BENCHMARKING OF EXPOSURES TO WOOD DUST AND FORMALDEHYDE IN SELECTED INDUSTRIES IN AUSTRALIA

JULY 2008

Australian Government
Australian Safety and Compensation Council

Benchmarking of exposures to wood dust and formaldehyde in selected industries in Australia

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Glossary

ABS	Australian Bureau of Statistics
AIOH	Australian Institute of Occupational Hygienists
AM	arithmetic mean
ANZSIC	Australia and New Zealand Standard Industrial Classification
ASCC	Australian Safety and Compensation Council
CCA	copper chrome arsenic
GM	geometric mean
HEPA	high efficiency particulate arrester
HSE	UK Health and Safety Executive
LEV	local exhaust ventilation
MDF	medium density fibreboard
MDHS	Methods for the determination of hazardous substances
mg/m^3	milligrams per cubic metre of air
NATA	National Association of Testing Authorities
NIOSH	US National Institute for Occupational Safety and Health
OSHA	US Occupational Safety and Health Administration
ppm	parts per million
RPE	respiratory protective equipment
SME	small and medium sized enterprises
STEL	short term exposure limit
TWA	time-weighted average

Executive Summary

This project was one of a series of concept studies commissioned by the Office of the Australian Safety and Compensation Council in 2006-07 to examine options for the collection of occupational disease hazard surveillance data. The aim of this project was to examine the extent to which existing surveillance data sources could be used as estimates of hazard exposure. The focus of the project was on exposures to wood dust and formaldehyde in selected Australian wood industries.

The objectives of the project can be broadly classified in terms of (1) the characterisation of an Australian exposure profile and its required elements; (2) the availability and accessibility of relevant data; (3) factors influencing variability of exposure data; (4) the extent and effectiveness of various exposure control approaches, with suggestions for best practice; and (5) the comparability of new (de novo) measurements with previous measurements.

Requisite information was gathered via a review of published Australian literature; requests to government agencies, consultants, industry associations, specific industries and researchers; telephone surveys and new air sampling. Responses and reports received by the study team within the project timeframe (January to July 2007) were reviewed by occupational hygienists and information was classified in accordance with a methodology agreed with the Office of the ASCC.

Exposure to inhalable wood dust, as represented by 521 discrete time-weighted average personal measurements across all wood industries yielded a median value of 2.1, an arithmetic mean of 5.8 and range of 0.06 – 210 mg/m3. This distribution is similar to a 1999/2000 UK-wide targeted (purposive) survey where the corresponding figures were 2.6, 6.6 and 0.05 – 157 respectively.

Depending on the task, control measures and work practices, exposures often exceeded the Australian occupational exposure standard of 1 mg/m3 in the case of hardwoods and 5 mg/m3 for other woods. It was found that 72% of hardwood dust exposures exceeded the relevant standard. Corresponding percentages for solid softwoods, reconstituted woods and mixed woods were 22%, 28% and 25% respectively.

On the other hand, gaseous formaldehyde exposures were generally low compared with the standard of 1 ppm, with a median of 0.1, an arithmetic mean of 0.3 and a range of <0.01 – 11 ppm from 166 discrete measurements.

The wide range of personal exposures, spanning three orders of magnitude, is attributable to a host of factors including the type of wood processing activity, the availability and effectiveness of local exhaust ventilation and work practices, particularly cleanup and housekeeping procedures. In the case of wood dust, the relatively coarse particulate and inertial forces from woodworking may be associated with highly

directional (localized) exposures and breathing zone variability. This is evident visually from deposition patterns. There is some suggestion that the use of medium density fibreboard leads to greater levels of fine dust, although the evidence is mixed, depending on the process. Thus the required elements of an exposure profile for health hazard surveillance should reflect, amongst other things, the various factors influencing exposure, as well as basic characteristics of those exposed.

A feature of the exposure dataset was multi-tasking (23% of the personal measurements) and mixed wood exposure (37%). When considered with corresponding classifications in the UK (49% and 64%), it is apparent that wood dust exposure limits that differentiate hardwoods and softwoods are problematic. Furthermore, Australia has a softwood short term exposure limit of 10 mg/m3, but less than 6% measurements were consistent with a STEL sampling strategy, i.e. 15 minute TWA measurements. In many secondary wood industries, i.e. furniture and cabinet making, multitasking and mixed wood exposures will be the rule rather than the exception, and thus a review of the suitability of the current wood dust exposure limits appears warranted.

Uniformly lower exposures were recorded when local exhaust ventilation (LEV) was present, and when compressed air was not used for cleanup. There were insufficient data to evaluate the relationship between company size and quantitative exposure. However, it would be expected that smaller companies would have fewer control measures in place. Nor was there adequate information to evaluate the relationships between exposure and worker characteristics, such as age, and temporal variables, e.g. day of the week and shift. Less than 5% of records had this information at the individual level. The vast majority of records refer to day shift and males.

Personal respiratory protection was relatively uncommon. Approximately 3% of records had information about the use of respirators, and where mentioned, half face respirators were most common.

The availability of exposure data from government and consultant sources was relatively poor and variable. Three out of 67 consultants replied with information, and 5 out of 8 government agencies were able to provide data. Duplication of data occurred in one case only.
It appears that wood dust sampling is undertaken infrequently (compared with say noise monitoring), but it is also possible that scientific reports and data are not readily available for reasons of commercial confidentiality or are judged by providers not to be in a form that can be included in a systematic exposure database. In any case, the available exposure data for this study were often the result of research projects, carried out from 1989 to 1999. Furthermore, it is unlikely that simply truncating the compiled dataset to recent exposure measurements (say in the last 10 years) will satisfactorily address the issues of potential selection and reporting bias, for example the availability of data from small business.

Accurate estimates of the workforce size of the wood industry are not available. ABS data for 2004/5 in ANZSIC codes 23 and 29 indicate approximately 100,000 persons of which 10,000 reside in South Australia, reflecting the population proportion. A pseudo random telephone survey of the relevant Yellow Pages-listed companies in SA (n=201, 48% response rate) indicate a workforce of 4,000, but this is likely to be an underestimate. Nevertheless, about two thirds of responding companies had less than 5 employees, and, depending on the size of the company, about 75% of employees are exposed to wood dust, mostly in the form of reconstituted timber and softwood. Few companies use solid hardwoods, except in door and window frames and specialist furniture manufacturing. This is consistent with the industry trend towards cheaper imported hardwood products, rather than local manufacture. The telephone survey was also a valuable means of understanding user attitudes to wood products, e.g. the perceived toxicity and dustiness of MDF.

In a pilot study in SA, a limited amount of new personal monitoring for wood dust and formaldehyde was conducted, across a selection of primary wood production, furniture and cabinet making/joinery industries. The median, arithmetic mean and ranges for airborne wood dust were 0.7, 1.2 and 0.02 – 7.3 mg/m3 (n = 34). The corresponding figures for formaldehyde were 0.1, 0.1 and 0.01 – 1.1 ppm (n = 42). Although these results, and observations in previously monitored workplaces, would suggest an improvement, the sample size is too small to be meaningful. It may also reflect lesser usage of solid timbers (where dusty finishing tasks may be important) and altered production processes to meet modern market demands.

Best practice control measures for wood dust include local exhaust ventilation, notably integral extraction for hand tools, vacuum cleaning methods rather than compressed air or sweeping, isolation of dusty processes, external exhaust rather than recirculation through sock filters, separately enclosed areas for workers, and provision of overhead filtered air supply or air fed masks for non-mobile workers.

In the case of formaldehyde, the conventional hazard control hierarchy is appropriate. Full enclosure and push-pull ventilation systems can often be incorporated in reconstituted wood production processes.

In view of the limitations and potential biases in simply compiling existing data, it tempting to draw the conclusion that targeted survey work, as has been conducted in the UK, is a more reliable strategy for exposure profile development and trend assessment.

Aside from the compilation of existing data and the repeated generation of new data via targeted surveys, a third approach, based on modelling exposure from national and international data compilations may also be a cost-effective option under certain circumstances. In this case, an exposure "band" would be derived from the input variables of wood type, process and equipment, task duration, control measures and work practice information. Thus, a solid timber sawing operation with LEV, and vacuum cleaning would have an associated exposure band which is different from (and in this case lower than) that for a sanding operation with no LEV and uses compressed air for cleaning. One could envisage a desktop or web-based computer program, or a (handheld) PDA version for inspectors visiting woodworking companies. Such a program would be capable of generating a total daily exposure band from partial exposures in multitasking and mixed wood situations.

Conclusions: There is good evidence to suggest relatively low exposures to formaldehyde compared with the exposure standard, and some evidence to suggest that current wood dust exposure levels are lower than historical levels. However, the ensemble of Australian wood dust exposure data has some similarity with that for the UK, where 27% of measurements (particularly sanding and circular sawing) exceeded the UK limit of 5 mg/m3. Overexposure is likely to occur during machining of hardwoods, and more generally in sanding and cleaning processes. The observations of multi-tasking and mixed wood exposures raise issues about the applicability of the wood dust exposure limits, especially in furniture and cabinet making, and more specific guidance should be developed for those industries. Control measures such as LEV are effective, but the use of compressed air rather than vacuum systems exacerbates exposure by resuspending settled dust.

Direct exposure measurement, according to a well defined protocol and classification scheme, i.e. targeted sampling, is likely to be more expensive but more reliable and versatile than the compilation of existing data. In the case of wood dust, it is probable that the use of existing data sources will overestimate the current exposure, but there remains uncertainty as to the extent of selection and reporting bias associated with the existing data. The choice of wood dust and formaldehyde for this study was in some respects a decision based on the known availability of exposure and control data, as evidenced, for example, by published reports of industry-wide surveys in Australia. For other substances, such as styrene and chromium, there may be insufficient data to contemplate the use of data compilations for hazard surveillance purposes.

The following suggestions are made:

- Information on workforce characteristics, exposures, controls and work practices in the Australian wood industry, should be gathered by targeted (purposive) sampling rather than compilations of existing data. Roughly 1,000 measurements from 100 companies of various sizes, and across the spectrum of wood industries in Australia, would probably be required in order to generate a proper industry exposure profile for wood dust. The total cost of such a survey would be approximately $200,000. Subsequent surveys may require lesser numbers. In the case of formaldehyde, surveys should focus on the manufacture of reconstituted wood products, since exposures in secondary wood industries are low.

> The feasibility of modelling of exposures using existing national and international data should be explored.

> The Australian exposure standards for wood dust should be reviewed in order to better reflect the current situation of multi-tasking and mixed wood exposures.

Chapter 1: Introduction

Objectives of project

The overall aim of this project was to examine the extent to which existing surveillance data sources could be used as estimates of hazard exposure. The focus of the project was on exposures to wood dust and formaldehyde in selected Australian wood industries. The objectives of the project were broadly classified in terms of (1) the characterisation of a national exposure profile and its required elements; (2) the availability and accessibility of relevant data; (3) factors influencing variability of data; (4) the extent and effectiveness of various exposure control approaches, with suggestions for best practice; and (5) the comparability of new measurements with previous measurements.

The specific requirements of the Office of the ASCC were as follows:

- detail the methodology undertaken, including the number and nature of samples taken;
- report on stakeholder input into the Project;
- document the best practice measurement methods for the assessment of wood dust and formaldehyde exposures;
- document the key data elements required for the measurement and exposure reporting for wood dust and formaldehyde exposures;
- provide an indicative estimate of the prevalence of workers (by industry sector/business size) exposed to wood dust (by type) and formaldehyde in Australia in a representative range of industries and business sizes using the agreed template[1];
- provide an estimate of the current levels (intensity and/or duration) of exposures to wood dust (by workers, industry and dust type) and formaldehyde in these industries using the agreed template;
- document variations of exposure due to different ways of processing the materials (e.g. exposures resulting when being cut, or when wet etc.) taking into account that exposures will vary, particularly in small businesses, across the working week due to the job being undertaken;
- document the types of controls currently used in workplaces for specific exposures and their effectiveness in reducing exposures;
- recommend best practice methods for reducing these exposures where existing evidence exists;

[1] No template was agreed between the Office of the ASCC and the consultant.

> provide an evaluation of the adequacy of the nature and number of samples taken with the study.

