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 NO. 73-57-243

U.S. PLYWOOD-CHAMPION
LEBANON, OREGON

DECEMBER 1975

I. TOXICITY DETERMINATION

It has been determined that veneer dryer emissions, principally abietic and pimaric acids (condensed hydrocarbons) and α- and β- pinene (volatile hydrocarbons), present in the vicinity of the veneer dryer operations, under usual working conditions and at the levels found by NIOSH investigators, may cause transient irritation of the mucous membranes of the eyes, nose and throat as well as the upper respiratory tract producing cough and chest discomfort. On the day of the NIOSH investigation, eight (8) persons out of 37 (22%) reported the acute development of the following symptoms: six (6) persons reported mucous membrane irritation; 3 reported headache; and 2 reported cough and shortness of breath. Pre- and post-shift chest auscultations were within normal limits in all cases and did not reveal the development of rales, rhonchi, or wheezing over the shift. Baseline pulmonary function tests were within normal limits for all but six (6) persons (18%) tested. Comparison of pre- and post-shift pulmonary function tests revealed small but statistically significaly decrements in expiratory flow rates ($FEV_{1.0}$ and MMEF 25-75%) over the course of the usual work shift. The relationship between these acute changes and any subsequent development of chronic respiratory disease is not known at the present time; and only a long-term survey with periodic (annual) pulmonary function testing would evaluate this matter completely. There is no evidence from the present 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, physical examinations, and pulmonary function tests.

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

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202.

Copies have been sent to:

a. U.S. Plywood-Champion, Lebanon, Oregon
b. Authorized Representative of Employees
c. U.S. Department of Labor - Region X
d. NIOSH - Region X
e. Oregon State Accident Prevention Division

For the purposes of informing the approximately 180 workers, the employer will promptly "post" the Determination Report in a prominent place(s) near where affected employees work for a period of 30 calendar days.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S. Code 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 a Health Hazard Evaluation request from a representative of employees regarding exposure of the feeders, graders, and dryer tenders to veneer dryer emissions at the U.S. Plywood-Champion, Lebanon, Oregon.

IV. HEALTH HAZARD EVALUATION

A. Description of Plant Processes

The U.S. Plywood-Champion manufactures plywood. The green veneer is peeled in an adjacent area of the plant. The veneer sheets are hand-fed into continuous-feed, steam-heated or gas-heated veneer dryers which dry the veneer to a predetermined moisture content. As the veneer exists from the dryer the veneer sheets are removed and graded. The veneer is then joined, patched, and assembled into plywood panels which are then glued, pressed, trimmed, sanded and graded. This request involves only the veneer drying areas.

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 diagram of a 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 volatilized from the wood. The hydrocarbons include alcohols, ketones, esters, aldehydes, terpenes, fatty acids, resin acids, and others. These can be put 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 consisted of α - and β-pinene and the majority of the condensed hydrocarbons were abietic and pimaric acids.

The contents of the emissions varied with the species of wood being dried, whether it is heartwood or sapwood, the percentage of re-dry veneer, operating temperatures, and operating speed.

B. Evaluation Progress

On August 23, 1973, an initial environmental survey was conducted by Arvin Apol, Regional Industrial Hygienist and William L. Wagner, Regional Industrial Hygienist. It was subsequently decided that a more detailed environmental and medical investigation was necessary.

A literature search, contacts with the plywood associations, a plywood manufacturer, and governmental regulatory agencies revealed that sampling methods to characterize the veneer dryer emissions in the workroom air were not available. Also, it was not known if the existing analytical procedures used for stack sampling were sensitive enough to detect the low levels of hydrocarbons expected in the work atmosphere.

Air samples were collected in the veneer dryer area of a similar plywood plant in order to develop the sampling and analytical method. The pinenes were collected on charcoal tubes and abietic and pimaric acids were collected on fiberglass filters. Analysis of the samples indicated that either the sampling methods were not adequate, the analytical methods were 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 to 1975.

It was determined that the total acids could be collected with an electrostatic precipitator (ESP) and the pinenes collected on charcoal tubes after the acids have been removed by the ESP unit.

It was determined that the pinenes could be desorbed from the charcoal using carbon disulfide and analyzed on a gas chromatograph. It was also determined that the total acids could be removed from the ESP tube with chloroform and analyzed using infrared techniques. Difficulty was encountered in trying to analyze specifically for abietic and pimaric acids; however, it was possible to determine the total acids present. Since the bulk of the total acids [2,5] (no percentages given) are abietic and pimaric acids, it was decided to analyze for total acids and use the average molecular weights of these two acids in determining the concentration present.

C. Evaluation Methods

On April 17-18, 1975, a repeat environmental medical survey was conducted by Dr. Robert A. Rostand, NIOSH medical officer, and Arvin Apol, Regional Industrial Hygienist.

1. Environmental Evaluation

The evaluation consisted of measuring the concentrations of α- and β - pinenes and abietic and pimaric acids in the approximate area of the veneer dryer workers. The pinenes comprise 75 to 90% of the volatile material in Douglas Fir [2,5] and abietic and pimaric acids comprise the bulk of the condensible material[2,5]. A major portion of the wood dried in this plant is Douglas Fir.

On April 17-18, 1975, samples were collected in the general work area of the veneer feeders, graders, and dryer tenders. Area samples had to be collected because of the 110 volt AC power requirement for the electrostatic precipitator units; however, it was felt that they would be representative since the persons involved generally work 25 to 40 feet from the dryer, and spend greater than 90% of their time in the immediate area of the dryers. During the sampling period, Douglas Fir was being dried in dryers one through seven except for 1 and 3/4 hours when White Fir was being dried in the number seven dryer.

