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

HEALTH HAZARD EVALUATION 76-79, 80-543
WEYERHAEUSER CO.,
LONGVIEW, WASHINGTON
NOVEMBER 1978

I. TOXICITY DETERMINATION

At the request of authorized representatives of employees working at Weyerhaeuser Co., Longview, Wasington, The National Institute for Occupational Safety and Health (NIOSH) and the Department of Environmental Health, University of Cincinnati College of Medicine, under contract to NIOSH, conducted evaluations of potential hazards to employee health found in various operations at one Weyerhaeuser Co. location. Employees were interviewed, physical examinations were performed and pre and post-shift pulmonary function tests were administered over a three day period. Personal environmental sampling for wood dusts present in the ambient air of the work environment was conducted. Based on data collected in this health hazard evaluation, information available in the published literature and information obtained from public and private sources, the following determinations have been determined in the following areas.

A. The employees who work in the Shake Mill were exposed to potentially toxic concentrations of western red cedar wood dust. This determination is based on results of this study which show that 10 of 74 employees examined (13.5%) (three sawyers, two packers, one splitter, two millwrights, a truck driver, and a car-loader) had evidence of occupational asthma due to western red cedar wood dust. Asthma was documented by demonstrating a greater than 10% decline in forced expiratory volume at one second (FEV 1.0) from baseline preshift test on a Monday morning to subsequent test values obtained over the next three days, coupled with a positive history of asthma symptoms as determined by medical questionnaire. The mean value of 85 breathing zone, total wood dust concentrations was 4.72 milligrams per cubic meter (mg/cu m) and the median was 1.59 mg/cu m. Two individuals extremely sensitive to western red cedar dust had FEV 1.0 reductions of 23.3% and 24.4% while being exposed to concentrations of western red cedar wood dust of 0.23 and 0.54 mg/cu m respectively. Both individuals were former sawyers who transferred to less dusty jobs because of severe asthmatic symptoms.

B. There were 58 employees working in the New Planer who were potentially exposed to a combination of Douglas fir and hemlock wood dust and sodium pentachlorophenate. Three employees (one setup man, one grader and one trimmer) had evidence of occupationally related

asthma. The mean total wood dust concentrations were 1.28 mg/cu m and the median was 0.34 mg/cu m. Five of the 59 samples exceeded 5 mg/cu m, however, they represented isolated exposures in various job categories. It was not determined whether the employee's exposure to the wood dust or the sodium pentachlorophenate or a combination of both that resulted in the occupational asthma.

C. Potentially toxic concentrations of the following dusts occurred: Douglas fir and hemlock wood dust in the Old Planer; Douglas fir and alder bark dust in the Bark Plant; and alder wood dust in the Pres-Tock Plant. Dust levels were considered potentially toxic when the total time weighted average (TWA) wood dust concentrations exceeded the evaluation criteria of 5.0 mg/cu m. Medical evidence for wood dust toxicity was not observed by physical examination, medical questionnaire or by mid-shift pulmonary function tests.

D. The employees' exposure to Douglas fir and hemlock wood dust in the Presto-Log Plant and Douglas fir wood dust in the sanding operation of the Plywood Plant was not considered toxic. This is based on measurements which were less than the evaluation criteria of 5.0 mg/cu m and that wood dust toxicity was not observed by physical examination, medical questionnaire or by mid-shift pulmonary function tests.

E. Employees' exposure to phenol and formaldehyde in the Resin Plant was not considered toxic. This is based on measurements which was less than 10% of the suggested evaluation criteria for these substances.

F. Employees' exposure in the Plywood Plant to veneer dryer emissions (alpha and beta pinenes and abietic and pimaric acids) was probably not toxic. There are no standards for these substances. The concentrations of pinenes and total acids measured during the present health hazard evaluation were approximately 50% or less of the values obtained during two previous health hazard evaluations where medical evaluations were performed. In this evaluation it was determined that transient irritation of the mucous membranes of the eyes, nose and throat, and upper respiratory tract may occur but permanent respiratory disease is not likely to occur at the concentrations measured.

II. Recommendations

A. Medical

1. Preplacement: A comprehensive medical examination should be made available to include as a minimum: medical history, baseline forced vital capacity (FVC), and forced expiratory volume at one

second (FEV_1). The history should include administration of a questionnaire designed to elicit information regarding symptoms of chronic bronchitis, bronchial asthma, dyspnea, wheezing and rhinitis.

If a positive personal history of respiratory allergy, or asthma, previous sensitization to western red cedar wood (or other woods), chronic obstructive lung disease, or other diseases of the cardiopulmonary system are elicited, or where there is a positive history of smoking, the applicant should be counseled on the increased risk from occupational exposure to cedar dust.

2. For the first year, each newly employed person should be retested for ventilatory capacity (FVC and FEV_1) within four months of employment. This retest should be performed on the first day at work after at least 40 hours absence from exposure to western red cedar dust and should be performed before and after at least six hours of exposure on the same day and, in addition, again before work/exposure the following day or subsequent day during that week (e.g. total of three tests). Each new employee exposed to western red cedar dust should also be given a medical evaluation every four months designed to elicit information concerning sensitization to cedar wood and regarding symptoms such as onset of acute wheezing, chest tightness, nocturnal dyspnea or cough, or symptoms of allergic rhinitis.

3. Periodic: Each current employee exposed to western red cedar dust should have as a minimum a medical evaluation (as described above) and measurement of forced vital capacity (FVC) and of forced expiratory volume at one second (FEV_1). These tests of ventilatory function should be performed on the first day at work following at least 40 hours of absence from exposure to wood dust and shall be performed before and after at least six hours of exposure on the same day and again on the next or subsequent days before work during that work week. The medical evaluation and pulmonary function tests should be performed at least yearly and preferably twice a year.

4. Ideally, the judgment of the employee's pulmonary function should be based on preplacement values (values taken before exposure to cedar dust). When preplacement values are not available, then reference to standard pulmonary function value tables may be necessary. Note that these tables may not reflect normal values for different ethnic groups. For example, the average healthy black male may have an approximately 15% lower FVC than a Caucasian male of the same body build. The physician should consider, in cases of

significantly decreased pulmonary function, the impact of further exposure to cedar dust and evaluate the relative merits of a transfer to areas of less exposure or protective measures. Diagnosis of sensitization to cedar dust should be suspected with the development/occurrence of symptoms of acute wheezing, chest tightness, persistent cough, especially nocturnal, nocturnal dyspnea or wheezing, symptoms of allergic rhinitis or reduction in FEV_1 or FVC of 10% or greater or a decrease in FEV_1/FVC% of 6% or more when these tests are measured over any of the three periods of spirometry testing.

5. Medical records, including information on all required medical examinations, should be maintained for persons employed in work involving exposure to cedar dust. Medical records with pertinent supporting documents should be maintained even after the individual's termination of employment or job transfer (for as long as 30 years).

6. Each employee, before being assigned to a western red cedar work area, should be apprised of the hazards, relevant symptoms, and proper conditions and precautions for safe use or exposure, and should be instructed as to the availability of relevant information which should be kept on file. This should be accessible to the worker.

7. Other medical recommendations include:

a. Preplacement and periodic evaluations for workers in the New and Old Planer should be similar to that described previously for western red cedar exposure. Evaluations should be performed at least yearly for both the newly employed and current employees.

b. Preplacement and yearly evaluations should be made available for all other workers exposed to any wood dusts.

Recommendations for Management
Of Workers Exposed to Western Red Cedar
Dust According to Changes in FEV_1

FEV_1 * (% of Predicted)	FEV_1 ** (%)	Interpretation of FEV_1	Recommendations for Employment
> 80 (No evidence of chronic ventilatory impairment)	(a) -4 to 0 or more	(a) Minimal or no acute effect of dust on ventilatory capacity	No change; annual FEV_1, and questionnaire
	(b) -9 to -5 or more	(b) Moderate acute effect of dust on ventilatory capacity	Possible change; 4 mo. FEV_1, and questionnaire
	(c) -10 or more	(c) Definite and Marked acute effect of dust on ventilatory capacity	Move to lower risk area; 6 mo. FEV_1, and questionnaire
60-79 (Evidence of slight to moderate irreversible impairment of ventilatory capacity)	(a) -4 to 0	As (a) above	No change; 6 mo. FEV_1, and questionnaire
	(b) -5 or more	As (b) above	Move to lower risk area; 6 mo. FEV_1, and questionnaire
< 60 (Evidence of moderate to severe irreversible impairment of ventilatory capacity)	---	---	Work requiring no cedar dust exposure, detailed pulmonary examination, and questionnaire

* FEV_1 in absence of dust exposure (2 days or longer).
** Difference between FEV_1 before and after 6+ hours of cotton dust exposure on a first working day or any subsequent prework value during the same working week.

B. Environmental

1. Occupational exposure to western red cedar dust should be controlled to less than 2.5 mg/cu m TWA for any eight-hour workday. It has not been shown that this exposure level will prevent the onset of additional cases of occupational asthma. If this level is shown to be too high, then the dust levels should be controlled to still lower values. In addition, short term exposures exceeding 5 mg/cu m should be avoided.

2. Occupational exposure to alder, fir and hemlock wood dusts should be controlled to be less than 5.0 mg of wood dust per cubic meter of air.

3. Employee exposure to wood dust should be measured on a periodic basis. Records should be maintained for all sampling schedules. These records should include the sampling method, sampler locations, analytical method, type of respiratory protection in use, if any, and the measured dust concentrations in each work area. Each employee should be able to obtain information on his own environmental exposure.

4. Specific work practices should be established and posted for all work in the Shake Mill where dust is present. Practices such as avoiding unnecessary creation of dust by shaking or throwing material, and avoiding localized high dust level areas wherever possible should be included. Creation of a positive attitude toward dust control on the part of management and employees is essential.

5. "Blowing down" should not be done to clean the settled dust from areas and equipment. The use of a vacuum source or other methods that do not permit the dust to become airborne are preferred.

6. Local exhaust ventilation should be used on the band saws in the Shake Mill.

7. Local exhaust ventilation should be used on the bagging operation in the Bark Plant.

8. Engineering controls should be used on the bark grinder to reduce the operators exposures.

9. The set-up location and the chipper in the Old Planer should be evaluated and engineering controls installed.

10. The entire Pres-Tock operation needs evaluation. All points where the wood fibers and dust escape the operation should be identified and steps taken to reduce or stop these emissions.

11. NIOSH approved respirators for use with wood dust should be worn by employees who are exposed to wood dust:

(a) When western red cedar dust is in excess of 2.5 mg/cu m,

(b) When non-allergenic wood dust (e.g., fir, alder, hemlock, etc.) is in excess of 5 mg/cu m,

(c) When entering a hopper or other dust control system,

(d) When blowing down is absolutely necessary.

Respirators are considered temporary controls and should not be used in lieu of engineering controls.

12. Engineering controls could be installed to capture the smoke that is emitted when Presto-Logs are removed from the press.

13. All ventilation systems used to capture wood dust need to be inspected on a periodic basis to insure that obstructions, leaking duct connections, belt slippages, etc., are not preventing the maximum efficiency of the system.

III. DISTRIBUTION AND AVAILABILITY

Copies of this complete Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati address.

Copies of this report have been sent to:

(1) Weyerhaeuser Co., Longview, Washington

(2) International Woodworkers of America, Western States Regional Council #3, Gladstone, Oregon

(3) Plywood Workers Local #2498
Longview, Washington

(4) Washington State Department of Labor and Industries, Olympia, Washington

(5) Occupational Safety and Health Administration, Seattle, Washington

For the purpose of informing the "affected employees," the employer will promptly "post" Sections I, II and III of this Determination Report in a prominent place(s), near where the affected employees work, for a period of thirty (30) calendar days.

IV. 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 receipt of 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 National Institute for Occupational Safety and Health received such a request from the authorized representatives of the International Woodworkers of America, Local #2498, Longview, Washington, and Western States Regional Council #3, Gladstone, Oregon, to determine if the wood dust and other substances present are toxic as used or found. Substances involved and the area they are found include: (1) Wood dust - Shake Mill, New Planer, Bark Plant, Old Planer, Presto-Log, Pres-Tock, and the Plywood Plant; (2) Veneer dryer emissions (abietic and pimaric acid, alpha and beta pinene) - Plywood Plant; (3) formaldehyde and phenols - Resin Plant.

V. HEALTH HAZARD EVALUATION

A. Description of Process - Conditions of Use

The Weyerhaeuser Company is a diversified company. The request involves eight plants or processes in the Wood Products Division at Longview, Washington. The Wood Products Division employs approximately 1840 persons, of which approximately 340 employees are in areas of concern. The following is a description of the eight plants:

1. Shake Mill

The Shake Mill processes shake shingles from western red cedar logs. The logs are sorted and brought to the log chain by a yard man. The logs are cut to desired length by a deck sawyer and then split into smaller sections by a deck splitter. The sections are split into thin pieces, trimmed on the sides and then cut diagonally into two thin pieces (shakes) on a band saw. The shakes are packed into bundles by a packer, placed on a pallet and put into open storage for future loading into boxcars. There are approximately 30 employees per shift for three shifts. This includes: one deck sawyer, two deck splitters, seven splitters, seven sawyers, seven packers, a taper splitter, one chipper operator, and other miscellaneous job functions. The dust of concern in this area is western red cedar wood dust. There are presently no environmental controls to prevent wood dust from entering the breathing zone of employees.

2. New Planer

Rough sawn dimensional lumber is brought into the Planer Mill for planing. The lumber is sorted, passed through a planer, trimmed to the proper

length, and sorted according to grade and length. Douglas fir and Hemlock are processed in the New Planer. When green lumber is processed it is sprayed with sodium pentachlorophanate as it exits from the planer. When Hemlock is run it is sprayed with a Cherry Brown stain. There are approximately 70 persons employed in this mill over two shifts.

3. Old Planer

The operations conducted in the Old Planer are basically the same as the New Planer. The exposure there is to fir and hemlock wood dust. There are 60 people employed in the Old Planer mill on a 1-shift operation.

4. Bark Plant

Tree bark is collected from sawmills and plywood operations. The bark is first passed through a chipper to reduce its size. The material is then passed through a dryer, ground into fine dust, and bagged. The bark dust at this point is dry and is of small particle size. Although the plant uses an enclosed system, leaks develop at transfer points allowing dust to escape in the work environment. Bark dust is also emitted during bagging and bag-stacking operations. There are six to eight employees for each of the two shifts. The wood dusts present here are mainly Douglas fir and Alder bark dusts. In addition to routine exposures during the day, clean-up operations, such as sweeping and blow-down, create additional dust exposures.

5. Presto-Log

Sawdust is transferred to the Presto-Log Plant from the other plants in the area. Sawdust, dropped from hoppers into rotary presses, is compressed into fireplace logs. A small amount of Diesel Oil #2 is added to the sawdust as a lubricating agent. Compression creates heat and heated tree resins form the binder. Smoke and oil mist are released when Presto-Logs are removed from the press. There is no local exhaust ventilation on the presses. Wood dust exposure is greatest during blow-down operations or when work is occurring in the hopper. There are seven to eight persons working per shift for two shifts.

6. Pres-Tock Plant

Two products are made in the Pres-Tock Plant: Pres-Tock and Silvacel. The Pres-Tock operation is not run regularly, and was not in operation during the evaluation. In Silvacel production, wood chips are ground into fibers, are passed through a dryer and bagged as Silvacel. Silvacel is made from alder wood with no chemical additives included. The bagging operation is dusty causing dust to settle in all areas of the plant. There is no local exhaust ventilation on the bagging operation. Clean-up operations, such as sweeping and blow-down, create additional dust exposures. There are six employees per shift for three shifts.

7. Resin Plant

The Resin Plant produces glues for use in the Plywood Plant and for resale. Urea, para-formaldehyde, phenol, and caustic soda are added to the resin reactor. The resin is then mixed with water, wood flour, and bark dust fillers to make glue. There is a small local exhaust ventilation system on the mixer and resin tank. The chemicals listed above are handled for a short period of time during the day, therefore sampling for these materials is difficult. Formaldehyde and phenol vapors may be released from the resin tank during resin production. There are four employees on the day shift and two employees on the night shift.

8. Plywood Plant

The Plywood Plant produces finished plywood. Logs are debarked, peeled, and the veneer is sorted. The veneer is then passed through a veneer dryer to remove moisture. Many substances are given off during the drying process. The main constituents of the emissions are the abietic and pimaric acids, and alpha and beta pinene. The veneer dryer emissions are partially controlled by the use of ceiling fans and shrouding around the dryer area. After drying, the veneer is graded and sorted. There are then a series of operations which result in plywood production. After plywood is made, it is trimmed to size and sanded. There are approximately 25 employees per shift on each of three shifts in the veneer dryer operations and four employees for two shifts in the trim saw and specialty saw operations. There are approximately 8 employees in the sander area.

B. General Study Progress and Design

A combined environmental-medical survey was performed on December 13-16, 1976. This health hazard evaluation centered on potential toxic effects of wood dust exposure to employees. Detailed medical and environmental evaluations were conducted in the Shake Mill and New Planer Mill. The Shake Mill has 90 employees working three shifts; the New Planer has 70 employees working three shifts. The numbers of employees in these work areas were similar and thus provided adequate populations for comparison of environmental and medical data. Three varieties of wood were processed. Western red cedar was used exclusively in the Shake Mill and there was a mixture of Douglas fir and hemlock processed in the New Planer.

A variety of wood dusts were present in other plants. The Bark Plant processed fir and alder bark; the Presto-Log Plant used fir and hemlock; the Pres-Tock Plant processed alder; the old Planer processed fir and hemlock; and the Plywood Plant processed fir and cedar. Veneer dryer emissions were present in the dryer area of the Plywood Plant. The present evaluation report will be restricted mainly to respiratory effects of wood dust.

C. Design of Environmental Sampling

Environmental sampling was conducted over a four day period. The design of the schedule for sampling was intended to measure wood dust exposures for all job descriptions. All wood dust samples were collected at the breathing zone via personal samplers. Breathing zone samples are collected by allowing an employee to wear sampling equipment with air being sampled in the close proximity to the mouth; samplers are usually attached to the shirt lapel. Concentrations of formaldehyde, phenol, abietic and pimaric acids, and alpha and beta pinene were measured by general area sampling. One hundred ninety-one wood dust samples were taken in the Shake Mill over a three day period, covering all three operating shifts. Sampling in the New Planer Mill consisted of 89 wood dust samples over a three day period of both operating shifts. There were 12 wood dust samples collected in the Bark Plant over a single shift. In the Old Planer Mill, there were seven wood dust samples collected over a single shift. There were 12 samples collected in the Presto-Log Plant and 12 in the Pres-Tock Plant over one shift periods. The sampling in the Plywood Plant consisted of eight wood dust samples collected over a single shift; eight abietic acid and pimaric acid samples, and seven alpha and beta pinene samples over four shifts in three days. The sampling in the Resin Plant consisted of two samples each of formaldehyde and phenol.

D. Selection of Population for study

A total of 215 employees representing eight different plants and processes were evaluated. Two areas, the Shake Mill and the New Planer Mill, made up the largest numbers of employees investigated. These two areas were selected for serial medical evaluations to be repeated over a 3-day period. A third group consisting of clerical, technical and engineering employees was selected as a control group; these subjects were evaluated over the same three day period. Because of diversity of wood dusts, presence of other types of exposures and/or relatively few number of employees for study, workers in the Old Planer Mill, Plywood Plant (Sander Area), Pres-Tock Plant, and Bark Products Plant were evaluated on an individual basis. These evaluations were conducted on the fourth day.

The Plywood Plant Veneer Dryer Area and the Resin Plant were two areas that were evaluated by industrial hygiene studies only.

E. Description of Population Groups Studied

The employee participation from groups I, II, and III is shown in Appendix A-1.

1. Group I (Shake Mill)

The Shake Mill uses western red cedar wood exclusively. A total of seventy-four (82%) of the Shake Mill employees were evaluated and consisted of: twenty-five employees from the first shift, twenty-four employees from the second shift, and twenty-five employees from the third shift. The job categories included 21 sawyers, 20 splitters, 19 packers, and 14 maintenance and miscellaneous employees. All employees were male caucasian between the ages of 18 and 56, with a mean $\pm$ SD age of 28.9 $\pm$ 9.0 years.

2. Group II (New Planer Mill)

The New Planer Mill used a mixture of woods, mainly Douglas fir and smaller quantities of west coast hemlock. Sodium pentachlolophenate was sprayed on the green lumber. A total of fifty-eight (83%) of the New Planer Mill employees were evaluated: twenty-eight employees from the first shift, and thirty employees from the second shift. The job categories included nine set-up/feeder operators, 19 racker/graders, one trimmer, four pullers, and 25 maintenance/miscellaneous employees. The evaluated employees were males between the ages of 22 and 63 with a mean $\pm$ SD age of 38.79 $\pm$ 13.1 years. There were 57 Caucasians and one Negro in this group.

3. Group III (Control)

The office, engineering and technical group had only minimal or no exposure to any wood dust. These twenty-five employees from the first shift served as an environmental control group for the Shake Mill and New Planer Mill groups. There were seven office employees, eleven engineers, six technicians and one miscellaneous employee. The employees in this control group are male Caucasians between the age of 26 and 63 with a mean age of 42.5 years $\pm$ SD of 12.7 years.