In addition, the Office of the ASCC was interested to know whether new (de novo) measurements were comparable with published data.

At the outset, it should be noted that “wood” is not a single chemical entity[2], and that exposure to wood dust is rarely homogeneous[3]. Although formaldehyde is a specific chemical[4], it may be present in gaseous form or associated with reconstituted wood dust particles. Thus the choices of “wood dust” and the diverse “wood industries” make the characterisation of a national exposure profile problematic. As such, classifications and data comparisons, and even exposure standards tend to be crude and imprecise. On a positive note, such a profile is relevant for large numbers of workers, and does highlight the challenging issues of mixed exposures, between-day and between-worker variability, the impact of poor work practice, and the uptake/effectiveness of control measures. Importantly, the availability of such a profile will assist in hazard surveillance and the strategic development of interventions.

Scope and assumptions

This project is relevant for Australia as a whole, although new measurements, and much of the empirical data collection, pertain to South Australia[5]. The issue of generalisability beyond South Australia will be discussed later.

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[2] Wood is a complex material comprising a cellulosic matrix, and potentially containing semi-volatile organic components (terpenes, tannins), naturally occurring contaminants (e.g. crystalline silica), microbial agents, and impregnated substances (as in CCA or creosote –treated timber). Short and long term respiratory and skin conditions have been associated with many species, especially exotic irritant species, Western Red Cedar and certain hardwoods such as blackwood.

[3] with the potential for exposure to be highly variable in time and space, depending on the task or process, wood type, work pattern, ventilation etc.

[4] Formaldehyde is an irritant and suspect human carcinogen. With respect to wood industries, formaldehyde is present during composite wood manufacture and in processing/handling of panel boards. It is not present in forestry and sawmilling.

[5] This was due to time and practical constraints of the project. A variation of the contract was agreed.

Preliminary considerations

Origins of exposure data

There appears to be several reasons for quantitatively measuring and documenting exposure including:

> Regulatory requirements;
> Research;
> Company policy;
> Health, compensation or complaint investigation.

Thus, the sources of direct exposure and control information include:

> Regulatory agencies;
> Research groups;
> Industry (or government if the workplace is a government facility, school etc.);
> Occupational hygiene consulting companies (typically acting on behalf of industry).

Assumptions and definitions

Definition of “wood industries”

We assume that wood industries comprise those industries or activities where natural wood is processed, rather than grown. Thus, it includes wood working, but excludes forestry and tree felling.

Also included is the manufacture and use of composite woods, such as MDF and particleboard.

However, due to the diversity of end uses, many domestic, hobby or construction-related exposure scenarios are not covered in this report, e.g. wooden floor sanding.

Appropriate measures of exposure

In gross terms, and for the purposes of this report, exposure is based on proximity to sources, time spent near sources, and the presence of physical barriers.

In the context of a wood product manufacturing environment:

> *Exposed* – production staff and production supervisors, cleaners;
> *Partially exposed* – those in enclosed offices within a production area, or other staff with significant interaction with production activities (e.g. maintenance staff, quality control staff);
> *Unexposed* – those in office areas, enclosed and physically separated from production areas.

The likelihood of health effects due to wood dust and formaldehyde are best estimated by personal exposure measurements, rather than fixed position (static) measurements. The contributors to personal exposure are (1) locally generated contamination, e.g. by operating a hand held sander; and (2) ambient contamination, e.g. arising from background or nearby activities. Although (1) is typically dominant, there may be contributions by (2).

In the case of the inhalation of wood dust, the most appropriate measure is the “inhalable” dust fraction. In the case of formaldehyde, any specific measurement of the gas is appropriate, although the actual formaldehyde intake due to reconstituted wood containing formaldehyde-based resin may be somewhat higher as a result of hydrolysis of inhaled particles in the respiratory tract (Pisaniello et al, 1991)

Notwithstanding the above, there is the potential for exposure via skin or eye contact or via ingestion. These routes of exposure are significant for health effects such as dermatitis, but were considered to be outside the scope of this report.[6]

Best practice measurement methods for assessment of inhalational exposure

Airborne wood dust

The current Australian Occupational Exposure Standard for wood dust is:

> Wood dust (certain hardwoods such as beech & oak) 1 mg/m3 (8hr TWA);

> Wood dust (softwood) 5 mg/m3 (8hr TWA) 10 mg/m3 (STEL).

Although wood is a complex material, the personal time weighted average (TWA) inhalable dust concentration is currently the best metric for wood dust exposure[7] although there is some debate about the specific

[6] There are no exposure criteria for exposure via the skin, eye or gastrointestinal tract.

[7] For the purpose of any subsequent exposure modeling/model development, it is recommended that consideration be given (where possible) to the following:

> Fixed position air concentrations, provided these give an insight into the background contaminant levels, propagation characteristics, and spatial distribution.

> Particle size distributions related to process/wood type and other features.

> Type of wood (botanical classification or other descriptor)

> Origin of wood (affecting volatile organics, crystalline silica, tannin content etc.)

> Dryness of wood

> Treatment chemicals (if treated timber)

details of sampling devices[8]. Only measurements done in accordance with Australian Standard 3640 – 2004 (or equivalent)[9] should be incorporated into an exposure data set. The personal inhalable dust fraction corresponds to the size fraction specified in the Australian Occupational Exposure Standard for wood dust, and is relevant in a toxicological sense since it applies to health effects in both the lower and upper respiratory tract. Wood dust can induce effects in all parts of the respiratory tract.

Reconstituted wood (e.g. MDF and chipboard) is most often composed of softwood, in which case the applicable exposure standard is 5 mg/m3 of inhalable dust[10]. The sampling periods should be representative of the task/product/context (e.g. a representative time period for belt sanding of solid softwood timber in an enclosed workshop area)

Where there is potential for high exposure to softwood dust for brief periods, short term monitoring is relevant. In this case, it is 15-minute TWA or STEL measurements.

In the UK both hardwood and softwood dusts have a Workplace Exposure Limit (WEL) of 5 mg/m3 which must not be exceeded. WELs are limits on concentrations of dust in the air, averaged over 8 hours.

Formaldehyde

The current Australian Occupational Exposure Standard is:

> Formaldehyde TWA: 1 ppm or 1.2 mg/m3 STEL: 2 ppm or 2.5 mg/m3

> Review notice: Reason for review - irritant effects[11].

The personal time weighted average formaldehyde concentration is the best metric for formaldehyde exposure. Where there is potential for high

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> Other wood features (e.g. heartwood, bark etc.)
> Process details (type of machinery)
> Ventilation characteristics
> PPE
> Potential for skin and eye exposure
> Potential for product decomposition (pyrolysis due to excessive heat)

[8] Harper M, Akbar MZ and Andrew ME. Comparison of wood-dust aerosol size-distributions collected by air samplers. J. Env Mon. 6, 18-22 (2004)

[9] *Workplace Atmospheres - Method for the sampling and gravimetric determination of inhalable dust*. AS 3640 – 2004, Standards Australia, Sydney. The previous version of AS 3640 recommended the same types of sampling heads and flow rate for inspirable (inhalable) dust, thus data are comparable

[10] Plywood could be hardwood and softwood, which may complicate the interpretation of exposure standards.

[11] NICCAS (2006) has recommended that the occupational exposure standard for formaldehyde be lowered to 0.3 ppm 8h TWA and 0.6 ppm STEL.

exposure for brief periods, short term monitoring is relevant. In this case, it is 15-minute TWA STEL measurements.

One could consider a variety of sampling approaches (active and passive sampling, direct reading electronic instrument or short term detector tube) provided that the measurement is conducted in accordance with conventional occupational hygiene procedures and is representative of the task/product/context. Peak exposure monitoring (grab sampling) and fixed position monitoring may be acceptable provided the sampling strategy is well documented and the process/context/work activity pattern is consistent.

The quality of the data may be classified, so that an active sampling procedure in accordance with US NIOSH 2016, US OSHA 64 or a passive procedure such as UK HSE MDHS 78[12], with 2,4 –dinitrophenyl hydrazine and HPLC, or equivalent, would be considered as a gold standard measurement.

Quality

Quantitative measurements of exposure are usually carried out by professional hygienists. In this project, we examined available reports and made a judgement as to whether the work was done according to recognised methods. In general, work published in refereed scientific journals or presented at the AIOH Conference would be considered acceptable quality.

Formaldehyde measurements with short term detector tubes would not normally be considered acceptable, as the sensitivity is relatively low and there may be interfering compounds.

National Association of Testing Authorities (NATA) accreditation of the analytical laboratory is desirable[13] – but not essential, for example in the case of a research laboratory which has documented quality control procedures and which has published relevant results in the international peer-reviewed scientific literature.

Feasibility and issues of representativeness

This project was not designed to capture completely new data in a national profile and compare with a previous profile, as in the UK HSE surveys of 1989 and 1999 (UK HSL 2000). Rather it was to capture existing Australian data (mostly within the last 15 years), and to assess

[12] http://www.hse.gov.uk/pubns/mdhs/pdfs/mdhs78.pdf
[13] See the AIOH website for details (http://www.aioh.org.au/provider_lab.asp)

the adequacy of this method with additional measurements, in order to test the concept as to whether the use of existing data sources could simplify hazard exposure surveillance. Furthermore, the study was limited to responses received and information gathered in a defined data collection period (first 6 months of 2007).

As with much occupational hygiene work, it is often not feasible to sample large numbers of small businesses, especially in remote sites (or mobile small businesses), private residences or sample in conditions with a high degree of ambient variability (i.e. outdoor sites). Put another way, the vast majority of exposure data pertain to fixed, sheltered workplaces. In addition, sampling is typically only conducted in volunteer companies, which may represent the better performing fraction.

On the other hand, sampling is normally done under worst case conditions, with a limited section of the company workforce. Maintenance work (including cleaning), and work at odd times is often not assessed. Finally, workers may wear PPE which will influence the biologically relevant exposure, but also might influence exposure avoidance behaviour, body orientation relative to source etc. In the case of wood dust, the relatively coarse particulate and inertial forces from woodworking may be associated with highly directional (localised) exposures and breathing zone variability. This is evident visually and from deposition patterns.

For these reasons, routine occupational hygiene measurements often have significant limitations for epidemiological purposes. However, repeated measurements under the same conditions over a period of time will indicate whether exposures (and presumably health risk) have changed[14].

Furthermore, due to the similarity of equipment and the economic environment, it is likely that indoor wood working exposure profile in one Australian state will be similar to another Australian state. Similarly, the proportion of exposed workers and the relative number of woodworking SMEs is likely to be similar.

Ethical clearance

No ethical clearances were sought or required for this project. The information in this report is provided in aggregated anonymous format. The field work involved observations of workers undertaking their normal

[14] It has been noted that studies of exposures in wooden furniture industries in Australia, UK, Europe and the US have generally shown similar results, when examined from a process/task perspective (Jones and Smith 1986; Pisaniello et al, 1991)

duties. No personal data were collected. Participating individuals and companies were advised of the purpose of the project and site-specific results have been provided to participating companies.

Data was de-identified and kept in locked premises, or on computers requiring password access. Only members of the project team had access to raw data.

Exclusions

As already mentioned, many domestic, hobby or construction-related exposure scenarios are not covered in this report.

The following were excluded from new sampling, but otherwise assessed where information was available:

- Timber treatment facilities (e.g. CCA, creosote, bifenthrin, pentachlorophenol), as the health effects may be more or less determined by the specific treatment chemical;
- Warehousing and retail sale of timber, as sawing to customer-desired length is probably a marginal exposure;
- On site construction (reasons as above, but also including timber floor sanding, renovations etc.);
- Wooden pallet-making and repair (due the variable contamination on pallets);
- Small craft workshops, as variability is likely to be very large;
- TAFE, secondary and primary school woodworking facilities (due to highly variable exposure and non-routine training aspects of such exposure, i.e. unlike workplace exposures);
- Small business operations, particularly in non-metropolitan areas (due to logistic reasons, likely lack of data, likely lack of access to the workplace, and highly variable workplace layouts and exposure profiles)[15];
- Specialised small woodworking workshops associated with larger industries, e.g. foundry patternmaking.

[15] Small business operations being less than 20 employees.

