Timber Flooring

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Australian Government

Forest and Wood Products Research and Development Corporation

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by

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Cover photo:- Courtesy of Northern Suburbs Timber Flooring

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INTRODUCTION

SCOPE

This publication provides a reference guide for the installation of timber strip flooring over bearers and joists, timber based sheet flooring products and concrete slabs. Generally floors of this type are of solid timber or a laminated product made up from layers of timber, bonded together. Flooring fits together with a tongue and groove joint and after the flooring is in place the floor is sanded and finished. There are a number of other timber flooring products that are not of this type and are not covered by this guide. These include parquetry, pre-finished floors and 'floating' timber floor systems. When installing a strip timber floor many aspects must be considered and this includes assessing the house design, environment in which the floor is to be laid and the desired appearance of the finished floor. Such aspects influence the choice of species, cover width, fixings and finish to be applied. Information relating to product selection, assessing the installation environment, floor installation, sanding and finishing are provided in the guide together with additional information of importance to the floor installer, sander and finisher.

THE FLOORING PROCESS

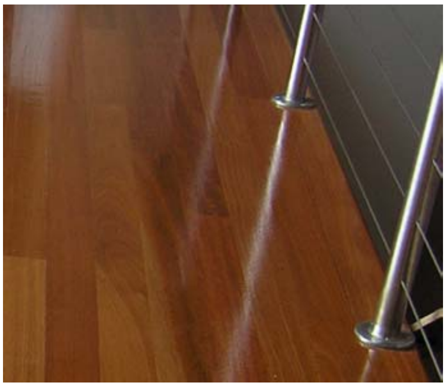
Strip timber flooring is available in a wide range of species colours, from harder and softer timbers and a variety of profiles and cover widths. However, prior to the finished floor being handed over, there are a number of processes that must be correctly undertaken to achieve a floor with the performance and appearance that is of professional standard. Each stage generally involves different sectors of the industry, each having specific skills. However each stage is of equal importance with defined responsibilities and a lack of attention at any particular stage that can adversely affect the finished floor. The stages are as follows.

Selective logging from sustainable managed forests often starts the process.

- Manufacture – Usually a sawmiller however dried rough sawn boards may be machined into finished floor boards undertaken by a separate operation.
- Distribution – Flooring is often sold to timber merchants who on-sell to the installer.
- Specification – Architects, designers and owners usually specify the product to be installed.
- Sub-floor – Builders provide the joists and bearers or slab over which a floor is laid.
- Installation – Specialist floor installers and carpenters install floors over the sub-floor
- Sanding and Finishing – Generally undertaken by professional floor sanders and finishers

THE OWNERS CHOICE

Aspects relating to what customers desire is of paramount importance and should not be taken lightly. They are relying on the expertise of those in the six stages outlined above and each area can influence the owner's satisfaction of their floor. Each floor is unique and is often seen by the owner as a focal point of the interior design. Those selecting a timber floor will often choose on colour with board width influencing how the natural colours are blended. Timber hardness or matching to an existing floor can also be of prime importance. In addition to this, aspects such as the origin of the flooring in terms of country, forest type or recycled, can also be of importance to the owner.



Client wishes need accommodating but not at the expense of floor performance.

Owners are much more aware and have much more access to information than ever before, however they are unlikely to have the same depth of knowledge as those dealing with timber flooring on a day to day basis. It is important to accommodate customer preferences, however this should not be to the detriment of the performance of the floor or its final appearance. Where customer preferences can not be accommodated then this needs to be brought to their attention. Where their choices can be accommodated but may affect the appearance of the floor, then this too needs to be brought to their attention and followed up in writing. Colour variation between showroom samples and the product provided, provision of expansion joints, high levels of sun exposure on an area of the floor etc are all areas which affect appearance and may necessitate specific discussion with the owner.

Showrooms provide an excellent environment where clients not only see many types of floors and finishes but where valuable information can be conveyed regarding floor systems, performance and care of timber floors.

Additional Resources

To complement this resource a series of five datasheets has been produced covering sections 1 to 5 of this publication. The datasheets are comprehensive but do not necessarily contain all the information included in each section of this publication.

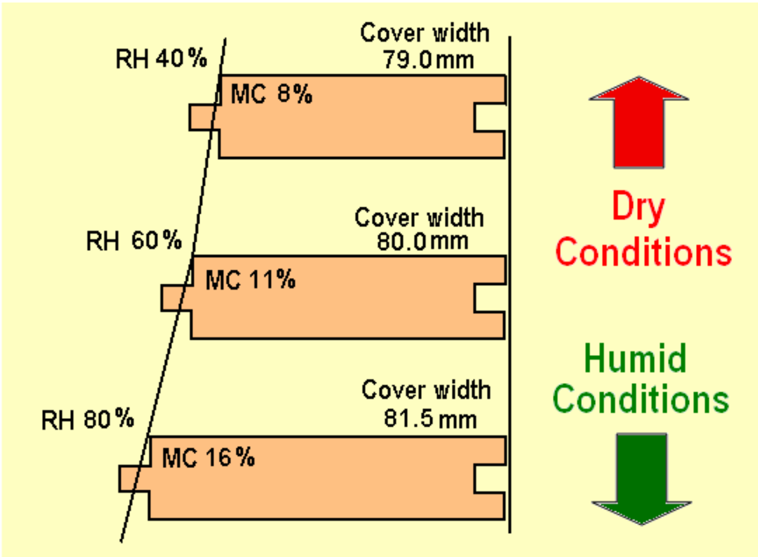
From publications it is often difficult to either obtain a quick overview of the whole flooring process or to determine the aspects of particular importance. For this reason a CD/DVD has also been produced with direct reference to the datasheets. For further details visit www.timber.org.au.

Timber Flooring CD.

SECTION 1 - TIMBER FLOORING & FLOOR FINISHES

MOVEMENT IN TIMBER FLOORS

Prior to discussing timber flooring products it is important to have an understanding of the relationship between timber, humidity in the air surrounding it and the dimensional changes that occur as the result of changes in humidity. During weather conditions of consistently high humidity timber will absorb moisture from the surrounding air causing it to swell or increase in size. Conversely, during drier times when humidities are low, timber will shrink, reducing in size. Unless T & G flooring is placed in a permanently controlled environment, it will always move in response to changing environmental conditions. Gaps between individual T & G boards will occur as the floor shrinks in dry weather. Similarly during either persistent wet weather or times of the year of naturally high humidity floors will tend to be tighter showing fewer and smaller gaps.



Cover width variation with changing relative humidity.

Due to this, a 'continuous mirror finish' cannot be expected from floor finishes. Localised shrinkage may also occur when areas of flooring are exposed to heat sources such as fireplaces or sunlight through large doors or windows. The overall movement and rate of movement of timber varies depending on the timber species and cutting pattern of individual boards. Small moisture content variations in boards at the time of installation and differing conditions within the house (i.e. from sun exposure or fireplaces) will also cause variation in board movement.

Consequently, gapping across a floor can be expected and may be relatively even, depending on individual circumstances, but actual gap size between individual boards will vary. For the same changes in moisture content wider boards will move more than narrower boards. Therefore, gaps in wide board floors are generally wider and more noticeable. An uneven distribution of gaps can detract from the appearance of the floor and may occur if a number of boards are bonded together by the finish penetrating into the joints. Floor finishes will not prevent timber movement, but may reduce the rate of response to climatic changes. Applying a finish to the underside of a floor may further assist to reduce the impact of sudden changes in the weather.

Small gaps at board edges may occur particularly during dry weather.

TIMBER SPECIES AND CHARACTERISTICS

Species, Colour, Grade and Hardness

The species or species mix chosen will generally determine the overall colour of the floor. It should also be noted that species mixes may contain different species from one producer to another and may therefore appear different. As a guide, Table 1 indicates the range of colours that may be expected. The sapwood of many hardwoods can be much lighter than adjacent heartwood and some boards may contain both light and dark colours. Even within a single species and within individual trees large colour variations can occur. The age of the tree can have a significant influence on the colour with younger timber often being lighter than more mature timber. The product supplied may differ in colour to showroom samples and this should be discussed with flooring suppliers and owners. Due to this it is also preferable that flooring is supplied from one manufacturing source and that the packs are of a similar age.

Lyctid susceptible sapwood of some hardwood species e.g. Spotted Gum is required by some state legislation, including Queensland and New South Wales to be preservative treated. Some treatments may impart a brown or green-grey tinge to sapwood, while boron preservative is non-colouring. LOSP treatment is also used. In this instance an H3 treatment may be used in lieu of H2 treatment to avoid the coloured dies often used with H2 LOSP treatments.

The character of the floor is influenced by the species characteristics and therefore the grade. Grading is a process that sorts boards according to the number and size of features present (e.g. gum veins and knots). The following table indicates the grades contained in relevant Australian Standards, but it should be noted that manufacturers often have their own grades. Often flooring that contains more feature is more moderately priced, however irrespective of the features present, there is no difference between the grades in terms of machining tolerances, permitted machining imperfections of moisture content.

Hardness indicates a species' resistance to indentation and abrasion. Damage to timber floors may occur due to continual movement of furniture, heavy foot traffic and in particular "stiletto-heel" type loading. The selection of a hard timber species ensures improved resistance to indentation and abrasion. Soft timber species, if used in feature floors can be expected to indent. Floor finishes will not significantly improve the hardness of timber flooring. In some species younger growth material the hardness can also be much lower than mature timber of the same species, but this varies from species to species.

Tasmanian Oak – Medium Feature Grade

Cypress - Grade 1

Jarah - Select Grade

Blackbutt - Select Grade

Grade, colour and board width dictate the floor's appearance.

Australian Hardwoods – to AS 2796 – Timber – Hardwood – Sawn and milled products Select Grade, Medium Feature / Standard Grade and in some species High Feature Grade					
Species		**Colour**	**Hardness**	**Common cover widths (mm)**	**Thick-ness (mm)**
Hardwood flooring species grown in Queensland and Northern NSW (may also be supplied as a mix of similar colour)					
Spotted Gum *(Corymbia citriodora)* *(Corymbia maculata)*	Qld NSW	brown, dark brown, light sapwood	very hard	60, 80,130	19,12
Blackbutt *(Eucalyptus pilularis)*	Qld ,NSW	golden yellow to pale brown	very hard	60, 80,130	19,12
White Mahogany *(Eucalyptus acmenioides)*	Qld, NSW	pale yellow brown	very hard	60, 80,130	19,12
Grey Ironbark *(Eucalyptus siderophloia)* *(Eucalyptus paniculata)*	Qld NSW	dark brown or dark red brown, light sapwood	very hard	60, 80,130	19,12
Red Ironbark *(Eucalyptus crebra & fibrosa)* *(Eucalyptus sideroxylon)*	Qld NSW	dark brown or dark red brown	very hard	60, 80,130	19,12
Rose Gum *(Eucalyptus grandis)*	Qld , NSW	straw pink to light red-brown	hard	60, 80,130	19,12
Brushbox *(Lophostemon confertus)*	Qld , NSW	mid red-brown even colour	hard	60, 80,130	19,12
Tallowwood *(Eucalyptus microcories)*	Qld , NSW	greyish yellow, olive green	hard	60, 80,130	19,12
Turpentine *(Syncarpia glomulifera)*	Qld , NSW	pale reddish brown	very hard	60, 80,130	19,12
Forest Red Gum *(Eucalyptus tereticornis)*	Qld	dark brown or dark red brown	very hard	60, 80,130	19,12
Gympie Messmate *(Eucalyptus cloeziana)*	Qld	yellow brown	very hard	60, 80,130	19,12
New England Blackbutt *(E.andrewsii)*	NSW	straw to pale brown	very hard	60, 80,130	19,12
Sydney Blue Gum *(Eucalyptus saligna)*	NSW	straw pink to light red-brown	hard	60, 80,130	19,12
Manna Gum *(Eucalyptus viminalis)*	NSW	pale straw pinks	mod. hard	60, 80,130	19,12
Hardwood flooring species grown in Victoria, Southern NSW and Tasmania					
Victorian Ash *(Eucalyptus regnans, E.delegatensis)*	Vic	pale pink to yellow brown	mod. hard	63,80,85,108,133	19,12
Tasmanian Oak *(Eucalyptus regnans, E. oblique, E.delegatensis)*	Tas	pale straw to light brown	mod. hard	60, 85, 108, 133 85, 112	19 13
Messmate *(Eucalyptus oblique)*	Tas	pale straw to light brown	mod. hard	60, 85, 108, 133 85, 112	19 13
Mountain Ash *(Eucalyptus regnans)*	Vic, Tas	pale straw to light brown	mod. hard	60, 63,80, 85, 108, 112,133	19 12,13
Alpine Ash *(Eucalyptus delegatensis)*	Vic, Tas	pale straw to light brown	mod. hard	60, 63,80, 85, 108, 112,133	19 12,13
Southern Blue Gum *(Eucalyptus globulus)*	Vic, Tas	pale brown with some pink	very hard	60, 63,80, 85, 108, 112,133	19 12,13
River Red Gum *(Eucalyptus camaldulenis)*	Vic	rich deep reds	hard	63,80,85,108,133	19,12
Yellow Stringybark *(E. muelleriana)*	Vic	even, yellow brown	hard	63,80,85,108,133	19,12
Manna Gum *(Eucalyptus viminalis)*	Vic	pale straw pinks	mod. hard	63,80,85,108,133	19,12
Shining Gum *(Eucalyptus nitens)*	Vic	pale brown some pinks	mod. hard	63,80,85,108,133	19,12
Myrtle *(Nothofagus cunninghamii)*	Tas	straw and light pink, light sapwood	mod. hard	60, 85, 108, 133 85, 112	19 13
Blackwood *(Acacia melanoxylon)*	Tas	light golden to deep brown	mod. hard	60, 85, 108, 133 85, 112	19 13
Hardwood flooring species grown in Western Australia					
Jarrah *(Eucalyptus marignata)*	WA	rich reddish-browns to soft salmon pinks	hard	80, 125	19
Karri *(Eucalyptus diversicolor)*	WA	rich reddish-browns to pale pinks	hard	80, 125	19

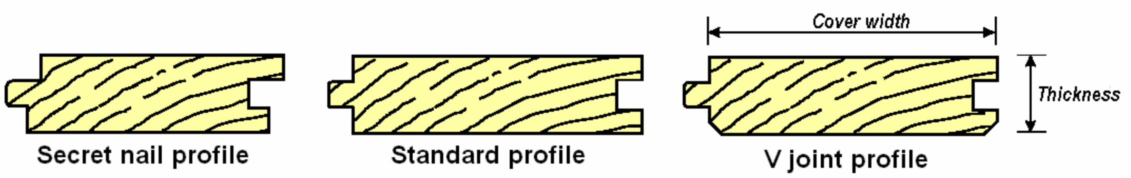
Cypress – to AS 1810 – Timber – Seasoned Cypress – Milled products Grades No.1 and No. 2					
Species		**Colour**	**Hardness**	**Common cover widths (mm)**	**Thick-ness (mm)**
Cypress (White) *(Callitrus glaucophylla)*	Qld , NSW	pale straw sapwood, dark brown heartwood	mod. hard	62,85	20

Australian Softwoods – to AS 4785 – Timber – Softwood – Sawn and milled products except Araucaria (hoop pine) for which industry grades apply Standard Grade for AS 4785					
Species		**Colour**	**Hardness**	**Common cover widths (mm)**	**Thick-ness (mm)**
Araucaria (Hoop) *(Araucaria cunninghamii)*	Qld , NSW	light straw	soft	87,89,102,133, 152	19, 20, 21
Radiata *(Pinus radiata)*	Vic, NSW, SA, WA	straw	soft	104	19, 21

Imported Hardwoods – to AS 2796 – Timber – Hardwood – Sawn and milled products Select Grade, Medium Feature / Standard Grade and in some species High Feature Grade					
Species		**Colour**	**Hardness**	**Common cover widths (mm)**	**Thick-ness (mm)**
Kwila / Merbau *(Instsia bijuga)*	S.E. Asia	dark brown	hard	80,130	19
Northern Box *(Tristania obovata)*	S.E. Asia	mid brown even colour	hard	80,130	19
Maple (Rock or Sugar) *(Acer saccharum)*	Nth. America	light straw	mod. hard	50, 57, 83	19

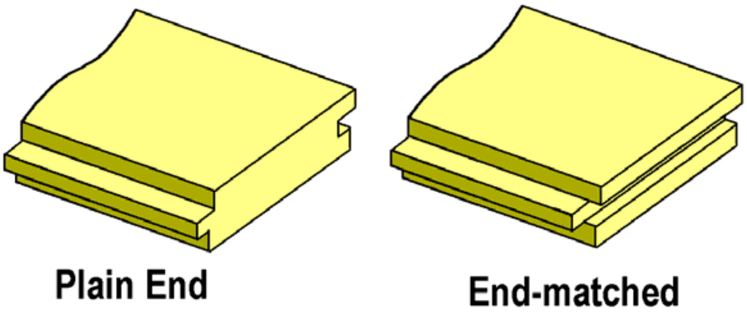
Cover Widths, Profiles, Spans and End-Matching

Typical cover widths and thicknesses for T & G strip flooring are as shown in the table above. Actual cover widths may vary from those shown and should be checked with individual suppliers. Typical T & G profiles are shown in the figure below. Some profiles are produced with grooves or rebates on the underside. Where the underside of a floor forms a ceiling, the board edges may be arrised to form a ‘v’ joint profile. The secret nail profile is used for both top nailing and secret fixing. When secret fixing, the cover width should be limited to a maximum of 85 mm. The “standard profile” is used for face nailing and is the profile commonly found on wider boards. Some wider board flooring has the secret nail profile which allows temporary secret fixing prior to top nailing.



If the species or species mix contains a significant variation in colours the appearance of the floor will differ depending on the cover width. Narrower boards tend to blend the colour variations together. Gapping between individual boards during drier times is also less with narrower boards than it is with wide boards. A maximum board width of 100 mm is recommended to limit potential gap size and other movement effects such as cupping (edges of the board higher or lower than the centre).

End-matching is a process where a tongue and groove joint is provided at the ends of boards. This allows joints to be placed between joists, resulting in less wastage than plain end flooring, which must have its ends fixed over joists.



Floor lengths

Flooring is generally supplied in random length packs up to 6 m in lengths. The average length is often between 2.1m and 3m. Packs of shorter overall length are also available from some suppliers to facilitate floors in high rise buildings that require product to be taken to the appropriate floor by lift. The minimum length for timber being fixed to joists is 900 mm, based on a 450 mm joist spacing. In some instances, if it is known that the floor will be laid over a structural sub-floor, then lengths shorter that 900 mm may be provided.

Ordering Flooring

When ordering timber flooring, the following details should be provided to the timber supplier:-

- species (or species mix)
- grade
- profile and end-joint type
- cover width
- thickness
- quantity (in linear metres)

Flooring is generally supplied within the moisture content range from 9% to 14%. For larger jobs in specific environments a different range may be specified.

To calculate the linear metres of flooring required, the following method is recommended.

$$\text{Total length of flooring required} = \frac{\text{area of floor (m}^2\text{) x 1000}}{\text{cover width (mm)}} + \text{Wastage}$$

Allowance for waste should be approximately 5% for end-matched flooring and 10% for plain end butt joined flooring.

FLOORS OVER DIFFERENT SUB-FLOORS

Depending on the T&G sub-floor supporting system (e.g. joists, plywood on slab etc), timber floors will both feel and sound differently when walked on. Generally T&G timber floors laid over joists or battens will have more spring under foot and there is likely to be some vertical movement at board edges and end matched joints when walked on. Some squeaks can therefore be expected from most timber floors of this type. ‘Squeaks’ can occur from movement of one board edge against another or from boards moving on nails. Squeaks are often more prevalent during drier weather due to loosening at the joints. Floors that are laid over plywood on a slab will have a firmer feel underfoot and some areas may sound drummy. Similarly when floors are glued directly to concrete, the feel is firmer, and again some boards may sound ‘drummy’ when walked on.

In cooler climates slab heating may be present and due to the direct heating effect on the timber and intermittent use of this type of heating system throughout the year, substantial seasonal movement can be expected. Although strip flooring can be used, if care is taken with appropriate product selection and installation practices, it may be preferable to use engineered timber flooring products where less dimensional changes would be expected. Even with these products care is still necessary.

