WOOD PROCESSING NEWSLETTER

forest research
creative wood-based solutions

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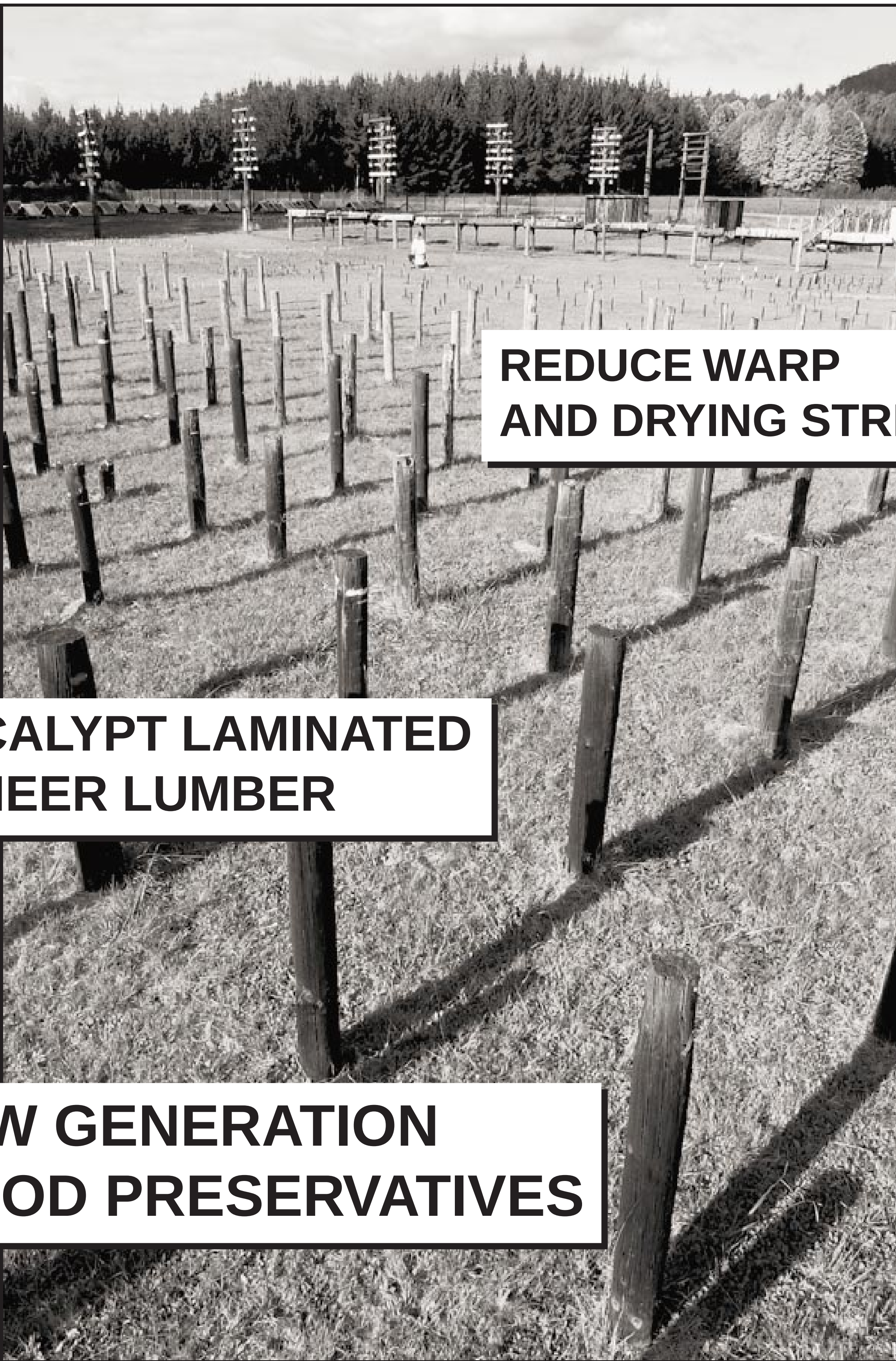

REDUCE WARP AND DRYING STRESS

EUCALYPT LAMINATED VENEER LUMBER

NEW GENERATION WOOD PRESERVATIVES

Sawmilling

Issue No. 29 May 2001

EUCALYPTUS NITENS LAMINATED VENEER LUMBER

Heather McKenzie and Doug Gaunt

Eucalyptus nitens is a rapidly growing species which was little planted in New Zealand due to severe defoliation caused by a beetle, *Paropsis charybdis*. In 1987 ***Forest Research*** released a parasitic wasp, successfully controlling the pest. Since then, *E. nitens* has been planted in the Bay of Plenty/ Taupo and Southland regions for local kraft pulp and export chip respectively. There may be a wider role for the species in New Zealand if it can be demonstrated that it can produce quality solidwood products. The ***Forest Research*** Management of Eucalypts Cooperative is collecting growth and wood quality information from most regions of the country and performance is being monitored in pulpwood plantations. A ***Forest Research*** sawing trial based on a 30-year-old stand showed there were some problems with sawn timber such as internal checking. The opportunity to extend the research to trees from another stand was provided by a unique stand of pruned fifteen-year old *E.nitens* in a ***Forest Research*** trial at Golden Downs Forest, Nelson. Whilst the butt logs were suitable for sawing, a structural product, laminated veneer lumber (LVL) was considered a likely appropriate use of the heavily branched second logs. This note summarises the main results of the LVL study.

Veneer showing stain and decay associated with knots

Veneer Production

Fifteen *E. nitens* trees were selected representing the range of wood density present in the stand. The trees were planted in 1983 and thinned at age 6 years to 100 s/ha. The average diameter of the selected trees was 57 cm and height 36 m. Butt logs were used for a sawing trial which will be reported later. The 5.5 m second logs were transported to Mount Maunganui, where they were measured for log size, branch-size and assessed for end-splitting. One log was too severely split to be peeled but the remaining 14 logs were cut into 2.6 m long peeler bolts and peeled to produce 2.6 mm thick veneer sheets. The veneer was dried to 18% and full-sized sheets (1.2 m x 2.4 m) were graded based on structural plywood AS/NZS 2269:1994.