The weather these two days was overcast, 45° to 55°F with intermittent drizzle. Workers were asked to record how much time was spent out of the general area of the veneer dryers.

a. Total acids - Sixteen 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 tubes were capped with polyethylene caps and sent to the University of Washington Industrial Hygiene Laboratory. The acids were removed from the tubes with chloroform and analyzed on a Beckman IR4 infrared

spectrophotometer at a wavelength of 5.85 u. (See attachment 1 for a complete description of the analytical method used). The sample times varied from 3 and 1/2 hours to 4 hours each.

b. α - and β -pinenes - Sixteen general area samples were collected on charcoal tubes using MSA personal sampling pumps at a flow rate of 1.01 pm. The samples were collected in the exhaust of the ESP units since the acids, if not removed, interfere with the adsorption of the pinenes on the charcoal. (See Figure 2 for a diagram of the sampling train). The charcoal tubes were capped with polyethylene caps and sent to the University of Washington Industrial Hygiene Laboratory The pinenes were desorbed from the charcoal with carbon disulfide and analyzed using gas chromatographic techniques. (See attachment 2 for complete description of the analytical methods used.) The sample time varied from 3 and 1/2 hours to 4 hours.

2. Medical Evaluation

On April 17-18, 1975, a concurrent medical evaluation was carried out. Since the Health Hazard Evaluation request specifically dealt with veneer dryer emissions, only those persons who work in the area of the seven dryers were evaluated. U.S. Plywood-Champion employs approximately 180 persons involved in the manufacture of plywood. This number includes the following job classifications: jitney driver, dryer grader, raimann grader, pressman and pressman helper, edge gluer, sheet layer helper, dryer tender, glue mixer, string machine operator, defect cutter and dryer feeder. It was decided that only the following persons would be interviewed since they would have the greatest exposure to veneer dryer emissions: dryer graders, dryer feeders, dryer tenders and dryer utility men. In this group there is a total of 67 persons who may be grouped as follows:

Dryer Grader	37	(55%)
Dryer Utility	6	(10%)
Dryer Feeder	17	(25%)
Dryer Tender	7	(10%)
Total	67	(100%)

Fifty-nine persons (88%) were initially interviewed employing a non-directed questionnaire which focused on possible work-related illness, the acute and chronic symptoms of veneer dryer emission inhalation, a short review of systems, a brief allergic history, a smoking history, an occupational history, and a review of past medical history. The acute signs and/or symptoms of exposure to veneer dryer emissions that were sought included: irritation of mucous membranes of eyes, nose, and throat, headache, nausea and/or vomiting, shortness of breath, cough, wheezing, and chest discomfort. The chronic symptoms and/or signs that

were sought included: development of a new allergy related to veneer dryer emissions, weakness, fatigue, weight loss, chronic cough, sputum production, chest discomfort and chronic shortness of breath. In addition, each person was asked to record how much time was spent out of the area of the veneer dryers as well as how many cigarettes were consumed during the shift.

From the original group of 59 persons, 40(68%) were selected for further studies which included pulmonary function tests, questionnaires, and chest auscultation. Persons with a history of symptoms that they clearly related to veneer dryer emissions as well as persons with a history of asthma or other chronic lung diseases, hay fever, or other medical illnesses that might be aggravated by veneer dryer emissions and who might show changes on pulmonary function testing were selected for further study. Persons with otherwise unremarkable histories were also included.

D. Evaluation Criteria

1. Environmental Standards

There are currently no occupational health standards or recommended levels at this time for α- and β- pinene or for abietic and 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 emissions of Douglas and White Firs. The intensity of veneer dryer emissions may vary with the variety of wood, whether it is heart or sapwood; the percentage of wood for re-dry; and the dryer temperature and speed.

The major substance found in veneer dryer emissions of Douglas and White Firs are: alpha- and beta-pinenes, abietic acid and pimaric acid. The literature on these compounds is scanty and incomplete.[6]

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, M.P. 55°C., B.P. 155°C., flashpoint 91°F, density 0.8585 at 20°C., vapor pressure 10 mm at 37.3°C, vapor density 4.7. The following information has been quoted 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. 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) 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 is 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.

c. Pimaric Acid: No information is available on this agent either in the standard references or in Chemical Abstracts. It is not listed in the NIOSH Toxic Substance List.

E. Evaluation Results

1. Environmental Results

Sixteen (16) samples were collected at four sampling locations for total acids and sixteen for pinenes. The samples were collected during the 4:00 p.m. to midnight shift on April 17 and the 8:00 a.m. to 4:00 p.m. shift on April 18. The individual sample results for the total acids and pinenes are listed in Table I. The total acid concentrations ranged from 0.02 mg/m^3 to 1.25 mg/m^3 with an average of 0.21 mg/m^3 and a median of 0.17 mg/m^3. The pinene concentrations ranged from 0.04 parts of contaminant per million parts of air (ppm) to 1.97 ppm with an average of 0.63 ppm and a median of 0.32 ppm.

Employees were asked to note how much of their time they spent out of the general area of the dryers. Review of these records revealed that employees spent on the average 40-50 minutes out of the area of the dryers; over 90% of their time was spent in the area of the dryers. Consequently, these area samples are representative of employee exposure to veneer dryer emissions over the course of the shift.

