Fo/56/E-7-d

UTILIZATION

SEASONING

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I. Seasoning Properties

The majority of the eucalypts are dense species with mean air dry densities in the range 40 to 60 lb./cu.ft.: of the commercially utilized species the densest is E. siderophloia at 71 lb./cu.ft. They are relatively impervious to moisture movement and are slow drying, and somewhat difficult to season. Despite this, with care and technical skill, seasoned timber of high quality can be produced commercially from a wide range of eucalypts.

Fibre saturation point for most species lies in the range 24 to 30 percent. For the commercially important eucalypts lowest recorded value is 22 percent for E. wandoo: lower values have, however, been recorded for several eucalypts of lesser importance. There appears to be some correlation between fibre saturation point and equilibrium moisture content for low values of each, but this has not been verified as yet for high values.

A. Shrinkage

Shrinkage varies markedly between species. Gross shrinkage invariably consists of two parts: one, the normal of true shrinkage; and the other collapse. Excluding moisture gradient effects the former does not occur to any degree until fibre saturation point is reached, whereas collapse is usually complete at this stage.

Correlation between shrinkage and density is poor irrespective of whether shrinkage is taken as gross shrinkage, or true shrinkage only. The relation is, however, usually a little more close within a species than between species.

(i) True Shrinkage. True shrinkage is influenced by thickness of specimen and drying conditions. In general, high temperature and high humidity conditions tend to increase shrinkage, and low humidity to reduce it because of tension set. The tendency for shrinkage to diminish with increasing cross sectional size is also due to tension set. Because of the relatively high shrinkage of eucalypts and the degree of collapse in many of them, these facts have to be given special consideration in determining drying conditions.

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As with most other timbers, tangential shrinkage approximates twice radial. E. maculata with a mean tangential/radial shrinkage ratio of approximately 1.3 shows the least shrinkage difference in the two grain directions, and E. viminalis the greatest with a ratio of approximately 3.5. Longitudinal shrinkage is negligible except where cross grain or tension wood is present.

True shrinkage often shows a significant variation from bark to pith, the trend being to increase with increasing distance from the bark; this is the reverse of the trend for non-pored timbers. For E. maculata the radial difference ranges from about ½ percent to 1 percent in both tangential and radial directions. On the other hand, in a given tree there generally does not appear to be any large or consistent variation for material the same distance from the bark, but at different positions around the tree or at different heights in the tree, provided tension wood is not present.

Of the commercial eucalypts those with the smallest and greatest shrinkage respectively are E. wandoo and E. diversicolor. For these, true volumetric shrinkage to a moisture content of 12 percent averages 2 percent and 14½ percent respectively. It is worth noting that collapse is small in both these species, approximating 1 percent to 2 percent only.

(ii) Collapse. Collapse in some eucalypts can be of such magnitude and so severely degrade timber that its utilization is seriously impaired. It is usually apparent as an irregular corrugation or deformation which, in E. dives, E. radiata, E. regnans and E. obliqua (the most collapse susceptible of the commercially used eucalypts) causes a mean volume loss of about 10 percent rising to as much as 20 percent in extreme cases.

It occurs during the early stages of air or kiln drying and so precedes, but is cumulative to normal shrinkage. Unlike normal shrinkage it can usually be completed or largely removed by reconditioning - a steaming treatment towards the end of the drying period - the effect being permanent. (See F - Reconditioning). Collapse inducing forces are generally believed to be due to liquid tension effects.

Although all eucalypts appear to be collapse susceptible, the most vulnerable in Australia are those mentioned above and E. globulus, E. viminalis, E. camaldulensis, E. umbellata, E. dalrympleana, E. goniocalyx, E. capitellata, E. nitens, E. macrorrhyncha and E. saligna. The collapse susceptibility of E. globulus grown in the U.S.A. and E. camaldulensis grown in Israel and in French Morocco has also been confirmed.

Australian experience has been that collapse tends to be greater in immature or fast grown material than in mature material of the same species.

Collapse intensity and non-recovery are increased by the presence of tension wood, at least in the lighter eucalypts; a consideration of factors influencing tension wood development in relation to plantation sites for susceptible eucalypts could, therefore, be of importance in site selection.