Large branches (8 to 13.5 cm diameter) led to most of the second log veneer sheets being lower than the accepted grades for structural plywood. There was evidence of stain and decay, associated with branches, in two of the logs and a small amount of kino in one tree.

Manufacture of the LVL panels and testing

Stiffness of all the sheets was assessed using acoustical methods measuring sound velocity. The resulting distribution of stiffness values was split into approximately thirds and used to rank the sheets into low, medium and high stiffness classes. The sheets were re-dried to 7% mc prior to gluing with phenolic resin into 13 ply LVL panels (38 mm thick).

LVL testing was in accordance with AS/NZS 4063:1992. Each LVL panel was ripped to produce twelve 90 x 38 mm by 2.4 m long studs which were tested for bending stiffness and strength, tensile strength and compression strength.

Test results and conclusions

A summary of the strength properties of the studs derived from bending strength tests for the three stiffness groups are shown in the table.

Table - Stud bending strength properties

Veneer Stiffness Group*	Average Stiffness of studs (GPa)	Strength of lower 5 percentile piece (MPa)
Low	12.7	61.6
Medium	14.0	62.3
High	16.6	103.4
No 1 framing radiata pine	8.0	17.0

*based on sound velocity.

The study concluded that 15-year-old Eucalyptus nitens trees can produce second logs suitable for peeling veneer for LVL. Decay and kino were minor defects in the sampled logs but their prevalence in stands would need to be determined along with the occurrence of log end splitting due to growth stresses. The high stiffness of the LVL suggests that *E. nitens* veneer could be used in combination with lower stiffness radiata pine veneers for a net gain in LVL stiffness.

A number of results and analyses available from ***Forest Research*** but not reported here include:

- Growth stress assessed in the standing tree compared with log-end splitting and veneer splitting;
- Log volumes and recovery of veneers sheets;
- Veneer stiffness variation by log height and from pith to bark;
- Stiffness related to wood density.
- Comparison of veneer stiffness with stiffness calculated from small wood blocks cut from the same trees.
- Statistical analysis of LVL bending, tension and compression strength tests
- Comparisons with characteristic grade stresses for the proposed New Zealand machine graded pine and existing framing grades.
- Comparison with New Zealand-grown radiata pine LVL.
- Conversion to Japanese Agricultural Standards (JAS) for structural LVL;

Acknowledgements

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Wood Preservation

Issue No. 29 May 2001

NEW GENERATION WOOD PRESERVATIVES ARE PERFORMING WELL IN NEW ZEALAND AND AUSTRALIAN FIELD TRIALS AFTER 6 YEARS IN GROUND CONTACT

R. Wakeling

Introduction

On a global scale, many of the traditional wood preservatives used for protecting wood in ground contact are likely to be replaced or used in fewer situations, in the near future. The driving force behind this trend is related to public and legislative demands for products that have a low environmental impact and are more benign in terms of their non-target toxicology. The extent to which new wood preservatives meet these demands and represent improvements over traditional preservatives varies, but the trend is towards replacement of the traditional preservatives.

One of the challenges of field testing candidate wood preservatives is selection of test sites that harbour a realistic cross section of the plethora of decay types that reside in soil and can affect wood preservative performance. In a recent study, this issue was addressed by exposing variously preservative-treated wood stakes in ground contact at 13 test sites in New Zealand and Australia, chosen on the basis of having different soil type, climate and vegetation. After 6 years, the wood soundness data are useful for assessing the impact of test site location on the reliability of field data, for prediction of likely in-service performance.

In the recent study 20 x 20 mm Radiata pine and European beech stakes were treated using 5 preservatives. Two traditional preservatives, copper, chromium and arsenic multisalt, (CCA) and a creosote and oil mixture; and three newer chemicals, ammoniacal copper plus a quaternary ammonium compound, (ACQ), copper amine plus triazole (CuAz),and chlorothalonil plus chlorpyriphos in oil (CC).

Additionally untreated controls, oil only and solvent only, were included for both pine and beech.

Preservative retention for radiata pine and beech stakes

	Active Ingredient (kg/m^3)						
	CCA			creosote/oil	ACQ	CuAz	CC
	Cu	Cr	As	creosote	Cu	Cu	CC
Pine	1.0	1.8	1.3	60.8	2.57	3.0	4.8
Beech	1.5	2.7	1.89	NA	NA	4.5	7.2

NA = not applicable, for beech

Test site locations used were: Canal Creek grassland, tropical North Queensland Tombleson's vineyard, Gisborne; Glenbervie pastoral site, Whangarei; Glenbervie radiata forest site; Hari Hari pastoral site, West Coast of South Island; Oak forest, Cheviot hills, Canterbury, Esk valley estate terraced vineyard, Napier; Whakarewarewa, ***Forest Research*** pastoral test site, Rotorua; Tapanui pastoral site, South Island; Mount Mee pastoral site, Brisbane; Hanmer pastoral site, South Island; Totara flat, *Notofagus* beech forest, South Island. Stakes were placed in the ground so that two thirds of the length was buried.

The stakes were assessed after nearly 6 years exposure. The stakes were removed from the ground and examined either at the site or in a laboratory. Each stake was assessed for decay and a rating indicative of the extent of decay assigned according to the American Wood-Preservers'Association standard method E7-93. Mean percentage soundness values were then converted to a mean soundness reduction value by subtracting percentage mean soundness from 100.

Site location had a major impact on performance of preservative treated wood in ground contact. In general, this could be attributed to the effects of temperature, water availability, soil type, and to a lesser extent vegetation and litter type. A warm, moderately wet climate, in combination with a good loam soil, resulted in a severe decay hazard. At some of the warm temperate test sites, decay hazard was as severe as occurred at a wet tropical site. In general, drier sites had lower mean soundness reduction values but not all preservatives gave better performance at these sites. For example at Hanmer, which had one of the lowest mean soundness reduction values, ACQ treated pine performed relatively poorly.

