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Forest and Wood Products Research and Development Corporation

Evaluation of Remedial Treatments for Surface Checks in Appearance Timber

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Evaluation of Remedial Treatments for Surface Checks in Appearance Timber

Prepared for the

Forest & Wood Products
Research & Development Corporation

by

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EXECUTIVE SUMMARY

Objective

The objective of this study was to review and evaluate the role and performance of fillers (and other potential treatments) as economical and practical remedial solutions to exposed internal checks in appearance grade sawn timber.

Key Results

The results from this study have revealed that there are a wide variety of commercial fillers available in the Australian and overseas markets. The products can be broadly broken down into seven different generic groups:

- Epoxy resin
- Shellac sticks
- Wax fillers
- Water-based fillers
- Oil-based fillers
- Auto body fillers (Flexible fibreglass putty)
- Glues

Extensive consultation with many timber suppliers, furniture manufacturers and research organizations, both in Australia and overseas, has confirmed that there are only minor differences in commercial products with little product differentiation. Many of the products found overseas appear to be very similar to those available in Australia. Wood conservation experts in Canada have critiqued a number of formulations and have developed two formulations based on epoxies and silicon rubber. These were filled with glass or phenolic microballoons to adjust the rheology, shrinkage and paintability/stainability of the fillers. There is some scope for the further investigation of these materials as additives to fillers.

The biggest drawbacks to the use of filling products by furniture manufacturers are the direct and opportunity costs, and the difficulty in matching filled areas with the surrounding wood after final staining. Attempts to quantify costs were unsuccessful. Anecdotal evidence suggests that some furniture manufacturers are starting to source timber species and suppliers with a reputation for producing timber with no or minimal internal checking.

Further Work

The remedial treatment of internal checking is a stop-gap approach that furniture producers are increasingly unwilling to undertake. Further work is recommended to investigate the causes of internal checking and methods of eliminating or minimising its occurrence. Some effort toward the development of practical means of detecting the presence of internal checking in timber is also warranted. The development of remedial treatments to either 1) match the characteristics of wood grain and colour or 2) remove the defective wood and replace it with another piece of wood with matching appearance, would

be of most benefit to the saw millers. A short term project addressing the immediate problem of creating a filler which matches timber grain and the colour of stained wood by the addition of an additive to the existing commercial filler products was suggested by members of the working group.

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INTRODUCTION

The use of Australian hardwood timber for the production of furniture can be regarded as a high value adding process. The value addition chain involves furniture manufacturers producing furniture components from the timber and assembling these components into a final product. The manufactured product may take the form of a table, chair, desk, cabinet, bed-frame or other pieces of furniture. The final step in the manufacturing process is the finishing of the product with stains and varnishes to enhance the natural beauty of the wood.

One disadvantage in utilizing some Australian hardwood species is the presence of defects in the timber. The most common defects found in hardwood species include:

- Internal checking
- Lifted grain
- Gum Veins
- Gum flecks

It has been suggested that internal checking (particularly in Victorian ash timber) is the greatest cause of customer complaints to Australian hardwood timber mills. One of the difficulties in using hardwood timber that is prone to internal checking is that it is often difficult to detect the presence of checking until late in the manufacturing process. Typically, checking is detected by a visual inspection of the face ends of the boards. The difficulty is that internal checking generally does not occur along the whole length of the board but only in certain areas. Sometimes the timber may have internal checking which is not evident on the face ends of the board. As a result, such defects can often be missed and are only detected either during the processing of the timber or, in the worst-case scenario, only exposed after the final sanding of a manufactured unit. The presence of internal checks in the timber is often revealed in profile mouldings or as lifted grain in flat-dressed products. This can lead to the downgrading or loss of an expensive manufactured product. Either way, a certain amount of value-adding to the timber has already been undertaken before these defects are detected.

Several hardwood mills incur considerable additional expenditure in attempting to detect internal checks before the timber is delivered to the customer. However, the detection methods are imperfect, and unacceptable levels of defective material are creating on-going problems for furniture manufacturers. Quantification of the dollar cost of this issue to both the timber and added-value manufacturing industries is difficult, owing to the commercial sensitivities involved, but it is acknowledged that costs are likely to run into the hundreds of thousands of dollars.

Figure 1. Internal checking in kiln dried Mountain ash window components (*left*) and lifting grain on dressed kiln dried Mountain ash (*right*).

Causes and prevention of internal checking in Eucalypts

Eucalyptus is generally a difficult timber to dry. The species are generally slow drying and collapse and collapse-associated drying degrade, particularly in low to medium density species, is common. Typical problems associated with drying include high shrinkage rates, steep moisture gradients, pronounced drying stresses and timber sets, surface checking of backsawn board faces and internal checking.

Good drying practice includes the protection of sawn timber before controlled drying in air-drying stacks or in pre-dryers. Protection of air-drying stacks from exposure to severe drying conditions, such as direct sunlight and high winds, is essential. Species susceptible to collapse are usually reconditioned in saturated steam at 100^{o}C after pre-drying to moisture contents of 15-20%.[1] Usually good recovery of collapse is obtained. Sometimes poor recovery of collapse can result if reconditioning is carried out while the core moisture content is above the fibre saturation point (FSP), i.e. >30%, or if the wood is dried below 12%. If timber containing a core moisture content above the FSP is reconditioned, poor recovery of collapse is usually associated with large internal checks and discolouration of the central zone.[1]

High levels of shrinkage due to collapse are common in low to medium density Eucalyptus species, particularly those from the pale-coloured ash group (*Eucalyptus regnans, E. delegatensis, E. nitens and E. viminalis,* and other species with distinct differences between earlywood and latewood). Collapse of the fibre walls during drying is a prerequisite for internal checking[2]. Collapse occurs during drying as water is removed from highly impermeable wood fibres which become distorted because of the high tensile forces generated in the lumen water. As a result the surface profile of the wood takes on a corrugated or otherwise deformed appearance. Internal checking is usually not evident until after the wood is further processed. It

[1] Rule, R., "*Internal Checking in Victorian Eucalypts. Identification of Techniques and Best Practices*" TPC, 2002.
[2] Ilic, J. (1999) "*Shrinkage-related degrade and its association with some physical properties in Eucalyptus regnans F. Muell*". Wood Science & Technology 33: 425-437

cannot be alleviated by reconditioning with steam. The effects of the checking are often seen in material after it is planed or deep moulded.

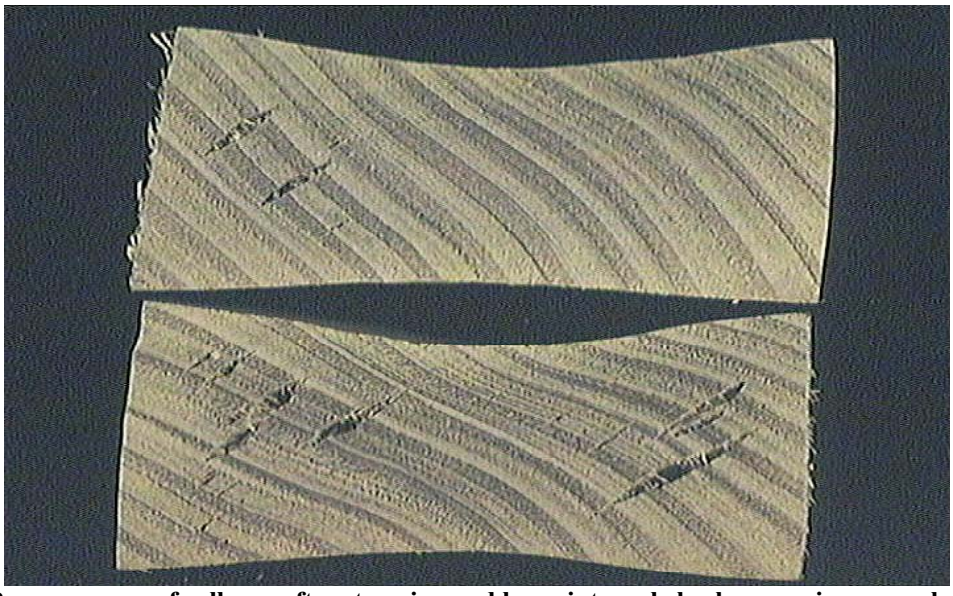

Figure 2. Poor recovery of collapse after steaming and large internal checks spanning several growth rings.

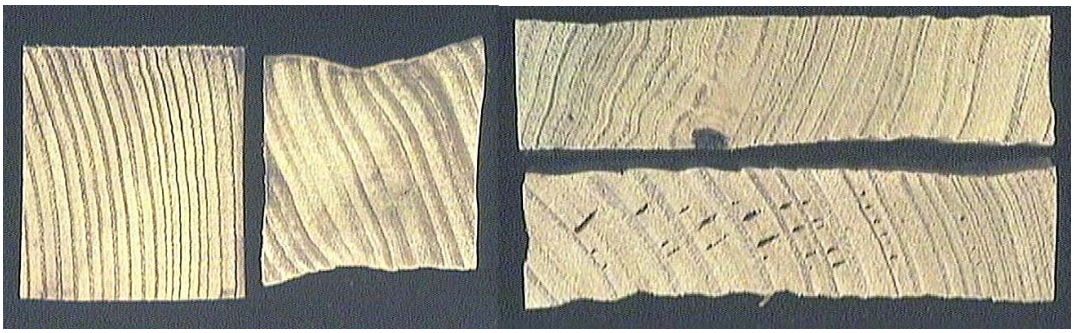

Figure 3. Collapse indicated by corrugated and distorted outline in specimen's cross-section compared with non collapsed specimen (left).

Why is drying slow and collapse high in eucalypts?

Upon transformation to heartwood, the death of living parenchyma cells is accompanied by the deposition of a variety of wood extractives and the frequent development of tyloses (growths) into the vessels through the vessel pit membrane, thus blocking the vessels. The wood extractives line and impregnate the fibre walls. One result of these processes in eucalypts is that the heartwood is highly impermeable, making it difficult for water to move during drying as there are no direct flow paths for the water other than diffusion. In addition, the moisture content in such material is high (often above 100% by dry weight of wood). This means that about half the weight of the wood is water. As it is the heartwood that constitutes most of the wood being

processed, drying is very slow in comparison to pine, which tends to consist predominately of sapwood.

Ordinarily, during wood drying, shrinkage is dependent on the wood density and the cell wall micro pores (capillaries) are large enough to allow the movement of moisture. Drying is then accompanied by the development of minor drying stresses, which cause little or no damage to the dried product. In eucalypts the porosity of the cell wall is low and pit capillaries are several orders of magnitude smaller than the openings in the pit membrane (margo) of the typical pine bordered-pit (ca 0.2µ). The evaporative forces associated with the removal of water exert very high stresses on the cell wall. When the cell lumen is water saturated, the removal of water is accompanied by a pulling together of opposite walls which causes collapse of the cell. Such cell collapse results in the overall shrinkage of the wood being much higher than that predicted by density alone. The different types of shrinkage that occur are illustrated in Figure 4.

Steam reconditioning can generally return collapsed wood to an appearance resembling its original shape, but if collapse is accompanied by internal checking, the checks remain. Reconditioning does not assist in the recovery of collapse arising from material containing reaction wood (tension wood).

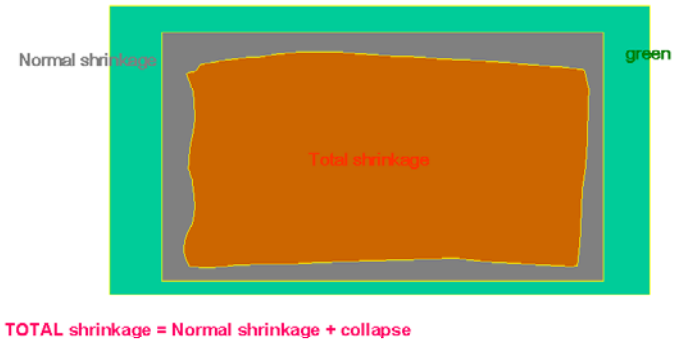

Figure 4. Comparison of shrinkages from green (outermost outline representing the undried state); normal shrinkage (uniform inner outline); total shrinkage including collapse (inner-most outline).