B. Refractoriness

Because of their high density and impermeability to moisture movement most of the eucalypts tend to develop steep moisture gradients and tension set. Collapse and high shrinkage also favor tension set and checking, and all these properties combine to magnify drying stresses and increase the probability of seasoning defects. Further, a tendency to split is characteristic of such species as E. diversicolor and E. globulus, and some of the lighter species.

Most species are also temperature sensitive at moisture contents above fibre saturation point, this sensitivity increasing the tendency to check and collapse. In kiln drying green timbers 1 in. thick or thicker, drying temperatures should not, in general, be allowed to exceed about 110° F. during the early stages, and relative humidity should be kept high otherwise surface checking or honeycombing may develop.

II. Seasoning Defects and Quality Control

The more common forms of visual seasoning degrade in the eucalypts are warping, checking and collapse. The non-visual factors of high moisture gradient and drying stresses are, however, always a potential hazard against satisfactory use. Knots are of no consequence, so knot fall-out, and knot splitting are unknown. Seasoning stain, sap stain or discolouration are also of no material importance. Resin (kino) bleed from gum veins is rare.

The genus shows no common pattern of seasoning degrade - the form of degradation varies with species, method of sawing, position in tree, tree maturity, sawn dimension and such ecological factors as site, climate and latitude. In this respect Australian, South African, American and Mediterranean experience has shown that except, perhaps, in the case of species like E. camaldulensis, no one of the above factors can be regarded as always having a greater influence than the others on seasoned quality. It seems that the result obtained is largely an integration of all these factors weighted appropriately by predominant local conditions. Inherently, certain species have a greater tendency to warp, to check or to collapse than others.

A. Warping

Warping is generally a result of a characteristically irregular cell orientation - as in the case of E. camaldulensis or E. umbellata. Many species have an interlocked grain as, for example, E. maculata, E. E. microcorys, E. resinifera and E. marginata, but the interlocking is generally sufficiently regular not to cause trouble in joinery sizes and thicker. The straight grained species, such as E. regnans, E. gigantea, E. pilularis and E. saligna, are comparatively free from warping characteristics due to grain except for an occasional spiral-grained tree, or where utilization requires crown or "head" logs to be used.

Tree growth stresses can cause certain forms of warping, especially spring, but the effects can often be minimized by appropriate sawing techniques (balances saw cuts), and suitable stacking for drying.

Growth stresses are also mainly responsible for the "popping" or end splitting of logs of some species on felling or cross cutting, particularly those from immature trees of species such as E. globulus, E. viminalis, E. gigantea and E. regnans. As yet no technique has been developed to prevent this loss. The best that present knowledge can recommend is care in felling, prevention of end drying, rapid conversion, and conversion into lengths as long as possible.

It is usually unwise to dry in multiple thicknesses for later deepsawing as this practice increases drying time and risk of degrade disproportionately, and also introduces the risk of cupping from drying stresses or moisture gradients on deepsawing. It is generally better to saw to nominal size and season with as small a dimensional margin as practicable consistent with shrinkage and machining allowance.

B. Checking

Most of the eucalypts have a tendency to check on backsawn faces during seasoning, some of them severely. In this category are E. diversicolor, E. regnans, E. gigantea, E. obliqua, E. pilularis and E. saligna. On the contrary, quartersawn surfaces usually remain comparatively free of checks.

For the above reason, and because of the greater dimensional stability of quartersawn timber, quartersawing is a desirable practice for seasoning quality material from most species.

Within a species, age appears to be a major factor in determining proclivity to checking. In general, material from immature and fast grown trees seems especially prone to check. Unfortunately, quartersawing such material is greatly hampered by size limitations. However, if widths are kept small quartersawing can often be done with advantage.

Much can be gained by eliminating pith and material adjacent to it in converting logs from immature trees. Australian studies have shown that material within about 2 in. of the pith is especially prone to face checking and end splits, and is likely to initiate degrade in material containing it.

III. Drying Practice

Good seasoning practice for the eucalypts has been developed to take account of their collapse susceptibility, impermeability, high shrinkage behaviour and tendency to check. With quartersawing where appropriate, and by rigidly applying good stacking practice and a suitable seasoning process good results can be obtained.

