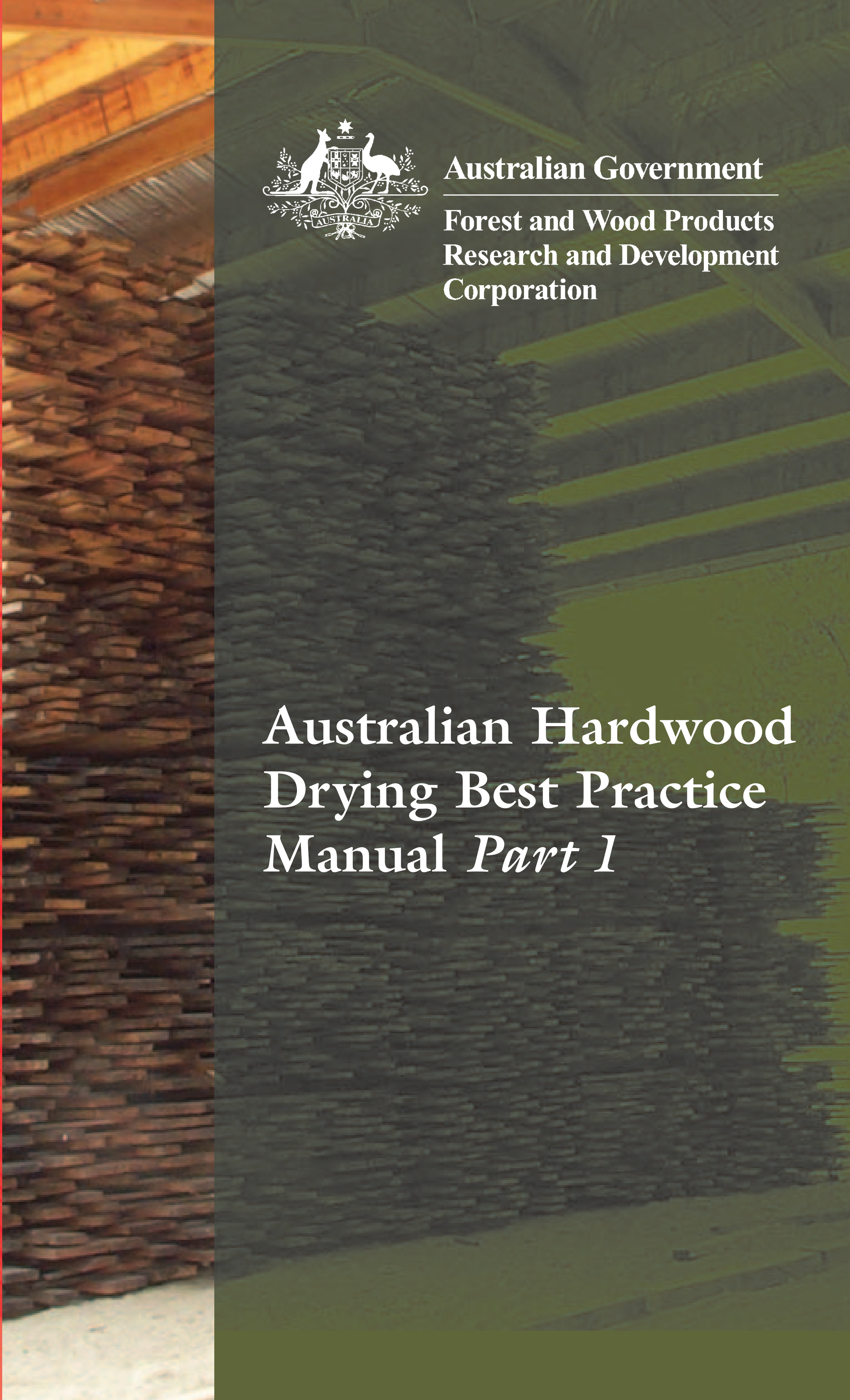

Australian Government

Forest and Wood Products Research and Development Corporation

Australian Hardwood Drying Best Practice Manual *Part 1*

Manufacturing & Products

Project No. PN01.1307

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Australian Hardwood Drying Best Practice Manual *Part 1*

- **Drying overview & strategy**
- **Coupe**
- **Log yard**
- **Green mill**
- **Green pack**
- **Bioprotection**
- **Rack timber**

Prepared for the
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Research and Development Corporation

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Contents

Introduction

Across Australia, hardwood producers process and dry a wide variety of native hardwood species into high quality visual and commodity structural products.

Like the species they process, these producers vary considerably in their skill, capacity and potential. However, to produce stable timber to an acceptable market grade consistently and profitably, they all face the same challenges:

- Australian hardwoods are natural materials with variable properties. This variability has to be recognized and managed;
- The timber from Australia's hardwoods must be dried from its original unseasoned condition to a moisture content suitable for its intended use if it is to remain stable;
- The timber must generally be dried slowly and with care. If the timber is subject to significant adverse conditions at any time as it dries, it may be damaged and lose value; and
- The producer needs to recover the maximum volume and value of dry material efficiently from the wood resource they have available.

To address these, the drying process must be managed and conducted effectively and efficiently. This is not the job of a single person. It must be the responsibility of everyone involved in the process. This requires that a 'best practice' approach be used.

Aim of the manual

'Best practice' in hardwood drying is a set of operations established and conducted to achieve high grade results in product quality and recovery, flexibility, innovation, cost, and competitiveness, through the cooperation of management and employees in all key aspects of the process.

This manual aims to provide guidance in establishing this set of operations. It outlines:

- economic and feasible technologies for increasing recovery and reducing avoidable loss during processing from the log to the finished board; and
- mechanisms that allow production value to be optimised in mills of disparate size.

The manual only deals with issues that materially affect the practice of drying timber. However, guidance in some sections is limited by:

- the diversity of producer capability, location, equipment and products;
- the range and variability of the species processed; and
- the state of knowledge. In many areas, it has not been possible to verify the benefits of one method of practice over another at all location.

The manual structure

This manual is arranged into modules that generally match the major work areas of the hardwood drying processes, such as the log yard and air drying.

Each module is generally designed to be a self contained document. Each module is then structured into discrete parts:

Objectives: This part includes a description of actions covered in the module and lists the performance requirements for those actions.

The performance requirements provide the gauge by which any practice should be judged.

Management: This part includes a general description of the theory, background and equipment relevant to the actions covered in the module.

It then details the management decisions relevant to the performance requirements, the procedures that need to be in place and the information that should be collected.

Operations: This part includes a brief description of the background to action in the area and the things that need to be done to comply with the performance requirements.

It also lists things that need to be checked and paperwork that needs to be completed.

Checklists: This part includes checklists that can be used in assessing performance in the actions covered in the module. Not all sections have checklists.

Avoidable Loss: This part shows what goes wrong when the practice does not match the performance requirements. It shows why certain things should be done, and why others should be avoided.

References: This part lists the references used in preparing the module.

Acknowledgements

Preparation of this manual has been a collaborative effort from all levels of the Australian hardwood industry.

It contains contributions from research and industry hardwood drying specialists from all over Australia and draws from the research results of many organisations. At the same time, it contains contributions from the managers and operators of many of Australia's hardwood mills who made their skill and experience available. In particular, the authors acknowledge the cooperation of:

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- Hyne & Son Pty Ltd
- Gould J L Sawmills Pty Ltd
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- McKay Timber
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1.0 – Drying Overview and Strategy

1.0 CONTENTS

1.0 – Drying Overview and Strategy

1.1 Hardwood Drying Overview

The whole art of seasoning lies in maintaining the correct balance between evaporating moisture from the timber surface and moving the water from the interior of the wood to the surface. If the correct balance is not achieved, the timber quality may be downgraded (seasoning degrade) through collapse, surface checking, internal checking and other problems.

The presence of moisture in wood, its removal and the resulting shrinkage of timber is a complex scientific and engineering topic. Though there is still the need for much research and study, the basic principles are clear.

1.1.1. Botanical Overview

Commercial timbers are normally classified into two main groups, that is, hardwoods and softwoods. Hardwoods are those woods from flowering trees bearing covered seeds. The botanical names for these are 'Angiosperms'.

1. The tree

A mature tree has three main elements: the root system, the trunk, stem or bole and the crown or leaf system. Each has a particular function and each has an involvement with water in one or more ways.

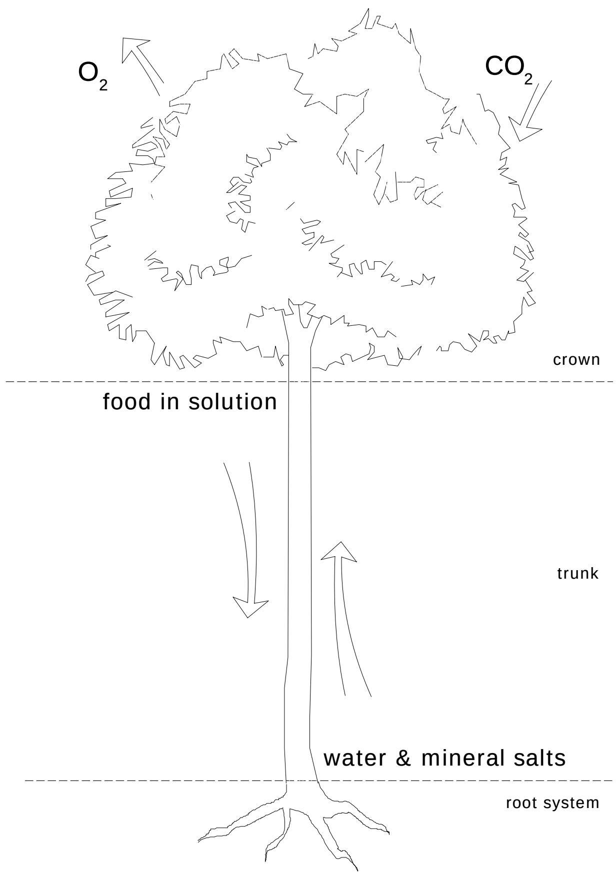

Figure 1.01. The main parts of the tree

1.0 – Drying Overview and Strategy

The root system is extensively branched and provides a firm anchorage against forces exerted on the trunk and crown by storms or strong winds. At the same time, the root system takes up water and mineral salts from the soil.

The main function of the crown is to manufacture food materials. Food for the tree (mainly sugars and starches) is formed in the green chlorophyll containing tissues of the leaves through the process of photosynthesis.

The functions of the trunk of the tree are to:

- conduct water and mineral salts to the crown;
- conduct manufactured food materials from the crown;
- store food;
- provide the rigidity necessary to keep the crown above competing vegetation

The trunk has several zones that, taken from the outer circumference to the centre of the tree in a radial direction are the outer bark, inner bark, cambium layer, sapwood, heartwood, and the heart.

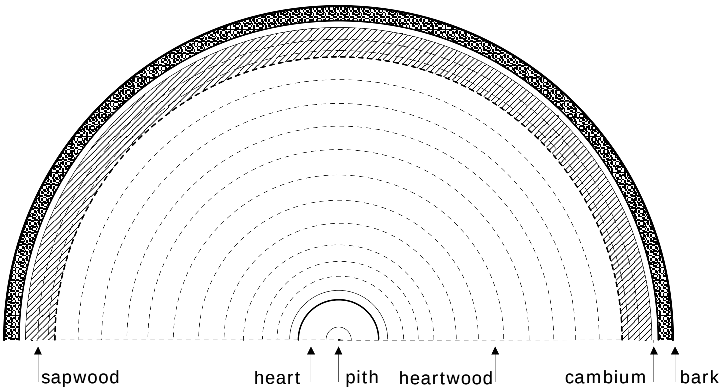

Figure 1.02. Sections of the tree trunk

1a. The outer bark

A corky layer of dead tissue whose chief functions are to protect the tree against damage, and to reduce loss of water by evaporation.

The outer bark has breathing pores known as lenticels, which allow oxygen into the live cells of the trunk, and disposal of carbon dioxide to the atmosphere.

1b. The inner bark

A comparatively soft moist zone of tissue through which food manufactured in the leaves is conducted down to the branches, trunk and roots.

1c. The cambium

This is a very thin layer of cells, invisible to the naked eye. It is responsible for all growth in the trunk diameter. This layer builds wood cells on the inside and bark cells on the outside.

This process pushes the cambium continually further from the tree's centre as the inner woody cylinder increases in diameter. Any increase in diameter or length in a tree is due to the addition of new wood cells, not elongation of individual cells.

A cell laid down at a particular time always maintains the same height above ground level, and distance away from the pith, as it originally had. This also applies to any article embedded in a tree, such as a nail, a fence rail, or piece of fencing wire. Outward growth continues in layers beyond these objects.

1d. The sapwood

This zone, immediately under the cambium, is composed of living cells whose function is to conduct water and mineral salts from the roots to the leaves. This zone varies greatly in width from species to species and even within a species. While the sapwood may be often no more than 25 mm thick on trees such as the Eucalyptus, some rain forest species consistently produce trees up to 1 metre in diameter which are practically all sapwood, with as little as 75 mm of heartwood around the pith. White Cheesewood (*Alostonia sholaris*, a Queensland species) is an excellent example of this extreme.

Sapwood is usually lighter in colour than the heartwood and the two layers are generally well defined; however this is not always the case. In species such as regrowth *E.regnans*, that have pale-coloured heartwood, the slight difference in sapwood colour is practically indistinguishable.

1e. The heartwood

Heartwood is the mature part of the tree. It is the inner zone of dead wood. Heartwood is usually darker than sapwood because its cells contain tannins, phenols and other pigmented substances deposited when the heartwood was formed. In some species these deposits can inhibit fungal activity and increase durability.

1f. The heart

The heart, also known as the corewood or inner heart, is the wood adjacent to and including the pith that is within 50 mm of the centre of the pith. In hardwoods this material has lower density, strength and durability than the surrounding heartwood. It is also has different and problematic drying and processing characteristics.

2. Types of wood tissue

All living tissue is built up of individual cells. In wood, the majority of the cells are not visible to the naked eye, varying from around 0.025 to 0.5 mm in diameter. Each cell has a woody cell wall around a cavity, known as the 'lumen'.

Wood cells perform at least one of the three functions: conduction, strengthening, or storage. They are classified accordingly.

2a. Conductive tissue

The conductive elements in hardwood are longitudinal cells called vessels or pores. These are relatively large diameter cells, open at each end, and built on top of one another to make up continuous vertical tubes.

2b. Strengthening tissue

Hardwoods have special longitudinal cells to give mechanical strength. These are known as fibres and are elongated, narrow, pointed and closed at the ends.

2c. Storage tissue

This is made up of brick-shaped cells whose thin walls have numerous pits. Unlike other wood cells, storage tissue remains alive for some years after completion of its development. Collectively, the storage tissue is known as parenchyma. It occurs in two distinct forms.

(1) Ray-parenchyma. This is present in horizontal bands called medullary rays. These radiate from the pith towards the bark like the spokes of a wheel. They vary in length, breadth, and depth. Rays are usually visible using a magnifying glass. Rays are mostly more than one cell wide in hardwoods.

(2) Wood-parenchyma is more abundant and more varied in distribution in hardwoods than in softwoods. In hardwoods, it appears as scattered strands, patches or bands amongst the pores and fibres and it is normally paler in colour. It is usually visible using a x10 hand lens.

3. Tree growth

The trunk of a tree is shaped like an elongated cone and, as the tree grows, sheaths of wood are deposited on this tapered core. In tropical and sub-tropical areas, this can be a continuous process, while in other areas, it occurs in growing seasons, such as spring and summer, or the wet season.

3a. Height growth

Seedlings or trees increase in height, or branches increase in the length, by the action of specialised cells in a zone at the top of the stem or end of the branch. In this zone, the cells divide and then elongate to give the only lengthways growth that occurs in the tree.

These cells do not produce wood tissue themselves but stimulate others dedicated to this function.

3b. Growth in diameter

As already stated, growth in diameter is the result of the division of cells that develop in the cambium. Growth in diameter in the stem, branches and roots are essentially similar.

3c. Formation of growth rings

In areas outside the tropics, a tree's rate of growth fluctuates, mainly with climatic or seasonal changes. This is particularly marked in climates with distinct wet and dry seasons or cold areas of Europe and North America. The growth rate is fastest during the wet season or in spring, tapers off during summer or after the wet and virtually ceases during autumn and winter, or in the dry season.

These cycles of growth produce rings of wood of different density on the transverse section of a trunk. These may or may not relate to one year's growth, as climatic or seasonal fluctuations can produce more than one ring in a year or season.

In hardwoods, spring or wet season growth is characterised by an increase in the number and size of pores specifically produced to improve the movement of fluids. Hardwoods with definite growth rings are usually said to be ring porous, as most of the vessels or pores are in concentric rings separated by zones consisting mainly of fibre, with smaller pores and parenchyma tissue amongst them.

3d. Reaction wood

Reaction wood is abnormal cell growth that develops in response to a lean in the stem. Leaning can be caused by wind-throw during wet weather, by the crown becoming unbalanced when a branch breaks off, or by the influence or removal of a dominating neighbour. Reaction wood attempts to make the stem straight again. In softwoods, it is known as compression wood, and in hardwoods it is called tension wood.

3e. Tension wood

This occurs in hardwoods on the ‘tension’ or upper side of a lean or bend, as though the tree was attempting to pull itself upright or straight. Tension wood fibres are shorter and thicker walled than normal fibres.

Tension wood is generally darker coloured than normal wood, shrinks more than normal wood transversely and is prone to ‘collapse’ on seasoning. The cell ‘collapses’ inwards under drying stresses and the wood can develop internal checking, with a distorted and often corrugated external appearance.

On the end-section of logs, the tension-wood zones show up as roughened areas when crosscut, and longitudinally sawn tension-wood has a ‘woolly’ appearance. An eccentric heart can also provide evidence of tension wood.

3f. Juvenile wood or heart

The wood formed close to the pith has characteristics that can be termed ‘Juvenile’ as distinct from the mature wood that forms later on. It is generally not visually distinct in hardwoods.

Juvenile wood is an ‘age-from-pith’ effect and each tree has a ‘juvenile core’ of wood with shorter, thinner-walled, larger-diameter fibres, low percentage latewood, lower basic density, higher spiral grain and more compression wood than in the more mature outer wood. Juvenile wood is continually being formed as the tree grows and extends up the stem in the form of a cylinder. The wood in this zone is weaker and tends to distort more in drying than outer wood.

Mature native forest trees all have a juvenile core with the same properties as those found in plantation-grown trees. Usually this core is smaller because the growth rate of native forest timbers is usually slower. Often, the juvenile core in older trees is damaged by fungal and termite attack. However the wood from first thinnings and 'tops' will obviously contain a high proportion of wood with juvenile characteristics. This proportion decreases as the age of the tree harvested increases.

1.1.2. Moisture & wood properties

1. The presence of water in wood

Under ordinary conditions, all wood contains some water. The amount of water contained in wood at a particular time is known as its moisture content. The moisture content is important as many other parameters such as strength, shrinkage, durability, etc all have a direct relationship to the moisture content.

In use, the moisture content of a piece of wood will eventually reach equilibrium with the surrounding atmosphere. This is called the Equilibrium Moisture Content (EMC). The value of the EMC depends primarily on the relative humidity and temperature of the surrounding air.

The moisture content (M.C.) of a piece of timber is defined as the weight of water contained in the piece expressed as a percentage of its oven dry weight.

M.C.% = (Weight of water in timber/ Oven dry weight of timber) x 100

The moisture content can be more than 100%. Freshly cut green timber in hardwood from wet forests may have a moisture content of about 120%, while the moisture content of mature hardwood such as Southern Blue Gum, may be in the region of 70% By contrast, the initial moisture content of dry outback timbers can be as low as 20%.

As previously indicated the conducting fluid in the tree is essentially water. Water takes dissolved mineral salts from the soil to the leaves where they are used in the production of sugars and starches; the food for growing cells. In turn, the sugars and starches move in a water solution through the inner bark back to the roots, nourishing the living cells on the way.

This watery solution is commonly known as sap, a term which is sometimes confused with resinous exudations. The heartwood, or zone of now non-living wood cells, also contains a considerable amount of sap, but no appreciable movement of this sap takes place.

Water in timber can be found in two different forms; as bound water or free water. Free water is found in the cell cavities and is relatively easy to remove from the wood. Bound water is chemically bonded (hydrogen bonds) to the cell wall and is much harder to remove.

As green timber dries the free water is removed first. The point at which all of the free water is removed and all of the bound water remains is the fibre saturation point (FSP). FSP generally occurs between 20 and 30% MC

2. The effect of moisture on the properties of wood

The amount of moisture present affects the properties of wood, and this influences its suitability for different purposes.

2a Strength

Dry timber is much stronger and stiffer than green timber (that is, timber with a moisture content above fibre saturation point), often by a factor greater than two. In structural applications, smaller dry timber sections can carry similar loads as larger green sections.

3. Shrinkage (Dimensional Change)

3a. Moisture loss and shrinkage

When drying most timbers, there is minimal shrinkage until the moisture content reaches fibre saturation point (FSP). From there on, as the bound water is removed, the cells start to harden and "normal" shrinkage commences (*see Figure 1.03.).* Timber for many uses needs to be dried to its equilibrium moisture content prior to use, as otherwise the shrinkage leads to many problems such as gaps and splitting from restraints or connections. Expansion can also occur when timber re-absorbs moisture after being exposed to more moist conditions than that for which it was dried.

Figure 1.04. shows that change in size (shrinkage or expansion) is directly proportional to the moisture content change (loss or gain) between FSP and EMC. That is, the graph in this region is a straight line. Because of this direct relationship, the term unit shrinkage can be defined as the percentage change in dimension following a moisture content change of 1%. The unit shrinkage is generally given in both the radial direction (for quartersawn boards) and the tangential direction (for backsawn boards).

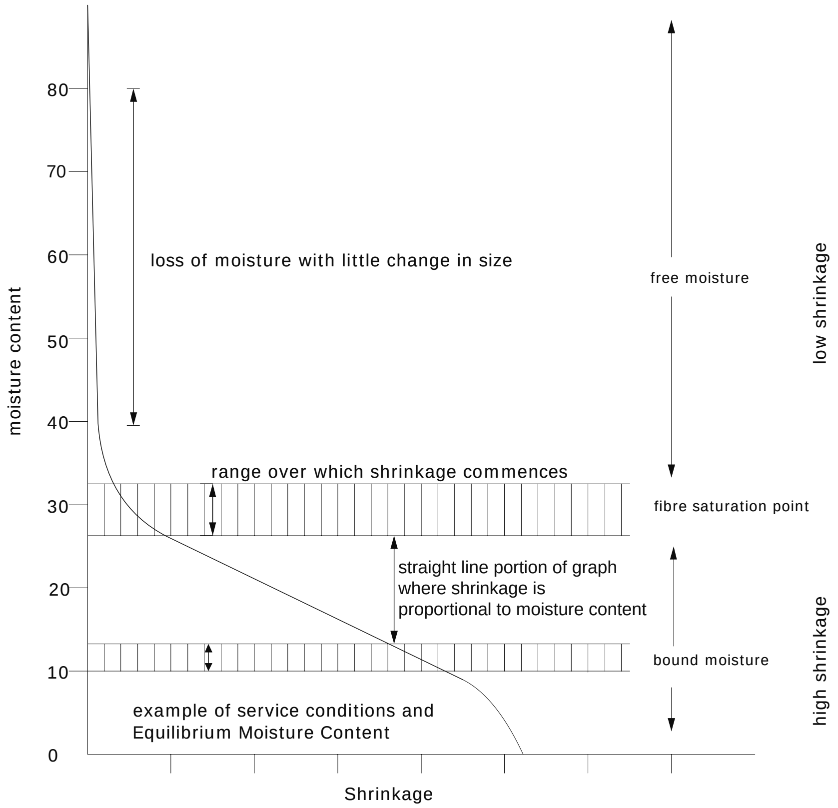

Figure 1.03 The general relationship of normal shrinkage to moisture content

Unit shrinkage (or "movement") is an important property for timber in high-value applications. It gives an indication of the dimensional changes that may be expected in timber in response to environmental changes, such as the movement in floorboards between summer and winter.

Timber usually shrinks more in the tangential direction (around the growth rings) than it does in the radial direction (across the growth rings); twice as much is fairly common. This results in distortion in the cross-section of a board as timber dries. Effectively, the growth rings tend to straighten. This is most noticeable in backsawn boards. They tend to cup across their width.

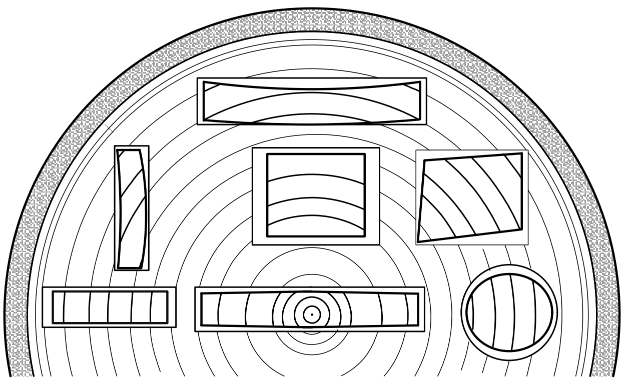

Figure 1.04. Characteristic shrinkage as wood dries

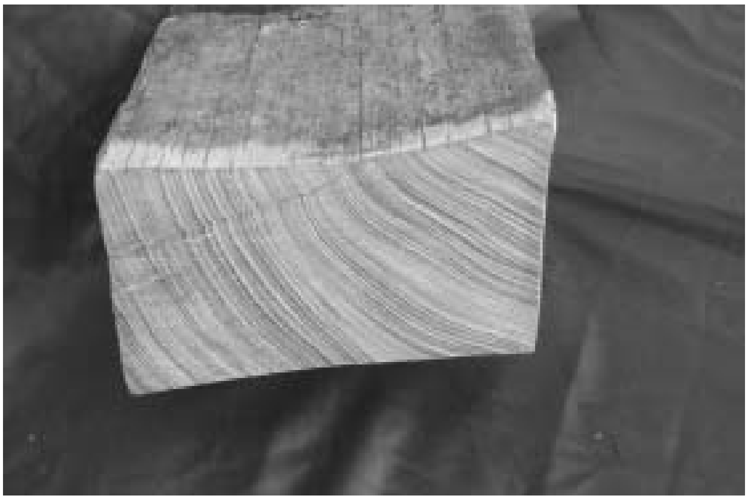

Figure 1.05. Diamonding of a large dried section

Figure 1.06. Shrinkage in 'identical' drying stacks. The stack on the right has been drying three months longer than the one on the left.

3b. Collapse

Collapse shrinkage is shrinkage additional to normal shrinkage. Collapse occurs at moisture contents above FSP and is generally accepted as being due to water tension within the wood fibres arising as a result of drying. It is seen on a microscopic level as a physical collapse of the fibre cells, much like a drinking straw that has been pinched and flattened. In the board, it is usually seen as a rippling or "washboarding" on the surface as generally only discrete earlywood growth rings will collapse under common drying conditions.

Collapse shrinkage can often be recovered by reconditioning with saturated steam for several hours. This is usually carried out when the board has an average moisture content of 18-20%.

Collapse can lead to internal checking. This is probably due to the differential shrinkage between growth rings that do collapse, and adjacent ones that don't. Internal checking is an irreversible form of degrade. It is particularly hard to detect, and is often not obvious until the piece of timber is undergoing final finishing. It is thus important to avoid collapse as much as possible during drying. This can often be achieved by drying at a lower temperature until all parts of the timber are below FSP.

1.1.3 The Drying Process

Conventional seasoning of timber involves water moving from the inside of boards to the surface where it evaporates into the surrounding air. Heat energy must be supplied to evaporate the water.

In engineering terms, the process is described as unsteady-state heat and mass transfer. It is unsteady because the heat and mass transfer process cannot continue indefinitely - sooner or later the timber will dry out and reach equilibrium with the surrounding air, or its EMC.

The process of drying involves two distinct processes: firstly the removal of water from the wood surface and secondly the movement of water from the interior to the surface.

1. Surface of the wood

The moisture content of the surface of the wood is controlled by the temperature, humidity and speed of air passing over it

The drier (or lower humidity) the air, the more water it can take from the wood surface and the drier the wood surface. If the air is stationary over the wood surface then it will quickly become saturated (full of water). If this air is replaced then the wood will continue to dry. Therefore, the rate of drying of the surface is also affected by the air speed and its humidity.

While free water is available to evaporate from the wood surface, the rate of drying is determined by the rate of heat transfer from the air to the wood. This in turn depends upon the temperature difference between the wood and air. While water is evaporating freely from the wood surface the surface behaves like the wick of a wet bulb thermometer, and its temperature remains at the wet bulb temperature of the air.

Thus while there is free water evaporating from the wood surface the rate of drying is closely related to the wet bulb depression.

As the water evaporates freely from the wood surface the rate of airflow must be sufficient to carry away the evaporated water vapour. If the air speed is too low a layer of moist air develops around the wood surface thus increasing the relative humidity and slowing the rate of drying.

When using conventional drying systems, the rate of evaporation from the wood surface will exceed the rate of movement of water to the surface. Thus, after a period of drying the moisture content of the surface layers of the wood will drop. As the moisture content of surface drops it falls below the fibre saturation point. The rate of evaporation will then fall and hence the amount of cooling to the surface by this drying also falls. The surface temperature then starts to increase.

