

Drying cocowood: Overview

Drying = stacking correctly + kiln drying or (pre-air + kiln drying) or air drying.

Cocowood boards must be dried adequately before they are profiled for solid flooring or manufactured into engineered flooring products. Drying reduces the moisture content (MC) of boards to meet market demands for flooring products.

Target moisture content for flooring products destined for export markets are:

- Australia 9–14%
- Europe 7–11%

Kiln drying is an accelerated drying process, incorporating an accurate determination of the end-point moisture content. Kiln drying is appropriate for export and domestic markets.

Pre-air drying, followed by final kiln drying may be appropriate when the sawing plant is remote from kiln facilities. Cocowood boards must finish drying in a kiln if they are intended for export or airconditioned situations in local markets.

Air drying is not suitable for international flooring markets. Air-drying in tropical environments can only achieve moisture contents between 15% and 18% because of the ambient conditions. Also, if flooring is to be produced for the domestic markets in airconditioned environment, it is also necessary to lower the final MC by kiln drying.

Drying methods match the market

Cocowood for export markets and airconditioned use in domestic markets:

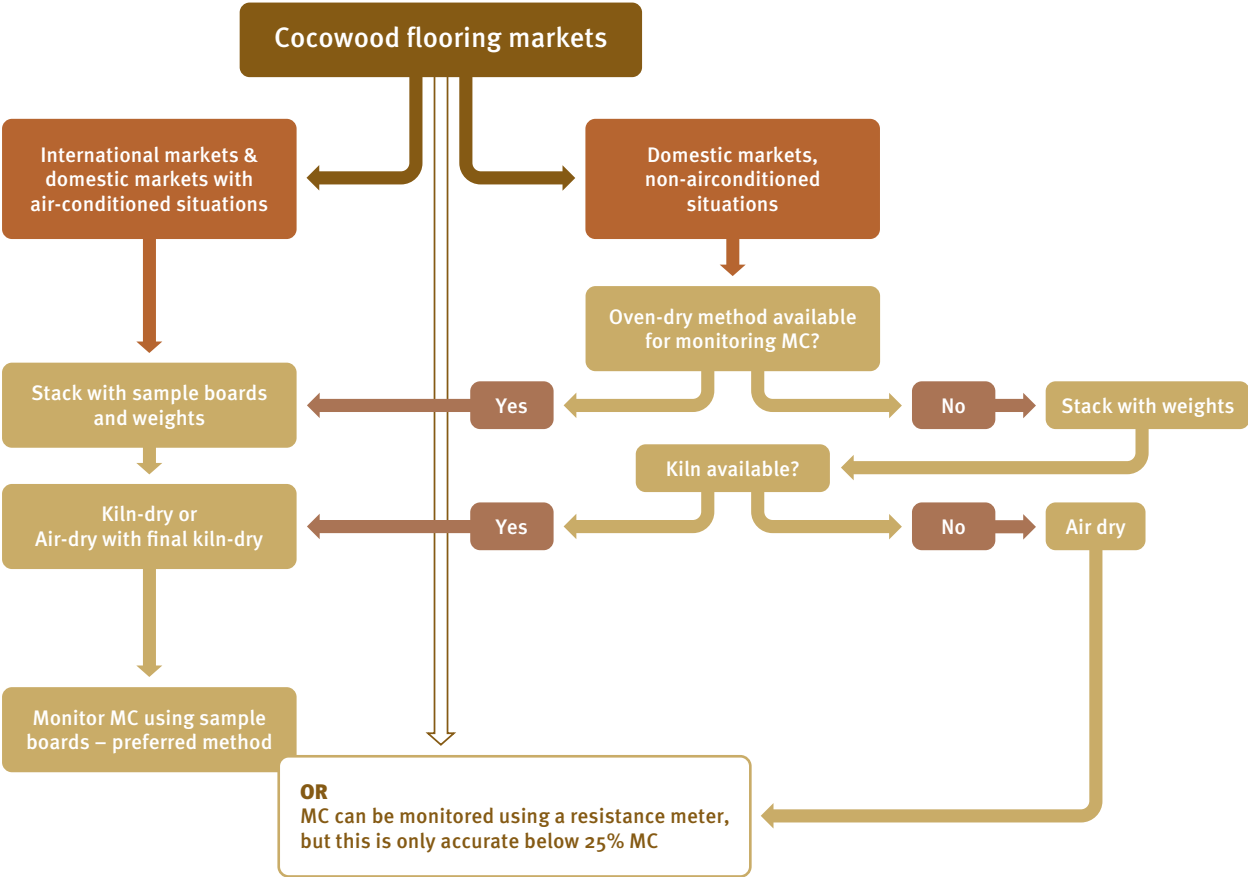
- Either kiln dry from green or pre-air dry, followed by a final kiln dry.
- Always stack correctly, using rack sticks, and sample boards to monitor changes in moisture content with the oven-dry method.

