FIELD TESTING OF WOOD PRESERVATIVES XIX: INDUSTRIAL PRESERVATIVES

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Abstract

There is no doubt that creosote, pentachlorophenol in oil, chromated copper arsenate (CCA), and ammoniacal copper zinc arsenate (ACZA) are effective preservatives, but in Canada there is always the concern about how well they will work in our refractory wood species. This paper reviews the results of field tests of commodity-sized samples treated with industrial preservatives set up by FPInnovations and its predecessor organizations since 1937. Some of the earliest installations of creosote-treated posts are still in test with estimated service lives exceeding 71 years for red and white pine. CCA-treated jack pine posts installed in 1951 have estimated service lives of over 57 years. Pentachlorophenol-treated jack pine posts installed in 1967 have service lives exceeding 41 years. CCA-treated lodgepole pine and white spruce lumber treated to CSA stanadards have remained serviceable for 15 years in an accelerated test and a further three years in a field test. Clearly creosote, pentachlorophenol in P9 type A oil, CCA, and ACZA are fully effective in Canadian wood species. Service lives of wood products treated to standard can be ten to twenty times that of untreated wood.

1. Introduction

Nobody today doubts that creosote, pentachlorophenol in oil, chromated copper arsenate (CCA), or ammoniacal copper zinc arsenate (ACZA) are effective preservatives that ensure the long term performance of industrial wood products. However, Canadian wood species are typically resistant to pressure treatment (refractory) so there is always concern regarding how well these preservatives can protect Canadian treated wood products. The Eastern Forest Products Laboratory of the Canadian Forest Service (CFS) initiated field tests of treated wood in 1937. This work was taken over by its successor organization Forintek Canada Corp. in 1979 and by FPInnovations in 2007.

The mainstay field test method for wood preservatives is the AWPA E7 stake test using fully penetrated pine sapwood stakes, these days usually 25 x 50 mm or smaller, though nominal 2x4 inch stakes are permitted. These tests demonstrate the effectiveness of the preservative but the data are not necessarily indicative of the long term performance of full sized commodities made from refractory species. This paper therefore focuses on commodity tests, primarily of refractory species, treated with industrial preservatives.

1.1 Post tests

In 1937, the Eastern Forest Products Laboratory initiated field testing of preservative- treated posts at the CFS Petawawa Research Forest near Chalk River, Ontario. The test site was moved to a new location in the forest in 1958. The site was taken over by Forintek Canada Corp, now

FPInnovations, upon privatization of EFPL and WFPL in 1979. In 2007, the Petawawa Research Forest became part of the Canadian Fibre Centre which, while remaining within CFS, is now a division of FPInnovations.

The site is a cleared and leveled area surrounded by a mixed coniferous/deciduous forest. The soil is a thin layer of dark brown loam above coarse sand. The pH is 6.0 at the surface and 5.4 at a depth of 90 mm. The average water holding capacity is 25%. The ground cover is moss, grass, wild strawberries and sweet fern, mechanically controlled by periodic mowing. The site has a relatively low soft rot activity but a high activity of soil-inhabiting strand-forming, wood-rotting basidiomycetes including *Paxillus panuoides* and *Leucogyrophana pinastri*. This site had a Scheffer Index of 41 (Setliff 1986) based on climate data from the 50s, 60s and 70s, and an updated Scheffer Index of 48 (Morris and Wang 2008) based on climate data from the 80s, 90s and 00s.

The method is an early version of the AWPA E8 post test. It uses 10 to 15 cm diameter posts of a variety of species, mostly cut in the local forest and treated by sap displacement or air seasoned and treated by hot and cold open tank, or pressure processes. Posts were planted to a depth of 1.0 m in a randomized array. They were evaluated annually up to 1985 then every 2 years and recently every 5 years. Posts were pushed at breast height with approximately 150 Newtons of force applied twice from alternating directions. The soil was tamped back around the base of the post following each rating.