4. Group IV (Old Planer Mill)

The Old Planer Mill used a mixture of Douglas fir and west coast hemlock woods. Ten employees from the first shift were evaluated. The job categories included: three set up/feeder men, one racker/grader, three pullers, one trimmer, and two maintenance/miscellaneous employees. The ten employees in this group are male Caucasian, between the ages of 41 and 64, with a mean $\pm$ SD age of 54.6 $\pm$ 7.5 years. Six female employees from the Old Planer Mill were also evaluated on an individual basis and are not included in Group IV for statistical analysis.

5. Group V (Plywood Plant Sander Area)

The Plywood Sander Area uses Douglas fir and western red cedar woods. Sixteen employees from the first shift whose wood dust exposures were expected to be the heaviest were evaluated. The job categories included: six sanders, one grader and nine miscellaneous employees. All employees in this group were male Caucasians between the ages of 29 and 63 with a mean ± SD age of 49.3 years ± 9.7 years.

6. Group VI (Pres-Tock Plant)

The Pres-Tock Plant used red alder wood. Four employees from the first shift and three employees from the second shift were evaluated. There were seven male Caucasians in this group. The ages ranged from 23 to 56 with a mean ± SD age of 39.4 ± 14.4 years.

7. Group VII (Presto-Log Plant)

The Presto-Log Plant uses Douglas fir and hemlock wood. Four employees from the first shift were evaluated. All were male Caucasians between the ages of 25 and 59 with a mean ± SD age of 42 years ± 16.5 years.

8. Group VIII (Bark Plant)

The Bark Plant processes Douglas fir, hemlock and alder bark. Three employees from the first shift and one employee from the second shift were evaluated. These four employees were male Caucasians between the ages of 20 and 54 with a mean ± SD age of 35.8 ± 13.3 years.

F. Materials & Methods Used for Environmental Sampling

1. Preliminary Studies

Employees' exposures were determined by the collection of breathing zone samples and general area samples in the occupations and areas of concern. During the initial survey in September 1976, samples were collected for wood dust in order to determine appropriate sampling and analytical methods. These initial samples were collected on vinyl metricel filters at a flow rate of 1.7 liters per minute. The 12 samples collected were weighed as received by the laboratory. They were placed in an oven for drying and reweighed at the following time intervals: 8 hours, 18 hours, 28 hours, 48 hours, and 68 hours. The

greatest weight change came from 0 to 28 hours. In this time span the weight loss ranged from 13% to 36% with an average weight loss of 21.4% and a median of 20%. The weight loss from 28 to 68 hours was in a range of 0 to 6% with an average of 2.6% and a median of 2.5%. Based on this knowledge, it was decided to weigh the samples as received by the laboratory, place them in a drying oven at 75°C for 24 hours and then reweigh them. This procedure was done on all samples received during the December study. There were some problems on the evaluation samples. After the drying period, 88% of the samples lost weight and 12% gained weight. Eighty percent of those that lost weight lost from 0 to 30%. Eight percent gained from 1% to 25% and 4% gained more than 25%. These figures are deceiving as 25 of the 39 samples gained only 0.03 mg or less and 6 of the 13 that gained more than 25% had initial weights of 0.04 mg or less. Some of the problems that occurred were that the filters, after initial weighing, were placed back in the cassette and upon removing the second time, some particles on the more heavily loaded samples fell off and thus an additional weight loss occurred. The chemist also felt that the second time they were removed from the cassette there was a possibility of some additional dust or brush hairs dropping on the filter and thus could account for the weight gains. An additional concern is that some wood dust originates from wood that has been kiln dried or dried in some other fashion and that not only is water removed but other volitile components such as alcohols, ketones, acids, turpenes, etc., therefore, the toxic effects of dry wood may vary from wet wood. Because of these problems and concerns it was decided to use only the weights of the samples as received by the laboratory. At the present time there are no standardized criteria for sampling and weighing wood dust samples; obviously, a simple procedure is desirable.

2. Sampling of Wood Dusts

The sampling method consisted of collection of total and respirable wood dust samples. The total dust samples were collected on vinyl metricel filters at a flow rate of 1.7 liters per minute. The respirable dust samples were collected on vinyl metricel filters after passing through a cyclone unit at a flow rate of 1.7 liters per minute. The samples were weighed as-received in the laboratory to determine the total weight gain.

3. Sampling and Measurement of Abietic and Pimaric Acids (62)

The sampling method consisted of collecting the acids with Bendex Electrostatic Precipitators operating at 12,000 volts DC with flow rates of 7.95 cfm to 9.35 cfm. The acids were removed from the sampling tubes and analyzed using an infrared spectrophotometer. The

sampling time varied from six to nine hours each.

4. Sampling and Measurement of Alpha and Beta Pinenes (62)

The sampling methods consisted of collection of the pinenes on charcoal tubes sampled at a flow rate of 1.0 liters per minute. The samples were collected in the exhaust of the Bendix electrostatic precipitator units since the acids, if not removed, interfere with the adsorption of pinenes on charcoal. The pinenes were subsequently desorbed from the charcoal with carbon disulfide and analyzed using gas chromatographic techniques. The sampling time varied from six to nine hours each.

5. Sampling and Measurement of Phenols (64)

The sampling method consisted of collection of the vapor in midget impingers at a flow rate of 1.0 liters per minute using sodium hydroxide as the absorbing reagent with subsequent analysis using gas chromatography.

6. Sampling and Measurement of Formaldehyde (64)

The sampling method consisted of collection of the vapors in midget impingers at a flow rate of 1.0 liters per minute using 1% sodium bisulfite as the absorbing reagent with subsequent colorimetric analysis.

G. Medical Evaluation Methodology

An initial visit was made to the various Weyerhaeuser Company plants in Longview, Washington on September 1 and 2, 1976 by two occupational medicine physicians from the University of Cincinnati. During this visit, approximately 30 employees were interviewed to obtain data related to general health, respiratory symptoms, employment history, and working conditions. Some screening physical exams were performed. A walk-through inspection was conducted through the various plants.

Based upon a review of the literature related to the hazards of the wood products industry and data from the initial survey, areas for further medical evaluation were determined.

A second visit to the Weyerhaeuser complex to conduct a comprehensive medical evaluation of eight (8) plants was made on December 13 through 16, 1976. The twelve member University of Cincinnati College of Medicine team consisted of five occupational medicine physicians, two respiratory and two occupational health nurse specialists who were

enrolled in masters degree nursing programs, one fourth-year medical student, and two pulmonary function research technicians.

The medical evaluation consisted of three parts: questionnaire, physical examination and pulmonary function testing. Employees were brought to the medical evaluation sites by company foremen and supervisors. Representatives from the International Woodworkers of America Local #2498 were also present.

1. The Questionnaire

The questionnaire was based on both the British Medical Research Council Respiratory Questionnaire and Bouhuys' modified version of this questionnaire. A copy is included in Appendix B.

The 25-minute questionnaire was individually administered by the trained medical personnel at a time convenient to both the employee and researchers on the first day of the evaluation period.

In addition to basic demographic data, this questionnaire sought comprehensive information on respiratory and skin symptomatology, personal and family history of atopy, occupational history including previous and current occupational hazardous exposures, non-occupational hazardous exposures, injuries, illnesses, and smoking habits.

An abbreviated follow-up questionnaire was administered to groups I, II and III on the second and third days of evaluation. This questionnaire was designed to identify development of respiratory or irritation symptoms for the previous 24-hour period. A copy is included in Appendix B.

2. The Physical Examination

The physical examination was conducted following the questionnaire administration on the first day of the evaluation period.

Each employee (groups I through VIII) was examined for upper and lower respiratory system signs, including allergic and/or irritant signs and skin rashes. A check mark ($\surd$) and graphic format was used to record the results. Space was available on the form for the examiner's additional descriptions and/or comments. A copy of the physical examination format is included in Appendix B.

3. Pulmonary Function Testing

Pulmonary function tests are a routinely administered medical procedures with a few known hazards, the following were considered: Cross-contamination of airborne respiratory agents could

theoretically occur. This possibility was minimized by using individual, disposable mouthpieces, instructing the employee not to inhale from the machine (mouthpiece) and deflecting the mouthpiece away from the subject's face after the test.

Dizziness or fainting in cardiac, elderly or debilitated patients and paroxysm of coughing in heavy cigarette smokers and some patients with respiratory problems may infrequently occur. Both physicians and registered nurses were present during testing to observe each employee. A chair was placed nearby. It should be noted that all the subjects' normal daily work consists of frequent physical exertion (with exception of the office control group). All employees in the control group were employees who work daily without restriction.

Pulmonary function tests were administered by trained medical personnel using Vitalograph spirometers. This single-breath wedge-bellows spirometer has a volume capacity of 7.8 liters when the spirometric tracings are graphically corrected to BTPS (body termperature, standard pressure, saturated with water vapor). Standard spirometric tracings for each employee, with maximum employee effort, were obtained during each testing period.

Measurements of forced expiratory volume at one second ($FEV_{1.0}$) forced vital capacity (FVC) and forced expiratory flow rate between 25% and 75% of the vital capacity (FEF 25-75) were obtained for each employee. The highest of three spirometric volumes was used for calculations on each testing occasion. The ratio of the $FEV_{1.0}$ to the FVC, expressed as a percentage ($FEV_{1.0}$/FVC) was calculated.

Groups I, II and III were tested both before shift and after shift beginning on a Monday following a 2-day weekend with no occupational exposure. Tests were continued for three consecutive days (Monday-Tuesday-Wednesday).

Pre-shift pulmonary function tests were done immediately before the employee reported to his/her work station. Post-shift tests were done immediately after the day's work was completed (6-7 hours after beginning work in group I) or nearly completed (7-8 hours after beginning work for groups II and III).

Group IV employees performed pulmonary function test a short time after their day shift began and shortly before it was completed on the fourth day of the medical evaluation period (Thursday).

Group V employees performed pulmonary function tests on one occasion in the early afternoon of their day shift on Thursday.

Group VI employees performed pulmonary function tests on one occasion during the shift change (Thursday). Thus, day shift employees were tested after their workday and second shift employees before their workday.

Group VII employees were tested on one occasion during the day shift on Thursday.

Group VIII employees were tested on one occasion during the shift change (Thursday). Thus, day shift employees were tested after their workday and second shift employees before their workday.

A summary of the design of the medical evaluation is shown in Appendix A-2.

4. Informed Consent

Following a brief explanation of the medical examinations, including an explanation of confidentiality, employee's right to ask questions and withdraw from the study at any time, written informed consent was obtained from each participant. A sample consent form is included in Appendix B.

H. Environmental Criteria

The evaluation criteria applicable to this evaluation is as follows: The Occupational Health Standards as promulgated by the U.S. Department of Labor, Code of Federal Regulations, dated July 1975, Part 1910, Title 29, Chapter XVII, Subpart Z, Table Z-2; American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) for Chemical Sustances and Physical Agents in the Workroom Environment for 1977; NIOSH Criteria Documents for Recommended Occupational Exposures to Formaldehyde and Phenol; and the British Columbia, Canada standard for allergenic wood dusts in their "Industrial Health and Safety Regulations." Appencix A-3 summarizes the environmental criteria used.

I. Background Medical Information/Criteria

1. Wood Dusts

Respiratory complaints associated with the inhalation of wood dusts are not uncommon (1-3). Carpenters, joiners and sawmill workers frequently inhale wood dust which is formed during the handling and sawing of the unfinished wood.

In this review of the early (1920-1946) wood dust literature, Ordman (4) found that boxwood, orangewood, pinewood, cedarwood, fir (Picea mariana),

mahogany, birch, tamarak and iroko have been associated with reported cases of asthma. More recently (1949-1978) kejaat (5), oak and mahogany (6), Cedar of Lebanon (7), iroko (8), California redwood (9) and African zebrawood (10) wood dusts have been investigated and associated with respiratory symptoms in exposed workers.

2. Western Red Cedar

Western red cedar (Thuja plicata) is found only in western Canada and northwestern United States. The tree grows in cool, humid coastal regions from Alaska to northern California and can be readily distinguished from the spruce, pines, firs and hemlocks by its scaly leaves (11). The species is also known as Giant Arborvitae, Canadian Cedar and in Japan, as "Beisugi" (12).

The Western Red Cedar Syndrome was first described by Milne and Gandevia (1969) (22). Usually the exposed worker first complains of eye and nose irritation with rhinorrhea and nasal stuffiness. These symptoms may progress over a period of several weeks or months, during which time an irritating, dry, non-productive cough develops. The cough characteristically is worse at the end of the day or at night. A gradual subsidence of the eye and nose symptoms may occur, leaving episodes of nocturnal cough and/or wheezing as the only persistent symptoms.

Initially, symptoms begin to occur at night following a day's work. This delayed reaction may occur over the weekend and complicate recognition of the cause and effect relationship. If exposure to western red cedar wood dust continues, symptoms may also occur immediately (within 15-20 minutes) upon reexposure. Some workers may experience dual reactions (e.g. immediate and late) following several months or years exposure to this wood dust (23). Characteristically, asthma symptoms persist for days or weeks after cessation of exposure; this is particularly true of the nocturnal symptoms.

In 1970 Gandevia and Milne (24) described the physiologic abnormality as "mid-airway obstruction"; it gradually resolved after removal from western red cedar exposure. Mid-airway obstruction was determined by measuring $FEV_{1.0}$ Partial relief occurred during weekends and vacations, but nocturnal symptoms persisted for several days or weeks after cessation of exposure. No correlation with a history of atopy was found. Symptoms might recur on the first day or evening after return to work, but might not reappear for several days. Diagnosis was difficult to make for workers with continued exposure since they manifested a clinical picture of persistent airway obstruction; there was little change overnight away from exposure and only partial recovery over the weekends. Serial pulmonary function testing over a period of several days is often necessary to detect the changes in $FEV_{1.0}$

which help to distinguish bronchial asthma from other chronic obstructive pulmonary diseases.

Chan Yeung (1971) (25) described a similar syndrome in which subjects exposed to western red cedar wood dust showed persistent symptoms for several days, even with avoidance of cedar dust.

Appendix E discusses the Health effects of western red cedar in greater detail.

It is generally believed that plicatic acid extracted from western red cedar is responsible for the respiratory symptoms which have been observed following exposure to this wood dust. Results of skin tests have been inconsistent and presently appear to be of no diagnostic value in predicting or confirming that observed respiratory symptoms are associated with western red cedar dust exposure. Bronchial inhalation tests with plicatic acid or water soluble western red cedar extract results in significant decline in FEV_1. Although the asthma symptoms may be on an allergic basis, this has not yet been proven. Demonstration of asthma can be accomplished by observing decline in FEV_1.

3. Douglas Fir

Douglas fir tree (Pseudotsuga taxifolia Brit.) grows abundantly in northwestern United States and British Columbia. It is also known as Oregon pine, Douglas pine, red fir, Douglas spruce, yellow fir and Puget Sound pine. It accounts for about one-fourth of the total timber reserve in the United States (12).

The wood of young trees with wide growth rings is reddish brown; the wood of older trees of slower growth and narrow rings is usually yellowish brown. Both woods may come from the same tree (12). The wood is soft and has an even and close grain. It was used by Indian tribes of western Washington for firewood, shafts for harpoons, salmon spears and handles for dip nets (31). Today, the wood is used for general construction, plywood, woodenware, crossties and processes where large timbers are required.

Health effects from exposure to Douglas fir are not common. Suskind (32) patch tested eighty-two British Columbia lumber workers who had eczema of the hands, and found two with allergic skin reactions to an extract of Douglas fir wood. He also states that allergic reactions to common conifers (such as Douglas fir) appear to be infrequent.

One other case of dermatitis has been reported. A messenger with slight exposure to many woods developed severe dermatitis on exposed skin. Patch tests were strongly positive for Douglas fir and negative with several other woods (17).

Neudorffer's report of general symptoms after wreath-making with Douglas fir boughs "is not convincing" (33).

McGill (34) stated that "A review of 500 death certificates filed over a short period of years in the insurance office of the largest conifer-wood products company in the United States, did not show any correlation between exposure to conifer woods and sarcoidosis, Hodgkins disease or cancer of the lung." Douglas fir accounted for over 70% of the total lumber production of this company from 1902 until 1976 (15).

No reports of respiratory symptoms due to exposure to Douglas fir wood dust have been reported in the literature. Numerous review articles which list respiratory response to various woods do not mention Douglas fir (35) (36) (37). Douglas fir is occasionally used as a control substance when testing responses to other woods (38). Douglas fir contains alphapinene and delta-3-carene, a related terpene.

4. Hemlock

This coniferous tree (Tsuga Heterophylla) grows from Alaska to northern California. The species is also known as west coast hemlock, hemlock spruce, Prince Albert fir, grey fir, Alaskan pine, and western hemlock fir (12).

The wood is light in color with a pinkish tinge, light in weight, moderately soft and straight grained. It is used for general construction, boxes, woodenware, and pulpwood. Hemlock often grows intermixed with strands of Douglas fir and is cut and processed at the same time (39).

Suskind (32) reported no cases of hemlock sensitivity in his study of eighty-two woodworkers with dermatitis. Suskind did report, however, that an extract of hemlock was sensitizing in a group of six guinea pigs.

No other instances of adverse health effects attributed to hemlock wood dust have been reported in the literature.

5. Alder

Alder (Alnus Oregona), non-coniferous tree of the birch family, is relatively common in open wooded areas in Washington and Oregon. This species is also known as red alder (12). The wood is commonly used for plywood and has a reddish-white color with a smooth fine grain. The wood was used preferentially by the Cowlitz and other Indian tribes in western Washington for smoking salmon (31).

A review of the medical literature reveals only one reference to alder wood dust. Brügel and Perutz (1927) (40) reported four cases from Russia of dermatitis to the sawdust of black alder (Alnus flutinosa) documented by positive patch tests.

6. Veneer Dryer Emissions: Pinenes and Terpenes

The pinenes and terpenes are colorless to yellow liquids with the odor of turpentine. The toxic properties of the pinenes include:

a. Inhalation: Among the effects observed in humans subjected to severe exposures were irritation of mucous membranes of nose and throat, cough, bronchial inflammation, salivation, headache, vertigo, and irritation of the kidney and bladder. It has been reported that continued inhalation of the vapor may cause chronic nephritis and predispose to pneumonia (41). Albuminuria and hematuria have been reported in men exposed to turpentine vapor (contains pinenes and turpenes) with subsequent recovery from such exposures. Animal studies indicate that turpentine vapors at low levels are not a chronic poison (42). There is scanty evidence to suggest that some individuals develop hypersensitivity to turpentine after prolonged, repeated exposure.

b. Skin Contact: There is little doubt that pinenes are skin irritants if allowed to remain in contact with the skin for a sufficient length of time. Some persons become hyperreactive so that even moderate exposure to vapors will cause a skin reaction. Most individuals do not develop dermatitis with just occasional contact to the substance.

c. Eye Contact: Pinene vapor concentration of 200 ppm is moderately irritating to the conjunctiva.

7. 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.

8. Abietic Acid

There is scanty toxicological data available on this chemical. According to Patty (42) 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. Sodium Pentachlorophenate

Prolonged or repeated contact with the skin can cause dermatitis and systemic intoxication. Low concentrations of the dust irritate the mucous membranes of the nose, throat, eyes and upper respiratory system (44).

J. Effects of Cigarette Smoking

There is little doubt that cigarette smoking is associated with numerous adverse health effects, including cancer of the lung (43). Other well known detrimental health effects of smoking include: heart disease, vascular disease, reproductive disorders, pulmonary disease and impaired ventilatory function. Extensive reviews of the adverse health effects of cigarette smoking are summarized in two major Public Health Service reports (44) (45).

A major effect of cigarette smoking is on the lung. The effects of smoking on pulmonary function may be more qualitative than quantitative (46). Brinkman (47), reporting on 301 men studied over eleven years, showed an inverse relationship between cigarette smoking and FEV_1; this relationship, however, could not be directly correlated with the number of pack-years of smoking. He concluded that "smoking" compared with "non-smoking" was a more reliable prediction of decreased FEV_1 than actual numerical pack years smoked. Furthermore, individual susceptibility to the chronic effect of cigarette smoking must be considered when comparing population groups.

K. Interaction of Smoking and Other Exposures on Pulmonary Function

In a study of 159 working men in a Sheffield factory, Howard (48) was unable to show a definite relationship between cigarette smoking and a decline in FEV_1. He found, however, that air pollution level and occupation each correlated with a decline in FEV_1. Smoking did correlate with a decline in FEV_1 when occupational exposures and air pollution factors are better controlled (49).

Lowe (50) studying 10,449 men in 114 occupational areas in two steel mills, confirmed that age and smoking were related to a decreased FEV_1. He concluded that age differences and differences in smoking habits among occupational groups could mask any effects that occupational exposure had on FEV_1.

Bouhuys summarized these variables in the following statements: "Such aberrant associations between smoking and lung function can occur when a

population is exposed to more than one inhaled agent that causes lung damage. The quantitative relations between the amount smoked and lung function become complicated by self-selection." He added that, "Whenever the relationship between cigarette smoking and ventilatory capacity does not follow the expected pattern, exposures to agents other than cigarette smoking should be considered" (51).