Cocowood for domestic markets in non-airconditioned situations:

- Either kiln dry from green; pre-air dry followed by final kiln dry or air dry only.
- If an oven and a pan balance are available to monitor moisture content with the oven-dry method, always include sample boards in the stack.

This decision tree overleaf clarifies the options.

Drying best-practice decision tree



Drying method 1: Kiln drying

Kiln drying is accurate and rapid, minimising the amount of degrade in the stack. Being able to control drying conditions makes it possible to achieve specific moisture contents that are suitable for engineered flooring products.

Steps

1. Build the stack with rack sticks, sample boards and weights.
2. Position the stack in the kiln
3. Attain target **moisture content** (MC) for 25 mm thick boards:
 - a. use the **kiln drying schedule**: up to 60–65° (dry bulb) over 10–14 days:
 - b. **monitor moisture content** using sample boards (for the full MC range) or moisture resistance meters and appropriate correction factors (where sample boards are not used because a suitable oven is not available). Note: resistance meters are only accurate for MC < 25%).
 - c. **equalise** the MC between boards in the stack.

Kiln drying schedule

Cocowood can be kiln dried up to 60–65°C (dry bulb) over 10–14 days for 25 mm thick material, depending on the equipment. Concrete weights should be used during drying to minimise distortion.

Drying rate is affected by board thickness, initial moisture content, weather conditions, stacking method, density and drying method.

Drying schedule for 25 mm cocowood boards (recommended)

Moisture content change points (%)	Dry bulb temperature (° C)	Wet bulb temperature (° C)	Relative humidity (%)	Equilibrium moisture content (%)
Green – 85	49.0	44.0	78.0	13.0
85 – 58	53.0	47.0	75.0	11.5
58 – 35	56.0	48.0	64.0	10.0
35 – 28	58.0	49.0	51.0	9.0
28 – 19	62.0	48.0	43.0	6.5
19 – 12	60.0	43.0	40.0	5.5
Equalisation – 48 hrs	60.0	55.0	55.0	8.0

Moisture content

Sample boards placed in the stack can be used to monitor the decrease in moisture, at all moisture contents, so it is the preferred method. Moisture content can be measured with **resistance-type meters** only at levels below 25% moisture content; they are inaccurate above this level.

1. Monitor moisture content (MC) using sample boards.
2. If sample boards haven't been used, monitor MC with a resistance meter, applying temperature and moisture correction factors. MC above 25% will be unreadable, but resistance meters can be used to monitor the final drying stages and determining the important end-point.
3. Equalise the stack of boards

1. Monitoring moisture content (MC) using sample boards

This method uses the sample boards, small MC sample sections and the oven-dry method to determine MC.

- a. Determine the moisture content (MC) of the small sample sections A & B using the oven-dry method and equation (1). Calculate the average of the two samples.
- b. Determine the MC of the sample board during kiln drying by calculating the oven-dry weight using equation (2).
- c. Determine the sample board MC every day during drying (Monday to Friday). First record the time and date, kiln set-point temperature and humidity values and the kiln actual temperature and humidity values. Weigh the sample boards and use equation (3) to calculate MC.
- d. If the average MC of the sample boards is less than the next kiln schedule set-point (see the MC content change points given in the drying schedule), then change the kiln temperature and humidity to the settings for the next phase recommended in the drying schedule.

$$\text{Moisture content (\%)} = \frac{\text{Original weight (g)} - \text{Ovendry weight (g)}}{\text{Ovendry weight (g)}} \times 100 \quad (1)$$

$$\text{Ovendry weight of sample board (g)} = \frac{\text{Original weight of sample board (g)}}{1 + \text{average MC of small samples (\%)}} \times 100 \quad (2)$$

$$\text{MC sample board (\%)} = \frac{\text{Current weight of sample board (g)} - \text{Calculated OD weight of sample board (g)}}{\text{Calculated OD weight of sample board (g)}} \times 100 \quad (3)$$

Abbreviations: MC: Moisture content | OD: Oven-dry | g: grams

2. Monitoring MC with a resistance meter

Moisture resistance meters are usually calibrated to Douglas fir (*Pseudotsuga menziesii*) so correction factors are needed for other timbers. The correction factors for cocowood are provided in Table ii). A temperature correction is applied (Table i) before moisture correction to estimate the correct MC.