Whilst it is impossible to test all the permutations of decay hazard likely to be encountered in service, it should be possible to select test sites that adequately represent the majority of decay hazards encountered in service. Based on site conditions and the affect these have on decay hazard, preservatives do not always perform as expected. Therefore it is probably unwise to rely on data from a single site, even if it is known to be a severe site in general terms. Based on the data from this study, a knowledge of decay types encountered (reported elsewhere) and empirical wisdom in general, it is possible to select 3 – 4 sites that collectively pose a diverse decay hazard, representative of the majority of situations encountered by wood in service. Possible exceptions are likely to involve situations where soil has an elevated decay hazard due to human activity, such as horticultural practices.

The value of field testing preservatives in climates where temperatures greatly reduce decay hazard for much of the year is perhaps questionable. Particularly in a world where public expectation of the service life of wood and other requirements of wood, may be changing faster than the time it takes to produce field performance data. Six years performance data is probably insufficient for service situations that require a high degree of performance assurance, such as for house piles, high decking, railings and telegraph poles. For many other situations, the results of this study suggest that the new generation preservatives tested can be used as replacements for traditional preservatives.

CAN LOSP BE REPLACED BY WATER-BASED TREATMENTS?

Kourosh Nasheri, Mick Hedley and Gavin Durbin

This is a question that American and many European countries have recently been asking, mainly due to environmental concern over emission from LOSP treated timber

European governments initiated a programme aimed at significantly reducing the emission of Volatile Organic Compound (VOC) by the year 2000. In response to this, research projects were developed to evaluate the potential for replacing organic solvent-based treatments (LOSP) with micro-emulsions of the same or substitute active ingredients as water-based formulations.

In Europe emulsions and micro-emulsions in water are now replacing LOSP treatment, although the treatment schedules used (double vacuum) are the same as were used for LOSP treatment. Wood swelling and raised grain, normally associated with water-based treatments, has been minimal in refractory species tested, such as sitka spruce.

In New Zealand, LOSP is the dominant preservative treatment for painted exterior boards, window joinery, and recently, interior flooring, battens, house framing and roof trusses. Due to its high permeability, radiata pine easily absorbs solvent. Thus, it was considered probable that double vacuum treatment of radiata pine with water-based formulations would result in a high uptake with complete sapwood penetration and substantial swelling.

Forest Research examined preservative uptake by radiata pine and compared this with uptakes by selected European and Australian species. The aim was to establish if differences existed between responses to LOSP and water-based treatments of these species while maintaining, in radiata pine, the required minimum penetration and preservative loading for Hazard Classes H1, H2 and H3 and minimising adverse effects on timber quality. Copper naphthenate was used as the preservative in the solvent-base and F-Bor (disodium octaborate tetrahydrate) was applied in the water-based treatments.

The double vacuum process used with both preservative systems was:

- Evacuate to –20 kPag for 5 minutes, then flood and release the vacuum

- Hold for 5 minutes at 0 kPag, (soak) then empty the vessel
- Final vacuum of –90 kPag for 30 minutes

Radiata pine sapwood had the highest uptake of all species, and consequently exhibited the greatest amount of swelling. With the two European species, a change of carrier from solvent to water did not significantly affect absorption, and thus swelling. In contrast, both radiata pine sapwood, 45 and 35 mm thick, and slash pine had almost double the uptake by changing the LOSP solvent to water when using the same double vacuum schedule (Figure 1).

Swelling after treatment in comparison to uptake with water-based double vacuum treatment for all species are given in Figure 2.

The graph (Fig. 2) shows why with sitka spruce, and to a lesser extent, Scots pine, LOSP treatment was easily substituted by water-based formulations without problems. On the other hand, implications of this change to treatment of radiata pine would be immense.

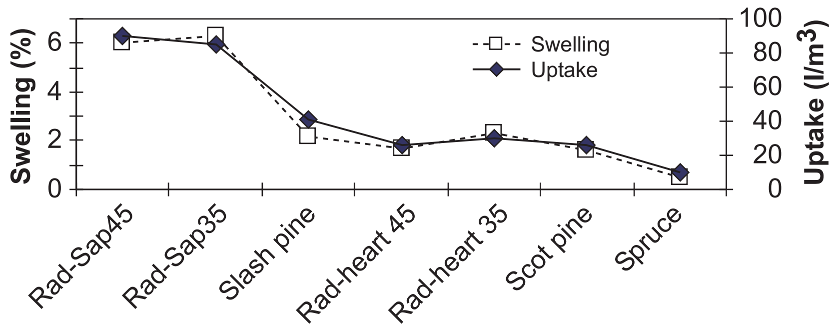

Figure 2 - Uptake and swelling in water-based system

Preservative penetration in all species for both solvents generally follows the uptake trend. This is shown in Table 1, which also includes percentage swelling after treatment in the water-based formulation.

Table 1 - Uptake, Swelling and Penetration for all Treatments

Spices	Solvent-base		Water-base		
	Uptake* (l/m^3)	Penetration* (%)	Uptake* (l/m^3)	Penetration* (%)	Swelling* (%)
Rad-Sap45	41.9	100	90.0	88	6.04
Rad-Sap35	42.1	100	85.3	93	6.28
Slash pine	22.7	60	41.5	22	2.17
Rad-heart 45	27.8	50	26.4	15	1.69
Rad-heart 35	20.3	55	29.9	18	2.33
Scot pine	26.0	55	26.4	20	1.58
Spruce	7.6	5	9.9	3	0.498