L. Western Red Cedar and Smoking Habit

Few investigations have studied the combined effect of occupational exposure to western red cedar wood dust and cigarette smoking. Gandevia et al. (52) reported that in their experience both smokers and non-smokers were affected by exposure to western red cedar wood dust.

In a later study of thirty men exposed to western red cedar dust, Gandevia (24) employed both before and after shift pulmonary function tests. A statistically significant mean decrease in FEV_1 (both Tuesday and Friday tests) for the eighteen smokers was 101 ml ($p<0.025$) and for the twelve non-smokers, 92 ml ($p<0.025$). There was a mean decrease of 139 ml ($p<0.02$) in ten smokers with symptoms of a productive cough; a mean decrease of 54 ml (not statistically significant) occurred in eight smokers with a dry (non-productive) cough. Smokers, expecially those with a productive cough seemed to show the greater decrease in FEV_1.

In a 1976 study of workers in western red cedar mills in British Columbia, Chan-Yeung and co-workers (53) found that current smokers had a higher prevalence of respiratory symptoms and lung function abnormalities than ex-smokers and non-smokers. This suggested that the effect of western red cedar wood dust exposure and smoking were additive or possibly synergistic; smoking cedar workers had the highest prevalence of symptoms and pulmonary function test abnormalities of any wood dust-smoking group they studied. Multiple regression analysis of the data demonstrated that the negative slope for the relationship between FEV_1 and age was greater for smokers than for non-smokers. That is, the negative slope was steeper for smoking cedar workers than for smoking control workers. No statistical analysis of this data was reported. It appears, therefore, that difference in effect of western red cedar wood dust on pulmonary function tests among workers who smoke compared to workers who do not smoke cigarettes have not been adequately analyzed.

In summary, western red cedar wood dust exposure is known to cause conjunctivitis, allergic rhinitis and/or occupational asthma. No specific toxic or allergic effects are documented for Douglas fir, hemlock or alder wood dusts, except those related to extractives of these woods, such as pinenes, terpine, abietic and pimaric acids associated with wood distillation and veneer dryer emmissions. Cigarette smoking causes alterations

in pulmonary function testing. This factor must be considered in any medical evaluation of occupational exposures to respiratory hazardous substances. Cigarette smoking impairs respiratory clearance mechanisms which may increase residual pulmonary contact time of inhaled particles. This is also an important factor to consider when determining respiratory effects of biologically active particles such as western red cedar dust. Other organic dusts such as cotton, hemp, and flax can also cause impaired pulmonary function in non-smoking workers (54).

M. Definition of Terms Used in this Report

The following terms are defined for purposes of this study:

1. Forced Vital Capacity (FVC): the maximal volume of air forcibly exhaled following maximal inspiration.

2. Force Expiratory Volume at One Second (FEV_1): the volume of air forcibly exhaled in the first second of the FVC maneuver.

3. FEF 25-75: forced expiratory flow occurring between 25% and 75% of the FVC (e.g. middle half). Formerly called the Maximal Mid-Expiratory Flow (MMEF or MMF).

4. FEV/FVC%: the ratio of the FEV_1 to the FVC expressed as a percentage.

5. Predicted Value: a "normal" value reported for a pulmonary function measurement based upon the subject's age, height, sex and race. The values are developed from data obtained from testing large numbers of apparently "normal" individuals.

6. Percentage of Predicted Value: the ratio of an actual observed pulmonary function test measurement to the predicted value, expressed as a percentage.

7. Pack/Year: product of the number of packs of cigarettes smoked per day (one pack is twenty cigarettes) and the number of years this amount was smoked.

8. Cigarette Smoker: a subject who smokes cigarettes regularly at the current time.

9. Cigarette Nonsmoker: a subject who has never smoked cigarettes or has not smoked in the last two years and has a total lifetime smoking history of less than one-half pack/year.

10. Former Cigarette Smoker: a subject who does not currently smoke cigarettes and has a total lifetime smoking history of more than one-half pack/year.

11. Previous Occupational Exposure to Western Red Cedar: any occupational exposure to western red cedar that occurred prior to employment at Weyerhaeuser Company.

12. Previous Other Significant Occupational Exposure: a subjective determination based upon each subject's questionnaire considering substances other than wood dust, circumstances, and duration of exposure and the possibility of an adverse effect upon pulmonary function.

13. Significant Non-Occupational Exposures: a subjective determination based upon each subject's questionnaire considering the substance, circumstances and duration of exposure, and the possibility of an adverse effect upon pulmonary function.

14. Personal History of Atopy: an individual's history of childhood eczema, asthma, hayfever or allergies which began prior to employment.

15. Total Dust: amount of all dust, by weight, collected via personal sampler.

16. Respirable Dust: Dust less than 10 microns in size that is selectively passed by a selector (in this study a cyclone).

17. Threshold Limit Value (TLV): the airborne concentration of a substance representing the conditions under which it is thought that "nearly all" workers can be exposed repeatedly, daily without adverse health effects (55).

18. Threshold Limit Value-Time Weighted Average (TLV-TWA): the time-weighted average concentration for a normal eight-hour workday or forty-hour workweek to which "nearly all" workers may be repeatedly exposed, day after day without adverse effect (55).

19. Time-Weighted Average: the time weighted average concentration for a normal eight-hour workday.

20. Clinical evidence of Occupational Asthma is defined both physiologically and clinically as an observed decline in $FEV_{1.0}$ of greater than 10 percent from the Monday preshift baseline value compared to one or more subsequent pulmonary function tests during the following three day exposure period, and a positive clinical history of occupationally related asthmatic symptoms as derived from the administered questionnaire.

21. A positive clinical history of occupationally related asthmatic symptoms includes: cough (particularly nocturnal cough), wheezing, chest tightness or shortness of breath, which began during employment and have been consistently present for at least six months during that employment, and these symptoms become less severe or resolve during weekends or vacations, and worsen or return within 24 hours to one week upon resumption of work.

22. Chronic Bronchitis is defined as cough and sputum production on most days for at least three months of the year for the preceding two years. In this evaluation, the above criterion combined with nonspecific pulmonary function abnormality as defined below, are considered diagnosis for chronic bronchitis.

23. Abnormal Pulmonary Function tests are considered to be present when the $FEV_{1.0}/FVC$ ratio is less than 70% and the FVC or $FEV_{1.0}$ is less than 80% of the predicted value (56). An FEF_{25-75} of less than 75% of the predicted value may be considered abnormal for individuals less than 50 years of age. Due to the variability of FEF_{25-75}, a single value below 75% was not regarded as abnormal. However, a decline of the FEF_{25-75} of greater than 20% from the Monday preshift baseline was considered to be significant. Similarly, in serial evaluation where an individual functions as his own control, decline in FVC or $FEV_{1.0}$ of greater than 10%, and/or decreases in the $FEV_{1.0}/FVC$ ratio greater than 6% were considered significant (57). This, however, was not absolutely diagnostic in the absence of a positive clinical history of asthma symptoms.

24. Chronic Obstructive Lung Disease is a term used to describe chronic respiratory disease/symptoms associated with generalized airways obstruction. The latter is manifested by FEV_1/FVC less than 70%.

VI. RESULTS OF STUDY

A. Results of Environmental Survey

The environmental results are discussed by area.

1. Shake Mill

There were 191 individual samples collected for western red cedar wood dust over three shifts for three days. These samples resulted in 85 total and 39 respirable dust time-weighted average (TWA) measurements. A summary of these results are shown in Appendix A-4. Individual results are presented in Appendix C-1 to C-14.

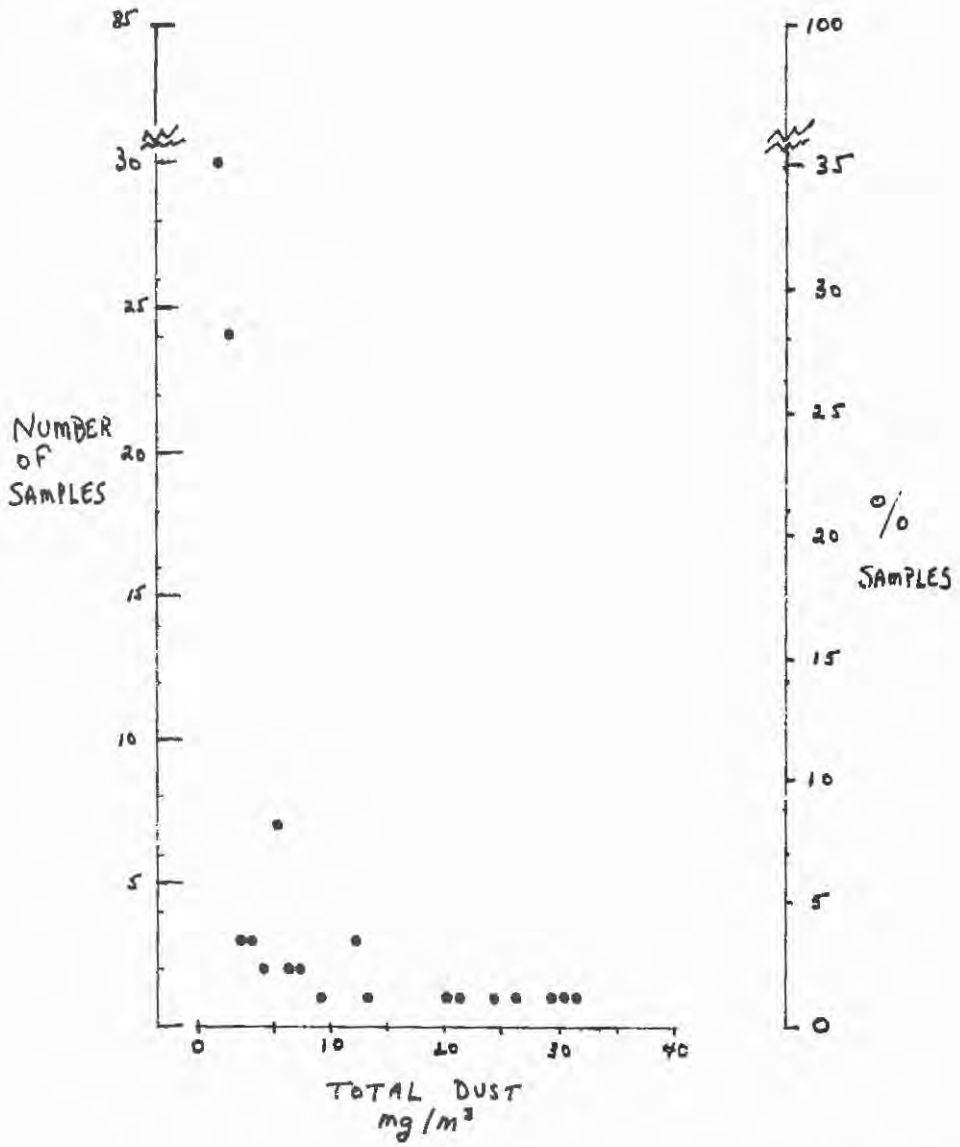
The 39 respirable TWA dust concentrations had a range of 0.01 to 1.21 mg/cu m. Thirty-six of the 39 (92%) were less than 0.45 mg/cu m. The other three were 0.54, 0.83, and 1.21 mg/m^3.

The concentrations of the 85 TWA total dust samples had a range of 0.06 to 31.90 mg/cu m. The particle size distribution (Appendix C-29) indicated that a large proportion of the total dust weight was contributed by larger, non-respirable wood dust particles.

The following jobs in descending order had the highest western red cedar wood dust exposure (Appendix A-5): chippers, sawyers, packers, and splitters. Chippers had a mean TWA of 18.26 mg/cu m (2 samples: 5.82 and 30.70 mg/cu m; sawyers had a mean TWA concentration of 6.84 and a median of 3.01 mg/cu m; the packers showed a mean TWA concentration of 4.81 and a median of 1.75 mg/cu m; and the splitters revealed a mean TWA concentration of 3.56 and a median of 1.20 mg/cu m. Several high sample concentrations skewed the results. Figure 1 demonstrates the frequency distribution of the total dust concentration (TWA). TWA concentrations of 11 of 85 samples (13%) were 10 mg/cu m or more; 62 of 85 samples (73%) were 5 mg/cu m or less; 57 of 85 samples (67%) were 3 mg/cu m or less. Eleven of the 85 samples (13%) were 12 mg/cu m and greater. If these 11 were not included, the mean TWA dust concentration for sawyers, packers, and splitters would be reduced by approximately 50%.

At the present time neither the U.S. Department of Labor nor the American Conference of Governmental Industrial Hygienists has no Threshold Limit Value for western red cedar wood dust, an allergenic wood dust. The Canadian Province of British Columbia has a standard for allergenic wood dust of 2.5 mg/cu m. Thirty-one out of 72 (43%) of the TWA total dust samples obtained for chippers, sawyers, packers, and splitters exceeded 2.5 mg/cu m. None of the 14 samples collected on the other jobs in the Shake Mill exceeded 2.5 mg/cu m.

Figure 1



This figure shows the frequency of concentrations of the dust samples collected. Thirty of 85 (35%) were 0-1 mg/M^3; 25 of 85 (28) were 1-2 mg/M^3; and 3 of 85 (3.5%) were 2-3 mg/M. Thus, 57 of 85 (67%) were 0-3 mg/M^3 and 62 of 85 (73%) were 0-5 mg/M^3.

It is of interest to note the variability that occurred in some dust measurements during the same shift. Environmental measurements during a shift were usually divided into two sampling periods which were used in determining the eight hour TWA concentration. Some major discrepancies were noted. For example, some measurements included: 1.57 mg/cu m on the first sample and 54.30 on the second sample, 3.09 and 66.40, 30.10 and 2.82 mg/cu m. The investigators were not able to identify the portion of the operation where the high dust levels occured. Since they were not under constant surveillance some contamination of the personal sampler was possible.

There is no local exhaust ventilation on the band saws. Since the splitters, sawyers, and packers all work near each other, their wood dust exposure could be reduced with the use of local exhaust ventilation on the band saws. A comparison of the results made between the chipper in the Shake Mill and the chipper in the New Planer indicates that the dust levels in the Shake Mill chipper can be reduced.

Clean-up in the Shake Mill at the band saw should be accomplished with a vacuum source. Equipment should not be blown off with air hoses.

2. New Planer

The New Planer Mill processes Douglas fir and hemlock lumber. Fir and hemlock dusts are considered non-allergenic wood dusts. The American Conference of Governmental Industrial Hygienists Threshold Limit Value (TLV) for non-allergenic wood dusts is 5 mg/cu m.

There were 89 samples collected in the New Planer Mill over two shifts for three days. These samples provided 59 total dust and 23 respirable dust TWA measurements. The summary of these results are found in Appendix A-6. Individual results are shown in Appendix C-15 to C-21.

The respirable TWA samples ranged from 0.07 to 0.29 mg/cu m, while the total dust TWA samples ranged from 0.17 to 16.7 mg/cu m.

Five out of the 59 total dust TWA samples (8%) exceeded 5 mg/cu m. It is difficult to explain these high results. Only one of the eight samples collected from the set-up men was high. This was 12.0 mg/cu m; the other seven samples were all less than 0.59 mg/cu m. The same is true for the break-down men. One measurement was 8.07 mg/cu m; the other four were less than 0.89 mg/cu m. Two of five samples for the tally and stappers exceeded 5 mg/cu m and one of three (actually two of four, as one was too overloaded to weigh) exceeded 5 mg/cu m. None of the other jobs in the New Planer had wood dust exposures that exceeded 5 mg/cu m. The disparities noted in sampling were not consistently found and were

not reproduced in subsequent sampling of the same worker. When there are results that indicate 1 of 7 or 1 of 5 employees performing the same job are excessive, it is difficult to find the cause so that either the dust levels can be reduced by engineering controls or by changing of work habits. Additional samples should be collected by the company to determine the reason for the occasional high exposure and corrective action can be taken. Once again, the cleaning should be accomplished with a vacuum source rather than blowing down with compressed air.

The Cherry Brown operator has an additional exposure of the Cherry Brown stain, the solvents used in the stain, and sodium pentachlorophenate. These were not sampled during this survey; however, they should be considered in evaluating the total exposure of the operator and the other employees in the area.

3. Bark Plant

Wood dust samples were only collected during one shift for one day so the number of samples is minimal. The summary of the results are shown in Appendix A-7. The individual results are presented in Appendix C-22; the total dust samples ranged between 1.22 and 8.28 mg/cu m. With a mean of 3.95 mg/cu m and a median of 2.43 mg/cu m. Two of the five TWA total dust samples exceeded 5 mg/cu m. Although the dust levels were 1.67 and 1.22 mg/cu m for the bagger and bag stacker, a local exhaust system could be utilized at the bagger, as much wood dust can be seen escaping from the operation. Depending on the fineness of the bark dust on any particular day and other localized variations in the operation, it is felt by the investigators that this operation is a potential problem.

The operator of the bark grinder had a wood bark exposure of 6.17 mg/cu m and the man who picks wood out of the hogger on the dike had an exposure of 8.28 mg/cu m. The source of the exposure was not determined, but wind direction was thought to be a factor.

4. Old Planer

There were 6 total dust and 1 respirable dust samples collected in the Old Planer on 1 shift for 1 day. The summary of the results are shown in Appendix A-7 and the individual results in Appendix C-23. The total dust samples had a range of 0.20 to 54.80 mg/cu m, a mean of 18.12 mg/cu m, and a median of 1.03 mg/cu m. The results were 1.47 mg/cu m or less for all but 2 samples. The chipper man had a total wood dust exposure of 51.40 mg/cu m and the set-up man 54.80 mg/cu m, both of which exceed the criteria of 5 mg/cu m. Environmental controls have not been installed on these 2 jobs as they have been in the New Planer Based

on the lower results obtained on similar jobs in the New Planer, it is possible to reduce these dust levels considerably. As an interim control, the chipper and the set-up man should wear respiratory protection effective for wood dust.

5. Presto-Log

There were 10 total wood dust samples collected which resulted in 5 TWA total dust samples, and 2 respirable dust samples. The summary of the results are shown in Appendix A-7 and the individual results in Appendix C-24. The TWA total dust samples had a range of 0.58 to 4.55 mg/cu m, a mean of 1.72 mg/cu m, and a median of 0.58 mg/cu m. All of the TWA samples were less than the evaluation criteria for non-allergenic wood dust of 5 mg/cu m. High dust exposures could occur during clean-up and when an employee has to enter the collector system. Blowing-down should not be permitted. A respirator for use with wood dust should be worn when entering the hopper and collector systems.

There are other substances present that were not sampled during this survey. These substances include the smoke that is given off when the logs are removed. This smoke would contain diesel oil breakdown products and some wood resins. These substances might also produce adverse health effects in the exposed employees.

6. Pres-Tock Plant

There were 10 total and two respirable dust samples collected in the Pres-Tock Plant. The 10 total dust samples provided five TWA samples. The summary of the results is shown in Appendix A-7; individual results are in Appendix C-25. The TWA total dust samples had a concentration range of 0.60 to 21.50 mg/cu m with a mean of 13.54 mg/cu m, and a median of 11.10 mg/cu m. Four of the five samples exceeded 5 mg/cu m by two to four times. This entire operation was very dusty. There was a thick layer of wood dust in the area, especially in the bagger area, balcony, and on the water fountain. The low respirable dust samples indicate that most of the particles were larger than 10 u. Several of the employees were wearing respiratory protection.

Based on the high sample results and obvious settled dust in the area, the entire Pres-Tock operation should be evaluated and engineering controls installed to reduce the amount of wood dust escaping into the work area, especially at the bagging operation. In addition, blowing-down should not be used to clean the area because of increased respiratory exposure.

7. Resin Plant

General area samples were collected on the balcony near the resin tank and the glue mixing tank for formaldehyde and phenol. Other substances that are used in the glue were not sampled as they were not handled during the sampling period. The results are shown in Appendix C-28. The phenol was not detectable. The formaldehyde concentration by the resin tank was 0.11 mg/cu m and by the glue mixing tank it was 0.21 mg/cu m. These are less than 10% of the evaluation criteria of 3 mg/cu m.

The operator could have short high level exposures as he opens the vessels, however, the remainder of the day he does not spend much time on the balcony where the samples were collected. Considering this, it is expected the operators TWA exposure would be lower than the evaluation criteria and, except for an occasional short period of eye irritation, there would be no adverse health effects.

The local exhaust system on the lid could be modified on the mixing tank. When the lid is open it blocks the lateral exhaust ventilation and its effectiveness is decreased.

8. Plywood Plant

There were eight total wood dust samples (Appendix A-26) collected over one shift in the Plywood mill, leading to four TWA samples. The TWA samples had a range of 0.25 to 1.31 mg/cu m with a mean of 0.62 mg/cu m, and a median of 0.46 mg/cu m. The sanders-graders were 0.25 and 0.43 mg/cu m; the skinner-saw operator was 0.48 mg/cu m; the special saw operator was 1.31 mg/cu m . All were less than the evaluation criteria of 5.0 mg/cu m for non-allergenic wood dusts.

In the veneer dryer area there were eight general area samples collected for abietic and primaric acids and seven for alpha and beta pinenes over four shifts on three days (Appendix A-27). The total abietic and pimaric acids ranged from 0.01 to 0.20 mg/cu m with a mean of 0.10 mg/cu m and a median of 0.08 mg/cu m. The alpha and beta pinenes concentration range was 0.01 to 0.08 ppm with a mean of 0.05 ppm and a median of 0.04 ppm. There are currently no standards for these specific substances.