No correlation was found between the acid and pinene concentrations collected at the same time (e.g., they were not present in a fairly constant ratio; therefore, it cannot be predicted what the pinene concentrations would be by looking at the total acid concentrations or vice versa). In general, the pinene concentrations were significantly higher in the feeder end of dryers 1-6 than at the grader end of the dryers while the acid concentrations were about the same.

Each dryer is located under a saw-tooth portion of the roof with each saw-tooth section having two or more electric powered fans. Next to these fans, window sections were open. It was observed by the investigators that the emissions were being exhausted by the fans but were re-entering through the open windows several feet away.

2. Medical Results

The following table summarizes the epidemiologic data of all persons interviewed by NIOSH investigators:

Operation	No.	%	Average Age Range	Average Length of Employment at U.S. Plywood Range
Grader	33	56%	42.6 yr. (19 yr. - 64 yr.)	9.8 yr. (1 Mo. - 31 yr.)
Utility	3	5%	55.3 yr. (48 yr. - 59 yr.)	12.6 yr. (3 yr. - 24 yr.)
Feeder	17	29%	39.3 yr. (20 yr. - 57 yr.)	8.6 yr. (6 mo. - 25 yr.)
Tender	6	10%	45.4 yr. (28 yr. - 60 yr.)	18.4 yr. (1 yr. - 34 yr.)
TOTAL	59	100%		

Fifty-nine persons were interviewed of whom 57 were men and two were women. Analysis of the questionnaires reveals no obvious clustering of symptoms, signs or medical illnesses to suggest that individuals working in any one operation or any one dryer are affected by veneer dryer emissions to a greater extent than individuals working in other areas or operations. However, several persons did mention that dryer #7 produced, on occasion, more emissions than other dryers. Analysis of the questionnaires with regard to smoking and non-smoking reveals no clustering of signs or symptoms with regard to veneer dryer emissions.

An analysis of the questionnaires was carried out and the results have been summarized (Table II). With regard to work-related problems or complaints, several individuals reported that they had chronic obstructive pulmonary disease. (Note: The term chronic obstructive pulmonary disease, hereafter called COPD, includes the following diagnoses: chronic bronchitis, emphysema, and asthma.) Seven cases of COPD, four cases of asthma and three cases of emphysema or chronic bronchitis were reported. None of the cases of asthma were clearly related to veneer dryer emissions although several persons noted that veneer dryer emissions might, on occasion, aggravate the underlying lung disease with resultant cough and/or chest discomfort. In addition, several persons noted that their hay fever (seasonal pollinosis) was, on occasion, aggravated by veneer dryer emissions. Headache was not a common complaint related to veneer dryer emissions. Two persons noted they had gotten sawdust in their eyes with resultant irritation. "Miscellaneous" problems included cases of hernia, peptic ulcer disease, decreased hearing, and other medical problems not related to veneer dryer emissions.

Nine cases of hay fever, two cases of allergy to Red Cedar Dust, and one case of epoxy glue allergy were reported. The most common cause of the hay fever was allergy to pollens, dust, feathers, and grasses. Red Cedar Dust as well as epoxy glues are known allergens.

A past history of mucous membrane irritation related to veneer dryer emissions was commonly noted by workers; 49% noted eye irritation, 34% noted nose irritation, 15% noted throat irritation and 14% noted cough. or other upper respiratory tract symptoms. "Smoke" was the most common cause of mucous membrane irritation reported. By smoke, it is inferred that most workers meant veneer dryer emissions; however, "dust" was not clearly defined in many cases. Several individuals noted that White Fir, Noble Fir, and Pine produced more "smoke" when dried than other wood and that dryer #7 produced more emissions than other dryers.

Seventeen persons--nine persons with acute chest symptoms related to dryer emissions and eight persons with cough or 17/59 (29%) -- gave a history of having developed in the past acute symptoms (cough, chest discomfort, wheezing, or shortness of breath) which they related to veneer dryer emissions. By far the commonest complaint was cough which was always transient and did not require medical consultation. Symptoms did not develop after the shift and suggest transient respiratory tract irritation rather than allergy to dryer emissions.

From the original group of 59 persons, 40 were selected for further studies. This group consisted of 24 graders, 11 feeders, 3 tenders and 2 utility men. There are no significant differences between this group and the original 59 from which they were selected when age and length of service are considered. Three persons refused to participate in subsequent pulmonary function testing; thus, only 37 participated in the follow-up studies which included pre- and post-shift questionnaires, chest auscultation and pulmonary function tests (PFT).

Eight persons out of 37 (22%) reported symptoms on the day of the NIOSH visit which was judged by management and the employees as a usual day. The following acute complaints were noted:

mucous membrane irritation	- 6
headache	- 3
cough, shortness of breath, wheezing	- 2

These complaints were not clustered in any one area or in any group of employees. The cause of cough, shortness of breath and wheezing was reported to be veneer dryer emissions. Of the two subjects (#5, #17) with these symptoms, #17 was known to have COPD by PFT criteria.

Pre- and post-shift chest auscultations were within normal limits in all cases and did not reveal the 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 meneuvers were carried out and the "best" curve was chosen and analyzed for forced vital capacity (FVC), forced expiratory volume in 1 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 the formulae of Morris, Koski and Johnson 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. [12] The results of these pulmonary function tests along with the predicted values for each subject are contained in Table III. (Note that only 33 subjects are listed since 4 subject's tracings were technically poor and cannot be evaluated.)

