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THE DURABILITY OF EUCALYPT TIMBERS AND THEIR PRESERVATIVE TREATMENT

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In any broad discussion of problems and practices relating to preservative treatment of eucalypt timbers it is most desirable to establish a background of Australian experience before considering the position in other countries. This approach does not infer that Australian experience should be accepted as an infallible guide in countries where local knowledge of eucalypts is slight. In all cases it should be applied cautiously with due regard to the fact that the rate of growth of the tree, the age at which it is cut and the conditions under which the timber is used, may greatly alter the result. Also it should be realized that large scale conventional preservation of eucalypt timbers is not practised in any country, and that in some respects, information though considerable, is still in the experimental stage.

I. Durability

A. Natural Resistance

Australian grown eucaplypts vary greatly in natural resistance to insects, fungi and marine organisms. Although the effect of species is most important, other factors should not be entirely disregarded. Thus, it is generally conceded, though not fully proven, that the durability of eucalypt heartwood is reduced if the density is less or the colour is paler than normal. This had let to the general belief that timber from young, fast grown trees is lacking in durability and to the requirement in some sleeper specifications that "Timber shall be cut only from mature trees". Also it is generally recognized that the central core of the tree for a variable radius usually up to several inches from the pith, has lower durability than the rest of the heartwood. This is reflected in Australian specifications which prohibit this central heartwood in durable eucalypt sleepers.

These requirements, based on practical observation over many years, should not be lightly dismissed in any country where untreated fast grown eucalypt timber is used for ground contact.

Natural resistance of eucalypt timbers may be considered more specifically as follows:-

(i) Borers. Except for ambrosia or pinhole borers (Platypodidae, Scolytidae, Lymexylonedae) which attack unseasoned wood, eucalypt

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heartwood is rarely susceptible to borer damage. Damage is however common in the sapwood during or shortly after seasoning and is caused mainly by members of the Lyctidae and Bostrychidae. Susceptibility to these borers is dependent primarily on the starch content of the sapwood, a characteristic which is determined more by the timber species than the locality of growth or season of cutting. In Australia it is sufficiently constant to permit grading of species according to degree of susceptibility as shown in Table 1.

(ii) Termites. Subterranean termites of economically important genera (Mastotermes, Coptotermes, Rhinotermes, Nasutitermes, etc.) occur in most parts of Australia. Australian durability ratings for eucalypt heartwood (Table 1) are therefore usually a composite of both decay and termite resistance, which fortunately seem to occur to about the same degree in the main commercial eucalypts. Exceptions are mainly among some of the heavy inland species which appear more resistant to decay than to termites.

Very limited data on the termite resistance of plantation grown eucalypts is available, though tests of some 25 species in South Africa have shown reasonable agreement with Australian ratings. Anomalies, such as a low rating for E. camaldulensis and E. resinifera could be explained if the test material came from small trees or from too near the pith.

(iii) Fungi. With some exceptions there is a useful degree of correlation between the decay resistance of Australian grown eucalypts and the mean air dry weight of the wood. Thus species below 50 lb./cu.ft. are generally not durable in ground contact while above 60 lb./cu.ft. most species have high decay resistance. In the intermediate group, the position is more variable, some species such as E. gummifera and E. marginata being more durable and others such as E. diversicolor and E. globulus less durable than indicated by their weight.

Published figures for the air dry density of plantation grown eucalypts are generally lower than Australian averages (Table 1) indicating that the durability of Australian material is probably considerably higher.

(iv) Marine Organisms. In tropical waters, sheathing or preservative treatment is necessary, as even the heaviest eucalypts have little resistance to Teredine borers. In the more temperate southern Australian waters the hazard is relatively low, and the heavier species give long service as piling without treatment.

B. Comparison of Species

The more important eucalypts are listed in Table 1, which shows the mean air dry weight of the species, the relative durability of the heartwood (combined decay and termite resistance in contact with the ground) and the susceptibility of the sapwood to Lyctus borers. Ratings given represent the approximate average Australian reputation of the timber excluding wood near the pith - or if used as round material, in sizes not less than about 9 in. butt diameter, under bark.