* Average 10 samples

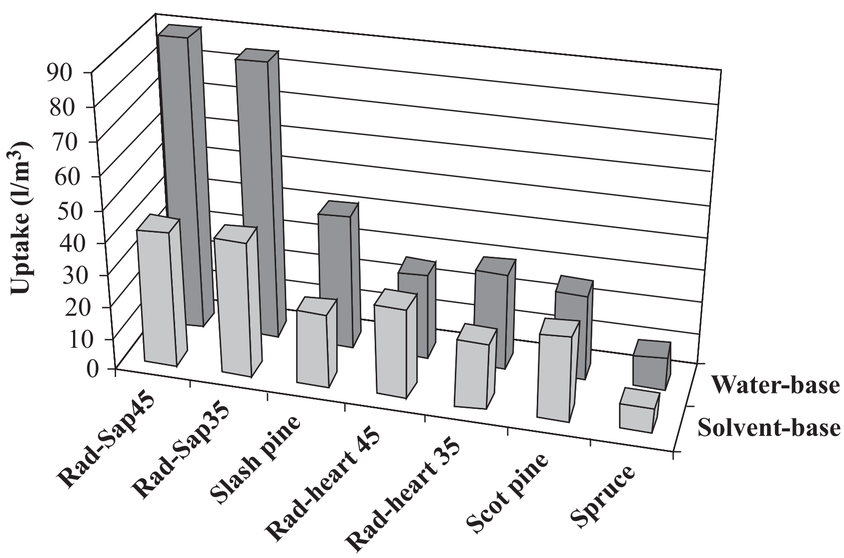

Figure 1 - Uptake for two treatments

Table 1 shows that penetrations in all water-base treatments were inferior to LOSP treated samples.

Due to high absorption of solution and unacceptable swelling, it is not possible to use the LOSP double vacuum process schedule for water-based treatments of radiata pine, as has been done in Europe for treatment of commercial species there. The high permeability of radiata pine sapwood, especially after kiln-drying, presents a problems. However, future work will focus on developing treatment schedules to reduce uptake and swelling while maintaining acceptable penetration into the wood.

MINIMUM INHIBITORY CONCENTRATION (MIC) DETERMINATION IN LIQUID CULTURE AND RADIATA PINE

Bernhard Kreber and Tripti Singh

A PhD programme has been initiated at ***Forest Research*** to advance our current knowledge on the mode of action of fungicides used in wood protetion. The work specifically aims to determine interactions that occur between fungi, wood and fungicides and how they govern satisfactory protection of unseasoned wood.

In the initial stage of the programme, the threshold levels (minimum inhibitory concentration, MIC) of the fungicide methylene bisthiocyanate (MBT) were determined against *Ophiostoma floccosum, Leptographium procerum*, *Sphaeropsis sapinea* and *Trichoderma viride.* Spores and hyphal fragments of each individual fungus were cultured in a liquid nutrient medium spiked with different concentration levels of MBT, ranging from 0.0016 to 0.00001 percent weight/volume (% w/v). After 12 days' incubation in the spiked nutrient medium, biomass produced by each fungus was determined and used as an indicator to define the lowest biocide concentration or MIC inhibiting fungal growth.

As expected, biomass decreased for all fungi as the concentration of MBT increased until growth stopped at the level corresponding to the MIC range (Table 1). Among the four fungi tested, *T. viride* showed the highest degree of tolerance against MBT. It was also shown that MBT was fungicidal and thus killed the test fungi when used at levels corresponding to the MIC. This was concluded because none of the test fungi developed mycelium after washing spores and hyphal fragments that had been incubated at MIC levels, and then plating onto fresh malt-agar media. However, all fungi tolerated higher levels of MBT than shown in Table 1 when incubated in liquid media for 5 days prior to spiking with MBT. This suggested that control is more difficult for established hyphae than spores and hyphal fragments.

Table 1 - MIC range (% w/v) determined for MBT towards fungi in liquid culture.

Fungi	MBT (% w/v)
L. procerum	0.00001 – 0.00002
O. floccosum	0.00003 – 0.00004
S. sapinea	0.00003 – 0.00004
T. viride	0.0004 – 0.0005

In a second set of experiments, MIC values were determined on radiata pine wafers (50x35x7 mm) that were inoculated with each test fungus and then dipped into MBT solutions. Six MBT concentrations, 0.02, 0.04, 0.08, 0.16, 0.32 and 0.64%w/v, were prepared. Inoculated and treated wafers were incubated at room temperature inside a covered plastic bin and were assessed weekly over five weeks by rating fungal growth over the wood surface of wafers.

On wood, higher concentrations of MBT were required to control fungal growth than in liquid culture, irrespective of the test fungus used. MIC levels of MBT varied on wood between test fungi as noticed for liquid cultures (Table 2). The highest degree of tolerance was observed for *T. viride* with a MIC of 0.64%w/v of MBT. The observed relative tolerance of this genus is in general agreement with the literature, where *Trichoderma* sp. has been noted on timber treated with antisapstain products containing MBT.

Table 2: Approximate MIC values of MBT (% w/v) against four fungi determined on radiata pine sapwood.

Fungi	MBT (% w/v)
S. sapinea	0.04
L. procerum	0.08 0.16
O. floccosum	0.32
T. viride	0.64

The fact that higher concentrations of MBT were required to control fungal growth on wood than in liquid culture medium is a common observation in wood protection. After dip-treatment, there is a dilution effect of the fungicide occurring on the fresh wood surface because of free water in the cell lumens. There is also a secondary dilution effect with MBT because it diffuses and penetrates into the sub-surface regions of wood.

The following conclusion can be drawn from this work so far:

- *T. viride* exhibited the greatest fungicidal tolerance against MBT.
- Higher levels of MBT were required to control growth of fungi on wood than in liquid culture. This suggests that interactions of wood with fungicide and/or fungus may play a significant role.
- Spores and hyphal fragments were more sensitive towards MBT than established hyphae, irrespective of the test fungus used. This has implications for control of fungi on unseasoned wood where they can become established prior to antisapstain treatment.

FUMIGATION TREATMENT OF NEW ZEALAND GROWN WESTERN RED CEDAR FOR EXPORT MARKETS

Bernhard Kreber and Gavin Durbin

Stringent phytosanitary measures such as heat sterilisation or fumigation are commonly used to ensure that diseases and pests do not leave or enter countries via movement of susceptible products. This is because of the risk of introducing non-native pests into a country which may have a potentially devastating effect on its economy. For example, pitch pine canker, which causes serious damage in radiata pine stands in California, is currently perceived as the most serious threat to plantations of radiata pine in New Zealand.