The data from three previous Health Hazard Evaluations, two of which were in the northwest (62,63), were reviewed. These evaluations dealt specifically with these substances. The total acid measurements noted in the northwest evaluations had a mean of 0.21 mg/cu m; the pinenes had a mean of 0.13 and 0.63 ppm. The total acids and pinenes for

the present study were approximately 50% or less than the two previous evaluations. These 2 prior studies included extensive medical evaluations. It was determined that at the concentrations found, the substances may cause transient irritation of the mucous membranes of the eyes, nose, and throat as well as upper respiratory tract producing cough and chest discomfort, but there was no evidence to suggest it would produce permanent respiratory disease. Based on these prior studies and the fact that the concentrations of the acids and pinenes in this evaluation were about half of those in the prior studies, it is assumed that similar transient irritations could occur but that permanent respiratory disease is not likely to occur.

B. Results of Medical Evaluation

Because of the wide variation in length of exposure among the Shake Mill, New Planer Mill, and Office/Control groups, it was decided to initially subdivide these groups by years of exposure. Employees from these three areas were categorized as having either less than 10 years exposure, or 10 years or more exposure. It was felt that statistical analysis of the sub-groups with less than ten years exposure would minimize the self-selection effect that would be expected to be a predominant factor in this type of cross-sectional study. The results and discussion will be presented in two parts: all of the participants in groups I, II and III (Population A) and sub-group with less than 10 years exposure (Population B).

1. Data Analysis of Employees with Less than 10 Years Exposure (Population B)

There were 193 workers employed in the exposure areas (groups I, II & III); 157 were selected for study (81%) in the Health Hazard Evaluation (Population A). Of these 157 workers, 97 (62%) had less than 10 years of wood dust exposure (employment) in their work area (Population B). Subject selection for study is summarized in Appendix A-8).

The 97 workers in Population B (< 10 years exposure) worked in three different areas. Group I (Shake Mill) was occupationally exposed to western red cedar; Group II (New Planer Mill) was exposed to a combination dust, approximately 80% Douglas fir and 20% hemlock; Group III (office workers) had no significant dust exposure (control).

Data from ex-smokers was not included for analysis of Population B (< 10 years exposure) because insufficient numbers (i.e. 10) were available for statistical analysis by wood dust category. Thus 87 (90%) smokers and non-smokers in the three exposure areas were analyzed.

The 53 white males in the Shake Mill ranged in age from 18 to 45 years with a mean age of 25.75 years. The average duration of exposure to western red cedar dust was 3.43 years. This data is summarized in Appendix A-9.

The influence of pack-years of cigarette smoking and years of occupational exposure on FEV_1 were analyzed (58,59). Pearson's product-moment correlation was used to determine the relative strength and direction of the relationships of the two quantitative variables with FEV_1 (Appendix A-10 shows the results of this analysis). One Pearson r value was significant showing a significant inverse correlation ($p=0.043$) between pack-years of cigarette smoked (among smokers in the New Planer Mill) and FEV_1 percentages of predicted. No other correlations reached statistical significance. In general, all smokers tended to show a fall in FEV_1 with increasing cigarette consumption. Because the variables did not demonstrate quantitative significance in influencing FEV_1, smoking consumption and wood dust exposure were treated as qualitative variables in subsequent analyses.

An additional variable considered in the preliminary analysis was an individual's history of atopy, or possible allergic predisposition. There were too few individuals with such a history for statistical analysis. Appendix A-11 presents the number of workers with an atopic history in each work area. Although there was a larger percentage of workers with a personal history of atopy in the New Planer Mill, the number of subjects in the New Planer Mill and office control group was too small to be meaningfully analyzed by percentages.

Two independent variables, wood dust exposure and smoking history, and one dependent variable, FEV_1, were analyzed by two-way analysis of variance. Two-way analysis of variance tests significance of the differences among means of groups created by the three categories of wood dust exposure and two categories of smoking history. The three categories of wood dust exposure were (1) western red cedar, (2) combination of Douglas fir and hemlock or (3) minimal, if any wood dust exposure. As shown in Appendix A-12, neither wood dust exposure, nor smoking history had any statistically significant effect on FEV_1. Individual information from each worker's questionnaire and pulmonary function tests are shown in Appendix D.

2. Data Analysis of All Employees (Population A)

Analysis of data took into account variables which could influence results. Appendix A-13 lists important variables which could influence pulmonary function.

Appendix A-14 summarizes information concerning the diagnosis of occupational asthma among workers exposed to western red cedar dust. Occupational asthma was diagnosed in 10 of the 74 Shake Mill employees using diagnostic criteria as described previously. This included a clinical history compatible with the diagnosis of occupational asthma and a decrease in FEV_1 during work of more than 10%. The resulting prevalence rate for occupational asthma of 13.5 among Shake Mill workers is high considering the projected annual employee turnover rate of 22%. Additionally, seven Shake Mill employees, with clinical histories very suggestive of occupational asthma, demonstrated declines in FEV_1 of 5.0-10%. While suggestive of a probably occupational asthma, these seven employees did not meet the established criteria for definitive diagnosis.

Three employees in the New Planer Mill (one setup man, one grader and one trimmer) had evidence of occupationally related asthma thus giving a prevalence rate of 5.2 in that area (Appendix A-15).

Asthma was documented by demonstrating a greater than 10% decline in forced expiratory volume at one second ($FEV_{1.0}$) from baseline preshift test on a Monday morning to subsequent test values obtained over the next three days, coupled with a positive history of asthma symptoms as determined by medical questionnaire. It was not determined whether the employee's exposure to the wood dust or the sodium pentachlorophenate or a combination of both that resulted in the occupational asthma.

A summary of the various respiratory disease diagnoses among employees examined in various work areas are shown in Appendix A-16. The Shake Mill and New Planer Mill employees had a higher prevalence rate of pulmonary disease (of all types), 40.5% and 37.9% respectively, compared to the office/control group (16.0%), Plywood (18.7%), Pres-Tock (14.3%) and Bark Plant (20%) workers.

When the additional factors such as age and pack-years of cigarette smoking were considered in this intra-group comparison, it is readily seen that the younger Shake Mill employees (mean age 28.9 years) showed a disproportionately higher prevalence rate of pulmonary disease than the older office employees (mean age 42.5); the office workers also had more cumulative pack-years of cigarette smoking (mean of 25.4) compared to Shake Mill workers (mean of 13.6). Smoking habits of the Shake Mill, New Planer and office groups are shown in Appendix A-17. There were slightly more smokers in the Shake Mill Group.

Other potentially hazardous respiratory exposures which could have influenced results are shown in Appendix A-18. Eight employees in the Shake Mill had one to two years of previous exposure to western red cedar wood. These previous years of exposure were added to their present years of exposure to give a total number of years exposure to this wood dust.

Family and personal history of atopy was considered as a possible variable which might affect sensitization to western red cedar. This data is presented in Appendix A-19. There were fewer atopic individuals in the Shake Mill than in the New Planer Mill or office groups. Two of the employees diagnosed as occupational asthmatics in the Shake Mill had a history of atopy. The prevalence of atopy (18.2%) among Shake Mill employees with confirmed occupational asthmatics is not significantly different from prevalence of personal atopy (13.5%) or family history of atopy (18.9%) in the Shake Mill population as a whole. This observation would confirm the findings of Chan-Yeung and Gryzbowski (28) that atopy does not appear to be an important factor in the development of western red cedar asthma.

Results of physical examination of signs indicating eye, nose or throat (ENT) irritation are shown in Appendix A-20. There was little difference among the three groups except that office workers showed more evidence of ENT irritation.

Response to questions concerning ENT irritation is shown in Appendix A-21. These results contrast markedly with actual physical findings of ENT irritation in the same groups. Only 4% of the office group (one person) gave a positive history of eye irritation; 80% of these employees had physical signs of eye irritation. Local air pollution may have been a relevant factor in causing the high prevalence of these findings.

Physical examination of the chest demonstrated no difference in number of employees with abnormal chest sounds (e.g. rhonchi, wheezes, or rales) in the three groups. However, current and former cigarette smokers showed greater prevalence of abnormal chest sounds. This is shown in Appendix A-22.

The prevalence of a history of either occupational or nonoccupational rhinitis is shown in Appendix A-23. A total of 51.3% of the Shake Mill workers as compared to 4.0% of the office employees complained of symptoms of rhinitis. Symptoms of rhinitis not work related were 8.1% in Shake Mill and 0% in office workers.

In general, there were no significant pulmonary function differences between the three exposure groups with 10 or more years of wood dust exposure. Appendix A-24 shows the mean $\pm$ SD for baseline (e.g. Monday morning) FEV_1% predicted for the Shake Mill, New Planer Mill and office workers.

Appendix A-25 lists the prevalence of at least one abnormal baseline tests among all workers in the three groups. A test was considered to be abnormal if the FEV_1 or FVC was < 80% of predicted, FEV_1/FVC was < 70% or FEF_{25-75} was < 70% of predicted. Again smokers and exsmokers had more frequently observed abnormal tests. No significant difference between groups was noted. However, the mean age of the employees with abnormal pulmonary function tests in the Shake Mill was lower (34.6 years) than either the New Planer Mill (46.1 years) or office/control workers (51.0 years). This is shown in Appendix A-26. It must be reminded again, however, that there was a 22% annual turnover rate for employees in the Shake Mill.

The diagnosis of occupational asthma was made on clinical symptomotology consistent with this diagnosis and fall in FEV_1 of greater than 10% on the workdays.

The prevalence and distribution of occupational asthma by job title among Shake Mill workers are shown in Appendix A-27. It appears that sawyers are at greatest risk for developing asthma; three of 21 (14.3% current sawyers were shown to have occupational asthma; two former sawyers who were transferred to other jobs also had asthma. The sawyers were exposed to high average concentrations of western red cedar wood dust. Figure 2 depicts data according to exposure and FEV_1 fall.

The prevalence and distribution of occupational asthma by job title for New Planer Mill workers is shown in Appendix A-28.

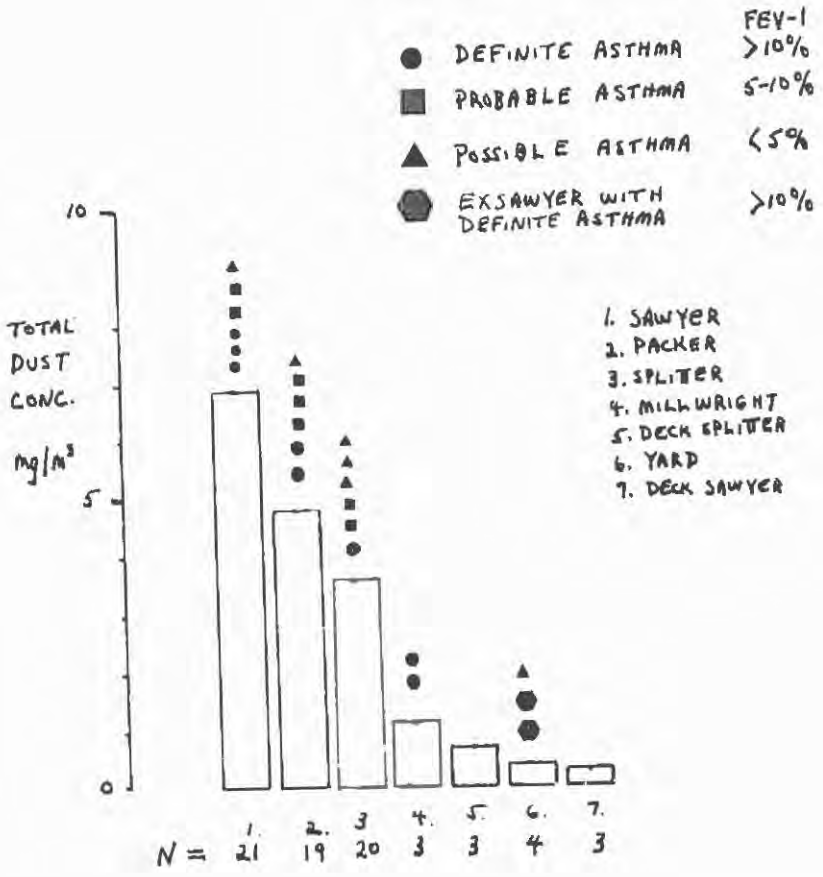
Appendix A-29 summarizes the changes in FEV_1 over the three days of study. A significant fall in FEV_1 between Monday pre and post shift was noted among the Shake Mill workers exposed to western red cedar dust ($p < 0.001$). This decrease in FEV_1 continued for the next two days not returning to original baseline values. No significant reduction in same day pre and post shift FEV_1 was demonstrated by New Planer and office workers. A gradual decline in FEV_1 was noted in the New Planer group during the three days; slight reduction in FEV_1 was also seen in office workers by the third day. These results were not statistically significant.

The fall in FEV_1 noted among Shake Mill workers occurred in smokers as well as nonsmokers. This is demonstrated in Appendix A-30. The magnitude of the change, however, is greatest among smokers and exsmokers. Among the nonsmokers 19 of 22 workers had some decline in FEV_1 during the period of study.

VI. DISCUSSION

In the present health hazard evaluation the frequency of symptoms and lung function abnormalities among workers exposed to western red cedar dust were compared to the frequency found among workers exposed to other wood dusts and to employees who had no occupational dust exposure. Clinical and physiologic measurements were made in these groups before and after each work shift for three consecutive days.

Figure 2



This figure shows the relationship between total cedar dust concentration in a specific job category (mean value given, see pg. 56) and the number of cases of diagnosed occupational asthma (N=the number of employees at risk in a particular job category). All subjects had a definitive clinical diagnosis for occupational asthma as defined on page 52. In addition, there were reductions in FEV_1 over the 3-day period of work, <10%, 5-10% or <5%. Based on these FEV_1 changes, employees in various job categories were classified as definite (10), probable (7) and possible (8) occupational asthma. It can be seen that sawyers, packers and splitters, employees with the "dustiest" jobs, have the highest prevalence rate of asthma. Also shown are two former sawyers who currently worked as yard personnel, having low dust exposure, but who had definite asthma. Not shown are two chippers with possible asthma. Note that by excluding the two former sawyers, the prevalence rate in the "less dusty" jobs (i.e., millwright, deck splitter, yard, deck sawyers) was two of 74 or 2.7%. This is near the prevalence rate of Chan-Yeung, et al. who noted a 1.1% prevalence with dust levels of 2.4 mg/M^3 (11).

A high prevalence rate of occupational asthma was observed among Shake Mill workers exposed to western red cedar wood dust. When strict clinical and pulmonary function test criteria were used, a prevalence rate of 13.5% was noted (see Appendix A-14). If diagnostic criteria for occupational asthma was relaxed (e.g. compatible history and FEV_1 fall of between 5% and 10%), another 9.5% of employees were identified with disease. This results in an overall prevalence rate of occupational asthma of 23%. These prevalence rates are much higher than those reported by other investigators (1, 11, 18, 53, 60).

This high prevalence rate for occupational asthma is probably the result of high concentrations of red cedar dust present in the work environment. Samples of red cedar wood dust were collected by personal samplers and provided time weighted average measurements (85 total and 39 respirable dust) for employees working over three shifts. The concentration of the 85 TWA total dust measurements had a range of 0.06 - 31.90 mg/cu m with a mean of 4.72 mg/cu m. Thirteen (15%) of the 85 samples were greater than 10 mg/cu m; 11 (13%) of the 85 samples were between 5 - 10 mg/cu m. The majority of the measurements (72%) were 5 mg/cu m or less, with 67% being 3 mg/cu m or less. The jobs with the greatest cedar dust exposure (see Appendix A-5) included sawyers (mean of 6.84 mg/cu m, packers (4.81 mg/cu m), chippers (two measurements only, 5.82 and 30.7 mg/cu m) and splitters (3.56 mg/cu m). Predictably, the employees working at these jobs showed the highest prevalence of disease (Appendix A-27). However, asthma was also seen among millwrights whose dust exposure was less; mean dust concentration was 1.17 mg/cu m and range of 0.39 - 2.33 mg/cu m (also see Figure 2).

At the present time there is not a specific TWA threshold limit value (TLV) assigned to western red cedar wood dust. This dust, however, is biologically active and results in sensitization and asthma, as well as producing significant upper and lower airway irritation (see Appendix A-21). The data from this health hazard evaluation supports the concept that allergenic or biologically active dusts must be considered to be different than inert non-allergenic (nuisance) dust (61). The documented difference between these two types of dusts (biologically active and non-biologically active or inert) should also be reflected in differences in permissible concentrations or threshold limit value standards. OSHA and NIOSH have recently acknowledged the difference of one biologically active; the cotton dust standard attests to this philosophy.

It appears, therefore, that maintenance of a 5 mg/cu m concentration for western red cedar dust, a very biologically active dust, can not be supported by the information gained from the present investigation or by information now available in the scientific literature. British Columbia Workers' Compensation Board has recently set the TLV standard for western red cedar wood dust at 2.5 mg/cu m. Chan-Yeung et al., reported a higher prevalence of respiratory symptoms among workers employed in "dusty" job classifications (11). A 1.1% prevalence of cedar asthma was reported with mean cedar dust concentration (area samples) for "dusty" jobs being 2.4 mg/cu m. Chan-Yeung

has suggested that even this level may be too high. The results of the present study would support the above observations.

Of the 74 workers in the Shake Mill who participated in the study, 22% (16 of 74) worked in this area for one year or less, even though the work force has remained at a relatively constant level for several years. Projected over a five-year period, a 22% yearly turnover rate occurring randomly in the working population would result in approximately four of the original 16 workers remaining as employees; only one of these workers would be employed at the end of 10 years.

The importance of this high turnover rate in the Shake Mill is that the 74 workers studied represented a survivor population. Even, as such, there was an observed 13.5% prevalence rate of occupational asthma. Chan-Yeung et al., noted a low prevalence of red cedar asthma of 1.1% (11). These investigators concluded that this low prevalence rate was the result of studying a selected worker population where employees with red cedar asthma leave the industry because of the disabling nature of their disease in the first few years of employment

There was an 11% (6 of 53) prevalence rate among currently employed Shake Mill workers who had less than 10 years of exposure to western red cedar. It has been reported that a majority of workers with red cedar asthma develop disease within three to five years of continuous exposure (28, 60). In the present investigation, however, four of 21 (19%) workers with cedar asthma were employed for more than 10 years. The onset of cedar asthma in these 4 workers was not established, however this indicates that some workers may have cedar dust exposure for many years before developing the disease.

There were no significant differences between mean FEV_1% predicted values between cedar workers with less than 10 years of exposure and those with 10 or more years of exposure. Chan-Yeung reported no significant differences in prevalence of lung function abnormalities among cedar workers and controls (11). Lung function decline, however, occurred more rapidly with age in cedar workers.

The detrimental effect of cigarette smoking on lung function and respiratory symptoms was reported by Chan-Yeung et al.(11). The effects of cigarette smoking and cedar dust exposure appeared to be additive and possibly synergistic. In the present investigation, Shake Mill cigarette smokers did not show pulmonary function test results significantly different from tests of nonsmokers. However, an inverse relationship (not statistically significant) between FEV_1% of predicted and pack-years of cigarette smoking was observed (Appendix A-11). In fact, in all wood dust groups, smokers demonstrated greater fall in FEV_1,with increasing cigarette consumption. abnormal baseline pulmonary function test occurred more frequently among smokers and exsmokers in all groups studied (Appendix A-25). The deleterious effects of cigarette smoking was also supported by the observed higher

prevalence rate of abnormal findings on chest examination among cigarette smokers compared to nonsmokers (see Appendix A-22).

Besides symptoms of ENT irritation and asthma, Shake Mill workers demonstrated a higher prevalence rate of occupational rhinitis. This could be on the basis of irritation or sensitization/allergy. Occupational rhinitis was indicated by medical history in 51.3% of the Shake Mill workers compared to 4% of the control group (Appendix A-23). The increased prevalence of rhinitis among cedar workers has been reported previously (1).

An unexpected finding was the high frequency of symptoms/disease in New Planer Mill workers exposed to other wood dusts (Douglas fir and hemlock) and sodium pentachlorophenate. A number of findings indicated that these substances acted as more than just nuisance dusts. The prevalence of chronic bronchitis was 22.4% in the New Planer compared to 8.0% in the control group. The age, atopic history, and smoking consumption were not influencing factors in the New Planer and control groups (see Appendices A-13, A-16, A-17 and A-19). Symptoms of occupational rhinitis were seen in 22.4% of New Planer employees and 4% of controls; 51.3% of cedar workers had this diagnosis. A 5.2% (3 of 58) prevalence rate of occupational asthmas was observed among New Planer workers (Appendix A-28). Mean total dust concentrations were 1.28 mg/cu m, with a median of 0.34 mg/cu m and a range of 0.17 - 16.7 mg/cu m. High exposure jobs (see Appendix A-6) were the tally and strappers (5.04 mg/cu m) cherry brown operator (4.86 mg/cu m), breakdown man (2.05 mg/cu m) and set-up man (1.88 mg/cu m). Occupational asthma was diagnosed in a set-up man, trimmer and grader. The latter two job categories had relatively low dust exposure: graders had mean TWA concentrations of 0.28 mg/cu m, range 0.12 - 0.60; trimmer had dust measurements of 0.35 mg/cu m (range 0.19 - 0-50). It is known that once an individual becomes sensitized to an allergen, very low exposures can produce asthmatic reactions. This effect was found, for instance, in two individuals working in the Shake Mill who were sensitized to cedar dust. These individuals showed a 23.3% and 24.4% decrease in FEV_1 following exposure to 0.23 and 0.54 mg/cu m TWA of western red cedar dust. A decrease from Monday preshift to postshift FEV_1 values was observed in New Planer and Shake Mill workers, but not office workers (Appendix A-29). Only the FEV_1 changes among cedar workers were statistically significant.

