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A CASE STUDY INVOLVING NON-STANDARD PROCEDURES IN QUALITY CONTROL ANALYSES OF CHROMATED COPPER ARSENATE TREATED WOOD

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INTRODUCTION

A wood treating company in western Canada submitted duplicate samples for analysis at two analytical laboratories. The results for the two sets of samples, when compared, were found to be quite different. Most samples exceeded the retention requirements based upon one analysis method while the results produced by the second laboratory were consistently much lower, and occasionally failed to meet the minimum retentions specified in the Canadian Standard (CSA 080.2). A study was therefore made of the two procedures being followed by the laboratories.

ANALYTICAL PROCEDURES

i. At laboratory I, split borings received from the treating company were first oven dried, then carefully weighed (W) before being digested using standard procedures (AWPA A-2 1978). An aliquot of the resulting solution was then taken and analyzed for copper, chromium and arsenic using atomic absorption spectrometry (AWPA A-11 1974). The results of the analysis provided the weights of copper, chromium and arsenic (expressed as oxides) in the weight of wood digested. To convert the results from this weight/weight basis to the weight/volume basis, used in the AWPA and CSA 080 standards, the laboratory decided to use a non-standard density value for the wood. This was calculated as follows: the volume of an individual boring was calculated using the diameter of the boring (d) and its length (l), i.e., the analysis zone specified in the standard.

$$[\text{volume of boring} = \pi \times \left(\frac{d}{2}\right)^2 \times l]$$

This was multiplied by 10 (i.e., 20/2) to produce the volume (V) of the twenty **split** borings supplied by the treating company. The weight/weight analytical results were then multiplied by the factor W/V to obtain the results on a weight/volume basis, e.g., lb/ft^3.

ii) At laboratory II (Forintek Canada Corp.) the whole cores supplied by the treating company were first oven dried and then ground together in a Wiley mill to pass through a 40 mesh screen. The sawdust from each composite sample was then passed a second time through the Wiley mill to ensure thorough mixing. 0.4 g of this sawdust was removed and carefully mixed with 0.1 g of cellulose powder before being compressed for three minutes at a pressure of 45,000 lb/in (300 MPa). The resultant disc was then analyzed using an energy dispersive X-ray spectrometer. Following analysis the peak areas for each chemical component were first corrected for background effects and then this data was analyzed using a second computer program to correct for matrix and interelement interference effects. The corrected results, which indicated the weight of CCA in a known weight of wood, were then converted to the weight per volume (i.e., lb/ft^3 or kg/m^3) basis using the density information supplied in the Canadian wood preservation standard.

RESULTS AND DISCUSSION

A comparison of the results produced by the two laboratories (Table 1) shows that the two methods produced quite different results. A detailed analysis of the methodology revealed the reasons for this.

Table 1

Comparison of the Analyses Obtained by Two Laboratories for Hem-Fir Lumber and Plywood

Sample No.	Preservative Component	Result* from Laboratory I	Result** from Laboratory II	Ratio of Laboratory Results
1	Chromium	0.30	0.22	1.36
	Copper	0.14	0.10	1.40
	Arsenic	0.28	0.16	1.75
	TOTAL	0.72	0.48	1.50
2	Chromium	0.22	0.15	1.47
	Copper	0.10	0.07	1.43
	Arsenic	0.20	0.11	1.82
	TOTAL	0.52	0.34	1.53
Plywood	Chromium	0.27	0.29	0.93
	Copper	0.12	0.12	1.00
	Arsenic	0.25	0.23	1.09
	TOTAL	0.64	0.64	1.00

* Units of results are lb/ft^3.
** Results presented for laboratory II are the average of three analyses.

The first laboratory in attempting to calculate a more accurate density figure had accidentally introduced a gross error in their conversion factor. The figure, for the diameter of the boring, of 0.156 inches (0.396 cm) used in the calculation by laboratory I, while being similar to the 0.166 inches (0.422 cm) measured core borer opening, differs markedly from both the diameter specified by the manufacturer of the borer, of 0.197 inches (0.500 cm), and also that measured for individual cores, i.e., 0.195 inches (0.495 cm). Although the differences may not appear to be large, for 0.625 inches (1.588 cm) long cores, the volumes calculated for the four diameters range from 0.0120 in^3 (0.1966 cm^3) calculated using laboratory I's diameter, to 0.0191 in^3 (0.3114 cm^3), calculated using the manufacturer's specified diameter.

