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A Manual for Decorative Wood Veneering Technology

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A manual for

Decorative Wood Veneering Technology

prepared for the
Forest & Wood Products
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by

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CONTENTS

DEFINITIONS

BALANCED CONSTRUCTION – A construction such that forces induced by uniformly distributed changes in moisture will not cause warpage. In veneered panels, a construction in which back and face veneers are essentially equal in thickness, grain direction and properties is normally balanced construction.

BALANCE MATCH – One or more pieces of uniform size used in a single face.

BIRD'S EYE – A figure created by local sharp depressions in the annual rings accompanied by considerable fibre distortions.

BLISTER – Spot or area where veneer does not adhere. Blisters are considered a bond line failure.

BOOK MATCH – Adjacent sheets from a flitch, opened like a book, with the figure on the back of the first sheet matched to the figure on the face of the next sheet. The fibres of the wood, slanting in opposite directions in the two sheets, create a characteristic light and dark effect when the surface is seen from an angle.

BURL (BURR) – A hard, woody, abnormal growth or excrescence on trunk or branch formed by the local development of numerous dormant buds and often caused by injury to the tree.

BURL FIGURE – A localised distortion of the grain generally rounded in outline. Frequently includes one or more clusters of several small adjoining conical protuberances, each usually having a core or pith, but no appreciable end grain.

CENTRE MATCH – An even number of pieces of equal size matched with a joint formed in the centre of the panel.

CHECKS

- **SEASONING CHECKS –** Small slits running parallel to the grain of wood, caused chiefly by strains produced in seasoning.
- **PEELER or SLICER CHECKS –** Closely spaced checks originating from one side of a veneer, usually the surface nearest the pith of the tree. Caused by stressing during veneer cutting (peeling or slicing).

COMPRESSION WOOD – Abnormal wood that can occur in non-pored timbers, characterized anatomically by short thick-walled cells showing spiral markings. The wood is denser, more brittle and prone to greater longitudinal shrinkage than normal wood.

CONTINUOUS MATCH – Each panel face is arranged from as many veneer sheets as necessary for the specified panel width. If a portion of a veneer is left over, it becomes the start of the next panel face.

CORE – The inner part of a veneered panel or plywood between face and back. Particleboard, MDF, sawn timber, hardboard, veneers or other material can be used as cores.

CROSS-BANDED – A veneered panel in which the grain direction of the veneers is parallel to the shorter panel dimension.

CROTCHWOOD – Crotchwood comes from the portion of a tree just below the point where it forks into two limbs. The grain is crushed and twisted, creating a variety of plume and flame figures, often resembling a well-formed feather. The outside of the block produces a swirl figure that changes to full crotch figure as the cutting approaches the centre of the block.

CROWN CUT – Sliced from a billet with successive veneers parallel to the axis of the billet and kept in sequence as cutting progresses across the diameter (see Figure 3). This method is also known as Flat Cut. In Australia, an equivalent term "back-sawn" is used for solid timber cut in such a way that the wide surface of the board is a tangential plane to the growth rings.

CURLY – Figure which occurs when the fibres are distorted producing a wavy or curly effect in the veneer. Primarily found in North American maple and birch.

DEFECT, OPEN – Open checks, splits, joints, knotholes, cracks, loose knots, gaps, voids or other openings interrupting the smooth continuity of the wood surface.

DISCOLOURATION – Stains in wood substances. Common veneer stains are sap stains, blue stains, stains produced by chemical action caused by iron in the cutting knife coming into contact with the tannic acid of the wood, chemical reaction between extractives in wood and glue or finish.

END MATCH or BUTT – Veneers as described for book matched, but the ends of the sheets are also matched.

EXTRACTIVES − Many species have a high tannin content, which reacts with iron to form black and insoluble iron tannates if the wood is in a wet or humid conditions. Any contact with iron can cause problems, therefore it is essential that special care be taken during storage and manufacture of these types of veneers, veneered panels and products. All external fixings and metal joints should be of heavily galvanised steel or of non-ferrous metals.

FACE VENEER – Better quality veneers used to cover the visible surfaces of a panel.

FIGURE – The pattern produced in a wood surface by annual growth rings, rays, knots, deviations from natural grain, such as interlocked and wavy grain, and irregular colouration.

FIDDLE-BACK FIGURE – A fine, strong, even, ripple figure in veneers. The figure is often found in red gum, myrtle, mahogany and maple, but also occurs in other species.

FLITCH – A section of log made ready for slicing into veneers, or the bundle of sliced veneers.

GRAIN – The direction, size, arrangement and appearance of the fibres in timber and veneer.

GRAIN SLOPE – Expression of the angle of the grain to the long edges or the length of the veneer.

GUM POCKETS – Well defined openings between rings of annual growth containing gum or evidence of prior gum accumulations.

GUM VEINS – A ribbon of resin between growth rings − a common feature of eucalypts. Gum forms as a protective response to injury to the tree, such as from insect attack, fire or mechanical damage.

HALF-ROUND VENEER – Veneer produced in the same manner as rotary cutting, except that the piece being cut is secured to a “stay log”, a device that permits the cutting of the log on a wider sweep than when mounted with its centre secured in the lathe. A type of half-round cutting can be used to achieve “flat cut” veneer.

HARDWOOD – Lumber or veneer produced from broad-leafed or deciduous trees in contrast to softwood, which is produced from evergreen or coniferous trees.

HEARTWOOD – The non-active centre of a tree, generally distinguishable from the outer portion (sapwood) by its darker colour.

INTERLOCKED GRAIN – The angle of the fibres periodically changes or reverses in successive layers.

JOINT – The line between the edges or ends of two adjacent sheets of veneer in the same plane.

JOINT, EDGE – Joint running parallel to the grain of the veneer or lumber.

JOINT, OPEN – Joint in which two adjacent pieces of veneer do not fit tightly together.

KNIFE MARKS – A raised or hollowed cross grain cut caused generally by a nick in the peeling or slicing knife.

KNOT – A portion of a branch, which is enclosed by the natural growth of the tree, with grains usually running at right angles to that of the piece of wood in which it occurs.

KNOT, OPEN – Opening produced when a portion of the wood substance of a knot has dropped out, or where cross checks have occurred to produce an opening.

LOOSE SIDE OF VENEER– In knife-cut veneer, that side of the sheet that was in contact with the knife as the sheet was being cut, and containing cutting checks (lathe checks) as a result of bending of the veneer at the knife edge.

MOISTURE CONTENT – The weight of the moisture in wood, expressed as a percentage of its oven-dry weight.

OVERLAP – A condition in which one piece of veneer overlaps an adjacent piece of the same ply.

QUARTER-CUT – A method of slicing veneers whereby the average inclination of the growth rings to the wide surface is greater than 45 degrees (see Figure 2).

QUILTED FIGURE − Although greatly resembling a larger and exaggerated version of pommele or blister figure, quilted figure has bulges that are elongated and closely crowded. Quilted grain looks three-dimensional when seen at its best and is most commonly found in mahogany, maple, sapele and myrtle. It occurs only rarely in other species.

POMMELE − This figure resembles a puddle surface during a light rain − a dense pattern of small rings enveloping one another. Some say it has a "suede" or "furry" look. It is usually found in extremely large trees of African species, such as sapele, bubinga and makore. Some domestic species with a sparser, larger figure are referred to as "blistered".

RIBBON GRAIN – The ribbon effect produced by quarter slicing woods with interlocking grain.

RIFT CUT VENEER – A variation on the quarter cut appearance specifically used to eliminate medullary rays in white oak, which results in a broader stripe. Veneer is produced by centring the entire log in a lathe and turning it against a broad cutting knife set into the log at a slight angle (Fig 5).

ROTARY VENEER − A veneer produced when a log mounted in a lathe is rotated against a cutting blade. This method of peeling is used to produce veneers for plywood manufacture.

ROUGH CUT – Irregular shaped areas of generally uneven corrugation on the surface of veneer, differing from surrounding smooth veneer and occurring as the veneer is cut by the lathe or slicer.

RUBBER MARKS – A raised or hollowed cross grain cut caused by a sliver between the knife and pressure bar.

SAPWOOD – The living wood occurring in the outer portion of a tree immediately under the bark. Sometimes referred to as “sap”. Generally, it is lighter in colour than the heartwood, the part of the tree used for veneer.

SLICED VENEER − Veneer produced by thrusting a log or sawn flitch into a slicing machine, which shears off the veneer in sheets.

SLIP MATCH – The top sheet of veneer is slid into position with the sheet beneath it. The face of both sheets are exposed, instead of the back of one sheet and the face of another, as in book matching.

SMOOTH, TIGHT CUT – Veneer carefully cut to minimize peeler or slicer checks.

SOFTWOOD – General term used to describe lumber or veneer produced from needle and/or cone bearing trees.

SPECIES – A distinct kind of wood.

SPIRAL GRAIN – The fibres form a spiral around the circumference of the tree.

SPLITS – Separation of wood fibre running parallel to the grain.

TELEGRAPHING – Visible irregularities in the surface of the face of the veneered panel or plywood caused by corresponding irregularities in the underlying core such as voids, zigzag stitches etc.

TENSION WOOD – Reaction wood formed typically on the upper sides of branches and leaning or crooked boles of hardwood trees. Characterized anatomically by little or no lignification and by presence of an internal gelatinous layer in the fibres. It has an abnormally high longitudinal shrinkage, tending to cause warping and splitting, and the machined surface tends to be fibrous or woolly especially when green.

TIGHT SIDE – In knife-cut veneer, the side of the sheet farthest from the knife as the sheet is being cut and containing no cutting checks (lathe checks).

WAVY GRAIN – The fibres form short undulating waves in a regular sequence.

Chapter 1
INTRODUCTION

The *Manual for Decorative Wood Veneering Technology* has been developed by the University of Melbourne and the Australasian Furnishing Research & Development Institute (Furntech) for the Decorative Wood Veneers Association. The project was financially supported by the Forest & Wood Products Research & Development Corporation (FWPRDC).

A growing use of decorative veneers and veneered panels in high value appearance wood products creates a need for an extensive technology transfer program related to veneering manufacturing procedures and product performance in various service conditions.

The Decorative Wood Veneers Association has identified that the industry would greatly benefit from the development of a “Veneer Bible”, a technical manual specifying the best veneering procedures to ensure the production of top quality veneered products. Such information is essential to veneer and veneered panel producers, furniture and joinery manufacturers, designers and architects, seeking to avoid product failures.

An extensive review of literature and databases undertaken by the researchers identified that there is limited information available in Australia and overseas on the production of decorative veneer panels and product requirements.

The manual covers all aspects of the veneering process, including the requirements for decorative veneers, substrate materials, glues and finishes, manufacturing procedures, storage and handling, typical problems related to veneered products and their prevention, and quality control in the production of decorative veneered products.

Members of the DWVA recognise the importance of the specifications and requirements provided in this manual and aspire to better incorporate these in producing and finishing decorative wood veneer products.

Chapter 2
THE USE OF VENEER IN WOOD PRODUCTS

2.1 Types of veneers and their usages

An increasing shortage of timber available for processing and manufacturing makes veneering technology extremely important from an environmental point of view. This method of manufacturing enables a small amount of resource to be extended substantially and enables furniture, cabinet and joinery manufacturers to accomplish designs that would be impossible or very expensive and difficult to create with solid wood.

A veneer is a thin slice of wood with its thickness determined by the end use. There are two major classifications of veneers:

- Constructional
- Decorative

Constructional veneers are produced mainly for plywood and laminated veneer lumber (LVL). Plywood consists of an odd number of laminations of veneer bonded at right angles to each other to equalise shrinkage and improve engineering properties.
LVL is made up of parallel laminations of veneer, glued and processed to form material of thickness similar to sawn timber. The distinguishing difference between LVL and plywood is the orientation of the veneer layers.

Decorative veneers are produced to display aesthetic surface appeal. There are four major types of markets or uses for decorative veneers:

- architectural
- secondary manufacturing, such as furniture and cabinets
- profile-wrapped mouldings
- panelling

2.2 Advantages of using veneered panels in wood products

The advantages of veneered construction can be summarized as follows:

- It results in more economical use of figured wood by enabling the maximum surface area to be obtained from suitable materials.

- It enables the utilization of highly figured timber showing unusual and beautiful effects due to grain irregularities. In many cases, such timber cannot be seasoned economically in the form of boards.

- Veneered panels are less prone than solid figured timber to shrink, check and warp.

- The cores of veneered panels are built up to provide stability and strength and the most suitable foundation for displaying the veneers to best advantage. Less expensive timbers can be used in them.

- More extensive use can be made of figured timber by matching consecutively cut sheets of veneer to produce effects impossible to obtain with solid construction.

- Bent and curved panels are readily fabricated by gluing up veneer between shaped forms or in a vacuum press, often using accelerated curing methods such as radio frequency or electrical resistance heating (Ref.10).

Chapter 3
PRODUCTION OF DECORATIVE VENEERS

3.1 Selecting veneer quality trees and logs

The manufacturing of quality decorative veneer is an exacting and expensive process. If a log ends up being lower in quality than anticipated, it can often cost more to manufacture the veneer than the amount for which it can be sold. As a result, veneer companies are usually very selective in which logs they can use. However, each company has its own specialised markets, and therefore the quality of logs that are acceptable varies from one company to another.

Determining the value of veneer trees is extremely difficult because a judgement has to be made on the quality of the wood without actually seeing it. The site, soil type, overall condition of the timber stand and its history are of major significance. Also of importance are tree form (straightness and taper) and visible defects.

It is difficult to select the highest quality logs because many internal defects such as gum vein, rot and insect damage are difficult to detect from the outside of the log.

3.2 Production of flitches

Logs selected for veneer production are usually checked with a metal detector. They are de-barked and cut to the desired length into flitches. In Australia, they are usually 2.4m to 3.9m long. The flitches can be squared up with a saw. The method of “shaping” the flitch depends on the log quality and size, which then determine the method of slicing. The shaping also eliminates the need to trim the veneers to manageable sizes and shapes.

The flitches are then heated in water vats or steamed to soften the wood, making them easier to slice or cut, and improving the quality of the veneer produced.

Heating or cooking schedules vary greatly, depending on the density of the species, the size of flitches and manufacturers’ heating schedules, which vary. The temperature usually varies between 50^{o} and 90^{o} C and the heating time between 24 to 36 hours. However, some high-density species need to be heated for many days.

Undercooked logs will not slice smoothly. Overcooked logs can become fuzzy and "hot cut." How a log is cooked will determine its colour in veneer form.

It is important to note that lighter woods such as maple and ash can easily turn brown if they are left to cook for too long, whereas, walnut is heated for extended periods to even the colour. After slicing, the walnut veneer is allowed to set overnight. This process is called “sweating”, and it allows the colour to darken before drying.

3.3 Veneer cutting methods

The method used to cut veneers is an important factor in producing the various visual effects. Two logs of the same species, but with their veneers cut differently, will have entirely different visual characteristics.

Generally, there are three major methods of the veneer cutting: rotary peeling, slicing and half-round slicing. These methods produce different grain patterns regardless of the wood species involved.

3.3.1 Rotary peeling

The log is mounted centrally in the lathe and turned continuously against a knife. The veneer is “unrolled’ much like a ribbon. Since the cut follows the log’s annual growth rings, a bold variegated grain marking is produced. Rotary peeled veneer is exceptionally wide. The veneer is then clipped to width and objectionable defects are removed. This is the common procedure for manufacture of commercial veneers for construction-grade plywood from softwood species. This method is also used for producing veneer from some hardwood species.