The following criteria were used to determine if a significant acute 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. One subject (#5) had an 11% drop in $FEV_{1.0}$ over the shift; in addition, this subject, as noted above, reported chest discomfort and wheezing due to dryer emission during the shift. The MMEF in this case could not be determined for technical reasons. There were nine subjects (#1, 2,7,8, 9,11,12,15, and 26) whose tests showed an average drop in MMEF of 15% (range: 11% - 20%). Of these, six were non-smokers and three were smokers; and only one gave a history of antecedent asthma. Although eight out of nine persons with acute changes in MMEF worked on the day shift, there was no correlation between acute change in MMEF and number of cigarettes consumed, time in area, job location, concentration of α - or β - pinene and total acids as measured environmentally, the development of symptoms or work shift. 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 their otherwise unexplicable changes in MMEF.

The following criteria were used to diagnose obstructive lung disease: $FEV_{1.0}$ less than 70% predicted value with a normal FVC; and/or MMEF less than 75% of predicted. Five subjects (#10, 17,18,19 and 24) fulfilled these criteria. Only one subject (#10) was a non-smoker; the remainder were all active tobacco users. One subject (#16) had PFT results consistent with early restrictive as well as obstructive lung disease. Two new cases of early obstructive lung disease (#10, 19) were found and three cases (#18, 24, 17) were confirmed.

Analysis of the mean pre- and post-shift FVC, $FEV_{1.0}$ and MMEF by work shift and smoking habit (Table IV) reveals small but statistically significant decrements in expiratory flow rates over the shift.

G. Summary of Investigations and Conclusions

A medical and environmental investigation to evaluate the possible relationship illness and occupational exposure to veneer dryer emissions were carried out. Analysis of the questionnaires revealed that exposure to veneer dryer emissions has been 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 ladened with moisture, little wind velocity present, or a temperature inversion; (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 settings, etc.

On the day of the NIOSH visit, which was considered by all parties to be a usual work day, eight (8) persons out of 37 (22%) reported the acute development of the following symptoms: 6 persons reported mucous membrane irritation; 3 persons, headache; and 2 persons, cough and shortness of breath. Pre- and post-shift chest auscultations were within normal limits and did not reveal the new development of rales, rhonchi, or wheezing over the course of the shift.

Baseline pulmonary function tests were within normal limits for all but six (6) persons (18%) tested. These 6 persons fulfilled the study's criteria for 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 work shift.

Analysis of the environmental data reveals that the concentrations of α- and β- pinenes were significantly higher at the feeder end of dryers #1 and 6 than at the grader end of the dryers while the total acid concentrations were about the same. However, no medical correlation of acute symptoms or PFT changes could be made with these environmental data.

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 as well as a mild but definite increase in airways 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 the present time; and only a long-term survey with periodic (annual) pulmonary function studies would evaluate this matter completely. There is no evidence from this survey to suggest that veneer dryer emissions cause allergic pulmonary disease or hay fever.

V. RECOMMENDATIONS

1. It is strongly recommended that suitable ventilatory changes be carried out so that employee exposure to veneer dryer emissions be reduced to a level below that found by the NIOSH investigation.

2. The dryer tender is an important man in controlling the dryer emissions. An increased emphasis in this area should aid in keeping the dryer emissions to a minimum.

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

4. Each dryer (#1-6) is located under a sawtooth portion of the roof which contains windows and electric powered fans. Re-entry of smoke and haze into

the building through the open windows was observed. The windows should be kept closed to prevent re-entry of the emissions. This will also permit more of the air to sweep across the dryers to aid in removal of the emissions. Increasing the exhaust volume, either by increasing the fan speed (if it is possible) or by the addition of more fans, will aid in keeping the veneer emissions out of the work area; however, the total effect is difficult to estimate.

5. 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.

6. The general ventilation in the area of number 7 dryer appears minimal. Increasing the exhaust volume over the dryers should aid in removal of the emissions from the work area.

7. 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 may be made symptomatically worse by working in close proximity to the veneer dryers, and individuals with a history of hay fever or asthma and other chronic respiratory conditions may find the use of an organic carteridge respiratory helpful under certain circumstances.

VI. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:	Robert A. Rostand M.D. Medical Services Branch
	Arvin Apol Regional Industrial Hygienist Region X Seattle, Washington
Originating Office:	Jerome P. Flesch, Chief Hazard Evaluation Services Branch Cincinnati, Ohio
Nurse Consultant	Eileen Philbin, R.N. Occupational Health Nurse Medical Services Branch
Industrial Hygienist	Bobby J. Gunter, Ph.D. Region VIII Denver, Colorado
	Robert E. Rosensteel Industrial Hygienist Hazard Evaluation Services Branch
Laboratory Analyses	University of Washington Industrial Hygiene Laboratory

The following personnel assisted in the completion of this evaluation:

