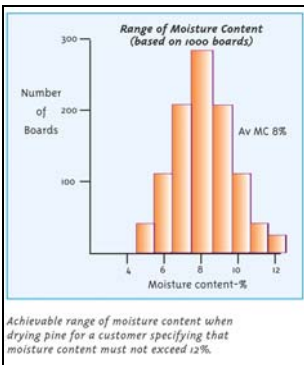


KILN DRYING OF SOFTWOOD



MEETING THE QUALITY CONSIDERATIONS OF THE MARKET

The key to a successful timber drying operation is to dry as rapidly as possible whilst keeping timber quality within specification. Windsor kilns are designed and built to the highest standards but quality drying goes beyond this. It depends on many factors:

- Care of timber during storage and handling prior to drying
- Drying properties of the timber
- Performance of the kiln, including ability to reach schedule settings rapidly, to maintain them within close limits, and for drying conditions to be uniform in the height and length of the chamber
- Skill of the operator in selection of drying schedules, operation of the kiln, determination of the end point of drying and carrying out of quality control checks on the dried timber
- Care of timber between drying and point of sale

Although they are used for drying many softwood species, Windsor kiln systems were initially developed for drying plantation-grown radiata pine in New Zealand and Australia and subsequently in Chile, Southern Africa and then the USA. Initially the emphasis was on high temperature drying (i.e. in excess of 100°C). Schedules of the dry bulb (DB) 120°C/wet bulb (WB) 70°C allowed 50 mm material to be dried in 24 hours compared with a 4-6 days at conventional DB temperatures of 70°C. Quality of high temperature dried material was very satisfactory for structural grades even when the temperature was raised to 180°C, or up to 200°C for the drying of slash pine (*Pinus elliotii*) in Australia. It was also demonstrated that high temperature drying could be used for the drying of higher-quality products but commercial results have not been consistent.

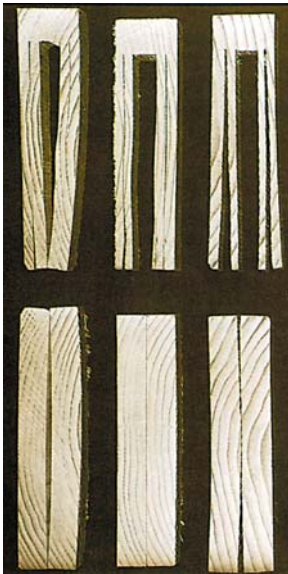
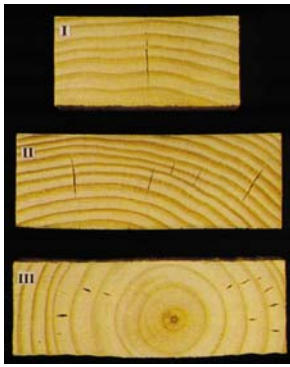
The medium temperature kiln was developed as an intermediate between high and the lower conventional temperatures - allowing rapid drying but with more assured control of critical quality factors. These kilns can operate at up to 110°C and have air flows of 6m/s or higher but are typically operated in the range of 90-100°C.

Quality considerations will determine how severe a drying schedule can be used.

Quality considerations:

These factors will differ for the various end uses but will include:

- **Final moisture content:**
Typical moisture content specifications that Windsor kilns have met are: 12% with nothing over 15% (framing for the Australian market). Average MC of 8% and nothing over 12% (shop grade to the US). 9% ± 2% for all pieces (overseas client drying for export). These are all achievable given that the kiln is well stacked and the material is uniform. Boards dry at different rates and it is sometimes necessary to run a conditioning step at the end of the drying schedule. This will bring the boards to the required moisture levels and reduce variability between boards. This is achieved by conditioning at close to saturation using steam at atmospheric pressure generated in a water bath. With medium temperature kilns, conditioning is usually carried out in the kiln whilst in high temperature kilns a separate conditioning chamber is usual. Steam conditioning times will vary from 1-3 hours per 25mm of thickness and serve the dual purpose of equalising and stress relief. This treatment has proved very satisfactory. When a close range of final moisture content is required, some companies use a period of equalising between drying and conditioning. For example, instead of drying at DB 90°C/60°C WB in 42 hours, reduce this period to 34 hours and equalise at 90/80 for about 14 hours. This equalising extends the total time but ensures that the driest pieces will not overdry while the wettest pieces continue to dry (but at a slower rate).
- **Warping:**
During drying the worst distortions can occur in pieces cut from near the centre of the log where the presence of spiral grain causes twist during drying of framing timber in high and medium temperature kilns with a fast heat-up. This problem is reduced provided the timber is well stacked and top weight of up to 1000kg/m² is added. The plasticising effect of the elevated temperature assists the restraining effect of the top weight, and the weight of the stack itself, in restricting warp. These drying methods not only keep warping within acceptable limits but also help to improve wood stability.