The volume for the 20 split borings used by laboratory I was 0.120 in^3 (1.956 cm^3), while that calculated from the actual measured diameter of cores was 0.187 in^3 (3.056 cm^3). Laboratory I was therefore **underestimating** the volume of the 20 split cores significantly, the actual volume being 155 percent of that used by laboratory I.

Since the specific gravity (SG) is inversely proportional to the volume,

$$SG = \frac{\text{oven dried weight}}{\text{volume}}$$

then the SG figure used by laboratory I is 155 percent of the correct value.

Consequently, the retentions calculated are also 155 percent of the actual retentions since,

$$\begin{aligned} &\text{preservative retention (weight/volume)} \\ &= \text{analytical result (weight/weight)} \times SG \end{aligned}$$

Laboratory I would therefore consistently overestimate the actual retention by 55 percent, due to the error in the volume determination.

A second source of error was also identified. The assumption by laboratory I that split cores will have exactly half the volume of unsplit cores is subject to a large error, **and in fact would be rarely correct.** Assuming an error of only 0.01 inches (0.25 mm) in splitting the core, would result in an error of approximately ± 10 percent.

Combining the two sources of error the results obtained by the two analytical laboratories could differ significantly with those of laboratory I being between 45 - 65 percent greater than those of laboratory II (assuming that the density of the wood was in agreement with the figure cited in the standard).

If one considers, in addition, the variation in the actual density from the standard value, the differences which can exist between the two sets of laboratory results would then extend over a very wide range. The effects of a ± five percent variation in the actual density on the agreement between the analyses produced by the two laboratories is shown in Table 2.

Table 2

Variation in Analyses Which Could Result Due To Actual Difference in Wood Density from the Standard Value and Incorrect Calculation of Volume of Boring by Laboratory I

Density	X-Ray Analysis by Laboratory II	a) Assuming exact splitting of boring	b) Assuming ± 10% error in splitting of boring*
A. Actual density equals CSA standard value	X-ray analysis correct (± 5%)	Retention is 1.55 x actual value	Retention is 1.45 to 1.65 x actual value
B. Actual density is 5% less than CSA standard value	X-ray analysis is 1.05 x correct retention	Retention is 1.55 x actual value and 1.48 x X-ray result	Retention is 1.45 to 1.65 x actual value and 1.38 to 1.57 x X-ray result
C. Actual density is 5% greater than CSA standard value	X-ray analysis is 0.95 x correct retention	Retention is 1.55 x actual value and 1.63 x X-ray value	Retention is 1.45 to 1.65 x actual value and 1.53 to 1.74 x X-ray result

* Accuracy of the X-ray method (i.e., ± 5%) not included in this calculation.

Combining all scores of variation [namely (1) the volume error made by laboratory I; (2) a possible error (10 percent) in assuming exact splitting of the core; (3) a possible ± five percent error in density from the value given in the Canadian standard, and (4) the known error of ± five percent which is the limit of the accuracy of the X-ray analysis under the conditions of operation], the analyses produced by the two laboratories could differ between 33 and 79 percent. Expressed more generally it is possible that for any analysis the two sets of results could be either quite similar, or the results of laboratory I could be almost double those of laboratory II. Examination of the results shows this to be the case. The chromium and copper retentions calculated by laboratory I are generally 36 to 47 percent greater than those found by laboratory II, while the arsenic ratio value is marginally higher.

A comparison of data developed by the two laboratories for hem-fir plywood cores (Table 2) confirms that when the volume error made by laboratory I for lumber is eliminated, the agreement between the analyses produced by the two laboratories is very good. (Laboratory I used density information supplied by the treating company for analysis of the hem-fir plywood.)