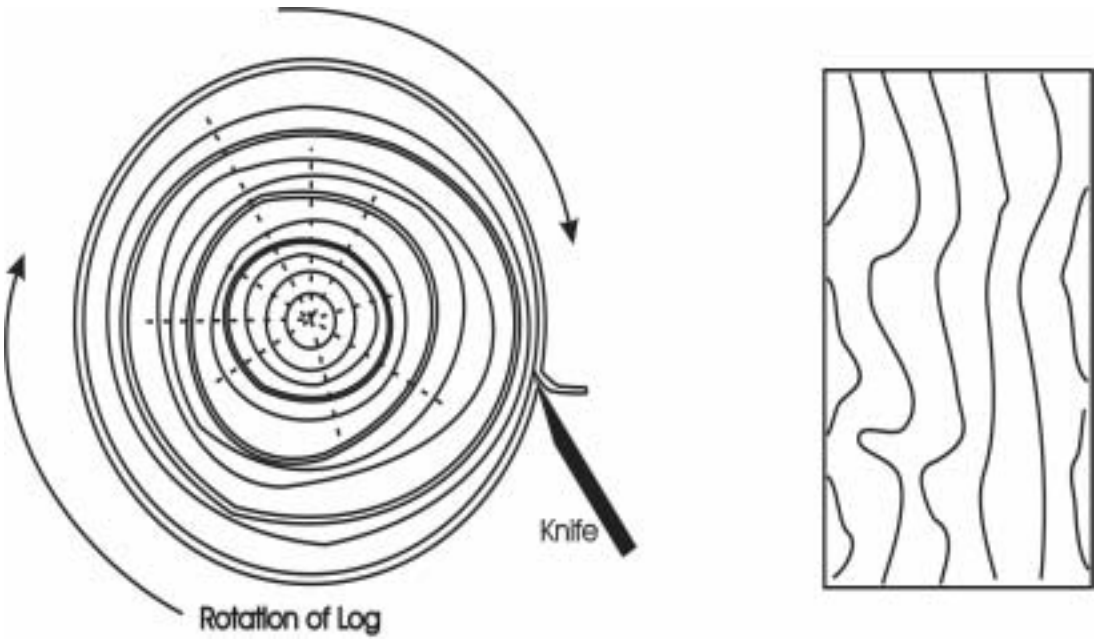


Figure 1 Rotary peeling

3.3.2 Slicing

Slicing is used to produce decorative veneers. There are various methods of veneer slicing such as quarter cut, crown cut, half-round and rift cut.

Quarter cut

The quarter log or flitch is mounted on a metal frame so that the growth rings of the flitch strike the knife at approximately right angles, producing a series of stripes, straight in some timbers or varied in others. This cut requires the largest diameter logs, usually from tropical species. In this method, the average inclination of the growth rings to the wide surface is greater than 45 degrees.

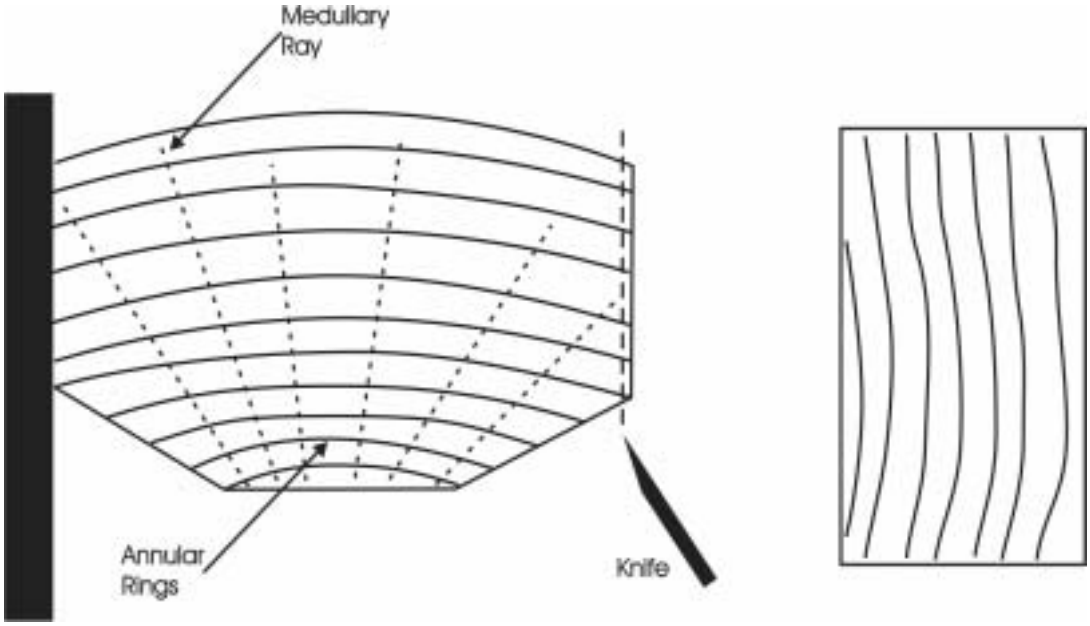


Figure 2 Quarter slicing of veneer

Crown Cut or Flat Cut

The half log or flitch, is mounted on a metal frame with the heart side flat against the guide plate. The frame moves up and down against a knife in a straight plane parallel to a line through the centre of the flitch.

As each slice of veneer is removed from the flitch, the knife moves forward the same distance as the thickness of the veneer that is removed. This is repeated until the entire flitch is converted into veneer. As the veneer is removed from the flitch, it is kept in the same sequence, and the flitch is literally re-built in veneer form. This is important for its future use.

The grain pattern gradually changes from one piece to the next and follows the grain of the log as it changes.

This cut of veneer is ideally suited for wall panels and furniture because of the consistency in its grain and the ability to match sequences of leaves in “book- and end-matches”.

In Australia, an equivalent term “back-sawn” is used for solid timber cut in such a way that wide surface of the board is a tangential plane to the growth rings.

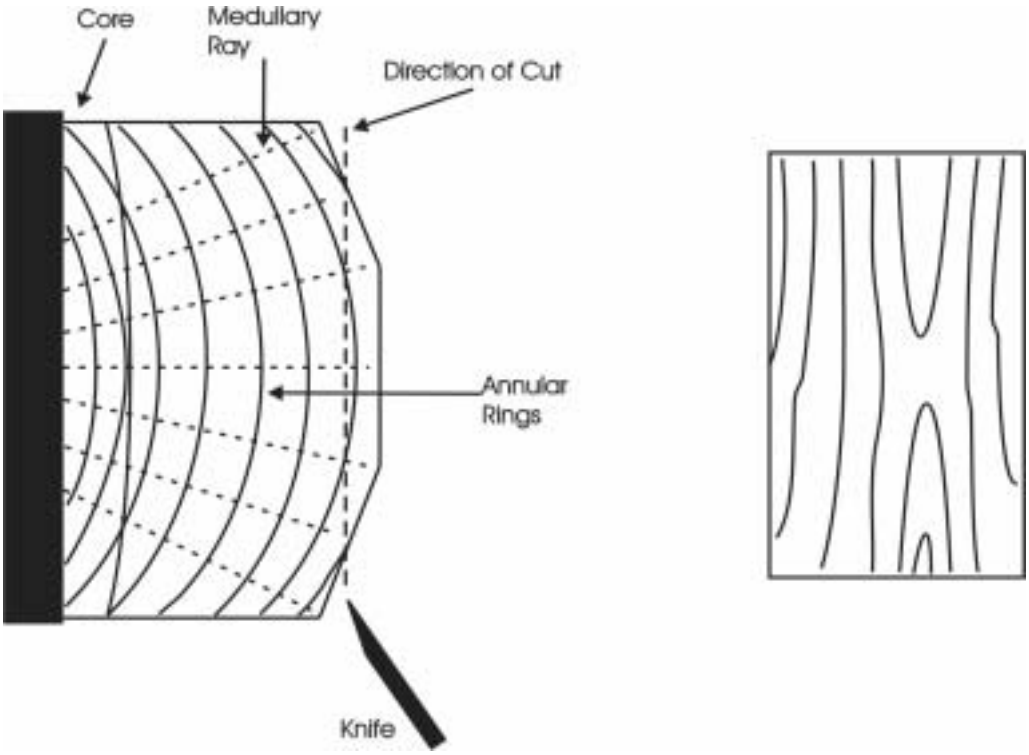


Figure 3 Crown cut or flat slicing of veneer

Half-Round Slicing

This method is a variation of rotary cutting. Segments or flitches of the log are mounted off-centre in the lathe and then rotated against a knife and a pressure bar. This results in the veneer being cut in a curved manner slightly across the annual growth rings. The veneer visually shows modified characteristics of both rotary and flat sliced methods.

This method produces a wider sheet of veneer from a given size of log compared to a flat-slicing method. As a result, smaller logs can be used for veneer production. This technique is ideally suited for the production of veneer from plantation logs of a relatively young age and smaller diameters.

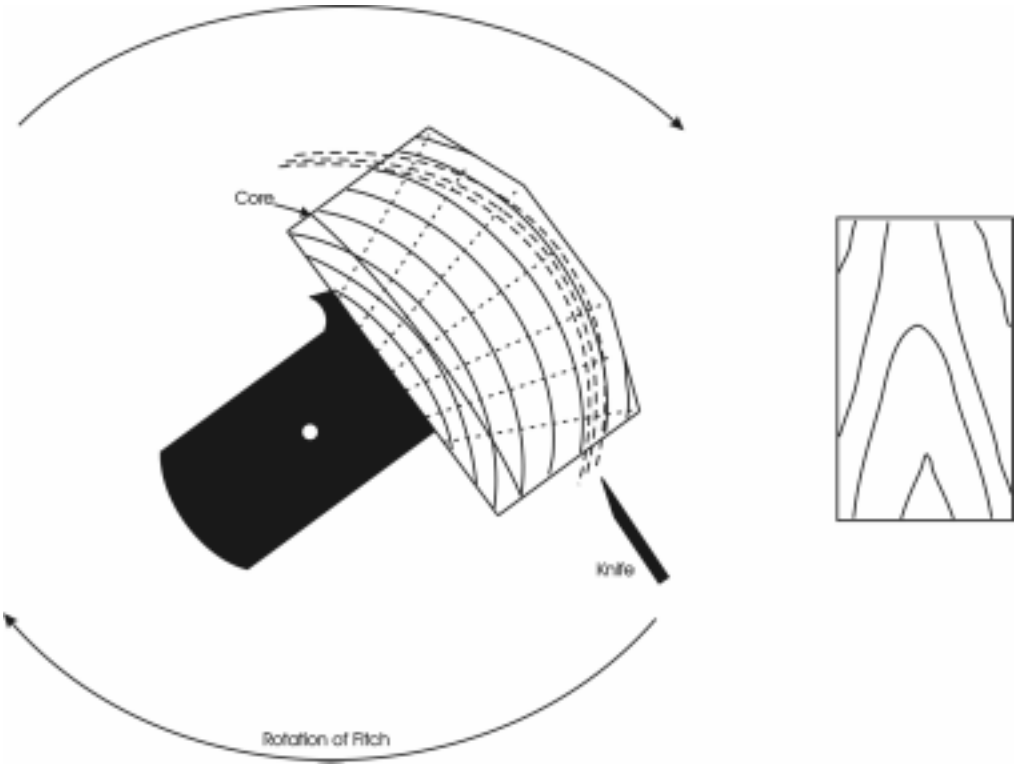


Figure 4 Half-Round Slicing of veneer

Rift-Cut Slicing

Rift cut veneer is produced in the various species of oak. Oak has medullary ray cells, which radiate from the centre of the log like curved spokes of a wheel. The rift or comb grain effect is obtained by cutting at an angle of about 15 degrees off the quartered position to avoid the flake figure of the medullary rays.

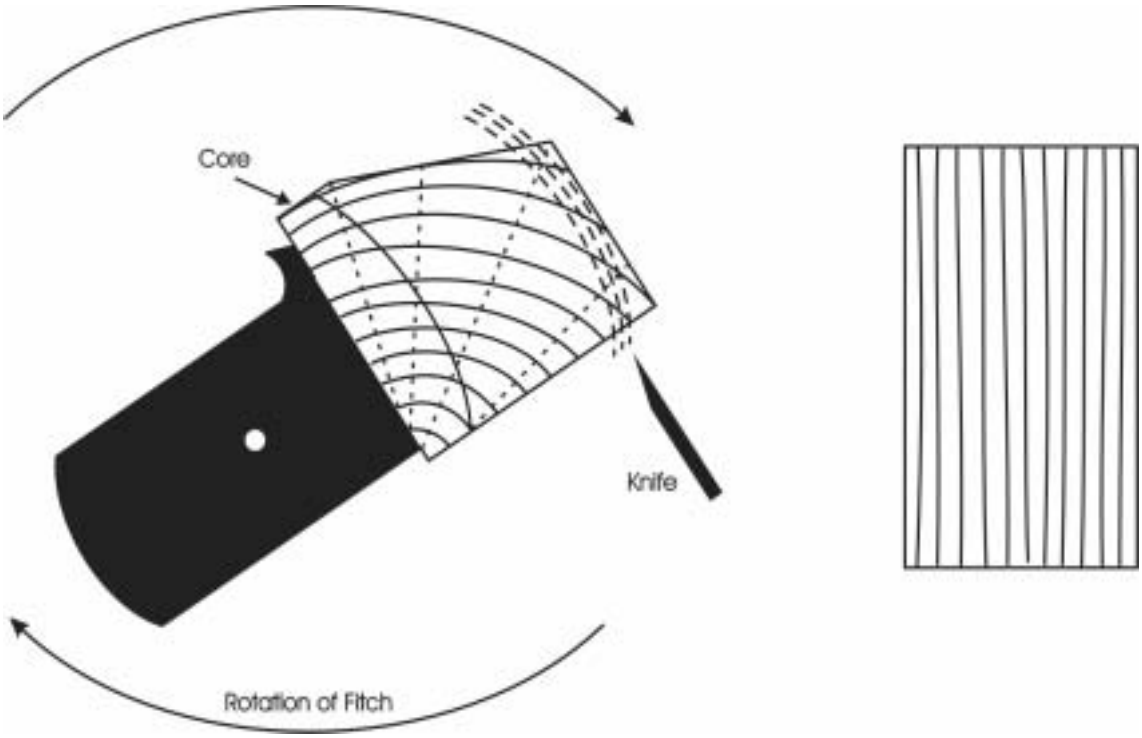


Figure 5 Rift-cut slicing of veneer

3.3.3 Reconstituted Veneer

The manufacturing process involves peeling of logs into veneers, which are dyed and dried. The layers of veneers are then glued into flitches of various shapes and geometric designs, which are then sliced into veneers.

The way the layers of the veneers are arranged and the way the flitches are sliced depend on the desired pattern. The process is fully automated and often involves the use of computer software developed for different veneer figures and patterns.

3.4 Veneer figure

The pattern seen on the surface of a veneer is known as the “figure”. It results from two main factors:

- Interaction of several natural features eg. the frequency of growth rings, the colour tone variations between earlywood and latewood, type of grain (wavy or curly grain, interlocked grain), markings and pigments in the wood structure, burls or curls.
- The way the flitch is cut to achieve the desired figure.

There are several types of figures, which are desirable in decorative veneers.

Burl or Burr
This is a large abnormal growth or excrescence on either the trunk or branches, and is formed by local development of numerous dormant buds, often caused by injury to the tree. The interwoven mass of wood elements gives an attractive and unusual figure whichever way it is cut.

Crotches and Buttresses
In the crotch of a forked tree or at the base of a buttressed tree, the folding or wrinkling of the wood elements is quite marked. These parts of trees of certain species are in demand for veneer. Blackwood and mountain ash are two such species, while much of the highly figured veneer from Queensland walnut is obtained from stumps.

Wavy Figure & Fiddle-back
Logs with wavy grains, when quarterly sliced, produce beautiful veneer with wavy patterns. Light is reflected at varying angles from quarter-cut surfaces because the individual elements are cut across at varying angles. When the wave is fine and regular, the markings on quarter-cut surfaces are also regular and appear as lustrous bars across the veneer leaf. Such grain is termed “fiddle-back” and is commonly found in such species as redgum (*Eucalyptus camaldulensis*), blackwood, mountain ash, alpine ash, jarrah (*E. marginata*) and others.

Curl
Veneer from the junction of a branch and the main trunk gives the attractive curl figure. Beautiful curl veneers are also cut from the main root members of some trees.

Bird’s eye
This figure can be seen on back-cut surfaces of certain species as numerous rounded areas resembling small eyes. It is caused by small conical depressions of the fibres and is common in maple (*Acer* spp.).It is also found in the Australian species musk (*Olearia argophylla*), which, as a result, is highly prized. Radiata pine sometimes exhibits a similar effect, but such material is not segregated commercially.

Quilted figure
Although greatly resembling a larger and exaggerated version of pommele or blister figure, quilted figure has bulges that are elongated and closely crowded. Quilted grain looks veritably three-dimensional when seen at its billowy best. It is most commonly found in mahogany, maple, sapele and myrtle, and occurs only rarely in other species.

Pommele
This figure resembles a puddle surface during a light rain: a dense pattern of small rings enveloping one another. Some say this has a "suede" or "furry" look. It is usually found in extremely large trees of African species, such as sapele, bubinga and makore. Some domestic species with a sparser, larger figure are referred to as "blistered".

Pecky and Masur Birch
This figure, as the name implies, appears to have been pecked by a bird, leaving darkened marks over the surface. It is much like the bird's-eye figure and is caused by the infection of the annular growth ring. When one species, the Scandinavian birch exhibits this figure, it is called Karelian or Masur birch. It is a pinkish white veneer with dark brown peck marks over the entire surface. Another North American veneer that often displays this figure is pecan.