Geoffrey Modest,
COSTEP
Medical Services Branch

John Morrison
Statistician
Division of Technical Services

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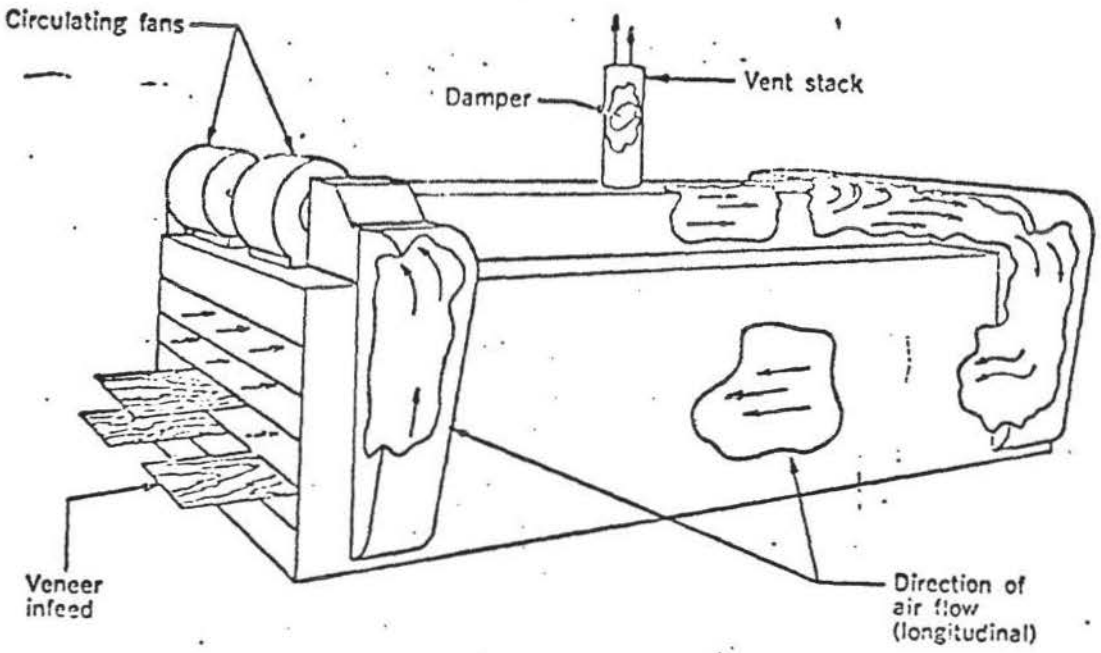

Figure 1 / Veneer Dryer (Single Zone)

