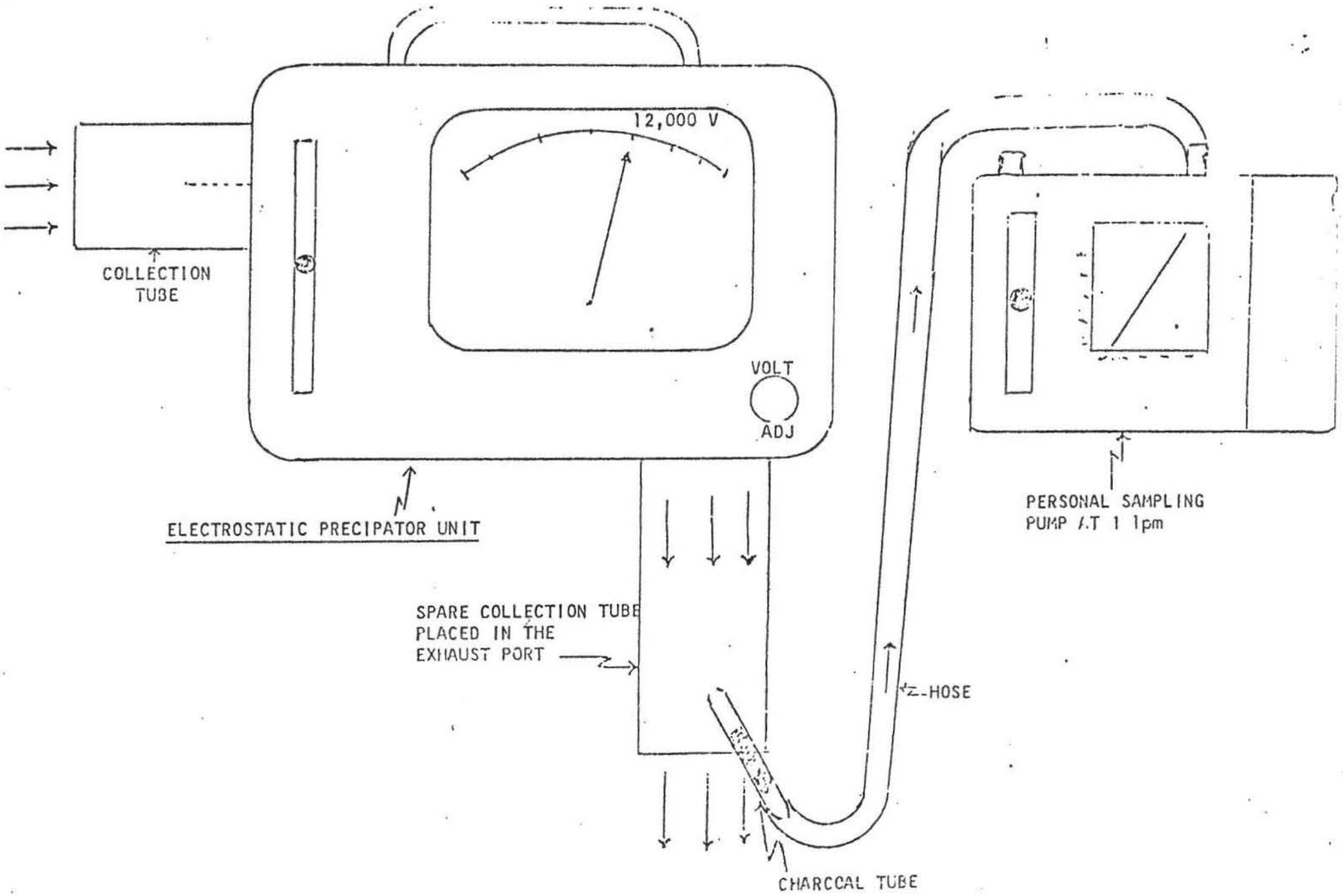

FIGURE 2. SAMPLING SCHEMATIC DIAGRAM

TABLE I

Evans Products Company, Missoula, Montana

November 3-6, 1975

α- AND β- PINENE AS TURPENTINE AND TOTAL ORGANIC ACID CONCENTRATIONS

LOCATION	DATE	SAMPLE PERIOD	TOTAL SAMPLE TIME (MIN.)	TOTAL ACIDS			α- & β-PINENE			TYPE OF WOOD DRIED
				SAMPLE #	SAMPLE VOL. CU. METERS	mg/M^3	SAMPLE #	SAMPLE VOL. LITERS	mg/M^3	
Feeder End #1 Dryer	11-4-75	7:00am - 10:55am	235	21	47.3	0.086	1	235	1.8	Fir-Larch
	11-4-75	10:57am - 3:05pm	248	25	45.6	0.004	5	227	1.5	Larch
	11-4-75	3:05pm - 6:50pm	225	29	45.2	0.102	9	225	2.0	Larch
	11-4-75	6:50pm - 10:30pm	230	33	44.2	0.088	13	220	3.3	Larch-Spruce
Feeder End #3 Dryer	11-4-75	7:10am - 11:00am	230	22	46.2	0.024	2	230	1.8	Fir-Larch
	11-4-75	11:00am - 3:05pm	245	26	49.3	0.063	6	245	1.1	Larch
	11-4-75	3:05pm - 6:54pm	229	30	46.0	0.041	10	289	0.4	Larch-Fir
	11-4-75	6:54pm - 10:30pm	216	34	53.0	0.038	14	216	2.3	Fir
Grader End #3 Dryer	11-4-75	7:05am - 11:05am	240	23	59.8	0.115	3	240	1.3	Fir-Larch
	11-4-75	11:05am - 3:04pm	239	27	58.6	0.063	7	235	0.7	Larch
	11-4-75	3:00pm - 5:35pm	155	31	38.0	0.053	11	155	2.8	Larch-Fir
Grader End #1 Dryer	11-4-75	7:06am - 11:10am	244	24	32.1	0.051	4	244	1.3	Fir-Larch
	11-4-75	11:10am - 3:00pm	230	28	30.4	0.147	8	230	0.6	Larch
	11-4-75	3:00pm - 7:00pm	240	32	32.0	0.089	12	240	0.92	Larch