Chapter 4
VENEER GRADING AND TECHNICAL REQUIREMENTS

4.1 Grading Rules

The development of grading rules for decorative veneers is a very difficult task because each flitch of the veneer provides a unique pattern of figure and grain.

In Australia, a great number of veneer species, both native and imported, are being used. All have different characteristics; varying in colour, grain pattern and features. Therefore, one set of grading rules for decorative veneers, would not fit all sliced veneer for all applications.

4.1.1 Overseas Grading Rules

In some countries, an attempt to develop standards for sliced veneers has been made. For example, a voluntary standard for sliced decorative wood face veneers has been developed in North America through an inter-industry group consisting of both producers and users (Ref.25). The purpose of the Standard has been to establish nationally recognised requirements for certain properties of sliced decorative wood face veneer. The Standard covers flitch sampling, veneer thickness and moisture content requirements. It also provides references to veneer grade characteristics.

The American Hardwood, Plywood & Veneer Association has established two grades for face veneers: Grade A and Grade B. The description of the grades is provided in the Association's technical document *Veneer Grades* Ref.24).

A *Product Standard for Imported Wood Veneer and Platforms* has been developed by the International Wood Products Association. The standard describes the grades of rotary cut and sliced imported veneer faces made from various wood species (Ref.14).

4.1.2 Grading rules in Australia

In Australia, there are no standards or grading rules related specifically to decorative sliced veneers. Therefore, most Australian veneer producers use the Standard AS/NZ 2270 *Plywood and blockboard for interior use* (Ref.5). The standard specifies the requirements for face and back veneers and is applicable to both rotary peeled and sliced veneers.

Detailed requirements for veneers used for the manufacture of veneered panels are specified in the Australian/New Zealand Standard AS/NZS 1859.3:1996 *Reconstituted Wood-Based Panels. Part 3: Decorative Overlaid Wood Panels* (Ref.4). Grading rules described in this standard have been adopted by the Australian veneer industry and they are widely used when specifying veneered boards. The grades are described in the *Veneer Product Information Manual* developed by DWVA (Ref.26).

According to the standard (Ref.4) each piece of veneer leaf must be of sound timber, smoothly and tightly cut to a uniform thickness. Depending on the quality of veneers, they are used for face or back veneers.

Other requirements of AS/NZS 1859.3 are set out below:

Face grade veneers:
Face grade veneers shall exclude the following:

- Open joints
- Overlapping joints
- Splits
- Non-natural discolouration
- Any other faults detrimental to the finish and appearance of the surface

Natural cracks and holes are permitted in some exotic veneers and burls. These might require attention during laminating and finishing.

Backing grade veneers
Backing grade veneers can be of lower quality than face grade veneers. The following imperfections are permitted:

- Minor open joints, overlaps, knots, knot holes, splits and mismatching
- Mild discolouration
- Natural blemishes such as gum veins and knots
- Other minor faults which do not impair the integrity of the veneer

Patching of open defects with suitable filler or matching colour can be arranged subject to agreement between supplier and purchaser.

The selection of the veneer grade depends on the intended use and the desired decorative effect. Therefore, the veneer grade characteristics are often agreed between buyer and seller.

4.2 Dimensional tolerances of veneer

Decorative veneers are produced in Australia at nominal thickness of 0.6mm (+/-0.1mm) or as specified between purchaser and supplier. Each piece of veneer must be sliced to a uniform thickness.

In North America, the thickness of veneers varies between 0.7 and 0.9mm and in Europe between 0.5 and 0.7mm. In Japan, fine furniture is produced using veneers of between 0.2 and 0.3mm thickness.

4.3 Veneer moisture content

As a very thin material, veneer responds quickly to humidity changes. Therefore, it is critical that the value of the veneer moisture content (MC) is as close as possible to the average value of the equilibrium moisture content for the intended service conditions.

According to the Australian standard (Ref.4) the moisture content of veneer must be in the range of 6% to 12% prior to making up into layon and also prior to pressing onto the substrate. However, it should be pointed out that according to the standard requirements (Ref.2 & 3) the MC of the substrate must be in the range of 8% and 12%. From the author's experience, the use of such a wide range of MC for the veneer and substrate could result in a high moisture gradient between two types of laminated materials. For example, the use of veneer of 12% MC and the MDF of 8% MC would certainly cause severe veneer checking in service. Therefore, to avoid any possible failure it is recommended that the MC of veneer and substrate should be between 8% and 10%. However, some brittle veneers are difficult to handle when their MC is below 11%. In such cases, the MC can be increased to 11% or 12%.

Severe problems can occur if the MC of veneer is too high or too low. If veneer with too high a MC is used for production of furniture panels and the furniture is then used in a dry environment (such as an air-conditioned or centrally heated building) it will dry out and shrink significantly, resulting in splitting and cracking.

The MC of the veneer should be measured with a moisture meter. There are special moisture meters available for measuring MC of veneers. It is important to use correction factors for various veneer species. These can be obtained from any supplier of moisture meters.

If the MC of veneers is too high they should be re-dried. There are various methods that can be used for re-drying veneers and which keep them flat. One method is to put a stack of veneers in a warm press (slightly above room temperature) and leave them overnight. Another method is to put a few sheets of veneer in a hot press (about 60^{o}C) for 2-3 hours, between two pieces of dry, absorbent board, which will remove excess moisture

REMARK
The correct MC of veneers and substrate is a critical factor in the manufacture of high quality and high performance veneered products.

4.4 Flattening of Veneers

4.4.1 General requirements

One of the main prerequisites for good veneering work is that the veneer must be flat. However, veneers often buckle or warp in various ways. The primary causes of general buckling of veneer are tension wood in hardwoods, compression wood in softwoods, irregular grain and non-uniform drying. In all cases, buckle is caused by unequal stresses across or parallel to the grain of a sheet of veneer.

Buckled veneer can be flattened by various methods, which are based on the application of moisture, heat and pressure. The most commonly used method involves applying a mixture of water and glycerine to the veneer to dampen the wood. Various proportions of the two liquids are recommended and a solution of 10% glycerine to 90% water is usually used. A sheet of dry absorbent material (eg. particleboard, brown kraft paper) is inserted between every 6-10 sheets of veneers (depending on the species and its density) to absorb excess moisture. The veneer is then kept flat in a warm press. The time in the press can be varied, but two hours at 60°C is thought to be adequate, provided sufficient absorbent material is included within the stack in the press.

4.4.2 Flattening burls veneers

Laying burls and curl veneers can cause difficulties because their surface usually is not flat, but presents a mass of brittle knots and short fibres. These veneers are often dried with a slightly higher MC than ordinary veneers, which makes them less liable to crack or break in handling.

However, it is almost impossible to prepare and handle burl veneer with low MC. To overcome this problem, the veneers need to be dampened to make them more flexible prior to flattening and, unless they are dried carefully, this treatment can increase the risk of cracking in later stages.

There are methods of flattening burls whilst minimizing the risk of cracking. The most effective procedure is as follows (Ref.12):

- Dampen every third or fourth veneer in a stack of 10 to 12 with a sponge or rag dipped in water.
- Wrap stack in a plastic film for 24 hours to enable all veneers to reach equilibrium
- After removing veneers from plastic film, place a panel of a dry particleboard in the centre of the stack.
- Lightly press the stack in a heated press at 80^0C for two hours.
- After removing the stack from the press, remove dampened particleboard from the centre and replace with a similar dry panel.
- Place stack under a light pressure between two panels of dry particleboard or plywood in a dry atmosphere for one or two days.

The above method can be used for flattening not only burl veneers, but also other buckled and wavy veneers.

Chapter 5

REQUIREMENTS FOR SUBSTRATE USED IN VENEERED PANELS

5.1 Types of substrates

Various types of substrates can be used for the production of veneered panels, such as particleboard, medium density fibreboard, plywood and blockboard. Requirements for most commonly used substrate materials are provided below.

5.1.1 Particleboard

Particleboard is a panel manufactured from lignocellulosic materials (usually wood) primarily in the form of particles, flakes or strands bonded together with synthetic resin, or other binder, under heat and pressure until cured.

The advantages of using particleboard in veneered panels are smoothness, surface integrity, uniform thickness, uniform properties, machinability, good dimensional stability and ability to stay flat. However, as the edges are not suitable for coating, the panels have to be finished with veneer or solid wood edgings. Both standard and moisture resistant particleboard panels are available.

5.1.2 Medium Density Fibreboard (MDF)

MDF is a wood-based panel manufactured from wood fibres bonded with synthetic resin or other binder under heat and pressure until cured. MDF is widely used as a substrate material due its smooth surface and edge-finishing qualities. Other advantages include good dimensional stability, flatness, close tolerances, impact resistance, good machining characteristics, low glue usage and lack of grain-telegraphing, high bond strength and screw holding characteristics. Both standard and moisture resistant MDF panels are available

5.1.3 Plywood

Plywood is used sometimes as a core material but not as widely as particleboard and MDF. It is a very stable product with a very little risk of warping. Decorative veneers are laid with its grain at right angles to that of the plywood surface in order to maintain the alternating grain direction in the structure of the substrate.

5.1.3 Blockboard

Blockboard is usually made of strips of wood about 25mm wide, glued together with the heartwood facing in alternate directions. In Australia, blockboard is rarely used in the production of decorative veneered products. In Europe, it is often used in joinery and architectural products.

5.2 Technical requirements for substrate materials

5.2.1 Thickness tolerances

The successful outcome of veneering and finishing operations is dependent on the use of boards with close thickness tolerance. Therefore, a close thickness tolerance of supplied boards is desirable. The Australian Standard (AS/NZ1859) specifies the thickness tolerance at +/-0.2mm (Ref. 2 & 3).

Significant changes in moisture content during transportation or storage can adversely affect the thickness tolerance of boards reaching the end user. Attention to correct storage conditions of the boards at all stages of the supply chain is recommended.

5.2.2 Moisture resistance requirements

From the point of view of resistance to moisture, there are two types of MDF and particleboard – “Standard” and “Moisture Resistant (MR)”. Selection of one type or the other should follow guidelines based on the service environment.

- **Standard Board** should be used for dry interior applications. It is not suitable for exposure to high humidity for extended periods. It can be used in a dry climate having no significant changes in relative humidity, or in fully air-conditioned buildings. If exposed to high humidity and fluctuating humidity, standard board will suffer a significant thickness swelling and loss of strength and stiffness.

- **Moisture Resistant Board (MR Board)** should be used for interior applications where resistance is required to high moisture conditions or where there is occasional risk of wetting (eg. in kitchens and bathrooms and in tropical areas). MR board exhibits much slower response rate to humidity changes, much lower thickness swelling and minimal residual swelling after drying out, although the board cannot be expected to perform satisfactory in continuously wet conditions. If the board is left in such conditions, degradation will occur through glue failure or fungal attack, or both.

Moisture resistant plywood, such as exterior or marine plywood, is also an option in damp applications.

Wood-based materials and solid wood, also respond to changes in relative humidity and consequently the dimensions are closely related to moisture content. The advantage of wood-based products over solid wood is the movement at they have only two-directional movements − in the plane of the panel and in the thickness. This property makes particleboard and MDF an excellent core material (Fig.6).

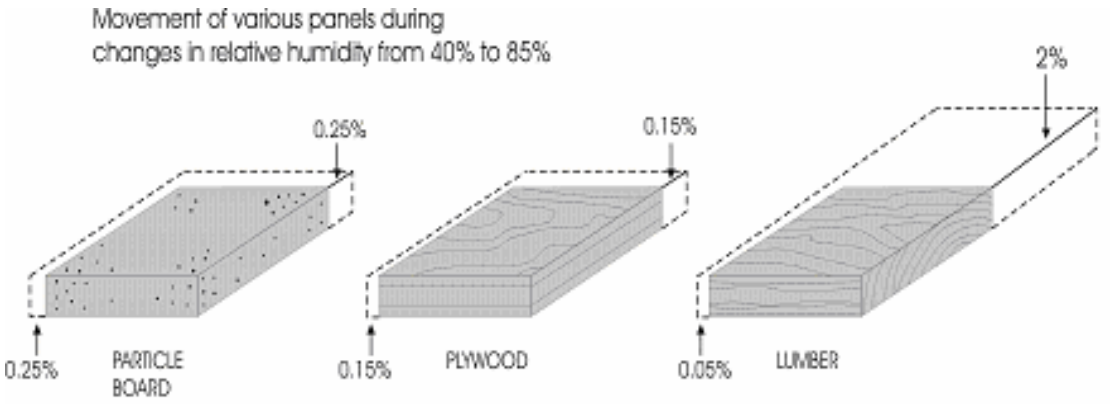


Figure 6 In-plane movement of various panels (Ref.17)

5.2.3 Moisture content requirements for substrate materials

According to AS/NZ 1859. Part 1 and Part 2 the moisture content of the substrate material should be between 8% and 12% (Ref.2 and 3). However, to minimise the differential movement of the substrate and veneer it is recommended that the moisture content of the substrate should be between 8% and 10% (Ref.18).

Extreme environmental conditions resulting in significant changes of moisture content above the specified range could cause significant deterioration of final products.

Chapter 6
CONSTRUCTION OF A VENEERED PANEL

6.1 Panel forms

As specified in the Australian Standard (Ref.5), veneered panels can be manufactured in various forms based on veneer grades and end use requirements, as specified in Table 1.

Table 1 Wood veneer panel forms

Ordering Code	Face Veneer	Backing Veneer
SSB	Face grade	Backing grade of same species
F2S	Face grade	Face grade
MOB	Face grade	Backing grade at manufacturer's option
CNB	Face grade	Grade and species nominated by the customer

Legend

SSB *same species on back sides (sometimes called "Down Grade Back" – DGB)*

F2S *face two sides (sometimes called "Good Two Sides" – G2S)*

MOB *manufacturer's option on back (sometimes called "Backs at Manufacturers Option" – BAMO)*

CNB *customer nominated veneer on back*

6.2 Veneered panel construction

It is essential that a balanced construction be applied in the production of a veneered panel. An unbalanced panel would warp on moisture gain (Fig.7).

Generally, the same species and thickness of veneer should be applied to both sides. There might be occasions where purchasers' requirements call for differing species on the face and back. These cases must be subject to consultation and agreement between purchaser and supplier. However, to avoid warping it is essential to ensure that if different species are used, both veneers must have similar strength properties and dimensional behaviour characteristics.

The grain of the veneer should be generally parallel to the long edges of the panel. There will be exceptions to this according to purchasers' requirements.