Floor Finish Types and Characteristics

Timber Floor Finishes

Timber floor finishes can be grouped into the four broad categories. These are the oil-based finishes, composite finishes (mixes of oil-based and solvent based polyurethane finishes), solvent based polyurethane finishes and water based finishes. With time all finishes will change in colour and film build as the wears. Therefore the ability to touch up becomes more difficult with time, however all coatings can be restored by recoating. In the long term a re-sand and refinish may be necessary depending on the wear and age of the floor.

Oil-Based Finishes

Oil-based finishes (alkyd/oleoresins) are the more traditional types of finish manufactured by reacting a natural oil (e.g. linseed and tung) with another chemical. Varnishes and the traditional tung oils fall within this category and are associated with the polished and waxed timber floors of the past. These types of finishes are still available and require greater regular maintenance than the other finishes. However, with the use of acrylic floor polishes, they have become easier to maintain. These finishes will darken with time. They are unlikely to edge bond boards.

Composite Oil-Based/Solvent Borne Finishes

Finishes containing oil-based alkyds with the addition of urethanes provide a finish with reasonably good abrasion resistance. Oil modified urethanes, which are one of the predominant floor finishes used in the USA and many of the 'tung oil' based finishes are of this type. The odour during application is very strong but dissipates as the finish dries. These finishes provide a subdued, satin to semi-gloss appearance and are unlikely to edge bond boards. They darken with time and require more frequent maintenance particularly in high traffic areas. Acrylic floor polishes may be used to protect the finish.

Oil modified urethane.

Solvent Borne Polyurethane Finishes

Solvent based polyurethanes (one pack and two pack) provide a harder finish, generally with limited flexibility but much greater abrasion resistance. Consequently, this greatly reduces the level of routine maintenance. They currently provide some of the hardest finishes available today with gloss levels from matt through to a very high gloss. These finishes, as with the oil-based finishes, will generally darken with time. The odour during application is very strong with these products but dissipates as the finish dries. Due to their high strength and generally limited flexibility, edge bonding of boards can occur.

Single pack solvent based polyurethane.

Water Borne Finishes

Some water based polyurethane/acrylic mixes of moderate durability are available but straight one and two pack water based polyurethanes with very good wear resistance are gaining in popularity. These finishes are generally applied over a sealer (either solvent or water based), that not only enhances the colour of the timber but can significantly reduce the risk of edge bonding. Rapid shrinkage in the floor and the associated stretching of the finish at board joints has on occasions caused the appearance of light coloured lines at board joints. Matt through to gloss finishes are available and these finishes generally darken little with time. During application there is low odour associated with water based finishes. A curing additive (catalyst) may or may not be recommended by the manufacturer.

The following table outlines the types of finish available and lists various characteristics of each.

PROPERTIES OF COATING SYSTEMS

Timber Floor Finishes							
Oil based Alkyds		Composite		Solvent based		Water based	
Tung oil	Linseed oil based varnishes	Oil modified Urethanes (OMU)	Urethane oil/alkyd 'Tung oil'	2 pack Polyurethane	Single pack Polyurethane (moisture cured)	Polyurethane/ Acrylic	Polyurethane (Single and two pack)
Less wear resistant finish requiring more frequent maintenance Unlikely to edge bond boards #				High wear resistant finish May edge bond boards#. There is a reduced risk of edge bonding when applied over an appropriate sealer.		Moderate to high wear resistant finishes Unlikely to edge bond boards # when applied over an appropriate sealer	
6-24 hour drying by solvent evaporation Some tolerance to waxes Moderate to strong odour on application Avoid inhalation and contact				1-4 hour drying by chemical reaction Not tolerant to waxes Strong odour on application Avoid inhalation and contact		2-4 hour drying by evaporation and reaction Not tolerant to waxes Minimal odour on application Avoid inhaling cross-linkers and hardeners	
Matt to gloss levels Darkens with age				Matt to very high gloss levels Darkens with age		Matt to gloss levels Less darkening with age	
Generally ready for use 2-5 days from completion*				Generally ready for use 2-3 days from completion*		Generally ready for use 2 days from completion*	
*Varies with weather conditions and product. Full curing may take a longer time. # Edge bonding relates to the finish acting as an adhesive and bonding board edges together. When board shrinkage occurs, this can result in wide irregularly spaced gaps at board edges or splitting of boards.							

SECTION 2 - PREINSTALLATION REQUIREMENTS

Storage and Handling Procedures

Flooring should be delivered by the supplier with plastic wrapping (to top, sides and ends) in good condition in order to maintain the flooring at the appropriate moisture content. It is the floor installers' responsibility to check that the timber is at the appropriate moisture content at the time of installation and therefore flooring products must be protected from weather exposure and other sources of dampness.

Ideally, flooring should not be delivered to site until it can be immediately stored under permanent cover. If this is not achievable, other precautions that are equally effective to prevent moisture uptake and excessive sun exposure, will be needed.

Plastic wrapping is easily damaged and should not be relied upon to keep the flooring dry. If moisture penetrates the plastic or timber is stored over a moist surface, subsequent moisture uptake can result in significant swelling of some boards. Flooring should not be laid in this condition, as wide gaps at board edges may result as boards re-dry. Wrapped packs should also be protected from excessive sun exposure as this too can have a detrimental effect.

Timber Flooring Standards and Specifications

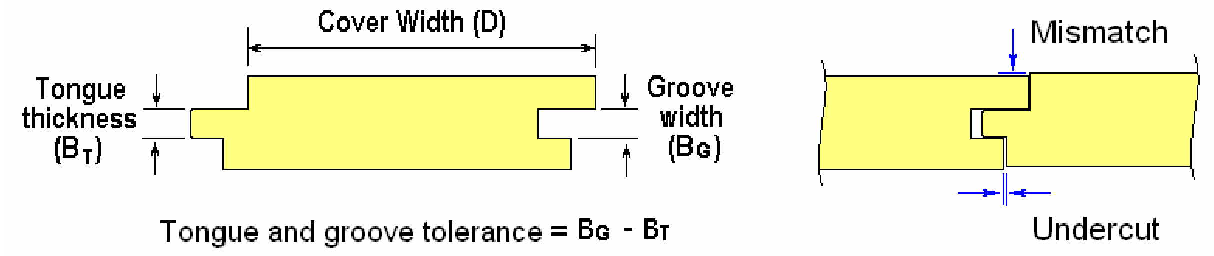
When timber flooring is received on site it should generally meet the following:-

- Grade - flooring to be supplied to the specified grade, which may be a manufacturer's grade. Note that if a manufacturer has given a specific name to a grade, the product may be similar to one of the grades contained within an Australian Standard but it is likely to differ in some respects. This may or may not be important to customers and should be resolved prior to supply.
- Moisture content - should be in the range of 9% to 14% (10 to 15 % for Cypress) with the average moisture content for all pieces approximately 11% (12% for Cypress).
- Timber moisture contents should be checked. (Resistance moisture meter readings must be corrected for species and temperature, and may be affected by other factors. Corrected readings are approximate only. If in doubt confirm results by oven-dry tests.) Water marks or a significant variation in cover width within a board may be indicative that the timber has been moisture affected.
- Cover width - not more than 1 mm difference between one board and another. Cover widths should generally be within ± 0.5 mm of the nominal cover width. (This reflects changes to board dimensions that can occur after milling and prior to installation and therefore outside the limits of Australian Standards).
- Boards should not be visibly cupped although Australian standards allows for 1 mm in 100 mm.
- Tongue and groove tolerance - not to be less than 0.3 mm nor greater than 0.6 mm. Boards should slot together to form a 'snug' fit. The fit should not be loose and sloppy or overly tight.

Grading rules for solid T&G strip flooring are contained in the following Australian Standards:-

AS 2796 – Timber – Hardwood – Sawn and milled products
AS 1810 – Timber – Seasoned Cypress pine - Milled products
AS 4785 – Timber Softwood – Sawn and milled products

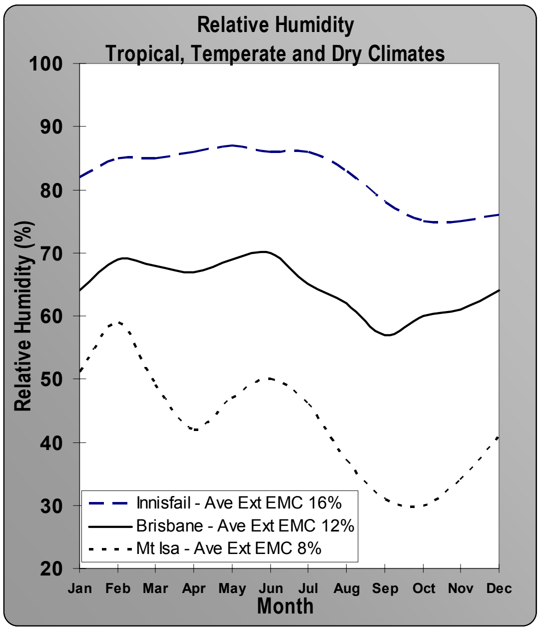
If the material supplied does not meet all the above criteria, **installation should not proceed until any problem is verified and rectified**.



Evaluating Site Conditions and the Installation Environment

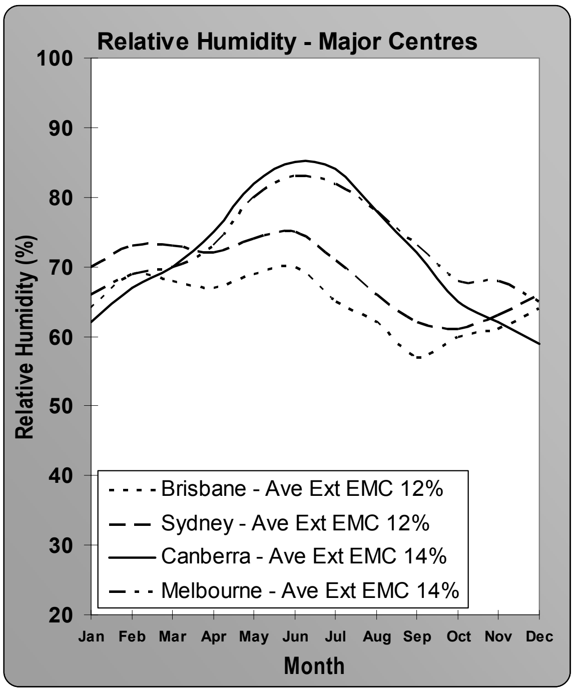
Evaluating Site Conditions

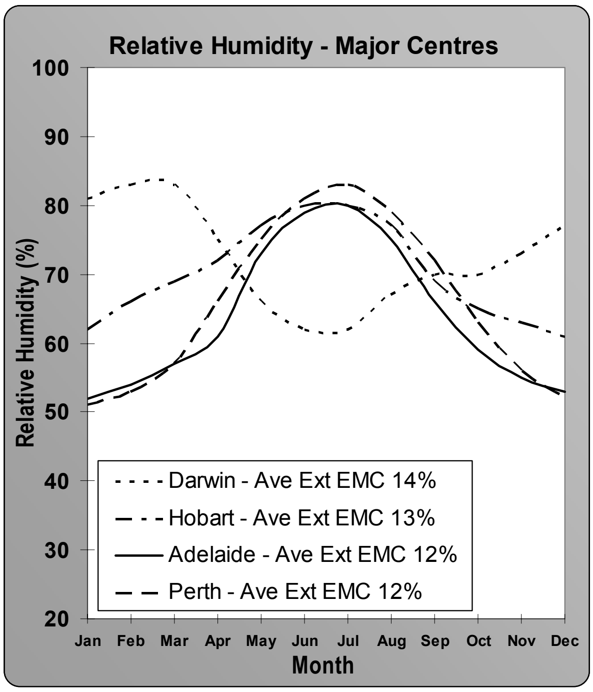
Every site requires assessment prior to the installation of a timber floor. It is important to know the climate in the area where a floor is being laid. Relative humidity is the major influence determining whether timber flooring will absorb moisture from the air and swell, or whether it will lose moisture to air and shrink. If the moisture content of the timber flooring is close to the average in-service moisture content then subsequent seasonal changes in humidity will only result in small changes in moisture content. The climate can be assessed from 9 am relative humidity data available from the Australian Bureau of Meteorology website at www.bom.gov.au/climate/averages. The adjacent figure shows annual relative humidity charts associated with a tropical climate, temperate climate and a dry inland climate. Approximate average external equilibrium moisture contents (EMC) are also provided on the graph for each climate. Equilibrium moisture content can be thought of as the moisture content that timber will approach under set conditions of relative humidity and temperature. It is evident from these graphs that the climate may result in moisture contents that can be either higher or lower than the average moisture content of the flooring that has been supplied.



Climatic effects on timber floors - These must be considered when laying a floor.

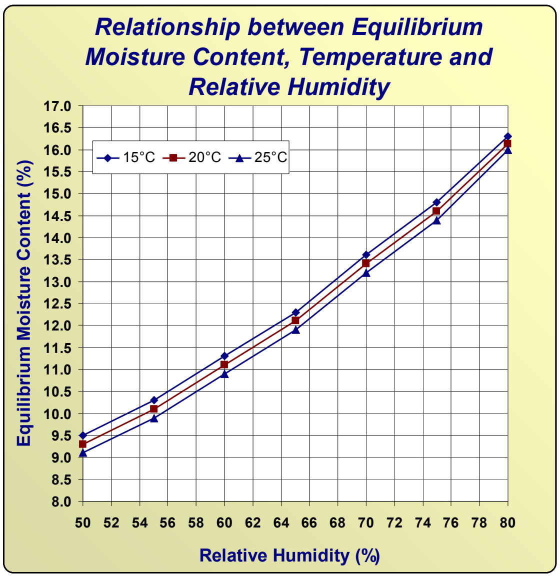
Relative humidity graphs for the major capitals throughout Australia are provided in figures below. Seasonal variation about the average can be seen to be greater in some locations than others. For example the seasonal variation in Sydney is much lower than Melbourne. Where there are greater seasonal variations, greater seasonal movement (shrinkage and swelling) can also be expected.





Major centre climates and external EMC's.

Timber flooring is generally manufactured to suit temperate climates with average external EMCs of 12% to 14%. To provide assistance in assessing climatic influences the following figure outlines the general relationship between temperature, relative humidity and moisture content. Average internal EMCs are generally lower than external by 1% to 2% without heating or cooling systems operating and can be 4% to 5% lower for the periods when such systems are operating. Therefore, in climates that have cold winters, heating systems often lower the humidity within the dwelling and reduce the effect of high external humidity on the floor. Similarly in tropical locations air-conditioning operated during hot humid times can also reduce the effect of high external humidity on the floor. Installation and finishing practices need to consider accommodating both the adjustment to climatic conditions associated with a locality and the seasonal movement that will occur in that climate.



Relationship between Temperature, RH and EMC.

In areas of higher elevation than coastal areas, average moisture contents are often higher due to the associated local weather patterns. Similarly, houses built in 'bushy' surroundings or gullies may experience higher average moisture contents. Moister conditions are also often experienced with houses on farmland or in rural type settings, particularly in coastal and hinterland areas experiencing higher or more consistent rainfall. Therefore, in these localities greater allowance for floor expansion is required at the time of installation.


Higher levels of expansion are experienced in moist localities and must be accommodated.

Floors in Moist Environments

In areas of higher elevation than coastal areas, average moisture contents are often higher due to the associated local weather patterns. Similarly, houses built in 'bushy' surroundings or gullies may experience higher average moisture contents. Moister conditions are also often experienced with houses on farmland or in rural type settings particularly in coastal and hinterland areas experiencing higher or more consistent rainfall. Therefore, greater allowance for floor expansion is required at the time of installation.

Building and Installation Considerations

Closed in Sub-floor Space

Many dwellings are 'bricked' in underneath and a lack of sufficient ventilation can result in high humidities in the sub-floor space. This may result in expansion and cupping of floorboards. Quoted figures for sub-floor ventilation are based on sub-floor spaces that are not subjected to seepage or where ventilation through the sub-floor space is inhibited. Where humidity remains constantly high beneath a floor, coatings to the


A dry sub-floor space and adequate ventilation is essential for floor performance.

underside of the boards will not reduce the moisture uptake into the flooring. 'Bushy' surroundings and dense gardens may also cause higher moisture contents and reduced airflow through the sub-floor space.

Houses with Open Sub-floors

Special precautions must be taken when timber floors are laid on joists in a house that is open underneath, particularly when built on steeply sloping land or escarpments. In such locations, very dry winds or wind-blown rain or fog can directly affect the moisture condition of the lower surface of the floor. This can result in either extreme shrinkage or extreme swelling. In the latter case the floor may lift off the joists and structural damage to the building may occur. Also where there is little restriction to the prevailing wind, floors can react more rapidly to dry winds. The species used in the floor and board cover width affect the rate of movement and shrinkage that occurs. Depending on the severity of the exposure, options to protect the floor include providing an oil-based sealer to the underside of the floor, which may provide short duration protection to changes in weather, and installing a vapour resistant lining to the underside of the joists or building-in the underfloor space.

Internal Environment

Within a dwelling a number of differing climates can develop, causing areas of flooring to respond differently within the same dwelling. These include large expanses of glass, fireplaces, refrigerators, air-conditioners, appliances that vent warm air, the aspect of the house and two-storey construction, all of which can have an effect on the dimensional movement of floorboards. When floors are exposed to the sun through large glassed areas, protection should be considered before, during and after construction. Evaporative coolers add moisture to the air and raise the relative humidity, resulting in moisture contents in the flooring that are higher than under ambient conditions.

Greater localized shrinkage and possibly some cupping can be expected with high sun exposure.

Araucaria (Hoop Pine) Flooring and Araucaria Floor Framing

Where Araucaria floors and floor framing are not fully enclosed it is necessary to seal the framing members and lower surface of the floor boards to prevent attack from the Queensland Pine Beetle. Attack is specific to the Araucaria species (including Bunya) and generally restricted to the area from Bundaberg to Murwillumbah and east of the Great Dividing Range. In this region exposed framing and floors (including ventilated sub-floor spaces) require sealing to meet the requirements of the QFS Technical Pamphlet No.1 and thereby the BCA. The sealer provided needs to be a film-forming finish and this may also reduce the effects from rapid weather changes.

CONSIDERING THE LIKELY MOVEMENT AFTER INSTALLATION

As discussed, timber is a natural product that responds to changes in weather conditions with seasonal humidity and temperature changes in the air causing boards to shrink and swell at different times throughout the year.

Edge bonding can result in wide irregularly spaced gap and split boards.

The overall movement occurring in individual boards and rate of movement will depend on the timber species and cutting pattern. Small differences in moisture content between boards at the time of manufacture (a 5% range is normally allowed by applicable standards) and variable conditions within the house (e.g. westerly facing room compared to southerly facing) will also cause further variation in board width. Consequently, it can be expected that small gaps will occur at the edges of most boards, particularly during the drier months, and that the actual gap sizes may differ across a floor. In cases where shrinkage occurs after installation, wider boards (e.g. 130 mm) will result in larger gap sizes at board edges than if narrower boards are used. Air-conditioning installed after a floor has been laid, may increase the size of shrinkage gaps at board edges.

Some movement usually occurs in timber floors after laying as the floor adjusts to the climate and although floor finishes may retard moisture content changes, they will not prevent this movement. In applications where greater movement is expected after finishing (e.g. from seasonal changes, use of wide boards, air-conditioning installed after floor installation), particular care is necessary to ensure that the finish does not act as an adhesive and bond a number of adjacent boards together. With subsequent shrinkage, wide gaps between groups of four or five boards may occur or boards may split.

The way different timber species respond in a floor depends not only on their moisture content but also on the rate at which they take up and lose moisture, the associated movement and also their density. High density species are extremely strong and those that take up or lose moisture more quickly (such as Blackbutt) will also follow seasonal moisture changes more closely than slower responding species (such as Spotted Gum). Particular care is necessary to be able to accommodate expansion of the higher density species and in moist localities this may necessitate providing small expansion gaps every 6 to 10 boards during installation, in addition to normal expansion allowances in order to accommodate this movement. Lower density hardwoods (e.g. Tasmanian Oak, Victorian Ash) and softwoods will, to some extent, compress at their edges when a floor expands. With these timbers, normal expansion allowance is generally able to accommodate the expansion in moist climates.