Chapter 2: Methodology

Overview

Several approaches were used to address the research questions posed by the Office of the ASCC including:

- analysis of online Yellow Pages® listings relevant to the wood industry in Australia;
- telephone interviews with a sample of listed companies in South Australia;
- analysis of recently published Australian Bureau of Statistics data;
- written requests for information from government agencies, industry, consultants etc;
- professional interpretation of reports by occupational hygienists;
- review of published occupational exposure data for Australia, including AIOH Conference Proceedings (1982 -2006);
- new measurements during the period January – May 2007.
-

This led to a compilation of the following categories of information:

- An exposure/control database for wood dust and formaldehyde in Australian wood industries, based on data acquired from various sources, including new measurements;
- A description of responses received from the requests for information, providing a picture of the availability and accessibility of data;
- Categories of the wood industries, as determined from Yellow Pages® listings and ABS information.

Classification of wood industries (processes), tasks, woods, controls

Neither an Exposure Template nor a Data Dictionary was available at the time of preparation of this report.

However, in order to provide a structure for certain key variables, we have classified industries, types of woods, tasks and controls as follows:

Classification of wood industries (An occupational hygiene scheme)[16]

1 Forestry

- 1.1 forest planting
- 1.2 forest maintenance
- 1.3 timber felling
- 1.4 other

2 Sawmilling

- 2.1 green sawmill – cutting, debarking
- 2.2 dry sawmill – cutting, kiln drying
- 2.3 other

3 Wood product raw materials manufacturing

- 3.1 MDF manufacture
- 3.2 Chipboard manufacture
- 3.3 plywood manufacture
- 3.4 other

4 Timber treatment

- 4.1 CCA
- 4.2 creosote
- 4.3 penchlorophenol
- 4.4 bifenthrin
- 4.5 other

5 Wood product manufacturing

- 5.1 cabinet making and joinery – kitchen manufacturing
- 5.2 furniture manufacturing
- 5.3 wooden toy making
- 5.4 foundry patternmaking

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[16] the numerical values are arbitrary

5.5 coffin making

5.6 pallet making

5.7 paper manufacture

5.8 boat making

5.9 other

6 Educational woodworking – TAFE and school

7 Woodworking in construction industries

7.1 carpentry

7.2 flooring

7.3 other

8 Warehousing and distribution

Domestic, hobby and other end uses

Note that a standardised classification for industries (ANZSIC) is given later. This was used for estimating the size of the workforce, based on ABS data.

Classification of tasks

(adapted from Jones and Smith, 1986)

Sawing:

(circular saws, straight line edgers, dimension saws, band saws)

Cutting:

(planers, thicknessers, moulders, shapers, mortisers, tenoners, spindle moulders, copy lathes, drilling, borers etc)

Sanding (hand):

(paper and block, portable hand sanding machines)

Sanding (machines):

(all sanding machines)

Other tasks:

edge banding

assembly (gluing, hammering, nailing, stapling)

debarking

chipmaking

Classification of woods

Bark

solid softwood timber (other than Western Red Cedar)

Western Red Cedar

solid hardwood timber

impregnated softwood

raw MDF

laminated MDF

raw Chipboard

laminated chipboard

Plywood

other composite

other

Classification of controls

Local exhaust ventilation (LEV)

Canopy or receiving hood – with outside exhaust

Canopy or receiving hood – with indoor bag filter and recirculation

Capture hood – with outside exhaust

Capture hood – with indoor bag filter and recirculation

Capture hood – with integral bag filter and recirculation

Downdraught extraction table – with outside exhaust

Downdraught extraction table – with indoor bag filter and recirculation

Push pull ventilation – with outside exhaust

Push pull ventilation – with indoor bag filter and recirculation

Full enclosure – with outside exhaust

Full enclosure – with indoor bag filter and recirculation

Other form of LEV

Dilution Ventilation (mechanical)

Evaporative cooling system

Pedestal fans

General Ventilation (no mechanical ventilation of work area)

Other forms of ventilation

Personal Protection

Half face disposable respirator

Air supplied respirator

Other forms of RPE

Gloves

Overalls

Eye protection

Other forms of PPE

Work Practices

Use of compressed air for cleaning equipment and/or clothing

Use of dry sweeping

Wet sweeping

Use of vacuum systems for cleaning

Other work practices

Industry Classifications

The following industry (ANZSIC) classifications were thought to be relevant to this project. They were taken from ABS Report 2004 – 05 8221.0 December 2006.[17]

23 Wood and paper product manufacturing

231 Log sawmilling and timber dressing

2311 Log sawmilling[18]

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[17] This publication presents estimates, from the annual Economic Activity Survey, of the economic and financial performance of the Australian manufacturing industry for 2004–05

[18] This class consists of units mainly engaged in producing rough sawn timber, sleepers, palings, scantlings, etc., resawn timber from logs sawn at the same units. This class also includes chemical preservation of rough timber or logs produced in the same unit. *Exclusions / References* Units mainly engaged in (a)

2312 Wood chipping[19]

2313 Timber resawing and dressing[20]

232 Other wood product mfg

2321 Plywood and veneer mfg[21]

2322 Fabricated wood mfg[22]

2323 Wooden structural component mfg[23]

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hewing or rough shaping mine timbers, posts, railway sleepers, etc., or cutting firewood in forests are included in Class 0302 Logging; (b) manufacturing softwood or hardwood woodchips are included in Class 2312 Wood Chipping; (c) kiln drying or seasoning timber are included in Class 2313 Timber Resawing and Dressing; (d) chemically preserving timber from purchased or transferred in as logs or sawn timber or in producing timber shingles are included in Class 2329 Wood Product Mfg not elsewhere classified (n.e.c.); and (e) both cutting and retailing firewood are included in Class 5259 Retailing n.e.c. *Primary Activities* Bark, ground, mfg; Shook mfg (for containers); Timber, resawn, mfg (from logs sawn at the same unit); Timber, rough sawn, mfg

[19] This class consists of units mainly engaged in manufacturing softwood and hardwood woodchips. *Primary Activities* Hardwood woodchip mfg; Softwood woodchip mfg

[20] This class consists of units mainly engaged in producing dressed timber such as floorboards, weatherboards or mouldings, resawn timber from timber already sawn at other units, or in kiln drying or seasoning timber. *Exclusions / References* Units mainly engaged in chemically preserving timber from purchased or transferred in logs or sawn timber are included in Class 2329 Wood Product Mfg n.e.c. *Primary Activities* Building timber, dressed, mfg; Dressed timber or mouldings mfg; Dressed timber, kiln dried or seasoned, mfg

[21] This class consists of units mainly engaged in manufacturing plywood and veneers. *Primary Activities* Cores, plywood or veneer mill, mfg; Plywood mfg; Veneer or veneer sheets, wooden, mfg.

[22] This class consists of units mainly engaged in manufacturing particle boards, chip boards, other fabricated boards of wood, or laminations of timber and non-timber materials (including decorative plastic laminates on boards or other substrates). *Primary Activities* Cellular wood panels mfg (except doors); Chip board mfg; Corestock mfg; Fabricated boards, wooden, mfg; Hardboard mfg; Particle board mfg; Resin-bonded board mfg (of wood chips, wood particles, wood wool or sawdust); Softboard mfg

[23] This class consists of units mainly engaged in manufacturing wooden structural fittings, wooden components for prefabricated wooden buildings, wooden or wooden framed doors or wooden roof trusses or wall frames or shop fronts, etc. (from standard wooden components or from wooden components manufactured at the same unit) or wooden joinery n.e.c. This class also includes units mainly engaged in installing (except on-site fabrication) shop fronts made of wood, or joinery (including custom made prefabricated built-in furniture). *Exclusions / References* Units mainly engaged in (a) manufacturing corestock (for sale or transfer out as such) are included in Class 2322 Fabricated Wood Mfg; (b)

2329 Wood product mfg not elsewhere classified (n.e.c).[24]

29 Other manufacturing

292 Furniture mfg

2921 Wooden furniture and upholstered seat mfg[25]

Telephone survey

Relevant businesses where workers were likely to be exposed to wood dust and formaldehyde were selected from categories in the on-line Yellow Pages® for South Australia.

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manufacturing wooden furniture (except custom made built-in furniture) are included in Class 2921 Wooden Furniture and Upholstered Seat Mfg; and (c) on-site fabrication of built-in furniture or other joinery are included in the appropriate classes in Division E Construction. *Primary Activities* Door-window unit, wooden, mfg; Door, wooden or wooden framed, mfg (except fire doors); Roof truss, wooden, mfg; Structural fitting, wooden, mfg; Wall frame, wooden, mfg; Wooden framed window mfg, complete with glass

[24] This class consists of units mainly engaged in manufacturing wooden containers, pallets or packing cases, or articles of cork, or wood, bamboo or cane products, n.e.c. (including turned wood products, ornamental woodwork, wooden picture or mirror frames or parquet strips assembled into panels). This class also includes units mainly engaged in chemically preserving timber from purchased or transferred in logs or sawn timber. *Exclusions / References* Units mainly engaged in manufacturing shooks for containers are included in Class 2311 Log Sawmilling. *Primary Activities* Barrel, wooden, mfg; Cask, wooden, mfg; Cork or cork good, mfg; Frame, wooden picture or mirror, mfg; Packing case, wooden, mfg; Parquet strip assembled in panel mfg; Tool handle, wooden, mfg; Vat, wooden, mfg; Wood flour or wool mfg; Wood products mfg n.e.c.

[25] This Class consists of units mainly engaged in manufacturing furniture of wood or predominantly of wood (except custom made built-in furniture or furniture for medical, surgical, etc. purposes), complete upholstered seating with wooden or metal frames (including seats convertible into beds) or in upholstering, re-upholstering or french polishing of furniture. This Class includes units mainly engaged in manufacturing upholstered seats for transport equipment. *Exclusions / References* Units mainly engaged in (a) manufacturing custom made built-in furniture or installing (except on-site fabrication) shop fronts made of wood or joinery n.e.c. are included in Class 2323 Wooden Structural Component Mfg; (b) manufacturing furniture predominantly of sheet metal are included in Class 2922 Sheet Metal Furniture Mfg; and (c) manufacturing furniture of material other than wood or sheet metal are included in Class 2929 Furniture Mfg n.e.c.. *Primary Activities* Bedroom suite, wooden, mfg; Chair mfg (except dentists' chairs fitted with mechanical device); Dining room furniture, wooden, mfg; Kitchen furniture, wooden mfg; Lounge suite mfg; Office furniture, wooden, mfg; Outdoor furniture, wooden, mfg; Prefabricated furniture, wooden, mfg; Seats, upholstered, mfg; Tables, wooden, mfg; Upholstered furniture mfg

- Kitchen Renovations
- Cabinet Makers
- Wood Windows
- Wood Floors
- Carpenters and Joiners
- Veneers

These were then contacted by telephone, using a pseudo random sampling strategy (stratified in alphabetical groups). If the business responded positively with respect to processing wood, they were then briefly asked for the following information:

- The total number of personnel in the business
- The number of employees processing wood/exposed to wood dust
- The types of wood they used, simplified into the categories;
- - hardwood, softwood, MDF, chip/particle board and treated timber

If there was no telephone response after 12 rings, no further pursuit of that business was undertaken. If there was a message bank, a message to return the call with a brief explanation of the information required was left. If the number was engaged, a later call was undertaken and if again engaged, there was no follow up call.

Relevant listings from other Australian states were also analysed, but companies were not telephoned.

Stakeholder engagement

The following stakeholders were contacted by e-mail, fax and/or telephone:

- Relevant government OHS agency contacts in each Australian jurisdiction
- Australian Chamber of Commerce and Industry
- Australian Council of Trade Unions
- Furnishing Industry Association of Australia
- Engineered Wood Products Association of Australasia
- Window and Door Industry Council Inc.
- National Association of Forest Industries
- Commercial Furniture Industry Association of Australia Ltd
- Australian Wood Panels Association Incorporated
- Timber Merchants Association
- Master Builders Association of Victoria

- AIOH Consultants who were listed as providing dust monitoring services[26]
- A range of major wood industry manufacturers
- Relevant researchers

Appendix 1 is a sample letter sent to government OHS agency contacts.

