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Effect of end treatment on CCA preservative distribution in regrowth karri transmission poles

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SUMMARY

An increasing number of regrowth karri (*Eucalyptus diversicolor* F. Muell.) poles were being used in transmission lines throughout Western Australia. In 1989 the formation of tyloses in vessels in the sapwood band after the tree was felled apparently caused some problems with achieving satisfactory distribution of copper-chrome-arsenic (CCA) preservative in poles. One method suggested to restrict tyloses formation was to end-seal sapwood bands, immediately after felling the tree and docking it to pole length. Two proprietory log end sealers, 'Pabco' and 'Cellavit WR151', were applied to sapwood bands immediately after felling and docking to test the theory. The poles were treated either green or dry (sapwood below 30 per cent moisture content) using a long-wet vacuum method.

No significant difference in CCA retention was found between poles sealed with 'Pabco', 'Cellavit WR151' or untreated, or between poles treated green or below 30 per cent moisture content. Using the SECWA pole specification 8 out of 23 specimens achieved the minimum retention requirement of 1.6 per cent mass/mass for individual poles. Australian Standard AS1604-1993 specifies a lower retention minimum of 1.2 per cent mass/mass for Hazard level 5, and in this trial one specimen failed the specified minimum retention requirements while two retentions (1.17 and 1.19 per cent) were borderline.

INTRODUCTION

The State Energy Commission of Western Australia (SECWA) require several thousand power poles each year for replacement in existing transmission lines, and for providing additional services. The Department of Conservation and Land Management, as manager of State Forest, is the principal supplier of these poles. The major species used are jarrah (*Eucalyptus marginata* Donn ex Sm.) and WA blackbutt (*E. patens* Benth.). However, in 1989 an increasing proportion of the supply was from regrowth karri (*E. diversicolor* F. Muell.), and in 1988/89 the Department supplied about 1200 karri poles.

In early 1989 a local timber preservation plant reported to the Department about occasional problems with achieving satisfactory distribution and retention of copper-chrome-arsenic (CCA) preservative into regrowth karri poles. Inspection of the sapwood band indicated apparently poor retentions in the treated cross-sections. The problem was thought to be the result of formation of tyloses in the vessels, which prevented penetration of the CCA in the preservation process. Tyloses are balloon-like structures inside the vessels, which occur when a living ray parenchyma (ray cell) borders an air-filled vessel (Wilkinson 1979). These growths are common to species with large diameter pits, such as eucalypts.

Although tyloses do not normally form in sapwood vessels, only in the heartwood, they can result from injury to the cambium. Other factors which may promote tyloses formation in sapwood include the following :

- air entering regions of water-conducting sapwood from dead branches;
- stresses resulting from rapid loss of moisture from regions of the sapwood actively involved in conduction of water and containing living ray cells with starch reserves;
- entry of micro-organisms through the root system or dead branches may cause increased activity of living cells to form enzymes which activate tyloses formation (Ilic 1989).

One or a combination of these factors would explain the formation of tyloses and consequent apparently poor penetration and retention of CCA in the sapwood of karri poles.

This paper describes the trial initiated to assess the theory that docking the poles to length immediately after the tree was felled, and then end-sealing the sapwood band with 'Pabco' or 'Cellavit WR151', would result in reduced formation of tyloses which would be reflected by improved penetration and retention of CCA in the power pole. After treatment using a long-wet vacuum method, penetrations and retentions of CCA preservative into green and dry (sapwood below 30 per cent moisture content) karri poles were compared.

METHODS

Thirty poles were harvested in January 1990 from 35-year-old regrowth karri growing in Mattaband Block, Walpole District. The trees were felled and docked overlength and extracted to a bush landing. At the landing each end was re-docked to actual length (11.0 m) and ten randomly selected poles end-coated with 'Pabco' or 'Cellavit WR151' within 10 to 15 minutes of felling or cutting, or left untreated. The poles in each treatment were colour coded at the time of coating for later identification, as follows :

Poles 1 - 10 -	'Pabco' (red)
Poles 11 - 20 -	'Cellavit WR151' (green)
Poles 21 - 30 -	Control - no end treatment (yellow).