The combination of all of the above mentioned data suggests that Douglas fir and hemlock wood dusts may be biologically active. In fact the presence of symptoms/disease in a number of employees in another wood operation with similar dust exposure (e.g. Old Planer) support the contention that wood dust concentration of 5 mg/cu m are in the least irritating and should not be considered as inert materials. Our data suggests that a TLV of 5 mg/cu m is not appropriate for Douglas fir and hemlock wood dusts. While the deleterious effects of cedar dust shown in our study confirm and support reports of others (1, 8, 11, 14, 18, 25), further studies are necessary for better defining the health effects of other types of wood, such as Douglas fir and hemlock.

The problems and shortcomings of the present investigation were not unlike those reported for other field studies,. i.e., relatively small population size; problems with environmental measurement of wood dusts; compounding effect of air pollution; possible variability among spirometers and individual technicians which could have influenced pulmonary function test results; true accuracy of our criteria for occupational asthma diagnoses without other confirmation tests (e.g. bronchial challenge test); selection of proper unexposed control group; and other confounding factors such as difference in age and cigarette smoking between groups. Many of the above mentioned problems, however, were controlled or considered in the present investigation.

While the wood industry is an extremely important component of our economy, relatively few epidemiologic studies have been performed in the United States on workers exposed to wood dusts.

In order to answer some of the questions brought up by the present study, further large scale epidemiologic investigations are necessary.

VIII. SUMMARY AND CONCLUSIONS

1. It was demonstrated that 13.5% of Shake Mill employees who were exposed to western red cedar wood dust demonstrated reduction in FEV_1 of greater than 10% at some point over a three day period of work as well as reporting a strong clinical history for occupational asthma. The mean value of 85 breathing zone, total wood dust concentrations was 4.72 mg/cu m and the median was 1.59 mg/cu m. In general, diagnosed occupational asthma was noted more frequently, but not completely, in employees engaged in "dustier" jobs. This was shown in that 3 of 21 (14.3%) sawyers with a mean wood dust exposure of 6.84 mg/cu m and a median of 3.01 mg/cu m; 2 of 19 (10.5%) packers with a mean wood dust exposure of 4.81 mg/cu m and a median of 1.75 mg/cu m; and 1 of 20 (5.0%) splitters with a mean wood dust exposure of 3.56 mg/cu m and a median of 1.20 mg/cu m had occupational asthma. None of the deck sawyers, deck splitters, yard personnel or maintenance men, except two former sawyers who were previously sensitized, had reductions in $FEV_{1.0}$ of 10% or more. All total dust samples collected in these jobs were less than 2.5 mg/cu m. There was evidence which supported previous observations that once sensitization to western red cedar occurred, any exposure, including concentrations far below 2.5 mg/cu m, would produce an asthmatic reaction. This was true in two sensitized individuals who currently work in the Shake Mill but who were former sawyers. These employees demonstrated FEV_1 reductions of 23.3% and 24.4% while being exposed to 0.23 and 0.54 mg/cu m of western red cedar dust respectively.

Based on information obtained from this health hazard evaluation and from information now in the scientific literature, it seems apparent that western red cedar total wood dust exposure levels of 5 mg/cu m will not prevent the onset of occupational asthma. The concentration below which occupational asthma can be prevented has not yet been determined. Additional

studies are needed to make this determination. It is felt that western cedar dust concentrations be maintained below 2.5 mg/cu m with the intent that if this concentration does not prevent occupational asthma, then the dust concentrations should be controlled to still lower levels.

2. The employees' exposure to Douglas fir and hemlock wood dust in the New Planer was considered potentially toxic when the concentrations exceeded a TWA concentration of 5.0 mg/cu m. This level was observed in only five of 59 or 8.5% of the samples. The mean total dust concentration was 1.28 mg/cu m; median was 0.34 mg/cu m; 54 of 59 samples had a range of 0.11 to 1.25 mg/cu m.

A number of clinical findings indicated that the employee's exposure to Douglas fir wood dust, hemlock wood dust, and sodium pentachlorophenate in the New Planer Mill was potentially toxic. The prevalence of chronic bronchitis was high (22.4%); occupational rhinitis occurred in 22.4%; and occupational asthma was diagnosed in 5.2% of the workers as evidenced by FEV_1 reductions of more than 10% and by positive histories.

It is concluded that exposure to Douglas fir and hemlock wood dust in the New Planer should be maintained at concentrations below 5.0 mg/cu m.

3. The employees' exposure to fir and hemlock wood dusts in the Old Planer, fir and alder bark dust in the Bark Plant and alder wood dust in the Pres-Tock Plant is considered potentially toxic when the total wood dust TWA concentrations exceed 5.0 mg/cu m. Two of the six TWA samples in the Old Planer, two of five TWA samples in the Bark Plant, and four of the five TWA samples in the Pres-Tock Plant exceeded 5.0 mg/cu m. A limited medical evaluation was conducted in these plants which consisted of work history, questionnaires, past medical symptoms associated with wood dust exposure and a mid-shift pulmonary function test. There was no conclusive medical evidence for determining specific toxicity due to the limited scope of the evaluation in these areas. However, a number of employees in the Old Planer showed evidence of respiratory symptoms/disease.

4. Employees exposure to fir and hemlock wood dust in the Presto-Log Plant and fir wood dust in the sanding operation of the Plywood Plant were less than 5.0 mg/cu m. There was no medical evidence to suggest that the employees in these plants were experiencing symptoms, but a definite conclusion cannot be reached because only limited medical evaluations were performed in these plants.

5. Employees' exposure to phenol and formaldehyde in the Resin Plant were probably not toxic. This is based on TWA samples which were less than 10% of the evaluation criteria. Detailed medical examination was not performed.

6. The employees' exposure in the plywood plant to veneer dryer emissions (alpha and beta pinenes and abietic and pimaric acids) were not considered

toxic. There are no standards for these substances, however, the concentrations of the pinenes and the total acids for this evaluation were approximately 50% or less of those measured in 2 prior similar evaluations (63, 64) which included extensive medical evaluations. Transient irritation of the mucous membranes of the eyes, nose and throat, as well as the upper respiratory tract may occur, but permanent respiratory disease is not likely to occur at the concentrations found.

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APPENDIX A

APPENDIX A-1

Employee Participation and Withdrawal in Groups I, II and III

	I Shake Mill	II New Planer Mill	III Office Workers	Total Number
Actual Total Number of Workers Employed in Plant/Operation	90	70	33	193
Number Employees Recruited for Study	90	60+	33	183
Number Employees Actually Consenting for Study	80	59	33	172
Number of Withdrawals and/or Incomplete Data	6	1	6	13
Number of Unacceptable Participants	0	0	2*	2
Number of Actual Participants in Study**	74	58	25	157
Percentage of Employees in Plant Participating in Study	82.2	82.9	75.8	77.3

* Significant previous exposure to western red cedar dust

** Defined as a subject who signed the consent form, performed a valid Monday pre-shift PF test and completed the questionnaire.

\+ These 60 were randomly selected (Medical team was set up to study 60)

APPENDIX A-2

Design of Medical Examinations

	Group Studied							
	I	II	III	IV	V	VI	VII	VIII
Medical Questionnaire	x	x	x	x	x	x	x	x
Physical Examination	x	x	x	x	x	x	x	x
Pulmonary Function Test (before & after shift)								
Day 1 (Monday)	x	x	x					
Day 2 (Tuesday)	x	x	x					
Day 3 (Wednesday)	x	x	x					
Day 4 (Thursday)								
Pre & post-shift				x				
Single test					x	x	x	x

APPENDIX A-3

Environmental Criteria

Substance	U.S. Dept. of Labor Standards TWA	ACGIH TLV TWA	ACGIH TLV STEL	NIOSH Recommended Level
Formaldehyde	3 ppm	2 ppm 3 mg/m^3	2 ppm 3 mg/m^3	1 ppm or 1.2 mg/m^3 for any 30 min. period
Phenol	5 ppm	5 ppm 19 mg/m^3	10 ppm 38 mg/m^3	---- 20 mg/m^3 60 mg/m^3 for any 15 min. period
Wood Dust Non-Allergenic e.g., Fir, Hemlock	---	5 mg/m^3	10 mg/m^3	----
Allergenic * e.g. Western Red Cedar	---	---	---	----
Abietic & Pimaric Acids	There are currently no occupational health standards or recommended levels for these substances.			
Alpha & Beta Pinene	There are currently no occupational health standards or recommended levels for these substances.			

TLV - Threshold Limit Value

TWA - Time Weighted Average

STEL - Short Term Exposure Level. Level not to be exceeded for a 15 min. period and no more than 4 such periods/day in less than 60 min. intervals. The STEL should be considered an absolute ceiling not to be exceeded at any time during the 15 min. period.

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

C - CEILING VALUE, a value not to be exceeded at any time

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

* British Columbia, Canada has a standard of 2.5 mg of allergenic wood dust (Western Red Cedar) per cubic meter of air in their "Industrial Health and Safety Regulations."

APPENDIX A-4

Summary of TWA Concentrations of Total & Respirable Dust by Plants (Groups I, II & III)

		Group I Shake Mill mg/m^3	Group II New Planer mg/m^3	Group III Office* mg/m^3
Total Dust N=85	Mean	4.72	1.28	-
	± SD	7.45	3.05	-
	Median	1.59	0.34	-
	Range	0.06-31.9	0.17-16.7	-
Respirable Dust N=39	Mean	0.20	0.16	-
	± SD	0.23	0.05	-
	Median	0.14	0.16	-
	Range	0.01-1.21	0.07-0.29	-

* No dust sampling was performed in the Office Area which was a separate building away from the Shake Mill and New Planer.

APPENDIX A-5

Summary of Time Weighted Average (TWA) Concentration of Wood Dust Collected in the Shake Mill for Various Jobs

Job	Total or Respirable	Number of Samples	Range mg/m^3	Mean mg/m^3	Median mg/m^3
Splitters	T	24	0.12 - 29.50	3.56	1.20
	R	9	0.01 - 0.36	0.16	0.15
Sawyers	T	25	0.36 - 31.90	6.84	3.01
	R	9	0.05 - 0.83	0.21	0.16
Packers	T	20	0.06 - 20.60	4.81	1.75
	R	8	0.06 - 0.45	0.20	0.13
Deck Sawyers	T	3	0.18 - 0.54	0.29	0.19
	R	3	0.04 - 0.54	0.29	0.30
Deck Splitters	T	3	0.17 - 1.74	0.70	0.19
	R	3	0.10 - 0.14	0.12	0.13
Chippers	T	2	5.82 - 30.70	18.26	17.90
	R	2	0.06	0.06	0.06
Millwrights	T	3	0.39 - 2.33	1.17	0.79
	R	2	0.04 - 0.24	0.14	0.14
Yard Personnel Car Loader Log Loader Truck Driver	T	5	0.18 - 0.74	0.38	0.23
	R	3	0.06 - 1.21	0.48	0.17

APPENDIX A-6

Summary of Time Weighted Average (TWA)
Concentration of Wood Dust Collected for
Various Jobs in the New Planer

Job	Total or Respirable	Number of Samples	Range mg/m^3	Mean mg/m^3	Median mg/m^3
Set-Up Men	T	8	0.31 - 12.0	1.88	0.45
	R	5	0.12 - 0.29	0.18	0.16
Breakdown Men	T	5	0.27 - 8.07	2.05	0.71
	R	3	0.14 - 0.22	0.18	0.19
Graders	T	19	0.12 - 0.60	0.28	0.27
	R	3	0.07 - 0.21	0.13	0.12
Chasers	T	4	0.11 - 0.86	0.44	0.37
Chippers	T	6	0.43 - 1.25	0.87	0.96
	R	6	0.13 - 0.19	0.17	0.18
Pullers	T	3	0.20 - 0.43	0.30	0.26
	R				
Rough Trimmers	T	2	0.19 - 0.50	0.35	0.35
	R	2	0.08 - 0.16	0.12	0.12
Tally & Strappers	T	5	0.17 - 16.7	5.04	0.54
	R	1	0.11	0.11	0.11
Cherry Brown Operator	T	2	0.33 - 9.38	4.86	4.86
	R	2	0.10 - 0.27	0.19	0.19
Loader Man	T	2	0.29 - 0.42	0.36	0.36
Fork Lift Operator	T	1	0.34	0.34	0.34
Stick Machine Operator	T	1	0.65	0.65	0.65
	R	1	0.13	0.13	0.13
Utility Man	T	1	0.25	0.25	0.25

APPENDIX A-7

Summary of TWA Concentration of Wood Dust
Collected in the Bark, Old Planer, Presto-Log,
Pres-Tock, and Plywood Plants

Plant	Total or Respirable	Number of Samples	Range mg/m^3	Mean mg/m^3	Median mg/m^3
Bark	T	5	1.22 - 8.28	3.95	2.43
	R	1	0.33	0.33	0.33
Old Planer	T	6	0.20 - 54.80	18.12	1.03
	R	1	0.31	0.31	0.31
Presto-Log	T	5	0.58 - 4.55	1.72	0.88
	R	2	0.19 - 0.22	0.21	0.21
Pres-Tock	T	5	0.60 - 21.50	13.54	11.10
	R	2	0.48 - 0.60	0.54	0.54
Plywood	T	4	0.25 - 1.31	0.62	0.46

APPENDIX A-8

Number of Subjects Studied Including
All Participants & Those Employees With
Less Than 10 Years Exposure

	I Shake Mill	I New Planer Mill	III Office	Total
A. All Study Participants				
Number of Employees Available	90	70	33	193
Number Selected*	74	58	25	157
Smokers	44	28	11	83
Ex-Smokers	8	13	3	24
Non-Smokers	22	17	11	50
B. Employees with < 10 Yrs. Exposure				
Number of Employees Selected**	59	25	13	97
Smokers	34	13	6	53
Ex-Smokers	6	4	0	10
Non-Smokers	19	8	7	34
Number of Subjects Included in the Data Analysis***	53	21	13	87

* Employees who agreed to participate in the Hazard Evaluation, completed the questionnaire, and completed the Monday Pulmonary Function Tests.

** Employees studied who had less than 10 years of occupational wood dust exposure.

*** Ten Ex-Smokers were not included in the statistical analysis.

APPENDIX A-9

Means and Standard Deviations for Selected Variables
By Wood Dust Exposure Area and Smoking History
of 87 Employees with Less than 10 Years Exposure

Variable	Shake Mill N=53		New Planer Mill N=21		Office N=13	
	Mean	SD	Mean	SD	Mean	SD
Age (in years)						
Smokers	27.35	6.79	31.76	8.19	38.33	5.60
Non-Smokers	22.89	2.96	26.37	2.92	28.00	2.88
Total	25.75	6.08	29.71	7.10	32.76	6.78
Height (in inches)						
Smokers	69.48	3.04	70.15	3.17	69.08	0.80
Non-Smokers	69.63	2.58	70.12	2.79	72.42	2.50
Total	69.53	2.68	70.14	2.69	70.88	2.53
Exposure (years in area)						
Smokers	3.55	2.23	6.61	2.21	3.16	1.83
Non-Smokers	3.21	1.78	5.37	2.66	3.14	2.67
Total	3.43	2.07	6.14	2.41	3.15	2.23
Pack-years						
Smokers	12.76	6.86	19.46	24.00	31.50	28.98
Non-Smokers	-	-	-	-	-	-
FEV_1 % of Predicted						
Smokers	114.66	15.66	105.45	18.76	117.52	17.80
Non-Smokers	116.94	13.43	112.87	14.81	116.44	14.77
Total	115.48	14.91	108.27	17.36	116.94	15.54

APPENDIX A-10

Pearson Product-Moment Correlations
For Years in Exposure Area or Pack-Years of Cigarette Smoking
And FEV_1 Percentage of Predicted by Relevant Subgroup

Source	N	Years in Exposure Area		Pack-Years	
		r	p	r	p
All Subjects	87	-0.0740	.248		
All Smokers	53	-0.1038	.230	-0.2183	.058
All Non-Smokers	34	0.0213	.452		
Shake Mill	53	0.1285	.180		
New Planer Mill	21	-0.1513	.256		
Office	13	0.0179	.477		
Shake Mill Smokers	34	0.0885	.309	-0.2479	.079
Shake Mill Non-Smokers	19	0.2619	.139		
New Planer Mill Smokers	13	-0.2187	.236	-0.4929	.043*
New Planer Mill Non-smokers	8	0.1010	.406		
Office Smokers	6	0.4497	.185	0.3617	.241
Office Non-Smokers	7	-0.2788	.272		

* Significant at p = < .05

APPENDIX A-11

Number and Percentage of Workers with Less Than
10 Years Exposure with Personal History of Atopy by
Smoking History and Wood Dust Exposure Area

	Smokers	Non-Smokers	Total
Shake Mill			
Number with Atopy	5	3	8
Percentage	14.7	15.8	15.1
Total Number in Subgroup	34	19	53
New Planer Mill			
Number with Atopy	3	6	9
Percentage	23.1	75.0	42.8
Total Number in Subgroup	13	8	21
Office			
Number with Atopy	1	1	2
Percentage	16.7	14.3	15.4
Total Number in Subgroup	6	7	13

Ex-Smokers were not included because of the very small numbers.

APPENDIX A-12

Analysis of Variance of Wood Dust Exposure and Smoking History on FEV_1 Percentage of Predicted Values

	Degrees of Freedom	Mean Square	F	p
Wood Dust Exposure (A)	2	362.53	1.46	.239
Smoking History (B)	1	125.26	.50	.480
A x B	2	78.43	.31	.730
Error (Within Cells)	81	248.68		

APPENDIX A-13

Selected Variables Which Could Affect Pulmonary Function

	Shake Mill N=74		New Planer Mill N=58		Office N=25	
	Mean	SD	Mean	SD	Mean	SD
Age (years)						
Smokers	30.7	9.8	39.8	12.1	45.3	8.3
Exsmokers	29.2	8.0	41.8	16.9	58.5	3.6
Nonsmokers	25.5	8.2	34.8	11.0	36.0	12.7
Total	29.0	9.4	38.8	13.0	44.2	12.5
Height (inches)						
Smokers	69.4	9.9	70.2	3.4	69.1	1.6
Exsmokers	69.2	2.2	69.9	2.8	69.2	2.2
Nonsmokers	69.8	2.6	69.9	2.8	71.8	2.4
Total	69.5	2.7	70.1	3.0	70.2	2.4
Exposure (years in area)						
Smokers	5.6	5.2	13.5	9.5	11.8	11.1
Exsmokers	5.7	5.9	16.1	11.0	23.7	6.3
Nonsmokers	4.1	3.8	12.9	9.2	9.2	9.6
Total	5.3	5.0	13.9	9.6	12.5	10.8
Pack-years						
Smokers	17.4	18.0	25.4	21.0	29.6	21.4
Exsmokers	13.6	14.8	16.4	13.4	24.5	15.1
Nonsmokers	--	--	--	--	--	--

APPENDIX A-14

HISTORY AND DIAGNOSIS OF OCCUPATIONAL ASTHMA DUE TO WESTERN RED CEDAR DUST IN SHAKE MILL EMPLOYEES

	Positive History of Occupational Asthma	Decline in FEV_1 <5%	<10%	>10%	Probable Asthma*	Diagnosed Occupational Asthma
Nonsmokers (N=22)						
Number	8	3	4	1	4	1
Percentage	(36%)	(14%)	(18%)	4	(18%)	(4%)
Exsmokers (N=8)						
Number	3	1	0	2	0	2
Percentage	(37%)	(12%)	(37%)	(25%)	(25%)	(25%)
Smokers (N=44)						
Number	14	4	3	7	3	7
Percentage	(32%)	(2%)	(14%)	(16%)	(16%)	(16%)
Total (N=74)						
Number	25	8	7	10	7	10
Percentage	(34%)	(11%)	(9%)	(13.5%)	(9%)	(13.5%)

* History positive for occupational asthma and FEV_1 decline of 5-10%

APPENDIX A-15

HISTORY AND DIAGNOSIS OF OCCUPATIONAL ASTHMA DUE TO WOOD DUST IN NEW PLANER MILL EMPLOYEES

	Positive History of Occupational Asthma	Decline in FEV_1			Probable Asthma *	Diagnosed Occupational Asthma
		5%	5-10%	10%		
Nonsmokers (N=17)						
Number	2	2	0	0	0	0
Percentage	12%	12%	0%	0%	0%	0%
Exsmokers (N=13)						
Number	3	0	0	3**	0	3
Percentage	23%	0%	0%	23%	0%	23%
Smokers (N=28)						
Number	0	0	0	0	0	0
Percentage	0%	0%	0%	0%	0%	0%
Total (N=58)						
Number	5	2	0	3	0	3
Percentage	9%	3%	0%	5%	0%	5%

* History positive for occupational asthma and FEV_1 decline of 5-10%
** FEV_1 declines of 15.2%, 15.5%, and 17.2% respectively.