[26] This service is very common amongst hygiene consultants. Permission to contact the consultants was provided by the AIOH Council.

Review of literature and reports

It was beyond the agreed scope of the concept study to undertake a systematic and comprehensive literature review of wood dust and formaldehyde exposure in Australian wood industries.

However, the principal occupational hygiene reports of wood dust and formaldehyde exposure were:

- Amer. Ind. Hyg. Assoc. J. 52, 485-492 (1991) “Wood Dust Exposure During Furniture Manufacture - Results from an Australian Survey and Considerations for TLV Development”. By D. L. Pisaniello, K. Connell and L. Muriale.
- J. Occup. Med. 34, 788-792 (1992) “Occupational Wood Dust Exposures, Lifestyle Variables and Respiratory Symptoms”, By D. L. Pisaniello, M. Tkaczuk and N. Owen.
- Aust. J. Otolaryngol. 2, 137-141 (1995) “Nasal Cytology in Australian Furniture Woodworkers”. By D.L. Pisaniello, M. Tkaczuk, R. Gun, M. Schultz and M. Stevens.
- Amer Ind Hyg Assoc J. 60:641–646 (1999) “Dust Exposures in the Wood Processing Industry” By U. Alwis, JM Mandryk, AD Hocking, J. Lee, T Mayhew and T Baker.
- Amer J Ind Med 35, 481-490. (1999) Work-related symptoms and dose-response relationships for personal exposures and pulmonary function among woodworkers” By JM Mandryk, KU Alwis and AD Hocking.
- J. Occup Health Safety – Aust NZ. 15(3) 249 – 252 (1999) Cabinet-makers: exposure to formaldehyde vapours. By P Dingle and P Tapsell.
- Korean Ind. Hyg. Assoc. J. 10 (2) 68-77 (2000) “A Study of Environmental Characteristics and Toxicity from Wood Dust”. By H.L. Park, N.W. Lee, S. B. Kim and D. L. Pisaniello.
- Ann. Occup. Hyg., 44, (4) 281-289 (2000) “Effects of Personal Exposures on Pulmonary Function and Work-related Symptoms Among Sawmill Workers. , JM Mandryk, AD Hocking and KU Alwis.

Relevant journal articles, conference papers, de-identified industry and consultancy reports and other publications, such as the NICNAS PEC Review of Formaldehyde (NICNAS, 2006) were reviewed by one or more occupational hygienists. Decisions were made as to whether:

> The measurements were done in accordance with appropriate occupational hygiene procedures (see Section 1);
> The samples results were discrete (single result) or were aggregate values (i.e. a mean with a range);
> The samples were personal samples or fixed position measurements;
> The samples were specific for a task;
> The results were duplicates, in which case one of the duplicates was excluded.

Development of exposure / control database and justification of variables

As much information as possible was utilised. Where available, data were entered into an Excel spreadsheet in accordance with the following (and previously mentioned) classifications in Tables 1a, b and c. See Appendix 2 for an explanation and justification of database variables. Appendix 3 is the electronic spreadsheet.

Table 1a: Industry/Company Information: key data elements for the development of an exposure/control database

Sample ID Number	Key Data Element
Type of Industry	Primary wood industry, wood product manufacturing etc. ANZSIC code
Type of Products made	Wood panels, furniture etc.
Business Size	Large, medium, small
Location	City metropolitan, country etc.
State (jurisdiction)	
Number of employees	
Number of employees exposed to wood dust	

Table 1b: Process and Sampling Information: key data elements for the development of an exposure/control database

Sample ID Number	Key Data Element
Date of sample collection	dd, mm, yyyy
Process	Wood machining
Task Description	e.g. bandsawing
Task Duration	hours
Daily / Weekly	
Shift Day / Night	
Indoors / Outdoors	
Equipment used	Router, wide belt sander etc.
Type of wood used	Hardwood, softwood, chipboard etc
Exposure duration	minutes
Exposure concentration	mg/m^3 (wood dust) ppm (formaldehyde)
Engineering controls	LEV, dilution ventilation etc.
Type of dust capture system	Bag filter, cyclone
Location of dust collector	Indoors, external
Cleaning method	Sweeping, compressed air, brush, vacuum etc
Type of sampling	Personal or static
Method of sampling formaldehyde	Active or passive
Source of formaldehyde	Resin, chipboard etc.
Source of exposure information	Occupational hygiene consultant report, research study etc

Table 1c: Worker Information: key data elements for the development of an exposure/control database

Sample ID Number	Key Data Element
Gender	Male or female
Age (or age group)	Age, or range (5 or 10 year intervals)
Years of woodworking experience	Years
Eye protection	Safety glasses, goggles, full face shield etc
Respiratory protection	Half face disposable, air fed helmet
Gloves	Rubber, cotton etc.
Other PPE	Apron etc.

Air sampling methodology for new measurements

The overall field sampling approach was similar to that reported by Black et al (2007), i.e. carry out measurements in a representative cross-section of primary and secondary wood industries[27].

Wood Dust

The personal inhalable sampling for wood dust followed the methods described in Australian Standard 3640 – 2004. The personal inhalable dust fraction corresponds to the size fraction specified in the Australian Occupational Exposure Standard for wood dust, and is relevant in a toxicological sense since it applies to health effects in both the lower and upper respiratory tract. Wood dust can induce effects in all parts of the respiratory tract.

This specifically involved personal inhalable wood dust samples being collected using IOM or seven hole dust sampling heads containing pre-weighed 25 mm Pall glass fibre (nominal pore size 1 μm) filters. Inhalable sampling heads were attached to the collars of employees within their breathing zone (within 30cm of their mouth and nose). SKC portable air sampling pumps were used to collect the airborne wood dust samples and the flow rates (set at 2 litres/minute) were checked prior to and at the completion of the sample collection periods using a calibrated rotameter. The sampling period was typically 3 – 8 hours. The filters used were allowed to acclimatise in the laboratory for 24 hours before being weighed and after sample collection they were allowed to acclimatise for a similar period before being re-weighed. The average concentration of wood dust was calculated from the weights obtained and the measured volumes of air sampled with the units given as milligrams per cubic metre (mg/m^3).

Formaldehyde

Both active and passive sampling procedures were employed; the former for shorter sampling periods.

The active sampling procedure followed the following methods, US NIOSH 2016, US OSHA 64 or a passive sampling procedure, UK HSE MDHS 78, with 2,4 –dinitrophenyl hydrazine and HPLC analysis. Passive sampling of formaldehyde has been characterised and found to be accurate and was used. This involved the use of a 2,4 dinitrophenyl hydrazine impregnated silica gel paper fitted into a special sampling cassette. After the samples were collected they were desorbed and analysed by the same method as for the active sampling method.

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[27] Within the constraints of the budget

Active Sampling

For short term exposure measurement, active sampling was carried out using a 2,4 dinitrophenyl hydrazine impregnated 25 mm Pall glass fibre filter. These were housed in Millipore 3 piece-cassettes attached to SKC portable air sampling pumps. The flow rates (1 L/minute) were measured prior to and after sample collection. A blank filter is used as a field blank so that the analysis considers fugitive emissions from all sources during handling of the filters and cassettes. Analysis of the samples was carried by the method described below for the formaldehyde passive diffusion badge.

Passive Sampling

Time weighted average formaldehyde concentrations were measured using passive sampling badges, described by Levin et al (1988), which had acidified 2,4 dinitrophenyl hydrazine impregnated (onto Whatman SG81) silica gel paper as the collection/derivatisation medium. The passive badge has two sections, one section which is not exposed to the atmosphere is used as the blank, and the second section which is exposed to the atmosphere by moving a sliding cover allows the formaldehyde present in the atmosphere to be collected. The effective sampling rate is 25.2 mL/ minute for formaldehyde. The silica gel impregnated paper is removed from the sample holder and cut into two sections, the two sections containing the 2,4 dinitrophenyl hydrazine and hydrazones are separately dissolved in known volumes of acetonitrile before being analysed by a High Pressure Liquid Chromatography system.

High Performance Liquid Chromatography (HPLC)

The system consisted of an ICI Instruments LC 1500 HPLC pump, TC 1900 HPLC Temperature Controller, DP 800 Data Station, Kortec K95 Variable Wavelength UV Detector and a Rheodyne 7125 Injection Valve (20 microlitre sample loop). A 25 cm x 4.6 mm Spherisorb ODS2 (C18) column, at 30C was used.

- Mobile phase: 55% acetonitrile in water
- Flow rate: 1.5 ml/min with helium sparging
- Detector set-up: UV at 360 nm

Statistics

Wood dust exposures, and indeed most occupational hygiene exposures, typically follow a lognormal distribution (Pisaniello et al, 1991), rather than a normal distribution. Results are expressed as arithmetic means, geometric means and medians, with ranges.

Data were entered into Excel spreadsheets, which were also used to generate descriptive statistics.

Chapter 3: Results

Overview

The results are grouped in terms of responses to data requests, the industry profile, exposure profile and detailed summaries of exposure data.

Responses to requests for exposure data

Acknowledgements were received from ACCI and ACTU. Mainstream industry consultation was with Kathryn Walton (ACCI) and Belinda Tran (ACTU). Responses to requests for data were received from a number of industry associations: Furnishing Industry Association of Australia (Paul Bird (General Manager)/Martin Lewis (CEO)); Engineered Wood Products Association of Australasia; Window and Door Industry Council Inc. (Mr James Bradley, Manager); National Association of Forest Industries (Alan Hansard, CEO); Commercial Furniture Industry Association of Australia Ltd (Peter Bishop (Executive Director)); Australian Wood Panels Association Incorporated (Mr Bruce Steenson (General Manager)); Timber Merchants Association (Secretary to Ron Caddy (President)); Master Builders Association of Victoria (Nicholas Grey, OHS Training Officer).

The following results relate to responses received up until the 9th of July 2007.

One industry association provided data, via a consultant. Data were pending from one association, and one was to confirm that there were no data. The others indicated a lack of available data.

Six out of 67 hygiene consultants replied, but only three with exposure data and 5 out of 8 government OHS agencies were able to provide data by the due date. Six weeks was allowed, and one reminder was sent. Duplication of data occurred in one case only. Thus the availability of exposure data from government and consultant sources was relatively poor.

Industry profile

ABS workforce characteristics (ABS, 2006)

Accurate estimates of the workforce size of the wood industry are not available. ABS data for 2004/5 in ANZSIC codes 23 and 29 indicate approximately 100,000 persons of which 10,000 reside in SA, roughly reflecting the population proportion (7.5% for SA in 2004; 1.5 million versus 20.1 million for Australia).

Table 2: Australian wood industry workforce characteristics

Industry Classification	Number of workers - SA	Number of workers - Australia	Percentage in SA	% companies < 100 workers
23 Wood and Paper Product manufacturing	6700	70417	9.5	58
231 Log sawmilling and timber dressing	-	15476	-	-
2311 Log sawmilling	-	7272	-	-
2312 Wood chipping	-	1415	-	-
2313 Timber resawing and dressing	-	6788	-	-
232 Other wood product manufacturing	-	35298	-	-
2321 Plywood and veneer manufacturing	-	1114	-	-
2322 Fabricated wood manufacturing	-	4775	-	-
2323 Wooden structural component manufacturing	-	21192	-	-
2329 Wood product manufacturing not elsewhere classified	-	8216	-	-
29 Other manufacturing	5100	74000	6.9	89
292 Furniture manufacturing	-	-	-	-
2921 Wooden furniture and upholstered seat manufacturing	-	33007	-	-

More precise figures are given in the table below, although there are no SA data in the three and four digit subdivisions. There is some overlap with paper product manufacture.

It is of interest to note that about 60% of companies in the wood and paper product manufacturing category have less than 100 employees[28].

[28] Information from the Plywood Association of Australia (PAA, Engineered Wood Products Association of Australasia) indicates that approximately 500 operative staff work in the processes of glue mixing, glue spreading, panel lay-up and pressing. These workers are potentially exposed to formaldehyde-containing adhesives used in plywood mills. No information is available on the total number of workers handling formaldehyde resins in the manufacture of particleboard and MDF (NICNAS, 2006).