All thirty poles were transported to Koppers Australia Pty Ltd, Picton for assessment and treatment. Five poles from each treatment were pressure treated with CCA while green, immediately upon arrival at Koppers, using the long-wet vacuum method (Richardson 1993). The CCA formulation ('Tanalith 0') used was :

34.5 per cent arsenic pentoxide,
18.5 per cent cupric oxide, and
47.5 per cent chromium trioxide (solution strength 7.42 per cent).

The remaining five poles were held until the sapwood moisture content was below 30 per cent, then treated using the long-wet vacuum method under the same conditions.

After treatment two samples (the third and fifth pole) from each treatment (total of twelve poles) had 1.5 m docked from the butt section, to a standard pole length of 9.5 m. The cross section of each pole was assessed visually for treatment penetration to observe any variation in treatability using sealants. The 1.5 m sections were then split longitudinally on a horizontal bandsaw to remove a sap-to-sap board 30 mm thick, cut through the centre. These boards were then assessed for variations in treatment with CCA in the sapwood zone of each board. There was no evidence of smearing effects.

After assessment each board was cut to three full length 30 x 30 mm sections, two from the sapwood zone (taper sawn from each side) and one from the outer heartwood zone. The sapwood sections included one from an apparently well treated zone, and one from an apparently poorly treated zone. These zones were identified by visual assessment of colour variations, which suggested marked differences in preservative retentions. From the sawn sections, three 30 mm squares by 150 mm long specimens were cut to provide one for laboratory assessment by the Queensland Forest Service, one for Koppers and one to bait a termite test mound at the Wood Utilisation Research Centre (WURC), Harvey. Heartwood specimens were not sent for analysis because no CCA had penetrated. Each specimen was numbered and marked according to end coating and CCA treatment schedule for later identification as follows :

Pole No. :	(3 or 5)
End treatment colour code :	R - ('Pabco') G - ('Cellavit') Y - (Control)
CCA treatment schedule :	Green 30 per cent MC
Treatment zone :	T - Well treated PT - Poorly treated H - Heartwood.

For example, 3 Y Green PT indicated pole No. 3, control, green at the time of treatment, and PT for poorly treated sapwood from visual assessment.

Chemical analysis of apparently well treated and apparently poorly treated specimens was carried out by the Chemistry and Wood Preservation Laboratory of the then Queensland Forest Service. Using methods outlined in AS 1605-1974 (Standards Association of Australia 1974), retention of individual elements (arsenic, chromium and copper), the total CCA elements (percentage mass/mass as the sum of individual retentions), and CCA oxide were determined. CCA oxide retention for each specimen was calculated from the following formula :

$$\text{Oxide retention (kg m}^{-3}\text{)} = \text{(Total CCA elements)} \times 1.62 \times \frac{\text{air-dried density}}{100}$$

Kingston and Risdon (1961) quoted a mean air-dried density (12 per cent moisture content) for karri as 905 kg m^3 and this was used to convert retentions from percentage mass/mass to mass/volume (kg m^{-3}).

Analysis of variance was used to test the effect of end sealants, difference between observed depth of penetration and the effect of treating green or at moisture contents below 30 per cent.

RESULTS AND DISCUSSION

Observations of regrowth karri power transmission poles treated with CCA using the long-wet vacuum method on green poles indicated variations in retention values. As stated previously, the purpose of this trial was to determine whether any improvement is possible in green pole treatment by using end coat sealants immediately after felling, while sapwood moisture content is at a maximum.