2. Moisture movement within the wood

There are generally two types of moisture movement within the wood: bulk flow of liquid or vapour, and molecular diffusion of vapour. Softwoods usually have a very open structure that allows easy flow of liquid or vapour; they are thus comparatively easy to dry. In comparison, most Australian hardwoods have a very closed cell structure, with most openings ("pits") between fibre cells blocked. Water within the cells must therefore diffuse through the cell walls to escape. Drying is thus very slow. Raising the temperature can usually increase the rate of movement of moisture through the wood.

3. Moisture distribution

When timber begins to dry, moisture is evaporated first from the surface layers so that the moisture content at the surface falls much more rapidly than that in the centre parts of the board.

Examination of the moisture distribution within a piece of timber which has been drying for a short period will thus reveal that the moisture content varies from its highest value at the centre of the piece to its lowest at the surface. This variation in moisture content is known as a 'moisture gradient' and it is the source of drying stresses.

4. Development of drying schedules

For economic reasons, the drying conditions in a kiln or predyer should be the most severe that a particular charge can accept without unacceptable degrade or loss of dried quality. The conditions are rarely kept constant throughout the process of drying. Wood is usually weakest when green, but gains strength as it dries. The conditions are rarely kept constant throughout the process of drying. As wood is usually weakest when green, but gains strength as it dries, the drying conditions applied in the early stages must necessarily be milder than those acceptable later.

The drying history of a given board will affect the moisture distribution and stress profile within that board. As the moisture distribution and stress profile within the board will affect its drying behaviour, the drying history of a board will affect the severity of drying conditions that can be used.

An example of this is the difference in surface checking observed in timber racked in the open and then placed into fixed temperature predryers. If this timber is racked on a hot dry day the checking is usually much worse than timber racked on a cool damp day.

The table of drying conditions used for a particular thickness and species of timber is known as a drying schedule. This is a series of combinations of temperature, humidity and airspeed, usually of increasing severity, each combination being applied over a particular stage in the drying process. Changes in conditions are usually based on either the drying time or timber moisture content.

Drying schedules are commonly developed empirically (that is, developed over time, based on many drying trials), but may be developed with the assistance of a computer program that simulates the drying behaviour of the timber.

1.1.4 The Development of Drying Stress

1. Surface checking

As timber dries, it shrinks. So, timber's response to a moisture content gradient is a shrinkage gradient. That is, early in drying, the drier outer parts of the board will have shrunk more than the wetter inner parts. This sets up a zone of tensile stress around the outer parts of the board, with the inner core subjected to compression as a result. In many slow drying hardwoods, the part of the timber under tension early in drying is very thin, often only 1mm or so. If the drying is too rapid, the moisture content gradient becomes too steep too quickly, the tensile stress increases above the failure point of the material, and the timber surface splits or checks.

2. Stress reversal

The outer parts of the board remain in tension until the inner core is mostly below FSP and is undergoing significant shrinkage. While the outer parts are under tension and drying is continuing, they effectively "stretch" due to creep and other effects. That is, the outer parts are restrained from shrinking as much as they would otherwise, by the inner parts of the board that have not yet begun shrinking. This leads to the formation of a "tension set". Similarly, the inner parts of the board are squashed slightly by the outer parts shrinking around them; this loss in size is a "compression set". It is generally much smaller in magnitude than the tension set as there is a far greater thickness of wood under compression, so that the magnitude of the compressive stress is smaller.

As the board dries further, the centre parts drop below FSP and start to shrink. Due to the tension set of the surface layers and the compression set of the inner layers, the inner parts of the board come under tension and the outer parts under compression.

Any surface checking formed earlier in drying may close up under this compression. This often leads to confusion, as the surface checking may re-open during reconditioning, and be thought to have been caused by that process.

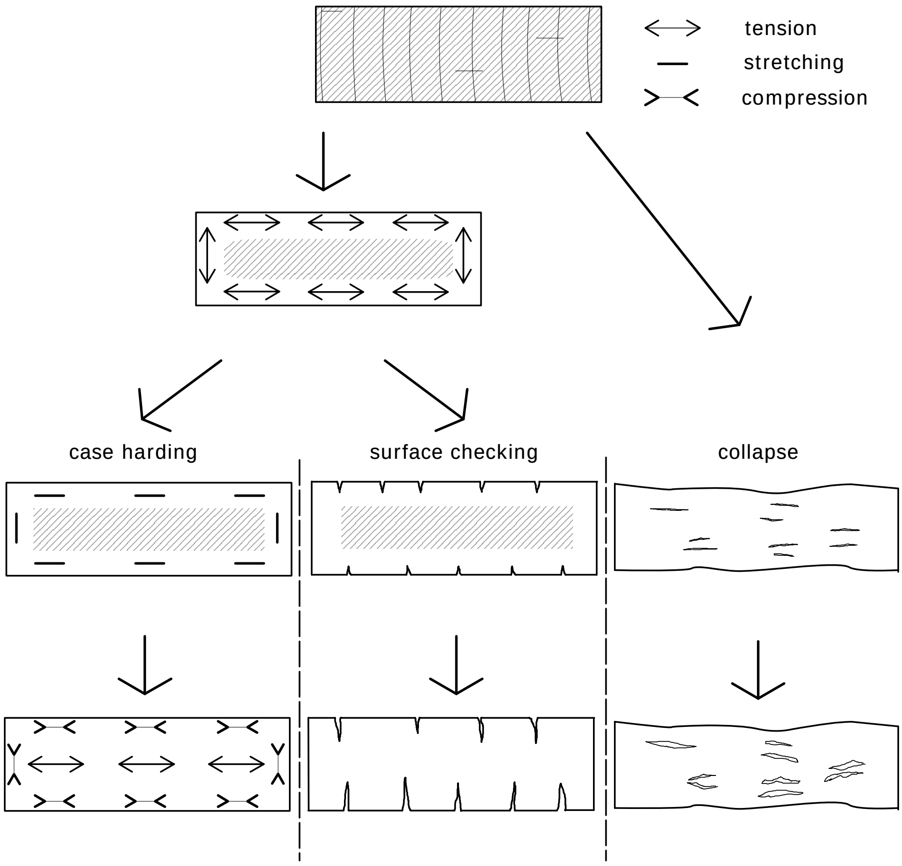

Figure 1.07. Progression of common forms of drying degrade

Tensile stresses in the central parts of boards late in drying may cause formation of internal checking, but computer modelling and experimentation have shown that this is unlikely in common Australian hardwoods.

3. Residual drying stresses

Seasoned timber may cup or distort when it is re-sawn or machined, even though the moisture distributed is reasonably uniform. This distortion is due to the presence of residual drying stresses.

A piece of seasoned timber may be set in a regular shape under the action of various balanced drying stresses. However, as soon as this balance is disturbed by re-sawing or removing a portion of the wood by machining, the then unbalanced opposing stresses will produce movement in the wood until they are in equilibrium once more.

It is common practice to apply a high temperature/high humidity treatment near the end of drying to relieve these residual stresses. The timing and conditions for these treatments have been largely based on empirical studies. There is currently no detailed scientific understanding of the mechanism of these treatments, so it is not possible to confidently provide generic recommendations on them.

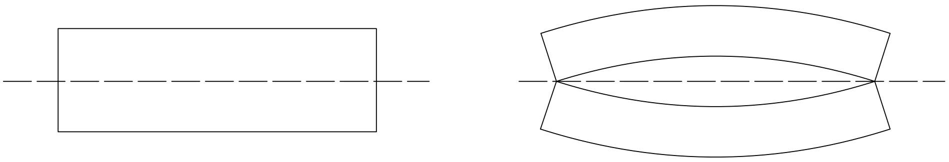

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Figure 1.08. Effects of residual drying stresses

4. Reconditioning

Reconditioning is the term given to the process used for the recovery of collapse shrinkage using a steaming treatment. It is carried out when all parts of the board are below FSP, typically at an average moisture content around 18-20%. Recovery may be affected if the timber is drier than this when reconditioned.

It is usually (though not necessarily) undertaken in a separate chamber into which wet steam (not more than 100 °C) is injected for several hours. Care should be taken when cooling down the timber following reconditioning. If cold, dry air is allowed to flood a stack of hot, moist timber, degrade may result.

This is different to conditioning. Conditioning is a process for relieving the stresses and reducing moisture content variations present in the wood at the end of final drying. It is generally achieved by applying a comparatively high temperature and high humidity treatment near the end of kiln drying.

1.2 Drying Strategy

The objective of a drying strategy is to establish:

- the optimal combination of products that can be drawn from the available log resource and
- the primary drying processes used on a site or in an organisation necessary to achieve that optimum.

It includes assessing existing operations and modifying strategies over time.

1.2.1 Drying Approach

The primary objective of drying hardwood is to:

- produce with the available equipment the most useful and valuable products from the available wood resources; and
- minimise any loss of quality that result in a loss of value.

There are functional, economic and environmental advantages in drying hardwood in this way.

1. Functional advantages of drying

Drying increases timber's value and versatility. For most applications, the properties of well-dried timber are superior to those of unseasoned or poorly dried timber. The properties that are improved include:

- **Dimensional stability:** Items made of dry timber will be as dimensionally stable as the surrounding environment allows. Items made of unseasoned timber will shrink considerably and lose their shape as they dry in service.
- **Strength:** Dry timber is about double the strength of unseasoned timber;
- **Durability:** Timber at less than 20% MC has no risk of sustaining the fungal activity that leads to decay, stain and mould. It also has reduced susceptibility to attack by some insects.
- **Gluing, machining and finishing** of seasoned material is much easier and produces superior results in almost all cases.
- **Fasteners:** Seasoned timber holds fasteners far better than unseasoned timber, especially when the unseasoned material subsequently dries.
- **Insulation:** Dry wood is a good insulator of both electricity and heat. Conductivity of both increases as the M.C increases.
- **Weight:** Dry timber weights 40-50% less than wet timber. This makes it easier to transport and use.

2. Economic imperative

There are direct economic incentives for producers to ensure that the most timber of the most valued grades is produced economically from any given resource.

Timber is sold at a price determined by its grade and its quality. Generally, seasoned timber is worth more than unseasoned material, and material seasoned well and achieving a higher grade is worth more and will sell more consistently than the same material seasoned poorly and of a lower grade.

The characteristics that govern the grade of any board fall into two major groups:

- **natural characteristics.** These are governed by the quality of the logs and are outside the immediate control of the production process; and
- **production induced characteristics.** These include splitting, checking, cupping, warping, excessive collapse and/or shrinkage. They are mainly caused by poor drying, handling or machining. All can result in a decline in the grade of the board and contribute to a loss in the value of the product.

If drying degrade results in a loss of grade or quality, the producer's financial return is adversely effected directly in two ways:

- the higher price for the more valuable grade is forgone; and
- the higher cost of producing the more valuable grade has to be borne, as degrade is often not apparent to the end of the drying process.

3. Environmental imperative

Timber is potentially one of Australia's few environmentally sustainable building materials.

Timber is a natural, renewable material that is beautiful and durable. It is easy to work and handle. Light and versatile, it is used for an extensive range of interior and exposed structures and surfaces, including framing, lining, cladding and flooring and roofing in domestic and industrial constructions. It also stores atmospheric carbon.

In the suite of timber products, hardwood plays an important part due to it visual appeal, strength, hardness and durability. Hardwood resources are limited, especially from native forests.

There are obvious environmental benefits from drawing the greatest amount of useful and valuable material from the available resources. It reduces the need for additional harvesting, reduces the environmental impacts from transport and production, and increases the amount of timber available to the market. It can then replace products that generate greater environmental impacts in production and use.

1.2.2 Management of Drying

The quality of drying is a fundamental aspect of quality hardwood production.

As quality production is a whole of process issue, drying Australian hardwood is also a whole of process issue. It begins at the coupe, with the felling of the tree and grading of the logs, and ends when the finished product is delivered to its final customer. It includes each company's management, sales, and production staff.

Converting variable raw materials, such as logs, into reliable and consistent products takes both managerial and operational skill.

Operational staff must use experience, flexibility and individual judgement throughout the process. To do this, they must understand the whole process of which they perform a part.

Management must ensure that the variables of the material and production process are understood and approached systematically. This can include making deliberate decisions to understand and reduce the number of variables that have to be addressed in each stage of the process. Material and production variables can be reduced by:

- Grouping material into defined batches;
- Standardising production sizes and lengths;
- Reducing the variability of drying by protecting the timber at every stage of the process
- Monitoring the timber continually; and
- Ensuring that all production equipment is adequate for the task.

An understanding of production and material variables should be developed over time. This requires effectively monitoring of the process and analysing the timber products that result.

Given the immediacy of production work, this is difficult for operational staff. However, it is an essential part of effective drying management and is the only effective way of recognising and accommodating the regional variability of Australia's hardwood species and the unique peculiarities of the sites that handle them.

1.2.3. Product Strategy

The fundamental aim of the business of producing seasoned timber is to sell a customer timber at a price that is greater than the cost of production and delivery. This simple equation requires that a producer develop a product strategy that recognises four major factors:

- **What the customer requires**. This is generally a product that matches an agreed grade for appearance or structural purposes;
- **The economic return.** The balance between price and the costs of production;

- **The available resource.** The logs that are available and their natural characteristics; and
- **The available staff, equipment and other capital**. This includes the skill of the staff and capacity of the equipment.

1a. Customer requirements

Customers require a wide range of dry hardwood products for appearance or structural purposes. The specification for these is detailed in either Australian standards, the standards of other countries, or in some other standard or specification agreed by the parties.

The relevant Australian Standards are:

- **AS 2796-1999**: Timber - Hardwood - Sawn and milled products; and
- **AS 2082-2000**: Timber - Hardwood - Visually stress-graded for structural purposes.

AS 2796 defines three major product grades; Select, Medium Feature / Standard, and High Feature. The grades are separated by the amount of natural and production induced characteristics found in each board. Natural characteristics include gum vein, knots and hobnail while the main production induced characteristic from drying is checking.

Select material has the least amount of each of these characteristics; Standard material includes a greater amount, while High Feature allows the most. The standard also defines acceptable amounts of bow, spring and cup in material of different product type and the target moisture content for the major product groups. These are set out in Table 1.01. These moisture contents apply to all grades.

Product	Required moisture content
Parquet, and Sawn or dressed furniture components	8 to 13 %
Strip flooring, Overlay strip flooring, Lining Boards, Dressed boards, Joinery Stock, Mouldings and sawn boards for Feedstock	9 to 14 %
Light decking, cladding, fascia and barge boards	10 to 18%

Table 1.01 AS 2796 Target moisture content for the major product groups

AS 2082 establishes the relationship between the strength characteristics of species of timber, the amount of strength reducing characteristics, such as knots, sloping grain and splits visible in a piece and the piece's strength grade. It requires that 90% of the pieces being graded have a moisture content not more than 15% with no piece having a moisture content of more than 18%.

Producers and customers can agree their own specification for products. These can often be more restrictive than Australian or international Standards, defining colour range or including types of natural feature. There are restrictions to them being more generous than the standards in Australia. It can be argued that appearance grade products that are not dried to at least equilibrium moisture content (EMC) may not be fit for the purpose, as they will shrink further as they dry to EMC. Also, the performance of structural products is bound up with compliance with a whole raft of other standards including the Building Code of Australia.

Other countries have similar standards, established by central organisations or customer and producer groups. These will have different moisture content requirements,

The target moisture contents prevalent in some other countries are detailed in Table 1.02

Area	**Average MC (%)**	**Range of MC (%)**
North America		
USA & Canada generally	8	6 to 10
Damp coastal USA	11	8 to 13
Europe		
UK		12 to 16

Table 1.02 Recommended MC values for most wood items for interior use for selected countries

1b. Economic return

The level of return from drying timber is directly related to the price received for seasoned timber of particular grades and the cost of producing and drying the timber to those grades.

Well-dried quality timber commands a high price. So, it can sustain a higher cost of production than a lower priced product while maintaining an acceptable level of return. A low price grade of timber price can only sustain a lower cost of production if the level of return is to be maintained.

In general, *Select* material commands the highest price in local and export markets. *Standard* and *High Feature* material command less than *Select* material but generally more by volume than structural products. Given that the cost of production of most grades of dry products is broadly similar, the highest return to the producer is from appearance products and especially select material.

Any downgrading of a *Select* grade board to *Standard* or *High Feature,* or of any appearance grade board to a structural one that results from a production induced characteristic represents a direct loss of return to the company.

Similarly, any reduction in the volume of dry boards recovered from the log is a direct loss of return to the company.

1c. Available resource

The quality of sawn timber is bound inextricably with the characteristics of the available resource, both the size of the log and the physical characteristics of the timber. While this manual addresses handling these characteristics, other aspects of the resource are beyond its scope.

1d. Staff, equipment and other capital

The staff and equipment on a site are the producer's primary production capital. Staff skill and experience and adequately functioning equipment are essential in handling a material that is naturally variable. This is discussed in detail in Section 1.2.4 Production Strategy

2. Common Australian product strategies

Every hardwood production company pursues a product strategy developed in response to the logs, equipment and capital they have available and the market they wish to service. While each company's product strategy is unique, product strategies in Australia appear to fall into three broad types:

- Appearance Products Strategy;
- Mixed Appearance & Structural Products Strategy; and
- Structural Products Strategy.

2a. Appearance products strategy

The basis of this type of strategy is to produce timber of the grades specified in **AS 2796** or its overseas equivalents, with a particular focus on Select & Standard grade products, or to a higher company standard underpinned by the Standard's provisions. Structural products are seen as recovery products from material that doesn't make these grades.

If this is due to natural characteristics, the products are streamed off for separate and more economic processing early in the production sequence.

If it is due to production induced characteristics, material is streamed off when it is first identified as not meeting the required grade.

Boards are generally cut to nominal thicknesses of 16, 25, 38 & 50 mm, depending on target product area. 16 & 25 mm material is used for flooring, paneling, and mouldings. 38 & 50 mm material is used for these applications as well as for doors and window manufacture, joinery and furniture stock.

For all these applications, users require minimal distortion, high stability and a narrow range of moisture contents.

The higher costs of production necessary to meet these requirements are offset by higher returns. Production techniques focus on economically reducing production variable, maximising grade value and minimising grade loss. They concentrate on maximising the quality of logs coming into the mill and reducing surface check, internal check, residual stress and uneven moisture gradients in the dry sawn product.

This type of product strategy requires a company to pursue a high quality production strategy.

2b. Mixed Appearance & Structural products strategy

Companies' producing this type of strategy is to produce a broad mix of appearance products for a general market and structural products for a specific or local market. While targeting appearance products, structural products are viewed as necessary complementary products, as any log may contain material of several grades. Structural products are manufactured to service an established customer base, usually of builders, and may be part of vertically integrated operations that includes manufacture of nail-plated and glue-laminated products, such as trusses and beams.

The economic importance of structural products in this strategy is directly related to the quality of logs entering the operation. Logs likely to contain a high proportion of structural material are generally streamed off for separate and more economic processing early in the production sequence.

Boards are generally cut to nominal thickness of 25, 38 & 50 mm. 25 mm material is used for flooring, paneling, and mouldings. 38 & 50 mm material is used for some doors, joinery and furniture applications but is also targeted to structural products such as studs, floor joist and beams.

Under this strategy, the lower expected average price for products must be met with by a lower average cost of production. However, a direct and diversified customer base cushions the level of returns.

This product strategy requires the company to pursue a quality production strategy.

2c. Structural products strategy

The basis of this strategy is to produce timber to the structural grades specified in **AS 2082**, with a particular focus on minimising strength reducing characteristics. As few of these are drying related, production techniques focus on drying the timber to the required moisture content economically and quickly.

Any higher-grade material recovered is generally regarded as either a bonus or inconsequential.

Under this strategy, the lower expected prices must be met with lower costs of production. This product strategy requires the company to pursue a low cost production strategy.

1.2.4. Production Strategies

The process for milling and drying Australian hardwood is broadly similar throughout Australia. The greatest variations in the process result from:

- **Species properties:** This is mainly whether the timber is collapse prone or non-collapse prone. Collapse prone material generally needs to be reconditioned before final drying and sale.
- **The adopted product strategy:** Each additional action in production adds cost and this can only be recovered if the improvement in product that result provides a net improvement in price.

The primary production flow and stages of drying for collapse prone hardwoods is mapped in Table 1.03. The primary production flow and stages of drying for non-collapse prone hardwoods is mapped in Table 1.04.

Almost all Australian hardwood producers maintain or contract facilities and staff for activities for:

- **the coupe**, the retrieval of logs from the forest;
- **the log yard**, the acceptance and storage of logs;
- **the green mill**, the milling of logs to sawn product; &
- **racking**, the arrangement of sawn product in a rack of rows separated by rack sticks.

After these stages, the process and the required staff and equipment is determined by the production strategy required to meet the product strategy.

1. Common Australian production strategies

Every hardwood production company pursues a production strategy developed in response to their product strategy, equipment, capital and resources. While each company's production strategy is subtly different, production strategies in Australia appear to fall into three broad types:

- Low cost production
- Quality production; and
- High quality production.

1a. Low cost production

Under a low cost production strategy, an operation would mill available logs and either rack them immediately or ship them to another location for racking. Material of species with lyctus susceptible sapwood destined for the NSW or Queensland markets or material sawn with this sapwood in the boards would be packed first and chemically treated before racking.

The timber is then air-dried. Air dried product is then either:

- Graded, milled and sold directly to a customer; or
- finally dried in a small conventional or solar kiln before being milled and sold.

In this type of operation, the expectation is not to optimise quality production, but to tailor a product for a price. Equipment is simple and material handling is kept to a minimum. Anecdotally, a quantity of high grade material is lost during this process.

2. Quality production

Under a quality production strategy, an operation would mill available logs and either rack in grade and thickness batches immediately or ship them to another location for racking. Material of species with lyctus susceptible sapwood destined for the NSW or Queensland markets or material sawn with this sapwood in the boards would be packed first and chemically treated before racking. If the timber was a collapse prone species it may be dimension sawn or slab sawn. If it is a non collapse prone species, it would be dimension sawn.

Racked timber would then be air dried in a well arranged and maintained yard. As the timber approached the target for air dried material, the timber would be assessed. Depending on the results, it would be scheduled for reconditioning and controlled final drying if it is a collapse prone species, or controlled final drying and possibly an equalisation and conditioning treatment if it is a non collapse prone species.

After the target moisture content was achieved, slab sawn material would be resawn to its nominal size. This and all other material would then be graded, sorted and milled. If it is to be sold rough sawn, the timber would then go into storage. If not, it would be moulded before storage.

In this type of operation, the expectation is to produce quality appearance products and structural products, within the bounds presented by the resource, staff and available equipment.

3. High quality production

Under a high quality production strategy, the basic process is nearly identical to that of a quality production strategy. The differences occur in drying the timber to fibre saturation point and in the operation's attitude to production and its detailed practice on the ground.

Significant amount of drying degrade can occur during air drying. It is also a slow process. To overcome this, many operations have installed and use predryers to dry racks of timber from green to fibre saturation point. Predryers tend to even out the rate of drying and can reduce both the amount of degrade occurring in the timber and time taken to dry it. However, predryers are expensive to install and operate, and require skill and rigorous practice to use effectively.

As a result, those operators who experience relatively low levels of degrade during air drying, due to benign climates, tractable species or good practice, tend to continue to air dry. Generally, they do so successfully. Those operators who experience relatively high levels of degrade during air drying, due to aggressive climates, refractory species or poor practice, or who wish to increase production throughput significantly, have tended to invest in predryers.

Both can pursue a high quality production strategy.

The other major differences between a high quality production strategy and a quality production strategy is in the time, resources and organisation put into improving performance in each step of the production process. This includes:

- Developing a stable, skilled and responsible work force;
- Establishing and maintaining good quality infrastructure. This includes major equipment items, such as: saws; predryers; kilns; reconditioners; buildings, shelters; and roads;
- Allocating skilled and trained staff to plan and coordinate product schedules and movement;
- Adopting effective information gathering and production assessment processes; and
- Broad, systematic and open assessment and review of performance at each stage.

While these add to production costs, they can significantly improve the quality and volume of output and hence the final price received.

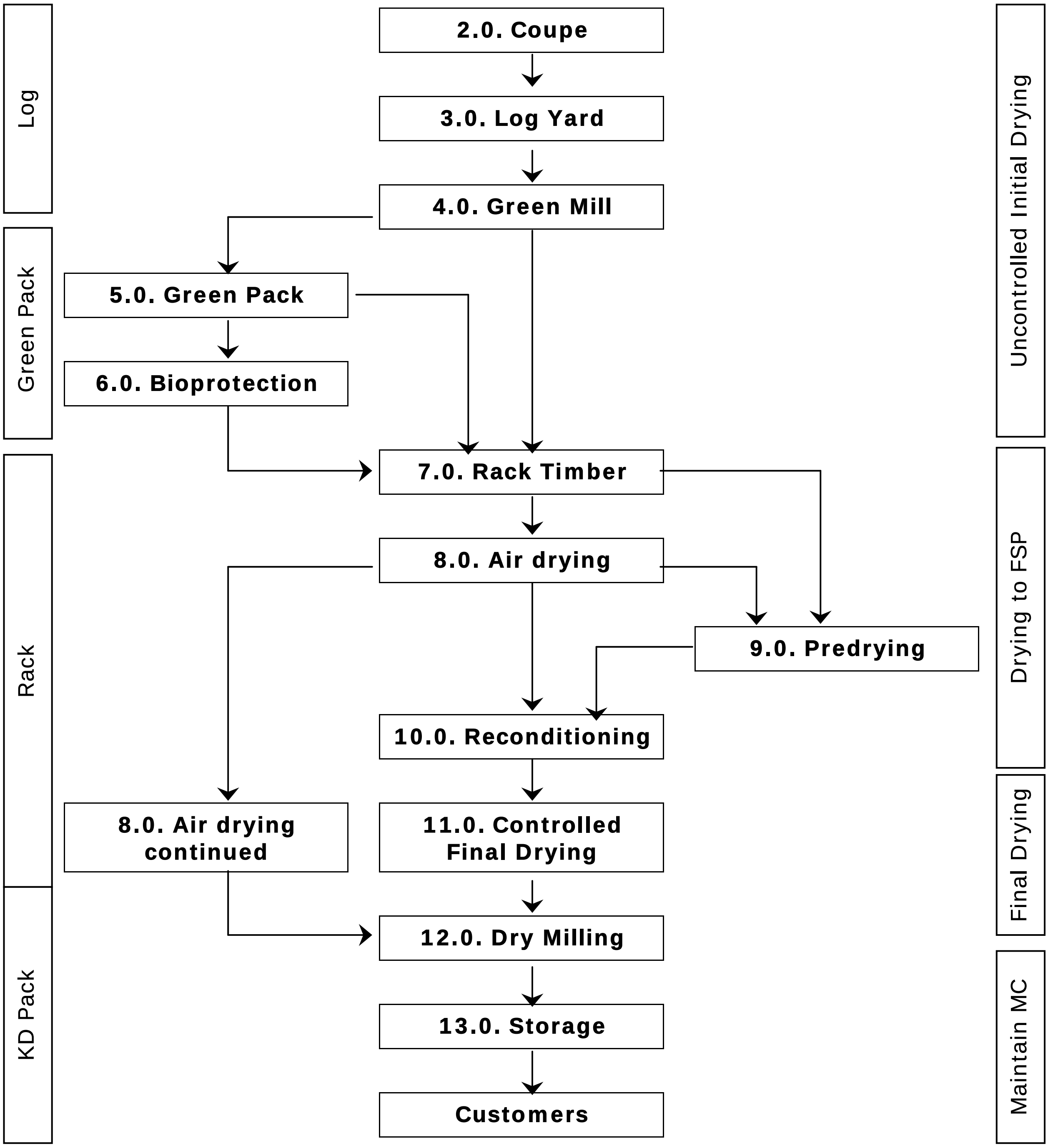


Table 1.03. General processing sequence for collapse-prone hardwoods and the relevant manual module

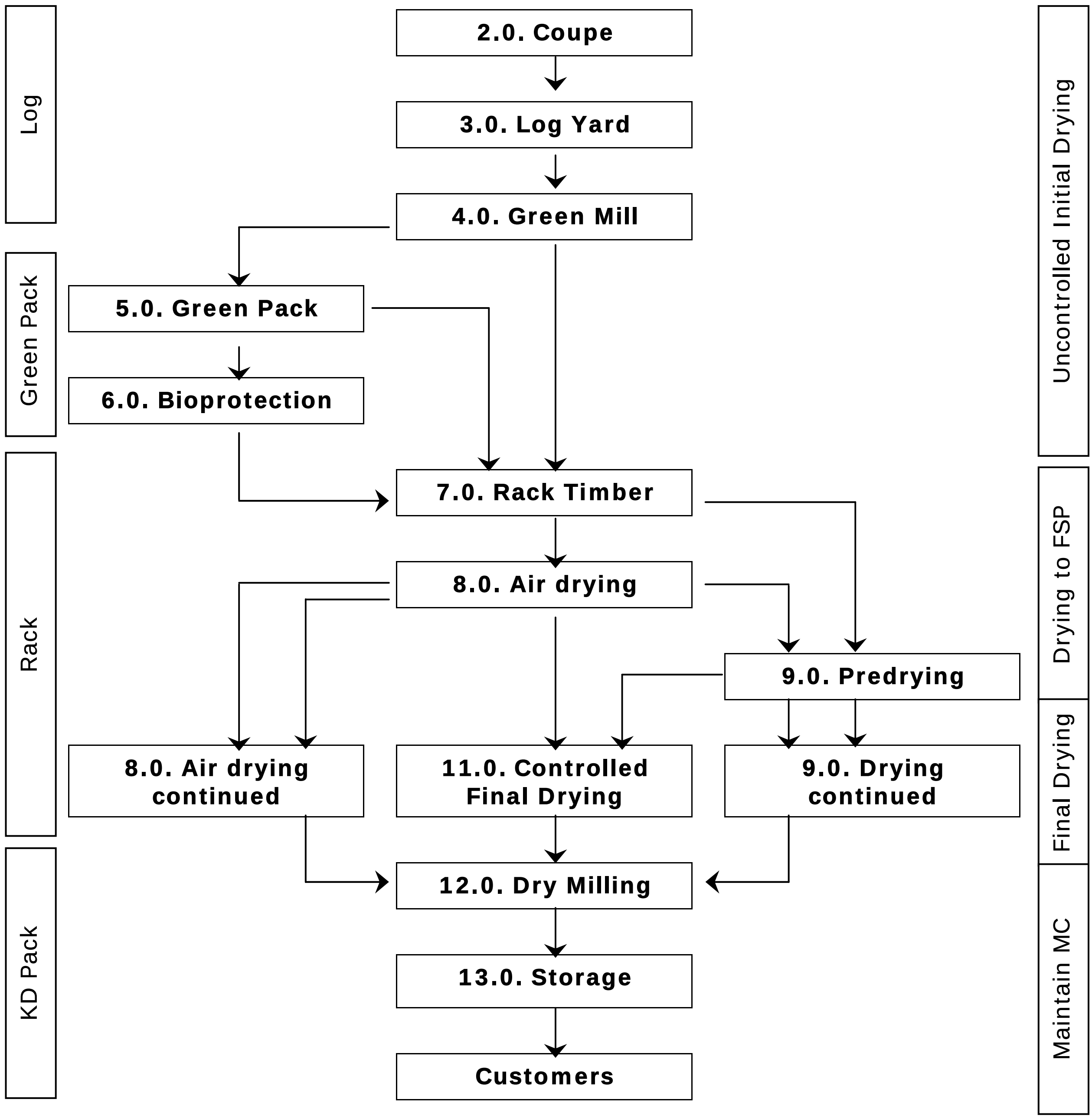


Table 1.04. General processing sequence for non collapse prone hardwoods and the relevant manual module

1.3 Applicable Standards

1. Hardwood Product Standards

AS 2796-1999: Timber - Hardwood - Sawn and milled products

Part 1 – Product Specification

Part 2 – Grade Description

Part 3 – Timber for Furniture Components

AS 2082-2000: Timber - Hardwood - Visually stress-graded for structural purposes

AS 3818-1998: Timber - Heavy structural products - Visually graded

Part 1 – General requirements

Part 2 – Railway Track Timbers

Part 3 – Visually Graded

Part 4 - Visually graded - Cross-arms for overhead lines

2. Other Timber Standards

AS/NZS 1080.1:1997: Timber - Methods of test

Part 1 - Moisture content

Part 2 – Slope of grain

Part 3 – Density

AS/NZS 1148:2001: Timber - Nomenclature - Australian, New Zealand and imported species

AS 1604:1997: Timber - Preservative-treated - Sawn and round

AS 1605:2000: Sampling and Analysis of Wood Preservatives and Preservative Treated Wood

AS/NZS 2843:2000: Timber preservation plant safety code

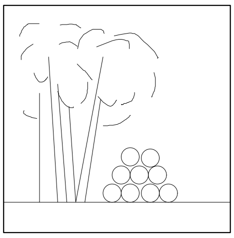
Part 1: - Plant design

Part 2: - Plant operation

AS/NZS 4491:1997: Timber - Glossary of terms in timber related Standards

AS/NZS 4787:2001: Timber - Assessment of drying quality.