The eucalypts are used in a great number of forms, including sawn or shaped sizes for joinery, furniture and other dressing purposes; as veneer; as sawn or sliced case material; as building frame timbers; as sawn and hewn heavy sizes such as railway sleepers, bridge timbers, mine timbers and decking; as round timbers such as poles and piles; as round and split posts; and as fuel.

Marked success has been achieved in solving the problems of seasoning timbers of joinery or dressing sizes. On the other hand, many of the other products named are used unseasoned - for example, eucalypt framing timbers for on-site building construction in Australia are rarely deliberately seasoned because they are difficult to nail when dry - or they are only partly seasoned as a prerequisite for preservation purposes. In this case the most likely alternatives for seasoning are air drying, or accelerated methods like vapour drying, boultonizing, or alternating steaming and vacuum treatment. Railway sleeper sizes in E. marginata, E. regnans, E. obliqua, E. diversicolor and E. radiata have been vapour dried in Australia on an experimental scale.

For seasoning the eucalypts in the flooring, weatherboard and dressing sizes complete air drying or combined air - and kiln - drying is commonly used. Kiln drying from the green condition is less common, more costly and more likely to cause degrade, but occasionally is practised where urgency dictates.

In climates unfavourable to air drying, predrying in very large, low cost, low temperature drying chambers, provided with forced air circulation and operated at constant psychrometric conditions equivalent to that of a warm summer day, is increasing in favour as a substitute for preliminary partial air drying.

A. Stacking

Sound stacking practice is essential for the eucalypts. For species prone to warp, e.g. E. camaldulensis or E. umbellata spacing of separating strips should not exceed 12 in., and stacks should be weighted on top. Where spring is a factor, this can often be reduced significantly by stacking on edge and then steaming for a few hours towards the end of drying.

In hot and dry conditions backsawn stock should be kept to the inside of stacks where practicable, quartersawn boards being placed in the outside tiers and in the top layers.

B. Air Drying

For complete air seasoning, drying times for 1 in. thick material range from about 3 months to about 15 months depending on species, position and condition of the yard site, construction of the stacks, wind conditions and general climate. Thicker timbers require rather more than proportionately longer time. South Africa has reported green 1 in. thick E. diversicolor as air drying to a moisture content of 14 percent in approximately 4 months, and 2 in. stock in about 9 months; and that 1 in. thick green E. saligna air dried in 3 months; 2 in. thick stock in about 8 months, and 3 in. stock in about 14 months.

The principal advantages of air drying are (i) the simplicity of the method, (ii) the low drying cost, and (iii) the usual ready response of air-dried collapsed timber to reconditioning. The principal disadvantages are (i) seasoning cannot be accelerated in case of urgency, (ii) there is no guarantee as to final moisture content or that fully seasoned material is available at any time, and (iii) the system requires large air drying stock and consequent capital investment in stock.

C. Combined Air and Kiln Drying

The combined process consists of air drying to at least fibre saturation point and then kiln drying to the final moisture content required. For 1 in. thick stock it usually involves an air drying time of 2 to 6 months followed by kiln drying for 2 to 6 days depending on species and air drying conditions.

Approximate kiln drying times for partially air dried timber for several thicknesses of several species are given in the table attached.

The advantages of this system are (i) the required final moisture content is reached irrespective of weather, (ii) for a given capital expenditure on buildings, yards and plant, maximum output is obtained, (iii) timber stocks do not need to be as large as for air drying, (iv) compared with kiln drying from the green, drying costs are less, less skilled attention is required, kiln and steam demand is reduced to one-third or one-half, dried quality is often superior as there is less risk of high moisture gradients, and reconditioning is more effective in removing collapse.

D. Kiln Drying from the Green Condition

Kiln drying from the green has the virtue of speed in times of emergency, but for high quality closer attention and greater skill in kiln operation are required than for the combined method.

The time required for kiln drying 1 in. stock from the green ranges from about 10 to 18 days (24 hr./day) depending on the species. Kiln drying times from the green condition for several thickness of several species are also given in the attached table.