C. Effect of Durability on Use

In the past, outdoor constructional timbers in Australia were typically durable eucalypts used without preservative treatment. This practice was economically more attractive than treatment of less durable species, particularly as eucalypt heartwood is difficult to penetrate by conventional pressure processes. This position is now changing as supplies of durable eucalypts dwindle and as high labour costs increasingly favour treatment. Also the technical problem of treating sawn material has been considerably reduced by the development of high pressure penetration of eucalypt heartwood.

(i) Sleepers. In Australia, untreated durable eucalypts have proved very suitable for rail sleepers. The best species in durability groups 1 and 2 rarely give less than 15 years life and mostly average from 20-25 years or more. In light traffic lines, lives of 30-40 years are not uncommon. Species in durability group 3 have more recently come into use, and without treatment are giving about 8-20 years service, with an average of about 12-16 years.

Under most Australian conditions, end splitting, wear at the rail seat and deep weathering of the surface are the main causes of failure of eucalypt sleepers in clean stone ballast, even for species in durability group 3. In gravel ballast, decay and termite attack may become more important.

At present, preservative treatment seems economically justified for sleepers in durability group 3, but except in gravel ballast, its justification is more dependent on retardation of mechanical than of biological failure. Treatment of sleepers of higher natural durability is even more dependent on successful retardation of mechanical failure. This conclusion may apply with even greater emphasis where plantation grown eucalypts are used for sleepers.

(ii) Crossarms. Satisfactory use of eucalypt timbers for crossarms is probably more dependent on freedom from collapse and on good mechanical behaviour than on high resistance to decay and termites. Thus, under most southern Australian conditions a life exceeding 20 years is obtained even from untreated selected timbers in durability group 3. As this approximates the life of a durable untreated pole, treatment of arms in Australia seems justified only where treated poles are used.

(iii) Poles. In Australia, the most durable eucalypt poles give an average life of about 18-25 years either without treatment or with only occasional creosote brushing or puddling at the butt. However, with adequate treatment, lives of 30-35 years are expected at reduced annual charge and with the further advantage that preservation of the sapwood allows use of smaller diameter poles than could otherwise be permitted.

(iv) Posts. Untreated sawn or split posts of durable eucalypts, substantially free from sapwood or central heartwood, give an average life of about 30 years in most Australian States. Except for large gate or strainer posts, untreated round eucalypts are seldom used as in small sizes their life is rarely satisfactory. Small round posts of most eucalypt species are however good material for preservative treatment being typically stronger than softwoods and more economical of preservative. Correctly treated they may outlast the most durable untreated split posts.

(v) Building Timbers. Except where prevention of *Lyctus* attack is necessary, there is little need for preservative treatment of building timbers in Australia. This statement assumes that species of moderate durability are used for external joinery and verandah floors, that subterranean termites are controlled by structural means or by soil poisons, and that building practice is generally sound. Control of *Lyctus* damage is seldom justified for scantling timber from species in which the sapwood does not exceed about 1 in. in thickness. With decorative woodwork however, susceptible sapwood should be treated or else completely eliminated. In areas where dry wood termites occur more general treatment of many eucalypt species may be desirable.

II. Preservative Practices

Practices necessary for satisfactory preservative treatment of eucalypts are generally similar to those which apply to other hardwoods of similar density in which the heartwood is difficult to penetrate. They may be discussed briefly as follows:

A. Preparation for Treatment

Hand barking of eucaplypts is not difficult during most of the year. In Australia it is usually done in the forest soon after felling by bruising off the bark with the back of an axe. Because of the relatively narrow sapwood, machine shaving of poles is usually undesirable.