Chemical analysis

Total CCA elements and CCA oxide retentions for each end treatment and preservative treatment method are listed in Table 1. Mean basic density of the regrowth karri poles

TABLE 1

Total CCA elements and CCA oxide retentions for regrowth karri poles using different sealers and treated at different moisture contents

POLE NO.	APPARENT TREATMENT	MOISTURE CONTENT(%) AT TREATMENT	END SEALER	TOTAL CCA ELEMENTS (% mass/mass)	OXIDE RETENTIONS (kg m^{-3})
1	Full	Below 30	Cellavit	1.17	17.2
	Partial	"	"	1.31	19.2
2	Full	"	"	1.55	22.7
	Partial	"	"	1.88	27.6
3	Full	"	Pabco	1.19	17.4
	Partial	"	"	0.94	13.8
4	Full	"	"	1.50	22.0
	Partial	"	"	1.90	27.9
5	Full	"	Control	1.20	17.6
	Partial	"	(unsealed)	1.68	24.6
6	Full	"	"	1.38	20.2
	Partial	"	"	1.34	19.6
7	Full	Green	Cellavit	1.57	23.0
	Partial	"	"	Insufficient sapwood for analysis	
8	Full	"	"	1.84	27.0
	Partial	"	"	2.35	34.5
9	Full	"	Pabco	1.54	22.6
	Partial	"	"	1.45	21.3
10	Full	"	"	1.63	23.9
	Partial	"	"	1.52	22.3
11	Full	"	Control	1.53	22.4
	Partial	"	(unsealed)	1.23	18.0
12	Full	"	"	2.05	30.1
	Partial	"	"	1.77	25.9

was 651.3 kg m^{-3} (standard deviation 34.9 kg m^{-3}) with range 578 to 719 kg m^{-3}. The Australian Standard AS 2209-1979 on timber poles for overhead lines (Standards Association of Australia 1979) gives minimum charge retentions of preservative as salt formulation, for example Tanalith 'C' or 'CA' has a minimum charge retention for hardwoods of 25 kg m^{-3}, which is equivalent to 14.7 kg m^{-3} oxide. Within that charge the retention of any pole shall be not less than two-thirds of that retention (i.e. 9.8 kg m^{-3} oxide). A preliminary redraft of AS 2209-1979, written in June 1992, specified the required salt and oxide retentions (Local Government Electricity Association of New South Wales 1992). For hardwoods the retention in an individual pole, in the penetration zone, shall not be less than 1.1 per cent mass/mass or 30 kg m^{-3} (salt) and 1.1 per cent mass/mass or 18 kg m^{-3} (oxide). The mass/volume figure is derived from those for retention on a percentage mass/mass basis using the calculation referred to. For this redraft the density of hardwoods was assumed to be that of spotted gum (*E. maculata* Hook.) at 12 per cent moisture content.

The SECWA specification is based on AS 2209-1979, however, retentions are given as oxides and consequently lower than the equivalent salt values. The conversion factor used is 1.7. SECWA specify the average retention of the inner half of the sapwood of all poles in any one charge shall not be less than 2.3 per cent (mass of preservative, expressed as oxides)/(mass of dry wood), which is 33.7 kg m^{-3}. The minimum retention in any pole shall be 1.6 per cent mass/mass (23.5 kg m^{-3} oxide) in the inner half of the sapwood, and the full depth of sapwood needs to be penetrated. The SECWA specification reflects industry standards on the East Coast of Australia, and is very similar to the requirements of the South East Queensland Electricity Board for both penetration and retention (Duff[1] personal communication). The retention referred to above is 1.5 times the minimum retention required in the redrafted AS 2209-1979 and 1.3 times the minimum retention required for hazard level 5 in the revised Australian Standard AS 1604-1993. In the present report percentage mass/mass and oxide retentions are used.

It must be stressed that any sample taken from a treated pole gives an indication only of penetration and retention of the preservative, because there is a gradient from the outside to the inside of the treated sapwood zone, and longitudinal variations also occur at a specific distance from the outside.

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Using the SECWA pole specification, only 8 out of 23 specimens had retentions greater than 1.6 per cent mass/mass, with 60 per cent treated green, while 15 had retentions greater than 1.4 per cent mass/mass. Using the redraft of AS 2209-1992, only one pole failed the minimum retention of 1.1 per cent mass/mass with a retention of 0.94 per cent mass/mass, slightly lower than the required minimum, and would require re-testing. Four poles would fail hazard level 5 in draft AS-1604 which requires a minimum retention of 1.2 per cent mass/mass.

Table 2 compares the mean retentions of preservatives in poles with and without end sealants. No significant difference was found between poles sealed with 'Pabco', 'Cellavit WR151', or left untreated (p = 0.250 NS).

