

This FIHRP bulletin discusses sampling methods and strategies for measuring workers' exposure to wood dust. The information is intended for Health and Safety Coordinators, technical personnel, and members of Joint Health and Safety Committees at BC pulp mills, to assist them in planning programs to evaluate workers' exposure.

WOOD DUST EXPOSURE

FOREST INDUSTRY HEALTH RESEARCH PROGRAM

c/o Pulp and Paper Forum
#100-620 Royal Avenue
New Westminster, BC
V3M 1J2
Telephone: (604) 777-1533
Facsimile: (604) 777-1567

The objectives of programs to measure personal and area concentrations of wood dust are:

- To identify workers who have exposures at or above the current exposure limits for wood dusts and to design controls to decrease exposure.
- To determine average concentrations and variability of personal exposures for risk assessments and in anticipation of lower exposure limits in the near future.
- To identify areas where engineering controls should be installed to reduce dust levels, and areas where workers should use respiratory protection for occasional entry.

FIHRP Bulletin No. 15 (02/95) summarized background information on the IARC decision to classify wood dust as a human carcinogen. The bulletin presents information on epidemiological studies relevant to workers in British Columbia, exposure limits, and future studies that will help to clarify the risk of exposure to wood dust. For a copy of the previous bulletin, contact **Agi Lee** at the **Pulp and Paper Forum (604) 777-1533**.

SAMPLING METHOD FOR TOTAL DUST

The method recommended for measuring personal and area concentrations of wood dust is Workers Compensation Board (WCB) of BC, Laboratory Services Method No. 1150, "**Particulate (Total) in Air**", dated 19 December 94. A copy of the method is attached.

Key elements of the WCB method are:

1. Dust samples are collected on polyvinyl chloride (PVC) filters with a cellulose support pad in a 3-piece styrene cassette. The PVC filters are 37mm diameter and 5.0µm pore size.
2. Open-face sampling is used. The top part of the cassette is removed during collection of samples.
3. This is a gravimetric method. Filters are weighed before and after sample collection on a 5-place balance capable of weighing to 0.01 milligrams. The increase in weight of the filter, after correction for blanks, is divided by the sample air volume to give a result in milligrams per cubic metre (mg/m³).

DISCUSSION OF THE WOOD DUST SAMPLING

- A. Open-face sampling gives higher results for airborne wood dust than closed-face sampling, and lower results than would be obtained with personal "inspirable" dust samplers.
 - i. **Open-face** sampling has the top part of the cassette removed during sample collection; closed-face keeps the top part in place. Open-face gives higher values because particles in the size range 20 to 100µm are sampled more efficiently. All airborne wood dust particles up to 100µm are important for assessments of workers' exposure and for designing engineering controls [1].
 - ii. One type of **personal sampler for inspirable dust** has been developed, and another version is under development, to improve the collection efficiency of "inhalable" particles from 0 to 100µm, particularly in the range 20 to 100µm. This type of sampling device may produce values for wood dust considerably higher than results obtained with open-face sampling. In the future, "total" dust sampling will probably require an inspirable dust sampler, after methods are validated and accepted by regulatory agencies [2].
- B. Gravimetric methods measure all particles (dusts, mists, fumes) in the air and do not differentiate between wood dust and soil, salt cake, fly ash, lime, or other dusts in the pulp mill. The filter should be examined visually or under a microscope and the sample rejected if the majority of particulates are not fibrous. If samples contain some non-fibrous material but are considered acceptable, this should be noted. Mills that do asbestos sampling and counting have the equipment and trained people to examine filters.
- C. Do not over load or under load the filter. The maximum filter loading is approximately 2mg, equivalent to a sample volume of 1m³ (1000L) for an airborne concentration of 2mg/m³. A collection time of 500 minutes (8.3 hours) will filter 1m³ at a sampling flow rate of 2L/min. The flow must be in the range 1 to 2L/min as specified in the method. At most B.C. pulp mills and wood products mills, a sampling time of at least four hours and a flow rate of 2L/min will be necessary to achieve an acceptable result.
- D. Collection of two consecutive 4 or 6-hour samples during an 8 or 12-hour shift is preferable to one sample for a full shift, unless the dust concentration is low and the amount collected on the filter would be too small to weigh accurately. As a rough guide, personal samples are often collected for a full shift, two consecutive area samples a shift are collected in a dusty location, and one area sample per shift in a relatively clean location. If personal samples exceed the capacity of the filter, repeat the sample collection over shorter time periods.
- E. A record of temperature and relative humidity in working areas and ambient weather conditions is desirable, as well as observations about the working environment, such as dryness and fineness of dust, ventilation systems, personal protective equipment, and other control measures.
- F. The WCB method describes use of a laboratory press, shrinking bands, static ionization devices and other items. If you do not have all the items listed, you can still get good results with acceptable alternatives. To discuss the method, contact the Workers' Compensation Board Laboratory & Technical Services (604) 276-3116.