2.0: – COUPE



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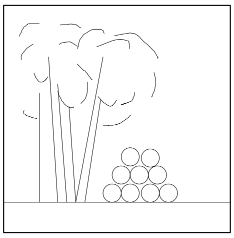
2.0: – COUPE



2.1 Objectives

The objective at the coupe is to produce, protect and deliver logs of known species, grade and source to timber mills with minimal physical and drying damage.

Any damage to the logs reduces the amount of useable timber recovered.

2.1.1 Functions & Performance Requirements

1. Felling trees

Trees are felled to minimise physical damage to the logs.

2. Grading and docking the resulting logs

Logs are consistently graded to accepted rules and docked to maximise material recovery and useable size.

3. Protecting the logs from physical and drying damage

Logs are end coated or stored on the coupe and during transport to minimise drying degrade.

Logs are handled on the coupe and during transport to minimise physical damage.

4. Maintaining product information

Information required for later production control is collected and passed with the logs effectively.

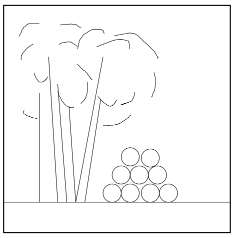
5. Identifying & reporting problems for correction

Details of individual and systemic problems are identified and distributed.

Problems are corrected.

6. Management of staff and equipment

Staff and equipment are available to conduct coupe activity safely and efficiently.



2.2 Management

2.2.1 Overview

1. Introduction

Activity at the coupe is to produce, protect and deliver logs of known species, grade and source to timber mills with minimal physical and drying damage. This is critical to economically producing quality, dried hardwood, as the coupe is the source of:

- **Graded logs.** Correct grading of the docked log is critical. This grade is used to determine the log's final customer and the return received.
- **Basic log information.** Information from the coupe is vital for later processing of logs; and
- **Initial damage to the timber.** Logs are delicate. They can be damaged at the coupe by improper felling, mishandling with equipment, uncontrolled drying & unrestrained stress release.

2. Grading logs

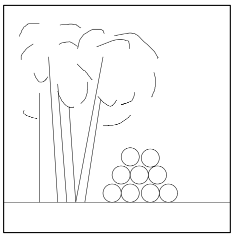
2a. Grading rules

Logs are of differing quality and are graded in the forest and in the log yard in accordance with rules established by forest owners, state forestry organisations, log purchasers or others.

These rules are based on a relationship between the value of the wood in the log for a specific end use and the log's major physical characteristics, such as the species, size, age, straightness, grain direction, and probable internal characteristics.

High grade logs are generally large, straight and have consistent wood grain. The rules for lower-grade logs allow greater variation in size, straightness and other characteristics, such as bumps, decay, limbs, scars and borers.

High grade logs are most suitable for making high-value products such as sliced veneer and appearance timber. Lower-grade logs may be suitable for sawn structural timber, peeling for plywood or for woodchips.



The publisher of crown log grading rules for each state are listed in Table 2.01

State	Title	Publisher
NSW	Negotiated on sale by sale basis	
Queensland	Hardwood Sawlog Classification Guidelines (3rd edition)	Department of Primary Industries
Tasmania	Log Specification Handbook	Forestry Tasmania.
Victoria	Hardwood Log Grading Interpretations	Department of Natural Resources and Environment – Forestry Victoria
West Australia	Manual of Management Guidelines for Timber Harvesting in WA	Forest Products Commission, WA

Table 2.01. Publishers of log grading rules

2b. Docking for grade recovery

Often, separate parts of full-length logs meet the requirements of different grades.

When they contain sections of log of differing grade that need to be supplied to different customers, full-length logs should be docked. This is the case when a full-length log has a veneer butt section, a sawlog in the centre part and a pulp section at the top. Logs are docked to retrieve the highest grade of material from a log while providing customers with the longest 'preferred' length of log. Most grading rules include minimum length of logs for each grade. However, customers may accept shorter logs for particular applications.

Full-length logs should not be docked if they contain sections of log of different grades that can be supplied to the same customer. This is the case when a full-length log is made up of a high grade sawlog at one end and a low-grade sawlog at the other.

Log and piece length is one of the major cost drivers for log transport, storage and timber production. If possible, the final decision of where to dock a multi-grade sawlog should be made as close to sawing as possible. These logs should be marked with paint where the grade changes.

If logs need to be docked, they must be adequately supported and restrained. The end of the logs can split when cantilevered, or when poorly supported logs are cut and one end of the log begins to move, or falls away.

Docking splits from logs at the coupe is probably counterproductive. Splits will form until the stresses that cause them are balanced out or the splits are restrained. Docking off existing splits may upset the balance of stresses and cause further splitting.

Figure 2.01. Support bearer for docking logs

2c. Log assessment and grading

Only trained log graders should grade logs.

Log assessment is usually made by an external examination of the log. There are few established methods of determining the internal quality of the log. Generally, the grader must rely on experience to relate signs on the outside of the log with internal grade reducing characteristics.

Boring logs with a chainsaw or other instruments automatically makes a defect in the log and should only occur when absolutely necessary. The cut in the log should be as small as possible and made parallel to the log's long axis.

3. Basic log information

Often, information about logs necessary for further processing can only be collected at the coupe. For example, in most states, it isn’t possible to determine the species of logs once the bark has been removed at the coup. So species information must be collected before the bark or leaves are removed.

The information listed in section 2.2.5 should be collected and made available to the timber mill by the time logs are being prepared for storage or subsequent processing.

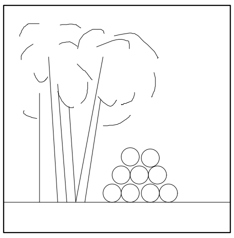
4. Initial damage to the timber

Logs are delicate. They can be damaged at the coupe by improper felling, mishandling with equipment, uncontrolled drying and unrestrained stress release.

4a. Mechanical damage

The timber in a log can be damaged during felling, handling, debarking and loading. If a log is dropped or it falls so that one point or area takes all the weight and force of the moving log, the wood fibres can be fractured, crushed, or split. All result in breaks, shatters, or distortions in the timber.

This damage is often microscopic and remains invisible until after the log is sawn and the timber processed. The distortions or shatters then show up as shakes in dry timber, in lifting grain on planed faces, or as irregular checks in boards.



Correct felling and log handling practice avoids most mechanical damage.

4b. Drying damage

Logs received on the landing dry at a rate determined by the exposure of the logs to the ambient weather conditions: primarily the temperature, wind and humidity. This drying can have significant effects on the end grain and outside surface of the logs.

When a tree is felled and every time a log is docked, the end grain of the log is exposed to the air and begins to dry. Exposed end grain dries quickly and, as it does, it shrinks. However, the timber further into the log's core doesn't dry and does not shrink. With the end of the log shrinking on this stable core, tension develops in the end grain of the log and radial end checks occur. These can form within half an hour of a cross cut being made. They grow as the log continues to dry and new end checks can develop between the initial ones.

If exposed to adverse conditions for long enough, the outside surface of the log also starts to shrink and barrel checks develop. Both end and barrel checking reduce the recovery of useable timber from the log and have to be controlled.

End checking is reduced in the short term by sealing the end of the log with a paint-on, rolled-on or spray-on sealer. Moving logs from the coupe as quickly as practical reduces both end checking and barrel checking.

For long term protection, logs need to be stored so that the rate of drying of the logs is so slow that ongoing drying damage is reduced to an acceptable level. To achieve this, the ambient environment around the logs has to be controlled to have a low temperature, reduced air movement and high humidity. This can be achieved by:

- **Spraying the whole log pile with water regularly**. In this way, the logs are kept wet and the water evaporating off the logs and surrounding area lowers the air temperature and raises the humidity.
- **Storing end sealed logs closely together**. In this way, air velocity over most logs is reduced. However, the logs on the top and edges of the log stack and the protruding log ends are still exposed to harsh conditions. Making a compact log stack and aligning the ends of logs can reduce this.
- **Covering the logs with shade cloth, bark and leaves, or a similar covering**. This reduces the impact of direct sunlight, and lowers the temperature and air velocity.

Logs stored for longer than a few days should be protected. The method employed on individual landings depends on the amount of logs stored, the species of log, how likely they are to degrade, the log grade, and the ambient conditions.

Figure 2.02. End and barrel checking of unprotected logs

Figure 2.03 End sealing logs as they are graded

4c. Other damage at the coupe

The ends of logs also split at the coupe due to internal stresses in the log. Trees naturally develop stresses in the wood as they grow and these appear to be highest in younger trees. In a standing tree, the stresses are balanced throughout the trunk, roots and branches. However, when the tree is felled and converted into a log, the stresses are no longer balanced and they can cause the ends of the log to split. The splits are usually radial but in some cases, can be tangential, occurring at an existing or induced shake in the log. Splitting stops when the split is restrained or the internal stresses are not strong enough to enlarge the split.

Figure 2.04. Log end splitting, caused by felling, initial drying, growth stress release or all three

Docking off end splits from logs before they are placed into controlled storage may again unbalance the stresses and cause further spits to form.

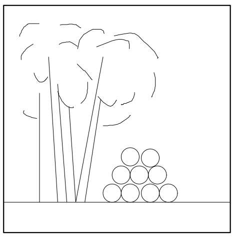
Residual stresses are not the result of any action at the coupe, other than felling and cross cutting. However, the effects of the splits can be reduced. End splits can be restrained by nail on or hammer in products. S irons and end straps that go around the log are not suitable.

Figure 2.05. Metal nail plates used to restrain end splits

End split restraints are vital for any logs that are likely to split significantly and have to be transported over long distances.

4b.Transport damage

Logs can sustain mechanical and drying damage during transportation from the coupe to the log yard or during transshipment from one mode of transport to another.



A log may be handled several times during transportation: on and off a truck; into a storage pile, and then onto and off a train. Every time a log is handled, it can be damaged so each time it is handled, the correct log handling practices and the correct equipment should be employed.

Logs may sustain additional end and barrel checking when transported over long distances in adverse weather conditions. They can be exposed to the sun for long periods or experience very high air movement (and drying) on moving trucks or trains. It is essential that these logs be correctly prepared. The ends should be sealed and any significant splits or checks in the ends of the logs restrained.

2.2.2 Equipment Options

Equipment in the coupe includes handling and log treatment equipment.

1. Handling equipment

Logs are heavy elements and require careful handling. The safe working capacity of log handling equipment on the coupe should easily accommodate the expected maximum log load and placement distance.

Handling logs on the limit of equipment working capacity creates a safety hazard for staff and encourages practices that increase damage to the logs.

2. Log treatment equipment

2a. End Sealer

Several companies make end sealing products. They are generally water based wax emulsions that are sprayed, brushed or applied with a roller to the end of freshly cut logs. As they dry, the wax forms a thin membrane over the end of the logs that slows drying and helps reduce end checking. As they reduce water movement, end sealer may also reduce the incidence of chemical or fungal stain in logs.

2b. End split restraints

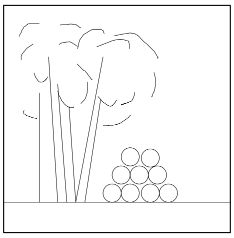
There are several types of nail-on log end split restraints available. Each works by gripping either side of a split and stopping it from opening further. Metal restraints are generally shaped nail plate products with teeth that are hammered into the end of the log. Generally designed to go into the longitudinal grain of seasoned material, their effectiveness in the end grain of unseasoned material varies. With many denser timbers, the teeth may not grip the timber sufficiently and they can pull out.

Plastic restraints are I shaped elements that are hammered completely into the wood across the split.

Both types of restraint may damage equipment such as saws or pollute by-products such as wood chips.

Figure 2.06. Metal and plastic end split restraints



2.2.3 Coupe Strategy

1. Felling trees

Trees should be felled to minimise physical damage to the logs. To do this:

- Trees should be felled in a direction and way that minimise damage; and
- Trees should only be felled by trained and accredited tree fallers.

2. Grading and docking the logs

Logs should be consistently graded to accepted rules and docked to maximise material recovery and useable size. To do this:

- Log grading rules should be readily available and understood;
- Logs should only be graded by trained log graders;
- Graders on the same coupe should discuss and review observed characteristics regularly;
- Logs should only be docked if they contain sections of log of differing grade that need to be supplied to different customers, or if they are too long for transportation;
- Logs should not be docked if they contain sections of log of different grades that can be supplied to the same customer and can be transported in the full length; and
- Logs should be adequately supported and restrained as they are docked.

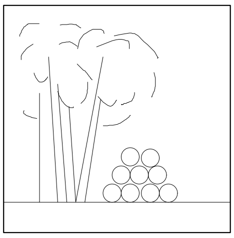
3. Protecting the logs from physical and drying damage

Logs should be end coated or stored on the coupe and during transport to minimise drying degrade. To do this:

- All exposed ends of logs should be coated with log sealer as soon as practicable after felling or docking;
- Subject to customer restrictions, any logs with significant end splits should be restrained with an end restraint as soon as practicable;
- Storage times at the coupe or during transshipment should be reduced as much as possible. Tree felling operations should be structured to achieve this; and
- Logs stored at the coupe or during transshipment should be stored in the shade, covered by a protective layer of bark or landing, shade cloth or water sprays if exposure to prevailing wind and temperatures lead to any observable barrel checking.

Logs should be handled on the coupe and during transport to minimise physical damage. To do this:

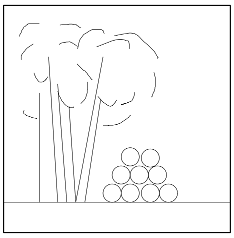
- Logs should not be dropped, subjected to shock or excessive loading or bending during snigging, debarking or other handling;



- Logs should only be stored parallel to each other in piles of similar length logs; and
- Logs should only be handled by adequately rated, purpose-designed equipment, operated by staff trained in its use.

4. Maintaining product information

Logs should be tagged so that their major characteristics can be used effectively in later production stages. The requirements for this are in Section 2.2.5.



2.2.4 Quality Control

Procedures should be established for:

Procedure	**General contents**
Felling trees	Falling requirements, minimising falling damage
Grading logs	Log grading rules
Log protection	End grain, short term storage, long term storage, log handling
Segregating and preparing logs for transport	Sorting, docking, required lengths, storing species groups separately or segregating effectively
Marking and tagging logs	Identification requirements
Staff accreditation	Training, qualifications
Equipment	Maintenance, fit for purpose

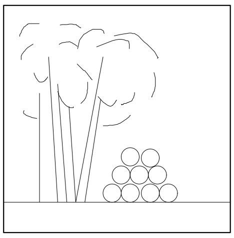
2.2.5 Information Management

1. Required attributes

Information required for later process control should be collected and passed with the logs effectively. This includes the following:

Required information on each log	
Unique log identification number	Grade
Species	Primary dimensions
Required process control information	
Unique log identification number	Age class
Species	End sealing
Grade	Location of harvest (coupe)
Primary dimensions	Date of harvest
Desirable additional information	
Method of harvest	The grader
The faller	

Table 2.02. Attributes required or desirable from the coupe for each log



2. Records and tagging systems

Recording methods must be suitable for all expected weather conditions and be easy to complete. Log dockets should be easy to complete and be mounted or protected so they can be completed in adverse weather conditions.

Information required on the log must be readable in normal daylight at least 1 meter from the end of the log. Primary segregation information, such as species, should also be marked on the log so that it is visible from the log handler equipment.

Log tags should be of resilient and weather resistant material securely fixed to the log. Ideally, they should be colour-coded by grade or species. Pens used to mark the tags should be permanent. Stamps or paint should be permanent and not be readily obscured by dust.

All tagging systems have to be able to survive any transshipment stage with less than a 0.5% loss rate.

2.2.6 Equipment Maintenance/Calibration

1. Handling equipment

Handling equipment should be maintained so that the expected maximum log load and placement distance remains within the safe working capacity of log handling equipment.

2.2.7 OH&S

The coupe and surrounding areas should be inspected regularly and hazards identified and eliminated. This can include:

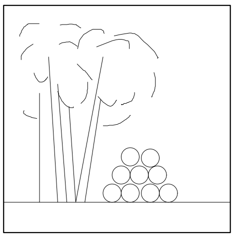
- Water and mud;
- Cross cutting, docking and log handling;
- Large log sizes; and
- Unstable log piles.

1. Microclimate control

The mud and standing water that results from rain and vehicle movement can create safety hazards. This complicates truck and operator movement. This mud can also get onto logs and create a hazard during cross cutting, docking and sawing.

2. Cross cutting, docking and log handling

All states have requirements for the safe movement of heavy equipment, cross cutting, the use of chain saws, etc. All staff operations should comply with these requirements.



3. Large log sizes

Very large logs can create safety concerns. They are often close to or beyond the lifting capacity of site equipment. Considerable care is needed to ensure that operations are conducted safely.

4. Unstable log piles

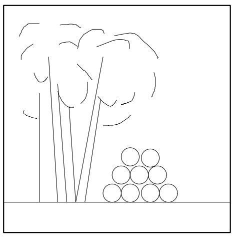
Log piles with logs piled too steeply or with logs out of parallel can create a safety hazard. Logs should be placed with care parallel to one another and chocked where necessary.

5. Major regulations

Major OH & S requirements relevant to this section are listed in Table 2.03. Note that this is not a complete list and other relevant codes and regulations may apply.

State	**Major code of practice**
Victoria	*Code of Practice – Safety in Forest Operations,* Workcover Victoria
NSW	*Codes of Practice – Timber Industry*, Workcover NSW
Queensland	*Forest Harvesting: Industry Code of Practice* - QLD Division of Workplace Health & Safety
Tasmania	*Forest Safety Code,* Workplace Standards Tasmania

Table 2.03. Major safety codes of practice



2.3 Operations

2.3.1 Objective

The objective in the coupe is to produce, protect and deliver logs of known species, grade and source to timber mills with minimal physical and drying damage.

2.3.2 Key Drying Factors in Coupe

1. Correct grading of logs

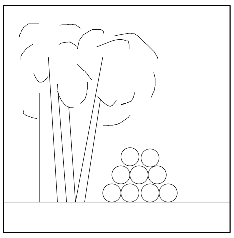
Correct grading of the docked log is critical. The grade is used to determine the final customer for each log and the return received. Logs can be used for veneer, graded sawlog, and non-graded sawlog.

2. Recording basic log information

Information from the coupe is vital for later processing of logs.

3. Avoiding initial mechanical or drying damage to the timber

Logs are delicate. They can be damaged at the coupe by improper felling, mishandling with equipment, uncontrolled drying and unrestrained stress release.



2.3.3 Preparation

1. Standards & Specification

Identify the requirements for grade and log usage. These can include log grading rules and customer specifications that describe the grade of log with consideration of species, length, diameter, shape and other factors.

Customer specifications may deviate from state or general log grading rules.

2. Procedures

Procedures should be in hand for:

Felling trees	Segregating and preparing logs for transport
Grading logs	Marking and tagging logs
Log protection	

3. Equipment

Saws and other equipment should be maintained in accordance with the standard procedures.

Log marking and tagging equipment should be in hand and operational.

2.3.4 Processing & Monitoring

1. Felling the tree

Trees are felled to minimise physical damage to the logs. To do this:

- Plan falling direction and sequence to minimise danger to operators and damage to the tree;
- Assess the tree's falling characteristics;
- Complete falling once initiated;
- Monitor the fall of the tree and movement on ground until tree is stable.

2. Grading and docking the logs

Logs are consistently graded to accepted rules and docked to maximise material recovery and useable size. To do this:

- Assess logs individually as soon as practically possible after arrival on the landing;
- Grade the log and mark sections of different grades;
- Cross-cut logs to maximise grade and preferred log lengths but only if the products are going to different customers;
- Leave logs as long as practically possible if they contain more than one grade going to the same customer;

- Support the log adequately before docking;

Figure 2.07. Adequately supported log

- Remove excessive tapering bases of logs;
- Mark logs that cannot be safely processed and/or evaluated.

3. Protecting the logs from physical and drying damage

Logs are end coated or stored on the coupe and during transport to minimise drying degrade. To do this:

- Seal the ends of all logs immediately;

Figure 2.08. All cut ends of logs are resealed immediately

- Restrain logs that are splitting unacceptably. Be aware of any customer restrictions on end restraints;

If barrel checking is observed, place logs into protected storage as soon as possible;

Figure 2.09. Desirable: Logs in ordered storage quickly

Figure 2.10. Undesirable: logs left exposed

- Place logs in piles that are parallel and safe, sound and stable.

Figure 2.11. Desirable: Log piles even

Figure 2.12. Undesirable: Logs ends exposed

- Plan the delivery schedule to minimise storage on the coupe.

Logs are handled on the coupe and during transport to minimise physical damage.

- Handle, load and unload logs with care. Do not drop them.
- Inspect logs regularly for handling damage.
- If damage persists, review log handling methods.

Figure 2.13. Unloading log with care

2.3.5 Marks, Tags & Records

Information required for later production control is collected and associated with the logs effectively:

- Attach log tags;
- Maintain log tags through storage, loading and any transhipment;
- Complete at least the following records:

Logs graded	Logs dispatched
Logs destination	

2.3.6 Feedback

If noticed regularly, report any of the following to the supervisor:

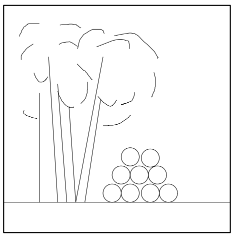
Felling shakes	Excessive broken wood
End splits	End or barrel checks
Transport damage	Unusual grade reducing defects
Log fractures	Repetitive incorrect log grading

2.3.7 OH&S

Maintain and wear all required safety gear. Ensure all protective guards and warning devices are operational.

Inspect the coupe regularly. Identify potential hazards and eliminate them. In the log yard, this can include:

- unstable piles of logs;
- wet, slippery or unsafe roads and landing;
- dangerous or damaged equipment;
- broken fences, gates and barriers; and
- poor or no safety signage.



2.4 Checklists

Use this checklist to monitor key aspects of your operation. Mark each item on the following scale:

1	2	3	4	5
Very bad, never	Bad, rarely	Satisfactory, usually	Good, almost always	Very good, always

1. Felling trees

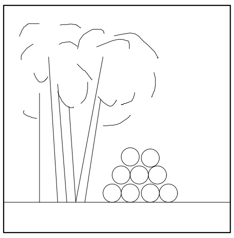
	1	2	3	4	5
Trees are felled with minimal damage					
Log characteristics determined from the standing tree are recorded					

2. Grading and docking the resulting logs

	1	2	3	4	5
Graded logs meet specification					
Logs meet marked size					
Logs are only docked when absolutely necessary					
Docked logs are at preferred lengths					
Documentation confirmed to be accurate					
Logs are marked with required information					
Tags and marks are visible 1 meter from end of log					

3. Protecting the logs from physical and drying damage

	1	2	3	4	5
Logs end sealed					
Logs splitting excessively are restrained					
Logs are handled with care at all times					
Log piles are sound, stable and safe					



2.5 Avoidable Loss

Avoidable loss results from:

1. Incorrect felling of trees

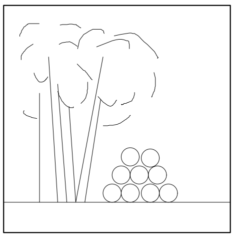
- **Damage from felling causes stress fractures and cracks in the timber.** Incorrect felling results from:
  - Falling trees over uneven surfaces (breaking the back of the tree or splitting it on the way down);
  - Falling trees onto other trees, causing damage to either;
  - Cutting the tree so that stresses are concentrated near the base; and
  - Grabbing or gripping the logs with machines that crush or split the timber.

2. Incorrect grading and docking of logs

- **Incorrect grading and docking leads to loss of value** - Logs that are graded below their true grade are used for lower value applications. Logs that are graded above their true grade are usually rejected in the mill. Incorrect grading results from:
  - Inadequate examination;
  - Incorrect docking; and
  - Inadequate marking and inappropriate segregation – such as when veneer logs are mixed with saw or peeler logs.
- **Logs are docked unnecessarily** - Docking exposes end grain to initial drying damage and can unbalance growth stresses. Both can result in a direct loss of material recovered from a log. Unnecessary docking also leads to mills having to handle more pieces of shorter timber during production. This increases production costs and reduces material recovery.
- **Logs are cross cut poorly** - Docking logs that are not properly supported, or with an incorrect cross cutting technique can cause end splits. Cutting to non-preferred sizes leads to waste during production.

3. Protecting the logs from physical and drying damage

- **Mechanical damage -** This damage leads to stress fractures, cracks, or weakened grain in the timber. It can occur at the coupe, on a truck or a rail car. Shatter can be caused by the gripping action of some mechanical harvesters and by handling in piles with excavators or other machinery.
- **Drying damage** - Exposing the log to adverse drying conditions causes splits in the timber. Losses appear to be in proportion to properties of the species, the age of the trees and the time the log is exposed to these conditions. Unrestrained initial drying of the logs, causing end or barrel checking.
- **Other damage** - unrestrained end splits leads to continuing splits, especially in regrowth logs.