Installation Moisture Content and Acclimatisation

The moisture content of timber is the percentage weight of water present in the timber compared to the weight of timber with all water removed. Moisture content varies with changes in the humidity and temperature in the surrounding air. To minimise the movement of a floor (swelling on moisture uptake, shrinkage on moisture loss) due to changes in moisture content it is important to lay and fix timber floors close to the average moisture content of timber in the environment where it is to be laid. Along coastal areas where higher humidities can be expected, moisture contents of flooring may vary from 9% to 14%. Timber flooring is usually supplied at an average moisture content between 10% and 12.5% and most boards can be expected to be within a few percent of the average. Where conditions are drier, such as inland areas or in air-conditioned buildings, average moisture contents of flooring may vary from 7% to 12%. In these situations flooring may need to be acclimatised on-site.

Where the average supplied moisture content of the flooring is near the expected average in-service moisture content, acclimatisation is not necessary.

In areas where higher average moisture conditions persist and where floors are expected to have higher moisture contents, additional allowance should be made for subsequent expansion. Such areas include tropical North Queensland and northern New South Wales, areas of dense bushland and rainforest, particularly at higher elevations and mountain areas.

Installation methods need to be considered to accommodate the difference between the average moisture content on delivery and the average expected in-service moisture content include either providing additional intermediate expansion joints or acclimatising the flooring.

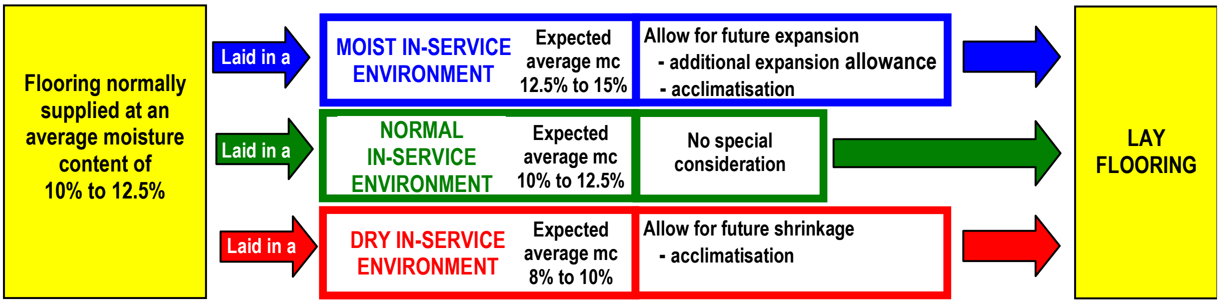
Acclimatisation can be effective if product MCs and in-service conditions are known. It is not compulsory.

Acclimatising is the process of allowing partial equalisation of the moisture content of the timber as supplied to the moisture content of the surroundings in which the timber is to be installed. Increasing the average moisture content of the flooring supplied will only be effective if the humidity in the air is sufficient to cause moisture uptake. Care must also be exercised as the rate of moisture uptake differs from species to species. Some higher density species are very slow to take up moisture from the air (e.g. Spotted Gum) while others react more quickly (e.g. Blackbutt and Brush Box). If flooring is to be laid in a dry environment such as western Queensland or a consistently air-conditioned building, then acclimatising can be effective in reducing the average moisture content of the flooring prior to laying and thereby reducing gap sizes at board edges from board shrinkage. In such climates, future expansion of the floor must be allowed for to accommodate periods of wet weather.

Acclimatising relies on each board being exposed to the in-service atmosphere and therefore packs must at least be opened up and restacked in a way that allows airflow between each board. Acclimatising can only be effective in an air-conditioned building if the air-conditioning is operating at the time or in dry localities during drier periods. The species and period for which it is acclimatised will also influence effectiveness. For some higher density species that are slow to lose or take up moisture, acclimatising may have little effect. Acclimatising in dry climates does not negate the need to provide for floor expansion during periods of wet weather and will not overcome poor drying practices.

A simple guide to pre-installation considerations is provided in the figure below which should be referred to in conjunction with the preceding text.

Pre-installation considerations



SECTION 3 - INSTALLATION

This data sheet outlines the recommended practices for laying timber strip floors over timber and engineered timber joists (it does not include steel joists), structural sub-floors such as plywood, particleboard and concrete. When laying a timber strip floors over joists, either directly on the joists or on sheet flooring fixed to joists, adequate sub-floor ventilation is essential for the satisfactory performance of the floor. Sub-floor ventilation recommendations are therefore included in this data sheet. Minimum fixing recommendations are provided. Note that top nailing is a more robust fixing method than floors secretly fixed with adhesives. Top nailed floors can therefore accommodate greater movement. Increasing the amount of adhesive used will also provide a more robust fixing. Where greater floor expansion is expected after installation the method of fixing chosen and associated spacing of fixings or amount of adhesive used requires consideration.

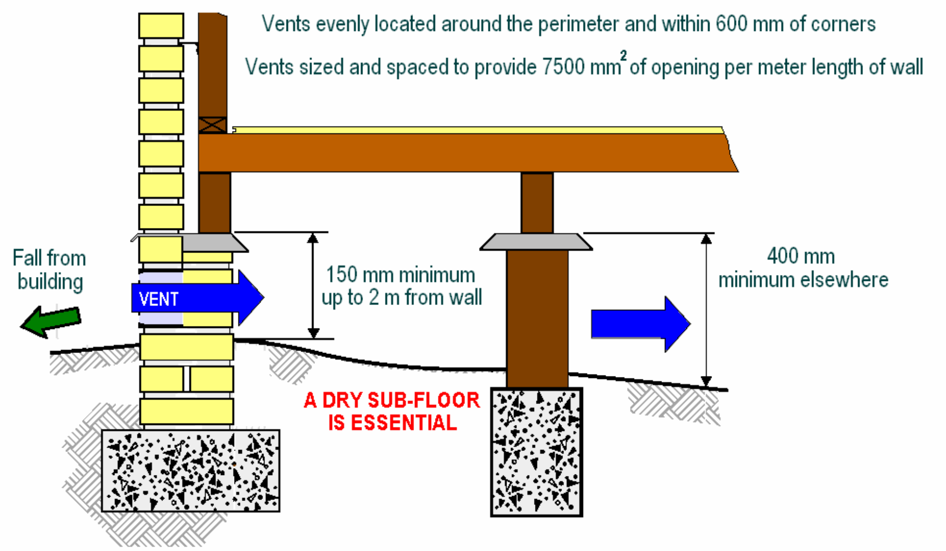
SUB-FLOOR VENTILATION

When the lower surface of timber floors or structural sub-floors (over which a timber floor is laid) are exposed to the ground and the space is enclosed (by brickwork etc), the sub-floor space must be adequately ventilated with permanent vents installed in the masonry during construction. The humidity in an enclosed sub-floor space can have a profound effect on the performance of a floor. If conditions are very moist, the lower surface of the boards may take up moisture, causing substantial swelling. Differential movement between the upper and lower surfaces of floor boards may also cause boards to cup. Similarly, caution needs to be exercised with timber floors laid in areas where the microclimate is often moist. In such locations the floor may reach higher moisture contents than in other nearby areas and additional allowance for expansion of the floor may be required (Refer Section 2 - Pre-installation Requirements). Timber floors should not be laid over moist sub-floor spaces, and structural sub-floors (e.g. plywood) cannot be relied upon to prevent moisture uptake in the T & G flooring if humidities in the sub-floor space remain high for extended periods.

Adequate sub-floor ventilation and a dry sub-floor space are a must for timber floor performance.

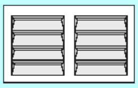
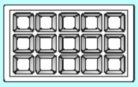
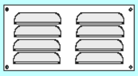
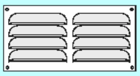
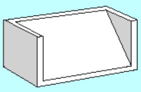
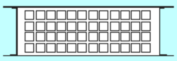
Ventilation requirements

T & G floors should be provided with sub-floor ventilation that exceeds minimum BCA requirements. The levels outlined in the BCA (currently limited to 6000 mm² per metre length of floor for higher humidity areas) are primarily to limit the moisture content of sub-floor framing timbers, which can generally tolerate greater fluctuations in moisture content, than timber floors. The recommended minimum ventilation for T&G timber floors is 7500 mm2 per metre length of wall, with vents evenly spaced to ensure that cross ventilation is provided to all sub-floor areas (refer to the following figure).



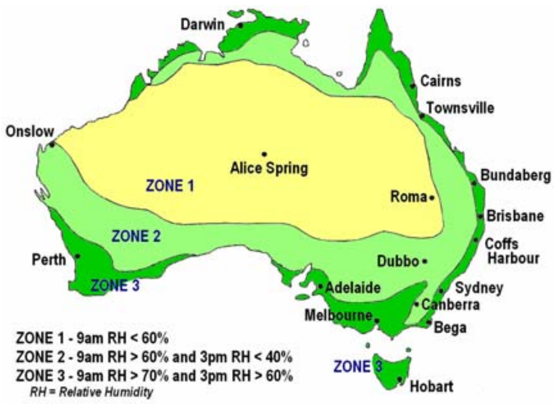
In some localities, to meet constraints associated with energy efficiency, it may be decided to reduce ventilation levels to the values provided in the BCA. The BCA also outlines that a moisture barrier over the soil beneath the building reduces ventilation requirements and this approach is equally applicable to timber floors. If ventilation below the recommended level is used, due consideration should be given to alternative measures as outlined above and particular attention should be paid to ensuring that the sub-floor space remains dry throughout all seasons. The type of vent may also need to be considered with buildings in bushfire areas which limits the mesh size used in vents. Some commercially available vents of various types, their dimensions, net ventilation area and required spacing is provided below for coastal Zone 3. BCA relative humidity zones and associated BCA ventilation requirements are also provided below. It should be noted that the maximum vent spacing irrespective of net ventilation area is 2000 mm and that any screens that may be necessary in bushfire areas or for vermin proofing may restrict airflow and this may need to be compensated for.

Vent Type and Specifications

Material	Diagram	Vent size	Vent Pattern	Nett Ventilation Area Provided per Vent (mm^2)	Maximum Vent Spacing (mm): ZONE 3 BCA Requirements ($6000 mm^2/m$) No-membrane	Maximum Vent Spacing (mm): T&G Flooring Requirements ($7500 mm^2/m$)
Clay		160 x 230	8 slots each 75 mm x 8 mm	4800	800	640
Clay		160 x 230	15 holes each 16 mm x 16 mm	3840	640	512
Metal		200 x 400	8 slots 10 slots each 100 mm x 8 mm	5900 7400	983 1233	787 987
Metal		200 x 400	8 slots 10 slots each 175 mm x 8 mm	10700 13360	1783 2000	1427 1781
Besser Louvre Block 15.745		200 x 400	1 slot each 320 mm x 90 mm	28800	2000	2000
Gradwell Cast Aluminium Air Vent		9" x 6" (230 x 160)	4 slots each 195 mm x 10 mm	7800	1300	1040
Pryda Vent Pryda Vent		230 x 75 230 x 165	52 holes 117 holes each 11 mm x 11 mm	6292 14157	1049 2360	839 1888
Pryda Slim Vent (GVS90) Pryda Slim Vent (GVS90H)		250 x 90 130 x 90	12 slots 6 slots each 110 mm x 8 mm	10560 5280	1760 880	1408 704

BCA Sub-floor Ventilation Requirements

CLIMATE ZONE, CONDITIONS & SELECTED LOCATIONS		Min. Sub-Floor Ventilation mm^2/m of wall: No membrane	Min. Sub-Floor Ventilation mm^2/m of wall: Ground sealed with impervious membrane
1	Average 9am RH < 60%	2000	1000
2	Average 9am RH > 60% and 3pm RH < 40%	4000	2000
3	Average 9am RH > 70% and 3pm RH < 60%	6000	3000



Source: BCA 2005 Vol 2

Ventilation efficiency and site drainage

The sub-floor space must be free from all building debris and vegetation. Obstacles that prevent air-flow to and from vents will reduce the efficiency of the sub-floor ventilation system. Landscaping should not limit air-flow around the external perimeter of the sub-floor space, and structural elements should not limit air-flow. Vents should be installed in the masonry course below floor bearers, and should not be obscured by engaged piers or piers/stumps/columns which support the floor structure, or by any services present. Where external structures (fences etc.) or landscape may reduce airflow, consideration should be given to the use of more than the minimum number of vents.

Where verandahs or decks are constructed outside the dwelling perimeter, care should be taken to ensure that the amount of ventilation provided around the verandah or deck perimeter is equivalent to or greater than the amount required for the adjacent external wall. Where ventilation is obstructed by patios etc., additional ventilation should be provided to ensure that the overall level of ventilation is maintained and cross flow is achieved.

If adequate natural ventilation cannot be provided to sub-floor spaces, a mechanical ventilation system should be installed which replaces all of the air in this space on a regular basis, and prevents the formation of 'dead-air' pockets.

If there are doubts over the sub-floor humidity (areas of high water table, reduced airflow due to minimum clearances between the sub-floor framing and ground, external structures etc.) again a polyethylene membrane laid over the soil should be considered (taped at joints and fixed to stumps and walls). As discussed above, this can significantly reduce moisture uptake by the sub-floor air. Increased levels of ventilation should also be considered in such instances. With dwellings on sloping blocks that have enclosed sub-floor spaces, the possibility of seepage should be taken into consideration and appropriate control measures taken prior to the installation of the floor.

The drainage system provided to the dwelling site, should ensure that run-off water will drain away from the building perimeter (not towards it) and that run-off water is prevented from entering the sub-floor space. The ground beneath a suspended floor should also be graded so that no ponding is possible. Where springs or aquifers are present (e.g. exposed by earthworks on sloping sites) and cause water to enter the sub-floor space, a closed drainage system should be installed under the dwelling to remove this water. The ventilation system will not cope with this level of moisture in the sub-floor space.

INSTALLATION OF STRIP FLOORING OVER JOISTS

Construction Method

Where the timber floor is to be sanded and polished (i.e. feature floor) then fitted floor construction needs to be used. With this method, the timber flooring is installed after the roof cladding and external wall cladding are in place and the house is weather tight. This prevents initial degrade due to water and sunlight exposure and reduces damage from trades during construction.

Sub-floor Framing - Bearer size, floor joist size and flooring spans

The size of timber members used to support the flooring boards can be determined from AS 1684 - Residential timber-framed construction. For end-matched flooring profiles, joists with a minimum thickness of 35 mm may be used. Where plain end flooring is butt joined at floor joists, 45 mm or 50 mm thick joists are recommended to reduce splitting problems at butt ends.

Timber floors are successfully laid over a range of solid timber and engineered joist systems.

If installing a secretly nailed floor over joists, seasoned timber or Cypress need to be used as secret nailing cannot be re-punched. If the joists shrink away from the floor, movement of boards on the fixings is likely to cause excessive squeaking.

Top (face) nailed floors may be fixed into either seasoned or unseasoned joists. If fixed into unseasoned joists they need to be of a species not exhibiting high rates of shrinkage and be in single or similar species. Species exhibiting high tangential shrinkage rates or prone to collapse or distortion should not be used unless seasoned. The potential effects of floor frame shrinkage require assessment prior to specifying or ordering unseasoned floor framing, and due allowance made in the building design and detailing. Similarly, after installation, the effects of both shrinkage and possible nail popping need consideration.

The allowable span of timber flooring is dependent on the timber species, density, grade, thickness and whether or not the flooring is end matched. The following table gives the acceptable joist spacing and maximum spans for various flooring products when fixed to timber joists. Maximum board span (the distance between where the timber is supported) needs to be considered in installations where flooring is at an angle to the joists, as this increases the board spans.

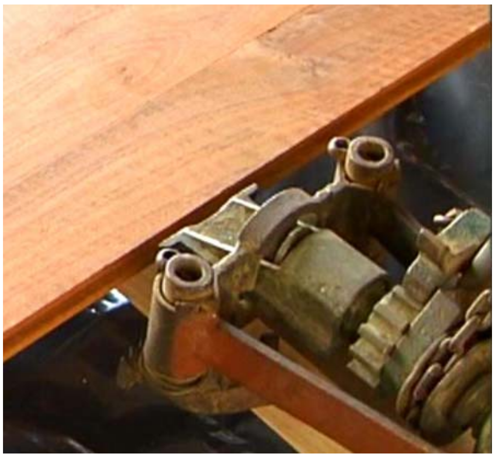
Allowable Joist Spacing and Maximum Span of Floorboards

Species Group	Grade	Thickness (mm)	Acceptable Species, Grade and Joist Spacing			Maximum Span	
			450 mm End matched	450 mm Butt joined	600 mm Butt joined	End matched	Butt joined
Hardwood	AS 2796						
All hardwood species listed on page 5	Select Grade	19	✓	✓	✓	500 mm	630 mm
	Medium Feature (Standard) & High Feature Grade	19	✓	✓	✗	450 mm	570 mm
Cypress	AS 1810						
	No. 1	19	✓	✓	✗	410 mm	510 mm
	No. 2	20	✓	✓	✗	410 mm	510 mm
Softwood	AS 4785						
Slash Pine	Select & Standard Grades	19	✓	✓	✗	410 mm	510 mm
Other pinus species	Select & Standard Grades	19	✗	✓	✗	350 mm	470 mm
Araucaria (Hoop Pine)	Manufacturers Grades	20	✓	✓	✗	410 mm	510 mm

Laying

The moisture content, size and profile of the flooring should be checked (Section 2 – Pre-installation assessment) prior to laying. If it is identified that the moisture content is not correct or the boards do not fit together properly, or are otherwise considered to not meet the specified grade, the installer should contact the supplier to resolve these issues before commencing laying. Similarly, any board found during laying that is considered outside the grade specification should not be laid.

In most instances boards are to be supported on at least three joists, however, there will be instances where some boards may not be (i.e. floor edges or the occasional shorter board within the floor), but this should be kept to a minimum. Flooring should be laid in straight and parallel lines. Butt joined boards must be cut to join over floor joists and joints in adjacent boards should be staggered. End-matched joints in adjacent boards should not occur within the same span between joists. It is essential that boards are in contact with the joists at the time of nailing, particularly when machine nailing is used, as this type of nailing cannot be relied on to pull the board down to the joist.

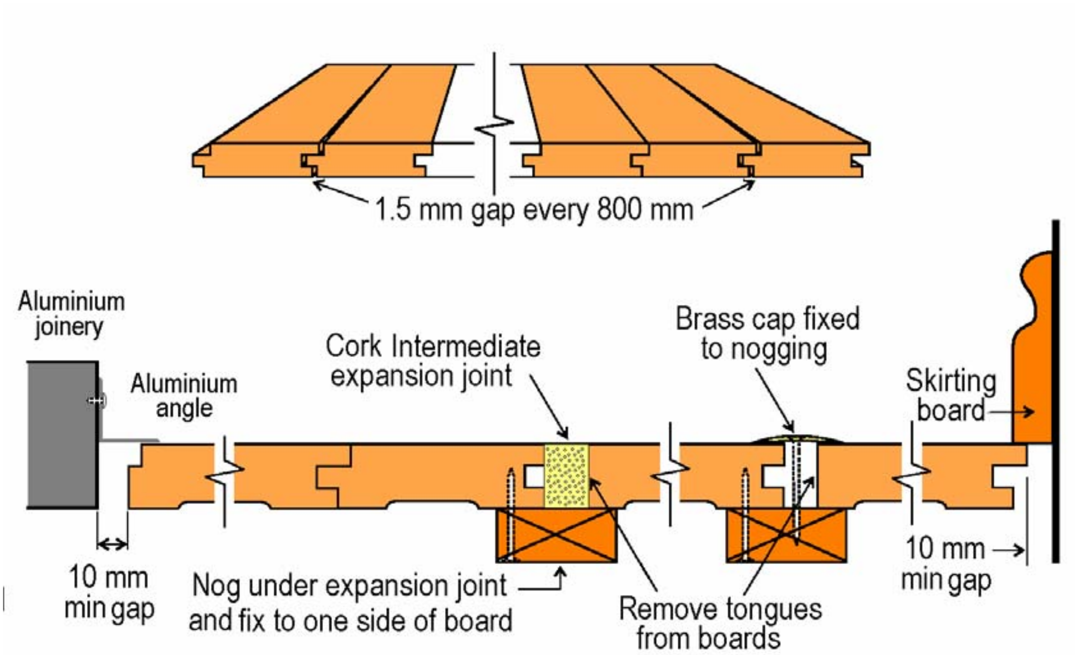


Cramping should be sufficient to just bring the edges of adjoining boards together.

It is generally recommended that not more than 800 mm of flooring is cramped at any one time, however, this may be varied by the installer depending on the flooring used and conditions in which the floor is laid. The pressure used to cramp the boards together will differ from one floor to another, depending on the moisture content of the flooring at installation, the air humidity and the average moisture content conditions for the location. As a general rule, cramping should be sufficient to just bring the edges of adjoining boards together while maintaining a straight line.