Unless the climate is unfavourable, air drying is normal preparation for treatment, accelerated methods being desirable only if dictated by special circumstances. Air drying may require some skill to reduce degrade to a minimum but with Australian grown eucalypts does not normally impose any serious technical difficulties. With good air drying practice in a Mediterranean climate, eucalypt poles or posts can be penetrated with high oil retentions to a full sapwood depth of at least 1 in. after a drying period of 3-8 months depending on season of the year and density of the timber species. With sawn timbers, high pressure treatment of the heartwood to a depth of 3/4 in. may usually be made after similar drying periods, though for maximum retention and uniformity of penetration in this zone, somewhat longer periods may be necessary.

Where possible, boring of sleepers and preframing of other timbers should be made before treatment. In penetrating the heartwood of most species, even at high pressures, incising is beneficial both to increase the retention and to improve the uniformity of treatment.

B. Treatment for Specific Purposes

(i) Rail Sleepers. With few exceptions, eucalypt heartwood is very difficult to penetrate and benefits considerably from treatment pressures up to 1000 lb./sq.in. (68 atmospheres). High pressure penetration has been developed recently by the Australian Forest Products Division and fully tested by treatment of several thousand eucalypt sleepers of various species ranging in air dry density from about 40-60 lb./cu.ft. The Division has also designed a quick closing cylinder to take maximum advantage of the rapid treatment possible at high pressures.

At present, the most promising treatment for eucalypt sleepers is high pressure impregnation with a preservative oil giving complete end penetration for a distance of about 6 in., and a uniform side penetration of about 3/4 in. Preboring gives additional small areas of penetration at the rail seat. This treatment can be made after a reasonably short drying period and is economical of preservative as only about half the sleeper volume is treated. With most eucalypts so far treated, oil retentions have averaged about 4-6 lb./cu.ft. without incision, and about 5-8 lb./cu.ft. after incision. As these figures are based on total volume they can be approximately doubled for the actual treated wood retention. They are obtained by Lowry treatment in which the pressure is quickly raised to 1000 lb/sq.in. and maintained until approximate refusal occurs - usually within the first hour. With most eucalypts, preservative temperatures of 160-180° F. can be maintained without damage to the wood. A reasonably clean surface can be obtained by the use of standard practices after release of pressure.

Because of the need to retard mechanical deterioration, preservative oils are preferable to water-borne salts, particularly for timbers of high shrinkage such as eucalypts. Present evidence favours creosote:furnace oil mixture in proportions ranging from about 60:40 to 30:70 depending on climate. Alternatively a 3-5 per cent solution of pentachlorophenol in heavy oil may be used.

(ii) Crossarms. High pressure penetration with preservative oils as described for rail sleepers is considered the most promising treatment for prebored eucalypt crossarms. A problem of treatment is to obtain a sufficiently clean arm as slow release of air from the vessels tends to cause bleeding after treatment. Use of pentachlorophenol in a heavy but clean oil, at retentions of about 5 lb./cu.ft. represents a compromise between reasonable cleanliness and maximum protection.

(iii) Poles. Conventional pressure or open tank treatment of eucalypt poles has presented no difficulty in Australia though in South Africa the sapwood of *E. saligna* has sometimes proved refractory.

For reliable results, complete and heavy treatment of the sapwood at the butt is considered essential. Australian tests have shown that a life of 30-35 years can be expected in the southern States from poles with a sapwood thickness of ½-1 in., treated with creosote oil to a retention of about 15 lb./cu.ft. of sapwood. Where the sapwood exceeds 1 in., lower retention can probably be used with safety.

With preservative oils, the higher retention can be obtained by Lowry treatment at pressures of 100-200 lb./sq.in., followed by final vacuum or other practices desirable for cleanliness. At this retention, bleeding does not appear to be objectionable.

Open tank treatment is also satisfactory and may be applied full length or to the butt only. In the latter case a light top treatment is desirable for species susceptible to borers, but otherwise may be omitted if the pole is well capped and the climate is not excessively wet.

Because of their ability to creep over any untreated wood exposed by splitting, preservative oils are preferred for poles, particularly where the sapwood is narrow and the seasoning period short. For clean treatments, however, water borne preservatives have considerable merit, and in Israel have been applied by the Boucherie method to E. camaldulensis poles.