The principal disadvantages of kiln drying from the green are (i) the high drying cost involved, and (ii) the relatively high capital cost of plant and equipment for a given output, as well as the other factors mentioned in the discussion on the combined process.

Thin eucalypt case stock from 1/4 to 3/8 in. thick is often commercially kiln dried from the green with satisfactory results in period ranging from 24 to 36 hr. Thicker case material, including 3/4 in. thick ends, is preferably partly air dried to about fibre saturation point before kiln drying, a kiln time of about 48 to 60 hr. then being needed.

E. Kiln Drying Conditions

Sawn timber thicker than 2 in. is rarely kiln dried because of the cost, the time required and the risk of degrade.

If flooring, weatherboard or joinery sizes are kiln dried from the green condition mild kiln schedules are essential otherwise checking, drying stress, moisture gradients and collapse are usually pronounced. Initial kiln temperatures for green stock usually range from 100° F. to 120° F. rising to about 140° F. or 160 ° F. towards the end of drying; the associated wet bulb depressions usually range from about 5° F. or 7° F. in the early stage, to about 20° F. or 30° F. in the later stages.

For partially air dried stock comparatively severe initial kiln conditions may be used safely: for example, a temperature of 130° F. to 140° F. with a wet bulb depression of 15° to 20° F. Temperatures up to 200° F. have been used for the final stages of drying of some species.

For mixed backsawn and quartersawn 1/4 in. to 3/8 in. thick material kiln dried from the green, temperature approximating 180° F. and a wet bulb depression of 30° to 40° F. may be used from the outset. For case ends approximating 3/4 in. thick a similar temperature may be used, but the wet bulb depression reduced to about 20° or 25° F. in the early stages.

Backsawn stock thicker than about 3/8 in. usually checks readily, so no attempt should be made to kiln dry from the green. As previously indicated, reasonable success can be obtained with immature material by quartersawing, keeping widths narrow, and eliminating all material within about 2 in. of the pith.

F. Reconditioning

Reconditioning is a steaming treatment given collapse affected timbers towards the conclusion of air or kiln drying to remove the collapse. It is an essential treatment for joinery or dressed sizes of all the eucalypts mentioned earlier as being collapse prone. The treatment is permanent, and gives an average recovery in size ranging from 5 to 10 percent. The optimum timber moisture content at the time of treatment is 15 to 20 percent, and if previously kiln dried the timber should be allowed to cool before being reconditioned. The duration of treatment ranges from 5 to 8 hr. depending on thickness.

The treating temperature of 212° F. should be obtained as rapidly as possible, and then held for the required period. Steam fed to the reconditioning chamber should be as low in pressure as practicable, as superheating appears to affect recovery adversely. Exhaust or wet steam appears to have advantages.

Reconditioning is now a standard commercial practice throughout Australia where collapse susceptible species are seasoned. It is a simple process involving only the transfer of the stickered timber stacks into a box-like reconditioning chamber, holding a steam atmosphere in this chamber for the required period, and then removing the timber for further drying. During the treatment the average moisture content of the charge increases by some 3 or 4 percent.

Provided the duration of treatment is kept to a minimum necessary for full size recovery, it has the further advantage of relieving "casehardening" and reducing moisture gradients.

G. Final Conditions and Stress Relief Treatments

In rapidly dried material drying stresses and steep moisture gradients can persist for long periods, and cause considerable trouble from cupping in deep sawn material, or movement in shaped or dressed stock. A combined moisture conditioning and stress relief treatment is an essential part of kiln drying practice for eucalypt timbers intended for critical manufacturing uses.

For non-collapsing species, or occasions when the reconditioning treatment is not warranted, this conditioning is best given as a high humidity treatment of some 24 to 48 hr. duration at temperatures approximating 160° F. to 180° F., and relative humidity slightly higher than the equivalent of the equilibrium moisture content for the use intended.

H. Veneer Drying

Veneers are peeled on a commercial scale from three eucalypts in Australia, namely E. diversicolor, E. maculata and E. regnans. Veneers have a tendency to buckle, end split and through-check: in the case of E. regnans this is partly due to collapse. Nevertheless, all are being satisfactorily kiln dried commercially from the green in approximately 60 min. for 1/16 in. material. Optimum conditions combine a high dry bulb temperature approximating 160° F. to 180° F. with a low wet bulb temperature approximating 100° F. and a high air circulation rate approximating 500 ft./min.