Table 3 lists the means and standard deviations for total element and oxide retentions for specimens from the full and poorly penetrated zones. These results indicated that the apparent differences in colour, and the occurrence of tyloses, were a perception that did not affect the retention of preservative and therefore the performance of the timber in-service. Inspection of transverse sections from different treatments had not indicated any differences in the occurrence of tyloses in the sapwood. Quantitative data were not collected because the occurrence of tyloses in individual vessels is not related to preservative penetration. One or a few tyloses may be sufficient to block penetration, although there could be many in a vessel. It cannot be categorically stated that end-sealing did reduce the incidence of tyloses.

The mean retentions of samples taken from the apparently well treated zones were actually less than those of apparently poorly treated zones with a non-significant difference of 0.07 per cent mass/mass (p = 0.365 NS). Comparing the well and poorly treated zones on individual poles, specimens from 5 out of 11 poles (45 per cent) had higher mean retentions in the apparently poorly treated zones, which meant that the colour variations in these zones did not necessarily indicate low retentions. As stated previously, the demarcation was based on visual assessment.

No significant difference in mean retention was found between treating poles green or below 30 per cent moisture content (p = 0.142 NS) (Table 4). However, poles treated green had a slightly higher mean retention (mean difference 0.26 per cent mass/mass) and of the nine that passed the SECWA specification 66 per cent were treated green.

The treatment method had no effect (Table 4). No significant difference was found between specimens from the well or poorly penetrated zones, treated either green (p = 0.339 NS) or at moisture contents below 30 per cent (p = 0.881 NS), indicating an even penetration of CCA preservative through the full sapwood depth. Tyloses may have formed in the sapwood as poles dried to a moisture content below 30 per cent or they had already formed in the living tree, which restricted the penetration of CCA preservative. Entry of micro-organisms through the root system or through dead branches, may cause increased activity of living cells to form enzymes which activate tyloses formation (Ilic 1989). This sample of poles and the majority of poles being commercially treated at that time had a number of external bumps along the bole which would have resulted from branch occlusion and associated insect or fungal damage, and possibly resulted in tyloses

TABLE 2

Effect of end treatment on total CCA elements and oxide retention in regrowth karri poles

END SEALER	'PABCO'			'CELLAVIT WR151'			UNTREATED CONTROL		
	MEAN	SD	RANGE	MEAN	SD	RANGE	MEAN	SD	MEAN
Total CCA elements (% mass/mass)	1.46	0.29	0.94 - 1.90	1.67	0.40	1.17 - 2.35	1.52	0.30	1.20 - 2.05
CCA oxide retentions (kg m^{-3})	21.14	4.25	13.78 - 27.86	24.48	5.86	17.15 - 34.45	22.28	4.40	17.59 - 30.06

TABLE 3

Total CCA elements and oxide retentions for regrowth karri sapwood.

	WELL TREATED ZONE		APPARENTLY POORLY TREATED ZONE	
	MEAN	SD	MEAN	SD
Total CCA elements (% mass/mass)	1.51	0.26	1.58	0.39
CCA oxide retentions (kg m^{-3})	22.14	3.81	23.16	5.72

TABLE 4
Total CCA elements and oxide retentions for regrowth karri poles treated green or at 30 per cent moisture content

	GREEN		30 PER CENT MC	
	MEAN	SD	MEAN	SD
Total CCA elements (% mass/mass)	1.68	0.31	1.42	0.29
CCA oxide retentions (kg m^{-3})	24.63	4.54	20.82	4.25

formation in the sapwood. Since this trial the karri poles being treated by Koppers generally have a smooth bole with few external bumps, and treatment using a long-wet vacuum process has resulted in good penetration and retentions of CCA (Duff personal communication).

GENERAL

In summary, the trial indicated that the apparently poor retention in sapwood affected by tyloses was a perception only. There were no significant differences in retention between different end-treatments which should restrict formation of tyloses, or between specimens from poles treated green or 30 per cent moisture content. The SECWA retention requirements are higher than those of Australian Standards, a matter which needs to be resolved.

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