Recently, the USDA expressed concerns that importation of New Zealand grown western red cedar posed a bio-security risk to the U.S.A., and threatened to prohibit entry of the product into the market in the future. Whereas western red cedar destined for the US market is fumigated in accordance with standard New Zealand procedure for exported wood products destined for the USA, no data existed on whether the fumigant completely penetrated into the centre of the product at levels that complied with prevailing standards.

To ensure that exports of western red cedar do not constitute a biosecurity risk to the US, ***Forest Research*** was asked to provide data to demonstrate that the fumigation procedures used on western red cedar were effective. The objective of the study was to clarify whether fumigation with methyl bromide penetrated into the centre of western red cedar at levels meeting the specification for exportation of wood products.

This can be determined by using gas-permeable plastic sachets containing an absorbent for methyl bromide in one compartment and a reagent in another. When mixed, the two-part contents of these sachets produce a distinctive pink to red colour if the sachet has been exposed to an effective dosage of methyl bromide. If, after mixing, a clear or yellow colour results, it indicates an ineffective dosage of methyl bromide.

Kiln-dried western red cedar (200 x 26 mm) was cut into 500 mm long boards and skim –dressed on all four edges and one face. A router was used to make a cavity 50 x 30 x 13 mm in the centre of each dressed face. One sachet was placed in each cavity, which was then sealed with aluminium foil. Boards were then glued together in pairs so that the samples for fumigation contained two sachets, each set 13 mm blow the surface of each face.

For field trials, samples were placed at different positions within the commercial packets of kiln dried western red cedar which were to be fumigated. One sachet was also placed on the upper surface of each sample board.

In the first trial, fumigation was undertaken in a shipping container placed outside in the open in winter. Concentration of methyl bromide and temperature was not monitored but day temperatures were below 10ºC.

In a second field trial, (using the same initial concentration of methyl bromide as the first), fumigation of packets was undertaken under a tarpaulin inside a building. A fan was placed beside the injection port and left on for the 24 hours. In this trial, methyl bromide concentration was monitored and the temperature noted which ranged between 11 and 16ºC.

After 24 hours of fumigation, sachets were retrieved from the samples and were individually assessed by mixing the two-part contents to verify that methyl bromide gas had penetrated to the centre of the samples.

In the first field trial, a negative colour change (yellow) was observed for sachets, either within sample boards or placed on their upper surfaces. This showed that fumigation had been ineffectual; the probable cause was the low temperatures experienced at the time. Temperature is the dominant factor concerning complete volatilisation of methyl bromide. Based on the assumption that no leakage of methyl bromide occurred, the first trial then indicated that fumigation in the winter of New Zealand, if day temperatures are below 10ºC, is unlikely to give satisfactory penetration of the fumigant into the wood.

In the second field trial, all sachets placed within sample boards, and all but one placed on upper surfaces of samples, showed a positive reaction.

The results of the trials indicated that western red cedar boards up to 50 mm thick can be satisfactorily fumigated to international requirements (80 g/m^3) provided that temperatures above 10ºC prevail at the time.

Wood Drying

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NEW PRESSURE STEAMING PROCESS REDUCES TWIST AND STRESS

Tony Haslett, Hamish Pearson and Chris Lenth

Laboratory research, followed up by industrial scale trials, has shown that final steaming at 130 to 150°C under pressurised conditions greatly improves stress relief and reduces twist by up to 40% as compared to normal water bath steaming at 100°C (**Table 1**). On the basis of these results companies should be asking two questions:

1. What is the cost resulting from grade loss due to twist, and from warp occuring when lumber containing residual stresses is recut?
2. Is the cost of this degrade high enough to warrant investment in sophisticated pressure steaming equipment?

Table 1 - Moisture content and twist immediately after drying/steaming

	100°C Water bath steam 3 h	150°C Pressure steam 0.25 h
Mean moisture content (%)	9.5 a[1]	11.5 b
Mean twist (mm)	6.9 a	4.6 b
Pieces with twist over 5 mm (%)	64	35
Pieces with twist over 10 mm (%)	19	3

[1] A different letter indicates a significant difference between treatments.

To reduce moisture content (MC) variation and relieve drying stress, most New Zealand kiln operators (ACT and HT) final steam at 98-100°C/100% RH. Stress relief in steaming occurs through two interacting mechanisms: wood softening and wood (plastic) deformation. Increasing the temperature and/or MC of lumber softens the wood structure, which allows molecular re-orientation (plastic deformation), and thus stress relief, to occur. The mechanism of plastic deformation is caused by moisture pickup under stress. As the dry outer layer of the lumber (the shell) absorbs moisture, from the steam, it tries to swell but is restrained by the inner layer (the core). This swelling force adds to the compressive stress that develops in the surface during drying. The resultant increased compressive stresses are usually beyond the yield stress of the wood, and unrecoverable deformation can occur within the wood structure. When the added moisture subsequently dries, the shell shrinks back but no longer contains compressive stresses because the wood structure has been permanently deformed ("set" in compression). This phenomenon is essentially a reversal of what happens in the early stages of drying, when the wet core restrains the shrinkage of the drying shell, which is deformed or set in tension. Then as the core dries shrinkage is restrained because the dry shell now restrains it from shrinking. The core now imposes a compressive drying stress on the shell.

The degree of stress relief (due to plastic deformation) is dependent on the temperature and moisture level achieved during steaming. Higher levels of temperature and MC lead to increased softening of the wood structure and thus the softened wood structure undergoes plastic deformation at a lower yield stress, which serves to enhance the moisture pickup effect. Steaming at 130°C as opposed to 100°C thus augments both of the mechanisms responsible for stress relief. Additionally, the relative importance of the two mechanisms of stress relief depends upon the type of stress that has been imposed during lumber drying. This will be the focus of further studies. Moisture pickup is likely to be important in stresses involving core/shell phenomena, such as transverse stresses and warp in remanufacturing, whereas it is reasonable to suggest that the mechanism of softening is more important in twist reduction.

