Appendix 3

[Editor's Note: This paper was intended as an attachment to the 1998 Report of Subcommittee T-4. It was inadvertently omitted from that Report.]

Fixation of CCA

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The essence of CCA fixation is the reduction of chromium from the hexavalent to the trivalent state, and the subsequent precipitation or adsorption of chromium, copper and arsenic complexes in the wood substrate. Some of the these reactions, such as the adsorption of copper and chromium onto wood components, occur within minutes or hours, while others are completed during the ensuing days, weeks or even months. Because adequate fixation is dependent on the reduction of the majority of the hexavalent chromium to the trivalent state, the degree of CCA fixation is often reported as the ratio of hexavalent to trivalent chromium in the wood.

It has long been recognized that the rate of CCA fixation reactions is highly temperature dependent, and more recently concerns have arisen that the time needed for fixation might be quite lengthy in cold climates. One study of CCA treated pine blocks reported that adequate fixation could be achieved in only 120 hours at 25 C (77 F), but required 30 days at 10 C (55 F) and 55 days at 3 C (34 F) (McNamara, 1989a). Other studies have indicated that 4 to 14 days are needed to achieve complete fixation at 21 C (70 F) (Christensen, 1990; Henshaw, 1979, McNamara, 1989b). Because fixation at ambient temperatures may be unacceptably lengthy, several techniques are used or have been proposed to elevate the wood temperature and accelerate fixation, including various forms of kiln drying, hot water baths and steaming (Alexander, et al, 1993; Boone, et al, 1995; Boonstra, et al, 1995; Christensen, 1990; Connell, et. al, 1994; Cooper and MacVicar, 1995; Cooper, et al, 1995; Cooper and Ung, 1992; Peek and Willeitner, 1981, 1988; Pendulbury, et al, 1994; Willeitner et al, 1986; (Wood, et al, 1980; Zahora, et al, 1993). For example, Peek and Willeitner (1988) found that nearly 100% reduction of hexavalent chromium could be achieved in 1 hour by steaming small pine samples at 110 C (230 F). On a more applied scale, Cooper and Ung (1992) noted that for red pine pole sections, 12 hours of exposure at 50-60 C (122 - 140 F) produced a degree of fixation equivalent to 20 days at 21 C (70 F). Similarly, Avramidis and Ruddick (1989) achieved fixation in 100 x 100 mm (3.9 x 3.9 inch) sections of hem-fir lumber in 24 hours in a conditioning room maintained at 55 C (131 F) and 92% relative humidity. Several researchers have also noted that the use of elevated temperatures can interfere with fixation or result in increased leaching if the moisture content of the wood is lowered too quickly (Alexander, et al, 1993; Avramidis and Ruddick, 1989; Boone, et al, 1995 ; Henshaw, 1979; Pizzi and Conradie, 1987), and thus small wet-bulb retentions are needed during kiln-drying. However, in general these studies have demonstrated that when properly applied, accelerated fixation techniques can dramatically speed fixation and reduce CCA leaching comparison to wood stored under ambient conditions for equivalent or much longer time periods.

The most common techniques of assessing the degree of CCA fixation are based on the reduction of hexavalent to trivalent chromium. Fixation is often considered complete when hexavalent chromium can no longer be detected in leachate or expressate from the treated wood. This approach has been found to be a fairly conservative measure of fixation when compared to levels of copper, arsenic and chromium actually leached from CCA treated wood (Cooper and Ung, 1992). Foster (1989) developed a rapid field method of detecting hexavalent chromium levels as low as 15 ppm. A core is removed from the wood, placed on white absorbent paper, and then washed with a few drops of 0.5% chromotropic acid in sulfuric acid. Available

hexavalent chromium is washed out of the wood and develops a purple color upon reacting with the chromotropic acid (Foster, 1989). This method, the Chromotropic Acid Test, was subsequently adopted into AWPA Standards (AWPA Standard A3, Section 11, Method for Determination of Hexavalent Chromium in Treated Wood).

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