Different types of checking

Surface checking

Most eucalypts tend to check on back-sawn (tangential) faces, sometimes severely, but quartersawn (radial) surfaces usually remain comparatively free of checks. For this reason, and because of the greater stability of quarter-sawn timber, it is the preferred method of sawing of wood in Victoria and Tasmania that is intended for use in flooring, mouldings, joinery and other appearance products. When checks occur they tend to close towards the end of the drying process and may be hard to detect on the surface of the timber.

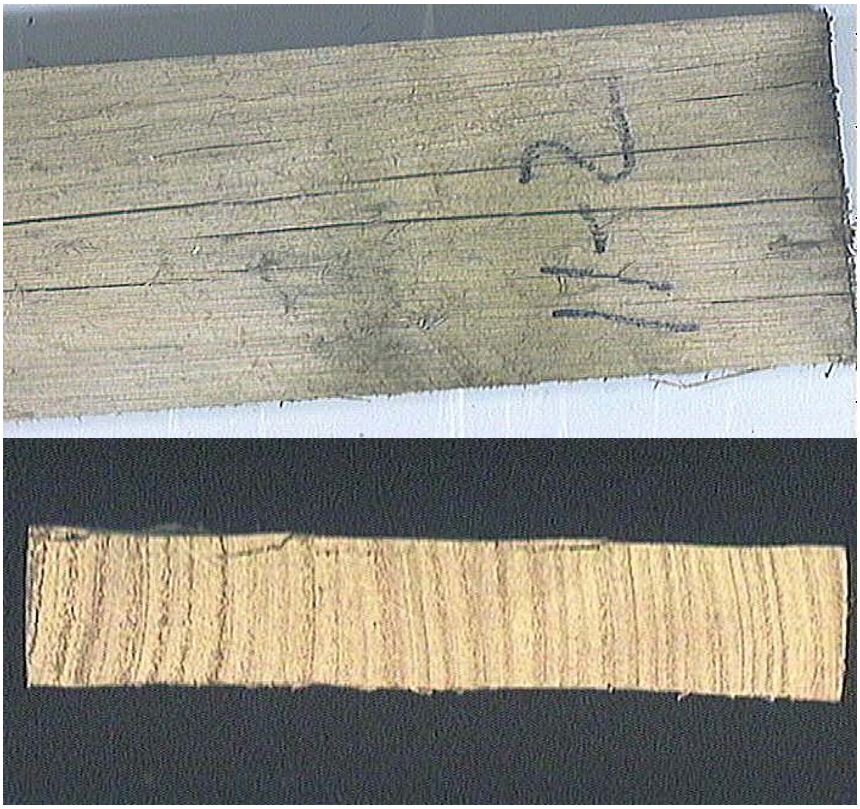

Figure 5. Surface checks in a backsawn board (above) not showing end-grain. Surface checks in radial face (below) caused by felling damage rather than as a result of drying.

Internal checking (honeycomb)

Internal checking is prevalent in young or old tress of susceptible species such as *Eucalyptus regnans, E. delegatensis E. nitens, and E. viminalis.* It is more common in material near the pith, and is more severe when high initial drying temperatures are used, although it can occur even at ambient temperatures.[2] Internal checking is usually more pronounced in boards greater than 15mm in thickness, and is usually absent altogether in thinner material.

Reconditioning tends to close the checks, but subsequent machining of the surface, especially deep moulding, can expose them and give them the appearance of surface checks. Currently there is no method that can be applied to eliminate checking in susceptible material.

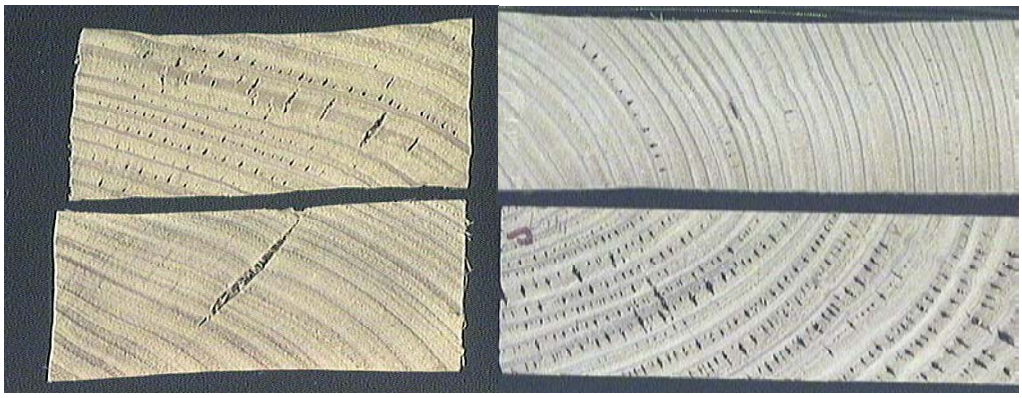

Figure 6. Internal checking with different levels of severity. The large drying check (lower left) is not associated with collapse.

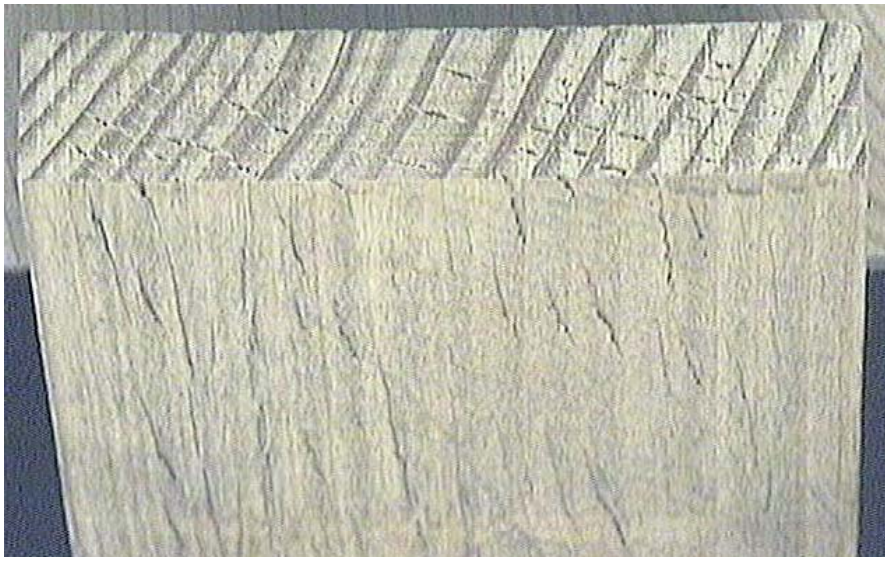

Figure 7. Internal checking evident on the surface of a board as raised grain.

Check formation

When wood begins to dry out, the surface layer attempts to shrink on an immovable (wet) core and is restrained from doing so. If the surface layer were removed from the surface and allowed to shrink unrestrained, it would normally shrink much more than it actually does. The same would apply to any thin layer taken from anywhere in the specimen. As a result, the layer dries in a stretched state creating a tensile stress. The more the layer stretches, the higher the stress becomes. There is a limit to which the wood can stretch across the grain, and the fibre strength properties have an important influence on this behaviour. This concept is illustrated in Figure 8 with the relative size of the 'difference' arrow indicating the severity of the stress. When the layer is stretched beyond the strength limit of the wood, a check will begin at the weakest point. The majority of these weak points in the wood structure will appear in the low-density earlywood as shown in Figure 9.

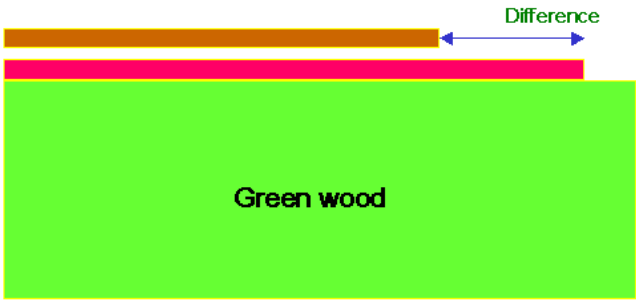

Figure 8. Shrinkage restraint. Upper rectangle indicates the shrinkage of an isolated layer of wood. The rectangle below indicates the amount that the restrained layer actually shrinks. "Difference" indicates how much it is effectively stretched.

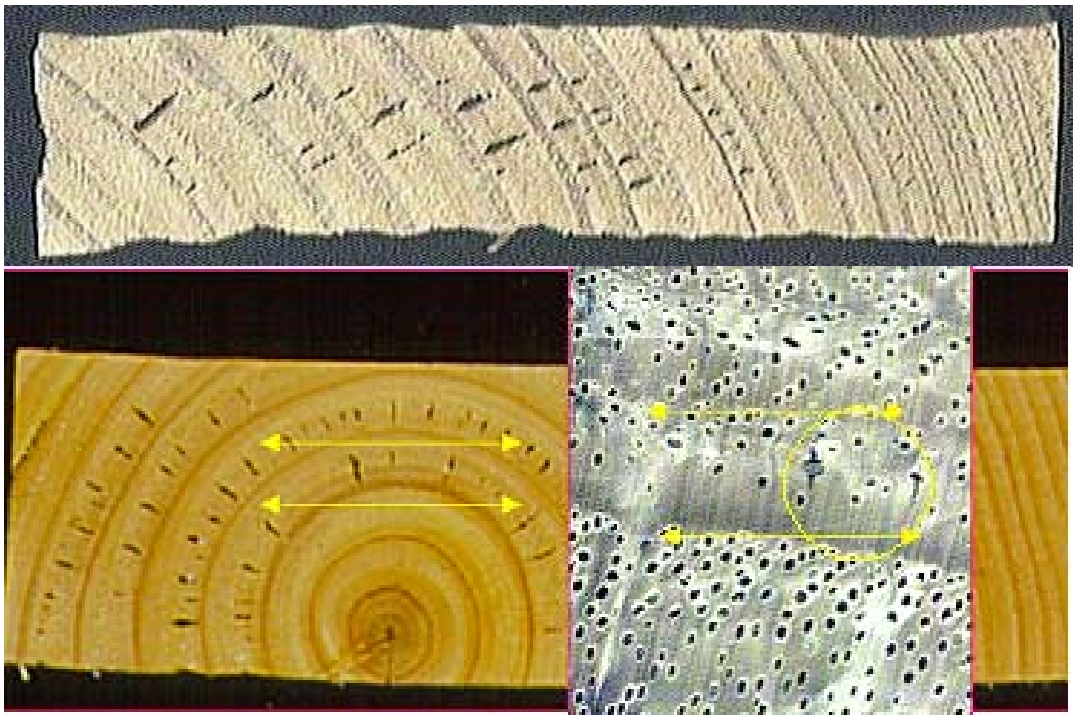

Figure 9. Internal checks mainly within the low-density earlywood (top). Differential shrinkage zones shown by arrows (bottom). Circle indicates the early formation of internal checks on a magnified portion of the cross section.

These points of low strength often occur at the junction of rays and vessels within the low-density earlywood. A clear association with wood collapse can also be seen from the distorted outlines of the wood vessels in the upper part of the enlarged image of the wood structure in Figure 9. In the collapse susceptible species that have a marked difference between earlywood and latewood, there is an interaction between normal shrinkage and collapse. The interaction will produce differential movement of the earlywood and latewood. During the early stages of

drying when the wood is still above FSP, excessive collapse occurs mainly in the earlywood zones. Collapse susceptible material often shows this corrugated outline a day or two after timber is sawn. This effect can be seen in Figure 9 (top). As drying progresses, areas of wood surrounding the rapidly collapsing zones of wood buckle. If the latewood bands or existing dry zones of wood are sufficiently strong to resist the tendency to deform, the collapsed earlywood zone will form checks in low strength material. This process will continue progressively from the outside of the board to the inside until all the wood is below the FSP.

When the moisture content of the central part of the board has fallen below the FSP, the timber can be reconditioned with steam. Usually the reconditioning process recovers the buckled or collapsed zones, and the checks tend to close, but they do not disappear.

Management of internal checking

Currently there are no specific drying schedules for preventing internal checking in some susceptible material. However, internal checking may be minimised by pre-drying with mild conditions.