RESPIRATORY DIAGNOSIS BY EXPOSURE GROUP

	Shake Mill I	New Planer II	Office (Control) III	Old Planer IV	Plywood V	Pres-Tock VI	Prestolog VII	Bark Plant VIII
Number of Employees Evaluated	74	58	25	10	16	7	4	5
Mean Age of Groups at Risk (Years)	28.9	38.8	42.5	54.6	49.3	39.4	42.0	35.8
Chronic Bronchitis								
Number	14	13	2	3	0	1	0	1
Percent	18.9%	22.4%	8.0%	30.0%	---	14.2%	---	20.0%
Bronchial Asthma								
Occupational								
Number	10	3	0	0	0	0	0	0
Percent	13.5%	5.2%	---	---	---	---	---	---
Nonoccupational								
Number	1	2	1	0	0	0	0	0
Percent	1.4%	3.4%	4.0%	---	---	---	---	---
COLD* Diagnosed								
Number	0	2	1	2	3	0	0	0
Percent	---	3.4%	4.0%	20.0%	18.8%	---	---	---
Total Pulmonary Disease								
Number	30	22	4	5	3	1	0	1
Percent	40.5%	37.9%	16.0%	50.0%	18.7%	14.3%	---	20.0%

* Chronic Obstructive Lung Disease does not include a positive history or diagnosis of either chronic bronchitis or asthma, but have evidence of obstructive airways disease by pulmonary function test.

APPENDIX A-17

Information on Smoking History of Employees
in Shake Mill, New Planer Mill & Office

	Shake Mill		New Planer Mill		Office		Total	
	N	%	N	%	N	%	N	%
Smokers	44	59.4%	28	48.3%	11	44.0%	83	52.8%
Exsmokers	8	10.8%	13	22.4%	3	12.0%	24	15.3%
Nonsmokers	22	29.7%	17	29.3%	11	44.0%	50	31.8%
	74		58		25		157	

APPENDIX A-18

Number of Subjects With Other Potentially Hazardous Exposures That Might Affect Pulmonary Function

Exposure*	Shake Mill N=74	New Planer Mill N=58	Office N=25
Previous Occupational Western Red Cedar Dust**	8	0	0
Previous Occupational Wood Dust--Not Western Red Cedar	5	0 ***	0
Previous Other Significant Occupational Exposure	0	0	0
Significant Nonoccupational Exposures	0	0	0

* See "Definition of Terms" on pages for definitions and criteria.

** Years of previous occupational exposure to western red cedar wood dust for these eight men has been added to their years of occupational exposure in this plant.

*** Sodium pentachlorophenate exposure was not asked in the questionnaire, however, the employees in the New Planer are potentially exposed to this substance.

APPENDIX A-19

Workers with Personal History
or Family History of Atopy

Exposure Area	Smokers	Exsmokers	Nonsmokers	Total
Shaker Mill (N=74)				
Personal History	6 (13.6%)	1 (12.5%)	3 (13.5%)	10 (13.5%)
Family History	6 (13.6%)	2 (25%)	6 (27.3%)	14 (18.9%)
New Planer (N=58)				
Personal History	5 (17.8%)	2 (15.4%)	6 (35.3%)	13 (22.4%)
Family History	3 (10.7%)	2 (15.4%)	5 (29.4%)	10 (17.2%)
Office (N=25)				
Personal History	2 (18.2%)	1 (33.3%)	3 (27.3%)	6 (24%)
Family History	3 (27.3%)	1 (33.3%)	4 (30.4%)	8 (32%)

APPENDIX A-20

Findings on Physical Examination of Signs Indicating Eye, Nose or Throat Irritation

	Shake Mill		New Planer		Office	
	N	%	N	%	N	%
Smokers	32	(72.7%)	17	(60.7%)	9	(81.8%)
Exsmokers	5	(62.5)	8	(61.5%)	2	(66.6%)
Nonsmokers	12	(54.5%)	12	(70.6%)	9	(81.8%)
Total	49	(66.2%)	37	(63.8%)	20	(80.0%)

APPENDIX A-21

Positive Response to Questions Concerning Eye, Nose or Throat Irritation

	Shake Mill		New Planer		Office	
	N	%	N	%	N	%
Smokers	14	(31.8%)	8	(28.6%)	0	0%
Exsmokers	4	(50.0%)	4	(30.8%)	0	0%
Nonsmokers	11	(50.0%)	9	(52.9%)	1	(9.1%)
Total	29	(39.2%)	21	(36.2%)	1	(4.0%)

APPENDIX A-22

Prevalence of Abnormal Chest Sounds (e.g. Rhonchi, Wheezes or Rales) on Auscultation of the Chest

	Shake Mill N=74		New Planer N=58		Office N=25	
	N	%	N	%	N	%
Smokers	9	(20.4%)	7	(25.0%	4	(36.4%)
Exsmokers	3	(37.5%)	5	(38.5%)	1	(33.3%)
Nonsmokers	1	(4.5%)	1	(5.8%)	0	(0%)
Total	13	(17.6%)	13	(22.4%)	0	(20.0%)

APPENDIX A-23

Symptoms of Rhinitis by Smoking Habit

	Shake Mill N=74		New Planer Mill N=58		Office N=25	
	N	%	N	%	N	%
Occupational Rhinitis						
Smokers	21	(47.7%)	4	(23.5%)	0	(0%)
Exsmokers	2	(25.0%)	2	(15.4%)	0	(0%)
Nonsmokers	15	(68.1%)	7	(25.0%)	1	(9.1%)
Total	38	(51.3%	13	(22.4%)	1	(4.0%)
Nonoccupational Rhinitis						
Smokers	3	(6.8%)	5	(17.8%)	0	(0%)
Exsmokers	2	(25.0%)	2	(15.4%)	0	(0%)
Nonsmokers	1	(4.5%)	3	(17.6%)	0	(0%)
Total	6	(8.1%)	10	(17.2%)	0	(0%)

APPENDIX A-24

Means and Standard Deviations of Baseline FEV_1 Percentages of Predicted for Workers with Ten or More Years of Exposure By Wood Dust Exposure Area and Smoking History*

	Shake Mill	New Planer Mill	Office
Smokers	115.28±21.47 (10)	110.00±16.94 (15)	102.55±17.57 (5)
Nonsmokers	117.49±14.47 (3)	112.55±17.60 (9)	136.23± 5.22 (4)
Total	115.79±19.53	110.96±16.85	117.52±21.92

* Number in parenthesis is number of workers in each category.

APPENDIX A-25

Abnormal Pulmonary Function
By Smoking Habit & Exposure Group

	Shake Mill N=74		New Planer Mill N=58		Office N=25		Total N=157	
	N	%	N	%	N	%	N	%
Employees with Abnormal Pulmonary Function *								
Smokers	10	(22.7%)	7	(25.0%)	5	(33.3%)	22	(26.5%)
Exsmokers	4	(50.0%)	6	(46.1%)	1	(25.0%)	11	(44.0%)
Nonsmokers	0	(0%)	3	(17.6%)	0	(0%)	3	(6.0%)
Total	14	(18.9%)	16	(27.6%)	6	(24.0%)	36	(22.9%)

* Abnormal Pulmonary Function defined as:

FVC < 80% of Predicted (KORY)
FEV_1 < 80% of Predicted
FEV_1/FVC ratio < 70%
FEF_{25-75} < 70% of Predicted

APPENDIX A-26

Mean ± Age of Employees With One Or More Abnormal Pulmonary Function Tests

	Shake Mill N=14	New Planer Mill N=16	Office N=6
Smokers	35.7 ±11.9	45.4 ±15.5	48.6 ± 8.9
Exsmokers	29.7 ± 6.8	52.5 ±12.6	63.0 ---
Nonsmokers	-- --	36.7 ± 8.1	-- ---
Total	34.6 ±10.2	46.1 ±14.2	51.0 ± 9.9

APPENDIX A-27

Prevalence and Distribution of Occupational Asthma by Job Title for Shake Mill Workers

Job Title	Number with Occupational Asthma	Number of Participants at Risk	Prevalence Rate of Occupational Asthma
Sawyers	3 (5)*	21	14.3 (23.8)*
Splitters	1	20	5.0
Packers	2	19	10.5
Millwrights	2	3	66.6
Chipper/operator	0	1	0
Deck Sawyer	0	3	0
Deck Splitter	0	3	0
Yard Personnel	2	4	50.0
Car Loader	1*	1	0
Log Loader	0	1	0
Truck Driver	1*	2	0
Total (All Jobs)	10	74	13.5

* Former sawyers with medically documented occupational asthma to western red cedar prior to transferring to an outside job.

APPENDIX A-28

Prevalence and Distribution of Occupational Asthma by Job Title for New Planer Mill Workers

Job Title	Number with Occupational Asthma	Number of Participants at Risk	Prevalence Rate of Occupational Asthma
Setup Man/Feeder	1	9	11.1%
Grader/Racker	1	19	5.3%
Puller	0	4	---
Cherry Brown Operator	0	2	---
Trimmer	1	1	100.0%
Chipper	0	1	---
Miscellaneous	0	22	---
	3	58	5.2%

APPENDIX A-29

Mean ± SD Values for FEV_1 Measurements Performed Before and After Shift for Three Consecutive Days Among Three Groups of Workers

	Shake Mill N=74	New Planer Mill N=58	Office N=25
Monday			
Preshift	4.75 ± 0.81	4.25 ± 0.96	4.49 ± 0.93
Postshift	4.65 ± 0.78*	4.19 ± 0.95	4.50 ± 0.91
Tuesday			
Preshift	4.63 ± 0.87	4.20 ± 0.94	4.45 ± 0.99
Postshift	4.62 ± 0.82**	4.14 ± 0.89	4.31 ± 0.93
Wednesday			
Preshift	4.67 ± 0.83	4.16 ± 0.99	4.38 ± 0.97
Postshift	4.61 ± 0.84 **	4.10 ± 0.92	4.36 ± 0.95

* Paired t test comparing the differences between the means of the pre and postshift values, $p < 0.001$.

** Paired t test comparing mean value for postshift (Tuesday and Wednesday) with preshift value for Monday, $p < 0.001$.

APPENDIX A-30

Mean ± SD Measurements for FEV_1 Among Shake Mill Workers According to Smoking Habits

Group	N	Monday		Tuesday		Wednesday	
		Pre	Post	Pre	Post	Pre	Post
Nonsmokers	21	5.00 ± 0.63	4.92 ± 0.50*	4.89 ± 0.66	4.92 ± 0.65	4.93 ± 0.62	4.85 ± 0.65**
Exsmokers	8	4.26 ± 0.61	4.16 ± 0.59	4.18 ± 0.71	4.09 ± 0.82	4.26 ± 0.68	4.08 ± 0.97
Smokers	43	4.73 ± 0.86	4.62 ± 0.82***	4.58 ± 0.95	4.60 ± 0.85****	4.59 ± 0.92	4.56 ± 0.88****

* Paired t test comparing differences between mean of pre and postshift values, $p < 0.02$.

** Paired t test comparing differences between mean of Monday preshift and Wednesday postshift, $p < 0.02$.

*** Paired t test comparing differences between mean of pre and post shift values, $p < 0.01$.

**** Paired t test comparing Tuesday or Wednesday postshift value with Monday preshift value, $p < 0.001$.

APPENDIX B

QUESTIONNAIRE, PHYSICAL EXAMINATION AND CONSENT FORMS

APPENDIX B

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
522 POST OFFICE BUILDING
CINCINNATI, OHIO 45202

Study Number _____

INFORMED CONSENT STATEMENT

I voluntarily agree to participate in a study at (Name of company, City, and State) _____ conducted by the U. S. Public Health Service and the National Institute of Safety and Health. I understand that the medical evaluation will consist of my answering questions about my health and working conditions, and a physical examination. In addition, pulmonary function studies (breathing tests) will be performed. Blood samples may also be collected. Chest x-rays may also be performed.

I understand that my participation in this study is voluntary and that my personal physician will be informed of the results of my tests, if I so request. I also understand that these results may be used in a publication at some future date. All information obtained will be held strictly confidential in accordance with U. S. Public Health Service Regulation (42 CFR Part 1). The information obtained will be used statistically, but I will not be identified as an individual without my express consent. I have the right to ask questions, and the right to withdraw from participation at any time.

Date _____ Name _____

Witness _____ _____ Signature _____

APPENDIX B

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
522 POST OFFICE BUILDING
CINCINNATI, OHIO 45202

HHE:_____ CONFIDENTIAL

Name_____Birth date_____
(day) (mo.) (yr.)

Social Security No:_____-____-_____.

Address_____
Street City State Zip

1. How long have you lived in this part of Washington?_____

2. Before this job, have you ever worked in a dusty job such as mining, rock quarry, farming, sandblasting, flour mill; or cotton Mill ?
What? _____

3. How long have you worked here?....._____(years)

4. What is your job title?_____

5. What shift do you work?_____

6. How long have you worked this shift? _____

7. When do you usually sleep? (Night, Evening, Day ?)

8. Have you ever worked in an area where you were exposed to:

___Welding fumes

___Exhaust fumes

__Excessive Noise

___Heat

__Smoke

9. Do you have any Part-time jobs other than this company during the year ?
YES NO

10. Do you have any exposure to any dusts, fumes, or gases at home, or with hobbies? What?_____ YES NO

11. Have you ever worked with or been exposed to any of these

____Asbestos

____Epoxy Resins

____Plywood Glues

____Solvents

____Urethanes(Plastic foam)

____Fungicides or wood preservatives

____Creosote

____Wood Dusts

____Paints, varnishes Paint Thinner

____Dyes, Wood Stains

____Acid Fumes

Regularly/ occasionally

How long_____

Where?_____

Regularly/ occasionally

How long_____

Where?_____

____Other chemicals gases, fuids, dusts or materials that you, or your employer consider to be dangerous or hazardous?

What?_____

12. Have you ever in your life been told by a Doctor that you ever had?

____Cancer

____Arthritis

____Rheumatic fever

____High Blood Pressure

____Heart Trouble

____Tuberculosis

____Asthma

____Bronchitis

____Pneumonia

____Pleurisy

____Allergies

____Hay Fever

____Sinus Trouble

____Skin Problems

____Serious Accident/ Injury

____Broken Bones

13. Are you being treated by a DOCTOR for any medical problems now?

    a. What?_____

14. Have you ever been told that you should change jobs for Health reasons by anyone, Wife, Doctor, Friends?

15. Have you ever "Bid-on" or changed jobs for health reasons while working for this company ?

    a. In the last 2 years?

    b. Old Job?_____

16. How many days have you lost from work for health reasons during the past year, other than injuries or accidents? .....

17. Have you ever been hurt or injured on this job?

    a. How many times ? _____

    b. Where was Injury_____

    _____

    c. Was this treated by a Doctor or the Medical Department?

18. How many days have you lost from work in the past year because of accidents or injuries? .....

19. Do you think you might have any hearing problems?

    a. Does your hearing seem to be getting worse in the past year ?

    b. Does your hearing get better on the weekends ?

    c. Does it seem to get worse at work?

20. Does anyone in your family have Asthma, hay fever, or Allergies

    a. Who/What?_____

Have you ever noticed any of the following problems, or a worsening of them while a work?:

(a.)
- Cough
- bringing up phlem
- chest tightness
- wheezing
- shortness of breath
- "choking feeling"

Did this begin after you started working here?..... YES NO
Does this go away or get better on weekends off?..... YES NO
On vacations? YES NO
Does this get worse when you come back to work?..... YES NO
How soon does it begin after you return to work?
1st day_____
2nd day_____
1st week_____
Longer_____
Has it gotten better or worse now than it was during the 1st year you worked here?..... YES NO

(b)
- Runny nose
- Itchy nose
- stuffy nose
- Frequent sneezing

(c.)
- Eye irritation
- Eyes burning
- Eyes itching
- Eyes watering

Did this begin after you started working here?..... YES NO
Does this go away or get better on weekends off?..... YES NO
On vacations?..... YES NO
Does this get worse when you come back to work?..... YES NO
How soon does it begin after you return to work?
1st day____
2nd day____
1st week____
Longer_____
Has it gotten better or worse now than it was during the 1st year you worked here?..... YES NO

(d.)
- Sore throat
- Scratchy Throat
- Hoarseness

(e.)
- Soreness of Mouth
- Skin rashes
- Skin irritation
- Skin Itching

22 If you answered yes to any of the above, what do you think caused it?

_____

23 Do you know of anyone else who works here that you think might have any job-related health problems?

What job?_____

Complete "Chest Supplement" if "YES" on #24 through# 36

24. Have you ever noticed any coughing, wheezing, chest tightness, or shortness of breath at work or at home? . . . . . .

25. Do you ever wheeze with exercise? . . . . . .

26. Do you ever get short of breath when you hurry or walk up a hill or flight of stairs? . . . . . .

27. Does cold, damp, or foggy weather affect your chest? . . . . . .

28. Does this kind of weather or a sudden change in the weather make you short of breath, wheezy, or cough? . . . . . .

29. Do you ever wake up because of coughing? wheezing? difficulty breathing?

30. Do you ever have trouble going to sleep because of coughing? wheezing? difficulty

31. Has anyone ever told you that you cough, wheeze or snore a lot while you are asleep? . . . . . .

32. Have you had any chest problems in the past two years which kept you away from work or your usual activities? . . . . . .

33. Do you usually cough first thing in the morning?

Do you cough on most days for as much as 3 months of the year?
About how many years have you had this cough? _____

34. Do you usually cough at other times of the day or night?

Do you cough on most days for as much as 3 months of the year?
About how many years have you had this cough? _____

35. Do you usually bring up phlegm, sputum or mucus from your chest first thing in the morning?

36. Do you usually bring up phlegm, sputum or mucus from your chest at other times of the day or night?

Do you bring up phlegm, sputum or mucus from your chest as much as 3 months of the year?
How many years have you raised phlegm, sputum or mucus? _____
What is the usual color of this phlegm, sputum or mucus? _____

APPENDIX B

CHEST SUPPLEMENT

a. How frequently do you experience this wheezing, coughing or shortness of breath?

- every day? ____
- one or two days a week? ____
- once a month? ____
- only with colds? ____

b. When did this wheezing, coughing, or shortness of breath begin? _____

c. Has this gotten worse in the last year? . . . . . YES NO

d. Is this worse on any particular days of the week? . . . . . YES NO

If yes, when? _____

e. Does this wheezing, coughing, or shortness of breath occur mostly .

- in the daytime? . . . . . YES NO
- at night? . . . . . YES NO
- both or varies? . . . . . YES NO

f. Does this seem to get better on weekends off? . . . . . YES NO

on vacation? . . . . . YES NO

g. Does this get worse when you come back to work? . . . . . YES NO

APPENDIX B

Chest Supplement (continued)

i. Does this coughing, wheezing, chest tightness or shortness of breath occur with colds or sore throats? YES NO

j. Does your coughing, wheezing, chest tightness or shortness of breath occur with episodes of increased phlegm in your chest? YES NO

k. Is or was your coughing, wheezing, or chest tightness associated with attacks of shortness of breath? YES NO

l. Is or was your coughing, wheezing, chest tightness or shortness of breath brought on or made worse by exposure to:

House dust _____

Other dust or fumes at home _____

Plants or pollens _____

Dusts, gasses, or fumes at work _____

Tobacco smoke _____

Other factors _____

m. Is or was your coughing, wheezing, chest tightness or shortness of breath worse during a particular season? YES NO

Which is the worst season? _____

Do/did these symptoms occur only during this season? YES NO

37. Have you had more than <u>three</u> colds in the last year? . . . . . .

38. Have you ever smoked cigarettes regularly?

Do you smoke cigarettes regularly now? . . . . .
How old were you when you started smoking? _____
How many packs do/did you smoke a day? _____
Have you stopped smoking? . . . . .
Since you started working here? . . . . .
How old were you when you stopped smoking? _____
Were you inclined to stop because of a cough, wheezing, or shortness of breath? . . . . .