Allowance for expansion in floors

Fitted floors require a minimum 10 mm expansion gap between the floor boards and any internal or external wall structures. However, where board ends abut doorways the gap may be reduced to a neat fit but with a small gap (approximately 1 mm) to prevent rubbing. Floors up to 6 m (measured at right angles to the run of boards) should not require intermediate expansion joints provided that normal atmospheric conditions exist. For floor widths over 6 m or where extra allowance for expansion is required (e.g. moist locations) cramping pressure needs to be considered along with providing an intermediate expansion joint, or a series of smaller expansion gaps every 800 mm to 1000 mm to provide equivalent spacing. If cork expansion joints are used, the cork should be 2 mm or so proud of the floor surface when installed. This will be removed during the sanding process. However, cork to the perimeter should be installed level with the timber surface.



Cork intermediate expansion joints blend in well with timber floors.

Particularly for wide floors or in moist climates small regular gaps at provide the additional expansion allowance needed. These often close during humid periods.

Fixing of floors

Boards with cover widths of 65 mm or less should be top (face) nailed with one or two nails at each joist. Boards with cover widths over 65 mm should be top (face) nailed with two nails at each joist. Secret fixing with a single nail or staple per joist is suitable with secret nail profile end-matched boards having nominal cover widths not greater than 85 mm. The recommended minimum fixing sizes are shown in the following table.

When fixing it should be checked that boards are tight on the joists.

Secret fixing is not recommended for boards over 85 mm in cover wide.

Recommended minimum edge distance for nailing at butt joints or board ends is 12 mm. All nails, including machine nails, should be punched a minimum of 3 mm below the top surface.

During fixing, the joint between floor boards and the top surface of floor joists should be checked to ensure that gaps are not present. If gaps are present, nails should be punched to draw boards tightly onto joists.

Minimum Fixing of T&G Flooring to Joists

TYPE OF FIXING	FLOOR JOIST TIMBER	
Top (Face) Fixing	SOFTWOOD, LVL and I - BEAMS	HARDWOOD & CYPRESS
Without Adhesive		
Hand driven	65 x 2.8 mm bullet head	50 x 2.8 mm bullet head
Machine driven	65 x 2.5 mm T-head	50 x 2.5 mm T - head
With Adhesive #		
Hand driven	50 x 2.8 mm bullet head	
Machine driven	50 x 2.5 mm T - head	
Secret Fixing		
With Adhesive # Machine driven	50 x 15 gauge staple	45 x 15 gauge staple

A continuous bead (6 mm approx.) of polyurethane flooring adhesive to be applied to the joist

INSTALLATION OF STRIP FLOORING OVER EXISTING TIMBER AND SHEET FLOORS ON JOISTS

Assessing the Existing Floor

Timber T & G flooring may be laid over existing T & G or sheet floors (plywood or particleboard). Where the existing floor is structurally sound, either overlay flooring (generally 11 mm to 14 mm thick) or structural flooring (generally 19 mm to 21 mm thick) can be laid. Floors may be fixed into the joists or with shorter fixings at reduced centres into the existing floor only. In instances where there is doubt over the structural adequacy of the existing floor, defective boards or sheets should be replaced to make the existing floor structurally sound, or structural flooring fixed through to the joists can be used. To provide a level surface, top (face) nails in existing flooring should be re-punched and the existing floor rough sanded. Adhesives require a clean, structurally sound floor that is free from moisture, loose particles and contaminants. It is also particularly important that if a new floor is laid at 90° to an existing floor, the existing floor must be structurally sound and level. In some instances sheet sub-floors (substrates) can sag between joists and if not leveled the sagging will show through to the new floor.

It is also necessary to check that the existing floor moisture content is appropriate to accept the new floor. The cause of any excess moisture (wetting during construction, leaks, inadequate sub-floor ventilation, etc) needs to be addressed prior to installation. Moisture meters are unpredictable in sheet flooring and this may necessitate oven dry testing. Prior to laying, the existing floor should be of similar moisture content (within a few per cent) to the new floor.

Squeaking present in an existing T & G floor may be reduced by providing a bead of polyurethane flooring adhesive to fill any gaps between the underside of flooring and tops of joists (caused by cupping, shrinkage etc). Further reductions may be achieved by fixing a seasoned batten (approximate dimensions 35 x 45 mm), to the underside of flooring (mid-span between joists) fixed with a full length bead of polyurethane flooring adhesive and screwed at approximately 300 mm centres.

Installation

Installation of flooring should not be done until other construction activities (particularly wet trades) are complete and after the building is roofed and enclosed, with the temperature and humidity as close as possible to the expected in-service conditions. Expansion gaps of 10 mm should be provided at all walls and other fixed obstructions, which are parallel to the run of floor boards. Intermediate expansion joints should also be provided in larger floors (width at right angles to boards exceeding 6 metres), to give an equivalent gap of 10 mm every 6 metres (approx. 1.5 mm every 800 mm).

Fixing flooring through sheet floors and into the floor joists will provide a more robust fixing and is particularly appropriate where greater expansion in the floor is expected after installation. Alternatively, if expansion after installation is expected to be small then mechanical and adhesive fixing into the sub-floor (substrate) may be used.

For secret fixing of structural flooring boards, secret nail profile boards should be used (maximum cover width of 85 mm) with one fixing per board at the appropriate spacing. For (top) face nailing, standard profile or secret nail profile boards may be used. Boards exceeding 65 mm cover width, which are top (face) nailed, require two nails per board at each fixing.

Secret Fixing into Sub-floor (Substrate) Only

When relying on the sub-floor or substrate for fixing, boards should be secretly fixed with the first and last few boards that do not allow secret fixing, top (face) nailed and adhesively fixed with polyurethane flooring adhesive. When laying over an existing T&G sub-floor the new flooring may be laid either parallel to it (with boards offset half a board width) or with boards at 90° to the existing floor, providing the sub-floor (substrate) is level. If edge bonding is present in an existing T&G floor over which the new floor is being laid, it is recommended that the bonding is relieved by a series of saw cuts down the length of the existing boards and that the new floor is laid at 90°. Fixings should be the maximum possible length as indicated in the table.

Minimum Secret Fixings of T& G Flooring to Sheet Sub-floor (Substrate) over Joists

FIXING METHOD	SECRET FIXING TO SUB-FLOOR (SUBSTRATE) ONLY
Staple fixing up to 250 mm spacing	Staples - 32 x 15 gauge to plywood or 38 x 15 gauge to particleboard for flooring 19 to 21 mm thick. Zigzag pattern of polyurethane flooring adhesive between fixing points. (For overlay flooring maximum length to suit sub-floor (substrate)).
Adhesive fixing with staples up to 450 mm spacing	Polyurethane flooring adhesive - zigzag pattern to achieve approx. 25% glue contact area after laying. Staples - 32 x 15 gauge to plywood or 38 x 15 gauge to particleboard for flooring 19 to 21 mm thick. (For overlay flooring maximum length to suit sub-floor (substrate)).

When staple or nail fixing at close centres is being used, provide a cushion of polyurethane flooring adhesive between the two floors to minimise possible squeaks. This is achieved by using a continuous bead of adhesive at 90° to board length, midway between fixing points. Where polyurethane flooring adhesive is used to provide much of the fixing, staples may be spaced up to 450 mm apart. Note that flooring cleats (as used with Powernailer) of a similar length may be used in lieu of staples.

Top (Face) Nailing into Joists through the Sub-floor (Substrate)

If the sub-floor is an existing T&G floor, boards should be run in the same direction as the sub-floor with boards offset by half a board width from those in the existing floor. This assists in offsetting the nails in the new and old floors. When structural 19 mm flooring is used, the floor should be top (face) nailed with 65 x 2.5 mm machine nails or 65 mm x 2.8 mm hand nails through the existing floor and into the joists. For thinner overlay flooring, 50 mm x 2.5 mm machine nails or 50 mm x 2.8 hand nails should be used. In all cases, continuous beads of polyurethane flooring adhesive should be provided at the joists and midway between them to provide a cushioning effect between the two floors. Board ends adjacent to walls should be fixed with polyurethane flooring adhesive and nailed to the sub-floor.

INSTALLATION OF STRIP FLOORING OVER CONCRETE

Assessing the Concrete Slab

Timber floors may be laid on battens or plywood over a concrete slab, or by direct fix. Direct fix to the slab is a specialist field and appropriate professionals in this field should be consulted if considering this method. The following covers installation of T & G flooring on plywood over concrete or battens over concrete. Prior to installation it is necessary to ensure that the concrete is sufficiently level to accept the system. Where the slab is greater than $\pm$ 3 mm out of level over any 1500 mm length, a concrete topping (leveling compound), grinding or packing should be used. Slabs on ground should be constructed with a continuous under slab vapour barrier (e.g. 0.2 mm thick polyethylene). Timber floors should not be installed until the concrete slab has a moisture content less than 5½% (generally achieved after slabs have cured for approximately 4-6 months). In old slabs, moisture contents should be below this level and if not, care should be exercised. Methods available to test the moisture content of concrete include resistance meters, capacitance meters and hygrometers (see Appendix 3).

Methods to lay timber floors over concrete slabs include battens, direct adhesive fix and over plywood. Direct adhesive fix should be undertaken by professional floor installers.

Installation

When floors are to be fixed over a plywood sub-floor, overlay or structural flooring may be used. For fixing to battens, structural flooring (19 mm or thicker) should be used. The plywood sub-floor or battens need to be at a moisture content within a few per cent of the flooring at the time of installation.

Installation of flooring should not occur until other construction activities, particularly wet trades, are complete. The building should be roofed and enclosed with the temperature and humidity as close as possible to the expected in-service conditions including the use of air-conditioning if applicable. For secret fixing, secret nail profile boards should be used (maximum cover width of 85 mm) with one nail per board at each fixing. For top (face) nailing, standard profile or secret nail profile boards may be used. Boards exceeding 65 mm cover width require two nails per board at each fixing. Expansion gaps of 10 mm should be provided at all walls and other fixed

Secret fixing to a plywood sub-floor. A polyethylene moisture barrier has been placed over the slab and both the plywood and flooring are clear of the wall.

obstructions, which are parallel to the run of floor boards. Intermediate expansion joints should also be provided in larger floors (width at right angles to boards exceeding 6 metres), to give an equivalent gap of 10 mm every 6 metres (approx. 1.5 mm every metre 800 mm) or the use of loose cramping.

As an added protection against moisture from the slab (from slab edge effects, beam thickening etc) or minor building leaks, a 0.2 mm thick polyethylene or poured chemical membrane over the slab is recommended. The polyethylene should be lapped by 200 mm, taped at the joints and brought up the walls (or fixed columns etc) above the top of the flooring. The polyethylene is then covered by the skirting. Note that fixings of plywood sub-floors or battens through the polyethylene is not considered to reduce the overall effectiveness of the membrane.

Fixing recommendations - plywood sub-floors to concrete slabs and flooring to plywood

Plywood sub-floors should be structural grade, a minimum 15 mm thick and with a type A bond. Sheets may be installed in a 'brick' pattern or 45° to the direction of the strip flooring with a 6 mm gap between sheets and a 10 mm gap to internal and external walls. Various methods of fixing are used including adhesives and mechanical fixing. The option detailed below is for hand-driven spikes which provide solid fixing to the slab:-

- Slabs should be level to $\pm$ 3 mm in 1.5 m. If not, the effect needs to be assessed and as appropriate the use of a topping compound prescribed for the purpose or other measures to provide a satisfactory floor installation should be undertaken.
- Install 0.2 mm polyethylene vapour barrier
- Fix plywood sheets to the slab with hand driven 50 mm long by 6.5 mm spikes ('Powers SPIKE' or equivalent). A minimum of 20 spikes to be used per 2400 mm x 1200 mm sheet, equally spaced and with the outer spikes 75 mm to 100 mm from the sheet edge. If a brick pattern is used, it is preferable that sheets be staggered by 900 mm so that fixings do not line up from sheet to sheet.

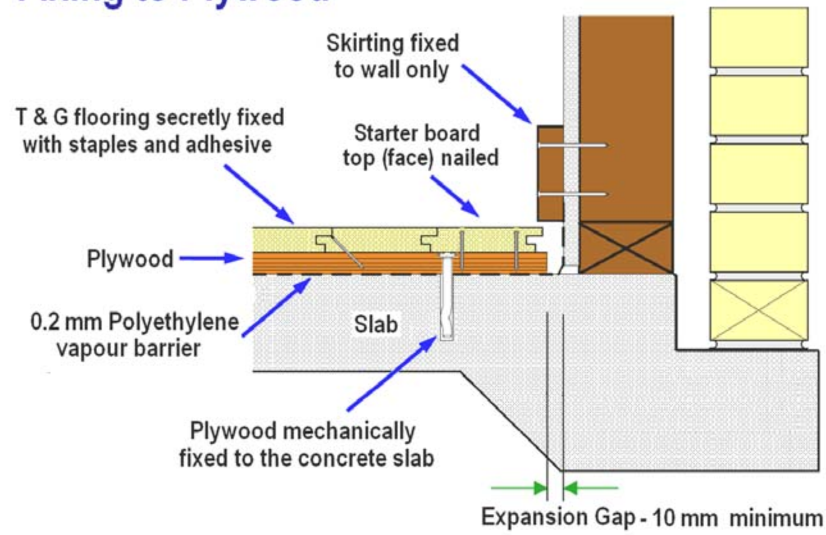
Fixing of the plywood sub-floor through the polyethylene membrane and into the slab

The table below outlines the minimum spacing and fixing details of the flooring to the plywood sub-floor. When staple fixing at close centres is being used, provide a cushion of polyurethane flooring adhesive between the two floors to minimise possible squeaks. This is achieved by using continuous bead of adhesive at 90° to board length, midway between fixing points. Where polyurethane flooring adhesive is used to provide much of the fixing, staples may be spaced up to 450 mm apart. Note that flooring cleats (as used with Powernailer) of a similar length may be used in lieu of staples.

Minimum Secret Fixings of T& G Flooring to Plywood Sub-floor (Substrate) over a Slab

FIXING METHOD	SECRET FIXING TO SUB-FLOOR (SUBSTRATE) ONLY
Staple fixing up to 250 mm spacing	Staples - 32 x 15 gauge to plywood for flooring 19 to 21 mm thick. Zigzag pattern of polyurethane flooring adhesive between fixing points. (For overlay flooring maximum length to suit sub-floor (substrate)).
Adhesive fixing with staples up to 450 mm spacing	Polyurethane flooring adhesive - zigzag pattern to achieve approx. 25% glue contact area after laying. Staples - 32 x 15 gauge to plywood sub-floor (substrate) for flooring 19 to 21 mm thick. (For overlay flooring maximum length to suit sub-floor (substrate)).

Fixing to Plywood



Fixing recommendations - battens to concrete slabs and flooring to battens

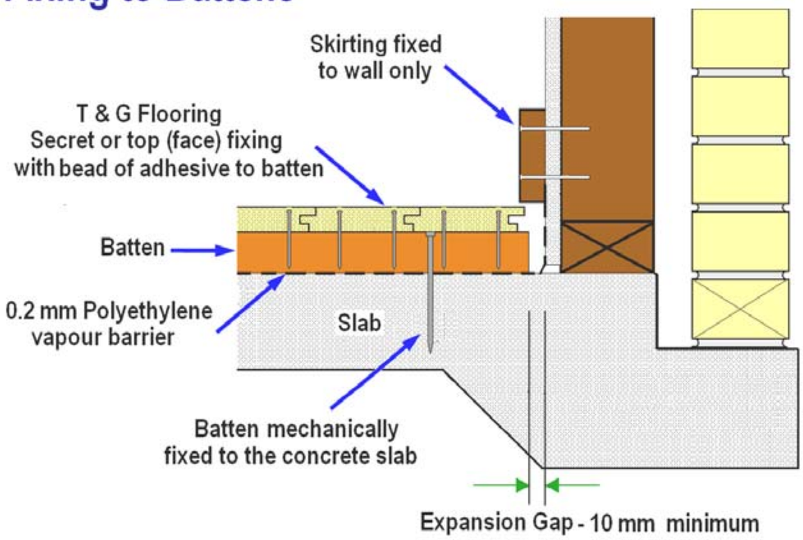
Battens are to be seasoned and may be either hardwood or softwood. Battens may be fixed to the slab using 75 mm gun nails at 600 mm maximum spacing, 6.5 mm dia. 'Powers Spike Fasteners' with a minimum embedment of 32 mm or equivalent at 900 maximum spacing or M6 masonry anchors at 900 mm maximum spacing. The following table and figure outline the minimum batten size and fixing requirements for structural flooring to battens. Batten spacing is dependent on the species and grade of timber used. It shall be the same as for flooring over joists provided above in the section on installing floors over joists.

Minimum Fixing T&G Flooring to Battens over a Slab

TYPE OF FIXING	BATTEN TIMBER & SIZE		
Top (Face) Fixing	**HARDWOOD & CYPRESS 35 X 70 mm**	**HARDWOOD 19 x 80 mm**	**SOFTWOOD 35 X 70 mm**
Without Adhesive Hand driven Machine driven	50 x 2.8 mm bullet head 50 x 2.5 mm T - head	–	50 x 2.8 mm bullet head 50 x 2.5 mm T - head
Secret Fixing			
With Adhesive # Machine driven	50 x 15 gauge staple	32 x 15 gauge staple	50 x 15 gauge staple

A continuous bead (6 mm approx.) of polyurethane flooring adhesive to be applied to 35 x 70 mm battens and the equivalent of 2 beads to 19 x 80 mm hardwood battens

Fixing to Battens



SECTION 4 - SANDING AND FINISHING TIMBER FLOORS

INTRODUCTION

The sanding and finishing process is particularly important to the overall performance and appearance of the timber floor and is an area that offers a wide array of methodologies and coating systems. The practices outlined are those employed broadly throughout the industry, however variations on sandpaper grades and procedures are common. The aim in all cases is to provide a smooth surface with the desired surface coating suitably applied to give an even level of sheen across the body of the floor.

ASSESSING THE FLOOR PRIOR TO SANDING

Prior to sanding the condition of the floor should be assessed to ensure that it is in a condition suitable for sanding. This may include assessing vertical movement at board or end-matched joints, an appraisal of the overall condition of the floor (e.g. degree of cupping in boards, gapping at board edges, signs of moisture) and if there are signs of abnormal moisture content, it should also include taking and recording moisture contents of the installed floor. This ensures a complete history of the floor, should issues arise in the future. Any issues should be provided in writing to the applicable person (e.g. principal contractor, owner) and an appropriate course of action taken. It is good practice to let the floor "settle" for a period, which may be 3 to 14 days before the sanding process takes place. This period is also beneficial for curing of adhesives where utilised.

Prior to sanding, the floor should be assessed to ensure that it is in a condition suitable for sanding.

PREPARATION FOR SANDING

Punching Nails and filling nail holes

Before the sanding process can begin, ensure that all nails are punched a minimum of 3 mm below the surface of the boards. Any nail that is not suitably punched will potentially damage the sanding equipment and affect the sanding process. It is important to note that secret nailed floors may have been top nailed adjacent to a wall or other areas where access is limited.

The punched nail holes can then be filled with either oil or non-oil based filler. Oil based fillers may bleed oil into the timber and affect the colour of the wood surrounding the nail hole or may not be compatible with various coating products. The colour of the filler should be carefully selected in order to minimise any visual impact of the filler. Many of these products are sold in colours pre-matched to specific species. In mixed species floors or where significant colour variations are present, it is usual to mix or select a neutral colour that is slightly darker than mid range between the extremes of colour. Generally all fillers are slightly darker and this allows for the boards to deepen in colour following finishing and UV exposure.

Nails to be punched and holes filled.

Filling can be done at this stage or after the first coat of finish is applied. By filling after the first coat any potential for the filler to impact on the surrounding timber through bleed or moisture is minimized. In all cases the filler must completely fill the hole so as not to impact on the finish quality.

Cleaning

The floor requires thorough cleaning to make it free from dirt, grit and debris. These particles, if not removed, can cause deep, uneven scratching in the timber surface requiring substantial additional sanding to remove. The floor should initially be swept followed by vacuuming, paying particular attention to areas which are not effectively cleaned by sweeping, such as gaps underneath the skirting, corners, window sills and the like. The vacuum should have sufficient capacity in terms of both suction and filtration to satisfactorily clean the floor.