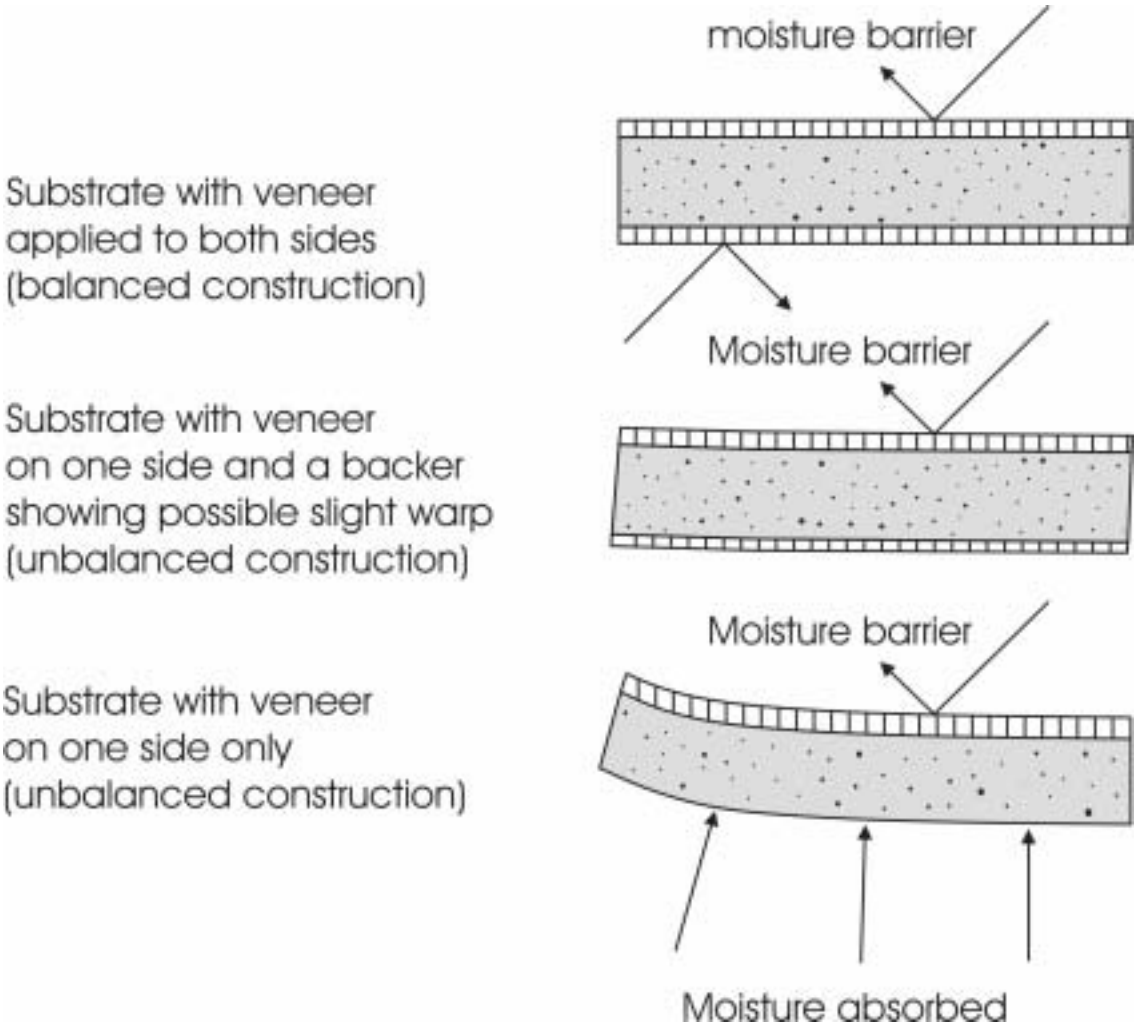


Figure 7 Balanced and unbalanced construction of veneered panel (Ref.17)

Chapter 7

PRODUCTION OF DECORATIVE VENEERED PRODUCTS

The production of veneered products consists of two manufacturing stages:

- Manufacture of raw veneered panels
- Manufacture of final products

The production of veneered panels involves the following processes:

- Veneer and board storage and handling
- Joining veneers into layons
- Gluing and pressing
- Panel conditioning
- Sanding

The manufacture of final products involves:

- Finishing of veneered panels
- Machining, jointing & assembly

The whole production process is as follows (Fig. 8).

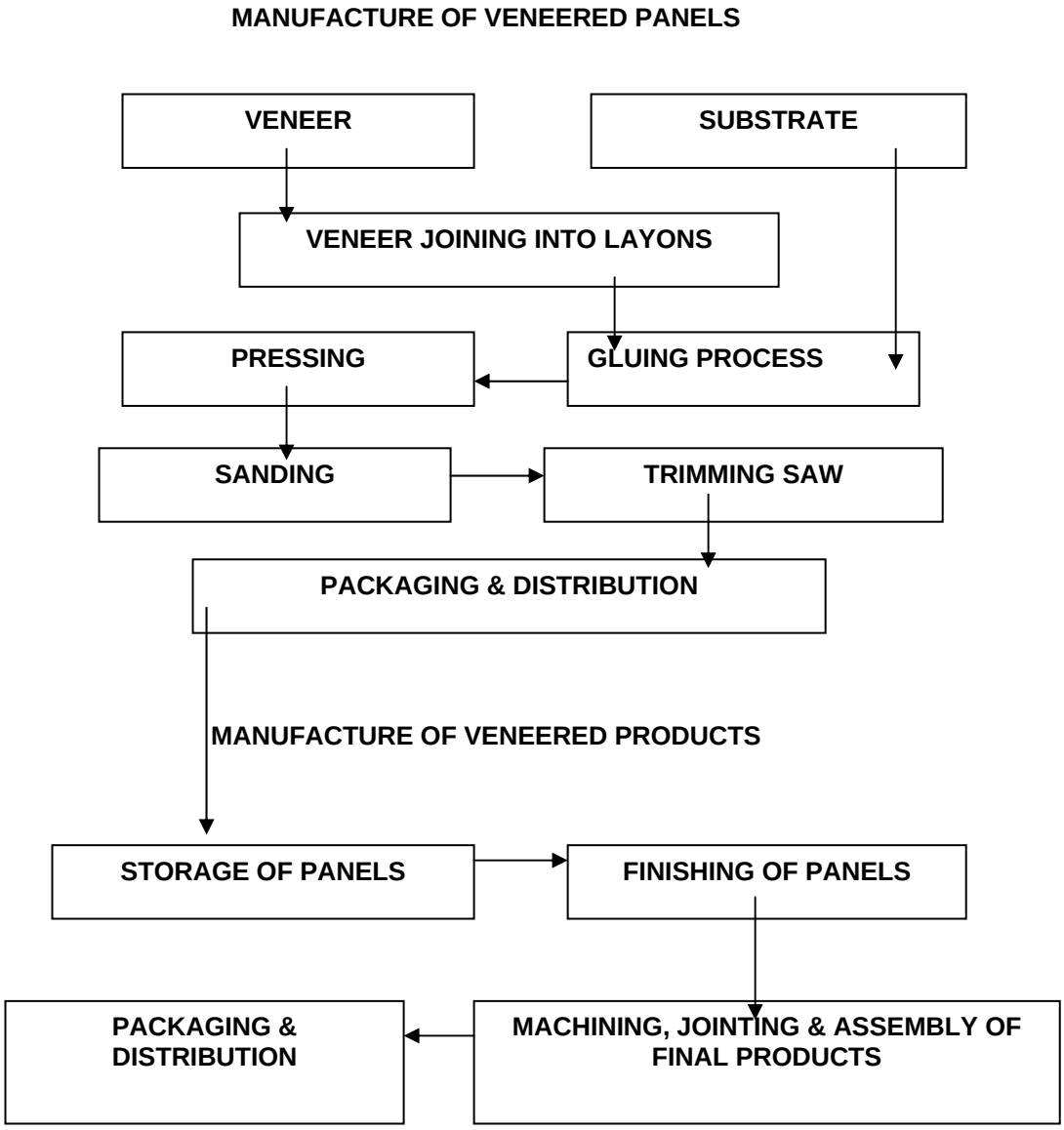


Figure 8 Manufacturing stages in the production of veneered products

The above manufacturing stages are usually undertaken in separate companies. The first stage is generally undertaken by companies specialising in the production of veneered panels with specialized veneering machinery. The second stage is often undertaken by furniture or joinery companies. However, occasionally the finishing process is performed outside the furniture/joinery factory by a subcontracted company.

The involvement of many companies in the production of veneered products makes the manufacturing process complex and can create difficulties in maintaining quality control. In case of dispute about product failure, it is sometimes difficult to establish which company is responsible for the problem. Therefore, it is critical that each company involved in the production strictly follows technical requirements and quality control specifications.

Requirements and recommendations for each step of the manufacturing process are provided in details in Chapters 8–13.

Chapter 8

STORAGE AND HANDLING REQUIREMENTS

Appropriate storage and handling of veneers, substrate and veneered panels is a critical factor in producing good quality products.

Requirements for storage and handling of veneer, substrate and veneered panels are provided in the AS/NZ 1859 series dealing with reconstituted wood-based panels:

- Part 1 Particleboard (Ref.2)
- Part 2 Medium density fibreboard (MDF) (Ref.3)
- Part 3 Decorative overlaid wood panels (Ref.4).

The following recommendations for storage and handling are essential in order to maintain veneers and panels in good order and condition:

- The storage area should be located in an enclosed dry building, which should minimise rapid changes in temperature and humidity. The area should be well ventilated with good air circulation. Open-sided sheds should not be regarded as dry stores. It is recommended that the humidity and temperature in the storage area be recorded.

- All packs should be evenly supported at each end and at intervals of not more than 600mm. Where packs are multiple stacked, all supports should be vertically aligned (Fig.9). This will reduce the potential for colour change of exposed edges if exposed to ultra-violet light.

- Should it be necessary to store in the open, veneers, layons and decorative overlaid wood panels should be covered with waterproof sheet, supported on battens laid on top of the pack allowing air to circulate around and over the pack. The cover sheet should protect both sides and ends to floor level and be tied to prevent lifting.

- The stack should be kept dry and clear of the ground, and be placed so that it will not be exposed to mechanical damage.

- Where packs are supported on bearers manufactured from decorative overlaid wood panels, care should be taken to ensure water does not make contact with the bearers. Added care can be taken by supporting each bearer on natural timber packing or other impervious material. The minimum thickness of packing should be 38mm.

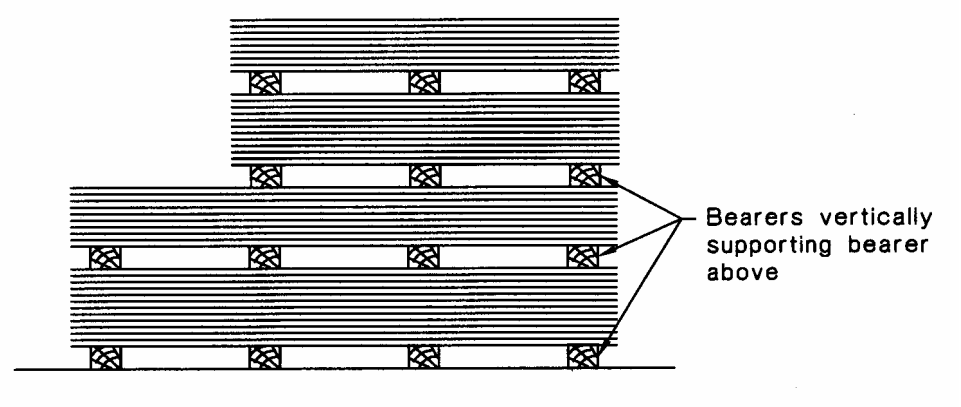
- To avoid staining and fading, the sheets should not be exposed to the weather while awaiting installation.

- The surface should be kept free of contaminants, e.g. dust, oil and adhesives that will affect the overlaying of veneer, plastic laminate and other surface finishes.

- Sheets should be installed in accordance with the manufacturer’s instructions.

- Small quantities of formaldehyde may be emitted from wood-based panels. Under normal conditions, atmospheric concentrations of formaldehyde will be well below recommended threshold levels. If large quantities of panels are stored together, there may be risk of formaldehyde build-up. Provisions for ventilation in storage areas should prevent formaldehyde build-up.

(a) Correct storage method



(b) Temporary cover

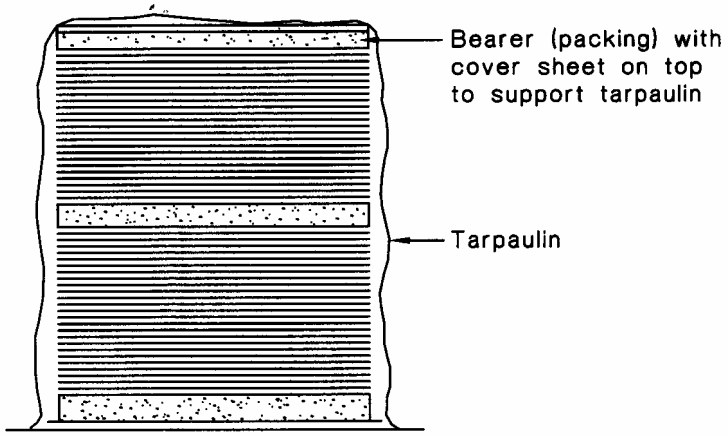


Figure 9 Recommended storage and handling of decorative veneered panels (Ref 4)

Storage conditions are often not satisfactory, with veneer and boards stored unwrapped in a large warehouse with open doors and the products subjected to significant changes in relative humidity and temperature, depending on outdoor environmental conditions. This can result in significant variation in the moisture content of the very thin veneers and this parameter should be measured.

Chapter 9
VENEER JOINING

Veneer leaves need to be joined together to form a “layon” in order to create the width necessary to cover the surface of substrate material which is to be veneered. Jointed veneer leaves should be suitably matched for figure and colour according to purchaser requirement.

9.1 Veneer matching

Matching is the term used to describe the method by which the individual leaves are jointed edge to edge into a layon. The method of match determines the final appearance of the panel. Careful choice of veneer colour and grain pattern may produce highly decorative effects.

There are several methods of veneer matching, which are described below.

9.1.1 Book matching

This method is based on the mirror image principle. To produce this image successive veneer leaves in a flitch are turned over like the pages in a book, and edge-joined in this manner. Since the reverse side of one leaf is the mirror image of the succeeding leaf, the result is a series of pairs. Book matching may be used with plain, quarter or rift sliced veneers.

When two sheets of veneer are book-matched, the "tight" and "loose" faces alternate in adjacent leaves. They reflect light and accept stain differently, and this may result in a noticeable colour variation in some species, which is often called a “picket fence” effect in Australia or a “barber pole effect” in America.

A book-match is commonly seen on furniture where veneer with a strong figure, such as swirl mahogany or walnut is used. This creates a dramatic visual effect on a cupboard door or tabletop.

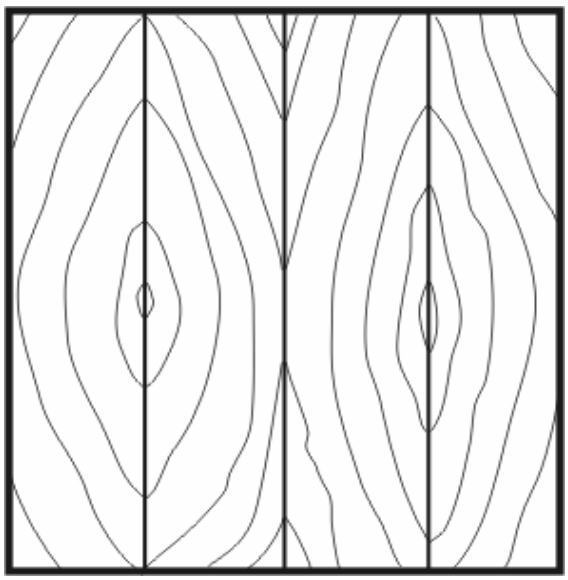


Figure 10 Veneer book matching

9.1.2 Slip matching

Successive veneer leaves in a flitch are “slipped’ one alongside the other and edge-glued in this manner. The result is a series of grain repeats, but no pairs. The danger with this method derives from the fact that grain patterns are rarely perfectly straight. Where a particular grain pattern “runs off” the edge of the leaf, a series of leaves with this condition could visually make a panel “lean”. This method gives the veneer layon the uniformity of colour because all faces have the same light refraction. This is in contrast to book matching where alternating leaves are turned over.

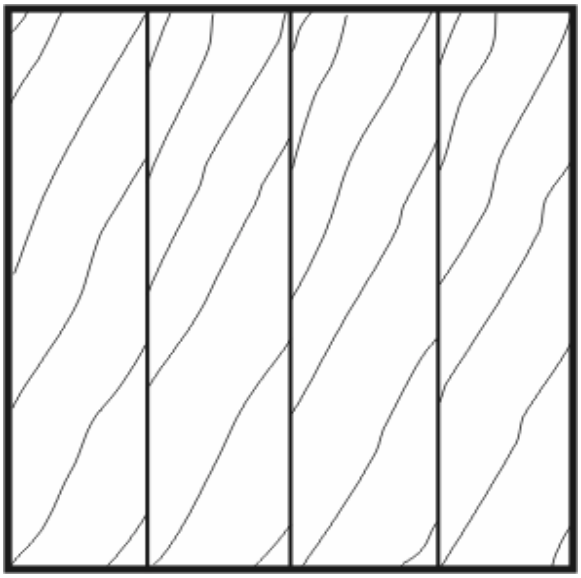


Figure 11 Veneer slip matching

9.1.3 Reverse slip matching

This method is generally used with crown cut veneers. Veneer leaves are slip matched, then every second leaf is turned end to end. The method is used to balance crowns in the leaves so that not all the crowns appear at one end.

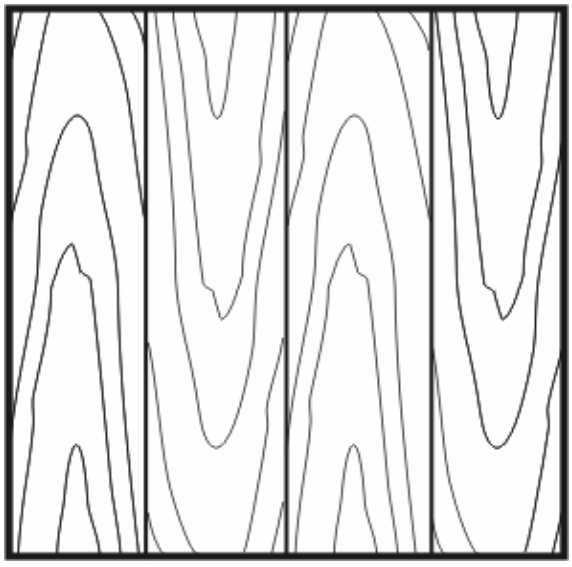


Figure 12 Reverse slip matching

9.1.4 Random matching

In this method individual leaves are random matched with the intention of dispersing characteristics such as knots or gum veins more evenly across the sheet. The advantage of random matching is that veneers from several logs may be used in the manufacture of a set of panels.