E. regnans veneer has also been dried satisfactorily in Australia in a roller type mechanical drier.

I. Other Seasoning Processes

For the more freely checking timbers, including immature stock, or where sizes are large, and minimum checking is essential, chemical seasoning has value. The salt selected should generally be one with low anti-shrink characteristics rather than the reverse as is favoured for softwoods. This is because a high "anti-shrink" salt would tend to increase case hardening effects with the generally high shrinking eucalypts.

A suitable salt is sodium chloride specially if buffered to diminish corrosion hazard with ferrous fastenings. The chemical seasoning of E. umbellata for windmill bearing blocks with sodium chloride as the treating salt is in commercial practice in Australia.

IV. Kilns and Reconditioning Chambers Suitable for Eucalypts

The internal fan, cross circulation, compartment type kiln is generally regarded as the most satisfactory for kiln drying eucalypt timbers. In Australia the cross-shaft unit is widely favoured because of the uniform drying conditions it provides.

There are advantages in keeping kiln units for eucalypts comparatively small. The principal reasons are (i) uniformity of drying conditions is more easily obtained, (ii) stacks greater in size, than say 6 ft. to 8 ft. wide and 7 ft. to 8 ft. high are heavy to handle; with stacks higher than 8 ft. there is also the risk of board crushing at separating sticker positions during reconditioning, (iii) with comparatively small stacks any lag in the accumulation of material in a given thickness of a given species is kept to a minimum so that variation in moisture content within a stack is minimized, (iv) different drying schedules are required for the many different species, for different thickness of the one species, and even for backsawn material as distinct from quartersawn stock.

The reconditioning chamber is best constructed in reinforced concrete, or with cavity brick walls and reinforced concrete floor and roof. It is a simple, box-like structure about 2 ft. wider and 15 in. higher internally than the timber charge it is required to hold. The only fitting required in it, apart from truck access rails, is a perforated steam pipe running centrally along the length of the floor. This pipe is usually $1\frac{1}{2}$ in. in diameter with $\frac{1}{4}$ in. diameter holes in it at about 12 in. centres along the length.

V. Equilibrium Moisture Content and Dimensional Stability

The dimensional stability of seasoned timber in use depends almost entirely on the uniformity and suitability of its moisture content at the time of manufacture, or for the use intended. This is of special importance with the eucalypts because of their generally high shrinkage; this causes comparatively large dimensional changes with relatively small moisture content change.

The eucalypts also show wide divergence in the equilibrium moisture content obtained in a given atmosphere. Of the species on which comparative information is available, i.e. E. gigantea, E. marginata, E. microcorys, E. obliqua and E. regnans, the first named reaches lowest equilibrium moisture content values and E. marginata the highest. As mentioned previously, the fibre saturation point of the last is also particularly high.

Equilibrium moisture content values for the eucalypts in indoor positions in Australian capital cities range from about 10 percent (± up to 3 percent depending on species, latitude and climate) in the dry season, and about 13 percent (± up to 3 percent) in the wet season. The range for external sheltered positions is from 12 percent (± 5 percent) in the dry season to 16 percent (± 5 percent) in the wet. The range for most countries in which the eucalypts are grown is probably similar.

VI. Precautions in Building Construction

Building practice with the eucalypts differs somewhat from recognized European and American methods because of the species hardness when dry, and their movement with moisture content change. Constructional and framing timbers are preferably used green, otherwise nailing is difficult. With the form of construction and bracing used, little trouble is caused by collapse or misalignment. Occasional minor irregularities are corrected by partial saw cuts or packing. Flooring, weatherboards and interior joinery and trim is carefully seasoned before use.

Common techniques to minimize movement, and to reduce weather and other damage during "on site" construction include temporarily laying flooring up side down while other work is proceeding, the priming or oiling of weatherboards before placing, the adjustment of floor cramping pressure to suit conditions, the use of slotted screw holes or other design features to enable free movement of critical components, and the use of quartersawn timber and/or narrow width stock where width stability is important.