(iv) Fence Posts. As with poles, satisfactory treatment of eucalypt fence posts requires complete and heavy penetration of the sapwood at the butt.

In addition to conventional pressure and open tank treatment, cold soaking of dry posts in a preservative oil for periods up to 7 days, gives satisfactory sapwood penetration in many species. A more rapid treatment, involving low pressure soaking, has been developed recently. In this method, the dry posts are treated in a cylinder of light construction at a pressure of about 10 lb./sq.in., usually applied by gravity from an elevated tank containing the exact volume of preservative required for treatment. Once commenced, this treatment is automatic and is usually complete in 24 hr. It is suitable for both oil and water-borne preservatives.

While full length treatments are usually desirable in wet climates, tests have shown that little or no top treatment is necessary for most species in the Australian wheatland climate provided the sapwood is not susceptible to borers and does not exceed about 3/4 in. in thickness.

With creosote oils, 8-12 lb./cu.ft. of sapwood volume is sufficient in Australia to ensure a life of about 30 years. Where top treatments can be made separately, 1/3-½ this retention is satisfactory above ground. For reasons of cleanliness and cost, fixed water-borne preservatives are an attractive alternative to oils.

(v) Building timbers. If control of Lyctus or other borer attack is necessary its organization should begin in the sawmill where susceptible species can be cut intelligently and where material requiring treatment can be readily segregated. Although pressure treatment with standard preservatives is satisfactory, it may be unnecessarily costly if its only purpose is to control borers in timber which will be protected from leaching. In Australia, the very economical treatment which is widely used for Lyctus immunization of rain forest timbers has been applied satisfactorily to eucalypts. This method gives complete penetration of green or semi-green sapwood with boric acid or borax using a combined hot and cold bath and diffusion treatment. It is economical because boron compounds are cheap and highly toxic, and because the timber can be treated green, in kiln sized packets, without high capital cost. The essential specification, which is controlled by legislation in New South Wales and Queensland requires that no part of the sapwood shall contain less than 0.2 percent H_3BO_3 on oven dry basis.

Current research in Australia and New Zealand has indicated that the Australian method of treating green veneer - by momentary dipping in a boron preservative followed by block stacking to permit diffusion - may have important application for building timbers. Highly concentrated solutions are necessary and solutions containing pentaborates and fluoborates are most promising. The Australian

Forest Products Laboratory has recently lodged a patent for a solution of this type containing up to 80 percent total solids in cold solution (w/w. basis).

III. Research Programme for Next Five Years

Some indication should be given of desirable future research on preservation of eucalypt timbers. Full discussion is not attempted as many important aspects are not confined to eucalypts, others have no immediate practical targets while others seek confirmation rather than extension of existing knowledge. In most respects progress in the next few years is likely to be measured by many small, rather than by a few large advances.

Some more important aspects may be summarized as follows:-

A. Natural Durability

Study should be made of reasons for durability in eucalypt timbers and should include extraction of toxic materials for laboratory testing against fungi and termites. The effect of sylvicultural treatment on durability should also be investigated together with the durability pattern within the tree.

B. Pressure Treatment of Eucalypt Heartwood

The problem of treating refractory heartwood should be investigated from histological, fundamental physical, and practical aspects in an effort to improve and simplify the existing high pressure treatment method.

C. Diffusion Treatments

Diffusion treatment of green eucalypt timber, by momentary dipping in highly concentrated preservatives followed by block stacking, should be fully investigated and commercially tested. Its main application would be for building timbers, firstly in the treatment of borer susceptible sapwood, and secondly in cases where treatment of the heartwood was necessitated by special circumstances.

D. Mechanical Deterioration

Mechanical deterioration, particularly in rail sleepers is an important project requiring fundamental and practical work.