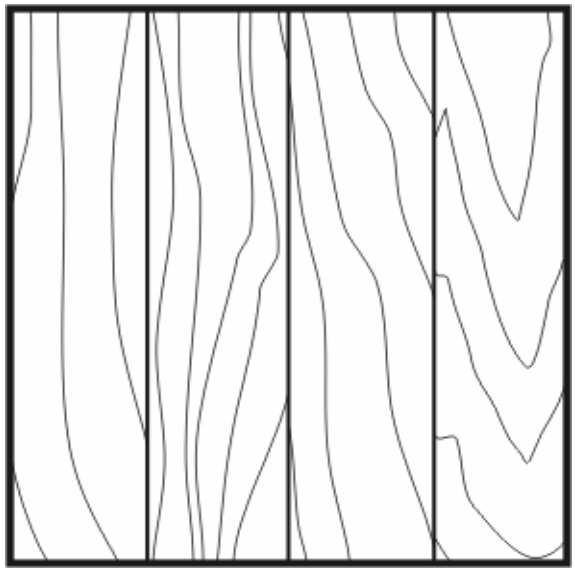
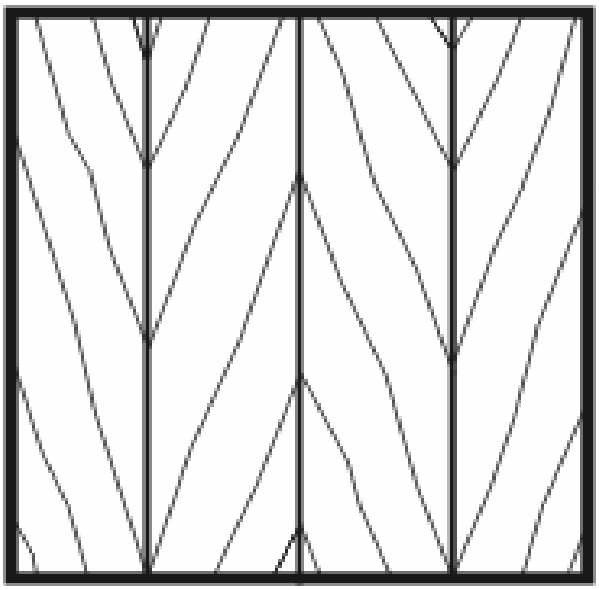


Figure 13 Veneer random matching

9.1.5 Herringbone matching



Veneer strips are used and matched to both sides of a centre line, at an angle to it. The resulting appearance is reminiscent of the bones in a fish as they are attached to the backbone.

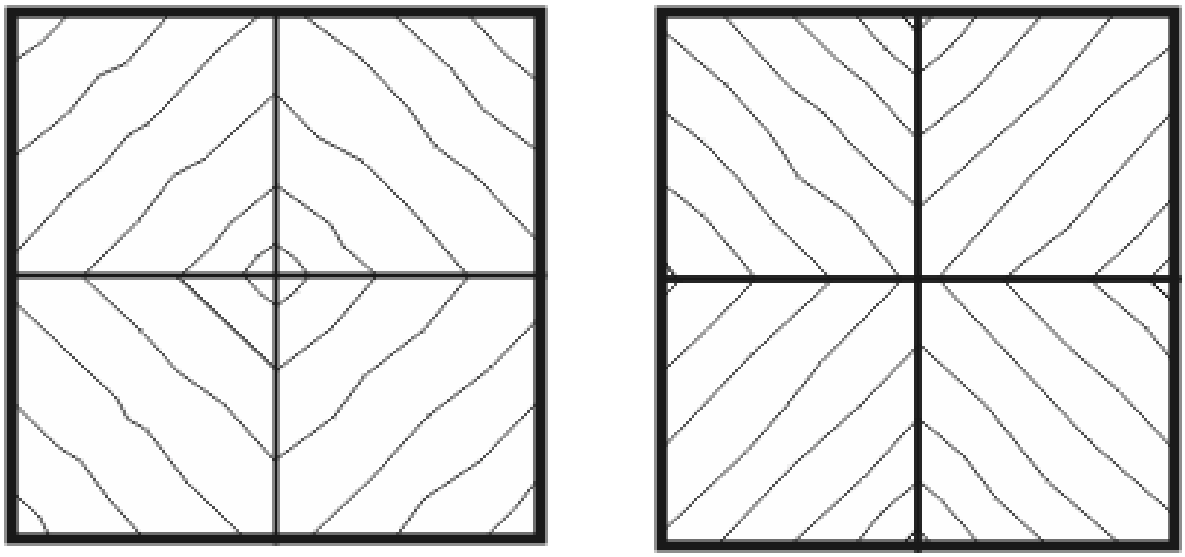
Figure 14 Herringbone matching

9.1.6 Diamond and reverse diamond matching

Diamond matching is a variation of quarter matching which can be used to advantage when the veneer is straight grained with not too much figure. The sheets are cut on an angle and quarter-matched to produce a diamond figure. Reverse diamond matching uses the same principle with the same kind of veneers, but the grains are matched to produce an “X” pattern rather than a closed diamond.

Figure 15 Diamond & reverse diamond matching

(a) Diamond matching **(b) Reverse diamond matching**



The above methods are frequently used for matching veneers. However, other individually designed matching methods can be used to develop beautiful unique patterns by utilizing exquisite patterns and colours of veneers.

9.1.7 Inlay

Cabinetmakers often frame a highly decorative wood grain with a plainer grain to accent it. To delineate it, a narrow strip or dark or patterned veneer is cut in along the joint line. This technique is called inlay. It has also come to mean cutting patterns into the basic veneer as well.

9.1.8 Marquetry

Veneer faces of various kinds are made up with small segments of veneer cut into patterns and fitted together. Often many different species and grain patterns, including many of the most exotic grains, are used in the marquetry work. Beautiful effects can be obtained using the marquetry technique It is generally applied in furniture manufacture and can be quite ornate.

9.2 Methods of veneer joining

Before jointing veneer leaves into layons veneer bundles must be trimmed. In the industrial situation, specialized guillotines are used for trimming. It is essential that the joint lines are straight, parallel and square with minimal tear-out. Joints that are not straight create gap problems. If the joint line is bowed in just one millimetre, the result is a two millimetres gap when two sheets are laid up. If the joint is bowed out one millimetre, the result is a two millimetres gap at either end, which will affect the joint quality.

There are various methods of veneer joining:

- **Zigzag stitching** – a special hot melt glue thread is passed through a heated tube in a zigzag pattern to the underside of the veneer to produce a tight joint. Immediately after the thread is applied, it is compressed flat by compression rollers. The glue thread is buried in the glue line, against the core, so that removing the glue-thread with a sander becomes unnecessary.

- **Butt joining (splicing)** − veneer leaves are edge glued together using PVA or urea formaldehyde glues. The veneer sheets are automatically aligned to allow a precise application of the glue.

- **Paper tape** − this method is used for specialist segmented or intricate veneer work.

In the industrial situation, veneer stitching and butt splicing processes are undertaken using specialized machines. There are many different types of splicing machines available on the market.

9.3 Recommendations for joining veneers

- It is essential that the moisture content of veneer leaves are checked before joining them into layons. It is recommended that the moisture content difference between adjacent leaves should not be greater than 2%. Otherwise, the movement of veneers due to changes in environmental conditions will result in veneer splitting and checking. As specified in Chapter 4.3, the recommended moisture content of veneers is between 8% and 10%.

- The thickness of veneers should be measured to eliminate any problems due to the thickness variation. If the thickness of the veneer leaves varies more than 0.1mm they should not be joined as the difference may give rise to problems during further manufacturing stages.

- The parameters of the joining machine should be checked prior to joining. Machine instruction/specification should provide recommended parameters (usually temperature and pressure applied to the joint) which should be applied for joining different types of veneers). When using zigzag stitching machines the grade of thread should also be checked against the machine specification.

9.4 Effects of poorly jointed veneer

9.4.1 Unparallel joints

Joints that are not straight create gap problems. If the joint line is bowed by just one millimetre, the result is a two millimetres gap when two sheets are laid up. If the joint is bowed out one millimetre, the result is a two millimetres gap at either end.

9.4.2 Unsquared veneer edges

Jointing with a dull knife or jointing the veneer improperly can leave a rounded edge on the leaf being cut. When two leaves are placed together, a groove will be formed. This is either filled with putty or worse yet, glue and the poor joint shows up when the panel is finished.

9.4.3 Zigzag telegraghing through the veneer

Zigzag telegraphing through the veneer can be caused by many factors involved in the veneer production process. In the majority of cases this problem cannot be detected by the manufacturer until after the veneer panel has been finished or when it is in service. Therefore, it is critical that all recommendations provided by the machine supplier are strictly followed.

The problem is recognised by the visual thread line on the face of the veneer panel and is caused by one, or a combination, of the following factors:

- Thickness of veneer
- Species
- Glue thread thickness/density
- Machine temperature setting
- Pressure of the compression rollers
- Press pressure
- Sanding

Various grades of threads are used depending on the type of veneer and type of machine used. If improper grade of thread is used the glue thread may be transferred through the veneer all the way to the face. The area where the glue is transferred is then impenetrable to finishes. This often happens in a thin, soft or open pore veneer.

The temperature on the zigzag splicer must be properly set according to the supplier's instruction. If the temperature is too high, the glue thread is overheated and can be easily "transferred" through the veneer. On the other hand, if the thread is not heated enough it is not completely melted and it may show through.

The veneer structure can be deformed around the thread when pressed in a hydraulic hot press at too high pressure. During sanding operations a small amount of veneer surface is sanded off, which can take the surface down to, or very near, the thread. The veneer around the thread is structurally denser because it has been compressed and deformed. During the finishing process, it will absorb finishes differently, thus causing a visual blemish.

If zigzag problems occur and it proves difficult to define the cause, the following experiment might help eliminate the problem:

- Run the stitcher at a lower temperature so the glue thread adhesive does not thin out too much
- Use a lower density glue thread
- Use a lower pressure on the zigzag compression roller
- Size the veneer
- Check the sanding operation (the amount of sanded veneer)

9.4.4 Discolouration of glue line in spliced veneers

Occasionally, problems with dark lines occurring along the spliced veneer joints are encountered. This occurs particularly in light colour veneers and is usually due to the use of improper glue for splicing. There are special types of glues available for veneer splicing, depending on the type of splicing machine.

The use of different types of glues for gluing veneer to the substrate (e.g. PVA) and for veneer splicing (e.g. urea formaldehyde) can cause problems with veneer joints.

Chapter 10
LAMINATING PROCESS

10.1 Veneer laminating requirements

10.1.1 Loose and tight sides of veneer

Face veneers should be laid with the tight side outwards, if it is possible to detect. The difference between the tight and loose sides of veneer sheet results from the slicing of flitches. When veneer is sliced from the flitch, the veneer side closest to the centre of the flitch usually has more fissures and checks than the other side. This side is often identified as the "loose" or inner side of the veneer leaf. The outer side is known as the tight side. It is much smoother and gives a better surface for finishing than the loose side.

The easiest way to distinguish the loose side of the veneer is to hold the sheet in both hands and flex it back and forth (Fig.17). The loose side will flex outward more easily as the knife checks open. When it is flexed inward, and the checks close, the sheet will feel stiffer. However, in the last 20 years, veneer-slicing technology has improved significantly and knife checking has been greatly reduced.

When two sheets of veneer are book-matched, the "tight" and "loose" faces alternate in adjacent leaves.

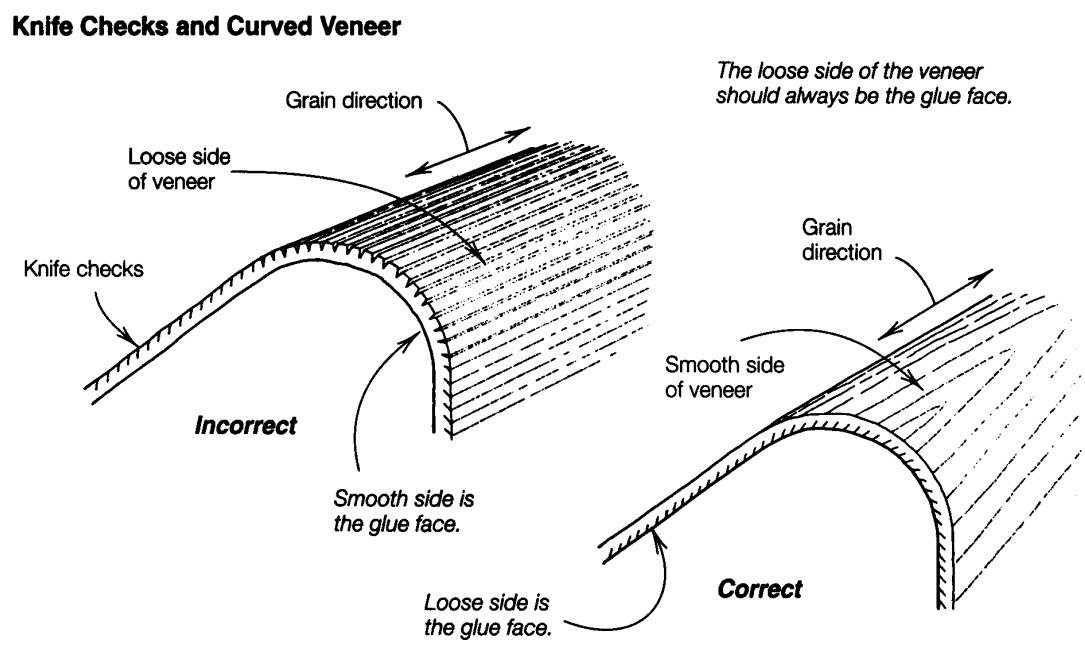


Figure 17 Loose and tight side of veneer

For some species, the difference between the tight side and the loose side is significant and easy to detect. However, there are species in which such identification is very difficult.

When the decorative veneer sheet is laid on plywood core, its grain should always be at right angles to that of outermost veneer of the plywood, otherwise cracking and checking can result.

10.1.2 Moisture content of veneers and substrate prior to laminating

Moisture content of veneer and substrate at the time of gluing and pressing is the one of the most important factors in achieving high quality panels.
Veneer panel producers must check the moisture content values of veneers and boards prior to gluing to ensure user confidence in veneered board. In particular, it should be noted that the majority of veneers are imported from overseas and are produced under different environmental conditions. Their moisture content could also change during transport in shipping containers.

The moisture content of both veneers and substrate should be checked shortly before gluing. It is essential that the moisture content of the two materials be held at about the same level in order to eliminate high stresses due to differential movement.

The recommended moisture content is:

- For veneers: between 8% and 10% (see Chapter 4.3)
- For substrate: between 8% and 10% (see Chapter 5.2.3)

REMARK
The above recommendations should be also applied by veneer merchants.

10.2 Gluing process

10.2.1 Types of glues used for veneering

In Australia, two major types of glues are used for veneering process:

- Urea formaldehyde
- PVA

Melamine urea formaldehyde glue is also used for moisture resistant bonding applications.

The majority of companies use PVA glue as is easier and faster to apply. Urea formaldehyde is probably a more effective and reliable bonding agent, but it has the disadvantage that its curing time is temperature dependent. Therefore, a hardener needs to be selected that is consistent with the ambient temperature and relative humidity in the factory.

10.2.2 Requirements for gluing

Before any adhesive is used for gluing, it should be checked that it complies with the glue manufacturers' specification. It is essential that all glue components be mixed strictly according to the specification provided by the glue supplier/producer. The actual quantities of glue mix ingredients should be recorded for each batch of glue in case of any future dispute. Ideally, the viscosity of the glue mix should also be measured and recorded to ensure compliance with the glue manufacturers' recommendations.
The amount of glue spread on the contact surfaces is a very important parameter of the veneer laminating process. Therefore, glue spread must be controlled within the limits set by the glue manufacturer. Spreader operators should measure and record glue spreads at least once a day. Particular care should be taken to obtain even spread on both top and bottom spreader rolls. Excessive glue spread will increase the moisture content of veneer and/or will cause steam blows as the water will turn into steam during the pressing operation. Too small an amount of glue will result in lack of bonding and will cause delamination of veneer.