	11-4-75	7:00pm - 10:30pm	210	36	28.0	0.054	16	210	1.0	Spruce

mg/M^3 = milligrams of substance per cubic meter of air

TABLE II

Summary of Epidemiologic Data

Evans Products Company
Missoula, Montana

November 3-6, 1975

Shift	No.	%	Average Age (Range)	Average Length of Employment at Evans Products (Range)
Day	17	61%	40 yrs. (23-59 yrs.)	9 yrs. (2-15 yrs.)
Evening	11	39%	34 yrs. (18-57 yrs.)	4.5 yrs. (5 mo.-12 yrs.)
TOTAL	28	100%	38 yrs.	7.3 yrs.

TABLE III

Summary of Alleged Work-Related Complaints and/or Illness

Evans Products Company
Missoula, Montana

November 3-6, 1975

Work-Related Symptoms or Complaints - Past or Present		Related To	Allergic History	
Mucous membrane irritation	- 4	Veneer Emissions pine smoke	Hay Fever	- 4
Headache	- 1	Heat and Emissions	Hives	- 1
Skin irritation	- 1	Larch wood	Penicillin Allergy	- 2
None	- 22		Epoxy Glue sensitivity	- 1
TOTAL	- 28		None	- 20

TABLE IV

Evans Products Company, Missoula, Montana
November 3-6, 1975

Past History of Symptoms
Related to Veneer Dryer Emissions

Shift	Eyes	Nose	Throat	Cough	Dyspnea	Wheezing and/or Chest Discomfort
Day (n = 17)	10 (59%)	4 (24%)	7 (41%)	2 (12%)	7 (41%)	2 (12%)
Evening (n = 11)	3 (27%)	2 (18%)	2 (18%)	1 (9%)	0	0
Total Complaints	13 (46%)	6 (21%)	9 (32%)	3 (11%)	7 (25%)	2 (7%)
No Complaints	15 (54%)	22 (79%)	19 (68%)	25 (89%)	21 (75%)	26 (93%)