TYPES OF SAMPLES FOR AIRBORNE WOOD DUST

Personal samples measure the exposure level for specific individuals. The cassette and filter are attached to the worker's clothing, on or near the collar, and worn continuously during all work and rest operations. Samples are normally collected for the entire shift to give a time-weighted-average concentration in milligrams of dust per cubic metre of air (mg/m³). Results of personal samples are compared with exposure limits to determine compliance and are used for risk assessments.

Area samples measure dust concentrations at a fixed location over the chosen sampling time. Area samples are valuable for evaluating sources of wood dust and defining areas where workers should wear respirators while in the area occasionally. Results of area samples do not provide enough information to estimate personal exposures.

Real-time dust concentrations can be obtained with a number of devices. However, these measurements are not useful for evaluating workers' personal exposures to wood dust.

EXPOSURE ASSESSMENT STRATEGIES

A program to monitor workers' exposures to wood dust can be done in different ways. The seven steps outlined below can be modified to suit the needs at each mill.

If your mill has little or no previous data on personal and area wood dust concentrations, start with a small sampling program over a couple of shifts to get baseline results. This information indicates where exposures at your mill fit in relationship to current limits and lower limits anticipated in the near future. Baseline results will help you to design better and more comprehensive programs based on random selection of workers.

1. *Identify major sources of wood dust and locations with high dust levels.*

A "walk-through" of the wood handling processes at your mill will help people involved in planning the monitoring program to decide on the dustiest areas and jobs most likely to have higher exposures. This "walk-through" can be a paper exercise with flow diagrams or a physical inspection.

Each pulp mill has different wood handling systems. Consultations between Health and Safety Coordinators, Joint Health and Safety Committees, and technical personnel should quickly result in identification of dusty areas and jobs. Consider areas such as: barges; chipper; chip screening; debarking; sawdust-handling systems; chip conveyers; galleries; chip reclaim, and so on.

2. *Identify workers who may be exposed to wood dust*

All workers who have jobs related to wood-handling systems from the unloading of barges to entry of chips or sawdust into the digesters are potentially exposed. Once the wood chips or sawdust are digested by kraft or sulphite processes the fibres should not be considered as wood dust for the purposes of the exposure assessment because the extractives have been removed.

Until further information is available to clarify the situation, TMP and groundwood mills would be prudent to treat all fibres as wood dusts because the pulping process does not remove extractives.

3. *Measure personal exposures for workers who are suspected of having high exposures.*

The first priority for a monitoring program is to identify those workers whose exposures are at or above the current exposure limits of 5mg/m³ for non-allergenic softwoods, 1mg/m³ for Western red cedar, and 2.5mg/m³ for other allergenic wood dusts. These limits are for 8-hour time-weighted-averages. High exposures could occur while working in very dusty areas for extended periods, such as for clean-up. Most clean-up people wear fabric respirators but their exposure should be measured to ensure that the respiratory protection is adequate, and to allow time to plan improved protection methods, if needed, in anticipation of lower exposure limits.

Sampling for two or three shifts is often adequate to identify workers with the highest exposures. Samples may have to be collected at different times of the year depending on the impact of weather conditions or process variables on dust levels.

If measured concentrations are at or above the current exposure limit, then immediate action should be taken to reduce the worker's exposure, preferably by engineering controls.

4. *Measure average exposures for selected workers.*

Workers within a particular section of the mill may be selected based on previous concerns expressed to health and safety people, or on first aid reports of health problems. Personal samples collected for a minimum of three shifts allows calculation of average exposures, and estimates of variability which examine the range of exposures that could occur and the probability of exposures exceeding specified limits. Samples may have to be collected at different times of the year to account for variations in dust levels.

5. *Measure average exposures for a group of randomly-selected workers*

Random selection is the best way of approaching exposure assessments because it removes much of the bias that we bring to decisions on who has low, moderate or high exposures. Be careful, however, about measuring exposures to dusts other than wood dust. Examination of filters for non-fibrous dusts is important.

Step 1. Decide who will be in the group of workers. One example is to select all workers in the area of the mill from barges to digesters, day and night shifts. Another example would be to choose people who work around the chip screening area. However, too many small groups is less effective than one or two larger groups.

Step 2. Decide what you want to know when you interpret the results. How important is it that you have workers with the highest exposures included in the monitoring program? The U.S. National Institute of Occupational Safety and Health (NIOSH) prepared tables to show how many workers should be sampled at different degrees of confidence. The tables are included at the end of the bulletin.