Total assembly time (the time that elapses between glue spreading and assembly of components, and pressing) should be controlled within the glue manufacturers' recommendations.

REMARK
Veneer adhesives available in Australia are known to have excellent properties and performance characteristics. However, it is essential that all instructions provided by the adhesive manufacturer/supplier are followed precisely if the full benefits are to be realised.

A booklet on gluing natural timber veneers has been developed by AV Syntec Pty Ltd, the supplier of adhesives to the veneer industry. The booklet provides valuable instructions and recommendations on bonding veneers, which are relevant to the information on gluing provided in this Chapter. The company agreed that parts of the booklet be included in this manual and they are provided below.

CROSSLINK PVA ADHESIVE
The pressing procedure for natural timber veneer has moved to use an automated flowthrough line. The speed of these lines is often such that Crosslink PVA or another quick setting glue is required. A typical press time is 30 seconds to 60 seconds at a press temperature of 100ºC to 120ºC. To press at these times the press has to be self-loading and unloading.

These press lines are very quick, efficient and, by using PVA, do not require a mixing station with a mixer, wheat flour, shell flour and water. There is also no need to keep checking viscosity and the clean up time is greatly reduced. With PVA a single pack or a two pack crosslink grade can be used.

When using PVA glues the following precautions should be taken to avoid veneering problems:

- If the moisture content of the veneer is slightly high the result can be open joints in the veneer, as the hot boards cool down and the adhesive is still soft.
- If the veneer and the board vary more than 1% – 2% in moisture at the time of pressing the result can be open joints after the furniture is in service, particularly if heating is used in the room containing the furniture.
- Bonds with single pack PVA can be unstuck with heavy coats of lacquer or stain.
- Excessive bleed through can clog sander belts and can discolour the veneer when polished. The PVA also does not accept stain well and the finished panel can be uneven in colour and finish.

UREA FORMALDEHYDE ADHESIVE
Urea formaldehyde has been used as a veneering adhesive for many years and still is used for quality veneer work as well as in the manufacture of plywood and moulded plywood. The main reason urea formaldehyde has lost favour in the flat pressing of veneer to particleboard and MDF is that it is too slow for the majority of automated flow through press lines. However, some modern machines can operate on higher speed using urea formaldehyde adhesive.

With urea formaldehyde, a batch in a 20-litre bucket can be mixed, but if a glue spreader is used then a glue mixer is needed for mixing large batches, say 100kg or more at a time. A typical mix of urea for a veneering line is urea resin, shell flour, wheat flour, plus hardener. The mix varies with manufacturers and applications.

Why do you need such a mix?
The wheat flour is an extender of the glue and a 25% − 40% extension is recommended.

Why do you need to extend the mix?
Urea formaldehyde is a very strong, brittle glue and can cause bowing of panels as they cool down. This is mainly caused by pre-curing of the glue on the bottom side of the board, as it sits on very hot platens while the press is manually loaded.

The wheat flour holds more water and retards the glue long enough to get the press closed before any curing occurs. The flour used for extending is always low protein flour, usually used for making biscuits. When you use flour to extend the glue you will also need to add water to keep the viscosity correct and this should be monitored throughout the batch.

After the glue is mixed in the glue mixer, large volume users pipe it direct to the glue spreader. Smaller users would take it off in 20 litre drums and add hardener to each drum as they use it. Doing it this way cuts down on the waste, and you have fresh glue in your glue spreader every 30 minutes or so. Any of the mix you have not catalysed can be saved for the next day.

ADHESIVE HANDLING
With steamed beech, wattle (Queensland blackwood) and to some extent Tasmanian blackwood, pink staining can occur from catalysts used with UF. Staining can also occur from two-pack PVA and single-pack crosslinked PVA on the same veneers.

Reactive glues like Urea Formaldehyde and Crosslink PVA, both one and two pack, have limited storage life due to their reactive nature. This storage life should be checked to ensure that excess glue is not purchased and then exceeds its storage life.

All reactive glues should be stored away from direct sunlight or heat and kept in a cool area of the warehouse or factory. Ensure glue is not stored or handled in metal containers, particularly iron or steel and that the glue does not come into contact with anything containing iron. Crosslink PVA in particular will contaminate easily from metal (even metal taps) and give black or grey iron stain on the finished veneered article.

Two pack glues have fast and slow hardeners. Select the hardener that suits ambient conditions for pot life and the press cycle required.

Seal all containers, glue and hardener after use. Most liquid hardeners are acidic and safety instructions for handling and mixing should be closely followed. Always wear goggles and gloves when handling.

Always clean up containers, spreaders, equipment prior to the glue setting. Cured or set glue is difficult to clean.

10.3 Veneer pressing

In the industrial situation hot presses are predominantly used for veneer gluing. When heat pressing, the two most important factors to consider are the temperature setting of the press and the pressing time. Both are crucial and should be controlled and monitored. The species of wood veneer should also be considered. Different densities require different times and application techniques.

There are many different types of presses available. Therefore, when purchasing a press it is important to select the type appropriate for the specific application.

The following criteria should be used for selecting a press:

To determine the size of press	W*hat will be the largest sizes of panels pressed?*
To determine the press capacity	*How often will the press be used?* *What volume of panels will be produced?*
To determine heating medium	*What type of overlay will be mainly pressed? (Eg. veneers, laminates etc.)*
To determine pressure and temperature	*What adhesives will be used for pressing?* *What cycle time is needed? (Cycle time is dependent on the thickness of the veneer, adhesive, core dimension and temperature).*

10.4 Requirements for bond quality

Veneer bond should be evaluated using test methods described in the Australian Standard AS/NZS 4266.32 (Ref.6). The standard specifies two methods for evaluation of the bond quality:

- Determination of veneer bond strength
- Determination of veneer bond durability

The criteria for satisfactory veneer bond strength and durability are described in AS/NZS 1859.3 (Ref.4). A simple testing machine is available for every day quality control process, but it is recommended that tests be undertaken by a specialist accredited testing laboratory on quarterly basis to validate and calibrate in house testing.

For a regular testing of the bond quality, the Chisel test can be used “in-house” for the quality control record purposes. The test, which is described in AS2098.2-1977 (Ref.7), is commonly used for determining the quality of bond in plywood. The test involves the removal of the surface veneer of the veneered panel by forcing the chisel along the glueline and evaluating the percentage wood failure. Although this method is not directly developed for the evaluation of veneered panels, it will give a good indication of bond quality.

10.5 Problems related to gluing and pressing

10.5.1 Glue bleed-through

Bleed-through or the penetration of glue through a veneer during pressing, depends upon veneer porosity, glue characteristics and pressing parameters. In veneers cut from interlocked grain timbers such as sapele and makore the pores run at an angle to the plane of the veneer, which gives a clear channel for the glue to penetrate from one surface to other. This may cause the glue to bleed through the veneer surface.

Bleed-through can be minimized by:

- Adding an extender to the glue (eg. wood flour or starches), which will increase viscosity and lower penetration,
- Reducing glue spread and pressing temperature.

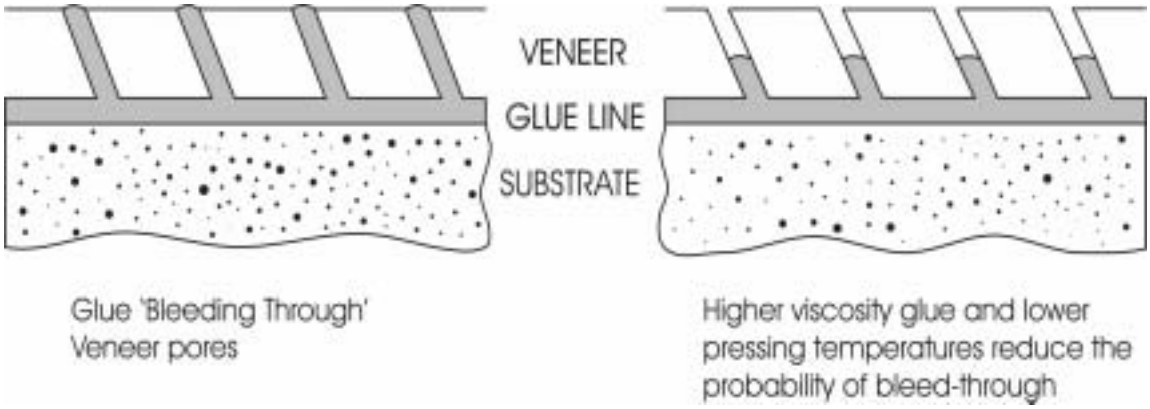


Figure 18 Glue bleed through (Ref. 12)

10.5.2 Veneer delamination

Several factors can lead to the veneer delamination in hot pressing, including steam blows, spotty bonds, complete glue failure and glue bleed through to the surface of the face veneer. All these factors can be caused by the use of inadequate gluing and pressing procedures, as follows (Ref.15):

Improperly mixed glue
If preparation of glue requires mixing of several components (eg. urea formaldehyde) it is essential that the mixing instruction is strictly followed to avoid veneer delamination.

Excessive glue spread
If glue spread is excessive, water will turn into steam. Recommendations provided by the glue supplier should be strictly followed.

Insufficient glue spread on veneer
If the spread is insufficient, there will be bonds in some areas and failures in others.

Too high a moisture content of veneer and/or substrate
Too high moisture contents will contribute water to that already in the glue line and will lead to problems with steam blows.

Too high a temperature of pressing platen
The temperature of the platen and the pressure should be set according the press specification.

Worn glue spreader rolls
Spreader rolls might be worn or the grooves may have a glue build-up. The only solution in this case is to re-groove the spreader rolls.

Assembly time too long
In this case, the glue lines may pre cure (set up) before pressure and heat is applied. A longer assembly time catalyst should be used if required by specific manufacturing conditions.

Variation in veneer thickness
Veneers should be checked with a micrometer for differences in thickness. Any difference over 0.1mm can cause problems.

Too short pressing time
If too short a press time is used the glue line will not cure sufficiently. Panels should be checked immediately after they are removed from the press.

REMARK
If the proper steps are taken in the process of veneer laminating and delamination is still a problem; one should assume that the wrong adhesive is being used or that something is wrong with the adhesive. In the latter case, the adhesive must be checked in the laboratory to pinpoint the problem.

10.6 Conditioning of veneered panels after pressing

After pressing, veneered panels should be stored in relatively dry conditions to allow the moisture from the adhesive to dissipate. If the ambient conditions in the factory are not considered dry, it is recommended that the completed veneered panels be stored in a purpose built area with controlled temperature and relative humidity. In particular, as the moisture content of veneer is related directly to relative humidity, control of humidity in isolation is known to be effective and less expensive to operate.

Panels should be allowed to condition to an equilibrium moisture content (E.M.C) of approximately 10%. If excess moisture is present, a hot conditioning area may be required. On the other hand, excessively dry panels might have to be humidified. All stock should then be maintained at this moisture content until sanded and finished.

Chapter 11
SANDING VENEERED PANELS

Sanding requires considerable care to avoid over sanding the panel edges and ends, and sanding-through thin sliced face veneers.

If the panels are sanded down too much the veneer is not able to withstand even small stresses and will be prone to checking.

The sanding operation is performed for the following reasons (Ref.22):

- To produce a clean finish suitable for subsequent polishing, painting etc.
- To produce a panel of a required thickness having a thickness uniformity within specified limits. This is called thicknessing.
- To remove veneer-repair tapes, to clean up filled splits or holes and remove dust, finger marks, dirt etc.

The quality of sanding should be checked regularly. This should involve:

- The visual evaluation of the surface to ensure that there is no sanding through the veneer
- The measurement of thickness of the panels to ensure the uniformity of the sanding operation

Various types of sanders are available for sanding veneered panels. Most commonly, wide-belt sanders are used wherein the abrasive belt is wider than the panel to be sanded.

Sanders vary considerably in the number of heads, hardness of contact rolls and provision of shoes and platens, so the instructions of the manufacturer should be followed in the initial set-up of the machine and during the sanding process.

After sanding the veneered panels should be stored in controlled storage conditions (see Chapter 8).

Chapter 12
FINISHING VENEERED PANELS

12.1 General requirements

Panels produced by veneered panel companies leave the factory as raw, unfinished products. This means that even if they meet all standard requirements, their performance and quality in the final veneered products depends on the further handling and manufacturing process, which is usually undertaken by furniture or joinery companies. The veneered panel producer does not have any control on how the panels will be handled and what production procedures will be applied. Therefore, it is critical that a manufacturer of veneered products who receives the raw panels understands and strictly follows the requirements and guidance developed for the veneer and veneered panels.

An important stage in the manufacture of veneered products is the finishing process. It is usually undertaken by furniture or joinery companies or by a specialised finishing factory.

The finishing of veneered panels should be taken with special care in order to eliminate any problems that could affect product quality and performance.

There are many different finishing systems, methods and equipment used on veneered products. This information is readily available in various finishing manuals, handbooks and training materials and is not within the scope of this manual. However, typical problems and faults related to finishing systems are described and provided on how to prevent them. Recommendations on proper finishing procedures are also outlined.

There are many claims related to poor performance and quality of veneered panels and products due to problems with finishes. Such claims are often difficult to investigate due to the many potential causes of the problem and lack of quality control records. Each problem has to be traced individually by enquiring into every detail of application in as methodical a manner as possible. The problem is very complicated when the fault is caused by more than one factor.

It is often difficult to get accurate and detailed information from a manufacturer or user of the product. In such a case, finding the facts becomes almost impossible.

12.2 Selection of coatings

Recommendations for the selection of coatings for finishing of veneered panels have been developed by the Australasian Furnishing R&D Institute (AFRDI/Furntech) at the request of the Decorative Wood Veneers Association (Ref.1). The information provided in this Chapter is based on these recommendations.

It is important that the selection of finish is suitable for the end use application of the finished piece of furniture. For example, a highly decorative display cabinet does not need the same durable coating as a kitchen table or a laboratory bench.

The guidelines for the selection of coatings for veneered panels are provided in Table 2.

Table 2. Guidelines for selection of coating systems for veneered products

Type of finish	Properties	Typical application area
Nitrocellulose	• *Simple, easy to use* • *Fast drying* • *Economical*	• *General lounge and bedroom furniture* • *Furniture restoration* • *Wall panelling* • *Casket manufacture*
Pre-catalysed	• *Improved mar and scuff resistance* • *Fast drying* • *Medium water and solvent resistance*	• *Dining room tables* • *Wall panelling* • *Office furniture*
Acid catalysed	• *High build* • *Superior mar and scuff resistance*	• *Dining and office furniture* • *Utility furniture* • *High use areas*
Polyurethane	• *Excellent chemical solvent and water resistance* • *High build* • *Excellent mar and scuff resistance*	• *Vanity units* • *Kitchen cupboards & doors* • *Kitchen units* • *Laboratory, hotel and office fittings and furniture* • *Bars and restaurants*

When selecting the finish, it is also important to take into account the type of veneer used in the veneered panel. Open grained veneers may require filling, especially if a high gloss finish is desired, or a more flexible lacquer. Some species of timbers contain a high level of various extractives (eg. phenols, tannins), which can cause discolouration when reacting with the finish. These species are best sealed with a specially formulated “isolator’ to stop the chemicals in the wood reacting with the chemicals in the topcoat. Lacquer manufacturers can provide advice as to the most suitable coating system for particular species.

It may be necessary to use two or more coating systems on a piece of furniture. For example, a dresser or sideboard needs a very durable serving surface, while the vertical surfaces can have a less durable, but just as an attractive coating.

REMARK
Under no circumstances should two-pack products be put over single pack coatings.

12.3 Typical problems with finished veneered panels

The majority of faults that become apparent on veneered surfaces are related to:

- Inadequate preparation of surfaces (sanding)
- Improper selection and application of finishes (including incorrect mixing)
- Inappropriate or wrongly adjusted equipment
- Poor environmental and service conditions

Most common faults with finishes are described below:

12.3.1 Crazing of the surface

Crazing is a common problem and gives a visual appearance like fine random crack lines, which are apparent, both along and across the grain of the veneer. There are many forms and degrees of crazing and there are a number of immediate causes.

Usually the crazing is caused by:

- The formulation of the lacquer being too brittle. A properly formulated lacquer should include a plasticiser, which will allow flexibility of the coating, therefore reducing the risk of cracking.

- Each consequent coating has been applied too thickly, particularly if the successive coatings are applied over too short a time, leading to excessive solvent retention and consequent movement underneath the top surface when it is dry.

- The use of a hard finish over a soft finish, or of a fast drying material over a slow-drying material.

- The mixing of incompatible materials.