2.6 References

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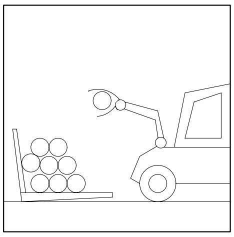
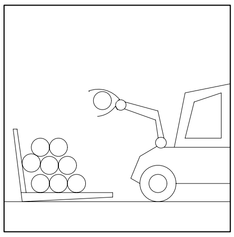
3.0: – LOG YARD



3.0 CONTENTS

3.0: – LOG YARD



3.1 Objectives

The objective in the log yard is to accept, store and prepare logs for milling so that damage to the logs and surrounding environment is minimised.

Any damage to the logs and any failure in log preparation reduce the amount of usable timber recovered from the log.

3.1.1 Functions & Performance Requirements

1. Accepting delivered logs

Logs accepted into the log yard meet log specifications.
Logs are sorted to established rules for species, size, preferred length, and product group.

2. Protecting the logs from physical and drying damage

Logs are end coated or stored in the log yard to minimise drying degrade.
Logs are handled in the log yard to minimise physical damage.
Log storage facilities do not degrade the local environment.

3. Prepare the logs for milling

Logs are cross cut to maximise material recovery in preferred sizes.
The protection of log end grain is maintained.

4. Maintaining product information

Information required for later production control is collected and associated with the logs effectively.

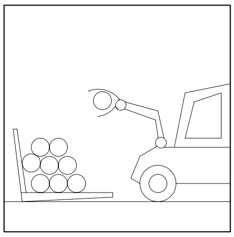
5. Identifying & reporting problems for correction

Details of individual and systematic problems are identified and distributed.
Problems are corrected.

6. Management of staff and equipment

Staff and equipment are available to conduct log yard activity safely and efficiently

3.0: – LOG YARD



3.2 Management

3.2.1 Overview

1. Introduction

Activity in the log yard is to accept, store and prepare logs for milling so that damage to the logs and surrounding environment is minimised. This is critical to economically producing quality hardwood as the log yard controls:

- the quality of logs entering the operation;
- potential damage to stored logs;
- the grouping of similar material going into the mill; and
- maintenance of basic log information.

2. Logs entering the operation

Logs entering the yard provide the basic resource for the milling and drying process. When they enter, each log should be assessed to ensure that the log:

- conforms to log specification;
- is sorted by batch (such as species group, age, preferred length, density and type) so that it can be milled and dried efficiently with other similar material; and
- is suitable and ready for any required period of storage.

2a. Log specification

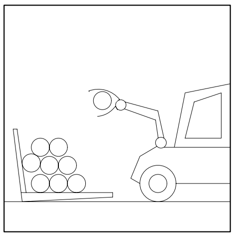
Logs are of differing quality and are graded in the forest and in the log yard in accordance with rules established by forest owners, state forestry organisations, log purchasers or others.

These rules are based on a relationship between the value of the wood in the log for a specific end use and the log's major physical characteristics, such as the species, size, age, straightness, grain direction, and probable internal characteristics.

High grade logs are generally large, straight and have consistent grain. The rules for lower grade logs allow greater variation in size, straightness and other characteristics, such as bumps, decay, limbs, scars and borer.

The major publishers of log grading rules for each state are listed in Table 2.01

In addition to assessment by log grade, logs can also be assessed for the likely timber products to be sawn from them. The log diameter, the amount of any particular characteristic, such as gum vein, or species properties may influence this.



2b. Batch characterisation

Timber should ideally be processed and dried in batches that have similar drying properties. The easiest place to establish these batches initially is when logs are accepted into the yard and assessed.

Logs should be sorted into batches that have specific and identified drying properties or requirements. Usually, these groups can be defined by:

- **Species**; Groups can be formed from single species that has unique drying properties, or a group of species that have very similar drying properties;
- **Age and diameter class**; Similarity in age and diameter suggests that the timber properties and drying characteristics may also be similar; and
- **Log grade or intended product area**; Logs of a similar grade or intended product area may also have similar timber properties and can be handled in a similar way.

Batches can also be defined by excluding certain species that are difficult to dry or species and grades that are very different from other material handled.

There is research under way into means of physically assessing logs for similar drying properties.

2c. Preparing logs for storage

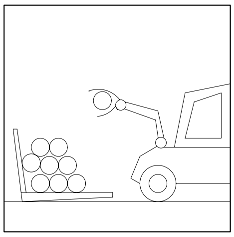
Logs entering the operation may come from a range of sources and suppliers and range in condition from sound, solid and clean to having significant end splits and checks, and barrel checking.

The causes of end and barrel checking, and means to reduce further end checking are discussed in detail below.

End splits often form due to internal stresses in the log. Trees naturally develop stresses in the wood as they grow. In a standing tree, the stresses are in equilibrium. However, when the tree is felled and the head removed, the stresses in the log are no longer restrained. They can then cause the ends of the log to split. The splits are usually radial but in some cases, can be tangential, occurring at an existing weak point in the log, such as a shake. Splitting stops when the split is restrained or the internal stresses are not strong enough to open the split further. Docking of end splits before storage can again unbalance the forces and cause further spits to open.

The effects of end splits can be reduced by restraining the log with nail-on or hammer-in restraints. These are described in Section 3.2.2. End split restraints may be necessary for any logs that are likely to split and which are to be stored for any period of time.

Generally, logs arrive in the log yard in a full range of lengths. However, logs should not be docked to preferred mill lengths before storage as it only exposes additional end grain to early drying. Increasingly, logs have their bark removed in the forest and logs are delivered to the mill without bark present.



3. Log storage

3a. The need to store logs

Logs are stored at mills to provide a period when the stresses or moisture content in the log may relax or even out and to balance out log supply.

Generally, logs should be milled as soon as possible. This reduces the chance of the log degrading due to uneven drying, insect attack and decay during storage. However, industry experience and some research indicate that storing logs in a high moisture environment, such as a water sprinkled log store, may allow growth stresses in the logs to relax and exceptionally high moisture contents to even out, reducing spring and internal check in sawn board. However, this appears to relate more to collapse prone and faster grown species than non-collapse prone and slower grown species.

In practice, milling logs immediately is rarely possible and some log storage will be needed. The volume of logs that needs to be stored in the yard depends on:

- The milling capacity of the mill to be served;
- The pattern of delivery of logs to the yard; and
- Any strategic reserve held to moderate any failure in log supply.

The supply of logs to mills is generally not guaranteed on a particular schedule and is dependent on weather, season and harvesting practice. Log stockpiles may only need to be sufficient to cover a few weeks of mill production, or be large enough to maintain production through months when access to the forest is restricted. In these cases logs have to be stored for periods up to a year.

3b. Inventory rotation

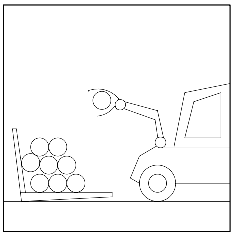
Logs in storage may deteriorate over time and their milling should be scheduled so that no groups of logs deteriorate in such a way that they become unusable.

3c. Protecting the logs from drying damage

Logs received into the log yard and stored continue to dry at a rate determined by the exposure of the logs to the ambient weather conditions: primarily the temperature, wind and humidity. This drying can have significant affects on the end grain and outside surface of the logs.

Whenever the end grain of a log is exposed to the air, it dries quickly and as it does, it shrinks. However, the timber further into the log’s core doesn’t dry and does not shrink. With the end of the log shrinking on this stable core, tension develops across the end of the log and radial end checks occur. These can form within half an hour of a cross cut being made. They grow as the log continues to dry and new end splits can develop between the initial ones.

If exposed to adverse conditions for long enough, the outside surface of the log also starts to shrink and barrel checks develop. Both end and barrel checking reduce the recovery of usable timber from the log and have to be controlled.



End checking is reduced in the short term by sealing the end of the log with a paint-on, rolled-on or spray-on sealer.

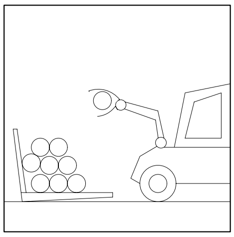
Figure 3.01. Both sealed and unsealed logs in a stack

For long term protection, logs need to be stored so that the rate of drying of the logs is slow enough that ongoing drying damage is reduced to an acceptable level. To achieve this, the ambient environment around the logs has to be controlled to have a low temperature, reduced air movement and high humidity. This can be achieved by:

- Spraying the whole log pile with water on a regular basis. In this way, the logs are kept wet and the water evaporating off the logs and surrounding area lowers the air temperature and raises the humidity;
- Storing end sealed logs closely together. In this way, air velocity over most logs is reduced. However, the logs on the top and edges of the log stack and the protruding log ends are still exposed to harsh conditions. Making a compact log stack and aligning the ends of logs can reduce this; and
- Covering the logs with shade cloth or a similar covering. This reduces the impact of direct sunlight, and lowers the temperature and air velocity.

Logs stored for longer than a few days should be protected. The method employed in individual mills depends on the amount of logs stored, the species of log, how likely they are to degrade, and the ambient conditions of the yard.

The most effective method of protection combines the first two methods above: sealed logs stored in close rows and sprayed regularly with water. This can increase sawn recovery by up to 7% of the total recovery from unprotected logs.



Logs do not need to be sprayed continually but they do need to be kept wet. Spraying regimes of 15 minutes spraying every 3 hours have been shown to be as effective for regrowth jarrah and karri as spraying continuously.

Figure 3.02. The combination of closely spaced log stacks and water from sprinklers reduces airflow, increases humidity and lowers temperature

3d. Protecting the logs from mechanical damage

The timber in a log can be damaged during handling and loading onto and off truck and log piles. Damage is often due to the log being dropped or falling so that all the weight of the moving log is taken by one point or area. The damage is done to the fibres in the wood and includes compression fractures, crushing, shakes or splits.

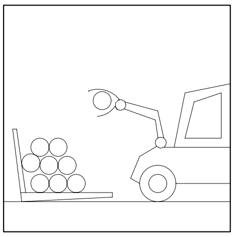
All these types of damage result in breaks, shatters or distortions in the timber that can be microscopic and remain unseen until after the log is sawn and the timber processed. The distortions or shatters then present as shakes in dry timber, in lifting grain on planed faces, or as irregular checks in boards.

Most mechanical damage can be avoided by correct log handling practice.

4. Prepare the logs for milling

4a. Production Batches

While each log is unique, logs should be grouped into batches for processing. If logs are not batched before going into storage, they can be batched when being prepared for milling.



In addition to the batch criteria listed above, logs can be cross cut and grouped by log length. Cutting logs to a preferred length is critical to economic timber production. The cost of timber production is broadly related to both the number of pieces handled and the total volume of timber. So, processing fewer longer length logs costs less than processing the same volume of shorter logs. There are less passes of the saw and less pieces to handle. Similarly, processing a few standard lengths is simpler than handling a more diverse range of sizes, especially for rack and pack assembly.

The preferred log lengths for any given mill have to be determined by balancing the available logs resource and the capacity of major equipment, such as racking frames and machines, saws, kilns and reconditioners.

4b. Cleaning

Logs being processed need to be clean and free of stones, dirt or mud that can damage saws and other equipment and create a safety hazard. Dirty or muddy logs should be hosed clean before docking or milling.

4c. Docking

Logs are cross cut to bring them to the correct length for milling, and docked to remove unsuitable ends or end restraints.

As the fresh log end exposed after cross cutting and docking begins to dry quickly, they should be sealed as soon as possible.

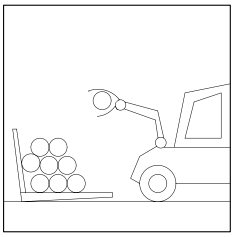
Cross cutting and docking should be conducted with care, ensuring that the log is as cut as close to the preferred length as possible and that the cut is perpendicular to the centre line of the log.

Figure 3.03. Logs batched by species, size and length into temporary stacks before milling. All new exposed log ends are sealed

3.2.2 Equipment Options

The log yard includes areas for:

3.0: – LOG YARD



- Log delivery, unloading and handling;
- Log assessment and preparation for storage;
- Log storage; and
- Log preparation for milling.

1. Log delivery, unloading and handling

Log yards need to be large enough to allow log trucks to enter and leave, and for logs to be unloaded and placed in temporary store before assessment.

Minimum turning requirements for many types of vehicles are included in **HB 72-1995**: Design vehicles and turning path templates, published by Standards Australia.

Roadways and unloading areas should be safe and trafficable in all weather conditions. Roads and driveways can be concrete, bitumen or compacted gravel. Unsealed earth is not stable in wet conditions and should not be used. It can lead to safety hazards and environmental contamination. Design recommendations for roadways and unloading areas are available in the Austroad Pavement Design Manual or from consulting civil engineers.

Figure 3.04. Firm and dry gravel hard standing

2. Log assessment area

Logs are assessed on series of parallel bearers, usually laid on the ground. Bearers allow examination all around the log and easy movement with log loaders. Bearers can be concrete, logs or poles. Decommissioned electricity poles are ideal as they are often preservation treated and are durable in contact with the ground.

Figure 3.05. Logs on an assessment deck

3. Log storage

Stored logs are usually arranged in parallel lines with particular lines designated for logs of similar length and batch type. Lines should be kept close together to reduce airflow. If the yard is in an open location and exposed to high or hot winds, the yard should be protected on the windward sides by tree wind breaks on natural ground or on earth berms.

Logs should be laid directly onto lines of bearers. Logs in storage need to be kept clean should not be laid on the ground as mud; dirt and stones can cover the surface of the log.

Figure 3.06. A large log storage yard with storage stacks, gravel roading, water sprays and drainage systems

Log storage in restricted areas can be maximised by using piled restraints. Pile restraints are logs or other piles driven into the ground and used to support the end of the log storage line.

Figure 3.07. Log storage stacks on log bearers and against piled restraints

4. Spray and water management

Log spraying systems usually include:

4a. Water supply and store

This is often a dam fed by a creek or a bore. The capacity of the dam is influenced by the size of the log yard to be served, the capacity of any water flow feeding the dam, the ground conditions and local climate.

4b. Pump

This must have sufficient capacity to service the number of sprinklers.

4c. Control mechanisms

This allows the spraying regime to be scheduled.

4d. Agricultural irrigation pipe

4e. Sprinkler heads

These need to be located so that sprinklers cover all exposed areas of the log pile, especially the ends of logs exposed to prevailing winds.

4f. Swales and drains

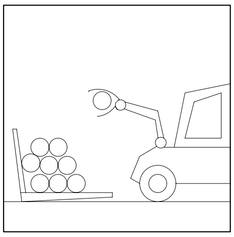
Water sprayed on logs need to be returned to the water store so that it can be reused. Swales or drains should run between lines of logs, and drain to the dam. In soils that erode easily, the base and sides of the swale should be protected.

Figure 3.08. Spoon drain being installed in a log yard

Advice on the construction of dams and swales, and design of pumps, agricultural lines and sprinklers are available from state agriculture departments and private suppliers.

Construction of dams and use of irrigation equipment are often subject to state regulation or local by-laws concerning: water management; pumping rates; land degradation; protection of vegetation; watercourses and wetlands; and other issues.

Figure 3.09. Irrigation sprinklers



5. Log preparation area

Like log assessment, logs are prepared for milling on series of parallel bearers, usually laid on the ground. Bearers allow examination all around the log, easy measuring and cutting and simplified movement with log loaders.

Unlike log assessment, log preparation often needs to occur in all weather conditions. A shelter or roof over all or part of the log assessment area can protect staff from adverse conditions and improves the quality of grading, docking and log preparation.

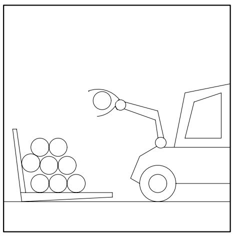
Figure 3.10. Shelter over log preparation area

6. Handling equipment

Logs are heavy elements and require careful handling. The safe working capacity of log handling equipment in the log yard should easily accommodate the expected maximum log load and placement distance.

Handling logs on the limit of equipment working capacity creates a safety hazard for staff and encourages practices that increase damage to the logs.

Figure 3.11. Heavy log loader



3.2.3 Log Yard Strategy

1. Accepting delivered logs

Logs accepted into the log yard should meet log specifications. To do this:

- All logs should be assessed against the log specification and grading rules as soon as practically possible after delivery;
- Log specification and grading rules should be readily available and understood;
- Logs should only be assessed by trained log graders;
- Logs that do not meet the specification for the grade marked on them are separated for future regrading or regraded; and
- Graders should discuss and review observed characteristics regularly.

Logs should be sorted to established rules for species, size and product group. To do this:

- Log batching rules should be readily available and understood;
- Logs should only be batched by trained log graders; and
- Logs should be piled in sorted groups.

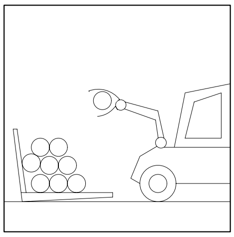
2. Protecting the logs from physical and drying damage

Logs should be end coated or stored in the log yard to minimise drying degrade. To do this:

- Upon arrival in the yard, or whenever logs are cross cut or docked, logs should be end coated as soon as practically possible;
- Unless being stored to relieve stress, logs should be processed as soon as practically possible after delivery or after being removed from protected log storage;
- Dependant on the species and age, logs with significant end splits are to be:
  - Sawn as soon as practically possible; or
  - Fitted with end restraints to minimise further splitting;
- Stock should be rotated to minimise the storage time of any log; and
- Logs stored for any period in adverse weather conditions, or that display an increase in end checking or any observable barrel checking should be protected by placing in a protected log pile and kept wet.

Logs should be handled in the log yard to minimise physical damage. To do this:

- Logs should not be dropped;
- Logs should only be stored parallel to each other in piles of similar length logs;



- Logs should only be handled by adequately rated, purpose-designed equipment, operated by staff trained in its use; and
- Roads and unloading areas should be safe and trafficable in all weather conditions.

Log storage facilities should not degrade the local environment. To do this;

- Roads, unloading areas and storage areas should have adequate falls to drains;
- Drains should fall to sumps or other water storage areas; and
- Drains, dams, bores and other irrigation equipment should comply with the requirements of relevant state or local government authorities.

3.Prepare the logs for milling

Logs should be cross cut to maximise material recovery in preferred sizes. To do this:

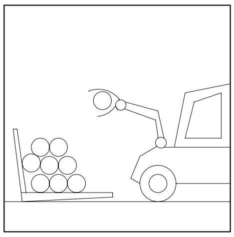
- Logs should be docked to the largest practical preferred length (or combination of lengths) consistent with the batch characteristics and intended product area;
- Log batching and length rules should be readily available and understood; and
- Logs should only be assessed, marked, and docked by trained log graders.

The protection of log ends grain should be maintained. To do this:

- All freshly cut logs should be immediately resealed.

4. Maintaining product information;

Logs should be tagged so that their major characteristics can be used effectively in later production stages. The requirements for this are in Section 3.2.5.



3.2.4 Quality Control

Procedures should be established for:

Procedure	General contents
Grading logs	Log grading rules and specification
Segregating logs for storage	Species, lyctus susceptibility, grade, batch definition product group, segregation processes
Log protection	Sealing end grain, short term storage, long term storage, Log handling
Segregating and preparing logs for milling	Sorting, batch maintenance, cross cutting and docking; and preferred lengths
Marking and tagging logs	Identification requirements
Staff accreditation	Training, qualifications
Equipment	Handling limits and maintenance

3.2.5 Information Management

1. Required attributes

Information required for later process control should be verified, collected and maintained with the logs effectively. This includes the following attributes:

Required information on log	
Unique log identification number	Primary dimensions
Species	Staff comments
Grade	
Required process control information	
Unique log identification number	Age class
Staff No	End sealing
Log arrival time and date	location of harvest
Species	Date of harvest
Grade	Intended product group
Primary dimensions	Staff comments

Desirable additional information.	
Method of harvest	Coupe log grader
Tree faller	Storage location
Unique identification number for parts of docked log	

Table 3.01. Attributes required or desirable from the log yard for each log

Minimum Batch Criteria	
Species / Species group	Diameter class / age
Desirable additional batch criteria	
Region of log source	Log length
Intended product group	

Table 3.02. Attributes required or desirable for batching log

2. Records and tagging systems

Recording methods must be suitable for all expected weather conditions and be easy to complete. Check sheets should be mounted or protected so they can be completed in adverse weather conditions.

A dry work area should be available close to the log yard to allow receipt of records for the forest, such as log dockets.

Logs should be tagged so that their major characteristics can be used effectively in later production stages. Information required on the log must be readable in normal daylight by a person standing at least 1 metre from the end of the log. Primary segregation information, such as species, should also be marked on the log so that it is visible by a log handler.

Log tags should be of resilient and weather resistant material securely fixed to the log. Ideally, they should be colour coded by grade or species. Pens used to mark the tags should be permanent.

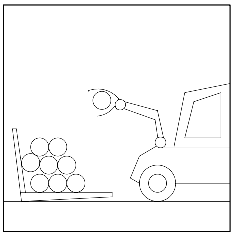
Stamps or paint should be permanent and not be readily obscured by dust.

3.2.6 Equipment Maintenance and Calibration

1. Storage facilities

Roadways should be safe and trafficable in all weather conditions

The log yard should be regularly graded to maintain stability of loaders and forklifts.



2. Handling equipment

Handling equipment should be maintained so that the expected maximum log load and placement distance remains within the safe working capacity of log handling equipment.

3.2.7 OH&S

The log yard and surrounding areas should be inspected regularly and hazards identified and eliminated. This can include:

- Water from microclimate control;
- Cross cutting, docking and log handling;
- Large log sizes; and
- Unstable log piles.

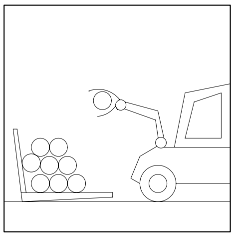
1. Microclimate control

The mud and standing water that results from spraying can create safety hazards. Even when drains and swales are in place, this continual flow of water can create a muddy environment that complicates truck and operator movement. This mud can also get on to logs and create a hazard during cross cutting, docking and sawing.

Figure 3.12. Mud associated with poor drainage in a sprinkled log yard

2. Cross cutting, docking and log handling

All states have requirements for the safe movement of heavy equipment, cross cutting, the use of chain saws, etc. All staff operations should comply with these requirements.



3. Large log sizes

Very large logs can create safety concerns. They are often close to or beyond the lifting capacity of site equipment and may exceed the capacity of the breakdown carriage. As primary breakdown is then done with a chain saw, considerable care is needed to ensure the operation is conducted safely.

4. Unstable log piles

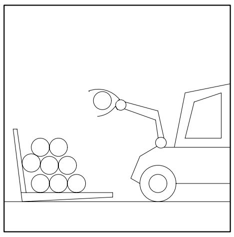
Log piles with logs piled too steeply or with logs out of parallel can create a safety hazard. Logs should be placed with care parallel to one another and chocked where necessary.

5. Major regulations

Major OH & S requirements relevant to this section are listed in Table 3.03. Note that this is not a complete list and other relevant codes and regulations may apply.

State	**Major code of practice**
Victoria	*Code of Practice – safety in forest operations,* Workcover Victoria
NSW	*Codes of Practice – Timber Industry*, Workcover NSW
Queensland	*Forest Harvesting: Industry Code of Practice* - QLD Division of Workplace Health & Safety
Tasmania	*Forest Safety Code,* Workplace Standards Tasmania

Table 3.03. Major safety codes of practice



3.3 Operations

3.3.1 Objective

The objective in the log yard is to accept, store and prepare logs for milling so that damage to the logs and surrounding environment is minimised.

3.3.2 Key Drying Factors in the Log Yard

1. Assessing log quality

The log provides the basic resource for the milling and drying process. Each log should be assessed to ensure that it is the correct grade for milling; sorted by species, age or type so that it can be milled and dried efficiently with other material in the operation; and suitable and ready for any required period of storage.

2. Avoiding damage to stored logs

Logs received and stored in the log yard continue to dry out. This drying can have significant effect on the end grain and outside surface of the logs. The timber in a log can also be damaged during handling and loading onto and off trucks and log piles.

3. Correct batching of logs going into the mill

Logs can be sorted into batches that have specific identified drying properties or requirements. Usually, these groups can be defined by: species; age and diameter class; and the log grade or intended product lines.

4. Recording basic log information

Information required for later process control has to be collected, checked and maintained correctly.

3.3.3 Preparation

1. Procedures

Procedures should be in hand for:

Grading logs	Marking and tagging logs
Segregating logs for storage	Staff accreditation
Log protection	Equipment
Segregating and preparing logs for milling	

2. Equipment

Saws and other equipment should be maintained in accordance with standard procedures.

Log marking, tagging and safety equipment should be in hand and operational.

3.3.4 Processing & Monitoring

1. Accepting delivered logs

Logs accepted into the log yard are the correct grade and size;

- Assess logs individually as soon as practically possible after delivery

Figure 3.13. Logs assessed quickly

- Confirm log grade and size.
- Mark and separate logs that do not meet grade requirements and size.

Logs are sorted to established rules for species, size and product group

- Sort logs into batches

Logs are tagged so that their major characteristics can be used effectively in later production stages.

- Tag logs with required information.

2. Log protection

Logs are end coated or stored in the log yard to minimise drying degrade.

- Seal ends of all logs immediately

Figure 3.14. All cut ends of logs are resealed immediately

- Restrain splitting logs.
- Place logs into storage as soon as possible.
- Place logs in piles that are parallel and safe, sound and stable.
- Place logs in the correct piles.
- Make sure water from the sprinklers covers the logs.

Figure 3.15. Sprinklers covering the logs well

Logs are handled in the log yard to minimise physical damage;

- Unload and handle logs with care. Do not drop them.
- Inspect logs regularly for handling damage.
- If damage persists, review log handling methods

Log storage facilities do not degrade the local environment

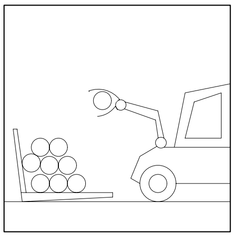
- Report any contamination of the local area or waterways.

3. Prepare the logs for milling

Logs are cross cut to maximise material recovery and useable size;

- Identify the grade marked on the log
- Look for degrade to the logs from storage such as end and barrel checks.
- Confirm log grade.

Figure 3.16. Measure the logs with a gauge



- Mark or re-grade logs that do not meet grade requirements.
- Clean dirty or muddy logs
- Measure out preferred length and mark cutting positions.
- Cross cut preferred lengths accurately and straight.
- Reseal cut ends immediately

3.3.5 Marks, Tags & Records

Information required for later production control is collected and associated with the logs effectively.

- Attach log tags.
- Maintain log tags through storage and regrading.
- Complete at least the following records:

Logs accepted	Logs regraded on arrival
Logs prepared for milling	Logs regraded after storage

3.3.6 Feedback

If noticed regularly, report any of the following to the supervisor:

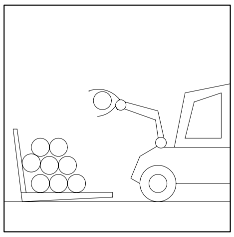
End splits	End or barrel checks
Transport damage	Unusual grade reducing defects
Decay in stored logs	Repetitive incorrect log grading
Log fractures	

3.3.7 OH&S

Maintain and wear all required safety gear. Ensure all protective guards and warning devices are operational

Inspect the log yard regularly. Identify potential hazards and eliminate them. In the log yard, this can include:

- Unstable logs on trucks;
- unstable logs on assessment decks or in storage;
- dangerous or damaged equipment;
- muddy or uneven roadways;
- broken fences and gates; and
- poor or no safety signage.



3.4 Checklists

Use this checklist to monitor key aspects of your operation. Mark each item on the following scale:

1	2	3	4	5
Very bad, never	Bad, rarely	Satisfactory, usually	Good, almost always	Very good, always

1. Accepting delivered logs

1a. Meeting log specifications

	1	2	3	4	5
Logs meet grade specification.					
Logs meet stated size.					
Logs meet delivery condition requirements.					
Non conforming logs separated for other treatment.					
Documentation confirmed to be accurate.					
Logs are marked with required information.					
Tags and marks are visible 1 meter from end of log.					

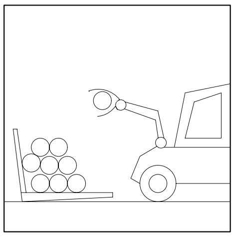
1b. Sorting to established rules

	1	2	3	4	5
Logs batched to site requirements for:					
• Species					
• Grade					
• Length					
• Like drying groups					
Batch identity marked.					
Batch records kept.					

2. Protecting the logs

2a. Log preparation and handling

	1	2	3	4	5
Logs meet requirements for end protection.					
Logs end sealed.					
Splitting logs restrained.					
Logs are handled with care.					

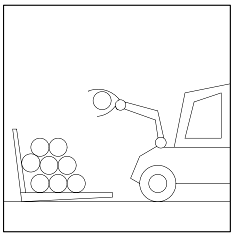


2b. Log Storage

	1	2	3	4	5
Log stacks are sound, stable and safe.					
All logs are clear of the ground on bearers.					
Sprinkler system operational.					
Stack watering regime applied to site specification.					
Stack watering covers the logs adequately.					
Ponding water and mud are reported.					
Logs are inspected occasionally for splits and checks.					