Companies and profiles as gauged by Yellow Pages® listings

These are given below in the table for SA with the number of businesses identified for each category given. Any duplicate listings were removed within the categories.

Table 3: Business types listed for the telephone survey in SA

Business Type	Number
Kitchen Renovations	26
Cabinet Makers	298
Wood Windows	27
Wood Floors	71
Carpenters and Joiners	226
Veneers	2

In total there were 725 businesses listed, with 75 businesses being listed under several categories leaving a final list of 650 businesses. Four hundred and twenty businesses were ultimately contacted by telephone to ask whether they processed wood and generated exposure to wood dust. Two hundred and one positive responses were recorded which is 48 % of the businesses contacted.

Table 4: The number of Yellow Pages-listed business responding by type of business

Business Type	Number
Kitchen Renovations	9
Cabinet makers	108
Wood windows	6
Wooden Floors	15
Carpenters & joiners	63

The other responses given from the 219 businesses where no information was obtained are listed below in Table 5.

Table 5: Unsuccessful contact categories

Category	Number
No response	120
Left message	77
Engaged twice	10
Disconnected/unable to contact	9
Retired	3
Total	219

Demographics

From the table below it can be seen that most businesses which responded were micro businesses with less than 5 employees. According to Alwis et al (1999) the joinery and carpentry industry in Australia consists of small private companies employing an average of 10 employees, processing native timbers and imported timbers as well as reconstituted softwood.

Table 6: The size of businesses that responded by telephone

Employee numbers	Number of businesses	Percentage
Less than 5 employees	135	67%
Greater than or equal to 5 and less than 20 employees	54	27%
Greater than or equal to 20 and less than 100 employees	11	5.5%
Greater than or equal to 100 employees	1	0.5%

Exposure profile as gauged from Yellow Pages® telephone survey

Table 7 gives the total number of employees (including owners and administration staff) from the positive responses and the number exposed to wood dust and formaldehyde. Included in this table is an extrapolation of numbers of workers (excluding construction work) for the whole of SA, assuming a similar distribution with that of non responses that the Yellow Pages® categories covered all relevant wood exposures.

Table 7: Number of employees and workers exposed to wood dust and formaldehyde (from positive responses and extrapolated for SA)

Employees	Number of employees	Percentage of employees exposed to wood dust or formaldehyde
Data for SA from positive responses	-	-
Total number of employees	1265	-
Number exposed to wood dust	937	74%
Number exposed to formaldehyde	757	60%
Extrapolation for whole of SA*	-	-
Extrapolated number of employees	4091*	-
Extrapolated number exposed to wood dust	3030*	-
Extrapolated number exposed to formaldehyde	2448*	-

* assuming similar distribution to positive response group and comprehensive cover of wood exposure work categories[29].

Obviously, there will be an underestimation of total number of employees exposed to wood dust or formaldehyde as all businesses will not be listed in the Yellow Pages® or possibly under a different category than considered.

In the 172 businesses with 10 or less employees, 90% of employees were reportedly exposed to wood dust, while in the 29 business with more than 10 employees, 67% were exposed.

The table below gives the distribution of wood types that employees are exposed to in the businesses that responded to the phone survey. The majority of business (79%) had employees exposed to reconstituted wood and formaldehyde.

[29] Extrapolation calculation was based on total number of business divided by positive response (650/201 x 1265 = 4091); 650 = total number of businesses in Yellow Pages, 201 = total number of business respondents, 1265 = total number of employees

Table 8: Distribution and categories of businesses with respect to use of softwood, hardwood and reconstituted wood

Types of wood/exposure	Number of businesses	Percentage of businesses
Hard, soft & reconstituted wood	73	36
Hard & soft wood only	24	12
Reconstituted wood only	52	26
Soft wood only	14	7
Soft wood & reconstituted wood	30	15
Hard wood only	4	2
Hard wood and reconstituted wood	4	2

Table 9: Comparison of number of businesses listed in Yellow Pages® for all Australian states

Business	Vic	SA	NSW	Qld	WA	Tas
Cabinet Makers	1248	324	668	1008	607	17
Kitchen Renovations	1580	45	2430	1381	486	203
Wood Floors	476	74	747	378	222	44
Carpenters and Joiners	686	232	1368	469	275	61
Wood window	236	35	226	102	24	17
Veneers	80	15	119	68	15	10
Total number	4306	725	5558	3406	1629	352
Estimated businesses removing duplications based on SA* data	3860	650*	4983	3053	1460	316
Estimated number of employees exposed to wood dust extrapolated from SA* data[30]	17994	3030*	23228	14232	6806	1473
Estimated number of employees exposed to formaldehyde extrapolated from SA* data	14537	2448	18766	11498	5499	1190

Table 9 compares all Australian states on the basis of listing and selected relevant categories in all Australian states. Also included in the table is an estimated number of businesses and employees exposed to wood dust

[30] No information on the total number of employees by state (other than that estimated from the SA telephone survey) was available. Information for other states was extrapolated from SA data. Thus for Tasmania with 352 companies listed, it was estimated that 316 would be actual companies (after removing duplications, derived from 650 out of 725 in SA). Then it was assumed that there would be 316/650 x 3030 = 1473 employees exposed to wood dust.

and formaldehyde in Australia using extrapolations based on data obtained in SA. Again, as mentioned earlier for the SA data, there will be an underestimation of total number of employees exposed to wood dust or formaldehyde as all businesses will not be listed in the Yellow Pages® or possibly under a different category than considered.

Throughout the telephone survey, it was noted that mention was made of the dustiness of MDF in particular the toxicity of MDF and the need to wear a mask the banning of MDF overseas and that Australia seemed to be a repository for the continuing use of this wood.[31]

Review of exposure and control data

Table 10 below illustrates the sources of data. Most of the data are from South Australia. The tables following (Tables 11 to 27) illustrate exposure measurements by industry category, type, task, cleaning method, substance and prevalence of LEV by cleaning method.

Table 10: Sources of exposure data

Sources	WA	Qld	TAS	ACT	NSW[32]	VIC	SA	NT
Journal Article (n=7)	1	-	-	-	4	-	2	-
Conference Proceedings Paper (n=5)	1	-	-	-	-	1	3	-
PhD Thesis/Dissertation (n=2)	-	-	1	-	1	-	-	-
Consulting Report (n=19)	-	-	2	-	3	1	13	-
Governmental Report (n=24)	-	16	1	-	1	1	5	-
Industry Report (n=2)	-	-	-	-	-	2	-	-
Research/Other Report (n=18)	-	1	-	-	-	-	17	-
Number of information sources = 77	2	17	4	0	9	5	40	0
Absolute[33] number of measurements = 840	23	80	4	0	88	276	369	0

NB. This table excludes *new* measurements

[31] On the contrary, no such bans have been imposed and MDF is one of the most commonly used wood products in the furniture manufacturing industry in Western Europe and the USA (Australian Wood Panels Association, 2005)
[32] Includes NICNAS PEC report for formaldehyde
[33] Includes all types of measurements (i.e. personal and fixed position measurements, wood dust and formaldehyde, discrete and aggregate values)

Table 11: Number of exposure measurements by industry category and state

Industry category	WA	QLD	TAS	ACT	NSW	VIC	SA
Saw Mills (n=62)	12	3	0	0	43	0	4
Panels/ Particleboards/Plywood (n=283)	0	24	4	0	0	250	5
Timber/Truss (n=36)	0	24	0	0	0	0	12
Frame, blinds, pallet, logging (n=3)	0	0	0	0	0	0	3
Furniture Industry (n=323)	2	0	0	0	0	26	295
Cabinet Making and Joinery (n=118)	7	27	0	0	34	0	50
Others (n=15)	2	2	0	0	11	0	0
Absolute number of measurements = 840	23	80	4	0	88	276	369

Table 12: Number of exposure measurements by wood type and state

Wood type	WA	QLD	TAS	ACT	NSW	VIC	SA
Hardwood (n=199)	16	0	0	0	50	24	109
Softwood (n=87)	0	3	0	0	7	31	46
MDF (n=86)	0	7	0	0	0	75	4
Plywood (n=4)	0	0	0	0	0	1	3
Chip/ Particle Board (n=178)	0	2	0	0	0	106	70
Others (e.g. timber mixture) (n=231)	7	60	0	0	20	39	105
Unknown (n=55)	0	8	4	0	11	0	32
Absolute number of measurements = 840	23	80	4	0	88	276	369

Table 13: Number of exposure measurements by measurement type and state

Measurement type	WA	QLD	TAS	ACT	NSW	VIC	SA
WOOD DUST							
Personal Monitoring (n=553)	12	45	0	0	87	127	282
Static (Area Monitoring) (n=183)	4	3	0	0	1	88	87
	16	48	0	0	88	215	369
FORMALDEHYDE							
Personal Monitoring (n=172)	1	21	4	0	0	104	42
Static (Area Monitoring) (n=97)	6	11	0	0	0	80	0
	7	32	4	0	0	184	42

Table 14: Number of exposure measurements by task and state

Exposure measurements	WA	QLD	TAS	ACT	NSW	VIC	SA
Sawing	11	28	0	0	22	106	105
Sanding	0	3	0	0	12	59	79
Assembling	1	0	1	0	2	0	24
Shaving/planing	0	1	0	0	5	0	3
Glueing	0	1	0	0	0	35	0
Drilling	1	0	0	0	0	0	4
Routing	0	1	0	0	8	40	25
Polishing	0	0	0	0	0	0	0
Edging	1	0	0	0	1	0	18
Boring	0	1	0	0	0	0	14
Nailing	0	0	0	0	0	0	3
Trimming	1	0	0	0	0	0	1
Grading	0	0	0	0	5	0	1
Pressing	0	1	2	0	0	50	0
Debarking/turning	0	0	0	0	2	0	0
Chipping	0	0	0	0	3	2	0
Sorting	0	0	0	0	1	0	0
Moulding	0	0	0	0	5	0	4
Stacking	0	7	0	0	3	0	1
Cleaning	0	0	0	0	0	6	3
Docking	0	0	0	0	2	0	1
Feeding	0	4	1	0	0	0	0
Forming	0	0	0	0	0	39	0
Others*	8	4	0	0	8	31	24
Multi Tasks	0	29	0	0	9	31	101

* Others: quality control, trolley operation, forklift driving, warehouse management, lab analysis, machining, foreman

Table 15: Number of exposure measurements by ventilation and state

Ventilation	WA	QLD	TAS	ACT	NSW	VIC	SA
Local exhaust ventilation	16	30	4	0	56	129	65
Natural ventilation or none specified	7	50	0	0	32	147	304
	23	80	4	0	88	276	369

Table 16: Number of exposure measurements by cleaning method and state

Cleaning method	WA	QLD	TAS	ACT	NSW	VIC	SA
Sweeping	0	0	0	0	5	0	22
Compressed air	0	1	0	0	16	10	206
Vacuum cleaner	0	1	0	0	7	0	0
None specified	23	78	4	0	60	266	141
Total	23	80	4	0	88	276	369

Table 17: Number of exposure measurements by task, measurement type and substance

	Wood Dust Exposure		Formaldehyde Exposure	
Tasks	Personal	Static	Personal	Static
Sawing	167	41	61	3
Sanding	99	27	27	0
Assembling	17	3	8	0
Drilling/Boring	11	4	4	0
Routing/Moulding	46	2	35	0
Others*	87	87	21	85
Multi	126	19	16	9
Total	553	183	172	97

*Others: shaving/planing, glueing, polishing edging, nailing, trimming, grading, pressing, debarking, turning, chipping, sintering, stacking, cleaning, docking, feeding, forming, driving, management, lab work, machining

NB. These data include discrete measurements and aggregate mean values with range.

Table 18: Personal exposures to wood dust by broad industry category

Type	Personal dust exposure (mg/m^3)				
	Sample size	Median	GM	AM	Range
Primary Wood (e.g. sawmills, board manufacture)	84	3.88	4.21	11.7	<0.2-113
Furniture Industry	245	2.1	2.23	5.14	0.1-210.3
Cabinet making	96	4.47	3.7	7.18	<0.3-49.3

NB. These data refer only to discrete measurements and do not include new measurements.

New personal exposures to wood dust by broad industry category are given in the table below. There were 34 measurements.