- Rapid and/or large changes of temperature and relative humidity.

- Undercoats thinned excessively and applied to inert fillers.

Crazing is more likely to occur as the “build” of the lacquer increases. The lacquer applied to a tabletop or sideboard top can craze within a few months, while the same lacquer applied to vertical surfaces remains free from cracks. This difference in performance can be attributed to the heavier coating of the tops.

As lacquer crazing can develop over a period of many months, identification of the cause of the crazing after it has occurred may be difficult, particularly if the details of the complete finishing system are no longer available. The control of lacquer crazing is in the hands of the formulator. Potential weakness of the lacquer can be identified by the cold check test, which involves exposure of a lacquered panel for one hour at 60^0C followed by one hour at -20^0 C. This cycle is repeated up to 30 times.

The remedy is to ensure a thinner initial application coat and to allow ample time for drying between coats.

12.3.2 Veneer movement on the substrate

Where cracks are seen along the veneer grain, this usually indicates cracking of veneer. This can be caused by improper bonding of veneer to the substrate, or because the moisture content of the veneer is not correct.

12.3.2 Orange peel

“Orange peel” is the name given to an uneven, rippled lacquer surface. It is usually associated with bad spraying technique. Examples of causes of veneer peel are, high air line pressure and fast spraying, too great a pressure on the material, spraying too closely and too slowly, too low an airline pressure. Orange peel can also occur in curtain coating and is then due to physical properties of the material coupled with the drying parameters.

12.3.4 Blushing

Blushing is caused by whitening of the wet lacquer film as it begins to dry. Evaporation of solvents results in cooling, and if the solvents evaporate too rapidly the film may cool so much that water from the air condenses on the film as dew. This effect is particularly likely in humid conditions. The water then has an unfortunate effect on the film and produces the whitening commonly known as “blushing”. The remedy is firstly to ensure that the spray shop is as dry as possible. If necessary, a slower solvent can be used or added to reduce the rate of evaporation and hence cooling.

12.3.5 Blistering

Substantial blisters are only caused on wood finishes where a foreign material such as water or grease, is present between coats, or at the dry film stage, where excessive heat is applied. Some forms of aeration can also cause blistering.

12.3.6 Aeration

Too heavy a coat may cause aeration with nearly all rapid drying materials, particularly if allied with high spraying pressures. In such cases, the fault arises from trapping of solvents, which then burst through the virtually dry top skin of the coating. In extreme cases, the aeration, which is not visible to the naked eye, gives the appearance of milkiness. Another form of aeration is caused by the trapping of air in the film. This frequently arises where a heavy coating is applied to open grain timber.

12.3.7 White-in-the-grain

Usually due to trapped filler solvent, which is a non-solvent for the lacquer, thus precipitating the lacquer solids. The condition is aggravated by the uses of inferior lacquers with weak solvent mixtures and consequent low tolerance for excess non-solvent. Prevention is simply a matter of using a faster drying filler or allowing a longer drying time. A better quality lacquer will reduce the possibility of the failure.

Bleed-through of glue used in the veneering process can give a similar looking effect and so can silica inclusions that occur in some timbers, but these are not finishing faults.

12.3.8 Cissing

This is the formation of craters in or on top of the film and is always associated with the presence of some foreign substances, either on the substrate or on the surface of the film itself. Greasy dirt or traces of silicones, which may be airborne from another part of the factory, are common causes of cissing. Prevention is a matter of ensuring cleanness, not only of the job itself but also of mixing containers, air lines etc. Cissing should be treated as a film defect.

12.3.9 Incorrect choice of lacquers

The choice of sealer and lacquer is very important. Problems often occur if components of the finishing system are incompatible with each other. In such cases, it is difficult to solve a dispute between the user and the suppliers of these various finishing components. It is essential that all the components of a finish are compatible and come from one supplier/producer.

12.3.10 Improper handling of finished panels & products

When a satisfactory finish has been obtained, it is essential to ensure that proper handling procedures are applied in order to maintain the quality of the finish. The following precautions should be undertaken:

- Allow ample time for lacquers to cure thoroughly before handling and packaging, otherwise damage to the lacquer will occur.
- The finished panels should not be placed into enclosed boxes too soon after lacquering, as there will not be sufficient air circulation to cure the lacquer.
- Panels should not be stored in damp, draughty or hot warehouses or factories.
- Maintenance instructions should be provided by the supplier of the finished product and should be strictly followed by the users of the veneered products. In particular, if an inappropriate cleaning agent is used regularly it will damage the coating and allow moisture to enter. This will lead to the loss of gloss, whitening, embrittlement and veneer checking.

12.4 Recommendations on finishing procedures

- Veneered panels should be stored according to standard requirements in order to eliminate any factor that could affect the quality of the panels. Storage and handling requirements are described in Chapter 8. In particular, it is important that veneered panels are not exposed to damp and humid conditions. Several veneer cracking problems have been attributed to exposure of furniture or veneered panels to such conditions for several weeks.
- It is essential to check the moisture content of panel before the finishing process. This requirement is particularly important if the finishing is done by a sub-contractor in another factory, as the moisture content of veneered panels can easily increase while in transit. Finishing materials should not be viewed as barriers to moisture content changes – they really only slow the process due to their low moisture vapour transmission characteristics.
- The panels should be free from marks, indentations, etc. that will detract from the panel's final appearance. They should be clean − dust and grit will adversely affect finish. Oil, wax and other contaminants also need to be removed before a lacquer is applied. If necessary a grease remover should be used.
- It is essential that the type of finish selected for a piece of furniture or other products is suitable for the end use application − domestic or commercial, damp or dry conditions, light, general or heavy use.
- Finishes should be applied under controlled environmental conditions, away from draughts, dust, moisture and other contaminants.
- It is essential that the manufacturer's instructions are carefully followed and that finishing products from different suppliers not be mixed or used on the same board.

- It is essential that all surfaces in veneered furniture/products be coated to provide a protective seal against changes in humidity. Failure to do so will be detrimental to the stability of the veneered products as moisture penetrates through the unsealed surface during any ambient change in relative humidity. This effect predisposes the panel to veneer cracking. Panels not sealed can also bow or cup. The sealing of all surfaces is a critical factor in maintaining high quality veneered wood products.

- It is strongly recommended that the finishes material data and the finishing process be recorded.

- Manufacturers of veneered products should provide instructions as to the ongoing, 'in service' care of the finished article. As these instructions largely apply to the treatment and protection of the surface finish, they should be formulated in conjunction with the lacquer supplier

REMARK
Even if the veneer panel producer supplies high quality panels, the elimination of veneer problems is also dependent on the quality controls applied by the furniture or other product manufacturer.

Chapter 13
MANUFACTURING AND MAINTENANCE OF VENEERED PRODUCTS

Generally, the manufacturing process, which uses veneered panels, involves machining, joining and assembly of various components. However, the production methods and procedures depend on the type of products, their design and the machinery available at particular manufacturing premises.

The description of various production methods is not within the scope of this manual. However, it is important to highlight that manufacturing companies have a great responsibility for the quality of final veneered products. High quality properly manufactured veneered panels can be seriously affected if further manufacturing procedures and maintenance of the final products do not meet the requirements specific to veneered products. Therefore, it is essential that all parties involved in the production of the products and their users strictly follow recommendations and requirements developed for the veneered products.

It is strongly recommended that:

- Finished veneered panels are not stored in warehouses/factories that are damp, draughty or hot. Standard requirements for storage of veneered products should be strictly followed (Chapter 8). The same requirements apply to the conditions in a factory in which the manufacturing process takes place.

- Final veneered products should be carefully packed to protect against mechanical and/or environmental damage during transport and storage.

- Products should not be placed or installed in wet, damp or very hot rooms/buildings. These extreme conditions may cause a serious damage to the veneered products. Too early installation of the products in newly constructed buildings may be particularly devastating. There have been instances of severe deterioration of the products (such as desks, tables and panelling) delivered to a site before contractors have finished internal work.

- It is essential that a proper cleaning agent be used by the users of veneered products. If an inappropriate cleaning agent is used regularly, it will damage the coating and allowing the ingress of moisture. This will lead to the loss of gloss, whitening, embrittlement and veneer checking.

Chapter 14
COMPLEX PROBLEMS IN VENEERED PANELS

Problems can occur in veneered panels/products at any stage of the process if the manufacturing procedures are not strictly followed. Examples of typical failures related to each of the manufacturing stage have been described in the earlier chapters. However, in some cases many different factors can cause the failure of the final product, making it difficult to trace back through all the stages of the manufacturing process in order to determine the cause of the failure. Typical examples of such a failure are veneer checking and discolouration of veneered panels. These two types of problems frequently occur in the veneered products that have been improperly treated.

14.1 Causes of veneer checking and its prevention

There are many causes of veneer checking, but they can be eliminated or significantly reduced if proper manufacturing and quality control procedures are in place. The most frequent factors which affect veneer checking are the selection of veneer species, type of core material and construction methods, moisture content of veneer and the core, adhesive and the gluing process, conditioning and storage, finishing process and the maintenance of the final products (Ref.13 & 23). These factors are analysed below:

Cause 1: Veneer species and quality
Species that are highly porous or "ring porous" such as oak and walnut are very susceptible to checking. This is also true of those woods that have a high degree of figure. Greater density woods are most prone to checking. There will, of course, be some overlapping between various types of wood and no hard or fast rules can apply.

Quality of veneer used is extremely important as defects greatly increase the possibility of surface checking by providing weak zones. Cracking of the more popular straight grain veneers rarely occurs although exceptions have been noted when items have been stored in a humid area for some weeks before finishing.

Cracking of the so-called “exotic veneers” is more common. The main difficulty here is that these veneers are brittle and, at the recommended moisture content of 10%, are probably too distorted for any preparation to be carried out without severe splitting of the veneers. These brittle veneers have to be wetted to improve their handling characteristics. The excess water is then removed by the “flattening” process.

Cause 2 Moisture content changes
Veneer cracking and checking mainly occurs as a result of the movement of veneer or the substrate due to changes in moisture content. As the dimensions change, stresses between the veneer and the core occur. When these stresses reach the point where they exceed the structural strength of the veneer, a rupture of the fibres takes place. This, in effect, shows up as a check or minute split on the surface. The cracks closely follow the grain direction of the decorative veneer.
Changes in moisture content can occur if:

- The moisture content of veneer or/and the substrate prior the manufacturing process commences is too low or too high.
- The ambient conditions in the storage area do not meet requirements (too humid or too dry).
- The ambient conditions in the veneering factory do not meet requirements (too humid or too dry).

- Veneered panels are not protected against the moisture changes during the transport and storage before the finishing process starts.

- An inappropriate coating system is used and the veneered panels are not sealed and coated on all surfaces.

- The maintenance of the veneered surfaces while in service does not comply with the lacquer manufacturer's recommendations.

- Veneered products (eg furniture) are exposed to extreme environmental conditions while in service.

REMARK

Contrary to some manufacturers' expectations, lacquers do not stabilize the moisture content of the underlying veneer, they merely delay the first appearance of any cracks. While a more flexible lacquer will absorb some of the movement of the veneer, a lacquer with good performance in other respects cannot be expected to bridge over open cracks in the veneer.

Cause 3 Improper gluing and pressing procedures

The veneer checking can occur if:

- There is too much water in the glue mix. The glue mix should not be extended too much with wheat flour and additional water.

- Assembly time is too long. Assembly time has been shown to have a significant effect on veneer checking – the longer the assembly time the more checking that will subsequently occur. It is important to keep the assembly time to a minimum – within minutes of spreading.

Cause 4 Improper conditioning and finishing of panels

Cracking of veneer often occurs when panels have been exposed to damp conditions for several weeks before finishing (transport or storage). Therefore, it is essential that the factory in which the finish is applied has a special conditioning room for storing panels. The moisture content of panels before finishing should be in the middle of the range that they will experience in service. It will be at or below 12%. It is important to check the moisture content of panels before finishing to reduce the potential for veneer checking. The furniture manufacturers should be aware that reasonable temperature and humidity requirements should be provided for storing completed furniture. If humidity rises substantially during storage, the manufacturers will encounter not only sticking drawers and doors, but also the possibility of creating veneer checking if that furniture is subsequently placed in dry ambient environment.

Cause 5 Improper maintenance of veneered products

Finishing materials should not be viewed as barriers to moisture content changes – they are only retarders. Moisture content changes are therefore possible which will result in veneer checking. The moisture change may occur if:

- The final product is exposed to extreme conditions of environment (too dry or too humid) or to changing conditions (dry-humid-dry-humid). There are areas in Australia where, during the winter period, the equilibrium moisture content of furniture in centrally heated rooms may be as low as 5-6%. However, in northern states during humid months the moisture content of timber products may be as high as 15%.

- Improper cleaning procedures are used (frequent wetting of veneered surface).

- Improper cleaning agent is used (eg. heavy-duty detergent or abrasives).

14.2 Discolouration of veneered products

14.2.1 Changes in colour of wood

The variation of colour within-species is a natural and valuable characteristic of wood, which makes solid wood and veneers much more attractive materials than the products that imitate wood's appearance.

The colour of wood depends mainly on the presence of extractives, complex organic compounds, such as polyphenolic compounds and quinines (Ref.8). It is impossible to maintain the colour exactly as it appears on the freshly dressed wood surface. When subject to long-term exposure to sunlight or moderate to strong interior lighting, these compounds undergo chemical change that result in the change of wood colour.

Even very clear finishes will change the colour of wood considerably. They fill the air spaces among the wood fibres and as they have a higher refractive index than air the result is a darkening of the colour. To obtain an indication of the effect of a clear finish on the colour of the wood, wetting a small area with water will give a good fast guidance.

14.2.2 Discolouration and staining of veneers

Veneer products are susceptible to discolouration and staining, which can be caused by various factors, such as:

- The effect of strongly acidic adhesives and/or coatings on the natural extractives in the wood, or from the reaction between extractives and strong alkalis.

- The reaction between tannin in timber and iron particles resulting in dark iron tannates. Many species have a high tannin content which reacts with iron to form black/grey and insoluble iron tannates if the wood is in a wet condition. Such stain is limited to the surface. Spotty iron tannate staining may even result from the atmospheric fallout of particles produced in tool sharpening, etc. Aluminium, monel metal and galvanized steel do not cause staining but in the latter case it is important that the galvanizing remains undamaged during the driving of the nail (Ref.8).

- Degradation by UV light can occur due to the exposure to sunlight. The exposure to sunlight results in a gradual bleaching of red/dark woods and a yellowing of blonde woods. Such changes are limited to the surface layers of wood and the original colour can be regained by sanding or planning the surface. UV-inhibitors can be added to finishes to reduce the yellowing effect on lighter timbers.

A survey of the veneer panel producers and the users of the veneered products has been undertaken in Australia aiming to identify the most common problems related to veneer discolouration (20). The results of the survey enabled the researchers to summarise the most common and most typical examples of veneer discolouration and these are as follows.

- ***Red/pinkish staining of blackwood, American cherry and European beech***
  The discolouration occurs on veneered panels in the form of red stains. This is caused by the reaction between extractives in the timber and an acid from the glue system or the finish used in the panels.

- ***White staining of steamed European beech veneers***
  This discolouration problem was serious a few years ago, but the occurrence of white staining has significantly reduced after the results of an experimental research project were published in 1998 (Ref.19), which recommended only polyurethane lacquer be used on beech veneers to avoid white staining and that moisture resistant substrates be used with beech veneer in wet areas (kitchen & bathrooms).

- ***Iron contamination of glues and veneers***
  Grey or black discolouration of glues due to contact with iron has been reported. Both PVA and urea glues can be affected by iron contamination if stored in steel containers. Low pH acidic PVA is most susceptible to this problem. Sometimes the glue does not change its colour while in the container, but the discolouration is visible after the veneer is laminated on the substrate. Therefore, no steel component should be used in the glue container, even in the tap. This recommendation applies to both the glue suppliers and the glue users who often pour the glue into smaller containers after purchasing.

- ***Black staining of Tasmanian oak veneer.***
  This type of staining has been identified as a serious problem and occurs mainly in tropical Queensland (around Cairns and Port Douglas). Black spots have also been known to occur on black wattle veneer in tropical applications.

- ***Pink discolouration of American maple, silver ash and beech***
  Individual cases of pink discolouration have been reported. According to the information provided, only a small proportion of the total number of veneered products was affected, although they were manufactured by the same company at the same time.

- ***Discolouration due to the exposure to the ultraviolet (UV) light***
  Some veneered products are particularly sensitive to UV light. It was reported that sapele veneers become significantly darker when exposed to the UV light while jarrah veneers become lighter. Some manufacturers have observed different effects, which suggests colour changes may depend on variation between logs.