3. Preparing logs for milling

	1	2	3	4	5
The grade of logs from storage confirmed.					
Log degrade from storage identified and recorded.					
Logs crosscut to minimise capping and splitting.					
Logs accurately crosscut to preferred length.					
Logs batched by length for processing.					
Fresh log ends resealed immediately.					
Exposure of prepared logs minimized before processing.					
Identity of prepared log maintained and recorded.					



3.5 Avoidable Loss

Figure 3.17. Exposing logs to wind and sun for an unnecessarily long period of time can cause severe end and barrel checking

1. Grading and sorting of logs

- **Incorrect grading of logs-** Logs that are graded below their true grade are used for lower value applications. Logs that are graded above their true grade are rejected. Incorrect grading results from:
  - Incorrect examination; or
  - Incorrect docking.
- **Incorrect sorting of logs** - Logs that are sorted outside their species group or batch result in boards from the out of batch timber being exposed to inappropriate conditions. Incorrect sorting results from:
  - Inadequate examination; or
  - Missing log information.

2. Initial drying damage

- **Exposing the log to adverse drying conditions.** This can cause splits in the timber. Losses appear to be in proportion to properties of the species, and the time the log is exposed to these conditions. Unrestrained initial drying of the logs causes end or barrel checking. Drying damage occurs when:
  - Logs are not protected in a stack;
  - Water sprays or covers are not in place or maintained; or
  - End grain is exposed and not end coated.

3. Mechanical damage

- **Mechanical damage can shatters or weakens grain in the timber.** This leads to stress fractures, shakes and cracks in boards. Shatter or fractures can be caused by:
    - the gripping action of some mechanical harvesters;
    - logs being dropped;
    - general rough treatment of logs during harvesting; or
    - rough handling of logs in piles.

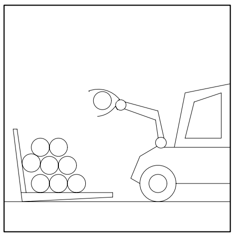
Figure 3.18. Mechanical damage to the log from a coupe or log yard visible in boards

4. Excessive or inappropriate cross cutting or docking

- If logs are excessively docked, potentially useful timber is cut off and discarded.
- Unnecessary early docking can reduce recovery as end splits open up again and checking may reform.
- If logs are crosscut at the wrong length, boards do no match rack support points. This leads to boards being unrestrained and suffering greater drying damage. This has to be docked off later in the process.
- If logs are not cut to the longest possible preferred length, the number of exposed board ends and the number of boards to be handled is increased. These can lead to more lost timber at a higher production cost.

5. Lost, obscured or ignored process information

- Adequate and visible process information (such a log tag or species identifier) is critical to the correct management and conduct of any production operation.



- Logs that are processed out of their proper batch have a much higher chance of drying degrade.

3.6 References

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4.0: – GREEN MILL

4.0 CONTENTS

4.0: – GREEN MILL

4.1 Objectives

The objective in the green mill is to convert logs to sawn boards or slabs of a pre-determined sawing pattern and specific dimension, then grade and deliver them to the pack or racking area with minimal damage.

4.1.1 Functions & Performance Requirements

1. Logs are sawn

Batch characteristics of logs are assessed and used to control processing.

Logs are sawn to boards or slabs to established rules for orientation, size and product.

Flitches are handled in the mill so that physical damage is minimal.

Board or slab thicknesses are accurate and consistent.

2. Boards are sorted and graded

Boards or slabs are graded consistently.

Boards are sorted into consistent species, size, grade and product group.

Boards are handled in the mill to minimise physical damage.

Boards are handled in the mill to minimise exposure to adverse drying conditions.

3. Maintaining product information

Information required for later production control is collected and passed with the boards effectively.

4. Identifying & reporting problems for correction

Details of individual and systemic problems are identified and distributed.

Problems are corrected.

5. Management of staff and equipment

Staff and equipment are available to conduct green mill activity safely and efficiently.

4.2 Management

4.2.1 Overview

Activity in the green mill is to convert logs to sawn boards or slabs of a pre-determined sawing pattern and specific dimension, then grade and deliver them to the pack or racking areas with minimal damage.

Sawing accuracy in the green mill is critical to several key drying factors, which contribute to economically producing quality dried hardwood.

Figure 4.01. Result of poor cutting

1. Logs are sawn

Sawing logs into boards is a complex field and further discussion is outside the scope of this document, except for those areas that influence the quality of dried boards. These are:

- Sawing pattern for quality & recovery;
- Overcut for drying;
- Sawing accuracy;
- Cutting and streaming batched and graded boards for the correct product; and
- Protecting the timber from drying and mechanical damage.

1a. Sawing pattern and method for quality & recovery

In the green mill, logs are sawn longitudinally into boards or slabs.

There are two basic approaches to cutting the board relative to the growth rings of the log. If the growth rings are generally at right angles to the face of the board, the board is known as a quarter sawn board. If the growth rings run generally parallel to the face of the board, the board is known as back sawn.

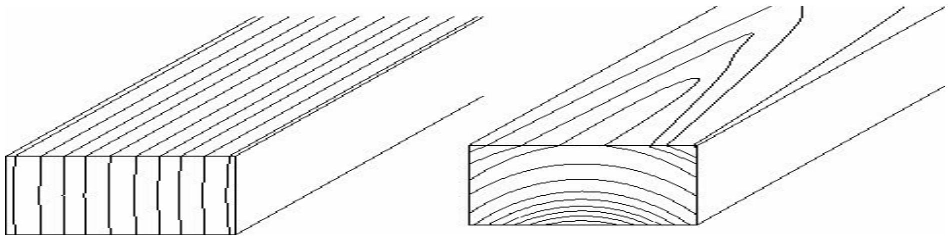


Figure 4.02. Quarter sawn and back sawn boards

In eucalypts, the timber shrinks considerably as it dries and the unit shrinkage is about twice the rate along the line of the growth rings (tangentially) as it is perpendicular to the growth rings (radially).

When a board is quarter sawn, the higher rate of shrinkage is across the shorter dimension of the board. In back sawn boards, the higher rate of shrinkage is across the longer dimension of the board. In high shrinkage species, this shrinkage can cause significant stress across the face of back sawn boards and lead to severe surface checks and a loss of grade. Both quarter sawn and back sawn timber can check while drying. However, for any given species or batch dried under the same conditions, the problem will be worse with back sawn material.

The sawing pattern selected depends on primary characteristics of the species and the intended final product. Non collapse prone, low shrinkage species can be quarter sawn or back sawn without major influences on the quality of the timber, though back sawn material can be more prone to surface checking.

Collapse prone and high shrinkage species usually have to be quarter sawn to regularly produce appearance grade products. Though quarter sawing generally reduces sawing recovery rates and width recovery of all grades, the recovery of appearance grade boards after drying is improved. The material also has a completely different visual character. For structural products, where checking is not a major grade determinant, boards of most sizes can be quarter sawn or back sawn.

Two sawing methods are commonly in use for high shrinkage and collapse prone species. These are:

- **Dimension cut**- In this method, logs are cut directly to a sawn dimension (nominal dimension plus overcut) before further processing; and
- **Slab cut**- also known as Saw, Dry, Rip (SDR). Slab sawing involves quarter and back sawing wane to pith slabs to the sawn thickness (plus overcut) of the desired product, racking and drying them to the desired moisture content and then ripping the dry boards to the final product width. In some mills, heart and sapwood affected timber is removed in the green mill before drying.

There are benefits and disadvantages to both methods. Some of these are set out in Table 4.01. There is still considerable debate about the most effective method. Some companies utilise both methods.

Dimension cutting	Slab cut
With thicker material, the back sawn edges (radial face) are exposed and can surface check.	Only the quarter sawn faces (tangential face) are exposed. Sacrificial wood (heart and sap) protects the back sawn edges. There are more transitional sawn boards that are not consistently back or quarter sawn boards.
The material doesn't have to be rehandled before final processing.	The material has to be ripped before final processing but can be cut to the most desirable sizes for current market demand from the available width.
Stock holdings of each size are known. These may or may not match the market.	The quantity or quality of material in stock is less well known.
Only the final material is dried. Dimensions cut boards also rack well and fill the kiln more efficiently.	A lot of material is dried that is eventually discarded. This limits kiln and predryer efficiency.
There is greater potential loss to spring and other distortion in the boards.	There is greater recovery on the best width of the cut. However, ripping to order can lead to significant material handling.

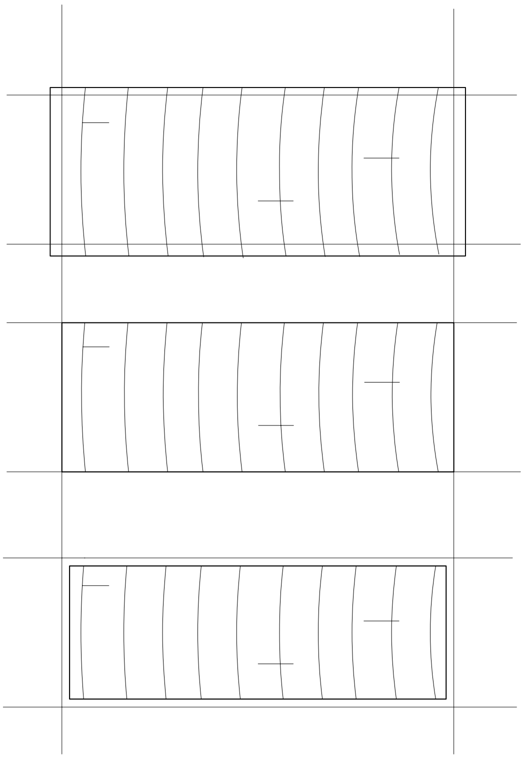
Table 4.01. Comparison of dimension and slab cutting

Non collapse prone, low shrinkage species are usually dimension cut, sawn directly to the overcut dimension for unseasoned boards.

2. Overcut for drying

Timber is generally sawn to produce a range of nominal dry dimensions. Thicknesses of 18, 25, 38 and 50 mm and widths from 25 to 350 mm are common.

However, from when it is cut until it is dry, milled and sold, the dimension of board changes through shrinkage and planing or moulding, so different terms are used to describe the actual size of the timber at each stage.



Dwg 6

Sawn dimension
The nominal dimension of the board plus an overcut to allow for shrinkage.

Nominal dimension
The intended size of the dry rough sawn board.

Machined dimension
The actual size of a machined or moulded board.

The amount of overcut should be developed recognising the species' drying characteristics, mainly the rate of shrinkage, the accuracy of sawing equipment and a realistic safety factor. This safety factor is usually higher in mills with older and less accurate sawing equipment. When a conservative safety factor is used, the boards are cut thicker, less material is recovered, the pieces dry more slowly and the cost of production goes up. When an unrealistically small safety factor is used, the boards are cut thinner. While initial recovery may increase, loss due to 'hit & miss' or 'skip' when machined or moulded also increases.

Common overcut allowance for selected species are include in Table 4.02.

		Thickness			Width		
Species	**Cut**	**25**	**38**	**50**	**100**	**150**	**200**
Tasmanian Oak	Q/s	28	43	56	110	165	218
Blackwood	Q/s	28	41	56	108	160	213
NSW Low Shrinkage Board	B/s	26	43		106	156	212
NSW High Shrinkage Board	Q/s	28	45		110	162	223
Northern NSW hardwood	B/s	28	41	56	110	165	
Qld Hardwood	B/s	27	40	54	106	160	212

Table 4.02. Common sawn dimensions for key species used by industry

There will always be compromises between the optimum overcut required for any species or batch and the number of standard sizes that can be practically handled in the mill. It is likely that sizes will need to be standardised so that there are a manageable number of standard green sawing targets on a site.

3. Sawing accuracy

The accuracy of sawing the boards to correct and consistent dimensions is critical to successful drying and further processing. If sawing is not accurate, out of specification material is dried and processed and:

- Material with less than the necessary overcut is discarded or downgraded due to hit and miss on the profile. It also dries at a different rate than other material;
- Uneven size in a board or between boards complicates rack and stack construction which can jeopardise drying quality, increasing the tendency for board to warp; and
- Oversize material blunts and clogs milling equipment when machined or moulded resulting in increased loss at planer.

Run off (or taper of a board at the ends) is characteristic of sawing on a breast bench or continuing to 'board off' sprung flitches without a straightening cut.

Sawing accuracy is the most important factor to monitor during the sawing process. Boards should be checked for dimension at regular intervals and the cause of any persistent variations rectified.

Figure 4.03. Uneven board run off

4. Streaming boards for correct products

As logs are sawn, characteristics occurring in the log become apparent and sawn boards of different grades are produced as a result. In general, sawn boards can be divided into two main categories, structural or appearance grade boards. The grading rules for appearance products are defined in **AS 2796-1999**: Timber - Hardwood - Sawn and milled products. The grading rules for structural products are defined in **AS 2082-2000**: Timber - Hardwood - Visually stress-graded for structural purposes.

Successfully dried appearance grade boards often have a greater value than dried structural grade boards. To preserve this value, they should be dried more carefully. To achieve this, boards have to be graded accurately and sorted into groups that have similar drying characteristics, such as species, age and thickness, and similar potential value. If logs have been batched before milling, most of the timber being produced at one time should have similar properties and only needs to be sorted by grade and size.

If logs have not been batched before milling, the sorting of sawn boards becomes more complex and it is likely that timber with varying drying properties will become mixed together. There is research under way into non-destructive means of measuring key drying indicators of individual boards.

Boards are sorted in a number of ways. The most common is for staff at a single grading station or area to mark each board with its grade (select, standard or high feature) or just separated into groups (i.e. appearance or structural). Boards are then sorted by grade and size on a green chain or a sorting line generally prior to loading on a packing or racking station.

4a. Docking

Docking is the cross cutting of a board to remove an undesirable characteristic, such as a split or a tapered end or to reduce the board to a more desirable length. As boards are cut from preferred length logs, they should only be docked before racking if the end of the piece presents an operational or safety hazard during later processing. For example, a board with a large knot in it may break during sorting or a tapered end board may jam in the feed line of machinery. Both should be docked.

5. Protecting the timber

As soon as timber is cut from the log or flitch, it begins to dry as the fresh surfaces start to lose moisture and is therefore vulnerable to drying damage. In the early stages of drying, the shrinkage within boards is small, so it is rare (but not unknown) to see drying degrade start on the saw benches.

Most of the degrade that arises during green milling occurs as the timber is sorted on the green chain. Microscopic and generally undetected small checks can form creating a weakness that can expand during further drying.

To protect the timber during sorting and subsequent assembly into racks or packs, the ambient environment around the board should be controlled by lowing temperatures, reducing air speed and increasing humidity. Ways of achieving this include:

- **Complete enclosure with environment control.** The sorting and assembly area is completely enclosed in a building that has temperature and humidity control;
- **Complete enclosure.** The sorting and assembly area is completely enclosed in a building. This reduces extremes of temperature, keeps the timber out of the sun and minimises air movement. It also provides staff with a more comfortable environment and encourages productivity and accuracy;
- **Complete roofing.** The sorting and assembly area is covered by a roof. This reduces extremes of temperature and keeps the timber out of the sun. It also provides staff with some shelter. Water sprays may also be installed; and
- **Partial roofing.** Generally, a roof only covers the sorting area. This reduces temperature extremes on boards on the green chain and provides staff with some shelter.

While the extent of loss avoided by protecting the timber depends on the species, product and local ambient conditions, maximum recovery is achieved by protecting the boards in at least a fully enclosed building.

Figure 4.04. High value boards in an aggressive climate stacked under local environmental protection

4.2.2 Equipment Options

1. Fixed equipment

Green sawing is conducted in a wide variety of ways from hand operated breast benches to complex band and circular saw combinations. While important in other ways, the mechanics of cutting are not critical to drying if the sawn material is accurately cut.

Equipment for sorting and batching material varies significantly. Some of the equipment options available and in use are shown below. The major drying concern during this process is that the timber be sorted accurately and is protected during initial drying.

Figure 4.05. A fully enclosed linear green chain grading table. The racking and stacking positions are protected from the weather

Figure 4.06. A covered linear green grading chain. The racking and stacking positions are exposed to the weather

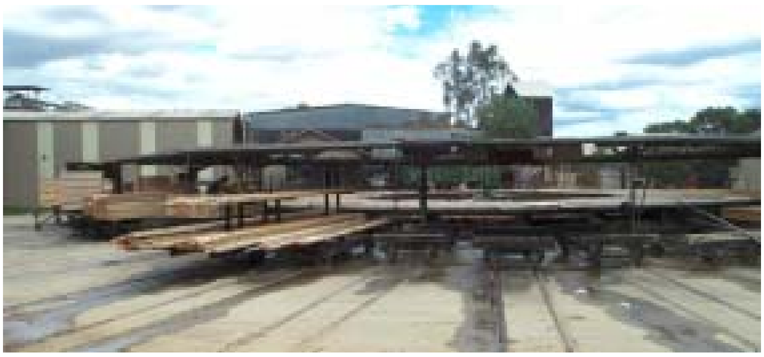


Figure 4.07. A covered circular green grading chain. The racking and stacking positions are exposed to the weather

Figure 4.08. A mechanical line sorter. Boards of the same grade and dimension are distributed to racking or stacking positions along sets of chains. The racking staff and boards are exposed to the weather

Figure 4.09. A pocket sling sorter. Boards of the same grade and dimension are assembled into groups before progressing to a stacker or racking machine

2. Monitoring Equipment

2a. Sawing accuracy

The simplest system for checking the timber's thickness regularly is to use a size gauge. Effective gauges can be:

- a rectangle of aluminium with rebates on each side that match standard sawn board sizes. The board size is engraved or stamped near each rebate; and

Figure 4.10. A thickness gauge used to check sawing accuracy

- a rectangle of aluminium with a stepped rebate on each side that match the tolerance limits for standard sawn board sizes. The first step of the rebate matches the maximum allowable size while the second step of the rebate matches the minimum allowable size. When the gauge is placed on board, it should fit into the first step of the rebate but not into the second step. Again, the board size is engraved or stamped near the rebate.

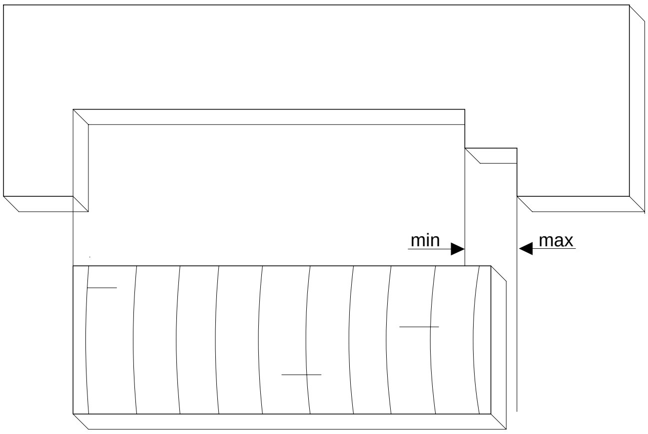


Figure 4.11. A thickness gauge allowing for a tolerance in the board size

Both these light and easy to use gauges can be used to quickly identify and confirm material outside acceptable tolerances. If there is more than one set of standard sizes operating in a mill, two gauges can be used but they should be clearly colour coded.

4.2.3 Green Mill Strategy

1. Logs are sawn

Batch characteristics of logs should be assessed and used to control processing. To do this:

- Batch integrity should be maintained as logs enter the mill for processing;
- Logs should be processed in batches for discrete and manageable production periods; and
- The relationship between batch characteristics and the character of the sawn boards should be reviewed regularly.

Logs should be sawn to boards or slabs to established rules for orientation, size and product. To do this:

- Sawing orientation and milling procedures should be readily available and understood;
- Target product groups and required sawn dimensions and tolerances are identified and understood;
- Logs should only be sawn by trained and qualified operator;
- Board should be regularly checked to ensure correct sawing orientation, dimension, product and grade; and
- Observed characteristics should be reviewed regularly.

Flitches should be handled in the mill so that physical damage is minimal. To do this:

- Milling operations should be observed regularly to identify potential points of flitch damage; and
- Flitches should be closely inspected periodically for splits, or grain shatter.

Board or slab thicknesses should be accurate and consistent. To do this:

- All guides, gauges saws and other equipment necessary to maintain sawing accuracy should be maintained regularly; and
- Boards should be checked for size and sawing deviation at regular intervals.

2. Boards are sorted and graded

Boards or slabs should be graded consistently. To do this:

- Grading rules should be readily available and understood;
- Boards should only be graded by trained timber graders; and
- Graders should discuss and review observed characteristics regularly.

Boards should be sorted into consistent species, size, grade and product group. To do this:

- Product and drying batch / group requirements should be readily available and understood;
- Boards should only be sorted by trained and qualified timber graders;
- Marking procedures should be identified and confirmed; and
- Graders / sorters should discuss and review observed characteristics regularly.

Boards should be handled in the mill to minimise physical damage. To do this:

- Milling operations should be observed regularly to identify potential points of board damage; and
- Boards should be closely inspected periodically for splits, or grain shatter.

Boards are handled in the mill to minimise exposure to adverse drying conditions. To do this:

- Sorting and grading areas should be continually protected from adverse drying conditions including direct sunshine, high temperatures, significant air velocity (breezes) and low humidity; and
- Boards should be closely inspected periodically for any indications of checks or splits.

3. Maintaining product information

Information required for later production control is collected and passed with the boards effectively. The requirements for this are in Section 4.2.5.

4.2.4 Quality Control

Procedures should be established for:

Procedure	**General contents**
Log input	Requirements for maintaining batch requirement from the log yard through periods of production.
Saw performance	Performance specification for sawing equipment.
Sawing orientation and milling	Sawing orientation required by species and product. Sawing method.
Product specification	Grade, Size, Overcut and Batch requirements for product groups including verification processes.
Grading	Company and standards based grading rules for appearance, structural and other dried material.
Drying group	Sorting requirements for products or grades into groups to be dried together.
Verification	Confirmation of size, grade and other key characteristics.
Marking and tagging logs	Identification requirements for grade and sorting.
Staff accreditation	Training, qualifications.
Equipment	Maintenance.

4.2.5 Information Management

1. Required attributes

Information required for later process control should be collected. This includes the following:

Required process control information	
Unique identification numbers of logs milled	Milling time and date
Staff number	Staff comments
Batch type	
Desirable additional information.	
Saw line number	Noted log defects

Table 4.03. Attributes required or desirable from green milling

2. Records and tagging systems

Log tags should be retained as logs are processed and recorded against the boards processed that period.

4.2.6 Equipment Maintenance

1. Storage facilities

Roadways should be safe and trafficable in all weather conditions.

The log yard should be regularly maintained to ensure stability of loaders and forklifts.

2. Handling equipment

Handling equipment should be maintained so that the expected maximum log load and placement distance remains within the safe working capacity of log handling equipment.

3. Sawing and sorting equipment

Sawing and sorting equipment should be maintained so that the expected maximum flitch and board load remains within the safe working capacity of the equipment and the required sawing accuracy can be achieved.

4.2.7 OH&S

Major OH & S requirements relevant to this section are listed in Table 4.04. Note that this is not a complete list and other relevant codes and regulations may apply.

State	Major code of practice
NSW	*Codes of Practice for the Sawmilling Industry* – Workcover Authority
Victoria	Victorian Workcover Authority
Tasmania	*Code of Practice for Sawmill Operation* – Tasmanian Forest Industries & Workplace Standards Tasmania
QLD	*Sawmilling Industry Health & Safety Guide* – QLD Division of Workplace Health & Safety
WA	*Timber Milling and Processing Occupational Safety & Health Code*- FIFWA

Table 4.04. Major safety codes of practice

4.3 Operations

4.3.1 Objective

Activity in the green mill is to process logs to sawn boards or slabs of a pre-determined sawing pattern and specific size, then grade and deliver them to the pack or racking area with minimal damage.

4.3.2 Key Drying Factors in Green Mill

1. Sawing pattern for quality & recovery

The sawing pattern selected, either quarter sawn or back sawn, depends on the primary characteristics of the species and products being sawn.

2. Overcut for drying

The overcut on an unseasoned board is to allow for the board to shrink to the nominal dimension suitable for milling into a dry board of a final target thickness and width.

3. Sawing accuracy

Sawing the board to the correct dimension accurately and consistently is critical to successful drying and further processing. If sawing is not accurate, out of specification material is dried and processed.

4. Cut and stream batched and graded boards for the correct product

The boards have to be graded accurately and sorted into groups that have similar drying characteristics, such as species, age and thickness, and similar potential value.

5. Protecting the timber from drying and mechanical damage

As soon as timber is cut from the log, it begins to dry as the fresh surfaces start to lose moisture. Boards are then vulnerable to drying damage. Most of the drying degrade that arises during green milling is likely to occur as the timber is sorted on the green chain.

4.3.3 Preparation

1. Standards

- **AS 2796-1999**: Timber - Hardwood - Sawn and milled products
- **AS 2082-2000**: Timber - Hardwood - Visually stress-graded for structural purposes
- Company or Customer Product Specification

2. Procedures

Procedures should be in hand for:

Log input	Verification
Saw performance	Marking and tagging logs
Sawing orientation and milling	Completing records
Product specification	Staff accreditation
Grading	Equipment
Drying group	

3. Equipment

Saws and other equipment should be maintained in accordance with the standard operating procedures.

Board marking equipment should be available and operational.

4.3.4 Processing & Monitoring

1. Logs are sawn

Batch characteristics of logs are assessed and used to control processing.

- Identify logs grade and batch correctly.
- Plan for optimum volume and quality of recovery from the log.

Logs are sawn to boards or slabs to established rules for orientation, size and product.

- Use the specified cutting patterns.
- Cut to:
  1. Correct grain orientation (back or quarter sawn); and
  2. Correct size (especially thickness).

Figure 4.12. Correct size	**Figure 4.13. Incorrect size**

Logs and flitches are handled in the mill with care.

- Do not drop or throw flitches.

Board or slab thicknesses are accurate and consistent.

- Check board and slab thickness regularly.

Figure 4.14. The thickness of boards must be checked regularly

- Report size inconsistencies immediately.
- Rectify sawing problems.

2. Boards are sorted and graded

Boards or slabs are graded consistently.

- Grade boards to relevant standards.
- Mark the grade of the board clearly.
- Mark & separate boards that do not meet grade requirements and size.

Boards are sorted into consistent species, size, grade and product group.

- Confirm production batch.
- Identify board grade.
- Sort board into the correct grade batch.
- Move sorted boards to the correct area.

Boards are handled in the mill with care.

- Do not drop or throw boards.

Boards are handled in the mill to minimise exposure to adverse drying conditions.

- Do not leave boards in the sun.

Figure 4.15. Protected Boards stacked under shelter

- Move boards out of hot or windy places as soon as possible.
- Maintain covers, roofs, sprinklers or humidity control.

4.3.5 Marks, Tags & Records

Information required for later production control is collected and associated with the logs effectively.

- Maintain and collect log tags.
- Mark boards with grade and, if necessary, size and batch.
- Complete at least the following records:

Logs milled	Production tally
Out of grade boards segregated.	

4.3.6 Feedback

If noticed regularly, report any of the following to the supervisor:

End splits	Unusual grade reducing defects
Undersized or oversized boards	Incorrectly graded boards
Grain fractures	Incorrectly sorted boards
Surface checks	Boards exposed to the weather

4.3.7 OH&S

Maintain and wear all required safety gear. Ensure all protective guards and warning devices are operational.

Keep work areas clean, tidy and clear of trip hazards such as wire and strapping ends, and pieces of timber.

Inspect the green mill regularly. Identify potential hazards and eliminate them. In the green mill, this can include:

- Unstable logs on assessment decks or in storage;
- Unstable stacks of boards or flitches;
- Dangerous or damaged handling equipment;
- Damaged or unprotected saws;
- Broken fences and gates; and
- Poor or no safety signage.

4.4 Checklists

Use this checklist to monitor key aspects of your operation. Mark each item on the following scale:

1	2	3	4	5
Very bad, never	Bad, rarely	Satisfactory, usually	Good, almost always	Very good, always

1. Logs are sawn

	1	2	3	4	5
Logs batched to site requirements for:					
• Species.					
• Grade.					
• Length.					
• Like drying groups.					
Batch identity confirmed.					
Batch records kept.					
Sawing orientation and alignment correct.					
Emergent defects recognised and catered for.					
Production of low value grades and sizes minimised.					
Board or slab thickness and board width off the saw checked regularly.					
Size problems are identified and corrected at source.					
Logs, flitches, and boards are handled carefully.					
Batch identity maintained and transferred to board.					
The timber is not exposed to harsh drying conditions.					

2. Boards are sorted and graded

	1	2	3	4	5
Boards meet grade and size specification.					
Boards are marked correctly.					
Boards are sorted to the correct batch.					
Non conforming boards separated for other treatment.					
Identity of sorted and graded boards is maintained.					

Boards are handled carefully.					
The timber is not exposed to harsh drying conditions.					