Material near the pith from approximately the first 10 growth rings may show signs of internal checking. In older wood, the incidence of internal checking will vary; it may be present or absent, although there are indications that it is more likely to occur in growth rings with very low-density earlywood particularly in boards thicker than 25mm.

Reduction in checking can be obtained in check-prone material by drying thinner boards e.g.

- Boards <12–15 mm thick tend to show no appreciable checks
- Checking increases with board thickness greater than 15 mm

Thin boards are less susceptible to internal checking because they can distort more readily during drying.

Temperatures above 30^{o}C, high air velocities and low humidity should be avoided during the initial stages of drying. Whether or not such mild conditions need to be maintained throughout the entire pre-drying stage is still unresolved, but a more conservative approach may be safer. However, it is absolutely critical that the core moisture content of the timber be dried below FSP prior to reconditioning with steam. This is important because little or poor collapse recovery will take place. Any part of a board still above FSP will re-collapse and probably check excessively upon kiln drying (see Figure 1).

Some degree of checking may be acceptable in applications where the checks will not be exposed or are concealed e.g. the underside of panelling or flooring. If the wood is to be used

for deep rebated furniture components and any checking is likely to be exposed, its presence may be revealed on the end-grain by exposing a cleanly cut cross-section 100 mm or more from the end of a board. Any internal checks will be seen in the low-density earlywood. Often, when the orientation of the growth rings is at an angle to the faces, raised grain may be evident as indicated in Figure 6.

Scope of the current study

Both timber mills and furniture manufacturers are investigating methods for the 'remedial' treatment of internal checks manifest either as internal checks on the face ends of the timber or as lifted grain on flat dressed surfaces. There are many commercial products available in Australia. However, no single product has currently been identified as being the solution to the problems faced by both the saw millers and the furniture manufacturers. Identification or development of a simple, cost-effective method for rectifying checked material during the (e.g. furniture) manufacturing process would generate substantial benefits to industry. For the timber industry, these benefits will take the form of improved relationships with end-user customers, reduced costs of reject material, and opportunities for increased sales. For manufacturers, benefits will include reduced costs associated with downgrading added value material, and better product quality.

The Forest and Wood Products Research and Development Corporation funded this project to evaluate the role and the performance of fillers and other potential treatments as economic and practical remedial solutions to exposed internal checks in appearance grade sawn timber.

The key elements of the project were to:

1. Establish an industry working group (timber industry, filler suppliers and end users).
2. Review current and potential filler types - including 'non-traditional' fillers - and application methods (input from working group), collate information and supply to the working group.
3. Rank the fillers and application methods for practicality, performance and cost (working group).
4. Produce a review document to identify and summarise project outcomes.
5. Transfer project outcomes to industry as follows:
    (a) Draft fact sheets on the themes of (i) a summary of causes of and management practices for internal checking (targeted at end users) and (ii) a proposed set of best practices for dealing with internally checked material.
    (b) Conduct two industry workshops to present the key findings of the review.

METHODOLOGY

Working Group

An Industry Working Group was established which met on 8 November 2001. The transcripts of this meeting are contained in Appendix E. As a result of the working group discussions, a list of remediation (filler) requirements was completed. The requirements for a filler for remediation purposes would have most or all of the following characteristics:

1. Non-shrinking
2. Acceptable cure time
3. Machinable
4. Stainable (colour matching)
5. Compatible with a range of finishes
6. Compatibility with abrasive methods (sanding)
7. Easy application
8. Capable of bridging checks
9. Adhesive properties
10. Flexible
11. Tough (act as reinforcement)

The working group listed the most likely defects to be filled in timber as:

- Lifting grain
- Gum veins
- Internal checks

An evaluation form (Appendix C) was forwarded to members of the Working Group who were requested to rate the various filler categories against the eleven criteria (see above) considered desirable for a remedial treatment to possess. Filler types were rated as *excellent*, *good*, *satisfactory* or *not satisfactory* against each criterion. Four completed evaluations were received.

Industry Contacts

Local and international timber, furniture, and filler manufacturers and suppliers and products and research organizations were contacted for discussions on products for the remediation of checked timber. Australian contacts were made by physical visits, telephone or email. Overseas information was obtained through Internet searches, by telephone and by email. A list of individuals, companies and organizations contacted is given in Appendix D. In many cases, the Australian timber and furniture manufacturers were willing to discuss their approach to the remediation of checked wood. Discussions with manufacturers and suppliers of filler products

centred on the variety of products that are available in Australia and overseas and the qualities of those products. The following questions were addressed:

1. What is nature of their operations? (eg. furniture manufacturer)
2. Is internal checking an issue?
3. What species of timber does internal checking occur in?
4. Are remediation techniques employed? What are they (materials, manufacturers and suppliers)?
5. Man hours the filling process takes?
6. What are the finishes that filling is compatible with? (eg. 2-pack polyurethane)

The questions listed above were also given to sawmills to give to overseas representatives to discuss with overseas furniture manufacturers. No responses were received back.

Many of the overseas furniture manufacturers were unwilling to disclose the products, if any, they used. Several overseas research organizations that specialized in wood and timber products were contacted and asked whether they were aware of any work on, or review of fillers that had been undertaken with a view to their use in filling checked timber. These organizations could offer very little assistance but some were able to provide information on manufacturers of fillers who were in turn contacted.

RESULTS AND DISCUSSION

A comprehensive review of the range of commercial fillers available in Australia has been undertaken. This list is given in Appendix A. A list of wood fillers available in the United States and Europe has also been collated and is listed in Appendix B. Grain fillers, which are designed to fill pores in the wood surface and produce a smooth and flat finish, have been excluded.

There are a large number of brand name wood fillers available in the market. These products can be broadly differentiated into seven different classifications depending on their chemical make-up[3]:

- Epoxy resin
- Shellac sticks
- Wax fillers
- Water-based fillers
- Oil-based Putties

[3] Gerner, A., *"Using Wood Fillers."* Australian Wood Review, Loganholme, Qld: Interwood Holdings Pty. Ltd.; 34:88-90 (2002).

- Auto body fillers (Flexible fiberglass putty)
- Glues

The products available within these seven different groups may have slightly different characteristics depending upon their specific formulations. For example, some of the water-based putties are so soft they are difficult to sand while other water-based putties are of acceptable hardness for sanding.

Most of the 'novel' fillers that have reportedly been experimented with in the past by the industry players were actually trial and error variations of existing formulations (eg. addition of sawdust to putty). Some of the products from overseas appear to have slightly different formulations and may act favourably on Australian timbers.

The following is a brief description of the different classes of fillers found both here and overseas.

Epoxy Resin

Epoxy resins are two-part mixtures that must be mixed accurately to achieve correct hardening. Epoxies are clear or can have oxide powders or other materials (eg. hairs) incorporated in them (either by the end user or by the manufacturer) to create a coloured or textured look. They set hard and can be used as reinforcement for the wood. Many of these systems are used for the repair of rotted or decayed wood such as joins in windows and doors. They can also be used in large holes and, because they cure hard, they are resistant to damage after setting. Epoxy resins tend to shrink as they cure so holes may have to be topped up during the curing process. These fillers are applied to the timber before staining and hence can be used by both furniture manufactures and timber producers. Polyfilla's Painter's Putty is an example of an epoxy-based filler found in Australia.

It should be noted that epoxy-based fillers have been tested by wood conservators both in Australia and overseas. Many formulations have been tested where the epoxy resin (quite often some form of Araldite) is mixed (either by the manufacturer or the end-user) with a number of inert fillers such as whiting, wood dust, china clay, glass or phenolic microballoon.[4] An epoxy/microballoon mixture has been adopted for use in the Ethnology Laboratory of the Canadian Conservation Institute.[4,5] Epoxies that have been further modified with other additives

[4] D. W. Grattan and R. L. Barclay, "A study of gap-fillers for wooden objects", *Studies in Conservation*, **33** (1988), 71-86.
[5] R. Barclay and C. Mathias, "An epoxy/microballoon mixture for gap filling in wooden objects", *Journal of the American Institute for Conservation*, **28** (1989), 31-42.

and fillers have been used for the repair of historic wooden buildings.[6] Other conservators have used silicone rubber mixtures[7] but there can be some difficulty in painting these materials.[8] There appears to be some scope to further investigate the use of epoxy-based fillers that have been modified by the inclusion of modifiers such as microballoons.

One of the overseas research organizations (BRE) contacted suggested that the Dry Flex system by Window Care Systems was one of the better products for giving a flexible, durable repair. Window Care Systems Ltd. is a wholly owned subsidiary of the Dutch Company, Repair Care Systems B. V. specialising in all aspects of timber repair. This product is a modified two-part epoxy that contains a special two-part liquid epoxy primer. One of the marketing points for this product is that there is colour change from green to yellow when the two components are correctly mixed. It is claimed that this product behaves just like wood and can be planed, routed, nailed, screwed and is very flexible. It is further claimed that it has good "slump" resistance and can be painted with all types of solvent and water based decorative paints and wood stains. This product is used with a primer to promote good adhesion to the wooden substrate.

Shellac Sticks

Shellac sticks are small hard sticks made of a blend of shellac and wax. The sticks are heated, usually with a hot knife, to soften the wax, which is then melted into the holes in timber. Chiselling followed by sanding is the usual method used to remove the excess because shellac dries very hard and very quickly (just a few minutes). Colours vary according to manufacturer. Like wax fillers, this type of filler is applied after staining and hence they are only suitable for use by the furniture manufactures.

Some examples of shellac filler sticks available in Australia are those made by Woodtek and Konig (Ko 142 Shellac and Ko 143 Hard Wax Plus).

Shellac sticks have an indefinite shelf life and can be used on an as needs basis. Shellac sticks are most appropriate for touch up work or for very small faults that are not very deep.

Wax Fillers

Wax fillers are used most commonly for filling small imperfections and for touch-up work. They are very similar to shellac sticks. They are commonly used in the restoration of furniture. Wax fillers can be further differentiated into two classes of products, natural waxes (such as

[6] M. Philips and J. Selwyn, "Epoxies for wood repairs in historic buildings", *Heritage Conservation and Recreation Service Publication No. 1*, US Department of the Interior, Washington DC (1978).
[7] D. W. Grattan and R. L. Barclay, "A silicone rubber/miroballoon mixture for gap filling in wooden objects", *ICOM Committee for Conservation, 8th Triennial Meeting*, Sydney (1987) Vol 1, 183-187.
[8] Benita Johnson, National Gallery of Australia, *private communication*.

beeswax) and synthetic waxes. The wax fillers are often sold as wax sticks which can be broken off and worked with the fingers to soften the wax prior to pressing into holes in the timber or are rubbed on to small imperfections such as cracks and scratches. Waxes can also be melted and dripped into gaps and holes. This is usually the preferred method of application to be used if the holes to be filled are large. A chisel is used to remove the excess and a soft cloth can be used for buffing. Wax fillers come in a wide variety of colours that can be mixed and are often sold in boxed sets. Waxes are used after staining and hence can be well colour matched to the finished product. Some waxes can be used prior to the final protective coat being applied. Waxes have an indefinite shelf life and can be used on an as needed basis.

Some examples of waxes available in Australia are:

- Gilly Stephenson's Beeswax Filler Sticks
- Liberon Wax Filler Sticks
- Mirotone's Microwax Beeswax Sticks
- Woodtek Hard and Soft Wax Filler Sticks
- Inca Beeswax Instant Repair Sticks

Water-based Fillers

Water-based fillers are probably the best recognized of the filler products. These fillers are based on a general formulation of bulking agent, carrier and binder[9]. Many timber-coating companies offer a water-based filler in their range. These fillers can be already premixed as ready-to-use (RTU) systems or they are sold as dry powders and are mixed with water at the point of use. They are fast drying, have a long shelf life, and are compatible with a wide variety of finishes. They are easy to work and sand. Drying times depend on the thickness of the filler, the depth of the hole and the ambient air temperature. Drying times can be decreased by the use of heat guns. Most brands claim to air dry in about an hour. Many brands have a range of colours to choose from and can be colour matched by blending different colours. The colour of these fillers can also be changed by the addition of universal tinters to achieve the correct colour match. These materials are applied to the timber before staining and are therefore suitable for use by both furniture manufacturers and timber millers. Care needs to be taken with these materials as they have a tendency to shrink while drying.