It is important to remove any materials that may potentially impact on either the sanding or coating process. Additional care should be taken with silicone based sealants that may have been dropped onto the floor. These products can potentially be widely spread through the sanding process impacting on the bond between the coating and the timber.

Protection

During the sanding and finishing process it is imperative that access to the area of the work be restricted. Any trades working in or around the area can potentially generate dust, wet the floor, introduce silicone based mastics and sealants, walk over the area or generally contaminate it. Clear instructions should also be given to the owner or occupants regarding access, opening windows which may blow dust over the area and time required for coating systems to adequately cure.

SANDING

The sanding operation will vary based on the condition of the floor and the hardness of the flooring species. Where the floor is being sanded for the first time, the sanding process is made up of a number of separate sanding stages, which generally start with a course paper and progress to a relatively fine grade of paper. It should be noted that the sanding process is effectively scratching off the surface of the boards, and the reduction in grades of paper means that you start with a severe scratching action and finish with a more subtle scratching action.

During the sanding process progressively finer papers are used.

Level / Basic Sanding

The level/basic sand, as the name suggests, is to cut the boards level, taking out any ridges or high points in the floor. It typically comprises of three passes with the sanding machine. The level or basic sanding is to provide a level, completely sanded floor - each of the sanding procedures that follow this step are designed to remove the sanding scratches generated by this initial step.

Pass 1 is done from a small angle or up to a 45 degree angle to the direction of the grain (diagonally). This angle is dependent upon the layout and size of the area to be sanded. A coarser grade of paper is used depending upon the species and the condition of the boards. A lower grade of paper may be used to enhance the effectiveness of the sanding process in a floor that is very uneven or with hard species such as Turpentine or Ironbark.

Each room is sanded starting at a point, which will allow the longest path of travel at approximately 45

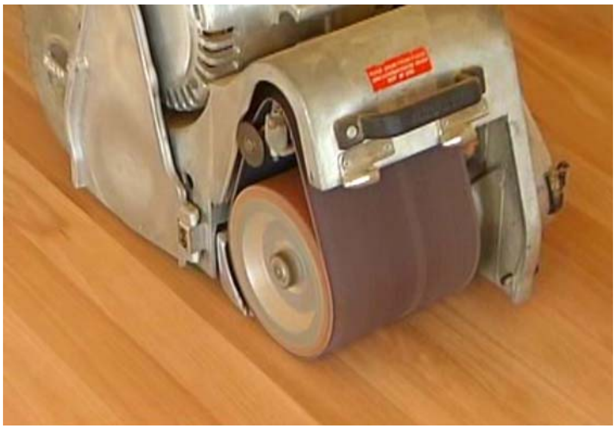
First and second pass of sanding at 45° to board direction.

degrees (or as is deemed appropriate given the room parameters) to the grain direction (run of boards). The machine is started ensuring that the drum is not touching the boards and walking slowly forward, the drum is eased onto the boards. A slow walking pace and consistent pressure is maintained. At the end of the pass the drum is raised smoothly off the floor and then by walking backwards, pulling the machine, it is eased back onto the floor for the return pass. The power lead, controlled by the operator, must be kept well clear of the drum.

When the original starting point is reached the drum is again gradually raised off the floor. The machine is then moved to the right or left hand side of the first path ensuring an overlap to the first cut path. Sanding continues in that direction, sanding strips and maintaining a similar overlap in each forward and backward pass. When the limit of accessibility has been reached in the corner of the room, the machine is brought back to the starting point and the remainder of the floor is sanded in the same direction and manner but to the opposing side of the first cut. That is, if sanded to the left of the first cut, sanding then takes place to the right of that first cut, ensuring that there is an overlap of around 200mm between the two sides of the floor.

The second pass is carried out on the opposite diagonal to Pass 1 using a similar grade paper.

The third pass continues in the direction of the boards using a similar grade paper to remove the sanding lines from the action of pass 1 & 2. Typically the operator should start at a point that is a few meters off the side wall. The process of walking speed and easing the drum onto the floor is as previously described.



Third pass of sanding in the board direction.

Once a forward and reverse path is sanded, the machine is moved ensuring an overlap to the previous cut and sanding recommences in the same manner. This process is carried out across the room. When the full width of the room is sanded, the operator should turn 180 degrees and sand the unsanded band of floor.

At the completion of the level or basic sanding the boards should be generally smooth and free from cupping and mismatching of surface levels between adjacent boards. If this has not been achieved the floor will require additional passes to achieve this state.

The sanding drum should never contact the floor unless moving forward or backward. Doing so will cut a groove into the floor (drum mark), which may not be recoverable. Specialist equipment and manufacturers recommendations, and user instructions should be followed.

Edging

The sanding machine will not be able to sand the boards along the edges of the room, in corners or areas of reduced access such as wardrobes etc. In these areas the boards need to be sanded level and generally blended into the body of the floor. For these areas an edge sander is used. The machine used may vary from either a disc, orbital or belt sander. In all cases, care is necessary to ensure the operation does not dig grooves into the boards and the finished edge is level with the body of the boards.

Edge sanding require a smooth action to blend into the floor.

The most commonly used machine for the edging process is the disc sander. When using this machine the operator should move the machine in a smooth even pattern at board ends and across the grain. The pattern of sanding should overlap and blend into the body of the sanded floor. It is important that the machine is held level as the boards are easily grooved with any uneven pressure. On each movement, the machine should sand approximately 50 mm section of unsanded floor. Along walls parallel with the boards, the edge sanding machine should be smoothly moved, back and forth in the direction of the grain overlapping some 100 mm into the body of the sanded floor.

On new and old floors, in good clean condition, finer grit papers are usually sufficient for the purpose of edging.

It may be necessary in areas of very limited access or at the corners of the room, to hand scrape the floor. The scraping action should always be in the direction of the grain with the surface being hand sanded or machine sanded with a smaller machine i.e. orbital sander. With orbital sanders too much pressure or use an overly aggressive grade of paper can result in deep swirl marks, which will show up in the finish. Once again, care needs to be taken to blend in these hand scraped areas with the body of the floor.

This process is repeated following the second sanding process of the body of the floor.

Finish Sanding

The finish sanding operation involves two separate stages of operation.

Stage 1 - Initial Cuts

The initial cuts utilise a finer grade of paper to that used in the level or basic sanding operation. Typically an F60 - 100 grade paper is used and the floor is sanded in the direction of the grain (board run). The purpose of the initial cuts is to smooth off the coarse sanding marks left by the level or basic sanding. Once a suitable level of smoothness is achieved, the final stage of sanding may be carried out.

Stage 2 - Final Sand

The final sand utilises an even finer grade of paper - once again reducing the depth of scratching and preparing the floor for the coating system. The floor must once again be fully cleaned of dust, grit and debris. Any matter left on the floor will invariably impact upon the quality of the finish.

Typically, the final sand is carried out using a rotary sander, plate orbital sander or similar machine with a 100 - 150 grade paper or screenback. The sanding should be carried out in the direction of the grain ensuring a smooth action, and applying a balanced control of the machine. If a water based coating system is specified the final sand may need to be carried out using a new or worn 150 mesh screenback dependant on the waterborne system being used (See manufacturers recommendations). The floor is then vacuumed thoroughly and if required tack rag cleaned. Special attention should be paid to any potential dust traps in the floor (dig out any dirt or dust and vacuum away). These can contaminate the floor coating system if not cleaned adequately, as the applicator will most certainly pull the dirt onto the body of the floor. It should also be noted that heavy sanding equipment may have the potential to create wheel marks on low density floor boards. Additional care should be taken in these applications.

The initial cut and final sand.

COATING SYSTEM APPLICATION

The following information is a typical application methodology, which might be utilised for the various finish types with minor product specific variations.

Cleaning

The floor finish will be easily contaminated with any dirt, dust or other extraneous matter left on the floor. It is essential that the area be thoroughly cleaned / vacuumed, paying particular attention to any areas which may have caught dust during the sanding process such as window sills, picture rails, skirtings, power and light switches, light fittings, handrails, etc. The floor needs to be well lit with adequate ventilation. It is important not to have draughts blowing across the floor during the process as they may well introduce contaminates from outside of the actual working area.

Mixing the Coating

The coating material should be well and thoroughly mixed so that all the solids are blended through the body of the liquid. Care should be taken not to stir too quickly or roughly as this may introduce air bubbles to the material impacting on the coating quality. If there are any additives to be used, ensure they are mixed thoroughly into the coating liquid. In all cases follow the manufacturers' instructions.

Cutting In

Using a clean, good quality brush, cut in the finish around the perimeter walls and any other obstructions or areas which may not be accessible to the main applicator. The cutting in should extend out approximately 150 mm into the body of the floor so that the applicator is not required to venture too close to the skirtings and other limited access areas. If any bristles fall out of the brush into the finish, remove immediately.

Cutting in the finish around perimeter walls.

Applying Coating

The initial coat applied to the raw sanded timber may be either a recognised sealer coat as prescribed by the coating manufacturer or the same material to be used as a finish, except when outside the manufactures' recommendations. Sealers are available in both water based and solvent based products. The use of a sealer can enhance the development of colour in the timber floor and can reduce the risk of "edge bonding". Penetrating and low rupture sealers are available. In all cases it is imperative to closely follow manufacturers' instructions.

There are many approaches and methods used in the application of floor finishes and coating systems. The following approach is one such application method, which has generally been accepted by the industry.

The applicator as specified by the coating system manufacturer (often a 6 mm Mohair roller or equivalent) is immersed in the coating contained in a large painter's tray or applicator bucket. These allow the applicator to be lightly squeezed on the shallow portion of the tray to avoid drips. Applying the product to the boards should be carried out in a smooth action starting at one end of the boards and working the product in line with the grain of the timber boards. The finish should be feathered off at the outer edge to minimise any build up of coating at that point. This

Application of the initial coat.

process should leave a "wet edge" so that each successive section of application blends into the previous section without any ridging, which can occur if the material skins or dries off before the next application strip. The application process should continue in the same manner working from one end of the area to completion. An even, wet look should result without any dry patches.

Filling/Stopping

It is recommended when coating parquetry floors, that filler be trowel applied following the first coat. This aids in reducing the phenomena known as "quilting" where the finish does not flow across joints at board or parquetry edges. Filling of parquet floors may be carried out prior to or following the application of the initial sealer or first coat and is at the discretion of the floor sander. It is not a recommended practice to fill tongue and groove timber floors.

Any nail holes not previously filled and any cracks or other open faults should now be filled with a suitable filling compound that is compatible with the finish type. (Note: insure the coating system is dry) Generally, a non-oil based filler is best which is suitably colour matched to the timber.

The filler should be installed with a clean bladed applicator. Ensure the filler slightly overfills the hole and has been fully pushed into the void. If the material is not completely filling the void, it may potentially come loose in service. Clean off any filler that is spread over the floor surrounding the hole. Any excess will be sanded away in the light sanding between coats.

Sanding Between Coats

The floor will typically have a slightly rough feel to it after the first coat of finish depending on the system used and the degree of grain raise of the timber created. It is normal for more open grain timbers to exhibit a higher degree of initial grain raise than denser close grain species. The floor requires a light sand after the first coat to remove this roughness and to also key the surface for the next coat of finish. A 150 or finer grit paper or screenback is used at this stage with a rotary sander or similar. It is imperative that the sanding does not expose the timber as this will create further raised grain. The sanding process is required to smooth off the roughness in the coating, not the timber. Edges must be hand or orbital sanded to a similar smoothness.

Cleaning between coats

All dust should again be thoroughly removed from the floor along with any potential dust traps as previously described. Ensure that there are no draughts blowing through the area that could contaminate the final coat(s). In addition it may be prudent to use a tack rag over the floor to remove any dust missed by the vacuum. This will ensure that the floor is as clean as possible for the final coat(s).

Second Coat

The floor should again be edged with a clean brush coming out some 150 mm or more into the body of the floor. The application process is as per the first coat with the applicator being worked along the full lengths of the boards and lightly feathered at the outer edge of each strip of application.

Application of the second coat.

Additional Coats

Any additional coats shall follow the same process of light sand of the previous coat, thorough cleaning and application of the coating. Typically a three coat system is utilised, however all manufacturers' recommendations should be followed in regards to number of coats and sand paper grades, in addition to any requirements of the specifier. Various water and oil based coating systems require a finer grit of paper between coats as compared to the solvent based products.

SECTION 5 - OVERALL APPEARANCE TO BE EXPECTED

There are no standards that outline what an acceptable appearance of timber floor should be. There are standards that relate to the manufacture of timber flooring and when recommended sanding and finishing practices are undertaken, there is a general level of acceptance of the finished product in the marketplace. Floors of the same species can differ markedly in their appearance depending on timber source, age of the tree, board cover width, the finish system used and the lighting in which the floor is viewed. Timber is a natural product that will shrink and swell in response to changes in atmospheric humidity, no building environment is the same as another, the sanding and finishing is not undertaken in a dust free factory environment and finishes may darken with time. Even with these variables a high standard in the finished floor is achievable.

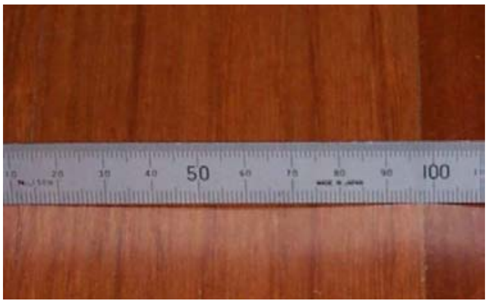
A high standard of appearance is achievable.

ACCEPTABLE APPEARANCE

Even timber surface

The following outlines some problems that affect the surface of the boards and these should not generally occur in timber floors. However, specific heat sources from appliances or sun exposure through large uncovered windows may induce some cupping of boards in the affected area. Similarly, wide boards or thinner overlay boards may also show some slight cupping in certain house environments. It should also be recognised that the actions or inaction of owners can contribute or even cause these to occur.

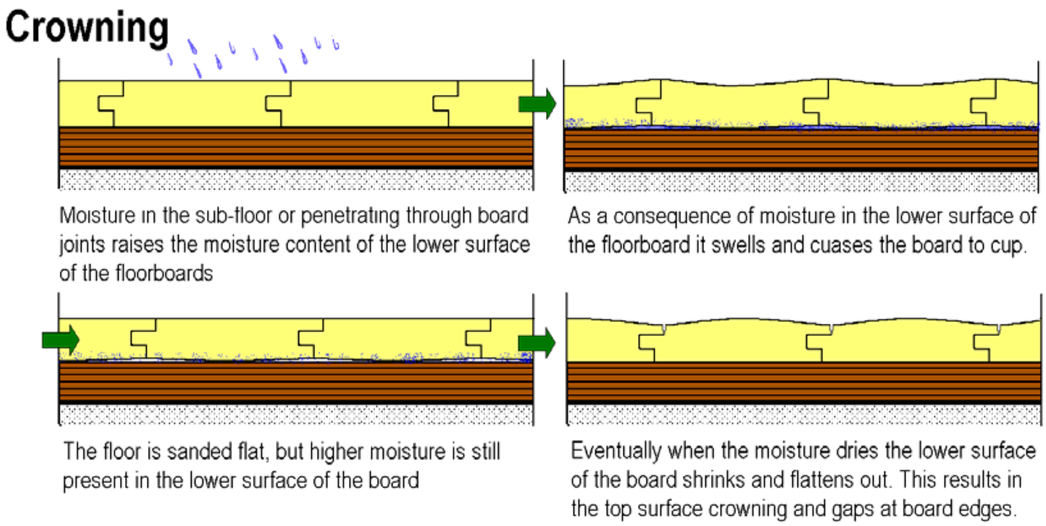
- Cupping - boards with their edges either higher or lower that the centre of the board. Heat in a specific location or a very dry environment above the floor may result in cupping. Moist sub-floor spaces can also cause boards to cup. Cupping is more likely to occur in overlay flooring and standard thickness boards that are wider than 100 mm. To some degree a small amount of cupping may occur in some locations within a dwelling (e.g. sun exposed floor) where these types of flooring are used.



Cupping: board edges higher than the centre of the board

- Tenting - two adjacent boards, where the adjoining edge has lifted above the level of the adjacent flooring. This is often associated with high moisture beneath the floor and can be from many causes.
- Buckling - a section of flooring containing a number of boards that is raised above an adjacent section of flooring.
- Crowning - floor boards that are flat on their lower surfaces but where the upper surface has its edges lower than the centre of the board. This may occur if a floor is cupped (board edges up) at the time of sanding. Crowning does not become apparent until some months after finishing.

Note: Floors exposed to heat sources after occupancy (e.g. no curtains, fireplaces, vents from appliances, houses closed up for extended periods) may cause boards to cup. Cupping and shrinkage from such sources may be the owner's responsibility.)



Relatively even gapping between boards in areas not exposed to specific heat sources

During drier times of the year, gapping between boards may average 0.75 mm. Some gaps may be larger than this and others smaller, however the appearance generally indicates gapping between most boards.

An appearance can be expected that is free from split boards and wide gaps between boards that may be irregularly spaced across the floor. Irregularly spaced wide gapping may occur from either the edges of boards being bonded together or from a proportion of boards being high in moisture content at the time of laying.

Limited vertical movement at T & G joints

Flooring is manufactured with the board tongue narrower than the groove. This is necessary so that boards will fit together during installation. When floor boards are laid over joists in particular, some differential vertical movement may occur between adjacent boards, when a load is applied to an individual board. This is due to the clearance between the tongue and the groove. The clearance should not exceed 0.6 mm.

Minimal Squeaking

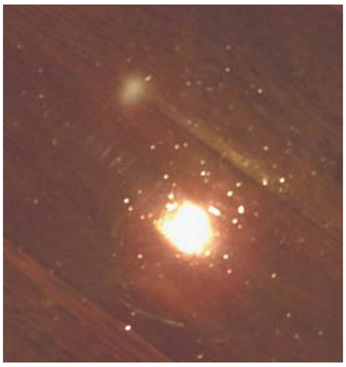
A small amount of noise can be expected from most timber floors, when walked on. Noises can occur from movement of one board edge against another or from boards moving on nails. A floor is often more noisy during drier weather due to loosening at the joints.

Indentations

Timber strip floors can be expected to show some indentations depending on the hardness of the species used, volume of traffic and foot ware worn.

A Finish with Minimal Contamination and Sanding Marks

A finish similar to that of fine furniture should not be expected. Timber strip floors are not finished in a factory environment and different pieces of flooring will sand differently. The home environment is also not dust free. However, the finished floor can be expected to have an even appearance free from heavy sanding marks, blooming or frequent air bubbles in the surface. A minimal level of contaminants, minor sanding marks and small depressions of the finish at board edges and in nail holes etc. may be visible. The perimeter and other hard to get at places are more likely to contain these irregularities. Due to this a mirror finish is an unachievable expectation. Some finishes will also yellow with time and if rugs are moved, a contrast in the depth of colour can be expected.



Downlights highlight dust in the finish. These specks often wear off quickly with foot traffic.

When floors are inspected for imperfections, the floor is to be inspected during daylight hours with lighting on. The overall assessment of the floor is from a standing position with the floor viewed from positions that are usually occupied by people. Internal and external reflections in areas not usually covered by furniture should be assessed. Acceptability relies on judgment that takes into consideration the effect of lighting on noticeable surface imperfections as well as initial wear of the floor, which can cause some imperfections to significantly lessen or disappear. A floor is subject to much heavier wear than furniture and although a good quality finish can be expected, the same finish quality to furniture should not be expected.

Some imperfections that could be expected to some degree in a floor but which should also be assessed include:- sanding quality; gloss variation; dust, insects and debris; bubbles and gel particles; coat leveling.

SECTION 6 – CARE AND MAINTENANCE

Timber floors are easy to maintain and greatly benefit from regular care. In doing so, the life of the floor finish and floor are greatly enhanced. However at some stage the floor will need to be rejuvenated and this requires buffing back and re-coating. Some of the softer floor finishes can also benefit from application of metalised polish which provides an additional wear surface. It is important that maintenance aspects are passed on to customers as it assists in ensuring ongoing customer satisfaction.