If you have already investigated the highest exposures, you may decide to sample the number of workers that will give a 90% confidence level of including one worker whose exposure is in the top 20% of the exposure range (Table A-3).

If you have not examined the highest exposures separately, then you would probably choose the number of workers to ensure including one worker whose exposure is in the top 10% of the range with 95% confidence (Table A-2).

For example, assume you select a group comprising 40 workers and you want one worker in the top 10% of the exposure range to be included with 95% confidence. Table A-2 shows that personal exposures for 20 workers should be measured. Each worker is assigned a number from 1 to 40 and a table of random numbers or a computer program is used to select 20 numbers at random. The personal exposures for these 20 workers are measured for a minimum of three shifts, and possibly repeated at a different time of the year if ambient or process conditions can change wood dust exposures to a large extent.

A program based on randomly-selected workers is ideal, but must often be modified by the reality of limitations on availability of resources, both people and sampling equipment. Sampling that includes some bias is still better than not doing any sampling.

6. *Interpret results*

If you have three or more results for individual workers, specific jobs, or groups of workers, you can do some statistical calculations that will help you interpret the variability of exposure. Results may be clustered around the average value and fit a normal distribution. The **arithmetic** average (mean)

exposure and standard deviation are calculated, and these values used to determine upper and lower confidence limits for the mean exposure concentration. On the other hand, most of the results may be low with a few higher results. These results might fit a lognormal distribution. The **geometric** mean and standard deviation are calculated and used to determine the upper and lower confidence limits around the mean. Consulting a person knowledgeable in statistics is desirable at this point. You will probably know someone at the mill who can help you with these calculations. When you have done one set of lognormal calculations, the next ones are relatively simple. FIHRP has available for member companies copies of a book published by the *American Industrial Hygiene Association* which describes calculation of upper and lower confidence limits from arithmetic and geometric means and standard deviations [Reference 3, page 130]. To obtain a copy contact **Dr. Robert Lockhart**, BC Research, 604-222-5598 or fax 604-222-0540.

7. Record results

Results should be recorded with sufficient details of sampling parameters to be useful in the future for health and safety audits, and for epidemiology studies. The measured concentrations and calculated data should be recorded with information on: job title; employee or payroll number, or participant's name; sample dates; sampling locations; times and duration of sampling; and other pertinent data. The report giving details of the sampling procedures should be filed so that it can be retrieved later. A site diagram indicating job locations would help auditors and researchers.

REFERENCES

1. Beaulieu. H.J., A.V. Fidino, K.L.B. Arlington, and R.M. Buchan. 1980. "A comparison of aerosol sampling techniques: "open" versus "closed-face" filter cassettes." Am. Ind. Hyg. Assoc. J.(41) 10: 758 - 765.
2. Hinds. W.C. 1988. "Basis for Particle Size-Selective Sampling for Wood Dust." Appl. Ind. Hyg., Vol. 3, No. 3 : 67 - 72.
3. Hawkins. N.C., S.K. Norwood, and J.C. Rock (Editors). 1991. "A Strategy for Occupational Exposure Assessment." American Industrial Hygiene Association. Akron, OH.

Table A-1:
Sample Size for Top 10% ($\tau=0.1$) and Confidence 0.90 ($\alpha=0.1$) (Use $n=N$ if $N \leq 7$)

Size of Group (N)	8	9	10	11-12	13-14	15-17	18-20	21-24	25-29	30-37	38-49	50	∞
Required No. of Measured Employees (n)	7	8	9	10	11	12	13	14	15	16	17	18	22

Table A-2:
Sample Size for Top 10% ($\tau=0.1$) and Confidence 0.95 ($\alpha=0.05$) (Use $n=N$ if $N \leq 11$)

Size of Group (N)	12	13-14	15-16	17-18	19-21	22-24	25-27	28-31	32-35	36-41	42-50	∞
Required No. of Measured Employees (n)	11	12	13	14	15	16	17	18	19	20	21	29

Table A-3:
Sample Size for Top 20% ($\tau=0.2$) and Confidence 0.90 ($\alpha=0.1$) (Use $n=N$ if $N \leq 5$)

Size of Group (N)	6	7-9	10-14	15-26	27-50	51- ∞
Required No. of Measured Employees (n)	5	6	7	8	9	11

Table A-4:
Sample Size for Top 20% ($\tau=0.2$) and Confidence 0.95 ($\alpha=0.05$) (Use $n=N$ if $N \leq 6$)

Size of Group (N)	7-8	9-11	12-14	15-18	19-26	27-43	44-50	51- ∞
Required No. of Measured Employees (n)	6	7	8	9	10	11	12	14

Source: Occupational Exposure Sampling Manual, NIOSH 1977.