TABLE V

Evans Products Company, Missoula, Montana
November 3-6, 1975

Pulmonary Function Test Results

Evans Products Company

Subject	PRE-SHIFT FVC (% Pred.)	PRE-SHIFT $FEV_{1.0}$ (% Pred.)	PRE-SHIFT MMEF 25-75% (% Pred.)	POST-SHIFT FVC (% Pred.)	POST-SHIFT $FEV_{1.0}$ (% Pred.)	POST-SHIFT MMEF 25-75% (% Pred.)	PREDICTED VALUES FVC	PREDICTED VALUES $FEV_{1.0}$	PREDICTED VALUES MMEF 25-75%
A. DAY SHIFT									
SMOKERS									
1	6.85 (133)	5.20 (132)	4.13 (102)	6.53 (127)	5.18 (132)	4.46 (110)	5.14	3.93	4.05
2	5.40 (100)	5.10 (125)	7.16 (175)	5.44 (101)	5.12 (125)	7.16 (175)	5.41	4.08	4.10
3	5.90 (104)	4.80 (121)	5.14 (146)	5.90 (104)	4.75 (120)	4.63 (132)	5.70	3.97	3.52
4	5.60 (106)	4.75 (116)	5.29 (124)	5.45 (103)	4.67 (114)	5.29 (124)	5.27	4.09	4.27
5	5.35 (115)	3.86 (111)	2.50 (70)	5.15 (111)	3.80 (109)	2.53 (70)	4.65	3.49	3.59
6	5.96 (113)	3.70 (90)	1.85 (43)	5.80 (110)	3.80 (92)	2.12 (49)	5.29	4.12	4.32
7	4.03 (103)	3.48 (113)	4.08 (118)	3.93 (101)	3.35 (109)	3.96 (114)	3.90	3.07	3.46
8	5.60 (109)	4.42 (113)	3.77 (94)	5.74 (112)	4.40 (113)	3.49 (87)	5.12	3.90	4.00
9	5.44 (129)	4.08 (126)	3.01 (86)	5.45 (129)	4.25 (131)	3.35 (96)	4.23	3.25	3.50
10	4.40 (108)	3.65 (111)	3.78 (101)	4.34 (106)	3.63 (111)	3.68 (98)	4.09	3.28	3.76
11	6.85 (107)	5.55 (115)	5.78 (122)	6.75 (106)	5.50 (114)	5.07 (107)	6.38	4.83	4.74
12	5.28 (124)	4.08 (117)	3.15 (79)	5.24 (123)	4.20 (121)	3.68 (92)	4.26	3.48	3.99
Mean	5.56	4.39	4.14	5.48	4.39	4.12			
SD ±	0.82	0.68	1.50	0.79	0.67	1.34			
NONSMOKERS									
13	5.02 (101)	4.10 (108)	3.90 (98)	4.93 (99)	4.14 (109)	3.12 (79)	4.97	3.81	3.96
14	5.28 (114)	4.20 (120)	3.50 (97)	5.28 (114)	4.19 (120)	3.41 (95)	4.65	3.49	3.59
15	5.45 (108)	4.46 (112)	4.30 (100)	5.20 (103)	4.38 (110)	4.68 (109)	5.05	4.00	4.31
16	5.05 (109)	3.95 (120)	3.52 (112)	4.88 (105)	3.72 (113)	2.82 (90)	4.64	3.29	3.15
Mean	5.20	4.18	3.81	5.07	4.11	3.51			
SD±	0.20	0.21	0.38	0.20	0.28	0.38			

TABLE V (Cont'd)