Moisture correction

- a. Estimate the board temperature based on kiln conditions.
- b. Correct for temperature, for example using Table i): if the kiln (board) temperature is 60°C and the moisture meter reads 20%, the new moisture reading is 14%.

i). Temperature correction (for resistance moisture meter)																		
Meter reading %	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Wood temp°C	Moisture reading corrected for temperature																	
25	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	-	-
30	7	8	9	10	11	12	12	13	14	15	16	17	18	19	20	21	22	-
35	6	7	8	9	10	11	12	13	14	15	15	16	17	18	19	20	21	22
40	-	6	7	8	9	10	11	12	13	14	15	16	16	17	18	19	20	21
50	-	-	6	7	8	9	10	11	11	12	13	14	15	16	16	17	18	19
60	-	-	-	6	7	8	8	9	10	11	12	13	14	14	15	16	17	18

Source: AS/NZS 1080.1:1997. Timber methods of test

c. Use this moisture reading correction factor in Table ii). to obtain the correct MC of 10%.

ii). Moisture correction factors for kiln drying cocowood (for resistance meters calibrated to <i>Pseudotsuga menziesii</i>)																			
Moisture meter reading (% moisture)																			
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Corrected moisture content (% moisture)																			
—	—	—	—	8	8	9	9	10	11	11	12	12	13	13	13	14	14	15	

Source: Alston, 1982. *Timbers of Fiji. Properties and potential uses.* Department of Forestry, Suva.

3. Equalise the stack of boards

When the target MC is reached, the boards must be ‘equalised’ in the stack. This will reduce the variation in the final MC; MC gradients within boards and the residual drying stress.

To equalise the boards:

Hold the kiln at the final kiln schedule dry bulb temperature for 1–2 days and adjust the kiln humidity to provide an equilibrium moisture content (EMC) equivalent to the target, final MC.



Stack ready for drying in a solar kiln. Weights still to be added.

Drying method 2: Pre-air drying + final kiln dry

Pre-air drying may be relevant:

- when waiting for available kiln space
- during short-term storage and transport from primary processing site to a kiln

Air-drying is only suitable for export market when:

- the recommended drying stack is constructed
- it is followed by final kiln drying
- sample boards are used to monitor moisture content using the oven-dry method

Steps

1. **Build** the stack with rack sticks, sample boards and weights.
2. **Position** the stack where conditions are suitable or can be moderated to optimise drying.
3. **Pre-air dry** the stack of boards (8–11 weeks to reach 17–20% MC)
4. **Monitor moisture content** using sample boards where there is access to:
 - a. an oven heating to 103°C+/- 2°C
 - b. a balance (e.g. top-pan balance)
5. **Kiln dry** to achieve target moisture content for export flooring products.
 - a. use the **kiln drying schedule** to optimise drying conditions (6–7 days)
 - b. **monitor moisture content** using sample boards (for the full MC range) or moisture resistance meters and appropriate correction factors (where sample boards are not used because a suitable oven is not available). Note: resistance meters are only accurate for MC < 25%).
 - c. **equalise** the MC between boards.

Follow the details given in the section on kiln drying.

Drying method 3: Air drying

Air drying alone is not suitable for export flooring markets because target moisture content of 9–12% cannot be achieved by air drying in humid, tropical or sub-tropical conditions. Also, if the flooring is for domestic markets in airconditioned environments, it is also necessary to lower the final MC by kiln drying.

Air drying is achieved by placing stacks of racked (stripped) cocowood (see the section on stacking cocowood) in natural conditions so that they dry as evenly as possible. Stack the boards using rack strips to space and restrain them in a form suitable for drying. The aim is to achieve a suitable moisture content with minimal degrade.

Steps

1. **Position** the stack where conditions are suitable or can be moderated to optimise drying. Natural conditions experienced by the stacks can be moderated by changing their position and orientation in the open, or their position in buildings or shelters. Protect stacks from adverse drying conditions by positioning them in the yard or drying buildings using the site drying schedule as a guide.
2. **Build the stack** incorporating:
 - a. **rack strips** to space and aerate the boards
 - b. **sample boards** where an oven and balance are available for monitoring MC **weights** to minimise distortion during drying.
3. **Protect** the stack or moderate conditions as necessary:
 - a. use fabric or other shades and screens on the drying building to reduce air flow
 - b. place stack ‘tops’ (pallet material or iron sheeting) on the top to minimise weathering in the top layers of stacks that are air drying outdoors.
4. **Monitor moisture content** by either:
 - a. using sample boards and the oven-dry method where there is access to an oven heating to 103°C± 2°C and a balance (e.g. top-pan balance)*
 - b. using resistance meters weekly until 25% MC is reached, then twice-weekly until the target MC is reached
 - c. a final MC of 17–20% can be expected after 8–11 weeks.

***Where oven and balance are not available:** Use a resistance moisture meter to determine when air drying is complete. Because resistance meters are inaccurate above 25% MC, take weekly measurements on four boards per stack to work out when the average MC is below 25%. Then test MC with the meter twice a week to determine when the boards have reached the target MC.

Note: This method is not suitable for the export flooring market. Air drying without using the oven-dry method for assessing moisture content may be suitable for domestic markets.