Through the combined effects of softening and deformation from moisture pickup, pressure steaming is also able to relieve longitudinal stress in addition to transverse stress. Longitudinal stresses are manifested as bow and spring in subsequent ripping and reprocessing of dry lumber. The low shrinkage and swelling of wood in the longitudinal direction means that it is virtually impossible to generate the swelling forces necessary to achieve plastic deformation in normal steaming at 100°C. Elevating the steaming temperature to 130 or 150°C reduces the stress level required for permanent deformation, and thus for the relief of drying stresses, to occur.

Recent research has shown that during pressure steaming at 150°C (500 kPa), the overall MC of 100x40 mm sapwood pieces increased from 8% to 25% MC in just 15 minutes at the target setting. On releasing the pressure, the MC dropped rapidly back to below 12% MC. In addition, the core temperature of the wood tracked very close to the steaming temperature, indicating that heating occurred very quickly throughout the 40 mm thickness. These results suggest that, due to a combination of softening and very high MC pickup, stress relief at 150°C would require only 15 minutes at the setpoint temperature and pressure.

A question you may ask is: “doesn’t pressure steaming at 150°C reduce the lumber strength”? Lab studies on in-grade 100x40 mm boards, as well as carefully matched specimens of clear wood, have shown that steaming for 60 and 15 minutes duration at 130 and 150°C respectively resulted in no loss of strength properties. Commercial scale trials have also confirmed that pressure steaming at 150°C does not adversely effect machine grade recovery. Additionally, standard manual and pneumatic nailing tests showed that pressure steaming did not affect nailing properties.

A concern was that lumber may have a twist “memory”, meaning that the twist reduction achieved in pressure steaming may not remain through subsequent exposure to high humidity. MC cycling tests allayed these fears. Results showed that the twist reduction from pressure steaming at 150°C was permanent **(Figure 1)**. In fact, the pressure steamed material showed less MC change and movement, indicating that it was more dimensionally stable, than the matched material which was steamed normally. The enhanced stability means that it may be possible to use juvenile wood in products for which it is currently considered unacceptable – thus opening up new uses for the juvenile component in the core of radiata logs.

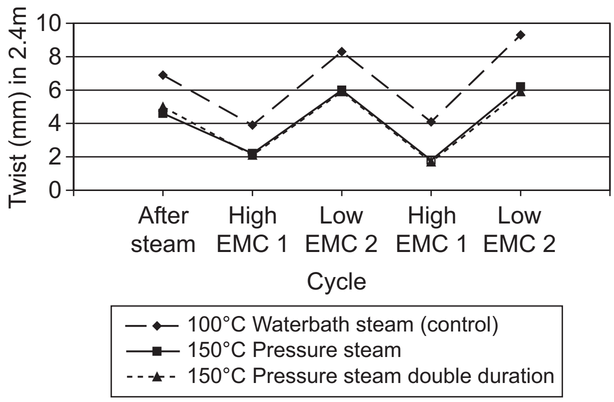


Figure 1 - Twist under humidity cycling following normal and 150°C pressure steaming.

Because re-manufacturers are increasingly experiencing problems of warp during the ripping of mouldings, we also assessed whether pressure steaming, through improved relief of longitudinal stresses, could reduce warp in recutting. **Table 2** illustrates that the pressure steaming process is indeed able to relieve the longitudinal stress and reduce bow. However, the negative average bow and the high proportion of ripped samples exhibiting reversed bow after pressure steaming shows that the process is actually over-effective and needs further optimisation.

Table 2 - Assessment of the influence of steaming conditions on bow in re-manufacturing.

Steaming treatment	Bow after deep ripping		% with bow in excess of	
	Average (mm)	Reversed (no.) [1]	12 mm	19 mm
Normal 100°C, 3 h	5.0	6	19	0
Pressure 150°C, 15 min.	-4.4. [1]	72	2	0

[1] means that relative to ripped surface bow is outwards rather than pinching inwards

An additional challenge was also to maintain the light colour of radiata pine. Although pressure steaming did cause slight darkening of the finished mouldings, the commercial moulding manufacturer thought that this degree of darkening was unlikely to be of concern to their clients.

Our current fundamental research into quantifying the relationships between MC, temperature and wood strength will help to increase our understanding of the development and relief of drying stresses and lead to further optimisation of the pressure steaming process.

Given the improved stress relief from pressure steaming, sawmills should be able to reduce or eliminate the 1-3 week holding period after HT drying. Improved stress relief should also improve two-out splitting during planning, and thus has potential to improve sawmill productivity.

So what is the impediment to industrial application of pressure steaming? Equipment!

To perform pressure steaming, companies must install an autoclave capable of achieving 500 kPa with a large volume of saturated steam being available. Although an autoclave costs 3-4 times that of a normal steaming chamber, it should be remembered that the pressure steaming process takes only one-third of the time of normal steaming. An autoclave could be sized to either take a full kiln load, whereby a single autoclave would service 3-6 HT kilns, or a single pack length, servicing 1 or 2, 3-pack-long HT kilns. Trials have also shown that twist and drying stress can still be reduced even when the packs are moved to another site for delayed pressure steaming. Thus a company could separate reject material for later steaming in a centrally located autoclave.

To assess whether or not investment in pressure steaming technology is justified, sawmill managers should determine their level of twist rejection and/or warp degrade in recutting, and tabulate the associated cost. To help in this we have prepared a cost benefit analysis procedure that enables companies to enter their own data and determine the payback from pressure steaming. Using the rejection rates from our trials, we estimate the payback period from investment in pressure steaming to be less than one year.

In summary, pressure steaming offers companies the following benefits:

- Reduced twist and rejection.
- Reduced stress, providing stability in ripping and two-out splitting.
- Improved long-term stability allowing possible new uses for material from the juvenile core.