Table 19: New personal exposures to wood dust by broad industry category

Type	Personal dust exposure (mg/m3)				
	Sample size	Median	GM	AM	Range
Primary Wood (e.g. sawmills, board manufacture)	20	0.53	0.71	1.08	<0.1-4.8
Furniture Industry	9	0.74	0.69	1.52	0.02-7.3
Cabinet making	5	0.83	0.76	0.81	0.38-1.2

The values in Table 19 above are lower than for Table 18. Only one value exceeded 5 mg/m^3.

In Table 20 below, gaseous formaldehyde exposures were 0.1 (median), 0.3 (arithmetic mean) and <0.01 – 11 ppm from 166 discrete measurements, with a breakdown by broad industry category.

Table 20: Personal exposures to formaldehyde by broad industry category

Type	Personal formaldehyde exposure (ppm)				
	Sample size	Median	GM	AM	Range
Primary Wood (e.g. sawmills, board manufacture)	124	0.1	0.1	0.15	<0.01-0.5
Furniture Industry	42	0.05	0.06	0.38	<0.01-11.5
Cabinet making*	0	-	-	-	-

NB. These data refer only to discrete measurements and do not include new measurements.

*In a Western Australian study of 14 cabinet making establishments in 1991/1992, Dingle and Tapsell (1999) reported a mean personal formaldehyde exposure of 0.1 ppm (maximum of 0.34). No individual data were reported.

It was found that less than 1% (1/166) of formaldehyde exposures exceeded 1 ppm.

In the NICNAS report (2006) results for most long-term personal monitoring in plywood mills were < 0.3 ppm (61/71). No short-term personal monitoring data were provided. It appears that formaldehyde levels are higher at mills using urea formaldehyde resin. In particleboard and MDF mills, limited data showed that most of long-term samples were < 0.3 ppm (5/8 for personal samples). No short-term data were available.

New personal exposures to formaldehyde by broad industry category are given in the table below.

Table 21: New personal exposures to formaldehyde by broad industry category

Type	Personal formaldehyde exposure (ppm)				
	Sample size	Median	GM	AM	Range
Primary Wood (e.g. sawmills, board manufacture)	28	0.1	0.09	0.11	0.01-0.3
Furniture Industry	14	0.07	0.09	0.24	<0.01-1.09
Cabinet making	-	-	-	-	-

Only one measurement exceeded 1 ppm.

Overall, new formaldehyde exposures were 0.1 (median), 0.1 (arithmetic mean) and <0.01 – 1.1 ppm from 42 discrete measurements. Thus, the new measurements are low and similar to previously recorded values.

Personal exposures to wood dust by wood type are given in the table below. There does not seem to be a significant difference between solid hardwood timbers and reconstituted wood in terms of dust exposure. However solid softwood exposures are somewhat lower.

Table 22: Personal exposures to wood dust by wood type

Type		Personal dust exposure (mg/m^3)			
		Sample size	Median	AM	Range
Solid timber	Hardwood	140	2.2	7.0	0.1-210
	Softwood	69	1.3	4.5	<0.2-37.2
Reconstituted wood		119	2.3	6.5	<0.2-113
Mixture		193	2.2	4.9	0.06-49.3

NB. These data refer only to discrete measurements and do not include new measurements

It was found that 72% (101/140) of hardwood dust exposures exceeded 1 mg/m^3, 22%(15/69) of softwood dust exposures exceeded 5 mg/m^3; 28% (33/119) of reconstituted wood dust exposures exceeded 5 mg/m^3, 25% (48/193) of mixed wood exposures exceeded 5 mg/m^3 and 25% of (129/521) of wood dust exposures (overall) exceeded 5 mg/m^3.[34]

New personal exposures to wood dust by wood type are given in Table 23 below.

Table 23: New personal exposures to wood dust by wood type

Type	Personal dust exposure (mg/m^3)			
	Sample size	Median	AM	Range
Solid timber	13	0.5	0.7	<0.1-2.6
Reconstituted wood	14	0.8	1.3	0.02-7.3
Mixture	7	0.8	1.7	0.13-4.8

The new values are generally lower than the earlier data. Only one value exceeded 5 mg/m^3.

Geometric mean personal exposures to wood dust and formaldehyde by task, are given in Table 24 below.

[34] A benchmark of 5 mg/m^3 was selected as mixed wood exposures are common. This is also the limit in the UK.

Table 24: Geometric mean personal exposures to wood dust and formaldehyde by task

	Wood Dust	Formaldehyde
Task	GM (range) (mg/m^3)	GM (range) (ppm)
Sawing	2.0 (<0.2-45.2), n=159	0.2 (<0.01-2.4), n=59
Sanding	**3.96** (<0.2-210), n=95	0.19 (<0.01-12.7), n=27
Assembling	1.26 (0.21-9.4), n=17	0.76 (0.29-1.48), n=8
Shaving/planing	1.8 (0.7-37.2), n=8	
Drilling	1.44 (1.29-1.6), n=2	0.88 (0.88-0.89), n=2
Routing	1.95 (<0.2-25), n=36	0.74 (<0.01-21.8), n=35
Edging	1.8 (0.87-3.3), n=12	0.87 (0.33-1.97), n=5
Boring	2.08 (0.7-7.1), n=9	0.06 (0.06-0.07), n=2
Nailing	1.03 (0.8-1.7), n=3	
Trimming	0.7, n=1	
Grading	0.57 (0.31-0.82), n=5	
Pressing	2.59 (0.35-25), n=9	0.25 (0.07-0.5), n=7
Debarking/turning	22.2 (14.2-34.6), n=2	
Chipping	1.88 (1.08-4.8), n=4	
Sorting	1.6, n=1	
Moulding	2.65 (0.55-50.9), n=8	
Stacking	2.01 (0.46-7.1), n=5	
Cleaning	**3.8** (1.5-14), n=8	
Docking	0.72 (0.54-0.96), n=2	
Feeding	1.43 (1-2.1), n=3	0.44, n=1
Forming	10.25 (2.5-42), n=2	0.22 (0.14-0.34), n=2
Others	1.29 (<0.1-67.4), n=18	0.14, n=1
Multi Tasks	2.39 (<0.3-47.2), n=112	<0.2, n=6; >0.1, n=8; 0.14, n=1

NB. These data refer only to discrete measurements and do not include new measurements

For wood dust, the two highest means (with n>5) was associated with sanding and cleaning.

In the 1999/2000 UK survey, circular sawing, sanding, cleaning and the ‘other’ categories created the highest values across the exposure range (Black *et al*, 2007)

The use of local exhaust ventilation would be expected to reduce dust exposures, and this type of information is often reported in occupational hygiene assessments.[35]

The geometric mean personal exposures to wood dust by wood type and ventilation are given in the table below. It can be seen that exposures are uniformly lower when local exhaust ventilation is documented to be present.

Table 25: Geometric mean personal exposures to wood dust by wood type and ventilation

Types of Wood	Personal dust exposure	(mg/m^3)
	LEV	Natural ventilation or none specified
Hard Wood	1.8 (<0.2-67), n=55	2.93 (0.3-210), n=85
Soft Wood	1.2 (<0.2-17), n=33	2.3 (0.3-37.2), n=36
MDF	0.7 (<0.2-7.1), n=16	4.23 (<0.8-113), n=11
Plywood	0.2, n=1	2.09 (1.09-4.65), n=3
Chipboard/ Particle Board	0.63 (<0.2-3), n=11	3.69 (<0.3-42), n=77
Others (i.e. timber, mixture)	2.1 (0.06-49.3), n=60	2.33 (0.1-40.8), n=100
Uncertain	1.75 (0.28-5), n=9	2.71 (<0.1-40), n=24

NB. These data refer only to discrete measurements and do not include new measurements

In the study by Pisaniello et al (1991), local exhaust ventilation was used widely with fixed woodworking machinery, but was generally lacking for hand tools. The latter was also noted by Alwis et al (1999).

Information from NICNAS (2006) indicates that half the number of companies using formaldehyde resins or products containing formaldehyde resins have local or roof exhaust ventilation in place. Others rely on general ventilation for the control of formaldehyde exposure.

The geometric mean personal exposures to wood dust by wood type and use of compressed air are given in the table below. It can be seen that

[35] Information about control measures (PPE and LEV) and poor work practices (such as the use of compressed air for cleaning) is usually reported, particularly where these factors appear to make a significant impact on exposures. However, systematic documentation of all control measures and work practices, is secondary to exposure assessment, and is often not available in the reports.

exposures are uniformly higher when the use of compressed air is documented.

Table 26: Geometric mean personal exposures to wood dust by wood type and use of compressed air for cleaning

Types of Wood	Personal dust exposure	(mg/m^3)
	Use of compressed air	Not used or not specified
Hard Wood	3.55 (0.1-210), n=59	1.81 (<0.2-67.4), n=80
Soft Wood	3.05 (<0.3-37.2), n=13	1.9 (<0.2-36), n=40
MDF	7.1, n=1	1.31 (<0.2-113), n=26
Plywood	-	1.16 (0.2-4.65), n=4
Chipboard/ Particle Board	3.93 (0.39-42), n=55	1.94 (<0.2-26), n=33
Others (i.e. timber, mixture)	4.03 (0.4-40.79), n=46	1.59 (0.06-31.9), n=100
Uncertain	4.89 (2.4-12.4), n=7	1.93 (<0.1-40), n=26

NB. These data refer only to discrete measurements and do not include new measurements

Information about the prevalence of LEV and the use of compressed air is given in the table below. Unfortunately, comparable data are not available from the existing Australian dataset, as not every record has information about controls and work practices. Similar data from the UK do not seem to be available.

Table 27: The prevalence of LEV and the use of compressed air for new monitoring data

Substance	Number of measurements	Controls and work practices	
		Presence of LEV*	Use of compressed air for cleaning#
Wood Dust	34	19 (56%)	15 (44.%)
Formaldehyde	42	22 (52%)	14 (33%)

*Leads to lower exposures; # leads to higher exposure

More than half of the exposures are associated with the use of LEV. However, the use of compressed air for cleaning of equipment still appears to be common in woodworking.

Use of personal protective equipment

Respiratory protection was relatively uncommon. Approximately 3% of records had information about the use of respirators, and where mentioned, half face respirators were most common.

In the study by Alwis et al (1999), the majority of workers (roughly 90%) did not wear appropriate respirators approved for wood dust, while the ones who did wear them, used them on average less than 50% of the time.

The NICNAS report on formaldehyde (2006) indicated that basic PPE (gloves, safety glasses and clothing) is worn at most sites during handling of formaldehyde resin products. Some reported use of respiratory protection during glue mixing.

Other variables: Gender, age, woodworking experience and company size

Only 253 exposure records had documented the gender of the worker, and these were all male. In the new sampling set, only 2 out of 56 persons were female.

It was not feasible to systematically gather information about age and years of woodworking experience during *new* sampling, but the age profile is assumed to be similar to that published by others (Pisaniello *et al*, 1991, furniture workers mean age of 30 yr, mean experience 12 yr, n=168; Mandryk *et al*, 1999, joinery and sawmill workers mean age of 37, mean experience 11, n=168).

Company size was generally not recorded in the available exposure records. Black *et al* (2007) found no statistically significant relationship between dust exposure and company size. In their survey, 80% of sites employed fewer than 25 exposed workers and 89% less than 50.

Chapter 4: Discussion

Profile of wood dust exposures

In this study, the majority of reported hardwood dust exposures (72%) and a minority of softwood (22%) and reconstituted (28%) wood dust exposures exceeded the relevant standards. One quarter of all personal exposures exceeded 5 mg/m^3.

The ensemble of Australian data is similar to that for the UK (Black et al, 2007), where 27% of measurements (particularly sanding and circular sawing) exceeded the UK limit of 5 mg/m^3.

In the NSW study by Alwis *et al* (1999), 62% [36] of the exposures exceeded the current Australian standards.

In the study of the SA furniture industry by Pisaniello *et al* (1991), 78% of hardwood and 16% of softwood exposures exceeded the relevant standards.