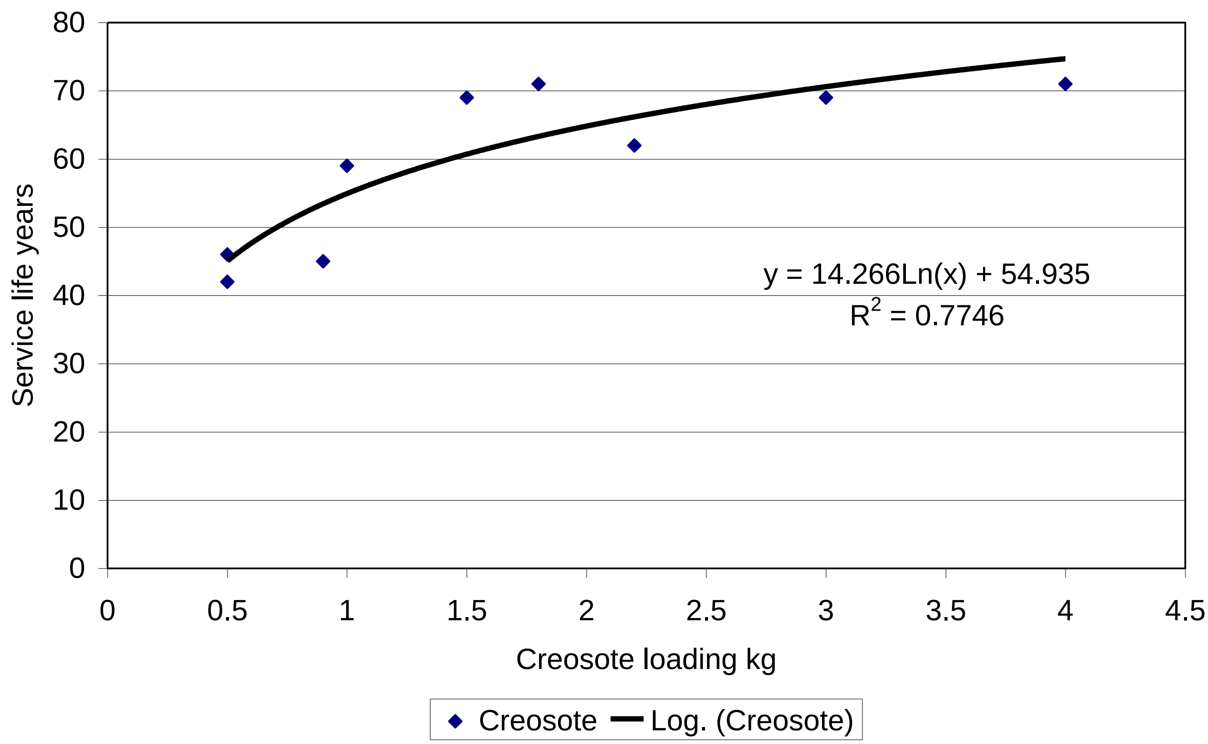
Table 1 Estimated Service Lives of Posts Treated with Creosote via the Thermal Process

Species	Absorption (kg)	Year of Installation	Proportion in Service in 2008	Mean life (years)
Red pine	4.0	1937	20/20	>71
Red pine	Untreated	1937	0	3.8
Jack pine	3.0	1937	19/20	>69
Jack pine	Untreated	1937	0	5.5
E. W. cedar	2.2	1937	15/20	>62
E. W. cedar	Untreated	1937	0	18
White pine	1.8	1937	20/20	>71
White pine	Untreated	1937	0	5.7
Tamarack	1.5	1937	19/21	>69
Tamarack	Untreated	1937	0	8.3
E. hemlock	1.0	1937	11/20	>59
E. hemlock	Untreated	1937	0	4.4
Balsam fir	0.9	1937	1/20	>45
Balsam fir	Untreated	1937	0	3.7
White spruce	0.5	1937	3/19	>46
White spruce	Untreated	1937	0	3.5
Black spruce	0.5	1937	1/20	>42
Black spruce	Untreated	1937	0	4.5

There were no posts pressure-treated with creosote in these tests but some of the first posts to be installed in 1937 were a range of wood species creosote-treated by immersion of the butts in hot oil followed by a full length soak in cold oil. Many of these were still in test at the last inspection in 2008 (Table 1). Since the variation in retention was not generated by dilution of the creosote or manipulation of an empty-cell process, the creosote retention basically reflects the penetration achieved in each species. Plotting estimated average service life against creosote loading (Figure 1) effectively demonstrates the relationship between preservative penetration and commodity performance. The red and white pine posts which would likely have been the best penetrated had an estimated service life of 71 years. The black spruce which would likely have been the worst penetrated had an estimated average service life of over 42 years. Excluding the naturally durable species, with the ultimate life still undetermined, the creosoted posts had between ten and twenty times the service life of untreated posts.

Figure 1

Estimated Average Service Life and Creosote Loading (Penetration)



Red pine posts pressure-treated with pentachlorophenol in P9 type A oil using a full-cell process were put in test in 1967, and every single one was still in service when last inspected in 2008. Consequently their estimated lives were well over 41 years (Table 2). This is at least ten times longer than comparable untreated posts. A retention of 8.0 kg/m³ is specified for red pine utility poles in Use Category 4.1 in CSA Series 2008. Jack pine posts pressure-treated with copper naphthenate in P9 oil using an empty cell process were installed in 1950. The retention of 1.2 kg/

m³ is the current retention for red pine utility poles in Use Category 4.1 in CSA O80 Series 2008. The estimated average service life was over 58 years with one failure to-date. This too is at least ten times longer than untreated jack pine.