However, pressure steaming requires specialised costly equipment, necessitating that companies carefully assess their payback from the process.

For more information or papers on pressure steaming, please contact the authors.

NEW IN-LINE MOISTURE METER AVAILABLE

Tony Haslett

High emphasis on the production of remanufacturing lumber for both the domestic and export market requires that producers have confidence that the moisture content of the lumber meets client specifications. In-line moisture meters, which enable sawmillers to efficiently test all production prior to dispatch, are a powerful tool to ensure that quality is maintained. ***Forest Research*** evaluations, of the Elliot Bay, Lignomat Moisture Register Products and Wagner 683 in-line moisture meter systems, provided correction values for 40 and 50 mm thick radiata (available on request from us) and showed that all of these systems were able to be used to identify lumber with 'out-of-spec' moisture content. Since these tests several new in-line meters (Brookhuis and Quasar) have been developed with the first of Brookhuis systems being installed in New Zealand.

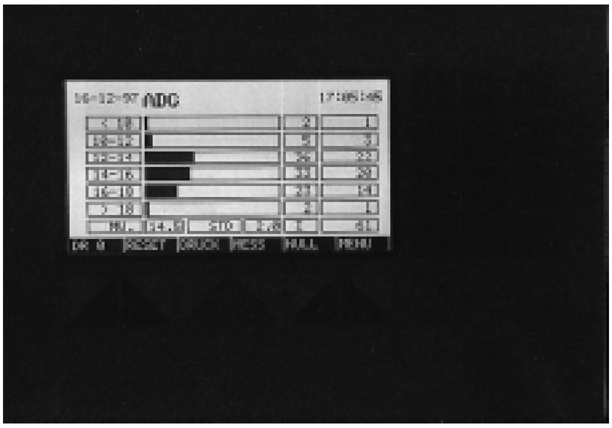
John Fogarty has submitted the following information on the Brookhuis System.

The Invercargill firm Fogarty Industries are the current sole New Zealand and Australian agent for the Brookhuis range of moisture meters. The agency covers the FMI In-Line contact free wood moisture meter, the FMC, FME and FMD range of hand held meters suitable for the wood, construction and furniture industries, as well as In-Kiln moisture measurement systems.

The FMI In-Line Moisture Meter is capable of reading up to 200 boards a minute in a transverse production line. The transversal system contains between one and three sensors that are situated on the dry-chain and linked back to the main microprocessor unit. This microprocessor unit stores data on the type of wood, its size and density, as well as the maximum and minimum permissible Moisture Content (MC) and what action is to be taken if the MC is outside these limits. It can either eject or mark 'rejects' and its output can be either sent directly to a PC using a data analysis package such as the ***Forest Research*** MContent™, or a printer. It also has an easy to read graphical display that gives FMI operators real-time information on the current wood batch at any time during a run. An operator can easily program this unit, and even fairly complex statistical information is shown in an easy to read format.

Inline transverse sensor

The FMI system is currently being used in two sawmills in Southland. John Cowan from Craigpine in Winton has just had an inline system installed and is very happy with the results. In this case marking equipment is set up on the dry-chain to individually indicate boards with either too high or too low MC readings. John tells us that "The In-line system is a vast improvement. We now have an accurate and easy to use MC system operating on the dry-chain which gives us excellent information to ensure that export quality demands are met".



Inline statistical screen

The Brookhuis Company is based in the Netherlands and has been a leading supplier of moisture meters around the world for more than 30 years. Fogarty Industries also use Brookhuis moisture equipment as part of its In-Kiln Lumber Dry program, which it supplies as an important component in their 'new generation' curved timber kilns.

For information on the complete range of Brookhuis Moistures Meters please contact:

John Fogarty Ltd
Phone: (03) 214-4316,
Fax: (03) 214-4315,
Email: johnfog@southnet.co.nz,

or write to

Fogarty Industries,
137 Crinan Street,
PO Box 295,
Invercargill.

You can also visit the Brookhuis website for the latest information at www.brookhuis.com.

ENERGY USE IN DRYING

Ian Simpson and Steve Riley

Energy sources

A range of fuels is used to heat timber dryers. Table 1 shows the volume of timber dried in New Zealand by each fuel type, in 1990 and 1998.

Wood waste is still the most common fuel type used for heating kilns. In the eight years from 1990 to 1998 there was a reduction in the volume of timber dried using wood waste, as gas and coal was increasingly used. Gas is a very convenient form of fuel as it easily handled, and coal may be used in combination with wood waste to improve the heating quality. However more recently there have been concerns over the disposal of wood waste and some companies have changed from using gas or coal to wood waste (in the 1998 kiln survey ten sites indicated that they would change from either gas, coal or oil to wood-waste). The amount of timber dried using electricity (mostly dehumidifiers and heat pumps) has reduced and is a reflection of the slight reduction in the number of dehumidifiers since 1990 (5 less chambers). Solar energy has not been used for drying timber commercially in New Zealand but it is an option in some places.

Table 1 - Comparison of volume of timber dried by fuel type in 1990 and 1998

Fuel type	Percentage of total dried (%)	
	1990	1998
Wood/bark	62	44
Gas	7	23
Coal	7	15
Electricity	15	4
Geothermal	2	6
Oil and diesel	5	7

Heat transfer

Steam is the most common method of heat transfer for installations using wood waste. The installations using gas and coal are generally newer and more commonly use pressurized hot water as a heating medium. More than 30% of the kilns that are heated with gas use direct firing, which has a lower initial capital cost than to a boiler.

Energy use components

Energy supplied to a dryer is used :

- To evaporate and release moisture from the timber
- To heat the moisture in the timber
- To heat the wood
- To heat the kiln structure and equipment
- To provide air circulation
- For conduction, convection and radiation from the kiln structure
- For venting of moist air

The relative size of these components depends on many factors, such as the ratio of kiln size to stack size, schedule used, air speed, initial moisture content, timber size and species. The energy to evaporate moisture from liquid to vapour dominates the process, and usually accounts for 70% of the total energy requirements. Table 3 shows measured results for a typical high temperature kiln.