A Newly Finished Floor

Although a floor may be walked on after initial curing, some precautions are necessary with a newly finished floor until the coating system has fully hardened and this may take in the order of two weeks. It is recommended that rugs are not laid until after the floor finish has fully hardened. While light furniture can be replaced and used during this period, it should be ensured that furniture protection felt pads are attached to the feet of tables and chairs etc and furniture such as chairs should be lifted. Similarly, it should also be ensured that heavy items such as fridges are moved carefully into position and at no time should they be dragged over either newly finished or fully cured floors. Consideration should also be given to chairs with castors. Again these should not be used until the finish has hardened and barrel type castors are less likely to damage a floor than ball castors.

Timber floors are easy to maintain and greatly benefit from regular care.

Ongoing Care and Maintenance

Ingress of Grit and Direct Sunlight

The are some things that are enemies to timber floor finishes and one of these is sand or grit that that can be brought into the house with footwear. These small particles act like sandpaper resulting in scratches in the floor. Mats placed both outside and inside external doors provide a simple and effective means of significantly reducing grit from entering the house. Similarly, in high wear areas, runners and rugs can be effective and can also add to the décor of the house. The kitchen floor generally experiences high wear and therefore a floor rug in this area can be particularly beneficial.

Floor mats at doorways provide a simple means of limiting the amount of grit from entering the home.

Another aspect that should be considered is the amount of direct sunlight that is reaching the floors. Direct intense sunlight can contribute to gapping and possible cupping of boards. It will also cause the colour of both boards and finish to change with time. Some floor finishes are more prone to darken with age and direct sunlight accelerates this process. Filtered sunlight through sheer curtains or blinds provides an effective means of slowing the colour change processes and is also effective in controlling gap size and possible cupping. In some instances it may be decided that window coverings will not be used, and if the sunlight has not been controlled by patio roofs or awnings then floors rugs can be used.

Maintenance Plan

Establishing a regular cleaning program will greatly assist in keeping floors in pristine condition. There are many aspects that affect how often the floor requires cleaning and these include the degree of grit present (particularly from children and pets), the level of traffic and general conditions of the area outside the house. Spills should be mopped up when they occur and any leaks must be attended to immediately. Failure to attend to leaking pipe work can result in severe problems with a floor particularly when laid over sheet flooring or directly adhered to a slab. Scuff marks or stubborn stains may be removed with light rubbing using a wood floor cleaner.

For regular cleaning of domestic floors an antistatic mop provides an effective means of collection dust and grit. Continual walking on a dirty floor will quickly damage the finish. If a vacuum cleaner is used then the condition of the brushes should be regularly checked. If they have worn thin, contact of the metal head on the floor can result in scratching.

On a monthly basis floors can also benefit from damp mopping. Providing the mop is only damp and the finish is in good condition, mopping carried out correctly will not affect either the finish or the timber. Damp mopping provides an effective deep clean and should be undertaken with a neutral pH wood floor cleaner or product recommended by the finish manufacturer. Harsh detergents or abrasive cleaners are to be avoided. After wetting the mop it should be wrung out until it is moist and the floor can be mopped in this condition. Using clean water, a final mopping with a mop wrung out till it is 'dry' may be used to further remove excess moisture on the boards. Periodically the protective pads on furniture legs should also be check to ensure that they are clean or in need of replacement.

Re-coating

Timber floors are subject to different wear patterns and it is in areas of higher wear that there will initially be signs that the floor requires re-coating. It is important to ensure that excessive wear has not occurred if a total re-sand and re-finish is to be avoided. The finish should be inspected in the high wear areas and if a few drops of water bead on the surface then the finish is still intact and may require cleaning rather than re-coating. If however, after a few minutes the water begins to soak in and the timber colour darkens, then the finish is partially worn and re-coating should be undertaken. It is important that the details of the original coating system can be made available to the sander and finisher to ensure compatibility between coats.

APPENDIX A1 - MOISTURE CONTENT AND TIMBER MOVEMENT

WATER IN WOOD

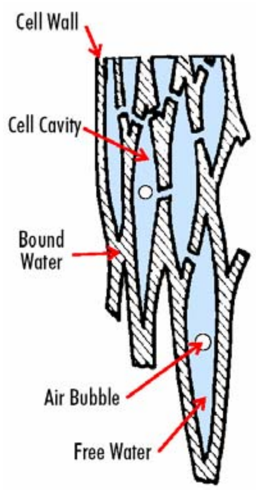
In all common applications, timber contains moisture. Even timber that has been in service for 100 years will contain similar amounts of moisture to seasoned timber that has just been put into service. The reason for this is that the moisture in the air (humidity) maintains a certain level of moisture in the wood. The moisture present in freshly sawn (i.e. green) timber, straight from the log, is much higher and as a consequence of this, the air absorbs moisture from green timber until a balance is achieved.

Moisture Content

For timber products such as flooring the amount of moisture present or its moisture content is defined as the mass of water present in the timber divided by the mass of the timber with all water removed, expressed as a percentage. The mass (measured in grams or kilograms) of water present can be determined from the difference in the mass of the timber with water (initial mass) to the mass of timber with the water removed (oven dry mass). Hence the following equation is used to determine the moisture content of timber:-

$$\% \text{ mc} = \frac{\text{“mass of water present”}}{\text{“oven dry mass”}} \times 100\%$$

$$= \frac{\text{“initial mass”} - \text{“oven dry mass”}}{\text{“oven dry mass”}} \times 100\%$$



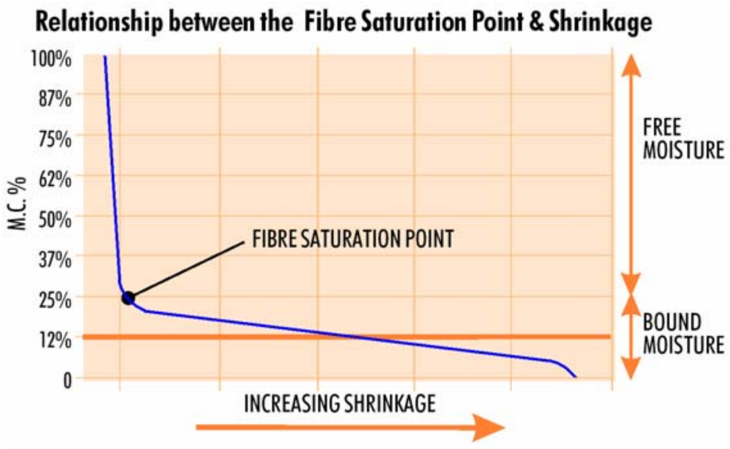
The structure of the cells in timber can be likened to a number of drinking straws glued together. If the straws were full of water it could be expected that the mass of water contained in the straws would be greater than the mass of the drinking straws alone. In such a case the moisture content as calculated above would exceed 100%. In a tree the moisture content may be as low as 40% but can be as high as 180%. Green off saw timber could therefore have moisture contents of 180%, which means the timber contains 1.8 kg of water for every 1.0 kg of dry timber that was present. In softwoods such as radiata pine and Araucaria the average moisture contents of 180 % or more often occur. In many of our common hardwoods the moisture content may be no greater than 70%. Cypress, a softwood that grows in drier areas, may only have average moisture contents of 45%. There can also be sizeable variations in moisture content between the outer sapwood of a tree to the inner heartwood.

THE DRYING OF TIMBER FOR FLOORING

Seasoning or drying is the process by which moisture is removed from timber and green (i.e. freshly cut boards) may be either air dried or kiln dried or a combination of both. The drying process for flooring often includes more than one stage. Timber is initially stacked to allow air movement between each layer of timber and in this state it can be either air dried by leaving it out in the open for some months or placed in a low temperature pre-dryer to gently reduce its moisture content under controlled conditions, prior to drying being completed at higher temperatures in a kiln. Some hardwoods are however kiln dried from green but many operations use initial air drying or a pre-dryer followed by kiln drying. Softwoods are generally air-dried or kiln dried from green.

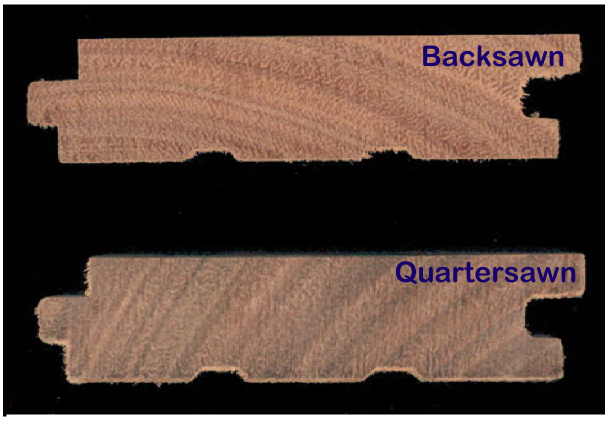
When we refer to seasoned timber, we are usually referring to timber that has moisture contents in the range from 9% to 14%. This range has been chosen because timber in coastal Australia will usually remain within this moisture content range, when used internally. Whether timber is dried by the air or in a kiln there is always a small variation in the moisture contents of individual boards (usually about 5%). Due to these variations, some boards will take up moisture from the air after being put into service, while others may lose moisture. When timber takes up moisture it expands and when it loses moisture it shrinks. The small moisture variations present at the time of flooring manufacture therefore translate into small differences in board widths as board moisture contents adjust to be in balance with the humidity in the air.

Movement in Timber with a Change in Moisture Content

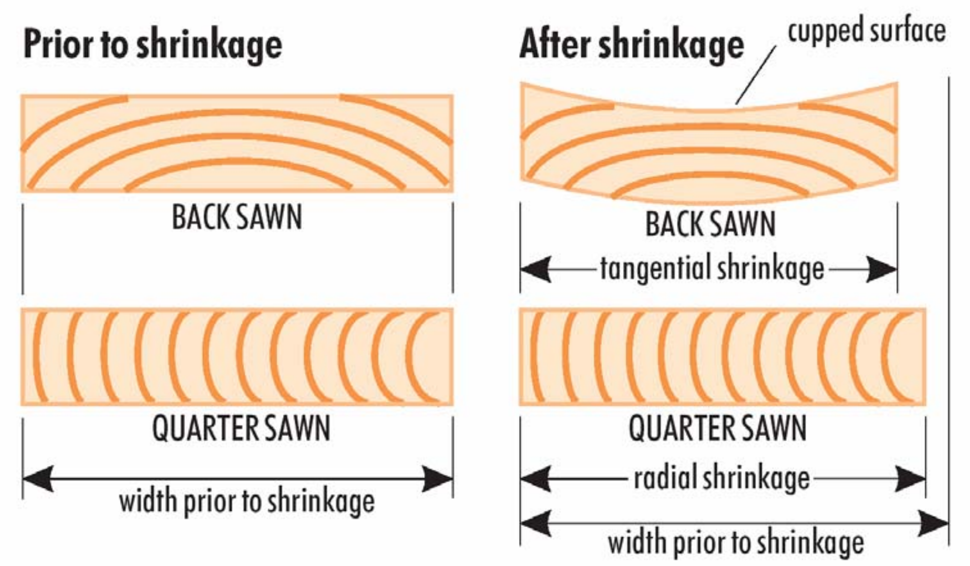


The cell structure of wood has been likened to a number of drinking straws that are glued together. With regard to this, water in wood resides both within the "straws" (called free water) and in the walls of the "straws" (bound water). As indicated above, the moisture content in living trees will vary greatly depending on the species, age of the tree and location in which it is grown. However, no matter what the initial moisture content is of the wood in the trees, shrinkage in timber is minimal until the moisture content reaches approximately 25%. At this level much of the free water has been removed and it is from this point (called the fibre saturation point) that there becomes a significant reduction in the bound water tied up in the cell walls. Associated with this, the cell walls begin to shrink and we observe shrinkage in timber. This relationship is shown diagrammatically in the graph.

Within the sawmilling industry, boards are refereed to as being either backsawn or quartersawn and the movement characteristics of each is quite different. In a backsawn board the angle of the growth rings on the end section to the widest face is less than 45 degrees. In quarter sawn boards this angle is greater than 45 degrees. Backsawn boards are often valued for the "figure" that appears on the surface of the timber flooring and with backsawing the amount of usable timber recovered from the tree is also usually greater. However, backsawn boards can be expected to shrink in width more than a quarter sawn board and due to the angle of the growth rings, backsawn boards will have an inherent tendency to cup when they dry.



Backsawn and quartersawn floor boards.



The amount of shrinkage that occurs radially (i.e. in a direction that radiates out from the center of the log) differs from that occurring tangentially (at right angles to the radial direction). Therefore, in a backsawn floorboard the cover width will vary as a result of tangential movement and in a quartersawn floorboard the cover width will vary from radial movement. Flooring manufactured from species grown in Tasmania and Victoria are often quartersawn whereas species from Queensland, New South Wales and Western Australia are predominantly backsawn.

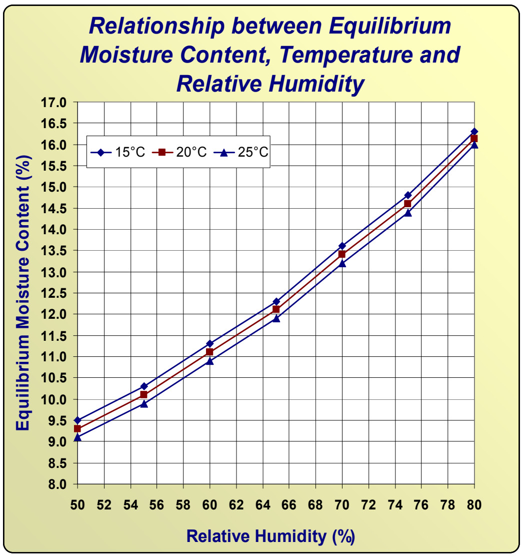
A useful measure of movement is what is termed the "unit tangential movement" (U.T.M.). This is the percentage dimensional change for each 1% change in moisture content between 3% and the fibre saturation point for the particular species. For example Brush box has a U.T.M. of 0.38. Therefore a 3% increase in moisture content could on average be expected, to cause an 80 mm wide backsawn floor board to increase in size by:

0.38 x 3% x 80/100 = 0.9 mm.

When dealing with seasoned timber, the U.T.M. can be used to estimate anticipated movement however actual movement is often less than the estimate, due to the presence of quartersawn material and with regard to applications such as flooring, some compression of the timber often occurs. Therefore care is necessary when applying these figures. Tables of U.T.M. are available from state timber organisations.

Flooring response to changes in humidity

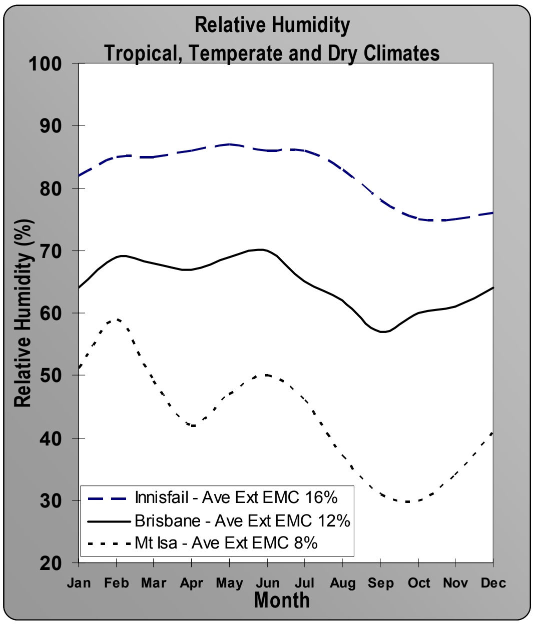
A relationship exists between the air temperature, relative humidity of the air and the moisture content that timber will try to attain. This relationship is shown in the following chart and it can be seen from this that humidity has the predominant influence over moisture content. As an example, if timber is in a room at 25°C and the relative humidity is 65% then the timber will in time try to reach approximately 12%moisture content.



Temperature, RH and EMC.

Obviously, humidity and temperature will change on a daily basis as well as on a seasonal basis. Because of timbers relatively slow response rate, we are usually more concerned with seasonal changes. The effects of seasonal changes may be observed in a polished timber floor by the opening and closing of gaps between adjoining boards at different times of the year.

Weather data provides information on the changes in relative humidity that can be expected in a particular locality and this is particularly important if installing a floor in a location that differs from the one that you are used to. There can be significant changes over short distances. For example between a coastal city and hilly rural environment, a half hours drive away. Examples of different climates, seasonal humidity fluctuations and average moisture contents are given in the adjacent graphs.



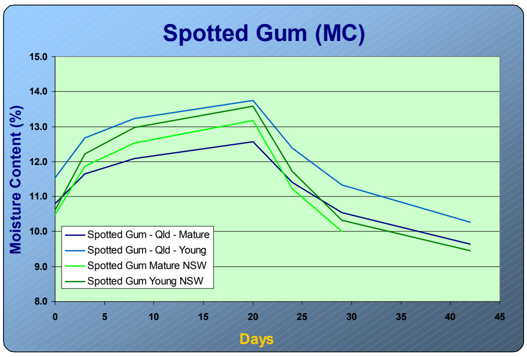
Climatic effects on timber floors.

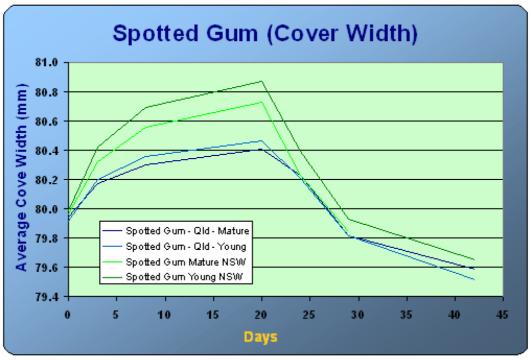
Although these graphs link timber moisture content to surrounding environmental conditions they do not show the response rate of different species to these changing conditions. The response rate of softwoods such as Hoop pine or Radiata pine is more rapid than that of the denser hardwoods such as Spotted Gum. However, even within the hardwood or softwood groups, response rates can also vary quite markedly. Indicative response curves from one trial for Spotted Gum when placed in a very humid environment

(18% EMC) followed by a dry environment (8% EMC) is shown in the adjacent graphs. The first graph shows moisture content changes and the second graph the change in cover width. Clearly this illustrates the variability that can be present. Blackbutt, although a dense hardwood, takes up and looses moisture quite rapidly.

The species that more quickly take up or loose moisture will generally follow seasonal changes more closely. The graphs also indicate that the rate of moisture uptake, which may result from a relatively quick and sustained change in weather conditions, can initially be quite rapid but the rate of increase then slows over time. This aspect is also reflected in timber floors. Floor installers sometimes comment that a floor may have shrunk a lot in the first week or so after laying but that it hadn't moved much since then.

As a guide, provided below is a table that outlines the density of the species, whether the flooring is predominantly backsawn or quartersawn and an indicative measure of the species response rate to moisture uptake and loss. In locations where floors are likely to expand after installation particular care is necessary to adequately accommodate the expansion that will occur (i.e. intermediate expansion joints, loose lay & acclimatisation). This is particularly so with higher density timbers and particularly those higher density timbers that respond quickly to seasonal humidity changes.





Results from the FWPRDC Research on Timber Flooring undertaken by Timber Queensland Ltd. The graphs show averages of ten pieces of Spotted Gum flooring from different sources placed in a conditioning chamber at 18% EMC for 21 days followed by 8% EMC for 21 days.

Species classification	Density classification	Cutting pattern	Movement in response to humidity changes
Radiata Pine	Low	Backsawn	Low
Tasmanian Oak	Medium	Quartersawn	Medium to high
Victorian Ash	Medium	Quartersawn	Medium to high
White Cypress	Medium	Backsawn	Low
Jarrah	Medium to high	Backsawn	Medium to high
Rosegum	Medium to high	Backsawn	Medium
Blackbutt	High	Backsawn	High
Spotted Gum	Very High	Backsawn	Low to medium
Grey Ironbark	Very high	Backsawn	Medium

APPENDIX A2 – MEASURING MOISTURE CONTENT OF TIMBER AND SHEET PRODUCTS

Checking the moisture content of timber flooring prior to installation is important to provide a check on the product supplied, evaluate the need for additional expansion allowance and to ensure that subsequent movement (shrinkage and swelling) remains within accepted bounds. This appendix outlines the various methods used to test the moisture content of timber. Also included in the appendix is a method to evaluate the moisture content compliance of packs of flooring.