Some examples of water-based fillers found in Australia are

- Agnew Water Putty Multipurpose Filler
- Cabot's Woodtone Putty
- Colonial Products Water-based Wood Filler
- Feast Watson Timberfill

[9] Jeff Jewitt, "Using Paste Wood Fillers" at http://www.wwforum.com/faqs_articles/fillers.html

- Franklin International Titebond Wood Filler
- Intergrain Woodblend
- J. W. etc Woodfiller
- Mirotone Microputty 916
- Timbermate Water-Based Wood Filler
- Wattyl Woods Stop Timber Putty

A number of overseas water-based fillers were also found. The following list is not exhaustive but covers the products commonly carried by the larger supply companies. Some of these fillers are:

- OSI FI:X Wood Patch-Easy Water Cleanup Formula
- BonaX Pacific Filler
- Colour Putty Company's Waterborne Colour Putty
- Dura Seal Trowelable Wood Filler
- Dura Seal Wood Patch
- Dura Seal Wood Putty
- Eclectic Products Inc Famowood Water-based Wood Filler
- H. F. Staples Miracle Wood Latex Filler
- H. F. Staples Wood Tone Putty
- Laurence-David Inc Celo-Set Wood Filler
- Mohawk Finishing Products Fil-O-Wood
- Red Devil Powder Wood Putty
- Woodwise Full-Trowel Filler
- Woodwise Wood Patch
- Woodwise Powdered Wood Filler
- Woodwise No-Shrink Patch Quick

In addition to the water-based fillers especially designed for timber, there are other materials, such as plasters, that could be used for filling checks. The disadvantage of these materials is that they often dry to a white finish and hence do not match the surrounding timber character. These materials would only be useful for timber objects that are to be painted over.

Oil-Based Fillers

Oil-based wood fillers are often based on natural oils such as linseed oil and were amongst the earliest fillers developed. Like the water-based wood fillers, the general formulation of oil-based fillers consists of bulking agent, carrier and binder[9]. Oil-based fillers are easy to apply but require a longer drying time than water-based fillers. Drying times are often in the order of days to weeks, limiting the industrial use of these products where time constraints are important.

Some examples of oil-based fillers in Australia include:

- Colonial Products Old-fashioned Linseed Oil Putty
- Polyfilla Putty
- Robertson's Putty
- Selleys' Special Putty
- Selleys' Wood Filling Putty

Some examples of oil-based putties overseas include:

- Bartley Oil-based Wood Filler
- Color Putty Company Oil-based Color Putty
- H.F. Staples Professional Wood-tone Putty

Auto Body Fillers

Auto body fillers are usually based on polyester resins. Some resins may be modified with styrene. They often come in two-parts that must be mixed accurately. Auto body fillers dry very quickly, within about ten minutes, to a very hard solid. Their hardness makes these products ideal for sanding. The hardness may be excessive for some uses and they can move if used to fill large holes. They can also shrink while curing.

Auto body fillers come in a large variety of colours and neutral shades and can be coloured using universal paint tinters by the end-user. Representatives of many of the hardwood producers contacted believe that this is the most effective product for filling gum veins. Some manufacturers have tailored some of these products especially for timber applications.

Examples of auto-body fillers in Australia include:

- GPI Automotive Products Kontor Light Weight Body Filler
- K&H Surface Technologies PRObuild series of body fillers (includes some formulations especially designed for use with wood)
- Selleys' Plasti-bond
- Tremco All Purpose Filler

Many of the manufacturers of imported Asian furniture exhibited at the recent 2002 Furntex furniture trade show appeared to have used auto body fillers to repair holes in the wood. Auto body fillers are inexpensive to use.

Glues

Glues can be used as fillers, but they have fairly limited applications. There are numerous types of glues including 'superglue', animal glues (which must be heated for application), PVA and urea formaldehyde. A glue-filled area tends to stand out after polishing and the glue may move over time. Glues can be effective in stabilising 'lifting grain'. Many woodworkers use mixtures of wood dust and glue to make a crude wood filler. Such mixtures may not be stable and can move over time.[3]

Glues are not supplied in a range of colours and most dry to a clear finish. However, they can be surface tinted with a spirit stain prior to polishing.

Ranking of Filler Classes by the Working Group

The working group was asked to rank the seven different classes of fillers according to a set of 11 criteria. These criteria were:

- Non-shrinking
- Acceptable cure time
- Machinable
- Stainable (colour matching)
- Compatibility with a range of finishes
- Compatibility with abrasive methods (sanding)
- Ease of application
- Capacity to bridge checks
- Adhesive properties
- Flexible
- Tough (act as reinforcement)

Four responses were received. The responses are summarised in Appendix C. Three were from timber saw millers and one from a furniture manufacturer. The furniture manufacturer commented that whilst they were aware of these fillers, they had not used many of them.

The three timber saw millers who responded had varying experiences of the different fillers. One saw mill had done extensive tests on a number of different fillers. No class stood out as exceptional across the range of criteria. Examples of each filler class were found to range from not satisfactory to good or excellent for the eleven criteria. The other two mills suggested that auto body fillers were very good. These were often used tinted with black to make the surface check resemble a gum vein or pocket. Water-based wood fillers and glues were rated satisfactory to good. The other filler classes were rated not satisfactory to good against the criteria.

Overall, there does not appear to be an extraordinary class of filler or product that is universally recognized. Saw millers have tested many different fillers across the seven classes. The furniture manufacturers have not tested as many and do not believe that any filler exists which would meet their requirements. They do not want to have to use fillers, mainly due to the increase in labour costs, and are increasingly turning to timber species with reputations for little or no checking.

Overseas Experience

A survey of filler suppliers, furniture manufacturers, timber suppliers and research organizations overseas was undertaken in the course of this project. Research organizations that had a wood background were especially targeted. The list of contacts can be found in Appendix D. The majority of overseas contacts were from North America and Europe. Some contacts from Indonesia were also made. There are a number of commercial wood fillers in the market. As in Australia, many of these fillers can be classified into the seven broad groupings discussed previously. It did not appear that there was anything new or unusual being used in the industry, any innovative fillers being commercially sensitive. Many of those contacted referred us to the major commercial fillers such as those produced by the Willamette group of companies in the USA or the ICI chemical company in the UK. Most of the research organizations contacted could not offer much assistance regarding fillers. The UK organization, Building Research Enterprises, was the only one that had done any comparison testing over the years. These tests were targeted more towards wood repair systems than the filling of appearance grade furniture.

One large American furniture manufacturer suggested that 'patching fillers' may be suitable. These fillers are based on resins of cellulose, rosin ester or emulsions with various extenders added. It was recommended that the emulsion type fillers gave the best results with good colour acceptance and no shrinkage upon drying. The rosin ester type of filler did not accept colour well while some of the cellulose fillers were acceptable though others were difficult to work with mechanically. The manufacturer declined to provide brand names of these types of fillers. Another effective method of filling was to reverse roll coat a panel with a water-based filler. The major disadvantage with this method is that the whole panel must be treated. Internal checking was not regarded as a significant issue with this manufacturer as it was seen only occasionally in the walnut, oak and beech timbers used.

The most innovative group of fillers encountered were those used by professional conservators of wooden artefacts. Barclay and Gratten at the Canadian Conservation Institute investigated many of these.[4] After a study of a number of formulations, they have focused on the use of either epoxy or silicon rubber based formulations filled with microballoons.[4,5,7] The microballoons (or microspheres) are used as rheology modifiers and as a filler. The use of

microballoons is well known in the formulation of adhesives, plastics and paints. One US filler (Carpenter's Finishing Wood Filler by Elmers) advertises the fact that it contains microspheres for easy staining.

In summary, it appears that there is little new or innovative in the North American or European marketplaces.

Industry Response

The general response to the use of fillers for the remedial treatment of timber has been unenthusiastic. The use of fillers is a labour and time intensive process with many furniture manufacturers unable to justify dedicated staff for filling alone. Most of the sawmills surveyed, including those cutting mixed species and Victorian ash, do not use fillers at all. The cost associated with using fillers is particularly significant when the opportunity costs are taken into consideration e.g. producing other furniture components. Some of the disadvantages of using fillers that were cited included:

- The length of time required for the filler to dry
- The difficulty in achieving a colour match between the stained wood and stained wood filler
- Incompatibility of some fillers with some finishes

Attempts were made to quantify the cost of using fillers versus the cost of downgrade and reject units. Due to the commercial sensitivities of this information, little insight was obtained.

Detecting internal checks in incoming timber packs or, worse still, on partially or completely assemble units, has led to considerable frustration within the appearance grade furniture industry. Furniture manufacturers would like to see the issue of internal checking resolved by the saw millers. There is anecdotal evidence that furniture manufacturers are turning to timber species or saw millers with a history of producing timber with no or minimal internal checking. It is recommended that future work look into the causes of internal checking and methods of eliminating or minimising its occurrence. It is also recommended that work be undertaken in detecting the occurrence of internal checking in dry timber in order to facilitate a reduction in its incidence in material supplied to furniture manufacturers. The use of non-destructive evaluation (NDE) techniques would be particularly beneficial.

The response by saw millers on the potential use of the fillers as a short term solution to the immediate problem was slightly more enthusiastic. One respondent indicated that the development of remedial treatments to either 1) match the characteristics of wood grain and colour or 2) remove the defective wood and replace it with another piece of wood with matching appearance, would be of most benefit to the saw millers. A project to create a filler which

matches timber grain and the colour of stained wood by the addition of an additive to the existing commercial filler products is also warranted and has been suggested by members of the working group.

RECOMMENDATIONS AND CONCLUSIONS

The purpose of this project was to review and evaluate the role and performance of fillers (and other potential treatments) as economical and practical remedial solutions for exposed internal checks in appearance grade sawn timber.

During the course of the work, many different commercial fillers were found to be available in the Australian and overseas markets. Despite the numerous brand names of filler, it was found that all of the products could be broadly classified into seven product groups based on their composition. These seven generic groups were:

- Epoxy resin
- Shellac sticks
- Wax fillers
- Water-based fillers
- Oil-based fillers
- Auto body fillers (Flexible fibreglass putty)
- Glues

An extensive consultation process encompassing timber suppliers, furniture manufacturers, fillers suppliers and research organizations, both in Australia and overseas has found that there are only minor differences in commercial products. Many of the products available overseas appear to be very similar to those available in Australia. No one stand out filler product was found. The choice of filler used was often based on personal preference and/or required need. The number of different end-user requirements combined with the number of different filler choices would make the testing of fillers cumbersome. Wood conservation experts in Canada were found to have critiqued a number of formulations, both commercial and homemade. They developed two formulations based on epoxies and silicon rubber fillers that have been modified with glass or phenolic microballoons. These microballoons were use to adjust the rheology, shrinkage, paintability/stainability and reduce the overall cost of the filler. There might be some scope for the further investigation of these materials.

There are several disadvantages in the use of fillers. The direct and indirect costs of using the filler and the difficulty in matching filled areas with the surrounding wood after final staining were cited as drawbacks. Attempts to quantify the costs were unsuccessful. The adoption of fillers as a solution to internal checks is seen as both uneconomic and impractical by both sawmills and furniture manufacturers and an approach that people are unwilling to make.

Anecdotal evidence suggested that some furniture manufactures were seeking to source timber species and suppliers with a reputation for producing check-free timber.

With many end users unwilling to adopt the wide spread use of fillers, further long term work is recommended to investigate the causes of internal checking and methods of eliminating or minimising its occurrence. Some effort directed towards the development of practical means of detecting the presence of internal checking in timber before use by the furniture manufacturers is also warranted. A short term project addressing the immediate problem of creating a filler which matches timber grain and the colour of stained wood by the addition of an additive to the existing commercial filler products is also warranted and has been suggested by members of the working group. Comparative testing between filler classes would have merit, but due to the number of different fillers on the market, combined with different end-user requirements, such a study could be scientifically challenging.