Although the results for *new* air sampling, and observations in previously monitored workplaces, suggest an improvement, the sample size is too small to be meaningful. The data may reflect lesser usage of solid timbers (where dusty finishing tasks may be important), newer machinery and altered production processes to meet modern market demands. On the basis of ABS and other data, South Australia has a wood industry which appears to be comparable (proportionally) with Australia as a whole.

Few companies now extensively use solid hardwoods, except in door and window frames and specialist furniture manufacturing. This is consistent with the industry trend towards cheaper imported hardwood products, rather than local manufacture.

The observations of multi-tasking and mixed wood exposures raise issues about the applicability of the Australian wood dust exposure limits, especially in furniture and cabinet making, and more specific guidance should be developed for those industries.

The data from this project show that control measures such as LEV are effective, but the use of compressed air rather than vacuum systems exacerbates exposure by resuspending settled dust.

The effectiveness of LEV has been demonstrated in a series of controlled experiments for the Australian Wood Panels Association (2005).

[36] 57% at sawmills and woodchipping, and 71% at the joineries

Profile of formaldehyde exposures

Formaldehyde exposures were low in comparison with the exposure standard of 1 ppm. Theoretically, the highest exposures should occur with wood panel and veneer manufacture - the concentrations of free formaldehyde in the resins used in the particle board and fibreboard manufacturing industry range from < 0.2% to 0.5%. Formaldehyde resins containing < 0.2% to up to 5% free formaldehyde are used in the manufacture of plywood and associated structural veneer based products, such as laminated veneer lumber (LVL). However, it appears that these exposures are well controlled. NICNAS (2006) has reported "Limited monitoring data indicate that formaldehyde levels at the majority of workplaces are < 0.2 ppm."

Apart from gaseous exposure, there is the potential for some additional exposure (roughly 5 micrograms per milligram of inhaled reconstituted wood dust) associated with the inhalation of particles containing formaldehyde-based resin (Pisaniello *et al*, 1991; SA Department for Industrial Affairs, 1995). This is thought to be minimal (Australian Wood Panels Association, 2005).

Factors influencing variability of data

The wide range of personal exposures, spanning three orders of magnitude, is attributable to a host of factors including the type of wood processing activity, the availability and effectiveness of local exhaust ventilation and work practices, particularly cleanup and housekeeping procedures. In the case of wood dust, the relatively coarse particulate and inertial forces from woodworking may be associated with highly directional (localized) exposures and breathing zone variability[37]. This is evident visually and from deposition patterns.

According to Alwis *et al* (1999), the significant determinants of personal wood dust exposures were found to be local exhaust ventilation, job title, use of handheld tools, cleaning method used, use of compressed air, and green or dry wood processed. The type of wood processed (softwood or hardwood) was not found to be statistically significant. The 1999/200 UK survey reported by Black *et al* (2007) did not identify significant differences in exposure to softwood dust compared to composite wood dust. It was also unable to show quantitative differences between the amounts of dust generated by machining hardwoods and other types of wood. There is some suggestion that the use of MDF leads to greater levels of fine dust, although the evidence is mixed, depending on the

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[37] Hinds WC. Basis for particle size-selective sampling for wood dust. *Appl Ind Hyg* 3(3) 67-72 (1988)

process. Chung *et al* (2000) have reported that sanding MDF produced more dust than sanding pine or oak although there were no significant differences due to sawing.

The results of a study for the Australian Wood Panels Association (2005) demonstrated that there is no significant difference in the quantity of dust generated, and the morphology of dust, from cutting of MDF when compared with softwood, hardwood or other reconstituted fibreboard (particleboard). The results also confirm that the sanding operation produces a much larger quantity of airborne dust for MDF compared with the other timbers tested.

Mikkelsen et al. (2002) have listed influences in the Danish furniture industry where exposures were well controlled.

To further emphasise this issue, variations in exposure for a particular task such as cutting timber with a power saw may be due to:

- work practices of the individual carrying out the task
- the type of saw being used
- how sharp the saw is
- the type of timber being used
- the quantity of timber being cut over a given amount of time
- the effectiveness of local exhaust ventilation
- the effects of general dilution ventilation
- the location of dust collection bags relative to the cutting process
- the effects of cleaning surfaces with compressed air to generate airborne wood dust

For a sanding process, the amount of wood dust generated during sanding will depend, amongst other things, on:

- the properties of the wood such as hardness and density
- the properties of the abrasive used, the grade and how long it has been used
- the surface area that the abrasive contacts the wood
- the degree of force being applied, and
- the effectiveness of any exhaust ventilation used during the sanding.

Furthermore, in small businesses most employees are multi-tasking so that the exposure measured for an individual over an average workday will depend on which day the monitoring was carried out on as the tasks allocated for a particular day may be different each day. For example, an employee may spend the first day measuring out the wood to be cut, then cutting the wood, then preparing joints using a borer, cutting profiles using a router, then sanding the wood, followed by spray application of a coating of paint or clear coat. The painted wood would be allowed to dry, then sanding the coated wood, then a final top coat of colour or clear coat before assembly and installation at a location outside of the workplace.

There is the same type of issue in larger companies, where only a few individuals may spend time carrying out one task for an 8 hour day. During the new measurements, most of the employees were observed to carry out several tasks, with one task occupying between 60 to 80% of the work day while production demands meant other tasks were also carried out and this mix of tasks varied each day depending on who was at the workplace. Even in assembly stages the products being made varied in size and complexity and the use of compressed air to clean products was variable.

It is clear that there will be significant between-worker and between-day variability, and the (typically) single 8-hour TWA measurement for a worker only tells part of the story.

Thus the required elements of an exposure profile for health hazard surveillance should reflect, amongst other things, the various factors influencing exposure, as well as basic characteristics of those exposed.

At the industry level, the issues of between-worker and between-day variability are resolved by a multitude of measurements. The targeted sampling by UK HSL in their 1999/2000 survey yielded 406 samples, with 102 being classified as multi-tasking. A total of 46 workplaces were sampled[38], as described below (Black et al, 2007):

Table 28: Distribution of samples by industry classification – 1999/2000 UK survey

Table 1. Distribution of samples by numbers of employees exposed, SIC and number of sites visited

SIC	Description	Number of sites visited	Numbers of employees exposed				Total
			1–9	10–24	25–49	50+	
			Numbers of samples collected				
20 100	Sawmilling and planing of wood	7	7	32	17	11	67
20 300	Manufacture of builder's carpentry and joinery	15	32	32	42	0	106
20 400	Manufacture of wooden containers	2	0	14	0	0	14
20 510	Manufacture of other products of wood	3	10	0	0	14	24
36 110–36 140	Manufacture of furniture	19	39	108	0	48	195
Total		46	88	186	59	73	406

Forestry, logging, shipbuilding etc were not included, but estimates have been provided by modelling.

[38] The original report (UK HSL, 2000) referred to 47 sites and 386 samples.

It is not clear from the literature how many measurements, and how many workplaces are required for a proper industry exposure profile. A practical target may be 100 workplaces and 1000 measurements. This is based on sampling in several different industry categories (e.g. primary wood industry, furniture industry etc), and approximately 20 workplaces in each category (to cover large, medium and small companies, and across regions). About 10 measurements, across a variety of tasks, in each company would seem necessary. The number and distribution of workplaces are important, but the spread of processes and tasks is also relevant.

Availability of data

The availability of exposure data from government and consultant sources was relatively poor and variable. It appears likely that wood dust sampling is rarely undertaken (compared with noise monitoring), but it is also possible that scientific reports and data are not readily available for reasons of commercial confidentiality or judged by providers not to be a form that can be included in a systematic exposure database. In any case, the available exposure data were often the result of research projects, carried out from 1989 to 1999.

Options for future data collection

It is tempting to draw the conclusion that targeted survey work, as in the UK, is a more reliable strategy for profile development and trend assessment, than compilation and review of existing data. It allows for much more controlled and comprehensive evaluations, e.g. assessment of regulatory compliance, training, control measures etc.

A third approach, based on modelling exposure from international data compilations may also be a cost-effective option under certain circumstances. In this case, an exposure "band" would be derived from the input variables of wood type, process, control measures and work practice information. Thus, a solid timber sawing operation with LEV, and vacuum cleaning would have an associated exposure band which is different from a sanding operation with no LEV and uses compressed air for cleaning.

Table 29: Comparison of three approaches to obtaining exposure data for hazard surveillance

	Compilation and review of existing data	Purposive survey	Modelling
Advantages	Relatively cheap Can consider a wide variety of situations and perspectives Screening/review of information by hygienists can yield useful information	Can be properly designed and controlled Can gather information for SMEs (with some effort) Repeat surveys can be used to assess trends	Cheap Flexible - can be easily used at the task level
Disadvantages	No guarantee of consistency, i.e. many information gaps Relies on the cooperation of companies, consultants etc, Not easy to obtain data for SMEs, i.e. selection bias	Relatively expensive Essentially a snapshot	Relies on the availability of data for many input parameters Should be validated with empirical data Likely to yield "bands"

Best practice control measures

Wood dust

Best practice control measures for wood dust include local exhaust ventilation, notably integral extraction for hand tools, vacuum cleaning methods rather than compressed air or sweeping, isolation of dusty processes, external exhaust rather than recirculation through sock filters, separately enclosed areas for workers, and provision of overhead filtered air supply[39] or air fed masks for non-mobile workers.

The UK HSE[40] has provided the following advice:

[39] Overhead air supply island (OASIS). One of the main advantages of the OASIS is that it is suspended over the worker and operates independently of any processing equipment. An example is described in Cecala, AB., Timko, RJJ. and Thimons, ED. , (2000) 'Methods to Lower the Dust Exposure of Bag Machine Operators and Bag Stackers', *Appl Occup Env Hyg*, 15:10, 751 – 765.

[40] http://www.hse.gov.uk/woodworking/dust.htm

> Provide local exhaust ventilation at woodworking machines
> Keep the extraction and collection system maintained to make sure it continues to work efficiently
> Use a vacuum system to clear up wood dust – either a free standing vacuum cleaner or preferably a vacuum pipe attached to the extraction system. Vacuum cleaners should be suitable and have a HEPA filter
> For particularly dusty tasks such as sanding use RPE as well as LEV

Mikkelsen *et al* (2002) have proposed the following preventive measures:

> Automate woodworking machines/processes, in particular when manual sanding is included
> Ensure effective local exhaust ventilation at all woodworking machines
> Balance general or local ventilation by the intake of supplementary fresh air
> Clean production areas daily, preferably by professionals
> Do not use compressed air for cleaning machines or workpieces. Use a vacuum system.
> Clean workpieces finally by brush

The Australian Wood Panels Association has produced a wood dust hazard control video and published it on their website (http://www.woodpanels.org.au). This video includes many of the control systems mentioned above.

Formaldehyde

In the case of formaldehyde, the conventional hazard control hierarchy is appropriate. Full enclosure and push-pull ventilation systems can often be incorporated in reconstituted wood production processes.

Chapter 5: Conclusions and Suggestions

Conclusions

Accurate estimates of the size of the workforce in the Australian wood industries are not available. ABS data for 2004/5 in ANZSIC codes 23 and 29 indicate approximately 100,000 persons. The SA workforce data appear to be representative of the national industry, on a general population basis.

A telephone survey involving 201 businesses listed in the South Australia Yellow Pages® under likely wood industries suggested a total of around 4,000 employees mostly in companies of less than 20 persons. Of these 3,000 were reportedly exposed to wood dust, and 2,500 exposed to formaldehyde. Smaller companies, with few dedicated administrative staff, will have a greater percentage of staff exposed to wood dust and formaldehyde, and as they represent the majority of companies, it is likely that most of the workforce in the wood industries are exposed to airborne wood dust and formaldehyde. The South Australia survey suggests 74% exposed to wood dust and 60% exposed to formaldehyde.

Given the diversity of the wood industry, wood processes/users and the nature of wood (natural, reconstituted, impregnated etc.) the construction of a systematic wood dust exposure/control profile is problematic. It is evident that there are many variables, and considerable variability.

Thus, there is a need for a well-defined classification scheme, consistency in methodology and large numbers of measurements across a broad cross-section of the industry. Only some of these criteria are met by compiling and reviewing existing data. This approach, although relatively cheap may suffer from poor response to requests for information, a distorted dataset arising from idiosyncratic research interests and inspectorate activity and difficulties/ambiguities in interpretation of reports. Targeted sampling is more expensive but is more reliable and appears to be feasible based on the UK experience.