E. Water-Borne Preservatives

Water-borne preservatives are desirable for maximum cleanliness in poles and to reduce the cost of fence post treatments. Apart from practical tests, there is need for intensive laboratory study of fixation mechanisms, resistance to leaching, residual toxicity, effect of timber species, etc.

TABLE 1

DURABILITY RATINGS FOR SOME EUCALYPT TIMBERS

Commercial Importance: The letters used refer to the quantity of timber cut annually in Australia - A, more than 10 million super ft.; B, 3-10 million; C, 1-3 million; D, less than 1 million.

Air Dry Density: Refers to average density of the heartwood at 12 percent moisture content before reconditioning.

Durability Ratings: Refer to the decay and termite resistance of the heartwood in contact with the ground and are expressed as - 1, very durable; 2, durable; 3, moderately durable; 4, non durable. Classes 1 and 2 give long life in contact with the ground without treatment; class 3 gives only a moderate life, while class 4 is not used in ground contact, unless preservative treated.

Lyctus Ratings: Refer to the sapwood only and have the following meanings - I - immune for all practical purposes; RS - rarely susceptible; MS - attack fairly frequent and may be severe; HS - highly susceptible, attack common and usually severe.

Species	Commercial Importance	Density Air Dry lb./cu.ft.	Durability Rating	Lyctus Rating
E. astringens	D	61	3	I
E. bosistoana	D	69	1-	RS
E. botryoides	C	57	2	RS
E. calophylla	C	53	3+	MS
E. camaldulensis	A	57	2+	MS
(E. carnea (E. triantha	B	60	1	RS
(E. capitellata (E. blaxlandi (E. baxteri	B	52	3+	I
E. cladocalyx	C	68	2	HS
E. consideniana		59		
E. dalrympleana	C	43	4	HS
E. diversicolor	A	56	3	I
E. dives	C	50	3+	MS
E. eximia	D	55	2	HS
E. fastigata	C	46	3-	MS
E. gigantea	A	41	4	RS
(E. globulus (E. bicostata	B	57	3+	MS
E. gomphocephala	C	65	2	MS
E. goniocalyx	B	54	3+	HS
E. grandis	A	47	3	RS
E. gummifera	C	55	1+	MS
(E. haemastoma (E. micrantha	C	56	2-	RS
(E. hemiphloia (E. largeana	C	70	1+	RS
E. leucoxylon	D	63	1-	
E. longifolia	C	66	2	MS
E. macrorrhyncha	D	56	3+	MS
(E. maculata (E. citriodora	A	62	2-3	HS

TABLE 1. (contd.)

Species	Commercial Importance	Density Air Dry lb./cu.ft.	Durability Rating	Lyctus Rating
E. maideni	C	60	2-3	HS
E. marginata	A	51	2+	RS
E. melliodora	D	67	1-	RS
E. microcorys	A	62	1	MS
E. muelleriana	C+	55	2	I
E. nitens	D	42	4	HS
E. obliqua	A	48	3	HS
E. paniculata	B	68	1+	RS
E. patens	D	53	2-	HS
E. pilularis	A	55	2-	RS
E. polyanthemos	D	66	1	MS
(E. punctata (E. propinqua (E. major	B	66	1-	RS-MS
E. racemosa	C	67	1	RS
✗E. radiata	C+	52	3+	MS
E. regnans	A	42	4	I
(E. resinifera (E. pellita (E. kirtoniana	B	58	2+	MS
E. rubida	C	46	3-	MS
E. salicifolia	C-	47	3+	MS
E. saligna	B	53	3+	MS
E. salubris	D	69	2	I
(E. scabra (E. globoidea	B	53	2-	RS
E. siderophloia	C+	71	1	RS
E. sideroxylon	C	68	1	HS
E. sieberiana	B	53	3+	I
E. tessellaris	C	68	2+	HS
E. trachyphloia	C	64	1-	HS
(E. umbellata (E. blakelyi (E. secana (E. bancrofti	C+	61	2+	RS-MS
E. viminalis	B	48	3	MS
E. wandoo	B	69	1+	I