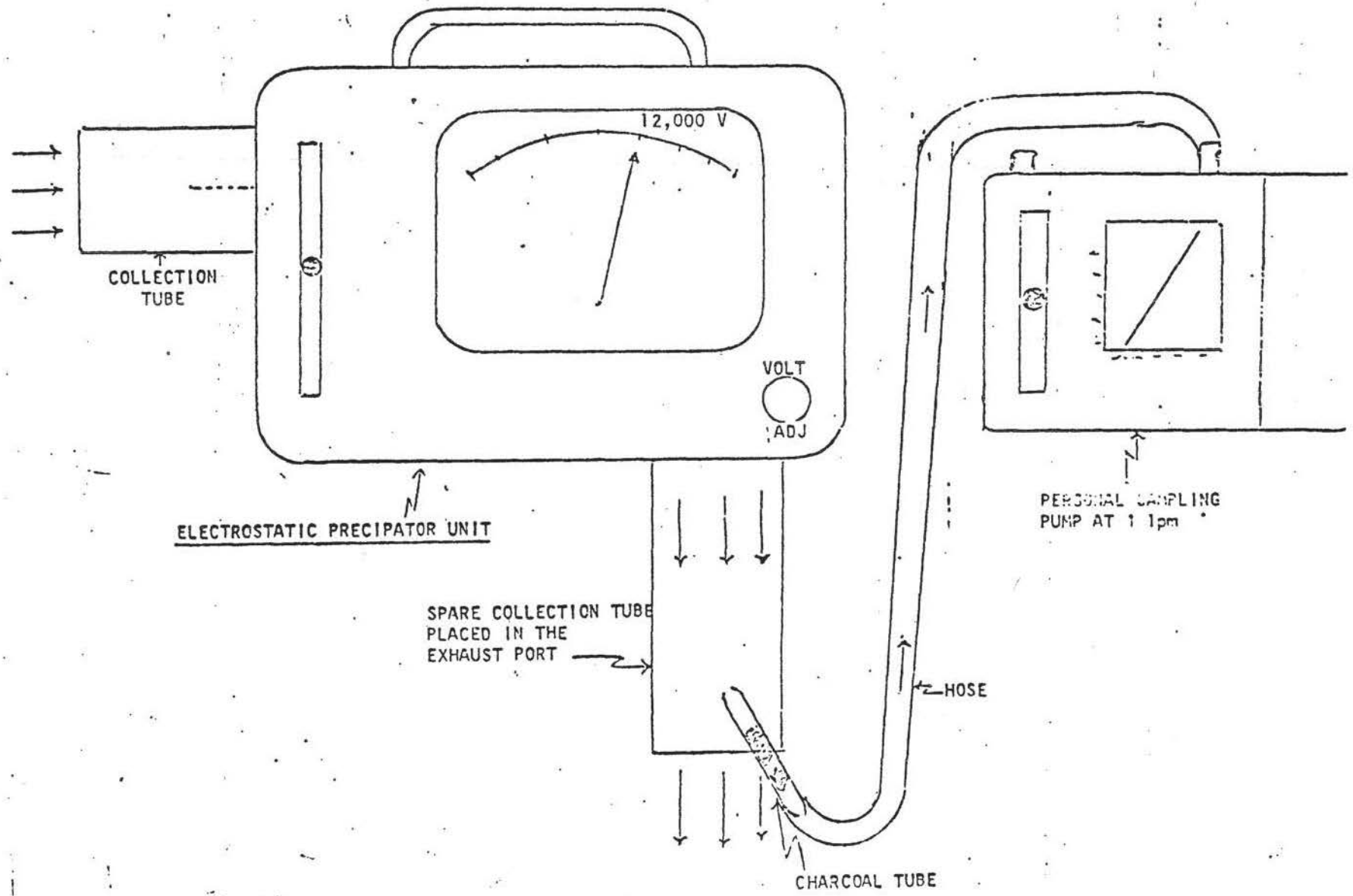

FIGURE 2. SAMPLING SCHEMATIC

ATTACHMENT 1

SAMPLING AND ANALYTICAL PROCEDURE FOR TOTAL ORGANIC ACIDS

SAMPLING PROCEDURES

The samples were collected in Bendix Electrostatic Precipitator tubes, at a flow rate of from 4.85 cfm to 8.55 cfm (the flow rates on each unit varies) for a period of from 3 to 4 hours. The tube can be capped and stored until ready for analysis.

ANALYSIS

The collected sample was extracted from the ESP tube by a minimum volume of chloroform. Since the abietic acid is not volatile, the excess solvent is evaporated by a stream of dry air. The condensed extract is transferred to a one milliliter volumetric flask and diluted to volume.

A portion of the sample is then transferred to a clean dry infrared cell (0.2 mm thickness) and run against a solvent blank on a Beckman IR4 Infrared Spectrophotometer. Peaks at 2.95, 3.4, 5.85 and 7.2 microns were observed but the 5.85 μ peak was most sensitive and characteristic of the abietic and other organic acids. The slope of a standard curve for the commonly found acids was similar and the total acid is reported as the quantity of abietic acid. By gas chromatography of the esterified acid mixture, the abietic acid constitutes a major portion of the extracted acids. There are not significant amounts of other interferring substances.

ATTACHMENT 2

SAMPLING AND ANALYSIS FOR PINENE

SAMPLING PROCEDURES

The sample is collected on a NIOSH charcoal collection tube which is mounted in the exhaust flow of a Bendix Electrostatic Precipitator to remove interferring aerosals. The charcoal sample is taken at a rate of one liter per minute for a period of 3-4 hours. The tube can be capped and stored until ready for analysis.

ANALYSIS

The front section of the charcoal tube is desorbed with one milliliter of carbon disulfide. The backup portion of charcoal is run separately and if its content is greater than 20%, breakthrough would be indicated and would lead to questionable results. The charcoal was desorbed for a period of at least one hour. Standard solutions of α- and β pinene in carbon disulfide are prepared and run along with the samples.

Microliter amounts of the samples were injected into a Model 1200 Varian gas chromatograph with a hydrogen flame ionization detector and a 1/8" x 6' Carbowax 20M on chromosorb G 60-80 mesh column. The column temperature for routine analysis was 85°C isothermal. For initial exploratory work, the column temperature was programmed from room to 200°C and the individual peaks were identified by mass spectrometry. Interferring compounds were not present. The concentration of pinene was determined from a ratio of peaks of samples to standards.

For the purposes of these samples, the α- and β-pinenes were both measured and the total pinene concentration was reported. The β-pinene concentration did not exceed 10% of the total in any of the samples.

TABLE I

α- AND β-PINENE AND TOTAL ACIDS

LOCATION	DATE	SAMPLE PERIOD	TOTAL SAMPLE TIME (MIN)	SAMPLE #	TOTAL ACIDS		α AND β PINENE			Type of Wood Dried
					SAMPLE VOL CUBIC METERS	mg/m^3 *	SAMPLE VOL LITERS	ppm **		
Grader end by # 2 & 3 Dryer	4-17-75	4:05P - 7:55P	230	19	46.2	0.17	230	0.15		Douglas Fir
	4-17-75	7:55P - 11:50P	235	22	47.2	0.07	235	0.68		" "
Grader end by # 5 & 6 Dryer	4-17-75	4:10P - 8:00P	230	17	46.2	0.16	230	0.20		" "
	4-17-74	8:00P - 11:45P	225	23	45.2	0.18	225	0.07		" "
	4-18-74	8:00A - 11:45A	225	27	45.2	0.29	225	0.31		" "
	4-18-75	11:45A - 3:30P	225	31	45.2	0.17	225	0.13		" "
Feeder end by # 1 & 2 Dryer	4-17-75	4:20P - 1:05P	225	18	54.5	0.05	225	1.41		" "
	4-17-75	8:05P - 11:55P	230	24	55.7	0.06	230	1.97		" "
Feeder end by # 3 & 4 Dryer	4-18-75	8:10A - 11:50A	220	25	53.3	0.12	220	1.30		" "
	4-18-75	11:50A - 3:30P	220	29	53.3	0.04	220	1.32		" "
Feeder end by # 5 & 6 Dryer	4-18-75	8:05A - 11:50A	225	26	45.2	0.17	225	1.00		" "
	4-18-75	11:50A - 3:30P	220	30	44.2	0.04	220	0.94		" "
Grader end by # 7 Dryer	4-18-75	8:05A - 11:45A	220	28	29.0	0.29	220	0.07		" "
	4-18-75	11:45A - 3:30P	225	32	29.6	0.02	225	0.04		" "
Feeder end by # 7 Dryer	4-17-75	4:25P - 8:00P	215	20	28.3	0.35	215	0.15		1 3/4 hrs White Fir
	4-17-75	8:00P - 11:40P	220	21	29.0	1.25	220	0.34		6 1/4 hrs Douglas Fir