APPENDIX A List of Commercially Available Fillers in Australia

Name	Company	Type of Filler	Notes
Inca Beeswax Instant Repair Sticks	Acecroft	Beeswax	
Water Putty Mutli purpose Filler	Angew		Powder
Plastibond	Aussie Grip		Translucent filler Sets in 20 min.
Cabot's Woodtone Putty	Cabots (Orica Woodcare)	Water-based	Can be finished with any Cabots water and oil-based clear finishes and wood stains
Permafix All Purpose Filler	Colonial Products	Acrylic	
Wood Filler (water-based)	Colonial Products	Water-based	
Old-fashioned Linseed Oil Putty	Colonial Products	Linseed oil-based	
Internal Filler	Colonial Products		Powder
Steelframe Putty	Conway	linseed oil-based (?)	
Timberfill	Feast Watson (Orica Woodcare)	Water-based	8 timber tones Can be stained
Titebond Wood Filler	Franklin International	Water-based Latex	Light yellow colour 10 min. dry time
Titebond Professional Wood Filler	Franklin International	Synthetic polymer Wood fibres	6 colours
Easy Filler	Fuller		
Building Filler	Fuller		
Beeswax Filler Sticks	Gilly Stephenson's	Pure beeswax	6 colours
Kontor Light Weight Bodyfiller	GPI Automotive Products	polyester	
Woodblend	Intergrain (Orica Woodcare)	Water-based	Interior/exterior use 9 colours (Australian timber)
Wood Filler	J.W etc	Water-based	
PRObuild flexi wood filler	K&H	Acrylic	
Kahfil	K&H	2 part body filler	
Toucan	K&H Surface Technologies	2-pack polyester	Automotive filler used in the furniture industry
PRObuild Interior Filler Powder	K&H Surface Technologies		White colour
PRObuild Quickset Builders Filler	K&H Surface Technologies		White colour
PRObuild All Purpose Filler ready Mix	K&H Surface Technologies		White colour
PRObuild All Purpose Filler Powder	K&H Surface Technologies		White colour

PRObuild Fine Surface Filler ready Mix	K&H Surface Technologies		White colour
KO 130 Quick Filler	Konig		
Ko 135 Edge Sticks	Konig		
Ko 140 Soft Wax	Konig		
Ko 141 Hard Wax	Konig		
Ko 142 Shellac	Konig	Shellac filling sticks	
Ko 143 Hard Wax Plus	Konig	Synthetic Shellac	
Ko 150-153 Rex-Lith Polyester Filler	Konig	2 component polyester	
Wax Filler Sticks	Liberon	wax	Liberon is winding down supply in Aust & NZ 25 colours
Microfil 914	Mirotone	Silica	Natural or range of colours Overnight drying
Mirowax Beeswax sticks	Mirotone	bees wax	
Microputty 916	Mirotone	water-based	9 colours
Putty Sticks	Miro-Wax	Wax	10 colours
Wax	Mother of Pearl	Pure beeswax	
Deep and Smooth	M-Utli-Mate	Acrylic	White 24 hour dry time Fills large holes
Timber filler	Nordsjo		2 hour dry time
Painter's Putty	Polyfilla	epoxy-based	
Interior Powder	Polyfilla	plaster-based	
Woodflex	Polyfilla		Exterior
Mirror Finish	Polyfilla		
Putty	Polyfilla	Linseed oil-based	2-3 days before coating
Skim coat	Polyfilla		Used for plaster
Interior Timber	Polyfilla		
Large Cracks	Polyfilla		
Quick-set Watercrete Multi purpose patching cement	Prep		
Patch'n'Fill Multi Purpose Filler	Red Devil		
Robertson's Putty	Robertson	Linseed oil-based	
XT 590	Sayerlack (Timbalac is Aust. Distributor)	one pack binder	To be mixed with wood dust
Wood filling Putty	Selleys	Oil-based	Used with oil or water-based top coats 1-4 weeks before coating
Spakfilla	Selleys	Plaster-based	Dries white Cellulose reinforced non-shrinking powder filler
Spakfilla Rapid	Selleys		RTU

Maple Plastic bond	Selleys	solvent based	Can be sanded or coated within hours
Plasti-bond	Selleys	polyester	
Aquadhere 2 part Gap Filling Wood Adhesive	Selleys	polyureathane	2 pack
Special Putty	Selleys	Linseed oil-based	
Timbermate Water Based 4-in-One	Timbermate	Water-based	Natural plus 9 colours 20-30 min. dry time
Waxstix	Timbermate		
Porion Exterior Flexible Filler	Timbermate		
All Purpose Filler	Tremco	polyester	
Builder's Bog	Turbo		Can be used with proprietary tinter
Pearl Hide Glue	U-Beaut Polishes	animal glue	Mix with talc to form a wood filler
Easy-fill Wood grain Filler	Wattyl	solvent based	Mix 4:1 parts with turps 5-8 min. dry time to sanding Designed for open grained timber eg Maple, Walnut and Cedar
Woods stop Timber putty	Wattyl	Water-based	9 colours 1 hour dry time to sanding
Wood-Fill	Wood-Man's Timber Finishes	Acrylic	White plus 8 colours 1 hour dry time to sanding
Wax	Woodtek	Hard and soft was fillers	
Shellac	Woodtek	Shellac filling sticks	

APPENDIX B List of Commercially Available Fillers Overseas

Name	Company	Type of Filler	Notes	Country of Origin
FI:X Touch Up Stix	OSI (a division of Sovereign Speciality Chemicals)	Wax-based	12 colours	USA
FI:X Wood Patch	OSI (a division of Sovereign Speciality Chemicals)		12 colours	USA
FI:X Wood Patch - Easy Water Cleanup Formula	OSI (a division of Sovereign Speciality Chemicals)	Water-based	1 colour	USA
Oil-based wood filler	Bartley	Oil-based	Used to fill open pores. Can be tinted	
Pacific Filler	BonaX	Water-based	2 tones (may be tinted)	USA
Yellow Label Interior Wood Filler	Brummer		13 colours	UK
Wooden Flooring Filler	Brummer			UK
Two-Part Wood Filler	Brummer			UK
Wood Filler Sticks	Brummer			UK
Waterborne Colour Putty	Color Putty Company	Water-based	Post-stain addition. 17 colours	
Oil-based colour Putty	Color Putty Company	Oil-based	Post-stain addition. 17 colours	
Ultra Tough Wood Filler	Cuprinol Ltd Wexham Rd Slough, Berkshire SL2 5DS		2 part system 2 tones	UK
All Purpose Wood Filler	Cuprinol Ltd Wexham Rd Slough, Berkshire SL2 5DS		5 colours	UK
High Performance Wood Filler	Cuprinol Ltd Wexham Rd Slough, Berkshire SL2 5DS		4 colours	UK
Miracle Wood	Cuprinol Ltd Wexham Rd Slough, Berkshire SL2 5DS		1 colour only	UK

Floor Filler	Cuprinol Ltd Wexham Rd Slough, Berkshire SL2 5DS		3 colours	UK
Vinyl Spackling	DAP		RTU	USA
Plastic Wood Solvent Wood filler	DAP			USA
Latex Plastic Wood	DAP			USA
Painter's Putty	DAP			USA
Water Putty	DAP		Dry Mix	USA
Wood Dough	DAP			USA
Dura Seal Trowelable Wood Filler	Dura Seal	Water-based	Stainable	USA
Dura Seal Wood Patch	Dura Seal	Water-based	Stainable	USA
Dura Seal Wood Putty	Dura Seal	Water-based	Non-stainable	USA
Famowood Wood Filler	Eclectic Products Inc (sudsidary of Willamette Valley Company)	Solvent-based	Comes in 20 colours	USA
Famowood Water-based Wood Filler	Eclectic Products Inc (sudsidary of Willamette Valley Company)	Water-based	Comes in 10 colours	USA
Famowood Finishing Putty	Eclectic Products Inc (sudsidary of Willamette Valley Company)		Comes in 8 colours	USA
Famowood Repair Stick	Eclectic Products Inc (sudsidary of Willamette Valley Company)		Comes in 8 colours	USA
Carpenter's Finishing Wood Filler	Elmers	Acrylic-based	Comes in light and dark tones Contains microspheres for easy staining	USA
Carpenter's Interior Wood Filler	Elmers			USA
Tinted Wood Filler	Elmers			USA
Water-Based Grain Filler	Fuhr	Acrylic	Clear and 3 colours	
Miracle Wood Quick Dry Filler	H. F. Staples	Solvent-based	Comes in 1 colour A blend of wood fibres and fillers	USA
Miracle Wood Latex Filler	H. F. Staples	Latex	Post-stain use Not suitable for water-based finishes	USA

Wood Tone Putty	H. F. Staples	Water-based latex putty	Dries hard Compatible with water and solvent finishes	USA
Decto-Stick Scratch repair Kit	H. F. Staples	Wax		USA
Wood Tone Putty Pencils	H. F. Staples	Wax		USA
Professional Wood tone Putty	H. F. Staples	Soy-oil based		USA
Epoxy Wood Rebuilder	H. F. Staples	Epoxy-based		USA
Celo-Set Wood Filler	Laurence-David Inc	Solvent-based		USA
Celo-Set Wood Filler	Laurence-David Inc	Water-based		USA
Fil-tite Wood filler	Laurence-David Inc	Solvent-based		USA
Wood Stopping	Liberon Products	Wood flour based	8 colours	France
Wood Filler	Liberon Products		4 colours (can be coloured using dyes)	France
Good As Wood	Liberon Products	Wood flour based		France
Wax Filler Sticks	Liberon Products	Wax		France
Stainable Wood Filler	Minwax	Latex		
Wood Putty	Minwax		Non-hardening Matched to Minwax Wood stains	USA
High Performance Wood Filler	Minwax	Polyester		USA
Epoxy Stick M743-1500	Mohawk Finishing Products, Inc.	Epoxy	30 min. dry time	USA
Epoxy Putty – 5 Minute	Mohawk Finishing Products, Inc.	Epoxy resin	30 min. dry time	USA
Color Fil Putty	Mohawk Finishing Products, Inc.		13 colours	USA
Wood Repair – Synthetic Wood Filler	Mohawk Finishing Products, Inc.		7 colours Interior/Exterior	USA
Fil-O-Wood	Mohawk Finishing Products, Inc.	Water-based	24 hour dry time 4 colours	USA
PC Woody Epoxy Paste	P.C. Protective Coating Company	Epoxy-based		USA
PC Lumber Epoxy Putty	P.C. Protective Coating Company	Epoxy-based		USA
Alsibois	Parasol Inc		8 shades Dries in 15-20 minutes Made in Switzerland	Canada
Polycell Wood Flex	Polycell Products Wexham Road Slough Berkshire SL2 5DS			UK
Powder Wood Putty	Red Devil			USA
Instant Wood Filler	Red Devil	Solvent-based		USA

Multi-Purpose Wood Filler	Ronseal		5 colours	UK
Easy Shape Wood-filling compound	Ronseal		1 colour only	UK
Colron Wood Filler	Ronseal			UK
High Performance Wood Filler	Ronseal		Natural colour and white	UK
Plastic Wood	Rustins			UK
Grainfiller	Rustins			UK
Woodstopping	Rustins			UK
Zar Wood Patch	UGL	Latex	2 tones	USA
Guardsman Pro series Wood Filler	Valspar			USA
E-400	Willamette Valley Company	Epoxy based		USA
E-600	Willamette Valley Company	Epoxy based		USA
E-800	Willamette Valley Company	Epoxy based		USA
Face Grade Putty 808	Willamette Valley Company	Acrylic based		USA
Water-based Face Grade Putty 264	Willamette Valley Company	Acrylic based		USA
Solvent-based Face Grade Putty	Willamette Valley Company	Solvent-based		USA
W-F-C	Wood-Kote	Solvent	To be mixed with wood flour to make a wood filler	USA
Full-trowel Filler	Woodwise		Available in 16 colours	USA
Wood Patch	Woodwise		Higher solids version of Full-trowel Filler	USA
Powdered Wood Filler	Woodwise		Powder	USA
No-Shrink Patch Quick	Woodwise		Powder	USA
Wunderfill		Water (?)	8 wood tone and white/black	
Smart Filler	Tetrosyl		White	UK
Fine Surface Filler	Tetrosyl		White	UK