4.5 Avoidable Loss

1. Logs are sawn

- **Lack of sawing accuracy** - Cutting boards under or over the allowable tolerances causes considerable loss of material and value. Processing irregular sized boards:
  - reduces correct support and restraint in the rack and reduces rack stability;
  - leads to boards of different thickness drying at a different rate;
  - increases unit production costs due to undersize boards not making grade, while oversize boards or clog milling equipment; and
  - decreases yield of dried milled product.
- **Excessive overcut allowance** - This reduces the number of boards recovered from the log, increases costs and reduces productivity.
- **Inappropriate sizing -** Cutting material into the incorrect sizes for the grade or not cutting the material straight results in a loss of return and profitability.
- **Inappropriate handling** - This causes stress fractures and splitting in the timber, especially in flitches, that later tend to develop into undesirable degrade such as checks.

Figure 4.16. Effect of poor sawing accuracy on a rack

2. Boards are graded and sorted

- **Exposing the timber to adverse drying conditions** - This tends to occur as freshly sawn boards are transferred to the packing area. Losses appear to be in proportion to properties of the species, and the time the boards are exposed to the conditions. Unrestrained initial drying of the boards causes end or surface checking.
- **Incorrect grading or batching** - Not batching material into the appropriate product group or grade leads to a waste of higher grade material and a loss in profitability. This occurs every time select or appearance grade material is graded as structural. As the timber will be subject to a harsher drying regime, the potential for degrade is higher.
- **Excessive or inappropriate docking** - This exposes further timber to splitting and complicates rack construction.

4.6 References

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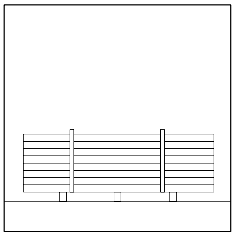
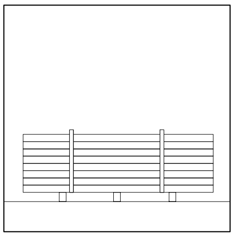
5.0: – GREEN PACK



5.0 CONTENTS

5.0: – GREEN PACK



5.1 Objectives

The objective during green packing is to pack, protect and transport sawn boards of the required size and grade with minimal inappropriate damage.

5.1.1. Functions & Performance Requirements

1. Packing the boards

Boards are end sealed to minimise uneven drying.

Boards assembled into packs are of consistent species group, grade and thickness.

Assembled packs are stable and rugged enough to be transported safely and without damage.

2. Protecting the packs from physical and drying damage

Packs assembled or stored in the green or drying mill or in transport are protected to minimise drying degrade.

Packs in transport and storage are handled to minimise physical damage.

3. Maintaining product information

Information required for later production control is collected and passed with the packs effectively.

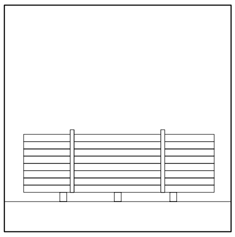
4. Identifying & reporting problems for correction

Details of individual and systematic problems are identified and distributed.

Problems are corrected.

5. Management of staff and equipment

Staff and equipment are available to conduct green pack activity safely and efficiently.



5.2 Management

5.2.1 Overview

1. Introduction

Activity during green packing is to pack, protect and transport sawn boards of the required size and grade with minimal inappropriate damage.

Packs (or slings) are bundles of timber boards that are transported from a sawmill to a drying mill. Often, this transfer is between companies so the form of the pack is not regularly under the direct control of the company responsible for the final drying of the boards. The packing stage is critical to producing quality dried hardwood economically as

- Key drying information about the boards in the pack must pass between sites and often companies; and
- Boards in a pack may be exposed to significant drying and mechanical damage.

2. Pack information

As packs are transferred between sites and companies, it is critical that:

- The boards are of a consistent species group, grade and thickness; and
- Sufficient information about the boards accompanies the pack.

Sorting and grading of boards is included in Module 4.0 Green Mill. At that stage, boards should be sorted into defined batches of material with similar drying characteristics. Batches can be defined by combinations of species, grade, product group, original log characteristics, such as age or diameter class, or other factors. For example, a pack may be of 25mm select regrowth Blue gum boards destined for flooring.

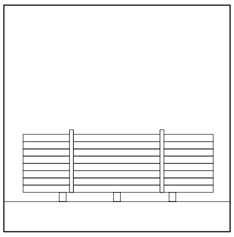
As packs are assembled, it is important that only boards of the required batch are included in a pack. In practice, particular packing stations can be dedicated to specific products or batches.

As the packs are transferred between sites, batch and other critical drying information must go with them so that those receiving the timber can identify the timber easily and process it the correct way.

3. Pack configuration

The faces and ends of freshly sawn boards start to lose moisture quickly and they are highly susceptible to initial drying damage, such as checking. While checks are not immediately evident, microchecks form and are points of weakness that grow later. Also, while boards are being sorted and packed, they are not restrained or protected by other boards. When in the pack, any exposed surface of boards continues to dry.

5.0: – GREEN PACK



The ideal pack has the least amount of exposed material for the amount of timber in the pack. This means that packs should be even rectangular prisms, with neat base, top, sides and ends.

Packs can be built in a number of ways. They can be assembled from boards of about the same length. Alternatively, boards of the full pack length are collected initially and laid out as the base of the pack. Other full pack length boards are used to form the sides of the pack. Shorter boards are then used to complete the inside rows. When the pack is strapped, the long boards on the base, sides and through the rest of the pack provide structural strength to the unit.

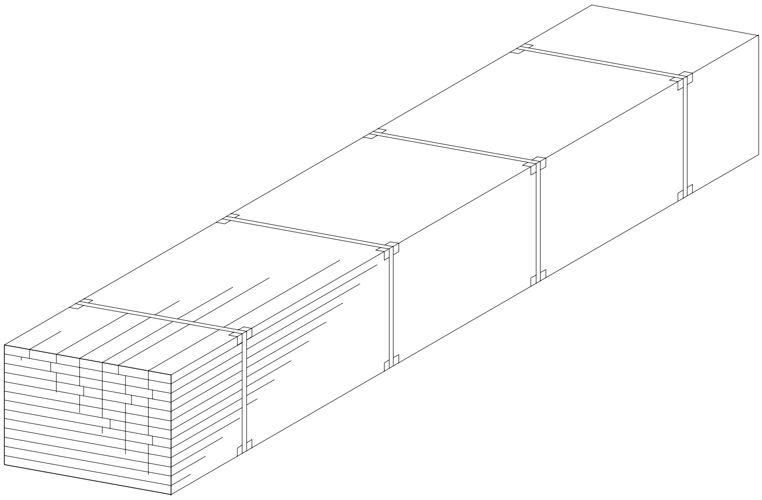
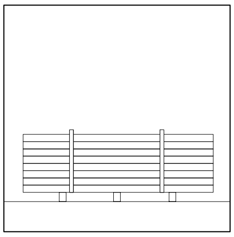


Figure 5.01. General arrangement of a pack

Figure 5.02. Desirable: Pack with even ends

Figure 5.03. Undesirable: Pack with uneven ends

Packs with one neat end and the other end staggered expose significant areas of timber to degrade and should be avoided.



4. Pack protection – During assembly and after receipt

4a. Drying Protection

As outlined in Module 3 Green Mill, the timber on the green chain and at packing stations is subject to uncontrolled drying. This continues after the timber is assembled into packs, while the packs are stored before transportation and after they are delivered to the drying mill. To protect the timber, the ambient environment where the packs are assembled and stored should be controlled to lower temperature, reduce air speed and increase humidity. Ways of achieving this include:

- **Complete enclosure with environment control.** This means in a building that has temperature and humidity control or in a building where local environment control is used around some packs;
- **Complete enclosure.** This means in an enclosed building that reduces temperature extremes and minimizes air movement;
- **Complete roofing with local environment control.** The roof keeps the timber out of the sun while local environment control protects valuable packs;
- **Complete roofing.** This keeps the timber out of the sun and reduces temperature extremes; and
- **Partial roofing.** Generally, a roof only covers the sorting area. This reduces temperature extremes on boards on the green chain but packs under assembly are exposed.

Local environmental control is when packs are protected as they are assembled and in storage with a cover of hessian, canvas or plastic. Given the packs are kept out of the sun, these covers can all reduce the temperature and air speed and increase the humidity around the timber. Care is needed when using impervious material such as plastic for local environmental control. If used for long periods or in warm weather, the high humidity and temperature trapped under the plastic can encourage mould growth on the timber.

The extent of loss avoided by protecting the timber depends on the species and local ambient conditions. Maximum recovery is achieved by protecting the boards as the packs are being assembled, before transport and after receipt at the drying mill in at least an enclosed building.

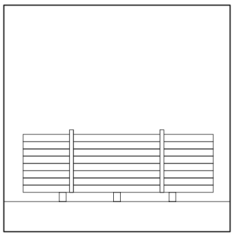
Figure 5.04. Collapse in exposed ends in packs

4b. Protection from mechanical damage

Packs are subject to mechanical handling that can cause impact or crushing damage to boards, particularly at the bottom and corners of the pack. This can be addressed by:

- taking more care in handling of the packs, or
- placing a sacrificial layer of material on the top and bottom of the packs. These can be lower grade boards, or material with wane that would otherwise be chipped. To ensure that this material is not confused with higher grade boards, the material should be obviously marked or visually distinct.

Figure 5.05. Waning boards as a pack cover. Any pack protection is better than no protection



Corner boards can also be damaged by binding strap. This can be avoided by using standard sheet metal, plastic, cardboard or timber corner protectors.

Figure 5.06. Desirable: Corners protected from pack straps

Figure 5.07. Undesirable: Corners crushed by pack straps

The integrity of the pack can be affected by how the packs are handled, stacked and stored. While the boards are strapped, they can still move relative to each other if the packs are unevenly loaded or positioned. Packs should be positioned on the ground on evenly spaced and relatively level bearers. These should be positioned within 300 mm of each end and at a maximum of 1.2 centres internally. Packs stacked on one another should be positioned on bearers as nearly as possible above the bearers on the ground.

4c. Board protection

Ideally, all logs being milled should have sealed end grain, so all boards should also be end sealed. Any boards not end sealed should be sealed as the pack is being assembled.

If packs are delivered and the boards are not end sealed, the blocked ends of the boards should be painted with sealer as soon as possible.

5. Pack protection – Transport

Timber in packs continues to dry during transport at a rate determined by the exposure conditions. Packs protected in a taut liner, or under a tarpaulin, are subject to lower temperatures, reduced air speed and increased humidity than packs exposed on the open tray of a truck. On the open tray, packs are exposed to the sun and heat radiated from the road, and to air speeds of up to 110 km /h (about 30.5 m/sec). This can cause significant damage to any exposed timber surface.

Figure 5.08. Packs exposed on a truck

Figure 5.09. End checking from exposure during transport

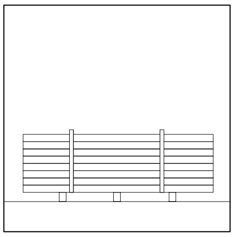
5.2.2 Equipment Options

1. Fixed equipment

Packs should be assembled in packing stations or on packing trolleys. These should provide a stable and flat platform for pack assembly and allow easy forklift access. Ideally, the station or trolley should have two square ends and one side. If not, they should have at least one end and one side.

2. Mobile equipment

Packs require careful handling. The safe working capacity of pack handling equipment should easily accommodate the expected maximum load and placement distance. Handling packs on the boundary of working capacity creates a safety hazard for staff and encourages practices that increase pack damage.



5.2.3 Green Pack Strategy

1. Packing the boards

Boards should be end coated to minimise uneven drying. To do this:

- End protection should be maintained through the sawing process;
- Any uncoated board in the assembled pack should have the ends sealed; and
- Any delivered packs that are not end-sealed should be sealed on arrival into the yard.

Boards assembled into packs should be of consistent species group, grade and thickness. To do this:

- Product and drying batch / group requirements should be readily available and understood;
- Marking procedures should be identified and confirmed;
- Grade and batch sorting from the green mill should be maintained to the packing station;
- Except for sacrificial layers on the top and bottom, only material of a single batch should be included in a pack;
- Graders and packers should discuss and review observed characteristics regularly; and
- Boards that do not meet requirements for the grade marked on them should be separated for future regrading or regraded.

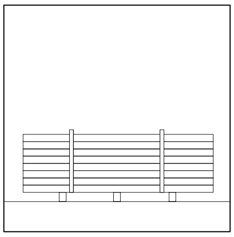
Assembled packs should be stable and rugged enough to be transported safely and without damage. To do this:

- Pack assembly requirements should be available and understood;
- Pack lengths should be adjusted to match the anticipated length of material being produced;
- Full length boards should be used for the bottom layer and be evenly distributed towards the sides of each layer for the full height of the pack;
- Packs should be bound with suitable transport straps; and
- The corners of packs should be protected at the strapping points.

2. Protecting the packs from physical and drying damage

Packs assembled or stored in the green or drying mill or in transport should be protected to minimise drying degrade. To do this:

- Pack protection requirements should be available and understood;
- Packs should be assembled and stored in an enclosed building, out of the sun and the wind;



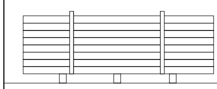
- If only protected by a roof, all packs should be out of the sun for at least 80% of daylight hours and local environmental controls should be used to protect high value packs; and
- Packs should only be transported between sites in taut liners or under covers such as tarpaulins.

Packs in transport and storage should be handled to minimise physical damage. To do this:

- Pack handling requirements should be available and understood;
- Packs should be adequately supported on evenly spaced bearers;
- Packs should only be handled by adequately rated, purpose designed equipment, operated by staff trained in its use; and
- Roads and loading and unloading areas should be safe, even and trafficable in all weather conditions.

3. Maintaining product information

Information required for later production control should be collected and passed with the packs effectively. The requirements for this are included in Section 5.2.5.



5.2.4 Quality Control

Procedures should be established for:

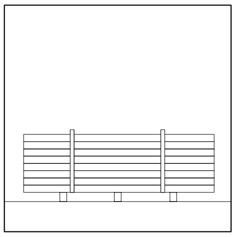
Procedure	**General contents**
Product specification	Grade, size, overcut and batch requirements for product groups including verification processes
Drying group	Sorting requirements for products or grades into groups to be dried together
Pack assembly	Pack size, assembly and binding requirements, including sacrificial and protection layers
Pack storage	Storage provisions including protection of high value packs, and shelter of other packs
Pack transport and handling	Allowable truck configuration, use of tarpaulins, forklift requirements
Marking and tagging logs and packs	Identification requirements for grade and sorting
Staff accreditation	Training, qualifications
Equipment	Maintenance

5.2.5 Information Management

1. Required attributes

Information required for later process control should be collected and passed with the packs effectively. This includes the following:

Required information on the pack	
Unique pack identification number	Pack grade
Pack supplier	Board thickness
Date pack complete	Board width
Batch type (species, age, etc)	Lyctus susceptibility
Required process control information	
Unique pack identification number	Board thickness



Staff number	Board width
Pack arrival / completion time & date	Board length
Pack supplier	Lyctus susceptibility
Batch type	Tally / tally number
Pack grade	Staff comments
Desirable additional information.	
Packer	Date packed started
Packing bay number	

Table 5.01. Attributes required or desirable from green pack

2. Marking & tagging

Recording methods must be suitable for all expected weather conditions and be easy to complete. A dry work area should be available close to the loading area to allow receipt of records.

Information required on the pack must be legible in normal daylight at least 1 m from the end of the pack. Primary segregation information, such as species or product, should also be marked on the pack so that it is visible from a forklift.

Pack tags should be of resilient and weather resistant material securely fixed to the pack. Ideally, they should be colour coded by grade, species or product group. Pens used to mark the tags should be permanent. Stamps or paint should be permanent and not be readily obscured by dust.

All tagging systems have to be able to survive any transshipment stage with less than a 0.5% loss rate.

Figure 5.10. Pack number on end coated packs

5.2.6 Equipment Maintenance

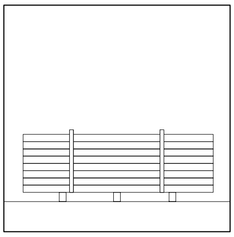
Handling equipment should be maintained so that the maximum expected load and placement distance remain within the safe working capacity of handling equipment.

5.2.7 OH&S

Major OH & S requirements relevant to this section are listed in Table 5.02. Note that this is not a complete list and other relevant codes and regulations may apply.

State	Major code of practice
Victoria	Victorian Workcover Authority
NSW	*Codes of Practice for the Sawmilling Industry* – Workcover Authority
QLD	*Sawmilling Industry Health & Safety Guide* – QLD Division of Workplace Health & Safety
Tasmania	*Code of Practice for Sawmill Operation* – Tasmanian Forest Industries & Workplace Standards Tasmania
WA	*Timber Milling and Processing Occupational Safety & Health Code-* FIFWA

Table 5.02. Major safety codes of practice



5.3 Operations

5.3.1 Objective

Activity during green packing is to pack, protect and transport sawn boards of the required size and grade with minimal inappropriate damage.

5.3.2 Key Drying Factors in Green Pack

1. Basic pack information

Key drying information about the boards must pass between sites and often companies.

2. Protecting the timber from drying and mechanical damage

As soon as timber is cut, it begins to season as the new surfaces start to lose moisture. It is then vulnerable to damage. In the green pack, this happens during assembly, transport and storage**.**

5.3.3 Preparation

1. Standards

AS 2796-1999: Timber - Hardwood - Sawn and milled products

AS 2082-2000: Timber - Hardwood - Visually stress-graded for structural purposes

Company or Customer Product Specification

2. Procedures

Procedures should be in hand for:

Product specification	Marking and tagging
Drying group	Completing records
Pack assembly	Staff accreditation
Pack storage	Equipment
Pack transport and handling	

3. Equipment

Packing stations and other equipment should be maintained in accordance with the standard procedures.

Pack marking and tagging equipment should be in hand and operational.

5.3.4 Processing & Monitoring

1. Packing the boards

Boards are end sealed to minimise uneven drying.

- Seal or set aside boards with untreated ends.

Boards assembled into packs are of consistent species group, grade and thickness.

- Confirm the boards' batch.
- Separate boards that do not meet grade and batch requirements.
- Pack sorted boards in designated areas.

Assembled packs are stable and rugged enough to be transported safely and without damage.

- Build packs with both ends aligned neatly and sides vertical.

Figure 5.11. Desirable: Neat sides and ends

Figure 5.12. Undesirable: Uneven sides and ends

- Place full length boards:
  - completely across the bottom layer; and
  - in every third layer up the sides of the packs.
- Slide boards onto the pack – Do not lift and drop.
- Use corner protectors or protection layers.

Figure 5.13. Desirable: Corner protectors

Figure 5.14. Undesirable: No corner protectors

- Strap packs so that they are solid and rigid.

Figure 5.15. Unevenly built packs with unsupported board ends

2. Protecting the packs from physical and drying damage

Packs assembled or stored in the green or drying mill or in transport are protected to minimise drying degrade.

- Protect all packs from adverse conditions.
- Do not store packs in the sun longer than absolutely necessary.

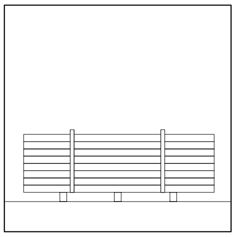


Figure 5.16. Packs exposed to the sun can be damaged

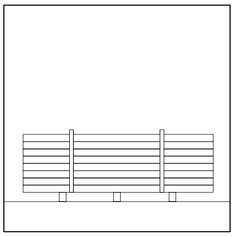
- Store delivered packs in an enclosed building out of the sun.
- Only transport packs in an enclosed trailer or under a tarpaulin.

Figure 5.17. Packs on open trucks can be damaged

- Do not transport packs on an open truck.

Packs in transport and storage are handled to minimise physical damage.

- Support packs on flat ground on solid bearers no more than 1.2 m apart.
- When stacking packs, place upper bearers directly over bearers on the ground.
- Stack packs no higher than 3 times the pack's width.



5.3.5 Marks, Tags & Records

Information required for later production control is collected and associated with the packs effectively.

- Tag packs with the required information.
- Mark packs with high visibility information if required.
- Maintain pack tags and marks during initial storage, during delivery and after receipt.
- Complete at least the following records:

Pack tally	Pack assembly information
Pack dispatch	Pack receipts

5.3.6 Feedback

If noticed regularly, report any of the following to the supervisor:

Boards not end sealed	Unusual grade reducing defects
Packs inadequately strapped	Repetitive incorrect sorting of boards
Packs transported on open trucks	Packs exposed to sunlight or other adverse conditions
Packs without neat ends and vertical sides	

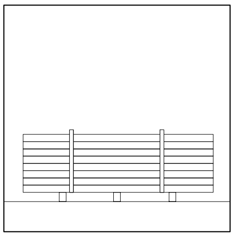
5.3.7 OH&S

Maintain and wear all required safety gear, including safety boots. Ensure all guards and warning devices are operational.

Keep work areas clean, tidy and clear of trip hazards such as wire and strapping ends, and pieces of timber.

Inspect the packing area regularly. Identify potential hazards and eliminate them. In the packing area, this can include:

- unstable packs on trolleys or in storage;
- dangerous or damaged handling equipment;
- broken fences and gates; and
- poor or no safety signage.



5.4 Checklists

Use this checklist to monitor key aspects of your operation. Mark each item on the following scale:

1	2	3	4	5
Very bad, never	Bad, rarely	Satisfactory, usually	Good, almost always	Very good, always

1. Packing the boards

	1	2	3	4	5
Boards in the packs are end sealed.					
Packs are made up of boards of a single batch type.					
Pack lengths match the board length.					
Packs are correct size.					
Assembled packs are solid and rigid.					
Packing straps are adequate and tight.					
Pack corners are protected.					
Packs are correctly, clearly and securely tagged.					
Packs are marked with required information.					
Tags are legible 1 meter from end of pack.					
Documentation completed accurately.					

2. Protecting the packs from physical and drying damage

	1	2	3	4	5
Packs are assembled in a protected position.					
Packs are stored out of the sun.					
High value packs are protected with local environmental controls.					
Exposed edges of high value packs are protected.					
Packs are covered or fully enclosed during transportation.					
Packs are supported evenly and adequately.					

5.5 Avoidable Loss

1. Packing the boards

- **Poor pack assembly -** This exposes an unnecessary amount of timber surface to adverse drying conditions. Boards can check and lose grade. Protruding ends of long boards in a short pack are regularly damaged, especially during transportation. Long boards are also subjected to creep. They bend and cannot be straightened.

2. Protecting the packs from physical and drying damage

- **Exposing the timber to adverse drying conditions** - Packing boards in the open, leaving packs unprotected on the truck, or leaving packs in the open can all damage the timber, cause checks to form and result in a loss of value. The damage and checks increase as the boards dry further and cannot be recovered.

Figure 5.18. Boards in packs of different lengths, supported unevenly and stacked in the sun dry unevenly and deform

Figure 5.19. Drying checks in the exposed ends and surfaces of boards left in the sun

5.6 References

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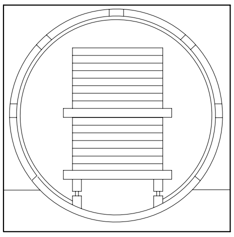
6.0: – BIOPROTECTION

6.0 CONTENTS

6.0: – BIOPROTECTION



6.1 Objectives

The objective of bioprotection is to protect the timber from insect or fungal attack during the drying process.

6.1.1 Functions & Performance Requirements:

1. Protecting the boards

Batch characteristics of packs or racks are assessed and used to control processing.

Packs of specific species are adequately treated with preservative to prevent fungal and insect attack during the drying process.

2. Protecting the packs from physical and drying damage

Packs stored in the mill or treatment area are protected to minimise drying degrade.

Packs in transport are protected to minimise drying degrade.

Packs in transport and storage are handled to minimise physical damage and loss of pack integrity.

3. Maintaining product information

Information required for later production control is collected and passed with the packs or racks effectively.

4. Identifying & reporting problems for correction

Details of individual and systemic problems are identified and distributed.

Problems are corrected.

5. Management of staff and equipment

Staff and equipment are available to conduct bio protection activity safely and efficiently.

6.0: – BIOPROTECTION

6.2 Management

6.2.1 Overview

Activity during bioprotection is to protect the timber from insect or fungal attack during the drying process.

As timber dries, it is susceptible to attack by fungus and insects.

Fungal attack can stain either the surface or body of a board and lead to a substantial loss in product value. Timber with a moisture content that remains above fibre saturation point (approximately 20-30% moisture content) is susceptible to fungal attack that can cause blue stain, mildew and mould on or within the wood. In locations subject to cold, damp and still winters or in racks sheltered from air movement for significant periods, the timber on the surface of boards can remain wet enough for the timber in racks to be affected by fungus. On sites where fungus has become established, susceptible racks can be infected very quickly.

To minimise fungal attack, the conditions that leave the timber susceptible to attack need to be modified or the timber chemically treated to increase its resistance to attack.

The timber of many Australian hardwoods is subject to insect attack prior to, during and after processing. The sapwood is especially susceptible as it retains starches from the growing tree. The most common and devastating attack for drying timber is from the lyctid borer. Lyctid borers are small wood-eating beetles that infect the starch rich sapwood of some hardwood timbers. Also known as "powder post borers", the most common lyctid beetle in Australia is *Lyctus brunneus.*

To be susceptible to lyctid beetle attack, the timber must have pores large enough for the female beetle to lay her eggs in, a relatively high starch content to sustain the growth of the larva, and a moisture content between approximately 8 and 25%. Lyctid attack can easily be seen as it produces mounds of fine powdery frass fine flour-like sawdust) from small holes in the wood. These holes are about 1-1.5mm in diameter.

Milling timber that includes *lyctus* susceptible sapwood presents significant production and marketing difficulties. Timber containing *lyctus* susceptible sapwood is particularly subject to infestation while drying in racks. **AS 2796-1999**: Timber - Hardwood - Sawn and milled products precludes *lyctus* susceptible material in appearance grade timber, while **AS 2082:2000***:* Timber - Hardwood - Visually stress-graded for structural purposes severely restricts it. Legislation overriding these standards in both New South Wales and Queensland prohibits the use of *lyctus* susceptible timber.

To eliminate the risk of infestation in susceptible species, the sapwood can either be removed during milling, which can dramatically reduce sawn recovery, or the sawn boards can be chemically treated. Chemical treatment needs to be performed in accordance with State legislation or to **AS 1604.1:2000:**

6.0: – BIOPROTECTION

Specification for preservative treatment - Sawn and round timber. Also relevant is **AS 1605**:**2000**: Sampling and Analysis of Wood Preservatives and Preservative Treated Wood. Treatment to at least hazard level 1 (H1) as defined in **AS 1604.1** is required to prevent *lyctus* infestation.

Treating timber

AS 1604.1-2000 lists most Australian hardwood species known to have *lyctus* susceptible sapwood. Similarly, state legislation, such as the Timber Utilisation and Marketing Act (TUMA) in Queensland, includes schedules that list either non-susceptible or susceptible species. The susceptibility of unknown timbers can be tested with a simple chemical test.

Timber is treated by impregnating the wood with chemicals. The type of chemical, the concentration retained within the piece and its penetration into the wood determines the level of protection against specific biological hazards.

The chemical is usually introduced by dip diffusion or infusion in a pressure cylinder.

Chemical treatments

Chemical treatments are prepared and marketed by a range of companies and organisations under varying trade names. The three major types of treatments used to protect hardwood timber during drying are:

- **Anti-sapstain treatments.** These fungicide solutions contain a range of chemicals including boron. They are designed to provide temporary protection to freshly sawn or debarked timber against sapstain fungi. Application is usually via dip, deluge or spray.
- **Boron based treatments**. Boron based preparations are both insecticides and fungicides. These preparations are currently available only as water-based preservatives and can be used as a vacuum-pressure or dip diffusion treatments. Waterborne boron can be applied to hardwoods either green or dry. Generally used as an insecticide, boron treatments are water-soluble and therefore are prone to leaching with continued wetting. These treatments are generally sufficient to protect the timber during drying and subsequent use in weather-protected applications.
- **Pyrethrum and permethrin based treatments**. Permethrin is a synthetic version of the natural insecticide, pyrethrum. They are highly effective insecticides and are readily biodegradable in the environment. Available as both a water based preservative and light organic solvent based preservative (LOSP), they can be used as a vacuum-pressure treatment or dip diffusion treatment.

Drying protection

As stated in Module 5, the timber in green packs can be subject to uncontrolled drying. This can continue after packs or racks are delivered to the treatment facility. To protection them, the ambient environment in assembly and storage area should be controlled in order to lower temperature, reduce air speed and increase humidity.

The extent of loss avoided by protecting the timber depends on the species of the boards, the local ambient conditions, and the time the timber is stored. Maximum recovery is achieved by protecting the boards in packs as they are being transported in treatment and after processing in at least an enclosed building

6.2.2 Equipment Options

1. Fixed equipment

The equipment that is required for treating timber varies with its intended purpose and level of treatment. It can include green chain dip baths, spray units, packet dip tanks, and pressure treatment cylinders. While the design and maintenance of treatment equipment is important, the mechanics of treatment are not critical to drying if the material is sufficiently treated.

Operation and control of treatment facilities is often subject to state environment and industrial legislation that covers safe handling and storage of chemical, the control of waste, maintenance of equipment and fumes. Standards covering the design and building of timber preservation plants are outlined in ANZECC guidelines and **AS/NZS 2843:2000**: Timber preservation plant safety code.