* mg/m^3 - milligrams of substance per cubic meter of air

** ppm - parts of vapor or gas per million parts of air

TABLE II

PAST HISTORY OF SYMPTOMS

Shift	Work Related Symptoms or Complaints-- Past or Present	Symptoms or Complaints Related to Veneer Dryer Emissions	Other Medical Problems or Complaints	Allergic History	Acute Symptoms Related to Emissions	PAST HISTORY OF			
						Throat Irritation	Eye Irritation	Nose Irritation	Cough
						Related to Veneer Dryer Emissions			
Day Shift (n = 30)	COPD - 3 Hay Fever -2 Misc. - 5	Chest Symptoms - 2 Heacache, irritation-2	COPD - 5 Misc. - 2	Pollinosis - 3	Chest Symptoms-5 (17%)	Smoke-3 Dust-1 4/30 (13%)	Smoke-11 Dust-4 15/30 (50%)	Smoke-10 Dust-2 12/30 (40%)	Smoke-2 (7%)
Swing Shift (n = 29)	Foreign body in eye - 2 Misc. - 4	COPD - 1 Hay Fever - 2 Headache - 1	COPD - 2 Misc. - 5	Pollinosis - 6 Red Cedar dust allergy-2 Epoxy Glue allergy-1	Chest Symptoms 4/29 (14%)	Smoke-3 Dust-2 5/29 (17%)	Smoke-9 Dust-5 14/29 (48%)	Smoke-5 Dust-2 Red cedar dust-1 8/29 (28%)	Red cedar dust-1 Smoke-5 6/29 (21%)
TOTAL n = 59			COPD-7	Pollinosis-9 Others-3	9/59 (15%)	9/59 (15%)	29/59 (49%)	20/59 (34%)	8/59 (14%)

TABLE III

PULMONARY FUNCTION RESULTS

U.S. PLYWOOD-CHAMPION

	PRE-SHIFT			POST-SHIFT					
USP - DAY SHIFT	FVC (% Pred.)	$FEV_{1.0}$ (% Pred.)	$MMEF_{25-75}$ (% Pred.)	FVC (% Pred.)	$FEV_{1.0}$ (% Pred.)	$MMEF_{25-75}$ (% Pred.)	Pred. FVC	Pred. $FEV_{1.0}$	Pred. $MMEF_{25-75}$
NON-SMOKERS									
1	6.15 (96)	5.20 (118)	5.84 (128)	5.95 (93)	4.85 (110)	5.07 (111)	6.39	4.40	4.55
2	5.15 (113)	4.25 (134)	3.53 (119)	5.65 (124)	4.25 (134)	3.20 (108)	4.54	3.16	2.97
3	5.40 (120)	4.35 (132)	4.02 (121)	5.25 (117)	4.35 (132)	4.24 (128)	4.50	3.30	3.32
4	6.30 (130)	5.35 (143)	6.06 (153)	6.05 (125)	5.20 (139)	5.62 (142)	4.85	3.75	3.95
5	5.10 (105)	3.90 (115)	3.75 (121)	5.00 (103)	3.50 (104)	-	4.87	3.38	3.11
6	4.85 (109)	4.10 (117)	4.41 (114)	4.95 (112)	4.10 (117)	4.30 (111)	4.43	3.50	3.86
7	5.30 (102)	4.27 (101)	3.64 (79)	5.40 (103)	4.35 (103)	3.64 (79)	5.22	4.23	4.63
8	6.85 (133)	4.95 (129)	4.41 (115)	6.50 (126)	4.95 (129)	3.86 (101)	5.14	3.83	3.83
9	5.85 (107)	4.60 (111)	3.92 (94)	6.00 (110)	4.40 (106)	3.09 (74)	5.47	4.15	4.19
10	3.75 (79)	2.55 (76)	1.34 (43)	3.95 (83)	2.60 (77)	1.33 (42)	4.77	3.35	3.15
MEAN	5.47	4.35	4.09	5.47	4.26	3.82			
SMOKERS									
11	3.75 (97)	3.10 (112)	3.42 (121)	3.55 (92)	2.85 (103)	2.64 (94)	3.85	2.77	2.82
12	4.50 (104)	3.52 (111)	2.59 (80)	4.55 (105)	3.35 (105)	2.12 (66)	4.33	3.18	3.23
13	5.00 (102)	3.85 (109)	-	5.20 (106)	3.80 (107)	2.48 (73)	4.92	3.54	3.42
14	5.18 (98)	4.15 (112)	4.30 (125)	5.10 (96)	4.10 (110)	4.63 (135)	5.29	3.72	3.43
15	4.45 (107)	3.48 (114)	3.42 (109)	4.45 (107)	3.48 (114)	2.87 (91)	4.15	3.05	3.14
16	3.28 (68)	2.52 (75)	1.96 (61)	3.30 (69)	2.50 (74)	1.85 (58)	4.79	3.38	3.20
17	2.65 (101)	1.33 (61)	0.62 (22)	2.60 (99)	1.42 (65)	0.72 (61)	2.62	2.17	2.80
MEAN	4.12	3.14	2.72	4.11	3.07	2.47			