The eucalypts are not satisfactory for laths in lath and plaster finishes, as water soluble extractives tend to stain through the plaster and lath movement may break off the plaster key. Australian practice has now standardized on fibrous plaster board applied direct to the framing timbers as a better interior finish.

VII. Research Programme for next Five Years

Major gaps in world knowledge on the seasoning of the eucalypts relate to (i) the behaviour of plantation grown, immature and regrowth timbers, (ii) collapse and recovery, (iii) the drying of large size round and sawn timbers, and (iv) the basic mechanisms of drying and moisture movement in these impervious species.

On plantation, immature and regrowth timbers the studies should aim at determining the effect of age, and probably site, on seasoning behaviour particularly for collapse and checking. The influence of growth stresses must be recognized.

In the field of collapse and recovery, the outstanding need is to find a means to prevent the occurrence of collapse during drying. Information on the mechanism of recovery is also required.

Work on the drying of large round and sawn timbers should aim at finding the optimum process for partial drying for preservation purposes.

Fundamental drying studies should aim at a clarification of the mechanism of drying and moisture movement in the impervious eucalypts, relating particularly to the effect of physical conditions such as temperature, pressure, vapour pressure, and density to drying rate and dried quality. Virtually no basic information is available in this field

TYPICAL SEASONING BEHAVIOUR FOR NINE REPRESENTATIVE EUCALYPTS

Species	Drying Behaviour of Mature Timber	Mean Shrinkage % Air Dried to 12% M.C.				Thickness of Stock (in.)	Kiln Drying Time (in days of 24 hr.)	
		Tangential		Radial			From the Green Condition	After Partial Air Drying to 25% M.C.
		BR	AR	BR	AR			
E. camaldulensis	(a) Collapse moderate to high (R) (b) Not prone to check unless conditions severe (c) Pronounced warp	9	4½	4	2½	1*	18 to 20	6 to 7
E. globulus	(a) Collapse high (R) (b) Prone to check if backsawn (c) Little warp	11	6½	5	3	1*	18 to 20	6
E. maculata	(a) Collapse low (b) Prone to check if backsawn (c) Slight to moderate warp	6	4½	4½	3½	1*	16 to 18	6
E. marginata	(a) Collapse low (b) Not prone to check unless conditions severe (c) Slight warp	8	6½	5	4½	¼ ½* 1* 2*	2 4 to 6 18 to 20 40 to 50	– 2 to 4 6 to 7 18 to 20
E. pilularis	(a) Collapse low to moderate (b) Prone to check if backsawn (c) Slight warp	7	5½	4	3	½* 1*	3 to 5 12 to 16	2 3 to 5
E. regnans	(a) Collapse high (R) (b) Prone to check if backsawn (c) Little warp	14	7½	7	4	¼ ½* 1* 2*	1 3 to 4 10 to 18 30 to 50	– 2 3 to 5 10 to 14

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TYPICAL SEASONING BEHAVIOUR FOR NINE REPRESENTATIVE EUCALYPTS (Continued)

Species	Drying Behaviour of Mature Timber	Mean Shrinkage % Air Dried to 12% M.C.				Thickness of Stock (in.)	Kiln Drying Time (in days of 24 hr.)	
		Tangential		Radial			From the Green Condition	After Partial Air Drying to 25% M.C.
		BR	AR	BR	AR			
E. saligna	(a) Collapse moderate (b) Prone to check if backsawn (c) Little warp	8½	5	6	4	½* 1*	3 to 5 12 to 14	2 4 to 6
E. diversicolor	(a) Collapse low (b) Prone to check if backsawn (c) Little warp except wide backsawn or thin stock	10	9½	5	5	¼ ½* 1*	- 6 to 8 20 to 25	1 2 to 4 7 to 9
E. grandis	(a) Collapse low (b) Prone to check if backsawn (c) Little warp	7½	6	4½	4	¼ ½* 1*	1 3 to 5 12 to 14	- 2 4 to 5

R = Reconditioning recommended.
* = Partial air drying before kiln drying recommended.
BR = Before reconditioning.
AR = After reconditioning.

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