APPENDIX C

ENVIRONMENTAL DATA

APPENDIX C-1

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Deck Sawyer	12-13-76	1	2460	229	389	T	0.52	0.52
	12-13-76		2602	VOID	-	-	-	
	12-13-76	2	2448	241	410	T	0.29	> 0.19
	12-13-76	2	2662	190	323	T	0.06	
	12-13-76	3	2520	178	303	T	0.18	> 0.18
	12-13-76	3	2463	156	265	T	0.19	
	12-15-76	1	2600	403	685	R	0.30	0.30
	12-14-76	3	2791	440	748	R	0.04	0.04
	12-15-76	3	2567	421	716	R	0.54	0.54

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-2

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Deck Splitter	12-14-76	1	2738	244	415	T	0.16	
	12-14-76	1	2720	181	308	T	0.19	> 0.17
	12-14-76	1	2518	243	413	T	2.81	
	12-14-76	1	2577	166	282	T	0.17	> 1.74
	12-15-76	3	2502	259	440	T	0.11	
	12-15-76	3	2522	164	279	T	0.32	> 0.19
	12-13-76	1	2467	411	699	R	0.14	0.14
	12-13-76	2	2632	405	689	R	0.10	0.10
	12-13-76	3	2565	317	539	R	0.13	0.13

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-3

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Splitter	12-13-76	1	2508	219	372	T	19.20,	29.50
	12-13-76		2612	168	286	T	43.00 >	
	12-13-76		2490	235	400	T	0.88	0.82
	12-13-76		2613	169	287	T	0.73 >	
	12-13-76		2403	217	369	T	0.38	0.37
	12-13-76		2617	165	281	T	0.36 >	
	12-14-76		2770	254	432	T	2.01	1.37
	12-14-76		2717	193	328	T	0.52 >	
	12-14-76		2708	237	403	T	13.50	12.70
	12-14-76		2726	126	214	T	11.30 >	
	12-14-76		2778	229	389	T	1.54	1.02
	12-14-76		2737	190	323	T	0.40 >	
	12-15-76		2578	255	433	T	0.76	0.77
	12-15-76		2545	165	281	T	0.78 >	
	12-13-76		2523	392	669	R	0.07	0.07
	12-14-76		2789	389	661	R	0.15	0.15
	12-15-76		2590	394	670	R	0.01	0.01

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-4

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Splitter	12-13-76	2	2622	240	408	T	1.74	> 1.51
	12-13-76		2616	166	282	T	1.17	
	12-14-76		2575	249	423	T	1.70	> 1.37
	12-14-76		2748	182	309	T	0.91	
	12-14-76		2571	243	413	T	9.59	> 6.02
	12-14-76		2596	161	274	T	0.62	
	12-15-76		2524	269	457	T	1.72	1.72
	12-15-76		2563	250	425	T	void-filter was received burned	
	12-15-76		2557	146	248	T	0.28	0.28
	12-15-76		2576	246	418	T	1.91	1.91
	12-15-76		2597	242	411	T	4.43	> 9.96
	12-15-76		2559	120	204	T	21.20	
	12-15-76		2529	359	610	T	5.77	5.77
	12-13-76		2626	379	644	R	0.31	0.31
	12-14-76		2594	400	680	R	0.06	0.06
	12-14-76		2795	412	700	R	0.36	0.36

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-5

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Splitter	12-13-76	3	2512	167	284	T	0.77	
	12-13-76		2550	130	221	T	0.95	> 0.85
	12-13-76		2514	166	282	T	0.85	
	12-13-76		2429	129	219	T	0.68	> 0.78
	12-13-76		2527	169	287	T	0.98	
	12-13-76		2525	126	214	T	11.40	> 5.43
	12-14-76		2693	247	420	T	0.12	0.12
	12-14-76		2671	223	379	T	2.50	
	12-14-76		2784	110	187	T	0.10	> 1.71
	12-14-76		2653	222	377	T	0.37	
	12-14-76		2796	170	289	T	0.13	> 0.27
	12-14-76		2759	220	374	T	0.64	
	12-14-76		2722	140	238	T	0.50	> 0.59
	12-15-76		2533	273	464	T	0.24	
	12-15-76		2537	95	162	T	0.25	> 0.24
	12-15-76		2539	400	680	T	0.56	0.56
	12-13-76		2589	263	447	R	0.16	0.16
	12-14-76		2745	345	587	R	0.27	0.27
	12-15-76		2553	409	695	R	0.06	0.06

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-6

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*		TWA** mg/m^3
Sawyer	12-13-76	1	2449	223	379	T	0.79	>	0.57
	12-13-76		2604	153	260	T	0.42		
	12-13-76		2401	230	391	T	3.68	>	3.15
	12-13-76		2672	160	272	T	2.39		
	12-13-76		2484	217	369	T	3.55	>	3.81
	12-13-76		2631	172	292	T	4.14		
	12-14-76		2743	232	394	T	1.57	>	24.20
	12-14-76		2760	175	298	T	54.30		
	12-15-76		2584	251	427	T	1.33	>	1.10
	12-15-76		2506	155	264	T	0.72		
	12-15-76		2534	268	456	T	1.16	>	1.55
	12-15-76		2504	161	274	T	2.19		
	12-15-76		2598	269	457	T	1.97	>	1.76
	12-15-76		2599	145	247	T	1.38		
	12-15-76		2591	250	425	T	4.05	>	2.76
	12-15-76		2519	155	264	T	0.68		
	12-13-76		2616	405	689	R	0.28		0.28
	12-14-76		2704	456	775	R	0.17		0.17
	12-14-76		2711	432	734	R	0.16		0.16
	12-15-76		2535	409	695	R	0.07		0.07

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-7

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*		TWA** mg/m^3
Sawyer	12-13-76	2	2425	245	417	T	0.38	>	0.40
	12-13-76		2684	176	299	T	0.43		
	12-13-76		2655	239	406	T	0.89	>	0.70
	12-13-76		2665	183	311	T	0.45		
	12-13-76		2645	235	400	T	9.05	>	12.30
	12-13-76		2688	171	291	T	16.70		
	12-14-76		2773	259	440	T	7.41	>	5.18
	12-14-76		2510	159	270	T	1.56		
	12-14-76		2513	242	411	T	23.00	>	26.80
	12-14-76		2574	158	269	T	32.70		
	12-15-76		2580	269	457	T	3.09	>	31.90
	12-15-76		2501	225	382	T	66.40		
	12-15-76		2548	256	435	T	2.39	>	1.88
	12-15-76		2531	150	255	T	1.02		
	12-15-76		2562	253	430	T	30.10	>	21.20
	12-15-76		2573	123	209	T	2.82		
	12-15-76		2587	346	588	T	5.00		5.00
	12-14-76		2588	239	406	T	7.88	>	7.95
	12-14-76		2517	194	330	T	8.03		
	12-13-76		2668	389	661	R	0.14		0.14
	12-14-76		2705	397	675	R	0.83		0.83

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-8

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Sawyer	12-13-76	3	2503	168	286	T	1.85	> 1.82
	12-13-76		2468	135	230	T	1.78	
	12-14-76		2664	410	697	T	5.08	5.08
	12-14-76		2636	377	641	T	4.01	4.01
	12-15-76		2530	255	434	T	0.41	0.41
	12-15-76		2566	250	425	T	0.87	> 1.30
	12-15-76		2581	103	175	T	2.34	
	12-15-76		2507	378	643	T	0.36	0.36
	12-15-76		2570	243	413	T	6.30	> 5.93
	12-15-76		2546	114	194	T	5.15	
	12-13-76		2547	298	507	R	0.22	0.22
	12-14-76		2735	376	639	R	0.05	0.05
	12-15-76		2579	252	428	R	0.07	0.07

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-9

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Packer	12-13-76	1	2532	221	376	T	1.01	
	12-13-76		2674	158	269	T	2.72	> 1.72
	12-14-76		2736	245	417	T	0.50	
	12-14-76		2762	155	264	T	11.40	> 4.72
	12-14-76		2742	245	417	T	1.92	
	12-14-76		2716	190	323	T	0.05	> 1.10
	12-14-76		2793	247	420	T	1.52	
	12-14-76		2706	158	269	T	4.09	> 2.52
	12-15-76		2538	257	437	T	1.24	
	12-15-76		2509	151	257	T	35.20	> 13.80
	12-15-76		2582	248	422	T	11.70	
	12-15-76		2552	147	250	T	35.70	> 20.60
	12-15-76		2544	247	420	T	1.29	
	12-15-76		2556	163	277	T	1.05	> 1.19
	12-13-76		2586	381	648	R	0.20	0.20
	12-14-76		2761	384	653	R	0.17	0.17
	12-15-76		2558	410	697	R	0.06	0.06

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-10

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Packer	12-13-76	2	2414	245	417	T	1.49	
	12-13-76		2675	176	299	T	6.99	3.79
	12-13-76		2686	237	403	T	2.98	
	12-13-76		2681	189	321	T	24.80	12.70
	12-13-76		2680	235	400	T	1.10	
	12-13-76		2673	167	284	T	17.40	7.87
	12-14-76		2555	249	423	T	0.17	
	12-14-76		2516	175	298	T	0.84	0.45
	12-15-76		2541	260	442	T	1.38	
	12-15-76		2505	127	216	T	0.83	1.12
	12-15-76		2554	254	432	T	2.18	
	12-15-76		2564	146	248	T	1.05	1.77
	12-15-76		2540	391	665	T	0.06	0.06
	12-13-76		2700	386	656	R	0.15	0.15
	12-14-76		2703	414	704	R	0.11	0.11

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-11

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Packer	12-13-76	3	2543	165	281	T	1.42	1.62
	12-13-76		2465	131	223	T	1.88	
	12-13-76		2515	171	291	T	1.03	1.07
	12-13-76		2450	125	213	T	1.13	
	12-13-76		2521	165	281	T	0.89	1.02
	12-13-76		2404	130	221	T	1.18	
	12-14-76		2642	239	406	T	12.70	12.10
	12-14-76		2782	115	196	T	11.00	
	12-14-76		2667	235	400	T	9.25	6.00
	12-14-76		2725	142	241	T	0.62	
	12-15-76		2536	245	417	T	1.12	0.96
	12-15-76		2561	120	204	T	0.64	
	12-13-76		2569	306	520	R	0.06	0.06
	12-14-76		2774	376	639	R	0.45	0.45
	12-15-76		2560	368	626	R	0.06	0.06

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-12

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Chipper	12-13-76	1	2412	233	396	T	30.7	30.7
↓	12-13-76	1	2696	174	296	T	Too overloaded, could not weigh	
	12-13-76	2	2644	233	396	T	1.11	5.82
	12-13-76	2	2633	167	284	T	12.40	
	12-14-76	2	2528	372	632	R	0.06	0.06
	12-14-76	3	2729	386	656	R	0.06	0.06

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-13

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Maintenance Millwright	12-14-76	1	2712	434	738	T	2.33	2.33
	12-13-76	2	2634	216	367	T	0.41	0.39
	12-13-76	2	2605	179	304	T	0.36	
	12-14-76	3	2607	404	748	T	0.79	0.79
	12-13-76	1	2488	399	679	R	0.07	0.07
	12-13-76	3	2595	293	498	R	0.24	0.24

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-14

WOOD DUST

SHAKE MILL

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Car Loader	12-13-76	1	2480	220	374	T	0.27	0.23
↓	12-13-76	1	2646	181	308	T	0.19	>
Log Loader	12-14-76	1	2710	369	627	R	1.21	1.21
	12-15-76	1	2542	228	388	T	0.62	0.74
↓	12-15-76	1	2593	143	243	T	0.95	>
Yard Man	12-15-76	3	2549	338	575	T	0.19	0.19
Truck Driver	12-14-76	2	2583	239	406	T	0.62	0.54
	12-14-76	2	2551	177	301	T	0.43	>
	12-13-76	2	2615	356	605	R	0.17	0.17
	12-13-76	3	2511	388	660	T	0.18	0.18
↓	12-15-76	3	2763	383	651	R	0.06	0.06

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-15

WOOD DUST

NEW PLANER

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Set-up Man	12-13-76	1	2409	439	746	T	0.44	0.44
	12-13-76	1	2428	432	734	T	0.33	0.33
	12-13-76	1	2413	432	734	R	0.19	0.19
	12-14-76	1	2492	509	865	T	0.58	0.58
	12-14-76	1	2464	508	864	R	0.12	0.12
	12-15-76	1	2781	411	699	T	0.37	0.37
	12-15-76	1	2766	411	699	R	0.16	0.16
	12-13-76	2	2452	498	847	T	0.31	0.31
	12-13-76	2	2430	469	797	R	0.13	0.13
	12-13-76	2	2493	525	893	T	0.59	0.59
	12-14-76	2	2485	466	792	T	12.00	12.00
	12-15-76	2	2459	449	763	T	0.45	0.45
	12-15-76	2	2432	449	763	R	0.29	0.29

* mg/m^3 - milligrams per cubic meter

** TWA - Time Weighted Average

APPENDIX C-16

WOOD DUST

NEW PLANER

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Breakdown Man	12-13-76	1	2423	431	733	T	0.31	0.31
	12-13-76	1	2405	431	733	R	0.22	0.22
	12-14-76	1	2427	490	833	T	0.89	0.89
	12-14-76	1	2454	490	833	R	0.19	0.19
	12-15-76	1	1980	410	697	T	0.27	0.27
	12-13-76	2	2419	431	733	T	0.71	0.71
	12-13-76	2	2500	431	733	R	0.14	0.14
	12-14-76	2	2458	473	804	T	8.07	8.07
Rough Trimmer	12-15-76	1	2758	412	700	R	0.16	0.16
	12-15-76	1	2771	412	700	T	0.50	0.50
	12-13-76	2	2437	428	728	T	0.19	0.19
	12-13-76	2	2462	428	728	R	0.08	0.08

* mg/m^3 - milligrams per cubic meter

** TWA - Time Weighted Average

APPENDIX C-17

WOOD DUST

NEW PLANER

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Grader	12-13-76	1	2453	451	767	T	0.60	0.60
	12-13-76		2471	443	753	T	0.32	0.32
	12-13-76		2499	439	746	T	0.27	0.27
	12-13-76		2451	457	777	T	0.32	0.32
	12-13-76		2455	357	607	R	0.21	0.21
	12-14-76		2497	484	823	T	0.28	0.28
	12-14-76		2435	486	826	T	0.25	0.25
	12-15-76		1998	413	702	T	0.16	0.16
	12-15-76		2746	410	697	T	0.32	0.32
	12-15-76		2015	413	702	T	0.27	0.27
Grader	12-13-76	2	2473	423	719	T	0.39	0.39
	12-13-76		2479	451	767	T	0.12	0.12
	12-13-76		2481	438	745	T	0.23	0.23
	12-14-76		2442	451	767	T	0.17	0.17
	12-14-76		2498	470	799	T	VOID	--
	12-14-76		2489	447	760	T	0.25	0.25
	12-14-76		2440	447	760	R	0.12	0.12
	12-15-76		2747	447	760	T	0.49	0.49
	12-15-76		2477	447	760	R	0.07	0.07
	12-15-76		2418	462	785	T	0.27	0.27
	12-15-76		2734	462	785	T	0.28	0.28
	12-15-76		2090	445	757	T	0.20	0.20
	12-15-76		2039	423	719	T	0.21	0.21

* mg/m^3 - milligrams per cubic meter

** TWA - Time Weighted Average

APPENDIX C-18

WOOD DUST

NEW PLANER

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Chipper	12-13-76	1	2420	232	394	T	0.53	0.66
	12-13-76		2447	189	321	T	0.81	
	12-13-76		2402	421	716	R	0.14	0.14
	12-14-76		2470	500	850	R	0.19	0.19
	12-14-76		2443	245	417	T	1.29	1.25
	12-14-76		2474	255	434	T	1.22	
	12-15-76		2024	430	731	R	0.18	0.18
	12-15-76		2767	230	391	T	0.92	1.07
	12-15-76		2794	200	340	T	1.24	
	12-13-76	2	2407	233	396	T	1.26	0.95
	12-13-76		2406	187	318	T	0.57	
	12-13-76		2457	446	758	R	0.18	0.18
	12-14-76		2478	244	415	T	0.36	0.43
	12-14-76		2422	225	382	T	0.50	
	12-14-76		2433	469	797	R	0.13	0.13
	12-15-76		2753	278	473	T	1.44	0.96
	12-15-76		2143	191	325	T	0.25	
	12-15-76		2411	449	763	R	0.17	0.17

* mg/m^3 - milligrams per cubic meter

** TWA - Time Weighted Average

APPENDIX C-19

WOOD DUST

NEW PLANER

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Chaser	12-13-76	1	2417	441	750	T	0.86	0.86
	12-15-76	1	2769	414	704	T	0.43	0.43
	12-15-76	2	1969	445	757	T	0.37	0.37
	12-14-76	2	2472	430	731	T	0.11	0.11
Puller	12-14-76	1	2486	467	794	T	0.20	0.20
	12-14-76	2	2438	296	503	T	too overloaded to weigh	
	12-14-76	2	2408	202	343	T	0.26	0.26
	12-14-76	2	2466	243	413	T	void	--
	12-14-76	2	2475	235	400	T	0.43	0.43

* mg/m^3 - milligrams per cubic meter

** TWA - Time Weighted Average

APPENDIX C-20

WOOD DUST

NEW PLANER

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Tally, Strapper	12-14-76	1	2444	492	837	T	0.29	0.29
	12-15-76	1	2707	409	695	T	0.17	0.17
	12-14-76	2	2441	472	802	T	0.54	0.54
	12-15-76	2	2495	428	728	T	7.49	7.49
	12-15-76	2	2436	442	751	T	16.70	16.70
	12-15-76	2	2439	442	751	R	0.11	0.11
Cherry Brown Operator	12-14-76	1	2431	480	816	R	0.27	0.27
	12-14-76	1	2483	480	816	T	0.33	0.33
	12-14-76	2	2456	272	462	T	too overloaded to weigh	
	12-14-76	2	2446	188	320	T	9.38	9.38
	12-14-76	2	2424	460	782	R	0.10	0.10

* mg/m^3 - milligrams per cubic meter

** TWA - Time Weighted Average

APPENDIX C-21

WOOD DUST

NEW PLANER

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Fork Lift Spotter	12-15-76	1	2169	414	704	T	0.34	0.34
Stick Machine Operator	12-14-76	2	2421	461	784	T	0.65	0.65
	12-14-76		2434	461	784	R	0.13	0.13
Utility Man	12-13-76	2	2476	473	804	T	0.25	0.25
Loader	12-13-76	1	2426	169	287	T	0.42	0.42
	12-14-76	1	2415	494	840	T	0.29	0.29

* mg/m^3 - milligrams per cubic meter

** TWA - Time Weighted Average

APPENDIX C-22

WOOD DUST

BARK PLANT

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Bagger	12-16-76	1	2647	215	366	T	1.61	> 1.67
	12-16-76	1	2635	210	357	T	1.74	
	12-16-76	1	2689	425	723	R	0.33	0.33
Utility-works on bark grinder	12-16-76	1	2561	212	360	T	6.13	> 6.17
	12-16-76	1	2619	210	357	T	6.22	
	12-16-76	1	2621	422	717	R	Tare wt. not available	
Bag Stacker	12-16-76	1	2658	210	357	T	1.57	> 1.22
	12-16-76	1	2606	210	357	T	0.87	
Picks wood out of Hogger on dike	12-16-76	1	2657	210	357	T	0.31	> 8.28
	12-16-76	1	2640	210	357	T	16.24	
Lead Man	12-16-76	1	2690	206	350	T	3.74	> 2.43
	12-16-76	1	2652	210	357	T	1.15	

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-23

WOOD DUST

OLD PLANER

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Rough Trimmer	12-16-76	1	2765	196	333	R	0.31	0.31
	12-16-76	1	2790	196	333	T	0.60	0.60
Feeder Planer	12-16-76	1	2718	209	355	T	0.29	0.29
Grader	12-16-76	1	2687	190	323	T	1.47	1.47
Set-up Man	12-16-76	1	2643	192	326	T	54.80	54.80
Backer	12-16-76	1	2695	201	342	T	0.20	0.20
Chipper	12-16-76	1	2641	205	349	T	51.40	51.40

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-24

WOOD DUST

PRESTO-LOG

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*		TWA** mg/m^3
Maintenance	12-16-76	1	2659	428	728	R	0.22		0.22
	12-16-76	1	2676***	222	377	T	6.79	>	4.55
	12-16-76	1	2623	145	247	T	1.13		
Presto-log Operator	12-16-76	1	2663	412	700	R	0.19		0.19
	12-16-76	1	2677	217	369	T	0.76	>	0.88
	12-16-76	1	2698	135	230	T	1.08		
Presto-log Loader	12-16-76	1	2660	209	355	T	0.39	>	0.58
	12-16-76	1	2654	136	231	T	0.87		
Stacker-Packer	12-16-76	1	2610	205	349	T	1.86	>	1.75
	12-16-76	1	2648	151	257	T	1.60		
Forklift Operator	12-16-76	1	2678	210	357	T	1.18	>	0.82
	12-16-76	1	2614	192	326	T	0.43		

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

*** - Man was in feed bin for 30 minutes during this sample.

APPENDIX C-25

WOOD DUST

PRES-TOCK

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*	TWA** mg/m^3
Bagger Operator	12-16-76	1	2666	420	714	R	0.48	0.48
	12-16-76	1	2691	201	342	T	23.20	> 17.20
	12-16-76	1	2682	229	384	T	11.90	
Bagger	12-16-76	1	2609	396	632	R	0.60	0.60
	12-16-76	1	2624	194	330	T	10.40	> 11.10
	12-16-76	1	2699	232	394	T	11.70	
Bagger/Cleanup	12-16-76	1	2630	190	323	T	14.20	> 15.60
	12-16-76	1	2620	235	400	T	16.70	
Lead Man	12-16-76	1	2670	196	333	T	4.50	> 2.30
	12-16-76	1	2608	214	364	T	0.30	
Warehouse Man	12-16-76	1	2602	192	326	T	43.60	> 21.50
	12-16-76	1	2697	208	354	T	1.07	

