EFFECT OF WOOD DENSITY ON PRESERVATIVE RETENTION IN FENCE POSTS

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ABSTRACT

A survey of basic density in the retention zone of radiata pine (**Pinus radiata** D. Don) posts has shown that there is considerable variation in material treated in commercial operations throughout New Zealand. With high density material a plant operator can fulfill the treatment requirements as set out in the specification of the Timber Preservation Authority (TPA) and yet can fail to meet the retention zone requirements when samples are taken for analysis and results are expressed individually as a percentage of the oven-dry wood weight. This problem is most likely to be met in North Auckland where mean wood density is markedly higher than in the rest of the country.

INTRODUCTION

When fence posts are pressure-treated with copper-chrome-arsenate (CCA) preservatives a charge retention of 4.5 kg/m^3 Cu, Cr, and As (total elements) must be obtained. To achieve this the solution concentration is adjusted according to the expected absorption for the particular type of wood. Factors which affect the absorption are the amount of heartwood, the moisture content (which must not be above 30%), and the density of the wood.

The standard of treatment is checked (1) continuously from charge sheets showing details of net absorption, final salt retention, etc., and (2) by periodic sampling, when a pair of increment borer cores are taken from each of 10 posts and subjected to chemical analyses. For chemical analysis the outer 3 mm of each boring is discarded and the next 22 mm is analysed for Cu, Cr, and As. The minimum acceptable concentration of total elements (in 90% of samples) is 0.66% of the oven-dry wood weight. When preservative retention is expressed in this manner it is obvious that wood density will have a pronounced influence on the result.

The difficulty of meeting retention zone requirements in high density wood is compounded by the fact that not all posts in a charge will have identical density. If the solution concentration is correct for the mean density then those at the top of the density range will have a lower retention expressed as kg/m^3, and an even lower retention expressed as a percentage of the oven-dry wood weight.

To determine the extent of this problem a survey of density in the retention zone of radiata pine posts was carried out over a period of approximately 2 months.

METHOD

TPA officers throughout the country were asked to take a third boring from each post sampled and these were forwarded to FRI for density determination. The retention zone (3-25 mm) was cut from the borings and the basic density (BD) was determined by oven drying and then saturating with water by vacuum and pressure treatment. Basic density (oven dry weight/green volume) was calculated from the equation:

$$\text{Basic density} = \frac{100}{\text{saturated moisture content} + 66.7}$$

RESULTS

Twenty-eight sets of 10 borings were examined and the mean basic density was calculated for the whole series and for four regional groups. The over-all mean density was 388 kg/m^3. Regional means and variability were:

	Mean basic density (kg/m^3)	Coefficient of variation
South Island	372	14%
Southern North Island	376	12%
Central North Island	383	14%
Northland	427	15%

These observations and trends are in keeping with previously observed patterns of wood density variation throughout the country (Harris, 1965). To obtain confidence limits for the sample densities a check was made on the homogeneity of the group variances to see if a common value could be found which could be applied throughout the range. A Bartletts test revealed that on the arithmetic scale this could not realistically be accepted, as groups with larger means exhibited larger variability. However, application of a $\log_e$ transformation to the original data reduced this effect and the Bartletts test no longer indicated significant differences (significance level 5%). The within-group variance ($\log_e$ scale) of 0.01276 was therefore considered to be a reasonable estimate to use to calculate the limits of sets. These become unequal and depend on the mean when transformed back to an arithmetic scale. Using this value for the variance, and 1.28 standard deviations to exclude the upper and lower 10%, the limits for particular density groups are as follows:

Arithmetic mean BD (kg/m^3)	Log_e mean	Log_e limits	Arithmetic limits (kg/m^3)
300	5.7038	5.5593-5.8483	260-347
400	5.9915	5.8470-6.1360	346-462
500	6.2146	6.0701-6.3591	433-578
600	6.3969	6.2524-6.5414	519-693

These results are illustrated graphically in Fig. 1.