APPENDIX C. Working Group Ranking of Filler Classes

The table listed below was sent out to the working group to be completed. Group members were asked to evaluate the seven classes of fillers according to eleven criteria. These criteria were developed by the working group during the first working group workshop (see Appendix E). The ranking for each criterion were *excellent (E), good (G), satisfactory(S) or not satisfactory (N/S).* The table lists the range of responses received. (Note that there were some *no response (NR)* answers in the survey)

Filler Requirements	Respondent	Epoxy Resin	Shellac Sticks	Wax Fillers	Oil-based Fillers	Water-based Fillers	Auto Body Fillers	Glues
1.Non-shrinking	1 2 3	N/S E NR	G-S N/S NR	G-S S G	G-S N/S G	G-S S G	N/S E E	N/S NR G
2. Acceptable cure time	1 2 3	G-S N/S NR	S-N/S N/S NR	G S E	G-N/S N/S S	S S G	G-N/S E S	N/S NR G
3.Machinable	1 2 3	G S NR	S N/S NR	S S G	S N/S G	G S G	G E E	G-N/S NR G
4.Stainable (colour matching)	1 2 3	N/S N/S NR	G-N/S S NR	G-N/S S G	G-N/S N/S S	G-N/S S G	N/S E G	G-N/S NR S
5.Compatible with a range of finishes	1 2 3	N/S N/S NR	G-N/S S NR	G-N/S S G	G-N/S N/S S	G-N/S S G	S G N/S	G-N/S NR G
6.Compatibility with abrasive methods (sanding)	1 2 3	G-N/S S NR	G-N/S S NR	S E S	G-N/S S G	G-N/S S G	G-N/S E E	E-N/S NR G
7.Easy application	1 2 3	S N/S NR	S N/S NR	G E G	G S G	E-S S G	G-N/S E G	G NR G
8.Capable of bridging checks	1 2 3	G N/S NR	S S NR	S N/S G	G N/S G	G-S N/S G	G E E	E-N/S NR S
9.Adhesive properties	1 2 3	E E NR	S N/S NR	S N/S NR	S N/S G	G-N/S N/S G	E G E	E-G NR G
10. Flexible	1 2 3	N/S E NR	S N/S NR	S S S	G N/S S	S N/S G	G-N/S E G	E-N/S NR G
11.Tough (reinforcement)	1 2 3	G E NR	G N/S NR	N/S N/S N/S	S N/S G	S N/S G	G E E	E-N/S NR G

APPENDIX D List of Sawmills, Furniture Manufacturers and Filler Suppliers Contacted

Contact Person	Company Name	Address
	3M Australia	Pymble, NSW 136 136
	Abatron, Inc.	5501 95th Ave. Kenosha, WI 53144 Email: info@abatron.com
	Advanced Repair Technology	PO Box 510 Cherry Valley, NY 13320 Email: JHStahl@email.msn.com
	American Drew	4620 Grandover Parkway Greensboro, NC Tel: 336 294 5233 Email: americandrew@americandrew.com
Larry Runyan	American Furniture Manufacturers Association	Post Office Box HP-7 High Point, NC 27251 Tel: 336 884 5000 Email: lrunyan@afma4u.org
	Ashley Furniture Industries, Inc.	One Ashley Way Arcadia, WI 54612 Tel: 608 323 3377
Matthew Hughes-Gage	Austfurn	6 Turbo Dr. Bayswater North, VIC 3153 Tel: 03 9720 4555
Tammy Hromis	Australian Forest Products	PO Box 747 Bayswater, VIC 3153 Tel: 03 9762 9588
David Considine	Austimber	5176 1888 0409 529 809 PO Box 491 Traralgon, Vic. 3844
Linda Nathan	Australian Wood Review	Australian Wood Review http://www.woodreview.com Email: woodreview@ecn.net.au PO Box 4336 Loganholme DC, Qld Australia 4129 Tel: 07 3806 22288 Fax: 07 3806 2277
	Baker Furniture	1661 Monroe Ave, NW Grand Rapids, MI 49505 Tel: 616 361 7321
Leslie Matheson	BedCraft	25 Green St. Thomastown, VIC 3074

		Tel: 03 9464 2638
Carl Vuncannon	Bernice Bienstock Furniture Library	1009 North Main St. High Point, NC 27262 Tel: 336 883 4011
	Bondo Corporation	Atlanta, GA www.bondo-online.com
	Borkholder American Vintage Furniture	PO Box 5 Nappanee, IN 46550 Tel: 219 773 4083 Email: webmasters@borkholder.com
Jane Lyon	Brummer	Clam Brummer Ltd, London Road, Spellbrook, Bishops Stortford, Hertfordshire. CM23 4BA. UK Tel: +44 (0)20 7476 3171 Fax: +44 (0)20 7474 0098 Email: info@brummer-ltd.com
	Builders Merchants Federation	Builders Merchants Federation, 15 Soho Square, London, W1D 3HL Tel. 0870 901 3380 Fax. 020 77342766 Email: info@bmf.org.uk
Angus McMinn	Building Research Establishment Ltd.	Building Research Establishment Ltd. Centre for Timber Technology and Construction Bucknalls Lane GB-Garston Watford WD2 7JR Tel: +44-1923-66 40 00 Fax: +44-1923-66 40 10 GCP: Mr. Antony F. Bravery Email: braveryt@bre.co.uk
Cathy	Bundy Woodworking Supplies	5 Alexandra St. Bundaberg, QLD 4670 Tel: 074 152 8166
Stephen Castaldo	Burgess Furniture	45 Raglan St. Preston, VIC 3072 Tel: 03 9480 3333
Karen Elsbury	Cabots (Orica Woodcare)	
David Grattan	Canadian Conservation Institute	1030 Innes Rd. Ottowa, Ontario Canada K1A 0C8 Tel: (613) 998 3721 Email: David_Grattan@pch.gc.ca
Robert Barclay	Canadian Conservation Institute	1030 Innes Rd. Ottowa, Ontario Canada K1A 0C8 Tel: (613) 998 3721 Email: Robert_Barclay@pch.gc.ca
Erika Mayer	Canadian Wood Council	The Canadian Wood Council 99 Bank Street, Suite 400 Ottawa, Ontario K1P

		6B9
Neil Price	Canterbury Windows	50 Osborn Ave. Springvale, Vic. 3171 Tel: 03 9549 7303
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Jan Frausing	Coringle Furniture	7 Turbo Dr. Bayswater, VIC 3153 Tel: 03 9729 4622
Craig Shoemaker	Craftique LLC	Highway 70, West Mebane, NC 27302 Tel: 919 563 1212 Email: craig@craftiquefurn.com
	Cuprinol Ltd	Wexham Rd Slough, Berkshire SL2 5DS
Phillip Philippou	DIM Furniture	10-12 Dunstans Crt. Keon Park, VIC 3073 Tel: 03 9462 1999
	Elmer's Products Inc.	www.elmers.com
Craig Stout	Ethan Allen, Inc.	Ethan Allen Dr. Danbury, CT 6811 Tel: 203 743 8000 Email: rptasznik@ethanalleninc.com
Mr. Antony F. Bravery	Eurowood	http://www.network-eurowood.com/euwo_main.htm
Technical support team	Famowood	www.gtmands.com
Karen Elsbury	Feast Watson (Orica Woodcare)	Email: homecareassist@orica.com
	Fibre Glass-Evercoat (a division of Illinois Tool Works)	6600 Cornell Road, Cincinnati, Ohio 45242 Tel: (513) 489-7600 Fax: (513)489-9229
	FIRA (Furniture Industry Research Association)	FIRA International Maxwell Road Stevenage Hertfordshire SG1 2EW England Tel: +44 (01438) 777700 Fax: +44 (01438) 777800
Mr. Dede Rohadi, Dr. Subarudi	FORDA Forestry R&D Agency Indonesia	
	Franklin Adhesives	2020 Bruck St. Columbus, Ohio 43207
Geoff	Geoff's Woodwork website	http://www.geoffswoodwork.co.uk
	Getty Conservation Institute	Los Angeles, CA Email: gciweb@getty.edu

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	GPI Automotive Products	GPI Automotive Products Pty Ltd 275 Wellington Rd, Mulgrave, Vic http://www.gpi.com.au
Tom Stratton	H. F. Staples & Co	Email: info@hfstaples.com Mailing Address: P.O. Box 956 Merrimack, NH 03054
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Ryan Keating	Hafele	Dandenong Tel: 03 9212 2000
	Hickory Chair Company	PO Box 2147 Hickory, NC 28601 Tel: 828 328 1801 Email: info@hickorychair.com
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	Impra	mail@imprasystems.co.uk
Christine Bradshaw	Institute of Wood Science	The Institute of Wood Science Stocking Lane, Hughenden Valley, High Wycombe, Bucks. HP14 4NU, UNITED KINGDOM Tel: 01494-565374 Fax : 01494-565395 E-mail : info@iwsc.org.uk
Karen Elsbury	Intergrain Timber Finishes (Orica Woodcare)	Email: homecareassist@orica.com
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Leigh Kavanagh	K&H Surface Technology	105 South Gippsland Hwy. Dandenong, VIC 3175 Tel: 03 9792 5927
Lee Kidman	Kidman Furniture	29-41 Down Street Collingwood
Mark Bramlett	Kimball Home Furniture	1600 Royal St.

		Jasper, IN 47546 Tel: 812 482 1600 Email: mabraml@kimball.com
	Lexington Home Brands	PO Box 1008 Lexington, NC Tel: 336 236 5300 Email: info@lexington.com
	Liberon	Liberon Products (Australia) P/L1A Darley Street Darlinghurst NSW 2010 Tel: +61 2 9360 7780 Fax: +61 2 9360 7798 E-mail: info@liberon.com.au
Colin Bower	Maker Coating Systems Limited	Jetty Marsh Rd. Newton Abbot, Devon TQ12 2SL UK Tel: 01626-360582 Fax: 01626-356582 Email: mcs@globalnet.co.uk
	Menco Corporation	www.menco.com Tel: 1 800 972 7693
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	National Library of Australia	
	National Museum of Australia	
Neil Feldtmann	Neil's Restoration Time	104 Bridge St. West Benalla, Vic. Tel: 03 5762 3456
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	Polycell Products ICI Paints plc	Wexham Road Slough Berkshire SL2 5DS Tel: 01753 550000 Fax: 0800 371423
	Protective Coating Company	221 S. Third St. Allentown, PA 18102 pcsales@ptd.net
Spencer Regis	Pulaski Furniture Corporation	PO Box 1371 Pulaski, VA 24301 Tel: 540 980 7330
Theo Vugts	Repair Care Systems B.V.	P.O. Box 273, 5140 AG Waalwijk (NL) Tel: +31 (0)416-652702 Fax + 31 (0)416-652024 E-mail: repaircaresystems@planet.nl
	Restoration Works, Inc.	1345 Stanford Dr. Kankakee, IL 60901 Email: gwallace@restorationworksinc.com
	Riverside Furniture Corporation	PO Box 1427 Fort Smith, AR 72902 Tel: 479 785 8100 Email: info@riverside-furniture.com
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Des McNulty	Ryan and McNulty Sawmill	Sydney Rd. Benalla, Vic. 3672 03 5762 1877
Sam Conder	Samconder.com	www.Samconder.com