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-26

WOOD DUST

PLYWOOD PLANT

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	DATE	SHIFT	SAMPLE NUMBER	SAMPLE TIME MINS.	SAMPLE VOLUME LITERS	TOTAL OR RESPIRABLE	mg/m^3*		TWA** mg/m^3
Special Saw Operator	12-15-76	1	2787	165	281	T	1.17	>	1.31
	12-15-76	1	2792	180	306	T	1.44		
Skinner Saw Operator	12-15-76	1	2695	120	204	T	0.93	>	0.48
	12-15-76	1	2785	200	340	T	0.21		
Sander-Grader	12-15-76	1	1984	160	272	T	0.26	>	0.25
	12-15-76	1	2723	195	332	T	0.24		
Sander-Grader	12-15-76	1	2798	150	255	T	0.35	>	0.43
	12-15-76	1	2744	200	340	T	0.50		

* - mg/m^3 - milligrams per cubic meter

** - TWA - time weighted average

APPENDIX C-27

PLYWOOD PLANT

RESULTS OF ABIETIC AND PIMARIC ACIDS AND α AND β PINENE

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

LOCATION	DATE	SAMPLE NUMBER	SAMPLE TIME (MINS)	FLOW RATE	SAMPLE VOL CUBIC METERS	ABIETIC ACID mg/m^3	PIMARIC ACID mg/m^3	TOTAL ABIETIC AND PIMARIC ACIDS mg/m^3	α & β PINENE ppm**	TYPE OF WOOD DRIED
By Feeder End #3 Dryer	12-13-76	ESP-2	417	9.35 cfm	110.4	0.069	0.005	0.07	--	
		C-2	417	1.00 lpm	0.417	---	---	--	0.08	Fir
By Grader Station #4 Dryer	12-13-76	ESP-1	410	7.95 cfm	92.3	0.154	0.006	0.16	--	
		C-1	410	1.00 lpm	0.410	---	---	--	0.01	Fir
Between #3 and #4 Dryers	12-13-76	ESP-3	420	7.95 cfm	94.5	0.189	0.014	0.20	--	
		C-3	420	1.00 lpm	0.420	---	---	--	0.04	Fir
By Feeder End #5 Dryer	12-13-76	ESP-4	420	9.35 cfm	111.2	0.129	0.007	0.14	--	
		C-4	420	1.00 lpm	0.420	---	---	--	0.08	Fir
Off Bearing End of #2 Dryer Chain	12-14-76	ESP-5	553	7.95 cfm	124.5	0.010	<0.001	0.01	--	
		C-5	Void - Tube Broke		--	---	---	--	--	Fir
Between Feeder End of #1 & #2 Dryers	12-14-76	ESP-6	522	9.35 cfm	138.2	0.052	0.002	0.05	--	#1 Cedar
		C-6	522	1.00 lpm	0.522	---	---	--	0.04	#2 Fir
Off Bearing End Between #4 and #5 Dryers	12-15-76	ESP-7	395	9.35 cfm	104.6	0.075	0.002	0.08	--	#4 Fir
		C-7	395	1.00 lpm	0.395	---	---	--	0.01	#5 Cedar and Fir
By Feeder #4 Dryer	12-15-76	ESP-8	370	7.95 cfm	83.3	0.025	0.002	0.08	--	
		C-8	370	1.00 lpm	0.370	---	---	--	0.06	Fir

* mg/m^3 - milligrams per cubic meter
** ppm - parts of vapor or gas per million parts of air

Limits of detection: Abietic acid - 0.01 mg/sample; Pimaric acid - 0.05 mg/sample; α and β Pinene - 0.01 mg/sample

APPENDIX C-28

RESIN PLANT

RESULTS OF FORMALDEHYDE AND PHENOL SAMPLES

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

LOCATION	SAMPLE NUMBER	SAMPLE TIME (MINS)	SAMPLE VOL LITERS	FORMALDEHYDE mg/m^3*	PHENOL mg/m^3
By Resin Tank 2nd Deck	4	405	405	0.11	--
	1	405	405	--	ND**
By Glue Mixing Tank 2nd Deck	3	405	405	0.21	--
	2	405	405	--	ND

* mg/m^3 - milligrams per cubic meter

** ND - Non-Detectable (Phenol Detection Limit = 0.01 mg/ml of solution)

APPENDIX C-29

PARTICLE SIZING

Weyerhaeuser Co.
Longview, Washington
HHE 76-79,80

JOB	FILTER NUMBER	PERCENT OF PARTICLES IN EACH SIZE RANGE				
		0 u - 10 u	10 u - 20 u	20 u - 40 u	40 u - 60 u	> 60 u
Shake Mill						
Splitter	3078	54	28	14	2	2
"	3082	46	14	32	2	6
Sawyer	2638	34	22	18	10	16
Packer	2650	22	26	20	10	22
New Planer						
Graders	3089	54	28	12	2	4
"	AA-15	52	28	12	4	4
Set-up Man	AA-17	66	17	7	4	6
Rough Trimmer	3074	44	22	30	0	4
Stick Machine Operator	AA-14	62	8	4	6	8
Chipper	686	24	32	26	12	6
"	AA-18	26	36	34	2	2

APPENDIX D

SELECTED INFORMATION ON INDIVIDUAL SUBJECTS BY WOOD DUST EXPOSURE AND SMOKING HISTORY GROUPS

APPENDIX D

SELECTED INFORMATION ON INDIVIDUAL SUBJECTS BY WOOD DUST EXPOSURE AND SMOKING HISTORY GROUPS

I. D. Number	Actual FEV_1 (liters)	% of Predicted FEV_1 for Age and Height[1]	Previous Western Red Cedar Exposure (+ = yes)	Previous Other Wood Dust Exposure (+ = yes)	Personal Atopy + = yes	Pack-years (smokers)	Exposure (employment) (years)
			SHAKE MILL				
	Smokers						
102	4.09	101.27		+		80	5
103	5.30	112.71		+		9	3
105	3.53	101.07			+	19	7
111	5.21	116.13				30	3
115	4.06	90.13				2	2
118	3.51	99.98				8	6
119	4.96	115.66				9	3
123	6.90	157.08				5	8
125	4.78	108.84	+		+	11	6
130	5.70	134.67				6	1
131	5.36	127.72				15	8
136	4.71	113.31				5	5
137	5.38	123.83			+	7	2
138	6.00	137.22				5	3
139	5.24	114.90			+	8	3
142	3.61	93.17	+			6	4
143	5.01	133.43				19	5
145	5.12	121.48				17	2
152	5.30	118.92				3	1
156	4.80	121.81				15	5
157	4.85	112.36				2	5

APPENDIX D
(continued)

I. D. Number	Actual FEV_1 (liters)	% of Predicted FEV_1 for Age and Height	Previous Western Red Cedar Exposure (+ = yes)	Previous Other Wood Dust Exposure (+ = yes)	Personal Atopy + = yes	Pack-years (smokers)	Exposure (employment) (years)
159	5.40	123.22				4	3
161	3.66	94.02			+	7	1
162	4.51	124.49				12	1
164	4.92	117.85				3	1
165	6.00	132.38				6	1
166	4.56	113.02	+			8	1
169	4.30	104.86				7	1
170	4.58	95.89				3	2
173	6.45	134.75				6	5
174	3.30	91.55				69	1
177	4.90	119.49	+			12	4
179	4.30	101.35				1	7
180	3.10	89.94		+		15	6
	Nonsmokers						
101	5.95	130.47				0	3
109	5.67	145.96				0	5
112	5.40	121.39				0	3
132	4.45	102.43				0	5
133	5.25	124.33				0	5
134	4.85	120.21				0	4
140	3.92	106.85		+		0	2
144	5.84	122.52			+	0	1
146	5.18	126.88				0	8
147	5.70	120.75	+		+	0	4
148	5.18	113.33			+	0	2
150	5.45	128.52				0	3

APPENDIX D
(continued)

I.D. Number	Actual FEV_1 (liters)	% of Predicted FEV_1 for Age and Height	Previous Western Red Cedar Exposure (+ = yes)	Previous Other Wood Dust Exposure (+ = yes)	Personal Atopy + = yes	Pack-years (smokers)	Exposure (employment) (years)
252	4.02	101.50				20	3
253	5.15	122.78				15	6
254	3.55	95.72				27	7
259	3.80	96.38			+	1	9
	Nonsmokers						
223	5.75	124.50			+	0	8
230	5.57	127.09				0	7
241	4.30	106.31			+	0	7
242	4.96	109.43			+	0	1
243	3.42	83.98				0	6
249	5.19	116.67			+	0	8
250	4.08	106.29			+	0	3
257	5.35	128.71			+	0	3
	Former Smokers						
213	5.26	124.30				11	5
234	4.66	111.09				1	6
236	4.52	98.29				6	5
240	4.80	112.92				4	3
			OFFICE				
	Smokers						
307	3.90	101.57			+	9	1
313	5.52	141.01				13	3
319	4.79	103.38				18	5
320	3.80	102.69				42	1
325	5.08	136.24				86	5
327	4.74	120.22				20	4

APPENDIX D
(continued)

I. D. Number	Actual FEV_1 (liters)	% of Predicted FEV_1 for Age and Height	Previous Western Red Cedar Exposure (+ = yes)	Previous Other Wood Dust Exposure (+ = yes)	Personal Atopy + = yes	Pack-years (smokers)	Exposure (employment) (years)
151	4.01	92.30				0	3
160	4.62	110.40				0	3
163	5.72	123.15				0	1
168	5.11	119.43	+			0	4
171	4.68	111.09				0	1
175	3.86	88.85				0	3
176	4.96	112.97				0	1
	Former Smokers						
107	4.96	112.46				5	3
141	4.33	106.58			+	3	1
149	4.87	113.29	+			11	4
153	4.34	107.25				46	9
167	3.90	87.12		+		3	1
172	4.52	111.53				3	1
		NEW PLANER MILL					
	Smokers						
224	6.64	142.35				5	7
231	4.51	97.86			+	9	8
232	3.86	90.39			+	9	9
235	5.61	135.23				15	7
237	4.45	92.78				8	4
239	4.75	110.97				20	6
244	2.15	74.04				96	9
246	4.30	108.57				15	3
247	4.08	102.29				13	7

APPENDIX D
(continued)

I. D. Number	Actual FEV_1 (liters)	% of Predicted FEV_1 for Age and Height	Previous Western Red Cedar Exposure (+ = yes)	Previous Other Wood Dust Exposure (+ = yes)	Personal Atopy + = yes	Pack-years (smokers)	Exposure (employment) (years)
	Nonsmokers						
306	5.20	119.41				0	1
309	4.35	99.67			+	0	7
317	4.25	106.29				0	2
318	4.77	101.65				0	2
326	6.06	140.65				0	1
328	6.00	121.99				0	2
330	5.51	125.44				0	7

APPENDIX E

APPENDIX E

REVIEW OF PERTINENT WESTERN RED CEDAR LITERATURE

Western red cedar (Thuja plicata) is found only in western Canada and northwestern United States. The tree grows in cool, humid coastal regions from Alaska to northern California and can be readily distinguished from the spruce, pines, firs and hemlocks by its scaly leaves (11). The species is also known as Giant Arborvitae, Canadian Cedar and, in Japan, as "Beisugi" (12).

Imported western red cedar is an important commercial timber in Australia and Japan, and its use has increased in the past decade in its native North America. It is a soft, light reddish brown wood with a very straight grain (5). Western red cedar is characteristically different from other coniferous woods in its unusually high content of extractives (11). It is naturally resistant to decay because of the relatively high tropolone content. Tropolones are naturally occurring fungicides (13).

The durability and light weight of western red cedar make it an ideal material for telephone poles, lumber for exterior construction, and for split/sawn shake shingles for exterior roofing (11). Furniture and window frames are also made from this wood in Australia and Japan (14).

The first reports of adverse health effects associated with western red cedar were from Japan. Following the Tokyo earthquake in 1923, large quantities of western red cedar were imported from Canada and the United States in the form of "Jap Squares" (15). These large square-sawn logs were then resawn into lumber for housing construction and window frames (14). Localized epidemic of rhinitis, asthma and shortness of breath were reported among Japanese carpenters who used this wood (16). There were also sporadic cases of "Beisugi asthma" and allergic rhinitis occurring in people living in houses built of western red cedar (17). When the importation of this wood from North America was suddenly discontinued in 1940, no further incidence of western red cedar-induced asthma was noted in Japan until 1955 when this wood was again imported in quantity (18). In 1966, the prevalence rate of western red cedar asthma in Japanese woodworkers was as high as 5.5 percent (18).

A case of nasal irritation and pulmonary symptoms produced by the Thuja species was reported from Germany in 1926 (19). In 1937, Bridge (20) described severe nasal irritation produced in one man and possibly "bronchitis" in two other by the sawdust of "Canadian red cedar" which had been imported in England. This is more likely to have been Thuja plicata (17).

In 1949 minor epidemics of rhinitis and alterations of pulmonary function in joinery and sawmill workers using imported western red cedar were reported in England by Doig (21) and simultaneously in South Africa by Ordman (5).

No comprehensive description of adverse reactions to red cedar wood has appeared in the literature until this decade. Concurrently with the increased worldwide exposure to this wood, detailed reports on adverse reactions are now appearing. Milne and Gandevia (22) reported their experience with thirty-five (35) patients in Australia. This 1969 report was the first detailed description of the unique and characteristic pattern of symptoms resulting from exposure to western red cedar wood dust, which has subsequently become known as the "Western Red Cedar Syndrome."

The Western Red Cedar Syndrome was first described by Milne and Gandevia (1969) (22). Usually, the exposed worker first complains of eye and nose irritation with rhinorrhea and nasal stuffiness. These symptoms may progress over a period of several weeks or months, during which time an irritating, dry, nonproductive cough develops. The cough characteristically is worse at the end of the day or at night. A gradual subsidence of the eye and nose symptoms may occur, leaving episodes of nocturnal cough and/or wheezing as the only persistent symptoms.

Initially, symptoms begin to occur at night following a day's work. This delayed reaction may occur over the weekend and complicate recognition of the cause and effect relationship. If exposure to western red cedar wood dust continues, symptoms may also occur immediately (within 15-20 minutes) upon reexposure. Some workers may experience dual reactions (e.g. immediate and late) following several months or years exposure to this wood dust (23). Characteristically, asthma symptoms persist for days or weeks after cessation of exposure; this is particularly true of the nocturnal symptoms.

In 1970, Gandevia and Milne (24) described the physiologic abnormality as "mid-airway obstruction;" it gradually resolved after removal from western red cedar exposure. Mid-airway obstruction was determined by measuring $FEV_{1.0}$. Partial relief occurred during weekends and vacations,

but nocturnal symptoms persisted for several days or weeks after cessation of exposure. No correlation with a history of atopy was found. Symptoms might recur on the first day or evening after return to work, but might not reappear for several days. Diagnosis was difficult to make for workers with continued exposure, since they manifested a clinical picture of persistent airway obstruction; there was little change overnight away from exposure and only partial recovery over the weekends. Serial pulmonary function testing over a period of several days is often necessary to detect the changes in $FEV_{1.0}$ which help to distinguish bronchial asthma from other chronic obstructive pulmonary diseases.

Chan Yeung (1971) (25) described a similar syndrome in which subjects exposed to western red cedar wood dust showed persistent symptoms for several days, even with avoidance of cedar dust.

The search for the etiology of the western red cedar syndrome involved the classical approaches to allergy testing.

Gandevia (26) reported that skin tests with extracts of western red cedar were unreliable; bronchial inhalation tests, however, were positive in patients with clinical symptoms of asthma. There was a slightly reduced $FEV_{1.0}$ in men without clinical manifestations of asthma, but who were exposed to western red cedar dust.

Bleumink, Mitchel, and Nater (27) described a case of dermatitis in a sawyer. This individual gave a strongly positive patch test with water soluble extracts of western red cedar. Thuja plicata and one other tropolone also gave positive skin reactions.

Ishizaki (14) reported the prevalence of asthma (3.4%), rhinitis (9.4%), urticaria (3.6%), dermatitis (4.5%), and conjunctivitis (9.5%) among 1320 Japanese sawmill workers and carpenters exposed to western red cedar. He found a high correlation between positive skin test reactions to western red cedar extract and atopic individuals with asthma. This suggested that atopy might be an important factor in the development of western red cedar asthma.

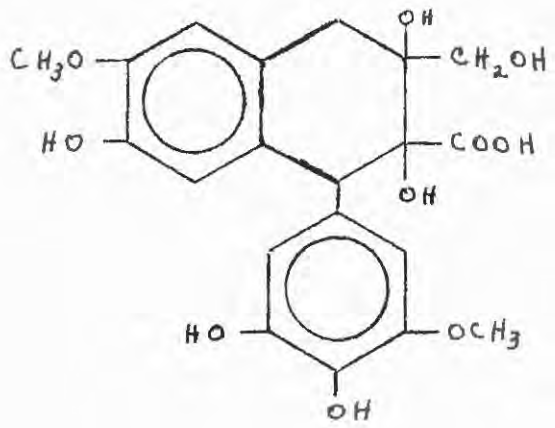
In 1975, Mue and coworkers (18) determined that eighty-six (86) of 154 workers (56%) exposed to western red cedar had positive intradermal skin tests when tested with material containing the water soluble extract of western red cedar. These investigators reported that only twenty-three (23) (15%) of these 154 workers had respiratory symptoms and that only seventeen (17) (11%) had positive skin tests.

Chan-Yeung and Barton (1) studied twenty-two (22) wood workers with respiratory symptoms associated with western red cedar exposure and found that skin tests with purified, protein free extracts of western red cedar were of no diagnostic value. None of the twenty-two subjects

studied had any history of atopy. Eighteen of the twenty-two (22) subjects showed a decline in FEV_1, ranging from 17% to 69% following bronchial inhalation of nonvolatile, water soluble extracts of western red cedar sawdust. It was further demonstrated that bronchial inhalation of purified, protein-free extracts of plicatic acid produced declines in FEV_1 ranging from 16% to 75% in sixteen (16) subjects tested. None of these sixteen (16) sensitized subjects reacted to plicatic acid-free extract of western red cedar.

Thus by using inhalation provocation tests, Chan-Yeung, et al. have demonstrated that plicatic acid produces bronchial reactions identical to those produced by western red cedar dust in persons sensitized to western red cedar. It is now generally accepted that plicatic acid is responsible for the respiratory symptoms associated with western red cedar exposure in humans.

Western red cedar (Thugia Plicata D. Don) is characteristically different from other woods in that it has a higher content of water soluble compounds, as well as the non-water soluble aromatic oils which are primarily responsible for the characteristic odor and preservative nature of cedar wood. Plicatic acid, the major fraction (40 percent by weight) of the extract of the nonvolatile water soluble components is a highly substituted aromatic and saturated ring compound containing phenolic and alcoholic groups, as well as the carboxylic acid group. Plicatic acid is a unique compound for western red cedar and has not been identified in the water soluble extract of other woods. The structural formula is shown below:



Plicatic acid is believed to be closely related to the intermediate hydrolysis products of several similar water soluble parent compounds, such as podophyllotoxin, sikkimotoxin, alpha and beta peltatins. These parent compounds are generally known to be highly irritating to eyes and mucous membranes. Podphyllotoxin, an irritating substance, is present in small amounts in a related wood species, eastern red cedar, Juniperus virginiana. Small animals such as guinea pigs and gerbils occasionally develop symptoms of irritant/allergic rhinitis when animal bedding/litter consisting of eastern red cedar shavings is used in cages. This phenomenon does not, however, appear to be a problem when laboratory rats are kept in eastern red cedar bedding.

Chan-Yeung and Barton (1) further reported that while plicatic acid is responsible for respiratory symptoms, it did not produce positive skin tests in sixteen (16) workers with positive bronchial challenge tests (greater than 15% fall in FEV_1) to plicatic acid. Three of sixteen (16) workers had mildly positive skin tests to unpurified water soluble extracts of western red cedar.

Chan-Yeung and Grzybowski (28) have been unable to confirm the high correlation of intradermal skin tests and western red cedar asthma reported by Ishizaki (14) using his method and techniques.

The incidence of atopy in patients with red cedar asthma is about 10%, approximately the same as that in the general population of North America (28). A recent survey of 441 cedar mill workers in British Columbia further demonstrated that atopic individuals have no greater risk for developing asthma to western red cedar dust than nonatopic individuals (11).

The numerous Chan-Yeung studies reporting that skin tests with protein free water soluble western red cedar extract were unreliable, that bronchial inhalation tests of similar extract gave uniformly positive responses in individuals with western red cedar asthma and that atopy was not a relevant factor for development of the western red cedar syndrome, confirmed the earlier findings of Gandevia and Milne (26).

Recent reports (29) (30) (11) have suggested that chronic effects on pulmonary function, particularly reduced FEV_1, may persist for several months or longer after exposure is ended in workers chronically exposed to western red cedar sawdust. This also supports earlier findings of Gandevia and Milne (26).

In summary, it is now generally believed that plicatic acid extracted from western red cedar is responsible for the respiratory symptoms which have been observed following exposure to this wood dust.

Results of skin tests have been inconsistent and presently appear to be of no diagnostic value in predicting or confirming that observed respiratory symptoms are associated with western red cedar dust exposure. Bronchial inhalation tests with plicatic acid or water soluble western red cedar extract results in significant decline in FEV_1. Although the asthma symptoms may be on an allergic basis, this has not yet been proven. Demonstration of asthma can be accomplished by observing decline in FEV_1.