However reduced warp will only be achieved if:

- Timber is well stacked and (ideally) of uniform length
- Fillets are of uniform thickness and in good vertical alignment 400-600 mm apart depending on timber thickness
- Timber is reasonably uniform in thickness.

Quality of stacking is also important for remanufacturing grades but weighting is reduced to 350-500 kg/m² to avoid the risk of checking under the fillets and also because the material is normally outerwood which is less prone to warp.

- **Checking:**

Getting the timber into the kiln as soon as possible after sawing is strongly advised as checking can develop while the filleted timber is outside waiting to go into the kiln.

Internal checking is of more concern. There are three types as illustrated in the photograph:

- i. Typically a single check or a pair extending along the length. This is the type of check which occurs in high temperature drying if the drying stresses have not been adequately relieved in final steam conditioning.
- ii. Seen as a larger number of checks. These are usually end checks that have extended beyond the point where the end has been docked. Again these occur mostly in high temperature drying.
- iii. Checks occurring within the annual ring are confined to earlywood. Unlike the other types of internal check, these form in the first few hours of drying and are associated with collapse of the earlywood. Characteristically, they are found only in sapwood, within 12 growth rings from the pith. They can develop in the full range of drying methods from conventional to high temperature but tend to be more numerous the higher the drying temperature.

- **Stress Levels:**

Final steam conditioning at the end of drying, to relieve drying stresses (case hardening), is vital to the final quality of drying, especially for material that is to be resawn. If it is not done effectively, the two halves of a deep ripped board will cup and recut material will sometimes spring or bow off the saw. In the extreme case of high temperature drying, boards with residual stress will develop internal checking (type i) after cooling.

Windsor medium temperature kilns are provided with a low pressure steam generator in the form of a water bath in the floor of the kiln. This provides a steam source that is superior to the traditional steam spray which is normally fed from boiler steam that is too dry to be effective. Conditioning is carried out at a maximum humidity and provides for moisture equalisation as well as stress relief.

Typically a drying schedule would be followed by final steam conditioning in the kiln or in a separate conditioning chamber at 100°C and maximum achievable humidity for up to 6 hours. Provided the drying brings the average moisture content down to about 8%, adequate conditioning can achieve a final moisture range that is satisfactory for demanding markets. The kiln operator is expected to check the adequacy of conditioning by carrying out stress tests as illustrated.

- **Colour changes:**

It is important to guard against fungal staining by prompt drying after sawing and use of anti-sapstain chemicals. Chemical stains of various sorts can also cause discoloration. The surface of timber darkens increasingly as the drying temperature is raised, but after subsequent machining it is difficult to detect any difference in colour. There is one form of sub-surface brown stain that affects the sapwood of some pines including radiant pine. It is seen as thin, dark coloured zone 0.5 - 1 mm below the surface formed from an accumulation of water-soluble chemicals migrating outwards during drying and being left at the point where free water vaporises. This brown stain tends to be more severe if the timber is dried at high temperature but is also found in timber dried in conventional kilns at 70°C.

Conclusion:

A range of kilns is now available to meet the varying needs of producers. High temperature kilns are recommended for the drying of structural timber. Medium temperature kilns are proving ideal for companies drying for quality markets. A Windsor kiln ensures drying will be rapid and uniform while meeting the quality requirements of exacting markets.