TABLE III

PULMONARY FUNCTION RESULTS

U.S. PLYWOOD-CHAMPION

USP SWING SHIFT	PRE-SHIFT			POST-SHIFT					
	FVC (% Pred.)	$FEV_{1.0}$ (% Pred.)	MMEF 25-75 (% Pred.)	FVC (% Pred.)	$FEV_{1.0}$ (% Pred.)	MMEF 25-75 (% Pred.)	Pred. FVC	Pred. $FEV_{1.0}$	Pred. MMEF 25-75
SMOKERS									
18	4.98 (113)	2.74 (86)	0.98 (31)	4.85 (110)	2.85 (89)	1.04 (33)	4.42	3.20	3.19
19	4.65 (101)	2.68 (76)	1.00 (30)	4.98 (102)	2.81 (80)	1.01 (30)	4.89	3.51	3.38
20	4.82 (98)	3.95 (98)	3.86 (84)	4.60 (95)	3.85 (96)	3.75 (82)	4.83	4.02	4.58
21	5.95 (157)	4.75 (145)	3.97 (99)	5.95 (157)	4.70 (144)	3.86 (96)	3.79	3.27	4.03
22	5.30 (103)	4.20 (102)	3.64 (81)	5.15 (100)	4.00 (97)	3.31 (74)	5.15	4.13	4.49
23	6.30 (115)	5.35 (119)	5.62 (115)	6.18 (112)	5.45 (122)	5.84 (119)	5.50	4.48	4.90
24	4.45 (93)	2.95 (85)	1.65 (46)	4.15 (90)	2.75 (79)	1.56 (44)	4.62	3.46	3.55
25	5.73 (99)	5.00 (110)	5.29 (112)	5.40 (94)	4.90 (108)	5.95 (126)	5.77	4.53	4.73
MEAN	5.27	3.95	3.25	5.16	3.91	3.29			
NON-SMOKERS									
26	4.35 (105)	4.02 (120)	4.53 (118)	4.33 (105)	3.90 (116)	3.97 (103)	4.14	3.35	3.85
27	3.90 (98)	3.48 (110)	4.53 (127)	3.75 (94)	3.40 (107)	4.42 (123)	3.99	3.17	3.58
28	6.10 (105)	5.13 (113)	4.97 (104)	6.17 (107)	5.13 (113)	4.96 (104)	5.79	4.56	4.77
29	5.35 (111)	4.19 (122)	3.53 (107)	5.45 (123)	4.19 (121)	3.47 (105)	4.84	3.45	3.29
30	5.20 (114)	4.35 (128)	5.29 (153)	5.06 (111)	4.35 (128)	5.95 (172)	4.57	3.40	3.46
31	5.77 (122)	4.55 (120)	3.93 (94)	5.75 (123)	4.55 (120)	4.00 (96)	4.73	3.79	4.18
32	5.85 (108)	4.87 (114)	4.74 (104)	5.70 (105)	4.77 (111)	4.82 (106)	5.42	4.28	4.54
33	5.93 (111)	4.70 (110)	4.30 (93)	5.55 (104)	4.50 (105)	3.90 (84)	5.35	4.29	4.63
MEAN	5.31	4.41	4.48	5.22	4.35	4.44			

U.S. PLYWOOD CHAMPION

tegory	Mean Pre-Shift	Mean Post-Shift	% Change Over Shift	p Value	Statistical Interpretation ($p < 0.05$ is Sig.)
Y					
n-Smokers					
FVC	5.47	5.47	%	> 0.9999	Not Significant (NS)
FEV	4.35	4.26	- 2.07%	0.1045	NS
MMEF	4.13*	3.82	- 7.51%	0.0327	Significant
mokers					
FVC	4.12	4.11	- 0.24%	0.8602	NS
FEV	3.14	3.07	- 2.23%	0.1814	NS
MMEF	2.72	2.42*	-11.03%	0.2132	NS
DAY-TOTAL					
FVC	4.91	4.91	0%	0.9447	NS
FEV	3.85	3.77	- 2.08%	0.0312	Significant
MMEF	3.57*	3.28*	- 8.12%	0.0105	Significant
SWING					
Non-Smokers					
FVC	5.31	5.22	- 1.69%	0.1563	NS
FEV	4.41	4.35	- 1.36%	0.0510	Near Significant
MMEF	4.48	4.44	- 0.89%	0.7573	NS
Smokers					
FVC	5.27	5.16	- 2.09%	0.1627	NS
FEV	3.95	3.91	- 1.01%	0.4468	NS
MMEF	3.25	3.29	+ 1.23%	0.7229	NS
SWING-TOTAL					
FVC	5.29	5.19	- 1.89%	0.0386	Significant
FEV	4.18	4.13	- 1.20%	0.0775	Near Significant
MMEF	3.86	3.86	0%	0.9523	NS
ALL NON SMOKERS					
FVC	5.40	5.36	- 0.74%	.4605	NS
FEV	4.38	4.30	- 1.83%	0.0191	Significant
MMEF	4.29*	4.11	- 4.20%	0.0610	Near Significant
ALL SMOKERS					
FVC	4.73	4.67	- 1.27%	0.1744	NS
FEV	3.57	3.52	- 1.40%	0.1296	NS
MMEF	3.02	2.94*	- 2.65%	0.4151	NS
GRAND TOTAL					
FVC	5.10	5.04	- 1.18%	0.1482	NS
FEV	4.01	3.94	- 1.75%	0.0046	Significant
MMEF	3.72*	3.58*	- 3.76%	0.0461	Significant

* Note: One or more observation not used because its pair missing.