Subject	PRE-SHIFT FVC (% Pred.)	PRE-SHIFT $FEV_{1.0}$ (% Pred.)	PRE-SHIFT MMEF 25-75% (% Pred.)	POST-SHIFT FVC (% Pred.)	POST-SHIFT $FEV_{1.0}$ (% Pred.)	POST-SHIFT MMEF 25-75% (% Pred.)	PREDICTED VALUES FVC	PREDICTED VALUES $FEV_{1.0}$	PREDICTED VALUES MMEF
B. SWING SHIFT									
SMOKERS									
17	5.45 (102)	3.97 (95)	2.69 (61)	5.30 (99)	3.97 (95)	2.89 (66)	5.34	4.19	4.41
18	7.50 (129)	6.28 (137)	6.43 (133)	7.24 (125)	5.83 (127)	5.14 (107)	5.81	4.59	4.82
19	6.00 (106)	5.21 (113)	5.34 (107)	6.05 (107)	4.97 (108)	5.26 (105)	5.67	4.60	4.99
20	5.65 (101)	5.15 (117)	7.44 (161)	5.52 (99)	5.03 (114)	7.16 (155)	5.59	4.41	4.63
21	3.72 (88)	2.82 (84)	2.17 (58)	3.69 (87)	2.94 (87)	2.48 (66)	4.25	3.37	3.73
Mean	5.66	4.69	4.81	5.56	4.55	4.59			
SD ±	1.09	1.08	2.18	1.02	0.89	2.21			
NON-SMOKERS									
22	4.60 (91)	3.77 (97)	3.65 (89)	4.90 (97)	3.88 (99)	3.27 (80)	5.05	3.90	4.09
23	4.40 (94)	3.63 (108)	3.56 (110)	4.27 (91)	3.60 (107)	3.86 (119)	4.69	3.36	3.24
24	5.68 (129)	4.42 (135)	3.69 (109)	5.08 (115)	4.08 (125)	3.86 (115)	4.40	3.27	3.37
25	4.78 (133)	3.98 (140)	3.76 (113)	4.63 (129)	3.91 (137)	4.26 (128)	3.60	2.85	3.34
26	4.55 (121)	4.00 (136)	3.78 (112)	4.28 (114)	3.67 (124)	4.19 (124)	3.76	2.95	3.37
Mean	4.80	3.96	3.69	4.63	3.83	3.89			
SD ±	0.51	0.30	0.09	0.36	0.19	0.39			

TABLE VI

ANALYSIS OF PULMONARY FUNCTION DATA
EVANS PRODUCTS COMPANY
MISSOULA, MONTANA
NOVEMBER 3-6, 1975

Category	Mean Pre-Shift	Mean Post-Shift	%Δ Over-Shift	p Value
A.M. Shift				
NON-SMOKERS (N=4)				
FVC	5.20	5.07	- 2.50%	.0977*
FEV	4.18	4.11	- 1.67%	.3190
MMEF	3.81	3.51	- 7.87%	.3577
A.M. SMOKERS (N=12)				
FVC	5.56	5.48	- 1.44%	.0478**
FEV	4.39	4.39	0%	.9493
MMEF	4.14	4.12	- 0.48%	.8640
A.M. TOTAL (n=16)				
FVC	5.47	5.38	- 1.65%	.0073**
FEV	4.34	4.32	- 0.46%	.4530
MMEF	4.05	3.97	- 1.98%	.4103
SWING SHIFT				
NON-SMOKERS (N=5)				
FVC	4.80	4.63	- 3.54%	.3047
FEV	3.96	3.83	- 3.28%	.2085
MMEF	3.69	3.89	+ 5.42%	.2669
SMOKERS (n=5)				
FVC	5.66	5.56	- 1.77%	.1216
FEV	4.69	4.55	- 2.99%	.2335
MMEF	4.81	4.59	- 4.57%	.4686
SWING TOTAL (n=10)				
FVC	5.23	5.10	- 2.49%	.0949*
FEV	4.32	4.19	- 3.01%	.0583**
MMEF	4.25	4.24	- 0.24%	.9357
ALL SMOKERS (n=17)				
FVC	5.59	5.50	- 1.61%	.0084**
FEV	4.48	4.43	- 1.12%	.2588**
MMEF	4.34	4.26	- 1.84%	.4730
ALL NON-SMOKERS (n=9)				
FVC	4.98	4.83	- 3.01%	.0942*
FEV	4.06	3.95	- 2.71%	.0861*
MMEF	3.74	3.72	- 0.53%	.9054
GRAND TOTAL (n=26)				
FVC	5.38	5.27	- 2.04%	.0029**
FEV	4.33	4.27	- 1.39%	.0428**
MMEF	4.13	4.07	- 1.45%	.5121

*Near Significant, p greater than 0.05
**Significant, p less than 0.05