Drying efficiency

Since the energy components vary depending on many factors, it is difficult to compare drying methods or practices within drying methods. The one common thing that dryers must do is remove water by evaporation, so a convenient expression for drying efficiency can be defined as:

$$\text{Total drying energy} = \frac{\text{energy required to evaporate moisture}}{\text{total energy supplied to the drier}}$$

Table 3 - Measured results for a typical high temperature kiln

	Energy input (%)		Energy use (%)
Electricity for fans	1.3	Circulation of air	1.3
Heat input	98.7	Evaporation of water	69.7
		Venting	13.6
		Heating timber	10.4
		Heating dryer	2.7
		Heat lost from dryer	2.3

Usually for conventional heat and vent dryers this value is between 0.6 and 0.7 under optimal conditions. There is surprisingly little difference between low and high temperature drying, because energy for evaporation changes only slightly and low temperature kilns have a lower rate of heat loss but dry for a longer time. Commercial kilns often have a lower efficiency because of extension of drying due to uneven drying conditions in the kiln, leakage and/or poor baffling

Table 2 - Heating methods by fuel type

Fuel type	Percentage of kilns using heating method by fuel type (%)				
	Steam	Direct fired	Hot oil	Hot water	Hot air
Wood waste	60	1	6	29	4
Gas	2	34	9	38	17
Coal	24	10	0	54	12

of the stack. Dehumidifier type dryers can have an efficiency of greater than 1.0 (as high as 1.5), as some of the energy for evaporation is recovered. Drying efficiency is quite difficult to measure, but past measurements by ***Forest Research*** (Table 4) have shown values ranging from 0.48 to 0.62 for steam heated kilns and for a dehumidifier charge the efficiency value measured was 0.76. However the dehumidifier used the electrical heaters extensively during drying because the dehumidifier was under-sized.

Table 4 - *Forest Research* drying efficiency measurements

Dryer type	Drying efficiency
Conventional kiln	0.48
High temperature kiln	0.62
Dehumidifier	0.76

Energy Comparisons

Many factors must be considered when choosing an energy source these include: the capital cost of equipment to generate the energy, energy unit cost, efficiency of converting the energy source to heat energy and the availability of the energy source. Table 5 attempts to summarise these factors.

Table 5 - Energy comparisons

Energy	**Capital Cost**	**Energy Unit Cost**	**Maintenance**	**Efficiency**	**Availability**
Direct electric heating	Low	Very High	Very Low	High	Everywhere
Heat pump using electricity	Moderate	Moderate	Moderate	Very High	Everywhere
Wood waste (dry)	High	Low	High	Moderate	Everywhere
Natural gas					
Direct	Low	High	Low	High	Regional in NI
Boiler	Mod. - High	High	Moderate	Moderate	Regional in NI
LPG boiler	Mod. - High	High	Moderate	Moderate	Everywhere
Coal	High	Low	High	Moderate	Everywhere
Geothermal	High	Low	High		Regional

Venting losses

UPDATE : SELECTING KILN FILLETS.

Tony Haslett

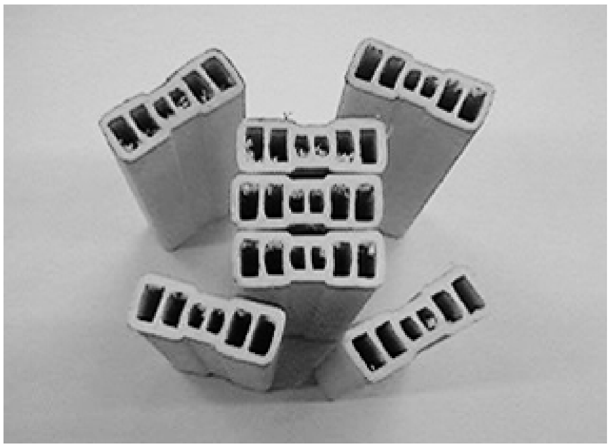
Well it always happens. Since Issue No.28 of the Newsletter was sent out, we have been contacted by Dynex Extrusions Limited to let us know about a new plastic kiln fillet that they have developed and which has recently now been introduced to the market. Dynex have provided us with the following information on their new fillet.

"The Dynex Honeycomb Fillet is manufactured for use in Kiln Drying and Air Drying, being more suited to the selected length board operations. Maximum Kiln operating temperature is recommended as being up to 100°C dry bulb temperature.

The Dynex Fillet has been developed over a seven year period in conjunction with Panahome Innosho, Rotorua. The composite material finally settled on has been tested with an excess of 30 cycles at up to, including final steaming, and has proven to be very successful.

Ron van den Berg, Kiln Manager at Panahome Innosho, suggests that from their experience some of the advantages of the Dynex Fillet over the traditional timber fillets are:

- no waste,
- no splinters,
- easy handling,
- non staining,
- strong and durable,
- lightweight,
- uniformity of size,



Dynex fillet

- clean,
- suited for automatic or manual filleting,
- do not absorb treatment chemicals, and
- no waste or removal costs.

The benefits received from the ease of handling follows down to less downtime and more productivity which in turn leads to a significant COST BENEFIT".

For more details please contact:

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WOOD PROCESSING CONTACTS

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Sawmill Improvement & Quality Control	Peter Bayne
Scanning & Image Processing	Peter Bayne
Log Quality / Grade Recovery	John Roper / Don McConchie
Timber Grading / Timber Utilisation	John Turner
Remanufacturing	Jeremy Warnes
Wood Quality	Don McConchie
Alternative Species (to radiata) / Wood Quality	John Roper / Russell McKinley
Hardwood Sawing	John Roper / Tony Haslett
Timber Drying	Tony Haslett
Kiln Design / Kiln Control / Dryspec	Steve Riley / Richard Dandoroff
Moisture Meters	Ian Simpson
Antisapstain Treatments	Robin Wakeling
Preservative Treatments	Mick Hedley
Preservation Standards	Mick Hedley
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