14.2.3 Investigation of causes of veneer discolouration

A research study was undertaken by the University of Melbourne and the Australasian Furnishing Research and Development Institute (Furntech) aiming to investigate causes of veneer discolouration in decorative veneered panels and develop guidelines on the prevention of veneer staining and discolouration (Ref.21). The project was initiated and developed by the Decorative Wood Veneers Association, and financially supported by the Forest & Wood Products Research & Development Corporation (FWPRDC).

Discolouration of four of the most "problematic" species, selected by the industry, was investigated:

- blackwood − *Acacia melanoxylon*
- European beech − *Fagus sylvatica*
- American maple – *Acer saccharum*
- Tasmanian oak (sold as a mix of either *Eucalyptus delegatensis* − Alpine ash,
- *E. regnans* − Mountain ash, *E. obliqua* − Messmate)

The project involved experimental trials with the objective to analyse the possible causes of the discolouration and then to reproduce the discolouration of these veneers under laboratory conditions. The following experiments were undertaken:

Investigation of the effect of acidification on discolouration of selected veneers
The study aimed to determine the effect of pH of various formulations on the veneer colour.

Accelerated environmental exposure of veneered panels constructed according to the above findings
Veneered panels were manufactured using four veneer species, four types of substrates commonly used by the furniture and joinery industry, two types of adhesives with two values of pH and three types of lacquers (at various levels of acidity). The samples were subjected to an accelerated environmental exposure using high humidity and high UV radiation, which are known to be significant factors contributing to the discolouration of veneered products.

The effect of various acid catalysts in relation to pink staining
In addition to the investigation carried out by the University of Melbourne, an experimental study has been undertaken by AV Syntec Pty Ltd with the objective to investigate the effect of various acid catalysts in relation to staining, in particular the pink stain, in European beech and blackwood veneers.

The details of the studies are provided in the project report (Ref.21).

14.2.4 Recommendations on the prevention of veneer discolouration

Pink Discolouration of Veneers
The results of the study described in the previous Chapter indicated that the three veneers are susceptible to pink discolouration from acidic products. Therefore the recommendation to the industry is that for these veneers the pH of lacquers and adhesives should be close to the natural pH of the veneers to prevent such discolouration occurring.

When purchasing adhesives for "problematic" veneers, the veneer panel producers should specify the pH of the glues. Similarly, the users of veneer panels should ensure that the panels they purchase meet the required specification in regards to the pH of the adhesives. They should also ensure that the coating systems they purchase meet the required specification with respect to the pH range of the veneers.

The following pH ranges are recommended for "problematic" veneers:

- blackwood: pH range 3.6 − 5.2.
- European beech: pH range 3.6 − 6.3.
- American maple: pH range 3.8 − 4.6.

Dark Staining of Tasmanian Oak Veneers
From the study (see Chapter 14.2.3) and from the study undertaken in the industry it is evident that when handling Tasmanian oak particular care must be taken to minimise contamination with iron containing fragments or solutions from such sources as:

- Saw blades
- Veneer slicing blades
- Surface sanding and smoothing (eg, steel wool)
- Nails, screws and metal joints
- Contaminated water
- Contamination of glues and lacquers due to storage in metal containers, which have an iron component

It is evident that high humidity or water contamination of the veneer is essential for the process of staining to occur. The use of lacquer inhibits the progression of the staining. Therefore it is recommended that:

- A durable coating system such as polyurethane lacquer is used on Tasmanian oak veneers.
- All surfaces are carefully coated.
- Sharp edges, which allow moisture to readily penetrate to the veneer, should be avoided.
- When cutting and slicing Tasmanian oak veneers stainless steel blades should be used.
- The moisture content of veneer and substrate should be within the specified range between 8 and 10%.

Although there was only slight pink tinge in the veneers coated with acid catalysed lacquer it would be prudent to use glues and lacquers that are within the pH range of the Tasmanian oak which is between 3.6 and 5.2.

Iron stains may also occur in other species if veneers are severely contaminated with iron.

A practical guide has been developed for the industry on the prevention of veneer discolouration and staining, which is provided in Table 3. The recommendations are based on the results of the research study (Chapter 14.2.2), industry experience and an extensive literature review.

REMARK

Although the above recommendations have been developed for the veneer species selected by the DWVA, discolouration problems can also occur in other species. Therefore, the recommendations should be also applied to any species not mentioned in this manual.

Table 3 Practical Guidance on the Prevention of Veneer Discolouration

Veneer Species	Type of Discolouration	Methods of Prevention
Blackwood, American maple, European beech, American cherry	Red or pink discolouration or staining of the surface of veneered products. May occur along the veneer glueline.	▪ The pH of lacquers and adhesives should be close to the natural pH of the veneers. ▪ When purchasing adhesives, the veneer panel producers should specify the pH of the glues. Acidic glues should not be used. ▪ The users of veneer panels should ensure that the panels that they purchase meet the required specification in regards to the pH of the adhesives. They should also ensure that the coating systems that they purchase meet the required specification with respect to the pH range of the veneers. Acidic catalyst lacquers should not be used. ▪ The following pH ranges are recommended for the veneers: Blackwood: pH between 3.6 and 5.2. American maple: pH between 3.8 and 4.6. European beech: pH between 3.6 and 6.3. American cherry: no data available, but acidic lacquers and adhesives should not be used.
European beech	Whiting effect on the veneer surface and around edges any accessory holes, in particularly in bathroom and kitchen installations.	▪ Polyurethane sealer and op coat should be used on the veneered products. ▪ Only moisture resistant particleboard and MDF should be used as the substrate ▪ Sharp edges should be avoided.
Tasmanian oak **Tasmanian oak (continued)**	Dark brown/grey discolouration of veneers, particularly along the panel edges, holes, hinges and fittings, sometimes blotching effect on the veneer surface.	▪ When handling Tasmanian oak it is critical to minimise contamination with iron containing fragments or solutions from such sources as saw blades, veneer slicing blades, surface sanding and smoothing (eg, steel wool), nails, screws and metal joints, contaminated water, contamination of glues and lacquers due to storage in metal containers that have an iron component. ▪ A durable coating system such as polyurethane lacquer should be used on Tasmanian oak veneers. ▪ All surfaces should be carefully coated. ▪ Sharp edges, which allow moisture to readily penetrate to the veneer, should be avoided. ▪ When cutting and slicing Tasmanian oak veneers stainless steel blades should be used. ▪ Moisture content of veneer and substrate should be within specified range 8% - 10%.

14.3 Summary of typical problems in veneered products.

Typical problems that occur in veneered products and their possible causes have been summarised in Table 4.

Analysis of the table shows that some types of the product failures can be caused by multiple factors. Therefore, it is important to keep quality control records at each stage of the manufacturing process.

Table 4 Summary – typical problems occurring in veneered products and their causes

Possible causes of the Problem	*Typical Problems Occurring in Veneered Products*							
	Veneer checking	**Veneer discolouration**	**Zigzag tele-graphing**	**Discolouration of glue line**	**Glue bleed-through**	**Veneer delamination**	**Lacquer crazing**	**Lacquer blushing**
Veneer species	✓	✓	✓	✓	✓	✓		
Veneer quality	✓	✓	✓		✓	✓	✓	
MC of veneers	✓	✓		✓	✓	✓	✓	
MC of substrate	✓	✓		✓	✓	✓	✓	
Improper selection of substrate	✓	✓				✓		
Thickness variation (veneer and/or core)	✓					✓		
Veneer joining		✓	✓	✓		✓		
Glue selection & preparation	✓	✓		✓	✓	✓		
Gluing process	✓	✓			✓	✓		
Pressing process	✓		✓		✓	✓		
Sanding of panels	✓		✓		✓			
Conditioning & storage by veneer producer	✓	✓					✓	
Storage before finishing	✓	✓					✓	
Selection & preparation of finish	✓	✓		✓			✓	✓
Finishing process	✓	✓					✓	✓
Conditioning & storage after finishing	✓	✓					✓	✓
Manufacturing of veneered products	✓							
Service conditions	✓	✓					✓	
Maintenance of veneered products	✓	✓				✓	✓	

Chapter 15

QUALITY CONTROL IN PRODUCTION OF WOOD VENEERED PRODUCTS

15.1 Requirements for quality control process

The production of veneered products is a complex process, which consists of many variables and parameters. Various problems may occur if even one of these variables or parameters fails to meet the process requirements.

Although a particular operation may be correct, the quality of the final product will be directly affected by what takes place in the plant before this operation commences. For example, when veneer delamination occurs, assuming all instructions provided by the adhesive supplier are followed properly, one must ask questions and explore possibilities to discover where the process could have gone wrong.

The best method of tracking the cause or causes of the product failures is to backtrack through all steps of the veneer manufacturing process and examining the entire plant procedures, from veneer production to the finished product. Therefore, it is imperative to maintain a high standard of quality control with regular sampling and testing, monitoring and keeping comprehensive records of production parameters so that if there is a failure of the product there is documented evidence on which to base a defence of the product.

It has been shown in legal cases related to other manufacturing industry sectors that, unless the producer can show that the company has undertaken the manufacturing process within strict parameters and standard requirements, there is no basis to defend a claim against the company's products. Therefore, the industry is vulnerable to claims being made against an individual company when a veneered product fails in service, even though it might have nothing to do with the veneer manufacturing process. For example, there are examples of veneered products failing due to the wrong lacquer being used or inappropriate care after the product leaves the company. A fully documented quality control system is of great benefit to all companies. Adverse publicity about veneer failures impacts across the whole industry as the customer can distrust veneers and veneered products.

REMARK
In order to be able to defend any claim it is critical that a documented quality control process is in place and correct procedures can be shown to have been undertaken.

15.2 Quality control procedures – check list

To ensure veneered products are of a high quality and high performance, the quality control process should cover:

- Materials used in the manufacturing process (veneer, substrate, glue, finish)
- Storage and manufacturing processes
- Maintenance of final products

To assist industry in setting up quality control procedures a simple checklist has been developed, which can be used as guidance for ensuring that all stages of the production process are tested and monitored (Tables 5 & 6). It is recommended that the quality control procedures be undertaken on a daily basis and records kept. Every change to the manufacturing process (new species of veneer, substrate, new glue, coating system) should be recorded and the quality control process applied.

REMARK
The quality control checklist provides only recommendations of "best practice procedures". This is not equivalent to the formal accredited quality control system, which is a complex process of accreditation and frequent auditing.

Table 5 Quality Control Checklist for Manufacture of Veneered Panels

Production Stage	Requirements for testing and monitoring of manufacturing procedures	Reference to Manual
STORAGE OF VENEERS AND SUBSTRATE		
Storage conditions	• **Check ambient conditions daily inside the storage room: temperature and relative humidity.** • **Make sure that storage conditions meet standard requirements (recommended every month).** • **At the time of delivery check if the veneer and substrate meet your specification. (eg. check the moisture content of veneers and substrate, grade of veneers, type of substrate: standard or moisture resistant)**	**Chapter 8**
PRODUCTION OF VENEERED PANELS		
Factory conditions	• **Check ambient conditions daily in the factory: temperature and relative humidity.**	**Chapter 8**
Veneer trimming (guillotine)	• **Check if the edges are straight, parallel and square with minimal tear out.**	**Chapter 9.4**
Veneer joining	• **Check if the quality and grades of veneers meet your specification.** • **Check the moisture content of veneers (recommended MC = 8-10%). Do not joint veneer leaves if the moisture content difference between adjacent leaves is more than 2%.** • **Check the veneer thickness for any variation. Any difference over 0.1mm can cause problems.** • **Check parameters of the joining machine (usually temperature & pressure but it depends on the type of the machine). Check the machine instruction/specification what parameters are required for various types of veneers. Make sure that proper glue is used for joining according to the machine requirements.** • **In case of using a zigzag stitching machine, make sure that you use a proper grade of the thread to avoid problems.** • **After joining, check the quality of joints (glue bond quality, any delamination, straightness of joints, zigzag quality).**	**Chapter 4.1** **Chapter 4.3** **Chapter 9.3** **Chapter 9.3 & 9.4** **Chapter 9.4.3** **Chapter 9.4.3**

Gluing process **1. Preparation of substrate** **2. Preparation of veneer for gluing** **3. Gluing process** **4. Pressing process** **5. Glue bond quality**	• **Check the moisture content of substrate using moisture meter (recommended MC = 8-10%)** • **Check the thickness of the substrate and record any variation (permitted variation = +/-0.2mm).** • **Identify loose and tight side of veneer to ensure that the face veneer is laid with tight side outwards where possible.** • **If veneer layons have been stored in uncontrolled environmental conditions after joining for more than 3 days check the moisture content of the veneer again just before the gluing process starts.** • **Make sure that the glue mixture is prepared according to the glue supplier's specification.** • **Measure the amount of glue spread on daily basis. Adjust the glue spread to various types of veneers (according to the glue supplier's instruction)** • **Regularly check the glue spreader rolls. Adjust the gap between the rolls if required. Check if the grooves are not warn.** • **Always make a trial gluing and test the results when working with new adhesives or different species of wood** • **Check if pressing parameters (pressure, temperature of platens and pressing time) are set according to the press specification. Adjust the parameters if required.** • **Check the quality of the glue bond:** ➢ **visual regular assessment to identify any sign of delamination, glue bleed-through etc.** ➢ **occasional testing of the bond quality using Chisel test** ➢ **testing the bond strength and durability by an accredited laboratory according to the Australian standard (Ref.7)**	**Chapter 5.2.3** **Chapter 5.2.1** **Chapter 10.1.1** **Chapter 10.1.2** **Chapter 10.2.2** **Chapter 10.2.2** **Chapter 10.3** **Chapter 10.4**
Sanding process	• **Check sanding parameters according to the supplier's specification. Monitor the parameters and grid of sanding paper applied.** • **After sanding, check the quality of the sanding operation, in particular if the veneer is not sanded excessively.** • **Check the uniformity of sanding (thickness variation within the panel and the amount of veneer removed).**	**Chapter 11**
Storing and packing of veneered panels	• **Check ambient conditions inside the storage room (temperature and relative humidity).**	**Chapter 8**

Storing and packing of veneered panels	• **Make sure that the packaging material does not allow any wetting and protect the panels against rapid moisture content changes and any mechanical damage during transport.** • **Provide an instruction on the quality control during finishing and further manufacturing of veneered panels. In particular provide information on possible discolouration of various types of the veneers and recommendations on types of finish which should be applied on these veneers.**	**Chapter 12.1 & 12.4**

REMARK
Immediate action must be undertaken if even one measured factor does not meet the requirements provided in the Manual and/or the relevant standard.

Table 6. Quality control check list for finishing and manufacturing of veneered products

Production Stage	Requirements for testing and monitoring of manufacturing procedures	Reference to Manual
Storage before finishing	• **Make sure that storage conditions meet standard requirements.** • **Check ambient conditions daily inside the storage room: temperature and relative humidity.**	**Chapter 8 & 12.1**
Finishing process	• **Measure the moisture content of veneered panels (recommended 8-11%).** • **Check if surfaces of veneered panels are clean & free of contaminants.** • **Check if the selected coating system meets the requirements for the end use application.** • **Check if any special precautions should be taken for the type of veneer used on the panel.** • **Check if the coating system is prepared and applied according to the supplier's specification. Make sure that all surfaces be coated to protect the panels against moisture changes.** • **Make sure that the coated panels are conditioned in controlled environmental conditions before any further manufacturing process starts.** • **If the coated panels are transported to another company for the final manufacturing process, make sure that the coated panels are properly packed to eliminate any moisture changes or mechanical damage during transport.** • **Prepare information on the type of coating system used and the instruction on the cleaning of the panels (according to the information provided by the coating supplier).**	**Chapter 12** **Chapter 12.2** **Chapter 12.4** **Chapter 13**
Manufacture of veneered products	• **Check ambient conditions daily inside the storage room and factory (temperature and relative humidity).** • **Check the moisture content on the time of the arrival to the factory.** • **Handle the veneered panels with a special care during the production of final products.**	**Chapter 13**
Maintenance of veneered products	**Make sure that the instruction on the cleaning of the final product is provided to the user of the product.**	**Chapter 13**

Chapter 16
CONCLUSIONS

Recommendations provided in the manual should be strictly followed by both the producers and the users of decorative veneered panels to minimize any product failure and to enhance market confidence in veneered products.

The manual should be used by the veneer and veneered panel producers, furniture and joinery manufacturers, designers and architects, interested in producing and promoting high quality and high performance veneered products.

REMARK
Although this manual has been written for the Australian industry, its principles and practices are applicable worldwide.

Chapter 17

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