Figure 6.01. Fungicide treatment vessel and shed

Figure 6.02 Chemical treatment pressure cylinder

6.2.3 Bioprotection Strategy

1. Protecting the boards

Batch characteristics of pack or racks should be assessed and used to control processing. To do this:

- Timber requiring treatment should be clearly differentiated from other material when packs are assembled or delivered;
- Pack of unidentified or untagged timber or timber that may contain *lyctus* susceptible sapwood should be tested to determine if treatment is required. State legislation may require testing or treatment of unidentified material;
- Packs for treatment should be stored separately and segregated in accordance with the treatment hazard level required; and
- Packs should be clearly tagged before and after treatment. State legislation may outline specific labelling or branded requirements for treated timber.

Packs of specific species and grade should be adequately treated with preservative to prevent fungal and insect attack during later processing. To do this:

- Preservative treatment requirements should be available and understood;
- Packs of batches and grades liable to suffer grade loss from fungal attack should be treated with suitable fungicide at recommended rates;
- Packs of timber that contain *lyctus* susceptible sapwood should be treated to Hazard level 1 (H1) or in accordance with State legislation, or to **AS 1604**;
- Treated material and treatment performance should be tested regularly to ensure the retention and penetration rates are adequate; and
- Treatment and associated facilities should comply with the requirement of relevant regulatory authorities.

2. Protecting the packs from physical and drying damage

Packs stored in the mill or treatment area should be protected to minimise drying degrade. To do this:

- Pack protection requirements should be available and understood;
- Ideally, packs should be stored in an enclosed building, out of the sun and the wind; and
- If only protected by a roof, all packs should be out of the sun for at least 80% of the time and local environmental controls should be used to protect high value packs.

Packs in transport should be protected to minimise drying degrade. To do this:

- Packs should only be transported between sites in taut liners or under covers such as tarpaulins.

Packs in transport and storage should be handled to minimise physical damage and loss of pack integrity. To do this:

- Pack handling requirements should be available and understood;
- Packs should be adequately supported on evenly spaced bearers;
- Packs should only be handled by adequately rated, purpose designed equipment, operated by staff trained in its use; and
- Roads, loading and unloading areas should be safe, even and trafficable in all weather conditions.

3. Maintaining product information

Information required for later production control is collected and passed effectively with the packs or racks. The requirements for this are included in section 6.16.

6.2.4 Quality Control

Procedures should be established for:

Procedure	**General contents**
Preservative treatment	Batches requiring fungal treatment, species requiring protection from lyctid borers treatment methods, treatment hazard level, penetration and retention
Preservative testing	Processes for sampling and testing treatment solution and treated material for penetration and retention
Treatment segregation	Identification of packs requiring treatment, separation from other material
Marking and tagging packs	Identification requirements for grade and sorting
Staff accreditation	Training, qualifications
Equipment	Maintenance

6.2.5 Information Management

Information required for later process control should be collected and passed with the packs effectively. This includes the following:

Required information on pack (prior to treatment)	
Treatment required	
Required information on pack (after treatment)	
Treatment received	Date treated
Required process control information	
Unique pack/rack identification number	Unique treatment charge record number
Staff number	Time and date loaded
Facility number	Staff comments

Desirable additional information	
Store location number	
In store time and date	Out of store time and date

Table 6.01 Attributes required or desirable for handling at the treatment facility

Required process control information	
Unique treatment record number	Operational conditions for each step in treatment
Staff number	Treatment start time & date
Facility number	Treatment end time and date
Intended treatment number	Staff comment
Treatment test number	

Table 6.02 Attributes required or desirable for treatment charge

1. Marking & tagging

Recording methods must be suitable for all expected weather conditions and be easy to complete. A dry work area should be available close to the treatment area to allow receipt of records.

Information required on the pack must be legible in normal daylight at least 1 m from the end of the pack. Untreated packs should have a clear and unique tag that treatment is required. Treated packs should have a clear and unique tag of the treatment received.

Pack tags should be made of resilient and weather resistant material and securely fixed to the pack. Ideally, they should be colour coded. Pens used to mark the tags should use permanent ink. Stamps or paint should be permanent and not be readily obscured by dust.

All tagging systems have to be able to survive any transhipment stage with less than a 0.5% loss rate.

Figure 6.03. Timber marked for treatment

6.2.6 Equipment Maintenance

Operation and control of treatment facilities is subject to state environment and industrial legislation.

6.2.7 OH&S

Timber preservatives are hazardous to operators, co-workers and the surrounding environment. Companies that make and distribute preservative treatments generally provide safety, handling and operational instructions with their products. State and other regulatory authorities also issue advice and have regulations that control the use of preservative chemicals.

Any handling or use of preservative treatments should be in strict accordance with the manufacturer's instructions and any additional regulatory requirements. This will generally be in the form of a Material Safety Data Sheet (MSDS), which will outline the proper procedures for handling or working with a particular substance. In particular, MSDSs include information such as physical data (melting point, boiling point, flash point etc), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment and spill/leak procedures.

The following codes of practice may also apply:

State	**Major code of practice**
NSW	*Codes of Practice for the Sawmilling Industry* – Workcover Authority
Victoria	Victorian Workcover Authority
QLD	*Sawmilling Industry Health & Safety Guide* – QLD Division of Workplace Health & Safety
Tasmania	*Code of Practice for Sawmill Operation* – Tasmanian Forest Industries & Workplace Standards Tasmania
WA	*Timber Milling and Processing Occupational Safety & Health Code*- FIFWA

6.0: – BIOPROTECTION

6.3 Operations

6.3.1 Objective

The objective of bioprotection is to protect the timber from insect or fungal attack during the drying process.

6.3.2 Key Drying Factors in Bioprotection

1. Protecting the boards

As timber dries, it is susceptible to attack by fungus and insects. Fungal attack can stain either the surface or body of a board and can lead to a loss in value. In particular, the sapwood of many Australian hardwoods is subject to insect attack due to the presence of starch. The most common and devastating attack for drying timber is from the lyctid borer. These small wood-eating beetles infect and eat away the starch rich sapwood. They can easily be identified by the presence of frass (flour-like sawdust) surrounding affected timber. Timber likely to be affected by fungus or insect attack needs to be protected with preservative chemicals.

2. Protecting the timber from drying and mechanical damage

Timber in green packs or slings is vulnerable to damage as the timber begins to dry. In the green pack, this happens during assembly, transport and storage.

6.3.3 Preparation

1. Standards

AS 1604.1:2000: Specification for preservative treatment - Sawn and round timber.

AS/NZS 2843:2000: Timber preservation plant safety code.

Chemical manufacturer's recommendations and material safety data sheets (MSDS).

- Relevant state legislation and regulatory requirements.

2. Procedures

Procedures should be in hand for:

Preservative treatment	Marking and tagging packs
Preservative testing	Staff accreditation
Treatment segregation	Equipment

3. Equipment

Treatment and other equipment should be maintained in accordance with the standard procedures. Pack marking and tagging equipment should be available and operational.

6.3.4 Processing & Monitoring

1. Protecting the boards

Batch characteristics of pack or racks are assessed and used to control processing.

- Clearly mark packs of batches requiring treatment at packing or on arrival.
- Identify and test any untagged or unidentified timber for *lyctus* susceptibility.
- Store and segregate packs for treatment in accordance with the hazard level of treatment required.

Packs of specific species are adequately treated with preservative to prevent fungal and insect attack during later processing.

- Confirm moisture content of timber.
- Ensure preservative solution strength is appropriate for application.
- Apply and monitor appropriate treatment processes/cycles.
- Confirm effectiveness of treatment.
- Mark treated packs.

6.0: – BIOPROTECTION

2. Protecting the packs from physical and drying damage

Packs stored in the mill or treatment area are protected to minimise drying degrade.

- Protect all packs from adverse conditions.
- Do not store packs in the sun longer than absolutely necessary.

Figure 6.04 Packs in the sun can be damaged

- Store delivered packs in an enclosed building out of the sun.

Packs in transport are protected to minimise drying degrade.

- Only transport packs in an enclosed trailer or under a tarpaulin.

Figure 6.05. Packs on open truck can be damaged

- Do not transport packs on an open truck.

Packs in transport and storage are handled to minimise physical damage and loss of rack integrity.

- Support packs on flat ground on solid bearers no more than 1 200 mm apart.

- When stacking packs, place upper bearers directly over bearers on the ground.
- Stack packs no higher than 3 times the pack's width or less depending on site risk assessment.

6.3.5 Marks, Tags & Records

Information required for later production control is collected and passed with the packs or racks effectively.

- Tag packs with the required information.
- Maintain other pack tags and marks during storage and treatment.
- Complete at least the following records:

Charge records	Pack process records
Pack receipts	Pack dispatch

6.3.6 Feedback

If noticed regularly, report any of the following to the supervisor:

Packs stored in treatment areas without tags	Repetitive machine difficulties
Damaged tags	Any chemical spillage
Unexplained difficulties with the treatment process.	Packs exposed to sunlight or other adverse conditions
Unusually grade reducing defects	

6.3.7 OH&S

Maintain and wear all required safety gear. Ensure all guards, containment systems and warning devices are operational.

Keep work areas clean, tidy and clear of trip hazards such as wire and strapping ends, and pieces of timber.

Inspect the treatment area regularly. Identify potential hazards and eliminate them. In the treatment area, this can include:

- unstable packs on trolleys or in storage;
- damaged or inadequate personal protective equipment;
- dangerous or damaged handling equipment; and
- poor or no safety signage.

Handle and store chemicals strictly in accordance with the manufacturer's instruction and any regulatory requirements.

6.40 Checklists

Use this checklist to monitor key aspects of your operation. Mark each item on the following scale:

1	2	3	4	5
Very bad, never	Bad, rarely	Satisfactory, usually	Good, almost always	Very good, always

1. Protecting the boards

	1	2	3	4	5
Packs needing treatment are stored separately.					
Packs needing treatment are tagged with the treatment required.					
Unidentified or untagged material identified.					
Treatment period is adequate.					
Packs are tagged after treatment.					
Treated packs are tested for retention and penetration.					
Treatment records are completed.					
Chemical are stored to manufacturer's recommendations and regulatory requirements.					
Chemicals are used to manufacturer's recommendations and regulatory requirements.					
Treatment equipment is maintained to manufacturer's recommendations and regulatory requirements.					
Safety equipment is maintained to manufacturer's recommendations and regulatory requirements.					

2. Protecting the packs from physical and drying damage.

	1	2	3	4	5
Packs are stored out of the sun and wind.					
High value packs are protected with local environmental controls.					
Exposed edges of high value packs are protected.					
Packs are covered or fully enclosed during transportation.					
Packs are supported evenly and adequately.					

6.5 Avoidable Loss

1. Protecting the boards

- **Inadequate fungal treatment** - Fungal stain effects the timber and material is either downgraded because of resulting stains, or the stain has to be milled off, leading to loss of size. Both can lead to a significant loss in value.
- **Inadequate insect protection** - Insects infect the timber and all inadequately treated material is damaged. Size is lost as affected timber is milled off, or the board is discarded completely.

2. Protecting the packs from physical and drying damage

- **Exposing the timber to adverse drying conditions**. Leaving packs unprotected on the truck or in an open storage area can damage the exposed timber. This damage can cause small checks to open that allow water into the boards during subsequent drying, or open further as the boards dry. They lead to a loss of grade and value.

6.6 References

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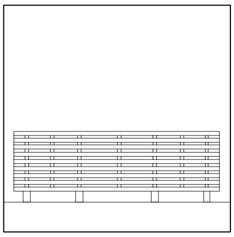
7.0: – RACK TIMBER



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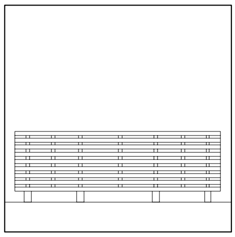
7.0: – RACK TIMBER



7.1 Objectives

The objective of racking timber is to space and restrain green sawn boards or slabs in a form suitable for the intended drying process and to transport them to the initial drying location.

7.1.1 Functions & Performance Requirements

1. Racking the boards

Unprotected boards are end coated to minimise uneven drying.

Boards assembled into racks are of consistent species group, grade and thickness.

Boards in assembled racks are adequately and evenly supported and restrained.

Rack sticks are sized and placed, and boards arranged so that the airflow through the assembled racks is even.

The dimension of assembled racks allows later production equipment and facilities to operate efficiently and effectively.

Assembled racks are stable and rugged enough to be transported safely and without damage.

Assembled racks are stable and even enough so that they do not experience or cause uneven loading when assembled into stacks.

2. Protecting the racks from physical and drying damage

Racks assembled or stored in the green or drying mill or in transport are protected to minimise drying degrade.

Racks in transport and storage are handled to minimise physical damage and loss of rack integrity.

3. Maintaining product information

Information required for later production control is collected and passed with the racks effectively.

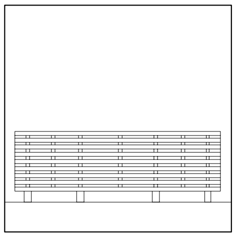
4. Identifying & reporting problems for correction

Details of individual and systemic problems are identified and distributed.

Problems are corrected.

5. Management of staff and equipment

Staff and equipment are available to conduct racking activity safely and efficiently.



7.2 Management

7.2.1 Overview

1. Introduction

Activity in racking timber is to space and restrain green sawn boards or slabs in a form suitable for the intended drying process and to transport them to the initial drying location.

A rack is a unit of timber where each row of boards is separated and spaced for drying with rack sticks. Correctly assembling the rack is vital to successfully drying, as the rack is the basic element handled through all the remaining stages of drying. The shape and arrangement of the rack influences:

- The restraint of individual boards;
- The consistency and quantity of airflow between the rows of timber;
- The effectiveness of air drying; and
- The quality and efficiency of controlled drying in predryers and kilns.

Poor racking practice can result in problems with that timber that will increase throughout the remaining stages.

The ideal rack has boards:

- of a batch of timber of similar grade, moisture content and drying characteristics;
- restrained and supported evenly along their full length and at both ends;
- spaced at regular intervals from boards in adjacent rows;
- assembled with very even sides and ends so that the airflow into the rack from any direction is as regular as practical; and
- arranged so that the rack is rugged and its dimensions are tuned to work neatly with other fixed equipment.

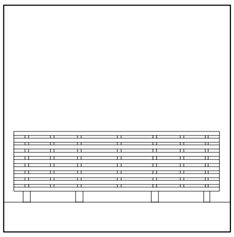
2. Batches and grading

The process of sorting, grading and batching boards is included in module 4.0 - Green Mill.

Boards or slabs in a batch should have similar drying properties. Batches can be defined by combinations of species, size, log age, log diameter class, grade, product groups or other factors. For example, 25mm select grade regrowth Blackbutt boards destined for flooring.

Boards should arrive at the racking station sorted into defined batches of material with similar drying characteristics. As all the timber in the rack will receive the same treatment, only boards of a single batch should be included in a rack.

7.0: – RACK TIMBER



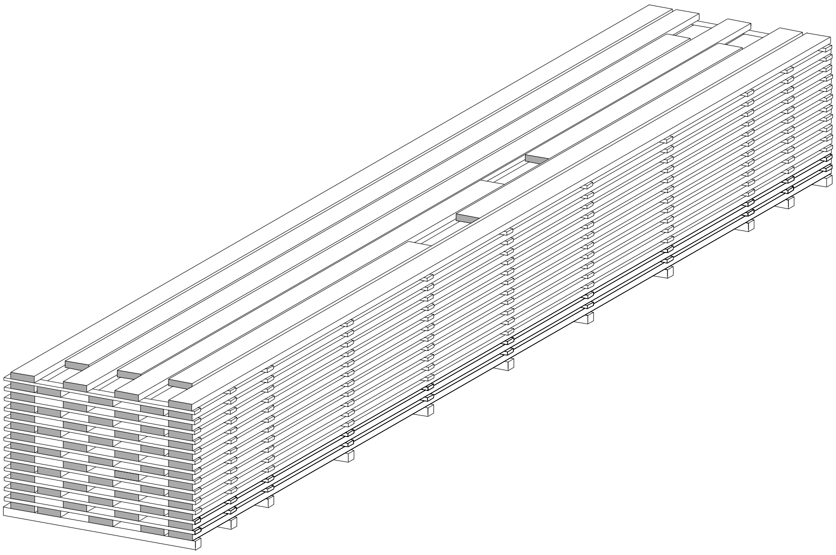


Figure 7.01. General arrangement of racks

3. Restraint and support of boards

Boards tend to distort as they dry with the ends of boards distorting the most. To dry flat and straight, boards need to be restrained at regular intervals along their full length.

In a rack, boards or slabs are restrained by the weight of timber above them and by any rack weights used. To allow air to circulate between the boards in the racks, the rows are spaced apart with rack sticks. These are strips of wood placed at right angles to the length of the boards between each row.

The characteristics of the species and the thickness of the material determine the required spacing of restraints. A thicker board is more rigid between points of restraint than thinner boards and so requires less restraint. Stick spacing also varies between racks with full length boards and those with random lengths.

Recommended rack stick spacings for different sawn board thickness are set out in Table 7.01.

Board thickness	**25 mm or more**		**Less than 25 mm**	
Rack type	Sorted length	Random Length	Sorted length	Random Length
Internal Spacing	600	450	450	350
End spacing *	300	300	250	250

Table 7.01. Maximum recommended rack stick spacing

* The reduction of spacing at the end of the rack serves two purposes. It increases the restraint at the end of the board, where distortion may be largest, and it ensures that boards slightly shorter than the preferred length have effective end restraint. In some circumstances, the extra stick may be unnecessary.

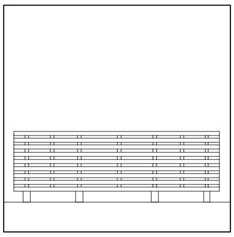


Figure 7.02 Inadequate rack stick spacing

If any regular deflection or distortion is noted in the boards at these spacings or the racks are of very high value material, the 600 mm maximum spacing should be reduced to 450 mm and the 450 mm to 300 mm.

To dry flat and straight, the boards need to be placed on rack sticks that are themselves flat, straight and of even thickness. To achieve this, rack sticks should be seasoned and milled to a standard thickness. Sticks that are not flat and of a standard thickness can cause distortion in the timber and instability in the rack. They should be discarded. Unseasoned rack sticks can twist and distort and can cause staining in the timber they support.

Figure 7.03 New dry and thicknessed rack sticks

Rack sticks support the weight of all the material above them and transmit it to the board below. Sticks narrower than 30 mm can indent boards on the bottom

of highly loaded racks stacks because of the reduced bearing area. If indentation is evident, use wider rack sticks. Sticks wider than about 40 mm can restrict drying at the areas of contact and may result in wet spots under the sticks.

4. Spacing the boards

The space between the rows of boards determines the volume of air that can flow through the rack and this strongly influences the rate at which the boards dry. Most hardwood species need to be dried relatively slowly, so the spacing between rows of timber is one variable that needs to be controlled. As all the timber in the rack should be dried at the same rate, the spacing between rows should also be regular.

The space between the rows of boards is determined by the thickness of the rack sticks. While there is theoretically an optimum thickness of rack stick for each product thickness, there are other means of controlling the potential air flow through a rack, such as sheltering racks in a yard or controlling air velocity in a predryer. To simplify site management and reduce the potential for errors, the thickness of rack sticks on a site should be standardised. Most sites use a standard thickness of about 20 mm.

On sites where production systems demand that rack sticks of differing thicknesses are used, sticks of different thicknesses should be colour coded and stored in separate bins.

All boards need to be fully restrained by the rack sticks. Rack sticks shorter or the same width as the rack may leave the edges of the outside board unrestrained. To avoid this, rack sticks should be at least 50 mm longer than the width of the rack.

5. Even and regular airflow

In air drying, predrying and kiln drying, it is necessary to ensure an even flow of air into and through the rack. To achieve this, racks should be assembled with the sides and ends flat, regular and even. Uneven sides and gaps tend to cause eddies and disruptions in the airflow. Air has a tendency to flow towards and through paths with the largest gaps, such as uneven board spacing at the ends of racks and bearer gaps in a stack. Uneven ends mean that the protruding ends of boards receive a greater airflow, dry faster and more likely to degrade. They also reduce the effectiveness of baffles in predryers and kilns and provide an easy path for circulating air around the racks, rather than through them. This reduces kiln efficiency and leads to uneven drying within the charge.

6. Dimensions of the rack

The dimension of assembled racks must allow other production equipment to operate economically and effectively. Their width, height and length should work into combinations that fill the available predryers, reconditioners and kilns efficiently.

Racks generally range in width from 1 m to 1.8 m. Most are around 1.5 wide. Racks have to be wide enough to be stable when assembled into stacks in the yard. There is a relationship then, between stack height and the necessary width of the rack. In addition, the wider the rack, the slower material in the centre of the rack tends to dry.

Rack heights vary from 0.9 to 1.5 m with 1.2 m being a common height.

Determining the correct length of racks requires balancing: the available log lengths; the sizes suitable for other equipment, such as forklifts, kilns and air drying yards; and the regularity of the lengths of boards being racked.

The best racks are made with boards of the same length or sorted to tight length groups. In these cases, the board ends can be adequately supported and it is much easier to ensure that the ends and sides of the rack are flat and even.

Figure7.04. A rack of short boards

It is not always possible to arrange or sort boards into tight length groups. In these cases, racks are built that match the longest common length of board expected, given that this size corresponds with a suitable module for the kilns and other equipment. This length is often 4.8 or 5.4 m.

While it is possible to build racks long enough to fill a kiln chamber or predryer, it is preferable to build racks that match a suite of common board lengths. Very long racks have several disadvantages. They are very difficult to handle with most equipment without damage to their general arrangement and it is very difficult to build them so that airflow through the rack is even.

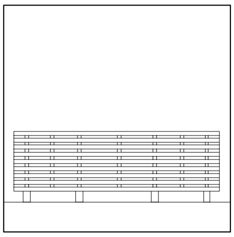


Figure7.05. Long rack of random length boards

Figure7.06. A very long rack

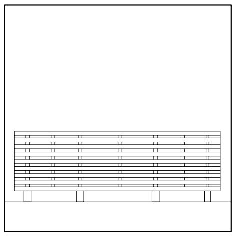
7. Board arrangement

When assembled manually, racks should be built with full length boards or slabs on their base and outside edges. Any boards less than full length should be arranged in the centre of rows in the rack so that alternate boards are neatly aligned to each end of the rack.

For machine assembled racks, it is often not possible to arrange the position of full length boards as timber is fed to the machine on a conveyer. In these cases, the longest boards available should be arranged to the outside of the row.

Boards are arranged close to each other in the row. As each row of timber is placed, alternative boards in alternative rows are kept flush with alternate ends. This gives a checkerboard arrangement at the ends of the rack and is called topping & tailing or push-pull racking.

7.0: – RACK TIMBER



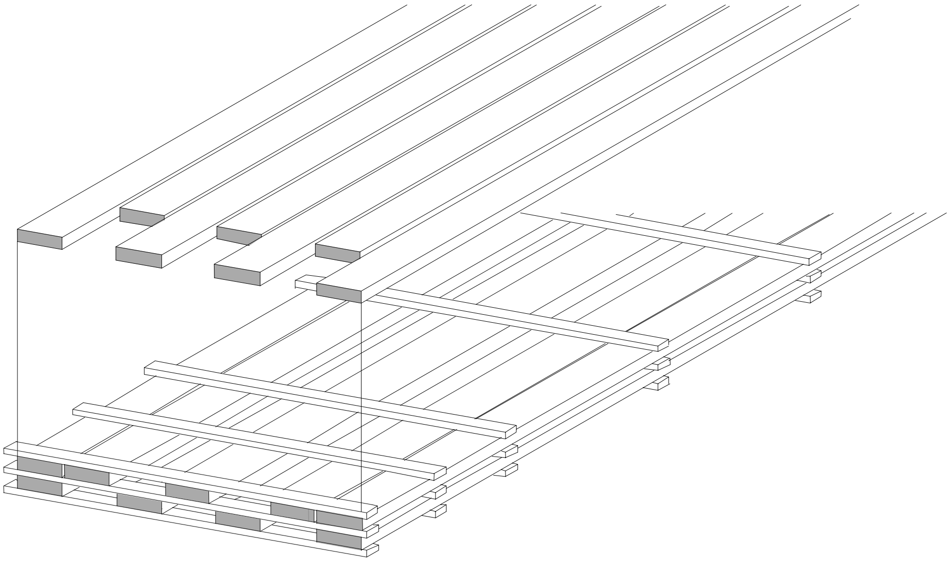


Figure7.07. Topping and tailing

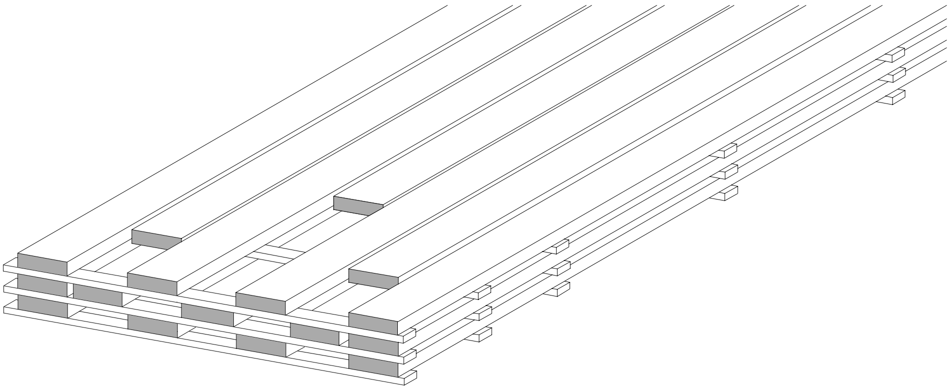


Figure7.08. Detail of topping and tailing

No board should overhang the last rack stick by more than 50 mm. Overhanging ends dry rapidly. This increases distortion, end splitting and end checking.

In this arrangement, the full length boards on the base and at the sides provide consistent airflow entry and exit paths and structural support for the rack. The alternating ends of the boards provide a relatively regular airflow at the end of the rack.

The length of short boards should be coordinated so that they match with the regular rack stick positions. The inside ends of shorter boards should either be butted together to share the one rack stick or else moved apart entirely so that they are firmly supported on separate rack sticks. However, the most important thing is that the ends of the racks are even.

Figure7.09. The checkerboard pattern of top and tail boards

To distribute loads evenly throughout a stack, rack sticks should be placed directly one above the other in a vertical line. As the rack is assembled, when it is complete and when it is repositioned, the rack sticks should be straightened so that they remain in vertical lines.

When complete, the sides of the rack should be flat, straight, and regular with evenly spaced gaps, the ends neatly squared off and rack sticks in regular vertical lines.

Figure7.10. A well constructed rack

8. Standardisation

The rack sizes, rack stick thickness, rack stick spacing, and racking frame arrangement should be standardised on any site. If racks are regularly bought in from another company, or transported in from other sites of the same company, they should also conform to the same standardised sizes and spacings.

9. Drying Protection

As stated in Module 04, the timber on the green chain and at racking stations is subject to uncontrolled drying. To protect the timber from damage, the ambient environment where the racks are assembled and stored prior to placing in the air drying yard should be controlled to lower high temperatures, reduce air speed and increase humidity. Ways of controlling conditions at the racking stations includes:

- **Complete enclosure with environment control.** This means in a building that has temperature and humidity control, or in a building where local environment control is used around some racks;
- **Complete enclosure.** This means in a building that reduces temperature extremes, eliminates direct sunlight and minimises air movement;
- **Complete roofing with local environment control.** The roof keeps the timber out of the sun while local environment control protects valuable racks;
- **Complete roofing.** This reduces temperature extremes, keeping the timber out of the sun while protecting staff;
- **Partial roofing.** Generally, the sorting area only is covered by a roof. This reduces temperature extremes on boards on the green chain but racks under assembly are exposed; and
- **Partially enclosed racking carts.** Timber is sorted racked into carts that have three enclosed sides. This reduces airflow and provides some protection from the sun.

Figure7.11. In adverse environments, drying can be slowed by local environmental control

Local environmental control occurs when racks are covered as they are assembled and in temporary storage with material, such as hessian, canvas or plastic. Assuming the racks are kept out of the sun, covers reduce the temperature and air speed and increase the humidity around the timber. Care is needed when using impervious material such as plastic for local environmental control. If used for long periods or in warm weather, the high humidity and temperature trapped under the plastic can encourage mould growth and staining on the timber.

The extent of loss avoided by protecting the timber depends on the species, thickness and local ambient conditions. Maximum grade and value recovery is achieved by protecting the boards as the racks are being assembled, before placement in the air drying yard, and prior to predrying in at least an enclosed building.

Figure7.12. A fully enclosed racking building

10. Drying protection during transport

Timber in unseasoned racks continues to dry during transport between sites at a rate determined by the exposure conditions. Racks protected in a taut liner or under a tarpaulin, are subject to lower temperatures, reduced air speed and increased humidity than racks exposed on the open tray of a truck.

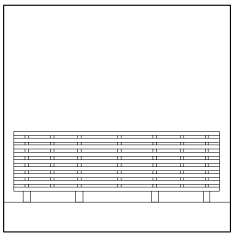
11. Protection from mechanical damage

As racks must be taken from a racking station to the start of the next production process, they are subject to mechanical handling that can:

- cause impact or crushing damage to boards, particularly in the bottom rows of racks; and
- disturb the physical arrangement of the rack.