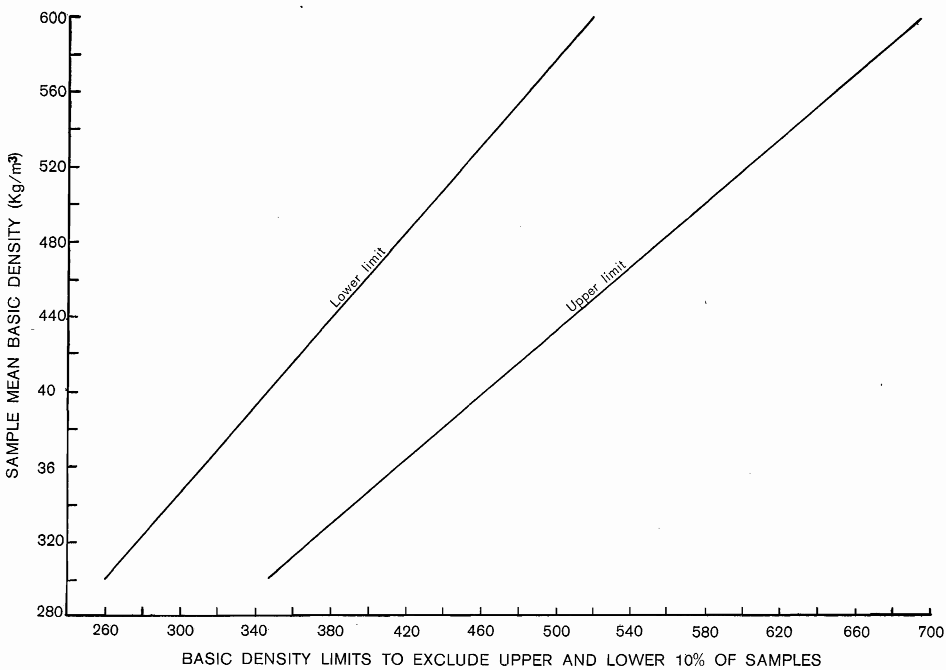

FIG. 1—Density limits (excluding upper and lower 10%) for groups with mean basic density as shown.

EFFECT ON RETENTION ZONE CONCENTRATIONS

The maximum absorption for any piece of partly dry wood is regulated by the proportion of solid wood substance (as indicated by the basic density) and the amount of water already in the wood (as indicated by the moisture content MC). A close approximation of the maximum absorption can be obtained using the equation.

$$\underset{(\text{litres/m}^3)}{\text{Max. absorption}} = 1000 - \frac{BD(MC+66.7)}{100}$$

By estimating a mean moisture content and basic density for a charge of sapwood posts an operator can use this equation to calculate his uptake and hence his required solution concentration. If the mean basic density is taken as 400 kg/m^3 and the moisture content as 30% then the uptake will be 613 litres/m^3. To obtain a charge retention of 4.5 kg/m^3 total active CCA elements he will therefore use a solution concentration of 0.734% elements. However at least 10% of the pieces in the charge are likely to have a basic density of, or above, 462 kg/m^3 (see Fig. 1) and the maximum absorption of these pieces will be 553 litres/m^3. With a solution concentration of 0.734% the retention achieved in them can be no more than 4.06 kg/m^3, i.e., 10% below that for the charge mean. When these retentions are expressed as a percentage of the oven-dry wood weight they become 1.12% for the mean and 0.88% for the high density material, i.e., a comparative reduction of 21%.

In the foregoing it has been assumed that the basic density of the retention zone is the same as that for the whole post, whereas in actual fact there is always a gradient from the centre to the outside. However, for comparative purposes the assumption is reasonably valid because, if anything, the gradient is likely to be steeper in those posts with higher density in the retention zone, thus accentuating the differences.

If the same calculations are made for several mean densities within the range shown in Fig. 1 a series of maximum retentions (% weight/weight) can be obtained for the 10% with higher densities in each group; these are plotted in Fig. 2.