	SL Hardwoods Quality Timber Stockist	http://www.slhardwoods.co.uk
	Smith Group	816 Nina Way Warminster, PA 18974 Email: bjzaslow@thesmithgroup.com
	Southport Furniture Inc.	PO Box 2979 Elizabethtown, NC 28337 Tel: 910 862 8850 Email: customerserv@southern-furniture.com
	Southwood Furniture Corporation	PO Box 2245 Hickory, NC 28603 Tel: 828 465 1776 Email: southwood@southwoodfurn.com
	Sovereign Chemicals	Sovereign Chemicals Ltd., Park Road, Barrow-in-Furness, Cumbria,LA14 4QU. Tel: (01229) 870800 Fax: (01229) 870850
Dr. Klaus Richter	Swiss Federal Laboratories for Materials Testing and Research Wood department	EMPA Dübendorf Abt. Holz/Wood Depart.CH-8600 Dübendorf Tel: 0041 1 823 44 82 Fax. 0041 1 823 40 07 Email klaus.richter@empa.ch homepage: www.empa.ch
	Tetrosyl	Bevis Green Works Walmersley Bury Lancashire BL9 6RE Tel: 0161 764 5981 (main switchboard) Fax: 0161 797 5899 Email: info@tetrosyl.com
Libby Storts	The Paint Dealer	National sales office Tel: [800] 9840801 Fax: [314] 9840866 Email: eostorts@aol.com
Selwyn Genrich	The Woodcraft Shoppe	Toowoomba, QLD Tel: 07 4635 3018
Peter Mehmet	Tilling Timbers	31-45 Orchard St. Kilsyth, Vic. 3137 Tel: 03 9725 0222
Ross Gobby	Timbecon	Perth Tel: 1 800 000 601
	Timber Trade Federation	Clareville House 26/27 Oxendon Street London SW1Y 4EL Tel: 020 7839 1891 Email: ttf@ttf.co.uk
Errol Mymin	Timbermate	PO Box 19 Eastern Mail Centre

		Melbourne, VIC 3110 Tel: 03 9983 9906
	TRADA (Timber Research & Development Association)	TRADA Technology Ltd Stocking Lane Hughenden Valley High Wycombe Buckinghamshire HP14 4ND Tel: 01494 569600 Fax: 01494 565487
Neil Ellis	U-beaut Polishes	U-Beaut Polishes - (Headquarters) 75 Little Fyans St. Geelong South, Victoria. 3220. Australia Tel: 03 5221 8775 Email: sales@ubeaut.biz
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	Woodtek (a division of Ruja Coatings Pty Ltd)	3/82 Rushdale Street, Knoxfield,Vic 3180
Ian Gardner	Woodtek (Ruja Coatings P/L)	PO Box 364 Carnegie, VIC 3163 Tel: 03 9571 9055
Gary Martin	Woodwise Products	Design Hardwood Products, Inc. 15060 N.E. 95th Street Redmond, Washington 98052 USA Tel: 425.869.0859 Toll Free: 800.424.7092 Fax: 425.881.2704
	Woodworking Magazine	www.getwoodworking.com

APPENDIX E Transcript of 1st Industry Workshop

FWPRDC Project No. 01.1303
Evaluation of Remedial Treatments for Surface Checks in Appearance Timber

Industry Working Group meeting, 8th November 2001

CSIRO Forestry and Forest Products, Bayview Avenue, Clayton

Present:

Neil Dawson	– Wattyl Australia Pty Ltd
David Goding	– JL Gould Sawmills Pty Ltd
Nils Gunnerson	– Neville Smith Timber Industries Pty Ltd
Jamie Hague (Chair)	– CSIRO Forestry and Forest Products
Joe Mimmo	– Carjo Furniture / FIAA
Alan Morris	– Neville Smith Timber Industries Pty Ltd
Richard Northway	– CSIRO Forestry and Forest Products
Bo Padkjaer	– Wattyl Australia Pty Ltd
Paul Spierings	– Mirotone Pty Ltd
Peter Ward	– Drouin West Timber Sales Pty Ltd
Peter Warden	– CSIRO Forestry and Forest Products

Apologies:

Steve Castaldo	– Burgess Furniture Pty Ltd

Meeting commenced at 2.15 pm

Introductions / Welcome by the Chair

Participants were welcomed by the chair and introductions made.

The scope of the project was discussed and clarifications made in light of the differing expectations of some participants. It was accepted that the project was limited to '*the review of current and potential filler technologies (including non-traditional fillers)*', and that addressing the problem of internal check formation and the development of fillers were therefore beyond its scope.

1. Ground rules for information exchange

The chair advised that information gathered during the course of the project would move to the public domain on its completion and sought the stances of those present regarding information exchange both within the Working Group and with third parties.

NG (NSTI) suggested that from a producer's point of view there would be no problem tabling any information that may assist. The consensus was that information gathered during the course of the project be made freely available to interested third parties.

BP (Wattyl) stated that Wattyl would assist with the provision of information/advice regarding its existing product range and any testing required, and sought an indication of the Group's position regarding the status of IP pertaining to any development work that may be undertaken as a result of leads generated during the project. There was a consensus that manufacturers be free to pursue product development outside the workings of the Group.

2. Participation of additional parties in Working Group

It was agreed that interested parties not formally identified as Working Group members be allowed to participate in its meetings.

3. Definition of the problem / potential treatments

RN (CSIRO) explained the nature of internal checking and the mechanisms involved in its formation for the benefit of the coatings and furniture manufacturers present.

The difficulty in discerning the presence of 'lifting grain' in boards was briefly discussed. The problem generally becomes evident during sanding, with the heat of sanding contributing to the lifting of the grain. Compressed air can be used to assist in locating incidences of lifting grain. DWTS supplies a shot of air to material exiting their sander for this purpose.

DG (JL Gould) raised the issue of gum vein treatment and suggested that the project scope be widened to enable its inclusion. There was no apparent opposition within the Group to this being done.

DG highlighted kitchen cabinetry as an application where there is little tolerance to the presence of gum veins. As the timber is rarely stained in this application, any filled areas tend to be more prominent. There is a need to reproduce the 'character' (e.g. natural dark flecking in stained *E. regnans*) of the timber in the filler itself. Efforts at JL Gould to achieve this, including the incorporation of hair in the filler, have met with limited success. Japanese work in this area was described as 'state of the art'.

The allowable limits for the presence of gum vein in Select Grade were discussed and taken to be: width than 2 mm and aggregate length less than half that of the board. The reverse side may be a grade lower: width less than 5 mm and aggregate length less than that of the board.

The areas to be addressed by the Working Group were summarised by the Chair as being:

- ‘stabilisation’ of lifting grain and semi-detached flakes
- ‘filling’ of shallow voids, checks and gum veins

A general discussion of the desirable attributes of potential fillers placed most importance on their possessing:

- a matching colour and similar character to the wood
- the ability to stain at the same rate
- ‘stability’ – *i.e.* the ability to be sanded without leaving a depression

JM (Carjo) was doubtful that a ‘filler’ can be developed to solve lifting grain as any treatment needs to penetrate under a flake and glue it down. Since remediation of lifting grain is largely an adhesion issue, the involvement of adhesives manufacturers such as National Starches, A V Syntec and 3M was recommended. Carjo has had some success with ‘glue sizing’ and sanding of e.g. tabletops and suggested that suitable products and similar processes be evaluated. Products would ideally be of low viscosity, quick setting and sanding, and able to accept stain. JM indicated that an investment of 15 minutes was acceptable in the reclamation of an item such as a tabletop.

4. Current knowledge of existing practices

DG explained that JL Gould had conducted considerable in-house work on the remediation problem and had been reasonably successful in developing techniques to both glue down lifting grain and fill voids resulting from the removal of larger flakes. Painting on (diluted PVA?) to raise the grain and flashing it off quickly with heat lamps had shown some promise. DG had been under the impression that the project would include a ‘development’ component that could be used to substantiate the performance of the procedures arrived at by JL Gould and then concentrate on the issue of imparting a wood ‘character’ to fillers.

DG and PW (DWTS) nominated the use of animal glue as a technically effective remedial treatment for lifting grain. PW considered the treatment too costly in terms of time and labour. DG has witnessed efficient remediation of (eucalypt?) dressing tables in the United states:

- defective items diverted to a dedicated person at a separate station
- grain raised with compressed air
- hot mix animal glue applied and flashed off with heat lamp
- voids located with the assistance of light and filled

The whole process was completed in about 5 minutes. DG conceded that the person was probably an experienced specialist. The particular type of animal glue being used was not ascertained.

PW (DWTS) and AM (NSTI) considered that the use of a 'TIMBERMATE' (water-based wood filler) type product to fill voids, followed by the application of animal glue to stabilise lifting grain and a delay prior to sanding, can be quite an effective treatment, but again, too complex and labour intensive. Although 'TIMBERMATE' can match wood colour, in some instances it may unacceptably soft (leaving a sanding depression) and too readily absorb stain.

Representatives of the hardwood producers present all considered polyester-based 'auto body filler' to be the most effective product for filling gum veins that they had encountered. Cited advantages included: an ability to accommodate wood movement, an ability to be pigmented to match wood colour and good sanding properties (stability). Manufacturers (e.g. K&H) were aware of this use of the product and had made efforts to improve it for the application. AM (NSTI) participated in the production of a TPC brochure covering its use for Natural Feature Grade timber about four years ago. Auto body filler was also considered suitable for filling voids left by flake removal if their incidence was not too high.

PW (DWTS) and DG (JL Gould) stated that auto body filler satisfied Japanese requirements for some applications, generally where dark stains applied. Of various products used in to fill components forwarded by DWTS and JL Gould for assessment in the research laboratory of a large Japanese firm, it was rated 'best by far' in terms of taking stain and sanding properties. A movement toward the use of lighter stains in Japan is causing some concern. PW and DG had heard of stain 'bleeding' from body filler but had not encountered the problem. JM (Carjo) had experience of it in furniture production with a reddish colouration becoming evident.

The present lack of a technique for imparting a matching 'character' in the auto body filler to that of the surrounding timber was considered the only impediment to its being a highly effective treatment in the case of gum veins.

PW (DWTS) had witnessed remediation techniques producing excellent results work in China but not consider their use to be feasible in Australia because of the time and labour costs involved.

DG (JL Gould) suggested that the export managers and overseas representatives of the hardwood producers be provided with a suite of questions that could be to put to furniture manufacturers in their respective regions regarding their experiences and solutions.

5. AOB

DG (JL Gould) and AM (NSTI) strongly suggested getting a project to actually conduct filler research and development underway – there being a need to find solutions while the current project only documents existing knowledge, most of which is already known to stakeholders.

JM (Carjo) suggested that remedial treatments for exposed internal checks were a 'stop gap' solution, and that there was a real need to address the problem of check formation. Significant support was expressed for the drafting of a research plan by the Working Group

as a committee, with representation being made to the FWPRDC to support fundamental research into the causes of internal checking. To be discussed further at a later meeting.

6. Next meeting

Early February, 2002. Draft report to be circulated to Working Group members by end January, 2002.

Actions:

PW (CSIRO) to:

- forward digital copies of images showing internal checking to interested participants
- contact adhesives companies regarding participation in the project
- prepare a list of questions regarding remediation techniques for representatives of the hardwood producers to put to overseas furniture manufacturers

There being no further business the meeting closed at 4.20 p.m.

Evaluation of Remedial Treatments for Surface Checks in Appearance Timber

Industry Working Group meeting, 8th November 2001

AGENDA

Introductions

1. Ground rules for information exchange

within the group

with third parties (local and international)

2. Participation of additional parties in Working Group

3. Definition of the problem / potential treatments

Desirable / acceptable attributes of potential remedial treatments?

- capable of bridging checks to what size?
- clear/coloured – translucent/opaque?
- adhesive properties
  - penetration of surrounding wood (with swelling to partially close checks?)?
- flexibility/toughness – reinforcement?
- non-shrinking
- acceptable cure time (UV cure?)
- machinability
- ability to accept stains
- compatibility with finishes (which?)

4. Current knowledge of existing practices

local

international

contacts

6. AOB

APPENDIX F. Drying checks in Eucalypts – Fact Sheet.