MOISTURE CONTENT MEASUREMENT

Moisture content

Moisture content is simply the mass of moisture present in wood divided by the mass of the wood with no moisture in it, expressed as a percentage. What's important about the moisture content in timber is that the board width will increase with increasing moisture content and will decrease with decreasing moisture content. At the time of machining cover width variations are usually minimal and subsequent variations that occur in board widths are usually due to changes in moisture content. Note that it is often the current and future variations in board width that is of primary importance and one important purpose of moisture content testing is to indicate what future movement can be expected.

Initial mass 32.63 gm
Oven dry mass 29.49 gm

$$MC = \frac{32.63 - 29.49}{29.49} \times 100\% = 10.65\%$$

By simply looking at the end of a pack of flooring, that may be a month or so old, it is often possible to obtain information about the moisture content of the timber within the pack even without using a moisture meter.

For example in a three month old pack of flooring, some moisture changes are likely to have occurred and if the nominal cover width of was 80 mm and:-

- board widths measure between say 79.6 mm and 80.4 mm then the material is likely to have been dried to within narrow moisture content bounds and should perform well in service.
- board widths range from say 78 mm to 81 mm and some boards are cupped, then the material is likely to have been dried to quite wide moisture content bounds and the floor is likely to show some wide gaps at board edges along the length of the board and near end matched joints.
- board widths range from say 80 mm to 84 mm then some of the material may have become wet after manufacture.

It is therefore important when considering moisture content to also take the board widths into consideration. Australian standards that cover the moisture content of flooring vary in their limits as this depends on the species. The table below provides some information on species types, the number of the applicable standard and the moisture content ranges applicable to flooring.

Species Group	**Moisture Content Bounds** (moisture content anywhere within a board)	**Number of the applicable standard**
Hardwood	9% to 14%	AS 2796
Softwood	9% to 14%	AS 4785
Cypress	10% to 15%	AS 1810

METHODS OF MEASURING THE MOISTURE CONTENT OF TIMBER

How moisture content is measured

Moisture content is generally measured by either a meter or through oven dry testing. The two common types of meters in use are the resistance meter and the capacitance meter. Meters use changes in electrical properties caused by the wood and water within it to provide an estimate of the moisture content. Oven dry testing requires a set of scales and an oven from which the moisture content is determined from the change of mass as the sample dries.

Capacitance moisture meter - Measures average moisture content – Need to set species density.

Resistance moisture meter - Measures moisture content between the pins – Need to correct reading for temperature and species.

Measurements by different methods

In any piece of flooring the moisture content is likely to vary to some extent down the length of the piece and from the outer surfaces (case) to the center (core). With regard to case to core differences some methods of measurement are able to measure this while others can only measure the average moisture content of the board. This can be an important consideration when choosing a measuring method as case to core variations or the difference between upper and lower case may need to be determined. At other times it may be important to gain many measurements quickly in order to gain an appreciation of the average moisture content. In cases of dispute, accuracy may be of prime importance.

Resistance meters measure the highest moisture across the exposed ends of the pins where as capacitance meters measure an average through the piece. Oven dry testing measures the average moisture content of the sample placed in the oven but by cutting the sample up into applicable smaller pieces, case and core moisture contents can also be determined.

The three common methods of measurement, including their application, benefits, limitations and accuracy are outlined below.

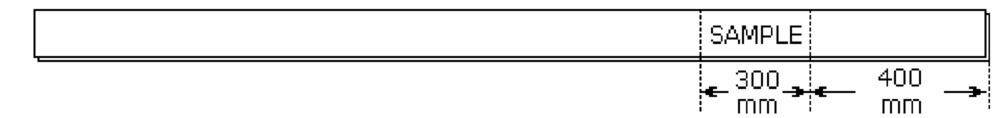
Oven dry testing – Provides the most accurate moisture content test.

OVEN DRY METHOD

- **When is it used**
  - Oven dry testing is often carried out where variations in moisture content in the final product can have a significant affect on the performance of the product.

- It is used where accurate results are required or meter readings are known to be inaccurate which can include some timber species but also particleboard and plywood sub-floors.
- In case of disputes Australian standards generally refer to this method as it provides measurements that are more accurate and reliable.
- Manufacturers of board products often undertake oven dry testing in the manufacture of their products.
- Some timber organisations also have the appropriate testing equipment and contract out these services.

- **Testing equipment and facilities**
  - The equipment required is an accurate balance or set of scales and a laboratory oven that is able to maintain a temperature of 103°C ± 2°C.
- **Sampling from a pack**
  - The samples need to be representative of the timber in the pack being tested and capture the variation present. This may therefore include some outside boards as well as some from within the pack.
  - If cupping is present or there is variation in the cover width by more than 1 mm, samples should be provided which include 2 boards that are cupped, 2 with wider cover widths and 2 with narrower cover widths. (Packing pieces are not to be provided as samples)
  - If boards are not cupped and there is little variation in cover width throughout the pack, 5 boards should be chosen. (Packing pieces are not to be provided as samples)
  - The samples from which test pieces will be cut should be taken not less than 400 mm from the end of a board and should be approximately 300 mm long.



  - (Note: If the sample is from a board on the top, bottom or edge of the pack, it should be marked as being an outside board.)
  - The samples should be individually wrapped in “glad wrap” or similar to reduce moisture content changes during transport.
  - The samples should be stored in a cool place and delivered to the testing facility within 24 hours.

- **Testing Procedure**
  - From the 300 mm long pack samples, test pieces are cut with a length between 15 mm and 30mm so that the required mass is achieved to suit the accuracy of the mass measuring equipment. If the equipment measures to 0.1g then a test sample of at least 50gm is required. The sample may be less than 50g if the equipment measures to 0.01g.
  - The initial masses of the test pieces (and usually the cover widths) are recorded. The test pieces are placed in the oven for at least 24 hours and then reassessed at four hour intervals until there is minimal change in mass. For longer samples in denser species times of 48 hours or so may be required. The mass after drying in the oven (i.e. oven dry weight) is recorded.
  - The moisture content is then calculated for each test piece by applying the following equation.
  - Moisture content (%) = ((Initial mass – oven dry mass)/ oven dry mass) x 100 %
  - For example if the initial mass is 57.6 g and the oven dry mass is 43.3 g then the moisture content is:- Moisture content (%) = ((57.6 g – 49.3 g)/ 49.3 g) x 100 % = 16.8%
  - This method provides the average moisture content for the test pieces. Case and core measurements can be obtained by cutting the appropriate sections out of larger test pieces prior to testing.
- **Interpreting results**
  - The sampling method outlined above aims to capture the variation present in a pack of timber and from this it can be assumed that most of the timber within the pack will fall within the upper and lower moisture content measurements.

- In applications where cover width is important, both the cover width and the moisture content should be considered. Often boards of lower cover width are also those of higher moisture content and further shrinkage of this material can be expected.

- **Benefits and limitations**
  - The main advantage of this method is its accuracy.
  - The method is time consuming, not portable and more expensive.
  - The most common error results from insufficient drying, which underestimates the moisture content. If sample masses are small then measuring errors can significantly affect the moisture content calculation.
  - Microwave ovens can produce good results and speed up testing, however there are no formal procedures and there is the risk of evaporating volatile compounds in addition to the water which affects accuracy.

RESISTANCE METER

- **Principal of operation**
  - The electrical resistance of timber reduces as the moisture in timber increases. These meters measure the flow of electricity between two pins where the timber acts as an electrical resistor between the pins. The scale on the moisture meter is graduated to read moisture content. Wood temperature affects the readings and for this reason wood temperature above or below 20°C, requires correction to the reading. Temperature correction if not already taken care of by the meter is applied before species correction. Species correction is necessary as two different timber species at the same moisture content may not have the same electrical resistance. Meters are generally set up relative to one species and that is Douglas Fir (Oregon) and species corrections are then applied for other species. There comes a point where the water in timber is so low that the resistance is difficult to measure accurately or on the other hand sufficiently high that the resistance does not change greatly and is prone to greater errors. These meters generally provide reliable results between 6% and 25 % moisture content.
- **Types of meters**
  - A wide variety of meters are available. All have two pins that are used to penetrate the timber but the pins may vary in length from approximately 6 mm in length up to 50 mm. The longer pins are often insulated up to the pointed ends to prevent surface moisture effects from interfering with core measurements. Those with longer pins are also usually of the 'sliding hammer' type, which provides a means of driving the pins into the timber. The sophistication of the meters varies greatly in terms of features such as inbuilt temperature correction, preprogrammed species calibration and depth indication. Many of the meters now come with a calibration block.
- **Using resistance meters**
  - The calibration of the meter should be checked prior to use and this is usually done with a test block that contains electrical resistors that correspond to the moisture contents specified on the test block.
  - Measurements are then taken in clear timber at least 400 mm from the ends of boards.
  - Some meters require measurements to be taken with the pins running down the length of the board while with others the pins are to run across the width of the board (check with the manufacturer's manual).
  - The pins are driven to the desired depth to which the moisture content reading is required. As case and core measurements can be significantly different, use of meters with short pins may require boards to be cut and the pins inserted in the end grain to provide a better estimate. In high density timbers holes may need to be drilled for the pins.
  - The pins need to be in firm contact with the timber, otherwise low readings may occur.
  - Readings should be recorded to the nearest 0.5% and read shortly after penetration.
  - Each reading is to be corrected for wood temperature first (provided this is not done automatically) and then for species (providing the species has not been set on the meter).
  - Refer to Table 1 for temperature correction factors and species correction factors for some common commercial species. Additional temperature and species correction factors are available in AS 1080.1.

- **Limitations, accuracy and precautions when using resistance moisture meters**
  When using meters a common sense approach is necessary and each reading should be evaluated and if not as expected, then the reasons for this should be investigated. The meters generally provide a reasonable estimate of the moisture content to $\pm$ 2% in the measuring range from 8% to 25% and as stated above readings should be recorded to the nearest 0.5%. There are a number of factors that are known to affect meter readings and these are:-
  - Measurement necessitates damaging the surface of the timber
  - The method is conducive to only taking a relatively small number of sample readings
  - Readings near the board surface can be significantly different from the core
  - Low battery can cause low readings in high moisture content material
  - Uncertainty over species they are being used in can make species corrections difficult
  - Species such as Brush Box have very high species correction factors and are prone to greater error
  - Use for extended periods in high humidity environments can raise meter readings
  - Meters only read wettest part that the exposed surfaces of the pins are in contact with
  - Surface moisture can provide artificially high readings not reflecting wood moisture content
  - Salt water or any preservative treatment salts can affect meter readings and will usually raise them
  - Electrical wiring in walls can affect the readings

If meter readings are not in line with what is expected, then this may necessitate oven dry testing to more accurately estimate the moisture content.

CAPACITANCE METER

- **Principal of operation**
  - These meters measure an electrical property called the 'dielectric constant' and in so doing an electric field produced by the meter and the presence of the timber on which the meter is positioned, form a 'capacitor' type of arrangement. The electric field can penetrate deep into the timber but meter readings are biased toward moisture in the surface layers. Both the moisture content and the density of the timber affect this electrical property. The effective range of capacitance meters is from approximately 0% to 30% moisture content. The more sophisticated meters can be adjusted for timbers of different densities. Less expensive meters do not have density compensation and for these meters corrections to meter readings must be applied based on the density of the species being tested. Such meters are usually preset to be more suited to softwoods and lower density hardwoods and this can cause limitations with higher density species (i.e. large correction factors are necessary).
- **Types of meters**
  - Meters are imported from overseas and range from those with few features to those with a wider range. Features may include settings for timber density (or specific gravity) and timber thickness as well as the ability to store readings and apply some statistics to the results. It is necessary to ensure that the meter is going to meet your specific needs and if being used with higher density hardwoods then timber density (or specific gravity) adjustment must be seriously considered.
- **Using capacitance meters**
  - The appropriate meter settings for density and board thickness etc should be applied and the meter checked for calibration.
  - The density (specific gravity) is often calculated differently for different reasons (i.e. green density, density at 12% moisture content or basic density). Specific gravity is the density of a material divided by the density of water (approximately 1000kg/m3). It is necessary to obtain from the meter supplier the relevant figures applicable to the meter being used. Table 2 provides densities at 12 % moisture content.
  - Measurements are then taken in clear timber away from knots etc.
  - Some meters require measurements to be taken with the meter in a particular orientation on the board (check with the manufacturer's manual).
  - The plate of the meter must be in firm contact with the board before a reading is taken.
  - Readings should be recorded to the nearest 0.5%. If no density (specific gravity) settings are available then these meter reading needs correcting.

- **Limitations, accuracy and precautions when using capacitance moisture meters**
  Similar to resistance meters common sense must prevail when using these meters with readings evaluated and investigated if not as expected. Providing the density is accurately assessed then these meters also provide a reasonable estimate of the average moisture content in a board up to approximately 25% moisture content. Again there are a number of aspects that need to be considered when using these meters:-
  - Readings can be taken very quickly both within a board or in a number of boards.
  - The meters do not damage the surface of the timber that is being measured.
  - Within species density variations can be quite high, particularly between mature and young growth material.
  - Estimating the correct density adjustment can be difficult, particularly if the meter is being used on a wide range of different timbers.
  - Density (specific gravity) information for Australian species relating to specific meters is not well documented.
  - Difficulties with setting density (specific gravity) adjustment often reduces field measurement accuracy.
  - If no timber thickness adjustment is provided then thicker pieces at the same moisture content are likely to read high.
  - Any gap between the meter and the board (e.g. a cupped surface) will cause a lower readings
  - Framing raises meter readings where exposed timbers cross (e.g. softwood floor over hardwood joists)
  - The presence of salts (either from salt water or preservation treatment) will cause readings to be higher
  - Readings also considered to be less reliable with Brush Box

  Again, if meter readings are not in line with what is expected, then this may necessitate oven dry testing to more accurately estimate the moisture content.

Assessing timber moisture content for conformity

Australian Standard 1080.1 – Timber – Methods of Test – Method 1: Moisture content outlines a procedure for moisture content acceptance testing of timber using a resistance moisture meter. For full details the standard should be referred to. Provided below is a summary of the procedure:-

- Sample at least 1 pack out of every 10 or 1 pack out of every 5 for higher value products (e.g. flooring)
- For each pack assessed (of up to 200 boards per pack) 15 boards are randomly selected and tested
- The pack is deemed to comply if not more than one test result (after applying temperature and species correction factors) is outside the allowable range. This is providing the result outside allowable limits is not too different from other results.
- This sampling procedure is based on at least 90% of the samples occurring within the allowable range

Measuring the moisture content of plywood and particleboard

Meters do not provide an accurate and reliable measure of moisture content in these materials. To determine the moisture content of these materials, the oven dry method should be used.

Table 1 - Temperature correction factors for resistance moisture meters. *(Note: This is wood temperature not air temperature)*

Meter reading %	**8 %**	**10%**	**12%**	**14%**	**16%**	**18%**	**20%**	**22%**	**24%**
Wood Temperature	Temperature correction to be added to or subtracted from meter reading before applying the species correction factor								
15 °C	Nil	Nil	+1	+1	+1	+1	+2	-	-
20 °C	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	-
25 °C	-1	-1	-1	-1	-1	-1	-1	-1	-
30 °C	-1	-1	-1	-2	-2	-2	-2	-2	-2

Table 2 - Species correction factors for resistance moisture meters.
(Note that this only contains some common species – refer to AS 1080.1 and FWPRDC report PN01.1306 for a more complete list. The tabled figure are based on the Deltron Moisture Meter. Figures may differ for other meters - refer FWPRDC report PN01.1306).

Meter reading %	**8 %**	**10%**	**12%**	**14%**	**16%**	**18%**	**20%**	**22%**	**24%**	**Density**
Species	Resistance meters are generally calibrated to Oregon (Douglas Fir). Apply the following species corrections after temperature correction.									**At 12% MC**
Oregon (Douglas Fir)	0	0	0	0	0	0	0	0	0	550
Australian Hardwoods										
Yellow Stringybark (NSW)	+4	+4	+3	+3	+2	+2	+1	+1	0	900
Red Ironbark Broad Leaved & Red (NSW)	+4	+3	+3	+3	+2	+2	+2	+1	+1	1100
Grey Ironbark (Qld)	+3	+2	+2	+2	+2	+2	+2	+2	+1	1105
Forest Red Gum - Blue Gum (Qld)	+3	+2	+2	+2	+2	+1	+1	+1	0	1000
White Mahogany – Honey Mahog. (Qld)	+2	+2	+2	+2	+2	+2	+2	+2	+2	1000
River Red Gum (Vic regrowth)	+2	+2	+2	+2	+2	+2	+2	No data	No data	900
Rose Gum - Flooded Gum (Qld & NSW)	+2	+2	+2	+1	+1	0	0	0	0	750
Sydney Blue Gum (NSW)	+2	+2	+1	+1	0	0	-1	-1	-1	850
Blackbutt (Qld & NSW)	+1	+1	+1	+1	+1	+1	+1	+1	+1	900
Turpentine (Qld & NSW)	+1	+1	+1	+1	+1	+1	+1	+1	0	950
Blackbutt (NSW regrowth)	+1	+1	+1	+1	+1	0	0	0	No data	900
Grey Ironbark (NSW)	+1	+1	+1	+1	0	0	0	0	0	1100
Red Ironbark Narrow Leaved (Qld)	+1	+1	+1	0	0	0	0	0	0	1090
Blackwood (Tas)	+1	+1	0	0	0	-1	-1	-2	-2	640
Myrtle (Tas)	+1	+1	0	0	-1	-1	-2	-2	-2	700
Spotted Gum (Qld *Citridora*)	+1	0	-1	-1	-2	-3	-3	-4	-5	1100
Shining Gum (Vic)	+1	0	0	0	0	0	0	-1	-1	700
Jarrah (WA regrowth)	0	0	+1	+1	+1	+1	+1	+1	No data	780
Grey Gum (Qld & NSW)	0	0	0	0	0	0	0	0	0	1050
Tallowwood (Qld & NSW)	0	0	0	0	0	0	0	0	0	1000
Alpine Ash (Vic & Tas regrowth)	0	0	0	0	0	0	-1	-1	No data	650
Mountain Ash (Vic & Tas regrowth)	0	0	0	0	0	0	-1	-1	No data	650
Messmate (Vic & Tas regrowth)	0	0	0	0	-1	-1	-1	-1	-2	750
Southern Blue Gum (SA plantation)	0	0	-1	-1	-1	-2	-2	-3	-3	700
Spotted Gum (NSW Regrowth *Maculata*)	0	-1	-1	-2	-3	-4	-5	-5	-6	1100
Brush Box (Qld & NSW)	0	-1	-2	-3	-4	-5	-6	-8	-9	900
Manna Gum - Satin Ash (NSW)	-1	-1	-1	-1	-2	-2	-2	-2	-3	800
Imported Hardwoods										
European Beech	+3	+3	+3	No data	No data	No data	No data	No data	No data	690
Kwila / Merbau (Malaysia)	+2	+2	+2	+2	+1	+1	+1	+1	+1	850
Sugar Maple (Nth America)	-1	0	+1	+1	+1	+1	+1	+1	No data	740
Softwoods										
Araucaria - Hoop Pine (Qld & NSW)	+3	+2	+2	+2	+1	+1	+1	0	0	550
Radiata Pine (Vic)	+2	+2	+2	+2	+2	+2	+2	+2	+2	550
Cypress (Qld & NSW)	+2	+1	+1	+1	+1	+1	+1	0	0	700

Note:- No correction factors are published for Gympie Messmate, New England Blackbutt or Northern Box.
Oven dry testing is the preferred method for Brush Box.

APPENDIX A3 – MEASURING CONCRETE SLAB MOISTURE CONTENT

PROPERTIES OF WATER IN CONCRETE

Similar to timber, concrete is a porous material that is able to hold water within its structure. As such the moisture within it can be transferred to adjoining materials and in a similar manner to timber, the rate of transfer to the atmosphere relates to the relative humidity of the surrounding air. Also similar to timber, water occurs as free water, bound water and water vapour held in the air within the pores. However the bound water remains in the structure and is not accounted for. The free water in concrete migrates by capillary action to the surface where it evaporates off relatively rapidly. Following this, vapour diffusion occurs through the pores and capillaries within the concrete and this is a much slower process. The water vapour naturally migrates to the exposed face of the slab where it evaporates until such time that equilibrium is achieved.