From Fig. 2 it can be seen that, as the mean basic density increases, the margin of safety above the TPA requirement of 0.66% total elements in the retention zone diminishes quite sharply. In fact if the mean density is over 500 kg/m^3 (a situation that

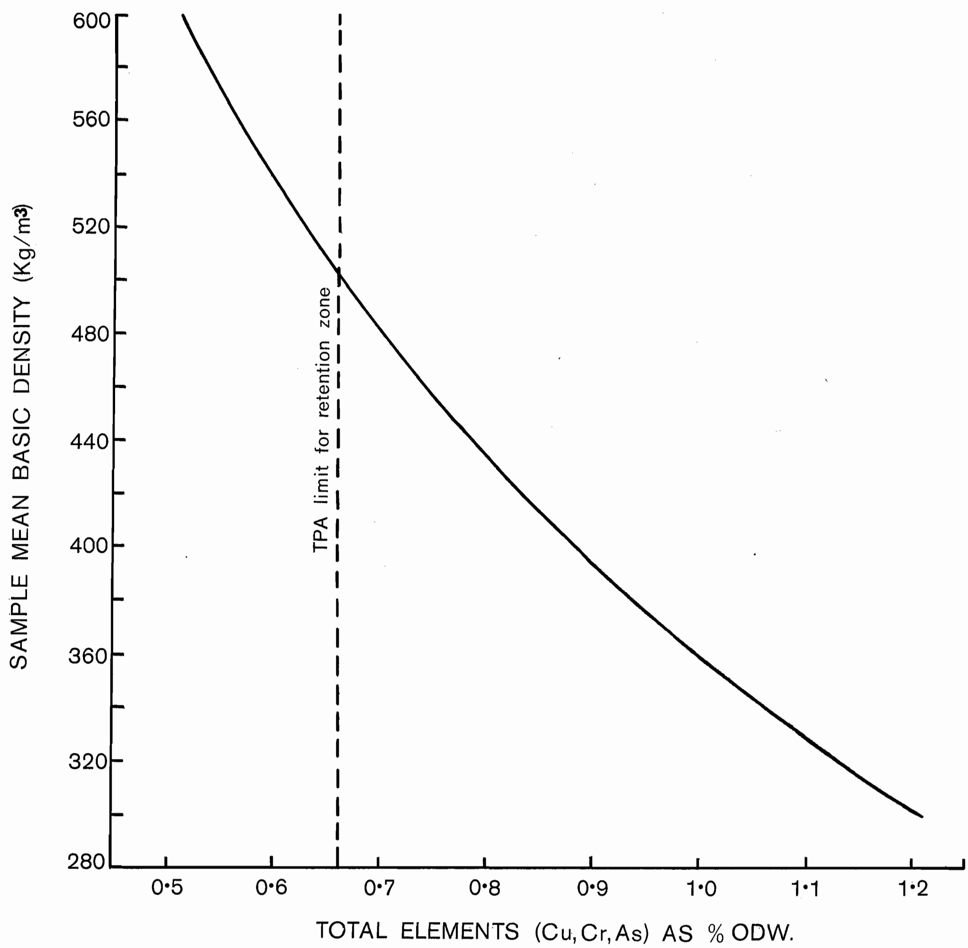

FIG. 2—Expected minimum retention zone concentrations (excluding upper 10% density samples) for groups treated to a charge retention of 4.5 kg/m^3 total active elements.

will occur more than once in every hundred throughout the country, and more frequently in Northland) it is likely that over 10% of the samples will be rated as sub-standard because of density variations.

For analyses of the retentions (as % ODW in the retention zone) in many groups of samples it has been found that the coefficient of variation is often over 25%. This is well above the variation that can be attributed to density alone, proving that other factors (of which moisture content is probably the most significant) are important variables. If this over-all variation is taken into account then plants treating posts of much lower mean basic density also face a considerable risk of exceeding the permissible 10% sub-standard samples.

In this paper no attempt has been made to suggest which method of expressing retention (weight/volume or weight/weight) is the more meaningful in terms of preservative performance. This is a complex problem that is being investigated and will be reported in a subsequent paper.

Until the problem is resolved the TPA has decided to make some concessions where samples are slightly sub-standard because of high density.

ACKNOWLEDGMENT

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REFERENCE

HARRIS, J. M. 1965: A survey of the wood density, tracheid length, and latewood characteristics of radiata pine grown in New Zealand. **N.Z. For. Serv. Tech. Pap. No. 47.**