Both can be avoided by the careful use of forklifts on even, all weather roading, and observation of the racks being moved. With thin boards or with long racks, the bottom rows flex considerably when lifted by forklifts and rack sticks can be displaced or fall out completely. If this occurs, roading should be improved and the ends of racks temporarily strapped.

When put into temporary storage, racks should be positioned on the ground on evenly spaced and level bearers of standard thickness. These should be positioned directly under the rows of rack sticks at each end and at a maximum



of 1.2 m centres internally. Racks stacked on one another should be placed directly over the rack below on bearers directly under the lines of rack sticks and directly over the bearers on the ground.

Any displaced rack sticks must be replaced or realigned.

Figure7.13. Even when stacked for temporary storage, bearers and gluts should be aligned with rack sticks

12. MC monitoring preparation

Moisture content monitoring can begin shortly after racks are assembled so preparations for the differing monitoring methods are generally made during rack assembly. These include preparation and placement of sample boards and setting up pins for resistance moisture meters.

Sample boards can give reasonable reliable results during air-drying but resistance meters are not accurate over fibre saturation point.

Moisture monitoring procedures are detailed in Module 16 MC Monitoring.

7.2.2 Equipment Options

1. Racking process equipment

Racks are assembled by hand or by racking machines.

1a. Manual racking frames

Hand assembled racks are usually built in a racking frame. This comprises a flat base, one or two end walls and a side wall. The end walls are usually a solid panel of boards or plywood. The side wall is usually a series of vertical steel posts at the same spacing as the rack sticks. These posts are grooved to receive the end of rack sticks. As the stack is assembled, full length boards are placed on the base as the bottom row of the rack. A row of rack sticks is then positioned, each with one end in a grooved post and laid parallel to each other at right angles to the length of the board. The next row of boards is placed, again with full length boards on the edges, pushed up neatly to the wall. Between the edge boards, shorter boards are alternated, one pushed up to the end wall, and the next lined up with the last rack stick or with the other end. This process is repeated until the rack is complete.

To allow the complete rack to be lifted out, either:

- the side walls of the frames have a central section that can be lifted out to allow forklift access; or
- the whole frame can be mounted on wheels or rails so it can be moved to allow forklift access

Figure7.14. Fixed racking frame with stick guides on one side. The central section lifts out so forklifts can remove the completed racks

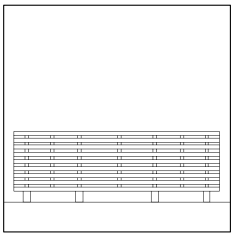


Figure7.15. Mobile racking frame. Mounted on wheels and rails, the frame is moved outside the building for unloading

Racking frames need to be robust, as they must stand up to rough handling.

Simple racking guides, as shown in Figure 7.16, can also assist with keeping rack sticks vertical. However, they are not as accurate or reliable as a full racking frame.

Figure7.16. Simple rack stick guide

1b. Racking machine

In operations with racking machines, the timber for each row is arranged on a conveyor belt before placement. The boards are topped and tailed to guides on either side of the conveyor then a complete row is placed on the rack with tynes similar to those of a forklift. The machine then places the next set of rack sticks from cartridges at spacings appropriate for that rack length. Another row of aligned timber is then placed and the process continues until the rack is complete.

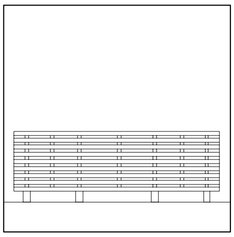


Figure7.17. Boards are topped and tailed before being stacked mechanically

Racking machines are considerably faster than manual rack building. When complete, a machine assembled rack should look the same as manually built racks. However, racks from automatic rackers are not always as straight and regular as manually built ones. This is due to:

- A tendency of the staff arranging the timber on the conveyor to favour one end over the other;
- The boards making up each row may not be perfectly flat when the rack sticks are placed on them from the cartridge. As a result, some sticks tend to sit up. They then move out of line when the next row of timber is placed above them;
- As the tyne that places the board on the stack is limited in depth to the thickness of the rack stick, they can bend with heavy material. This means one side of the row is placed down first, exaggerating or causing movement of any proud rack stick. Flexing in the tynes can also means the rack is built with a partial lean; and
- As the rack sticks may be no longer than the width of the rack itself, they are hard to see as a line and realign once the rack is complete.

Racking machines should accommodate rack sticks that are about 50 mm longer than the rack is wide, have mechanisms to align each new row so that it is directly above the rows below, and have tynes that place the row vertically onto the placed rack sticks as one unit.

The rack sticks in a machine-assembled rack should be checked and realigned after assembly.

Figure7.18. Timber being placed by a racking machine

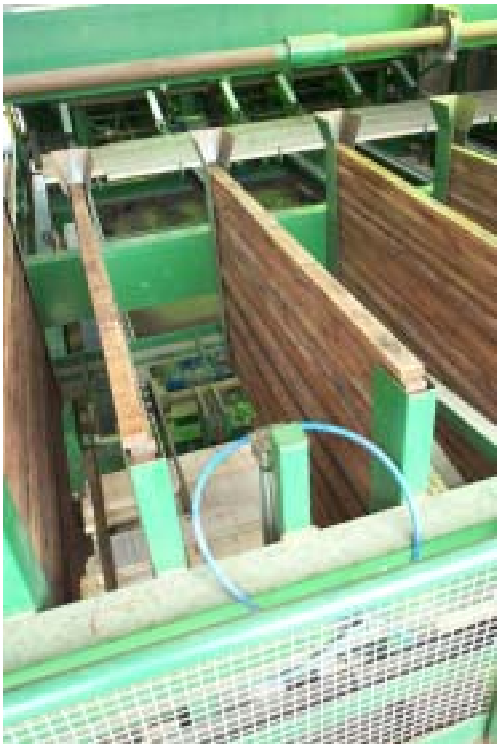
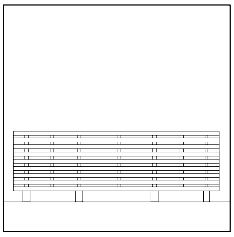


Figure7.19. Rack sticks in a racking machine cartridge

1c. Rack sticks, bearers and gluts

Rack sticks should be gauged to a standard thickness. Generally, this is about 20 mm thick. They are generally between 30 to 38 mm wide. They should be of sound and seasoned timber, dry, clean and free from decay and staining fungi. Sticks that are not of the standard thickness for the site or which start to come apart should be discarded.

Bearers and gluts should be gauged to a standard depth. Generally, this is about 90 mm. They should also be of sound and seasoned timber, dry, clean and free



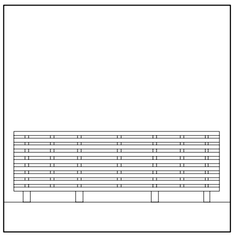
from decay and staining fungi. Materials that are not of the standard thickness for the site, or which start to come apart, should be discarded.

1d. Mobile equipment

Almost all rack handling is conducted with forklift trucks.

Racks require careful handling. The safe working capacity of the forklift should easily accommodate the expected maximum load and placement distance and height. Handling racks at the limits of working capacity creates a safety hazard for staff and encourages practices that increase rack damage.

Road ways should be safe, even and trafficable in all weather conditions



7.2.3 Racking Strategy

1. Racking the boards

Unprotected boards should be end coated to minimise uneven drying. To do this:

- End protection should be maintained through the sawing and racking process;
- Any racks that are not end-sealed should be sealed before progressing to the next production stage; and
- Any uncoated board in the assembled rack should have the ends sealed.

Boards assembled into racks should be of consistent species group, grade and thickness. To do this:

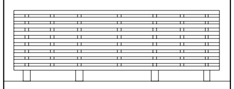
- Product and drying batch / group requirements should be readily available and understood;
- Marking procedures should be identified and confirmed;
- Grade and batch sorting from the green mill should be maintained to the racking station;
- Only material of a single batch should be included in a rack;
- Graders and rackers should discuss and review observed characteristics regularly; and
- Boards that do not meet requirements for the grade marked on them are separated for future regrading or are regraded.

Boards in assembled racks should be adequately and evenly supported and restrained. To do this:

- Rack assembly requirements should be readily available and understood;
- Preferred board lengths should match the support points provided by the rack sticks;
- Rack sticks should be placed at regular and even spacing, at right angle to the length of the boards with extra support at the rack ends;
- Rack sticks should be aligned vertically;
- The ends of boards should not extend past the last rack stick by more than 50 mm; and
- Any board that extends more than 100 mm past the last rack stick should be cut off and the exposed end resealed.

Rack sticks should be sized and placed, and boards arranged so that the airflow through the assembled racks is even. To do this:

- Rack sticks should be gauged to a standard thickness;
- In manually assembled racks, the two outside boards of each row should be full rack length. Shorter boards should be restricted to between these boards;



- In machine built racks, the two outside boards of each row should be as long as practically possible. Shorter boards should be restricted to between these boards;
- The ends of boards on the inside of the row should be neatly aligned alternately with one end of the rack and the other; and
- The outside edge of each row of boards should be directly over the outside edge of the row below.

The dimension of assembled racks should allow later production equipment and facilities to operate efficiently and effectively. To do this:

- The width, height and range of lengths for racks should correspond to a suitable module for the kilns and other equipment.

Assembled racks should be stable and rugged enough to be transported safely and without damage. To do this:

- The length of the rack should be limited to a size that can be effectively moved with the available equipment.

Assembled racks are stable and even enough so that they do not experience or cause uneven loading when assembled into stacks. To do this:

- The sides and ends of the completed rack should be even and vertical; and
- Rack sticks should be spaced to a standard module and aligned vertically.

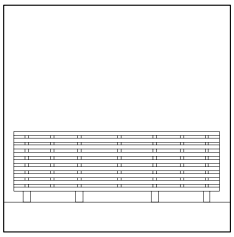
2. Protecting the racks from physical and drying damage during assembly

Racks assembled or stored in the green or drying mill or in transport should be protected to minimise drying degrade. To do this:

- Rack protection requirements should be available and understood;
- Racks should be assembled in an enclosed building, out of the sun and the wind;
- If only protected by a roof, all racks and racking stations should be out of the sun for at least 80% of the time and local environmental controls should be used to protect high value racks;
- If being stored between racking and the next stage of production, racks should be stored in a protected location, ideally in an enclosed building; and
- Racks should only be transported between sites in taut liners or under covers such as tarpaulins.

Racks in transport and storage should be handled to minimise physical damage and loss of rack integrity. To do this:

- Rack handling requirements should be available and understood;
- Racks should be adequately supported on bearers placed immediately under a line of rack sticks;



- Racks should only be handled by adequately rated, purpose designed equipment, operated by staff trained in its use; and
- Roads, loading and unloading areas should be safe, even and trafficable in all weather conditions.

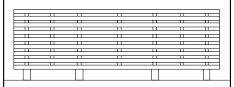
3. Maintaining product information

Information required for later production control should be collected and passed with the racks effectively. The requirements for this are included in Section 7.2.5.

7.2.4 Quality Control

Procedures should be established for:

Procedure	**General contents**
Product specification	Grade, size, overcut and batch requirements for product groups including verification processes.
Drying group	Sorting requirements for products or grades into groups to be dried together.
Rack assembly	Rack size (width, length and height); rack stick spacing and alignment, assembly and arrangement.
Rack stick, bearers and gluts	Rack stick and bearer dimensions, monitoring and handling.
Rack storage	Storage provisions including protection of high value racks, shelter of other racks, use of bearers, etc.
Rack transport and handling	Allowable truck configuration, use of tarpaulins, forklift requirements.
Moisture monitoring	Provision for sample boards and moisture meter positions.
Marking and tagging	Identification requirements for grade and sorting.
Staff accreditation	Training, qualifications.
Equipment	Maintenance.



7.2.5 Information Management

Information required for later process control should be collected and passed with the racks effectively. This includes the following:

Required Information on rack	
Unique rack identification number	Board width
Batch type / species	Board thickness
Date rack completed	Board length type
Rack length	Lyctus susceptibility
Grade	
Required process control information	
Unique rack identification number	Board width
Staff number	Board thickness
Batch type / species	Board length type
Rack arrival / complete time & date	Board source
Rack length	Lyctus susceptibility
Grade	Rack tally number
Staff comments	
Desirable additional information	
Racker	Rack started time and date
Racking bay number	

Table7.02. Attributes required or desirable from racking

1. Record collection & processing

Information required on the rack must be legible in normal daylight at least 1 meter from the end of the rack.

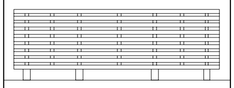
Rack tags should be of resilient and weather resistant material securely fixed to the rack. Ideally, they should be colour coded by grade, species or product group. Pens used to mark the tags should use permanent ink. Stamps or paint should be permanent and not be readily obscured by dust.

All tagging systems have to be able to survive any transhipment stage with less than a 0.5% loss rate.

Figure7.20. Rack identification details; rack number, board size, timber grade, length, tally and assembly date

Figure7.21. Rack information on a prenumbered card stapled to the rack

Figure7.22. A combination system



7.2.6 Equipment Maintenance

Racking trolleys and frames should be maintained so that the quality of rack stick placement and the form of finished racks do not deteriorate unsatisfactorily.

Racking machines should be maintained in line with the manufacturer's specification

Handling equipment should be maintained so that the expected maximum load and placement distance remains within the safe working capacity of handling equipment.

7.2.7 OH&S

Covered work areas should be provided for those manually assembling racks. Workers should not be required to work in strong sunshine and they will not be able to work effectively in the rain.

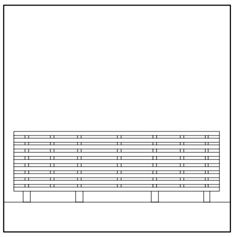
The racking area should be regularly inspected and hazards identified and eliminated. These may include:

- unstable stacks of boards;
- broken rack sticks;
- dangerous or damaged handling equipment or trolleys;
- broken fences, gates or guards; and
- poor or no safety signage.

Major OH & S requirements relevant to this section are listed in Table 7.03. This is not a complete list and other relevant codes and regulations may apply.

State	**Major code of practice**
Tasmania	*Code of Practice for Sawmill Operation* – Tasmanian Forest Industries & Workplace Standards Tasmania
QLD	*Sawmilling Industry Health & Safety Guide* – QLD Division of Workplace Health & Safety
NSW	*Codes of Practice for the Sawmilling Industry* – Workcover Authority
Victoria	Victorian Workcover Authority
WA	*Timber Milling and Processing Occupational Safety & Health Code*- FIFWA

Table7.03. Major industry codes of practice



7.3 Operations

7.3.1 Objective

Activity racking timber is to space and restrain green sawn boards or slabs in a form suitable for the intended drying process and to transport them to the initial drying location.

7.3.2 Key Drying Factors in Racking Timber

1. Racking is a critical stage of drying hardwood

Correctly assembling the rack is vital to successfully drying timber, as the rack is the basic element handled through all the remaining stages of drying. Any mistakes here lead to problems in later production.

2. Rack batches of similar grade and drying characteristics

Boards or slabs in a batch should have similar drying properties. As all the timber in the rack will receive the same treatment, only boards of a single batch should be included in a rack.

3. Boards and slabs must be supported evenly along their full length and at both ends

Boards tend to distort as they dry with the ends of boards distorting the most. They need to be restrained by the rack sticks and the other timber in the rack and stack.

4. Boards must be spaced at regular intervals

Boards in adjacent rows need to be spaced apart regularly so that airflow between the rows is as even as practical;

5. Racks need to be assembled with very even sides and ends

This is to ensure that the airflow into the rack from any direction is as regular as practical.

6. The rack must be rugged enough not to become damaged in transport

Badly out of line racks cannot be stacked properly and can jam in kilns and predryers.

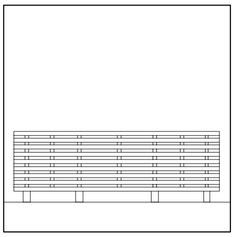


Figure 7.23. The results of poor racking practice

7.3.3 Preparation

1. Standards

- **AS 2796-1999**: Timber - Hardwood - Sawn and milled products
- **AS 2082-2000**: Timber - Hardwood - Visually stress-graded for structural purposes
- Company or Customer Product Specification

2. Procedures

Procedures should be in hand for:

Product specification	Rack transport and handling
Drying group	Moisture monitoring
Rack assembly	Marking and tagging
Rack stick, bearers & gluts	Staff accreditation
Rack storage	Equipment

3. Equipment

Racking stations and other equipment should be maintained in accordance with the standard procedures.

Rack marking and tagging equipment should be in hand and operational.

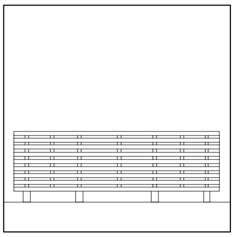


Figure7.24. Procedures, checking equipment and marking material should be readily available

7.3.4 Processing & Monitoring

1. Racking the boards

Unprotected boards are coated to minimise uneven drying. End sealing reduces uneven drying at the end of the board.

- Seal or set aside any unsealed material.

Boards assembled into racks are of consistent species group, grade and thickness. The entire rack will receive the same drying treatment, so it should consist of material of similar thickness and drying properties.

- Confirm the boards' batch.
- Separate boards that do not meet grade and batch requirements.
- Rack sorted boards in designated areas.

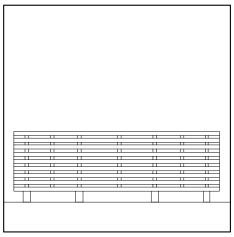


Figure 7 25 Segregate non-conforming product

Boards in assembled racks are adequately and evenly supported and restrained. Boards will deform if not adequately supported or restrained and will deform most at the end of the boards.

- Use a racking guide or frame to ensure regular spacing.
- Place rack sticks at regular and even spacing in the guide.

Figure7.26 Racking frame with neat rack stick placement

- Place rack sticks at right angles to the length of the boards.
- Align the rack sticks directly above the rack sticks in the row below.

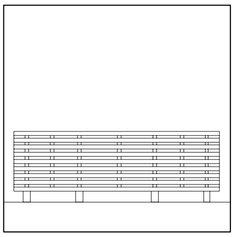


Figure7.27. Desirable: Neatly aligned rack sticks

Figure7.28. Undesirable: Poorly aligned rack sticks

- Boards are not to extend past the last rack stick by more than 50 mm.

Figure7.29. Desirable: Neat rack end

Figure7.30. Undesirable: Uneven rack end

Rack sticks are sized and placed, and boards arranged so that the airflow through the assembled racks is as even as practical.

- Check that rack sticks are the standard thickness
- Discard rack sticks that are not of the standard thickness, are split, broken or show signs of decay.

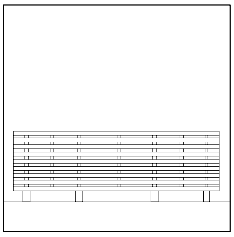


Figure7.31. Rack sticks in good condition

Figure7.32. Rack sticks in poor condition discarded

1a. For manually built racks

- Select full rack length boards for the bottom row.
- Set aside full rack length boards and use them for the outside board of each row.

Figure7.33. Long boards are saved for the sides and base of a hand assembled rack

- Press the far board of the row neatly against the sidewall of the racking frame.
- Align the near board of the row directly above the edge of the board below.

7.0: – RACK TIMBER

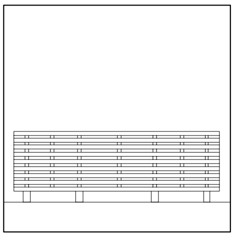


Figure7.34. Desirable: Neat edges to the rack

Figure7.35. Undesirable: Uneven edges to a rack

- Slide boards onto the rack – do not drop.
- Alternate boards in a row neatly up to each end wall of the racking frame or aligned them so that they just protrude past the last racking stick.

Figure7.36. Boards in a rack topped and tailed

- Redirect or dock boards that extend more than 100 mm past the last rack stick.
- Reseal any docked ends

Figure7.37. Docked ends being resealed

- Knock rack sticks in to line as the rack is assembled as regularly as required.

1b. For mechanically built racks

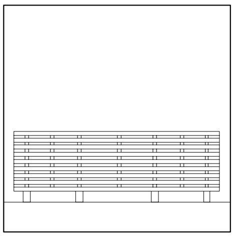
- Check racking machine for defects and report any damage.
- Arrange machine to produce rack of the required size.
- Keep rack sticks in the cartridges. Do not let them empty.
- Arrange boards on the machine in-feed to:
  - Place the longest boards available on the outside edges of each row; and
  - Align the boards in each row so they line up alternately with one end of the rack then the other;

Figure7.38. Top & tailing on a racking machine

  - Rearrange any overlapping boards.

The dimension of assembled racks allows later production equipment and facilities to operate efficiently and effectively. Racks that are the wrong dimension cause loading and drying problems in predryer and kilns.

7.0: – RACK TIMBER



- Finish racks at the correct row count or dimension.

Assembled racks are stable and rugged enough to be transported safely and without damage. Damaged racks do not dry as evenly and material is wasted, while unstable racks cause problems later in the process and can be a safety hazard.

- Check racks during assembly to ensure that:
  - the arrangement is stable; and
  - all boards are suitably supported, especially at the edges.
- Build racks with ends aligned and sides vertical.

Assembled racks are stable and even enough so that they do not experience or cause uneven loading when assembled into stacks. Uneven loading can crush or distort boards.

- Arranged rack sticks directly vertically over each other.

2. Protecting the racks from physical and drying damage

Racks stored in the green or drying mill or in transport are protected to minimise drying degrade. The timber continues to dry during storage and can be damaged if it is exposed to adverse conditions.

- Protect high value racks with local environmental controls.
- Do not store racks in the sun any longer than absolutely necessary.
- Store racks in an enclosed building out of the sun, or in roofed shelter.
- Only transport racks in an enclosed trailer or under a tarpaulin.

Racks in transport and storage are handled to minimise physical damage and loss of rack integrity.

- Check rack bearers and gluts are the standard thickness.
- Discard rack bearers and gluts that are not of the standard thickness, are split, broken or show signs of decay.
- Support racks on evenly spaced bearers

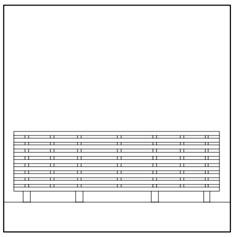


Figure7.39. Bearer poorly placed

- Place the bearers immediately under the line of rack sticks at a maximum of 1.2 m centres.

Figure7.40. Desirable: Bearers and gluts in line

Figure7.41. Undesirable: Bearers out of line

- Realign or replace any rack sticks that move or fall out during transport.
- Strap the ends of racks for transport if rack sticks keep falling out.

Figure7.42. Racks have to be transported carefully to minimise loss and movement of rack sticks

- Only handle racks with adequately rated, purpose designed equipment, operated by staff trained in its use.

3. Moisture monitoring equipment

- Install required sample boards or resistance moisture meter connections in correct positions.

7.3.5 Marks, Tags & Records

Information required for later production control is collected and associated with the logs effectively.

- Identify finished racks with marks or completed tags that include:

Unique rack identification number	Board width
Batch type / species	Board thickness
Date rack completed	Board length type
Rack length	Lyctus susceptibility
Grade	

- Complete at least the following records:

Rack Tally	Rack assembly information

7.3.6 Feedback

If noticed regularly, report any of the following to the supervisor:

Boards not end sealed	Unusual grade reducing defects
Rack sticks out of line	Repetitive incorrect sorting of

	boards
Racks sides or ends out of line	Racks exposed to sunlight or other adverse conditions
Boards that are not the preferred length	

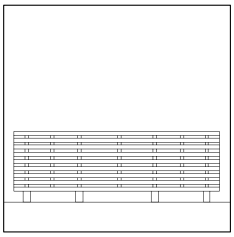
7.3.7 OH&S

Maintain and wear all required safety gear. Ensure all protective guards and warning devices are operational

Keep work areas clean, tidy and clear of trip hazards such as wire and strapping ends, and pieces of timber.

Inspect the racking area regularly. Identify potential hazards and eliminate them. In the racking area, this can include:

- unstable stacks of boards;
- broken rack sticks,
- short lengths of timber on sorting tables;
- dangerous or damaged handling equipment;
- broken fences, gates or guards; and
- poor or no safety signage.



7.4 Checklists

Use this checklist to monitor key aspects of your operation. Mark each item on the following scale:

1	2	3	4	5
Very bad, never	Bad, rarely	Satisfactory, usually	Good, almost always	Very good, always

1. Racking the boards

1a. Rack furniture

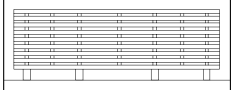
	1	2	3	4	5
Rack sticks gauged to common thickness, width and length					
Rack sticks are seasoned					
Rack sticks are sufficiently straight					
Bearers and gluts gauged to common thickness, and length					
Bearers and gluts are seasoned					

1b. Batching practice

	1	2	3	4	5
Racking stations are designated to size and batch					
Racking frames match standard rack configurations					
Racks are assembled of boards of a single batch					
Racks are assembled from common length board					

1c. Racking practice

	1	2	3	4	5
Racking frames are used for manual racking					
Broken or unsuitable rack sticks, bearers and gluts are discarded					
All boards are end coated					
Rack sticks placed accurately and aligned vertically at correct spacing					
For hand built racks, racks have full length boards on bottom and, if possible, two outside rows					
Boards shorter than full length positioned to the interior of rack and aligned neatly to alternative					



ends.					

1d. Assessing the completed racks

	1	2	3	4	5
The sides of the rack are even and vertical.					
The rack sticks are in neat and vertical lines.					
The ends of the racks are square, even and vertical.					
No board extends more than 50 mm past the last rack stick.					
Rack allows even air- flow through all rows.					
There are no significant areas of missing boards.					
Racks are stable for transport and placement in stacks.					
All racked material restrained and supported uniformly.					
Racks are correctly, clearly and securely tagged.					
Racks are marked with required information.					
Tags are legible 1 meter from end of pack.					
Documentation completed accurately.					

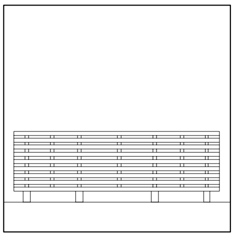
2. Protecting the racks from physical and drying damage

2a. Timber care during racking

	1	2	3	4	5
Racks are assembled in a protected position.					
Racking staff are protected from wind and direct sunlight.					
Boards are placed in the rack, not dropped.					

2b. Rack protection

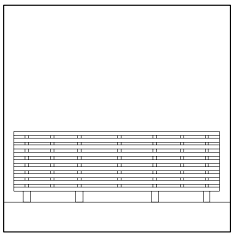
	1	2	3	4	5
High value racks are protected with local environmental controls.					
Racks are stored out of the sun.					
Racks are supported evenly and adequately.					
Racks are supported directly under the rack sticks.					
Exposed edges of high value packs are protected.					



Racks are covered or fully enclosed during transportation.					
Racks are handled with adequately rated equipment.					
Rack integrity is restored if disturbed during transport and handling.					

2c. Moisture monitoring

	1	2	3	4	5
Moisture monitoring equipment is in place and accessible.					



7.5 Avoidable Loss

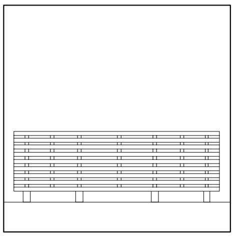
1. Racking the boards

- **Inadequate rack assembly** – If rack sticks are too far apart, the boards are not sufficiently restrained and twist or deform. Also, the ends of some board are often not restrained on sticks. Twisted or deformed boards do not process well and value and recovery is lost.

Figure7.43. Unsupported board ends distort during drying. This can be seen in the board second from the top

- **Inappropriate sticks and bearers** - If racks sticks are too wide, there is reduced drying under them while sticks that are too narrow can indent the timber. If the thickness of rack stick is variable, individual boards are unevenly loaded.

Figure7.44. Uneven rack stick thickness leads to board wave and uneven drying



- **Uneven rack assembly** – If rack sticks do not lining up, boards are unevenly loaded, causing twist and deformation.

Figure7.45. Rack sticks out of line twist and bend boards as they dry

Figure7.46. Uneven support of boards during racking leads to twisted and deformed boards, and unstable stacks

- **Uneven rack ends** – This exposes protruding ends to accelerated drying. The effected boards tend to distort or split. Protruding ends also complicate handling and further processing.

Figure 7.47. The end of poorly racked boards broken in a push through predryer

Figure7.48. Uneven sides and board spacing leads to irregular airflow and uneven drying

- **Inappropriate rack dimension** – If racks are too heavy for the forklift, the whole rack or boards can be damaged. If the rack dimension is not 'tuned' to the dimension of other equipment, efficiency is lost and standard schedules compromised. If racks are too narrow, stacks can be unstable.

2. Protecting the racks from physical and drying damage

- **Exposing the timber to adverse drying conditions** – Racking in the open leads to checks in the board and immediate loss of grade.
- **Rack damage** – Boards or sticks knocked off or out of line during transport are damaged or dry irregularly and are a direct loss to production output.

Figure7.49. Boards displaced during transportation dry irregularly and are often discarded

Figure7.50. Boards displaced during transportation are often damaged

7.6 References

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