Drying of wood

Wood contains water in the cell wall as well as within the central cell space. To use wood for furniture etc most of this water must be removed. The drying process normally involves the following steps:

- Heat is added to evaporate water
- Moisture movement to the wood surface
- Moisture removal from the surface
- Wood shrinkage as moisture is lost (shrinkage increases with wood density)
- Development of moisture & stress gradients in the wood – THESE GRADIENTS ARE RESPONSIBLE FOR MAJOR PROBLEMS IN DRIED WOOD

The drying process is slow. Board dimensions become smaller with drying and the total wood shrinkage is defined as normal shrinkage + collapse:

- Normal shrinkage (always occurs)
- Collapse – abnormal shrinkage (tends to occur in low density species)

Figure 1. Comparison of shrinkages from green (outermost outline representing the undried state); normal shrinkage (uniform inner outline); total shrinkage (inner most outline) which includes collapse

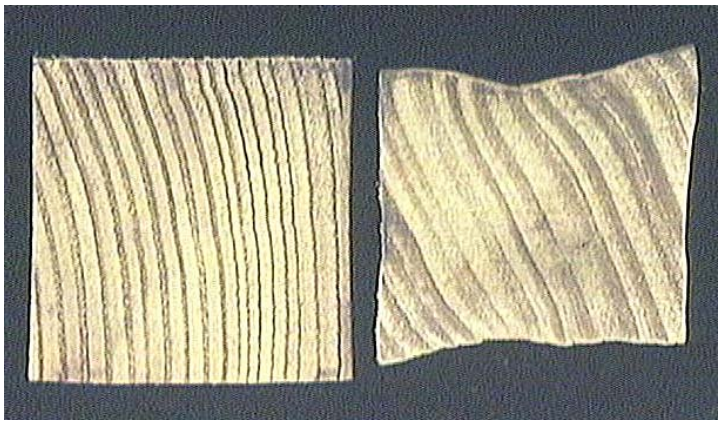


Figure 2. Collapsed specimen (right). Compare the irregular outline of the collapsed specimen with the uniform outline of the non-collapsed specimen (left).

Drying degrade is largely associated with collapse and checking

- Collapse can be recovered by reconditioning with steam after pre-drying
- Checking – on the faces of and inside the cross-section (internal) shows up as cracks or hollow gaps
- Reconditioning does **NOT** remove wood checks

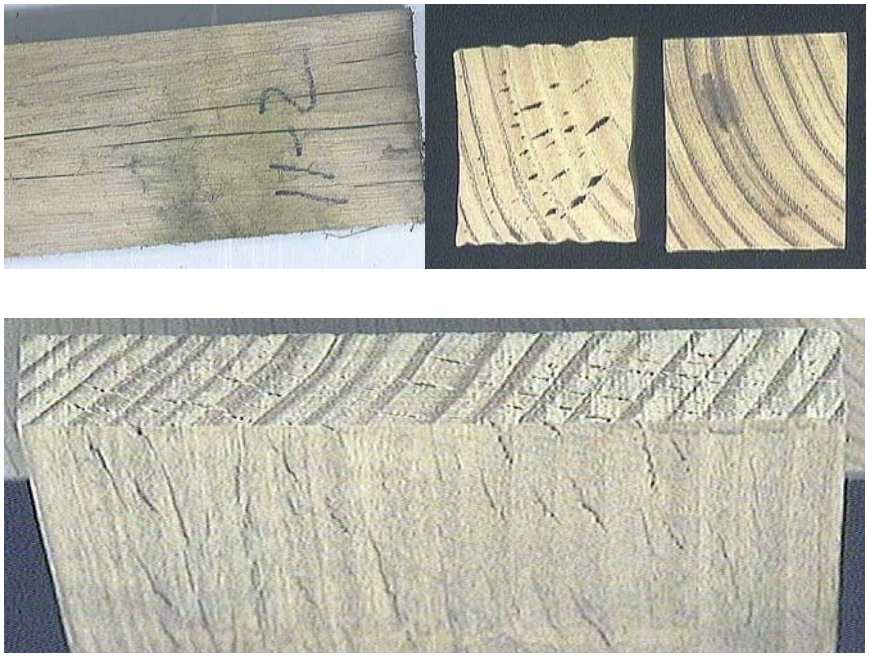


Figure 3. Surface (top left) and internal checking. Note the appearance of internal checks where they are exposed on the surface of the specimen below

Major causes of drying degrade

- Rapid drying of timber after sawing (timber is unprotected)

- Exposure to direct sunlight and wind
- Degrade is greater in thick timber
- Collapse - abnormal and irregular shrinkage
- Low permeability - water is difficult to remove quickly
- Degrade increases markedly with temperatures above 30^{o}C
- Variable strength of wood fibres – dependant on wood characteristics & physical properties:Wood age, species and density

Species prone to checking

- Surface checking
    - All species, particularly ones of high density – surface checking can be prevented by careful drying
- Internal checking (difficult or impossible to prevent)
    - *Eucalyptus regnans, E. delegatensis, E. nitens and E. viminalis* and other species with distinct differences between earlywood and latewood

Causes of collapse and checking

Collapse:

- Is additional to normal shrinkage and shows as irregular surfaces commonly termed "wash-boarding"
- Observed early in drying & continues to fibre saturation point (FSP[1])
- Collapse is the major cause of internal checking
- Collapse recovers with steam reconditioning - *CORE MUST BE BELOW FSP*
    - NO RECOVERY and further collapse occurs if the core is above FSP during steam reconditioning

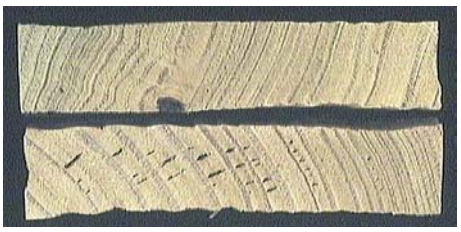
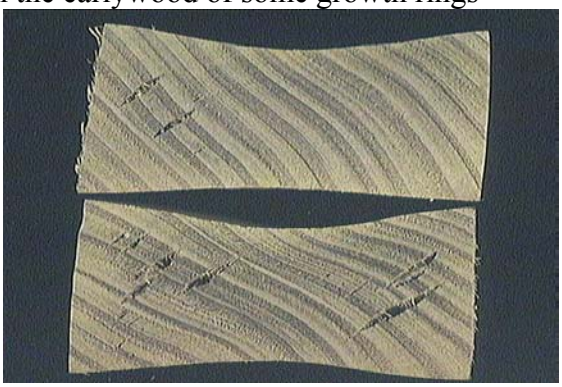


Figure 4. Corrugated ('wash-boarding') typical of collapse surface. Lower board shows internal checking in the earlywood of some growth rings



[1] FSP is taken as the moisture content (usually around 30% dry mass basis) at which the free water from the central part (lumen) of the cell has been removed. At this stage the cell wall is still at its maximum moisture content.

Figure 5. Poor recovery of collapse. Outer zones show recovery, inner parts are still collapsed. Note large checks and the darkened core.

Checking:

- Surface checking is worse in backsawn (growth rings parallel to the wide face) boards (sometimes this checking is from exposed internal checks)

How does it occur?

- Surface layer attempts to shrink on an immovable (wet) core
- Dries in a stretched state. The more it stretches the higher the stress becomes - Fibre strength properties determine if checks occur

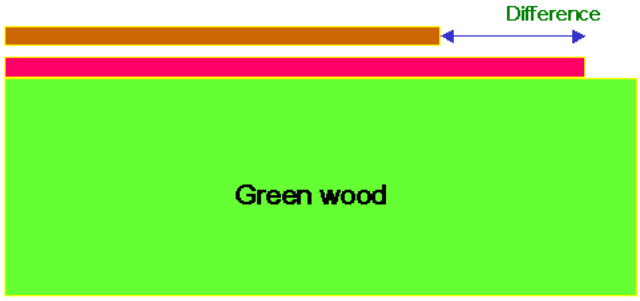


Figure 6. Relative tendency for wood layers to shrink. Upper rectangle indicates how much an isolated layer of wood could shrink. The rectangle below indicates the amount that it may actually shrink. "Difference" indicates how much it is stretched by being restrained by the block.

- The greater the "difference"- the higher the surface stress
- If stresses exceed wood strength it may fail and checks result
- Checks will initiate at weak points in the cell structure
- Wood cracks at the weakest point when the stretched layer extends beyond its strength limit
- Internal checking arises mainly in the low density earlywood from differential shrinkage between the wet and dry, and low and high density zones within the wood

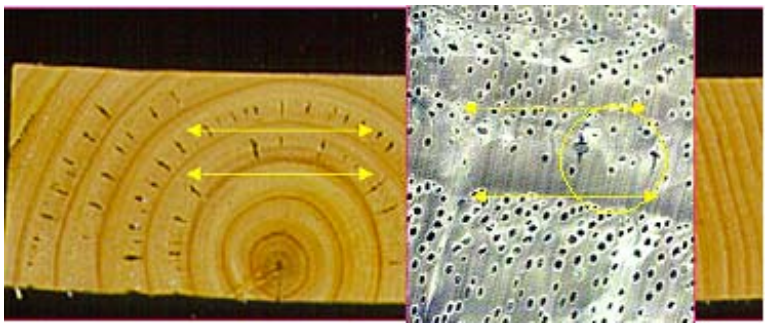


Figure 7. Differential shrinkage zones shown by arrows. Circle indicates the early formation of internal checks on a magnified portion of the cross section.

Management of internal checking

- Timber of species susceptible to collapse can be quartersawn (growth rings perpendicular to wide faces)
- Internal checking may be minimised by pre-drying with mild and uniform conditions

- Timber must not be reconditioned until the timber moisture content is below FSP
- Internal checking cannot be prevented in some check-prone material irrespective of the drying conditions
- Reduced checking can be obtained by drying thinner boards (in check-prone material) e.g.
    - Boards <12mm - 15mm thick show no appreciable checks
    - Checking increases with board thickness greater than 15mm
- Checked material may be suitable for some uses where its effects can be concealed e.g. underside of panelling or flooring

Simple means of identifying material with internal checking

- Internal checks are revealed on the end-grain by cutting approximately 100mm or more from the end of a board
- Raised grain viewed along the board faces will also indicate internal checking (See Figure 3).

APPENDIX G. Fact Sheet on Best Practices for dealing with internally checked material.

Detection of Internal Checks during manufacturing.

The Timber Promotion Council (TPC) has recently released a poster describing the identification of internally checked material.[1] It described three stages for detecting checking.

Stage 1: Prior to dressing the timber, inspect the ends of the boards for small, elongated checks. If these checks are found, mark the board and only use it for components that will be used in non-appearance positions.

Stage 2: After the timber has been dressed, examine the board to see if any small checks are present along the edges. If checks are present, use these faces on non-exposed surfaces.

Stage 3: The last stage is to run a hand over the board to detect the presence of any lifted grain. If present, then use face in concealed components.

Filling of Internal Checks.

If internal checking is present and the timber cannot be used on a non-exposed surface, then it might be feasible to use a wood filler to fill the check. There are a number of different commercial fillers available in Australia. These can be broadly classified into seven groups. The classes of fillers are:[2]

- Epoxy resin
- Shellac sticks
- Wax fillers
- Water-based fillers
- Oil-based fillers
- Auto body fillers (Flexible fiberglass putty)
- Glues

Anton Gerner recently described the use of wood fillers in filling holes and gaps in timber.[2] The following is a brief summary of the key points of that article.

- Good surface preparation is an important factor in getting a good fill. The wood should be sanded to at least 220 grit and any sawdust should be removed.
- It has been suggested that a coat of your chosen finish should be applied before the check is filled. This seals the timber (preventing the filler from potentially staining the timber) and identifies the final colour of the timber.
- The filler should be applied diagonally across the grain in each direction and then worked back and forth with the grain. Plastic or stainless steel putty knives or fillers are recommended for use with the fillers.
- Deep or large holes should be filled in layers to prevent the filler sagging or shrinking during drying.

[1] "*Identifying Internal Checking During Manufacturing*", Poster, Timber Promotion Council.
[2] A. Gerner, "*Using wood fillers*", Australian Wood Review, **34**, 88, March 2002.

- Colour matching of the filler to the wood can be difficult. It is recommended that test samples are prepared. Use scraps of the wood being used. Check the colour match of the filler with the wood before and after staining. Fillers can absorb stains differently to timber. Fillers can come in a range of colours or can be coloured with pigments. When mixing colours, it is important to thoroughly mix the filler to get an even colour distribution.
- Make sure the filler is completely dry before sanding and finishing. The drying process can be sped up by the careful use of a hair dryer or heat gun. After application of the filler and suitable drying time, sand the whole surface and continue with the finishing.