TIMBER FLOORS AND CONCRETE SLABS

Whenever a timber floor is laid over a concrete slab it is important that the slab is sufficiently dry irrespective of the method of installation of the timber floor. As an added precaution a polyethylene vapour barrier or slab sealer specific for use with timber flooring can be used. Note that not all sealers used on concrete are recommended for use with timber floors. Appropriate measures must also be taken when there are construction joints or where a new slab is added to an existing slab. It is also important to ensure that slabs have moisture barriers beneath them. The natural drying of the slab can take four to six months depending on its thickness, presence of beams within the slab and weather conditions. Regardless of the age of the slab its moisture content should be tested prior to laying a timber floor.

MEASURING SLAB MOISTURE CONTENT

There are various methods of measuring the moisture content of slabs and similar to timber, these include both electronic moisture meters. However, there are also other means that measure the vapour emission from the slab. These tests include a simple polyethylene film test, use of a hygrometer to measure the humidity above or within a slab and use of various chemicals.

Preferences of test method vary considerable and each has its limitations. Meters or use of a hygrometer are often preferred as they are relative quick and easy to use and results may be recorded. However, as with any electrical instrument the accuracy of the instrument needs to be taken into consideration and periodic calibration checks are necessary. Test methods relating to the polyethylene film test, moisture meters and hygrometer are outlined below.

Polyethylene Film Test

A reasonable check of slab moisture can be obtained by taping down pieces of clear polyethylene film over a slab and observing what happens. This method is considered to be adequate when used in conjunction with an appropriate slab sealer or vapour barrier over the slab, prior to installing the floor. The procedure is as outlined below:-

- Cut squares of clear polyethylene plastic film to approximately 600 mm x 600 mm.
- Place on various areas of the slab where the concrete colour is lighter and even.
- Secure around the edges with duct tape forming an air seal around all four edges.
- Observe after 24 hours and if condensation forms between the plastic and the slab or the slab beneath the polyethylene has darkened in colour then it is still too wet to install a timber floor and it should be allowed to cure longer.
- If the slab is of an age that you would expect to be dry and the test indicates that it is not, then moisture issues relating to drainage etc require investigation.

As an alternative to polyethylene a 300 mm square piece of glass can be used sealed at its edges with a non water based compound such as plastercine.

Moisture Meters

Both resistance moisture meters and surface meters that use electromagnetic waves are available and the general methods for using each are outlined below. It is important that those using meters are fully aware of their accuracy and limitations are able to interpret the results obtained. Manufacturers' instructions must also be followed. It is generally accepted that concrete needs to be below a moisture content of 5.5%, however with old slabs you would expect readings a few percent below this.

Resistance meters

The resistance meter works in a similar manner to a timber moisture meter, however in order to get the electrodes into the concrete, two holes need to be drilled and these are generally about 6 mm in diameter, 25 mm deep and 150 mm apart. To provide a conductive path an electrically conductive gel must fill the holes prior to insertion of the electrodes. Prior to filling the holes it is important that the dust is removed from the holes and that the holes are filled without air pockets. The meter readings provide the average moisture content of the concrete between the electrodes. This method is convenient in that it provides a reading at the press of a button and the meters do not usually require frequent recalibration. However, the method does rely on knowing the mix and type of concrete used and this is not always known.

When using this method the following should be taken into consideration:-

- The method is only suitable where there is no risk of the drilling impinging on plumbing pipes, electrical cables or heating elements.
- Readings should be taken after the electrodes have been in the gel for about half a minute.
- Readings should be taken along external walls at 3 m intervals and within 1 m of corners.
- Where columns or slab thickenings are present, further readings should be taken.
- Three tests should be taken in rooms of approximately 15 m^2 and an additional test for each 10 m^2 to 20 m^2 in addition to this.
- If readings are too high the floor requires a further period of drying.

Surface meters

These meters generally have plates on the base of the meter and use electromagnetic waves to determine an electrical property that relates to the moisture content of the slab. They benefit from being totally non destructive and provide instantaneous readings. Generally they can provide moisture content readings to a depth of between 12 mm and 19 mm depending on the make.

When using this method the following should be taken into consideration:-

- Meter readings should be taken in the same localities as for resistance meters. More frequent readings can be undertaken if desired due to ease of use.
- A clean concrete surface and firm contact with the concrete is necessary to obtain a correct reading.
- Some meters indicate that readings should be used as a guide for further testing.

Relative Humidity Method

The relative humidity of a sealed off air space above a slab can be used to indicate the amount of free water remaining in the slab. The method involves sealing an airtight box to the slab with a hygrometer (humidity measuring device) placed inside it. The box traps the water vapour evaporating from the surface of the slab causing the relative humidity in the airspace to rise. As the humidity increases the evaporation rate from the slab decreases and a point is reached at a particular relative humidity where no further evaporation occurs. The point where this equilibrium is reached is dependent on the moisture present in the slab. This method only provides accurate results with slabs that are allowed to dry 'normally'. The slab is of acceptable low moisture content for laying timber floors if the relative humidity reading is less that 70%. It should be noted that many relative humidity measuring devices are only accurate to $\pm$ 5%, however some instruments provide greater accuracy. Hygrometers depending on their type can be relatively sensitive pieces of equipment and recalibration checks at least annually should be undertaken.

When using this method the following should be taken into consideration:-

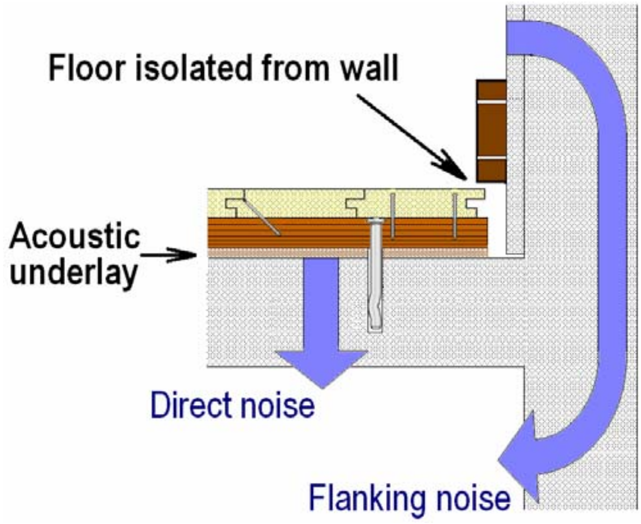
- The boxes need to be out of direct sunlight.
- The boxes must be sealed to the slab with a non water based sealant (e.g. plastercine).
- Measurements should be recorded at the time of installation and after approximately 16 hours.
- For areas up to 25 m^2 two readings should be taken, three readings to 100 m^2 and six readings to 500 m^2.
- If readings are too high the floor requires a further period of drying.

APPENDIX A4 – ACOUSTIC PERFORMANCE

Timber floors are used in many multi-storey apartments, both in new construction and renovation work. With new projects, building regulations often apply restrictions to sound transmission between units and in renovation work the noise associated with any replacement floor can often be no greater than the original floor. With regard to sound transmission, timber flooring is similar to other hard flooring surfaces and in particular it will freely transfer impact sounds. For this reason it is necessary to ensure correct detailing and installation measures in order to provide a floor system with the required sound performance.

NOISE TRANSMISSION THROUGH TIMBER FLOORS

Whenever the acoustic performance of a material is being tested great care is taken to ensure the material is isolated so that only the sound transmission through that material is being tested. When materials are not isolated as occurs in building, that is floors connected to walls and walls being common to upper and lower storey units, additional non-direct sound transmission paths or 'flanking' paths are introduced. Sound from a floor above can then radiate from the wall surfaces in the unit beneath and this can contribute considerably to sound transmission between units.



Acoustic underlay and floor isolation significantly reduces direct and flanking noise transmission.

This indicates that great care is necessary in building design and detailing to provide effective solutions and the system needs to consider providing isolation, absorptive materials and increased mass (i.e. slab thickness). Each of these is important in order to reduce sound transmission. Timber floors, as with other hard floor surfaces are particularly affected by impact noise resulting from foot traffic.

APPROACHES TO IMPROVE ACOUSTIC PERFORMANCE

Timber floors on battens

Timber floors over concrete slabs are often fixed to battens which are in turn directly fixed to the concrete slab. To provide a degree of isolation between the slab and the batten resilient pads may be used between the batten and the slab. Fixing of the batten to the slab is still necessary and this will result in some sound transmission. Generally, thicker battens require less frequent fixing and thereby reduce the frequency of direct fixing. With battens at 450 mm centers, 19 mm strip flooring may be used for domestic loading. The flooring may be secretly fixed to 19 mm thick hardwood batten or top nailed. If top nailing is used the hardwood battens needs to be at least 35 mm thick. For more specific details of floor fixing refer to Section 3 of this manual.

Timber floors over sheet floors

This system utilizes a complete sheet of acoustic underlay over an existing timber floor or slab. A plywood sub-floor is then laid over the acoustic underlay and fixed to the slab or timber floor beneath. Again the fixing of the sub-floor will result in some sound transmission. Both 19 mm thick and overlay flooring may be used in this instance as the boards are fully supported. Secret fixing with the addition of a polyurethane flooring adhesive is generally used to fix the boards. More specific floor fixing details are provided in Section 3 of this manual.

OTHER IMPORTANT CONSIDERATIONS

Selecting the underlay and isolation pads

The purpose of the underlay or pads is to provide isolation of the timber floor from the building elements beneath. Many products are available and each should have test data relating to performance. The products need to be:-

- Pads need to be sufficiently thick to ensure separation is maintained when the floor is being walked on.
- Rigid to prevent compression when the floor is walked on.
- Provide long term performance without flattening, particularly under heavy appliances and furniture.

Isolation at floor edges

It was outlined above that isolation is a key aspect to prevent flanking sound transmission. Gaps need to be maintained between the flooring and all walls, steps, window joinery etc. and a small gap is also necessary between the skirting and the floor boards.

Further improvements

Improvements in sounds transmission from a floor to a unit below can also be achieved at the design stage by ensuring that the slab is of adequate thickness. An extra 25 mm in slab thickness can make a significant difference to sound transmission. In addition to this, ceiling systems can also be used which isolate the sound source (i.e. timber floor) from the unit beneath. These systems generally consist of a grid of isolation mounts with furring channels attached. Insulation and plasterboard complete the system. With multi-residential timber framed construction (MRTFC) two layers of fire rated plasterboard are used. Such systems are effective and are considered to be relatively economical. Finally, rugs, hall runners and mats used in conjunction with timber flooring can not only complement the timber floor but with their sound absorbing properties, can also reduce noise levels both within and between units.

APPENDIX A5 – INSTALLATION CHECKLIST

Assessing Packs of Timber Flooring

Flooring Manufacturer: ………………………………………………

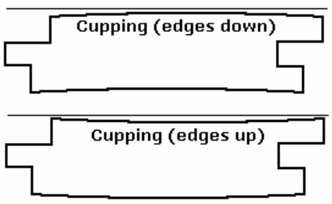
Pack Nos. …………………… …………………… …………………… ……………………

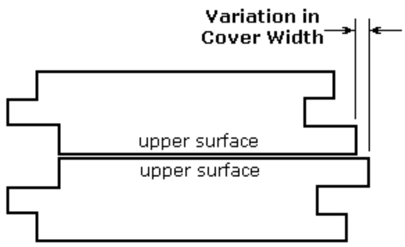
Species/Species mix: ……………………… Cover width …………………….. Grade: ……………………

Wrapping is in good condition and there are no signs of the product getting wet. Yes ❑ No ❑

Boards should be checked for:-

- Cupping *(Use a steel rule or similar)*
- Cover width (*Should not vary by more than 1mm between boards)*
- Tongue and groove tolerance *(Snug fit to slightly loose)*





Note:- Cover width variation exceeding 1mm, sloppy T&G fit, signs of moisture or cupping may indicate possible problems.

Records

Widest Boards	Moisture Content	Cover Width	Cupping
1			
2			
3			

Narrowest Boards	Moisture Content	Cover Width	Cupping
1			
2			
3			

Note:- Ensure that the appropriate moisture meter corrections have been applied. Moisture contents should be between 9% and 14% (average between 10% and 12% is common).

Site Conditions And Installation Environment

Site location ……………………………….. Average 9am RH ……………….. Average ext EMC ………………..

Note: If the external EMC is greater than 2% higher or 1% lower than the estimated average moisture content then additional provision for future expansion or shrinkage needs to be considered (refer Section 2).

If applicable, are sub-floor conditions dry, ground levels beneath dwelling not lower than external ground and graded to prevent ponding, ventilation to recommendations and ground sloping away from dwelling?

Yes ❑ No ❑

Note: If 'no' then these issues may need to be attended to or other measures taken prior to installing the floor.

If the floor is laid on joists ensure the joists are sufficiently level.

If the floor is over a concrete slab or sheet sub-floor, are the sub-floors adequately level, dry and in good condition?

Slab moisture contents or checks undertaken with the following results: ……………….. ………………..

Slab level checked and within ± ……………… mm in 1.5 m throughout (plywood or batten system).

Note: Maximum is ± 3 mm

If sheet sub-floors have become wet prior to or during construction and may not have sufficiently dried then moisture contents need to be checked. Moisture contents are as follows:

……………….. ……………….. ………………..

Note: Plywood and particleboard moisture contents need to be determined with oven dry testing. Sheet sub-floors should be within 2% of the timber flooring moisture content being laid over it. Slab moisture contents need to be below 5.5% in new slabs and can be expected to be lower in old slabs (refer Appendices A2 and A3).

If the floor is over a concrete slab then check it for construction joints and determine whether it has a moisture barrier beneath the slab.

Note: If construction or similar joints are present in slabs then possible moisture penetration from capillary action needs to be considered. Older slabs may not have moisture barriers beneath the slab and are more prone to seasonal moisture fluctuations that can affect timber floors.

The following slab moisture barrier as applicable has been applied to or over the slab.

……..………

EXPECTED MOVEMENT AFTER INSTALLATION

If wide board flooring is being used greater shrinkage can be expected during dry times.

In moist localities high levels of expansion can be expected *(Ensure adequate additional expansion allowance)*.

Is the building design such that the floor will experience high levels of sunlight or has heating/air-conditioning systems? *(Drier in-service conditions can be expected at certain times of the year - shrinkage gaps more likely)* Is the underside of the floor is exposed to dry winds or mist? *(Sealing or protection to the underside of the floor needs to be considered to assist in controlling both expansion and shrinkage)*. Is the floor an upper storey floor *(drier in-service conditions can be expected - shrinkage gaps more likely)* or below grade in shady conditions? *(Moister in-service conditions can be expected - ensure adequate expansion allowance - refer Section 2).*

INSTALLATION MOISTURE CONTENT AND ACCLIMATISATION

Based on the expected in-service movement the following pre-installation procedures have been undertaken.
Note: Acclimatisation (flooring stripped out or loose layed) or provision of additional expansion allowance etc should be recorded.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………

METHOD OF INSTALLATION

This floor is being laid by the following method.

………………………………………………………………………………………………

………………………………………………………………………………………………

…………………………………………………………………………………………

CHOICE OF FINISH SYSTEM

Based on the movement expected and condition of the floor at the time of sanding and finishing some floor finishes are more appropriate than others. *(Possible issues such as wear, grain raise, edge-bonding and white lines need to be considered).*

The finish system used on this floor is ……………………………………

(Note: The above is provided as a guide only. Additional testing may be necessary or there may be the need for other considerations).

APPENDIX A6 – TROUBLESHOOTING GUIDE

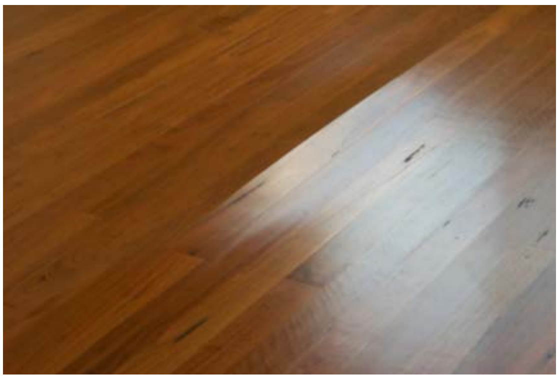
PERFORMANCE OF TIMBER FLOORS

In most instances timber floors perform well in a wide range of localities and with a wide range of installation practices depending on the sub-floor type. There can however be instances where the performance or appearance of the floor can be affected and the major contributing factors are as follows:-

- The manufacture of the product does not meet Australian Standards
- Recognized installation and finishing procedures are not followed
- Moisture ingress directly (e.g. leaks) or indirectly (e.g. seepage into sub-floor space)
- Aspects where the owner has not paid adequate attention to the floor

The table below outlines some of the performance issues with timber floors, common causes and how they appear in the floor.

Performance Issue	Common causes	Appearance in the floor
Cupping	• Moisture from beneath the floor. • Dry conditions above the floor. • High moisture contents in boards at time of manufacture.	• Boards cup throughout the floor and the floor is tight. • Boards cup throughout but gaps are present at board joints. • Some boards in the floor will cup in the floor but not others.
Crowning	• Moisture uptake and the floor sanded and finished in this condition.	• During dry periods the floor gaps at board edges and develops a washboard look.
Peaking	• High pressure on the upper shoulder of the board often resulting from atmospheric moisture uptake. Board tolerances and MC differences between supply and in-service also contribute.	• The joints at board edges are raised. This can have the appearance of cupping.
Tenting	• High expansion. May be directly related to high humidity or other moisture issues. May relate to inadequate expansion allowance, poor ventilation or inadequate fixing.	• Adjacent boards in the floor rise at the joint above the level of the floor.
Buckling	• High expansion. May be directly related to high humidity or other moisture issues. May relate to inadequate expansion allowance, poor ventilation or inadequate fixing.	• A group of adjacent boards lift off the sub-floor.
Wide or irregular gapping	• The finish gluing adjacent boards and the floor shrinking. • High moisture contents in boards at time of manufacture. • Boards inappropriately stored and have taken up moisture prior to laying. • Wide boards and dry conditions.	• Loud cracking noises, irregularly spaced wide gaps and splits through boards • Gaps at board edges associated with narrow cover width boards. • Frequent gapping and the measurement over sections of the floor is inconsistent. • Regular wide gaps.



Tenting resulting from atmospheric moisture uptake.

Wide gaps due to high moisture contents at the time of machining.

Sanding and Finishing Imperfections

A high standard of sanding and finishing can be expected when the floor is sanded and finished, however some sanding and finishing imperfections can be expected. The degree to which imperfections are apparent depends on many factors including timber colour and use of down lights both of which can highlight such things as sanding marks and dust in the finish. Consequently it is difficult to provide objective measures of finishing imperfections. Even so it is known that a high standard of workmanship also provides an equally high standard of customer acceptance and satisfaction. When the appearance of a floor is being assessed, the assessment should be carried out in daylight hours with lights on and curtains or blinds in their usual position. Imperfections should be viewed from a standing position a few meters away and from various directions. If the imperfection is difficult to discern then the appearance is generally satisfactory. It should be noted that viewing any imperfection directly toward light sources such as toward uncovered sliding external doors will always exaggerate imperfections and this needs to be considered when evaluating the floors appearance. In addition to this, aspects to be considered should include whether the imperfection is in excess of what would generally occur, whether it is likely to covered by furniture or floor rugs and whether the imperfection will decrease in time with foot traffic. The table below outlines some of the sanding and finishing imperfections with timber floors, common causes and how they appear in the floor.

Rejection and contamination in the finish.

Appearance Issue	Common causes	Appearance in the floor
Rejection	• Contaminants leaching out of the flooring affecting the curing of the finish.	• Ranges from a change in a localized gloss level to an 'orange peel' appearance.
Delamination	• Movement of the timber at board joints or at the end of the board. Inappropriate sealers.	• The finish peels at board joints or board end.
Quilting	• Surface coatings flow into the joints between boards	• A lack of consistency of the coating over board joints highlighting the joints and giving a bed quilt appearance
Contaminants	• Cleanliness of the floor • Windy external conditions • Dust in gapped boards or under skirting	• Small specks or insects in the finish which is often worse near poorly sealing external doors
Pimples	• Fine air bubbles occurring during coating application.	• Popped bubbles in the finish
White lining	• The rapid stretching of waterborne finishes when boards gap.	• White lines appearing along board joints
Edge bonding	• Finish flowing into gaps at board edges and gluing boards together. • Thinned finish used as a sealer and penetrating fine joints between boards	• Wide irregular spaced gapping at board edges • Splits in boards
Gloss variation	• Weather conditions • Surface evenness of the boards	• Shiny and dull patches in the finish
Swirl marks	• Rotary sanding particularly at the edges of floors	• Circular swirling scratch marks
Chatter marks	• Vibration in the floor • Sanding technique	• Undulations running across several boards

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