Unlike formaldehyde, the Australian wood dust exposure limits are often exceeded, especially for hardwoods, and for certain activities such as sanding and cleaning. However, recently collected data from a small targeted survey in South Australia indicate lower exposures, consistent with modern machinery and changes to wood products in favour of reconstituted wood panels requiring fewer dusty finishing tasks. The high prevalence of multi-tasking and mixed wood exposures coupled with the significant difference in hardwood and softwood exposure limits, makes the interpretation of compliance awkward. However, dusty tasks are well known, and more attention needs to be focused on the application of control measures, including changes to work practices.

Suggestions

The following suggestions are made:

> Information on workforce characteristics, exposures, controls and work practices in the Australian wood industry, should be gathered by targeted (purposive) sampling.
> Roughly 1,000 measurements from 100 companies of various sizes, and across the spectrum of wood industries in Australia, would probably be required in order to generate a proper industry exposure profile for wood dust. The total cost of such a survey would be approximately $200,000. Subsequent surveys may require lesser numbers. In the case of formaldehyde, surveys should focus on the manufacture of reconstituted wood products, since exposures in secondary wood industries are low.

> The feasibility of modelling of exposures using existing national and international data should be explored.

> The Australian exposure standards for wood dust should be reviewed in order to better reflect the current situation of multi-tasking and mixed wood exposures.

References

ABS Report 2004 – 05 8221.0 Australian Bureau of Statistics, December 2006

Alwis U, Mandryk JM, Hocking AD, Lee J, Mayhew T and Baker T. Dust Exposures in the Wood Processing Industry. *Amer Ind Hyg Assoc J.* 60:641–646 (1999)

Australian Wood Panels Association (2005) Investigation of wood dust and formaldehyde exposure and airborne particle morphology during cutting, sawing and routing of Medium Density Fibreboard (MDF), Particleboard, Softwood and Hardwood. Available at http://www.woodpanels.org.au/pdfs/AMCOSH_WOOD_DUST_STUDY_FEB05.pdf

Black N, Dilworth M and Summers N. Occupational Exposure to Wood Dust in the British Woodworking Industry in 1999/2000. *Ann. Occup. Hyg.,* 51 (3) 249–260 (2007)

Chung KY, Cuthbert RJ, Revell GS *et al.* A Study of Dust Emission, Particle Size Distribution and Formaldehyde Concentration during Machining of Medium Density Fibreboard. *Ann Occup Hyg*; 44: 455–66 (2000)

Dingle P and Tapsell P. Cabinet-makers: Exposure to Formaldehyde Vapours*. J. Occup Health Safety – Aust NZ.* 15(3) 249 – 252 (1999)

Jones PA and Smith LC. Personal Exposures to Wood Dust of Woodworkers in the Furniture Industry in the High Wycombe Area. A Statistical Comparison of 1983 and 1976/77 Survey Results. *Ann Occup Hyg* 30, 171-184 (1986)

Levin, J., Lindahl, R., and Andersson, K., "High-performance Liquid Chromatographic Determination of Formaldehyde in Air in the ppb and ppm Range Using Diffusive Sampling and Hydrazone Formation," National Institute of Occupational Health, Research Department in Umea, Analytical Chemistry Division, P.B. 6104, S-90006 Umea, Sweden Environmental Technical Letter 9, 1988, pp. 1423-1430.

Mandryk JM, Alwis KU and Hocking AD. Work-Related Symptoms and Dose-Response Relationships For Personal Exposures and Pulmonary Function among Woodworkers. *Amer J Ind Med* 35, 481-490 (1999)

Mikkelsen AB, Schluenssen V, Sigsgaard T *et al*. Determinants of Wood Dust Exposure in the Danish Furniture Industry. *Ann Occup Hyg*; 46, 673–85 (2002)

NICNAS Priority Existing Chemical Assessment Report No. 28 – Formaldehyde. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Ageing, 2006.

Pisaniello DL, Connell K. and Muriale L. Wood Dust Exposure During Furniture Manufacture - Results from an Australian Survey and Considerations for TLV Development. *Amer. Ind. Hyg. Assoc. J.* 52, 485-492 (1991)

SA Department for Industrial Affairs. Workplace Technical Bulletin 1, Formaldehyde Exposure from Gaseous Formaldehyde and from Inhaled Reconstituted Wood Dust in the Furniture Industry. South Australian Department for Industrial Affairs, Occupational Health Division. June 1995

UK HSL. Wood Dust Survey 1999/2000 Final Report, UK Health and Safety Laboratory 2000 URL: http://www.hse.gov.uk/fod/wd9900.pdf

Appendix 1: Sample letter sent to government OHS agency contacts

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Principal Advisor - Occupational Hygiene

Workplace Health and Safety - Queensland

DATE

Dear ___________,

Re: Request for Information on Exposures to Wood Dust and Formaldehyde in Australian Wood Industries

I write in relation to a project being undertaken by the University of Adelaide on behalf of the Australian Safety and Compensation Council.

The project entails the compilation of exposure and control data relating to airborne wood dust and formaldehyde in Australian Wood (and Wood-related) Industries.

The purpose of this project is to test the concept of direct worker exposure measurement, as an approach to data collection within a national framework of occupational disease hazard exposure surveillance.

We are gathering data from a variety of sources including published literature, unpublished reports etc. We are also undertaking measurements *new* where gaps have been identified or are likely.

Some relevant reports may exist in government files, as a result of measurements conducted by government hygienists and inspectors in the last 20 years.

We therefore seek your cooperation in identifying such reports in jurisdictional records. We understand that such records are catalogued and searchable electronically, including searches for files and dockets pertaining to relevant precursor agencies (e.g. Department of Labour).

It is likely that there will be a limited number of such reports, so that a broad search including keywords such as “wood”, “timber”, “cabinet” and “formaldehyde” would be appropriate in the first instance.

We would be grateful if one of your staff could undertake such a search and provide us with a de-identified copy of each report. This will be held in strictest confidence and returned at the end of the project. Alternatively, we can send you a template electronic file, and one of your staff can enter information onto the file. In that case, we would need the email address and other contact details of a relevant scientific officer.

If you have any queries about the request, please do not hesitate to contact either Dr Michael Tkaczuk (______) or Mr Ganyk Jankewicz (_______________). Hardcopy correspondence can be sent to Dr Su Gil Lee, Discipline of Public Health, University of Adelaide, 28 Anderson Street, Thebarton, SA 5031.

Yours sincerely

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A/Prof. Dino Pisaniello

On behalf of the Project Team

Appendix 2: Key data elements required in an exposure database for wood dust and formaldehyde

Sample (or record) ID – a unique sample identification is required so that information can be traced back to the original source and to verify that the information in the data record has been accurately entered. It is the unique identifier for an exposure measurement, although it may refer to simultaneous measurements of wood dust and formaldehyde, for example if a worker is wearing a monitor for wood dust and a monitor for formaldehyde.

INDUSTRY/COMPANY INFORMATION

Type of wood industry – provides a classification of industry, such as sawmill, chipboard manufacture, furniture manufacturing and cabinet making. Some industries entail exposures to specific woods, resins, machinery and have differing degrees of automation

Type of products made – different products (e.g. reconstituted wood panels, wooden cabinets, wooden blinds etc) will usually entail different manufacturing processes. Some products are very simple e.g. sawn timber.

Business size – broadly classified on the basis of the number of employees (small, medium, large)

Location: country/metropolitan – the degree to which professional OHS advice is available and can be sought (e.g. if improved controls are required) may depend on the location of the business. Furthermore, regulatory enforcement may also play a role depending on the location of the business.

State – used to classify jurisdiction. There may be systematic differences in exposure owing to different regulatory regimes and may be a proxy for climatic differences etc.

Number of employees – defines the size of the business in terms of workforce

Number of employees exposed to wood dust and/or formaldehyde - this is a subset of the overall workforce, and based on proximity to sources, time spent near sources, and the presence of physical barriers

In the context of a wood product manufacturing environment:

Exposed – production staff and production supervisors, cleaners

Partially exposed – those in enclosed offices within a production area, or other staff with significant interaction with production activities (e.g. maintenance staff, quality control staff)

Unexposed – those in office areas, enclosed and physically separated from production areas

It normally includes exposed and partly exposed workers.

WORKER INFORMATION

Gender – there may be systematic differences in exposure, owing to different heights, body position

Age group – older workers may be more or less skilled than younger workers, or have more supervisory roles

Years of experience – the number of years working in wood working industries can be used for stratification of data and allows inexperienced worker to be identified to determine if they have lower or higher exposures than more experienced workers.

Eye Protection – the type of eye protection should be documented, although it will not influence inhalational exposure unless it is a full face shield etc. It is important for ocular effects.

Respiratory Protection – the presence and type of respiratory protection worn is important for controlling exposure to wood dust especially during processes where high short term dust concentrations may be generated.

Gloves - type, style and material of construction should be noted. This will not influence inhalational exposure but is important for dermal exposure.

Other PPE – e.g. apron. This is not relevant for inhalational exposure, although it may be important for the control of dermal exposure.

PROCESS AND SAMPLING DETAILS

Date of sample collection – provides temporal data and may also show trends with time if sufficient data for different periods are available.

Process – a description of the general activity, e.g. wood machining

Task description – a detailed description of the task being monitored is important, e.g. paper and block sanding. There may be more than one task in a monitoring session.

Task duration – the length of time of the task. Exposure will depend on task duration.

Daily / Weekly – defines the frequency of the task, for example whether it was every day or every week such as cleaning out filters for the extraction system.

Shift Day / Night – refers to the shift classification. The working conditions and associated exposures during a night shift work may be different from those during a day shift – for example the workplace may be more enclosed due to noise considerations and the thermal comfort of employees.

Indoors / Outdoors – outdoor work may or may not entail greater inhalational exposure compared to indoor work, due to differences in air speed and direction.

Equipment used – the type of equipment in use (e.g. bandsaw, router etc) will determine the amount of wood dust or formaldehyde generated and the description allows comparison between different types of processes.

Types of wood used – the type of wood processed by the business may determine the amount of dust and formaldehyde that employees are exposed to in processes where wood dust is generated.

Exposure duration – defines the total time over which the sample was collected, i.e. provides the averaging period for the TWA measurements.

Exposure concentration – defines the magnitude of exposure, and is the average concentration of the air contaminant during the sampling period.

Engineering controls – the presence of engineering controls such as local exhaust ventilation will influence exposure, and these need to be documented as thoroughly as possible.

Type of dust capture system – for example, a bag filter or cyclone. This may influence exposure should there be a malfunction or poor maintenance.

Location of dust collector system – if LEV sock filters are used indoors, there can be recirculation of collected dust back into the work environment. Filters and exhausts external to the building are preferred.

Cleaning methods - the cleaning method may contribute to high wood dust exposure especially if compressed air or sweeping are used to clean up wood dust generated during processing.

Type of sampling – two types of sampling are usually carried out. Positional (fixed position or static) samples are fixed at a location. On the other hand, personal sampling refers to sampling within 30 cm radius of the midpoint between mouth and nose. Nearly all Australian occupational exposure standards specify personal monitoring. This includes wood dust and formaldehyde. Static sampling at breathing height may be suitable if the person does not move from a particular position while carrying out the task.

Method of sampling formaldehyde – active or passive sampling methods can be used. The passive sampling method is generally less sensitive and less accurate.

Source of formaldehyde - provides data on the possible sources of formaldehyde from MDF, chipboard, veneer or any combination of the types of reconstituted wood.

Source of exposure information – this may indicate the competence of the person collecting the data and the methodology followed. A qualified occupational hygienist would collect data via validated methods, and other sources may not be as reliable.

Appendix 3: Description of exposure and control database

The database is in Microsoft Excel and comprises a series of header variables relating to substance, industry, company, location and process details, sampling details, worker details, control details, source of information etc.

The raw data comprise a series of records. Existing exposure data may be discrete values or aggregate values with ranges (e.g. 1.0 (0.1 – 5.3), n = 3) where this is the only information available from published papers, reports etc.

The *new* measurements are included at the end of the *existing* raw data.