Table 2 Estimated Service Lives of Posts Treated with Pentachlorophenol and Copper Naphthenate

Preservative	Species	Retention (kg/m^3)	Year of Installation	Proportion in Service in 2008	Mean life (years)
PCPa*	Red pine	8.0	1967	10/10	>41
PCPb*	Red pine	7.2	1967	13/13	>41
None	Red pine	0.0	1937	0	3.8
Cu Nap	Jack pine	1.3	1950	13/14	>58
None	Jack pine	0.0	1937	0	5.5

* a were Boultonized, b were Steamed.

In 1951 a range of species were put in test pressure-treated with the original salt formulation of CCA type A, Greensalt, using a full cell process. Note the retentions are based on total amounts of salts not oxides so one needs to multiply by 0.66 to give the oxide retentions. The estimated service lives for jack pine, aspen and white birch were well over 57 years with zero failures up to 2008 (Table 3). Three groups of white spruce had average service lives ranging from over 39 to over 55 years. Yet again the average service life is at least ten times that of untreated wood.

Table 3 Estimated Service Lives of Posts Treated with CCA type A

Preservative	Species	Retention, salts basis (kg/m^3)	Retention, oxide basis (kg/m^3)	Year of Installation	Proportion in Service in 2008	Mean life (years)
CCA-A	Jack pine	7.7	5.1	1951	20/20	>57
CCA-A	White spruce	7.5	5.0	1951	9/15	>50
CCA-A	White spruce	8.0	5.3	1951	3/7	>39
CCA-A	White spruce	8.3	5.5	1951	7/8	>55
CCA-A	Douglas fir	6.6	4.4	1951	7/9	>52
CCA-A	Aspen	8.5	5.6	1951	19/19	>57
CCA-A	White birch	8.3	5.5	1951	19/19	>57

In 1960 jack pine and aspen posts treated with the oxide formulation used today, CCA type C, were installed at this site. All of the jack pine posts treated to 7.8 kg/m³, considerably below the 9.6 kg/m³ specified for utility poles in Use Category 4.1, were still in service after 48 years (Table 4). Even at retentions as low as 3.7 kg/m³, there had been only one failure, giving a service life estimation of over 43 years. Aspen posts were also performing well at retentions of 4.2 kg/m³ and higher.

Table 4 Estimated Service Lives of Posts Treated with CCA type C

Preservative	Species	Retention (kg/m³)	Year of Installation	Proportion in Service in 2008	Mean life (years)
CCA-C	Jack pine	7.8	1960	30/30	>48
CCA-C	Jack pine	3.7	1960	28/29	>43
None	Jack pine	0.0	1937	0	5.5
CCA-C	Aspen	8.4	1960	30/30	>48
CCA-C	Aspen	4.2	1960	26/26	>48
None	Aspen	0.0	1937	0	3.3

No fence posts have been installed in test with ACZA treatment but white spruce posts treated with the earlier formulation, ammoniacal copper arsenate (ACA), are still in test (Table 5). A retention of 6.4 kg/m³ ACZA is specified for fence posts in CSA O80 Series 2008. Higher retentions are required for utility poles. Installed in 1974, all the posts were still in service in 2008, with an average service life of over 34 years. ACA with polyethylene glycol to improve climbability installed a year later were all still in service after 33 years. Due to the better fixation of ACZA compared to ACA (Lebow and Morrell 1993), one would expect ACZA to perform even better than this.

Table 5 Estimated Service Lives of Posts Treated with ACA

Preservative	Species	Retention (kg/m³)	Year of Installation	Proportion in Service in 2008	Mean life (years)
ACA	White spruce	6.4	1974	60/60	>34
ACA + PEG	White spruce	4.8	1975	10/10	>33

1.2 Incised Lumber

There are very few long-term tests of lumber CCA-treated to meet CSA standards. One of the exceptions is a test of needle vs conventionally incised lodgepole pine and spruce set up by Prof. John Ruddick of UBC when he was working at Forintek Canada Corp. Retentions for the conventionally incised material were just below, and for the needle incised material just above, the 6.4 kg/m³ specified in CSA O80 Series 2008 for industrial sawn products in Use Category 4.1. The material was installed in a horticultural soil in an insulated raised bed fitted with heating coils to keep the soil above freezing in winter. This was situated in the rear yard of the Forintek building. Unfortunately no comparable material was installed in a natural field site so there is no means of calibrating the degree of acceleration of this test.

After 15 years in this exposure, the material was moved to the field test site at Maple Ridge operated with the assistance of the UBC Malcolm Knapp Research Forest. The site is a cleared and leveled area surrounded by a coastal coniferous forest. The soil is a sandy loam with a high organic matter content (18%) and a pH of 5.1. The ground cover is grass mechanically controlled by periodic mowing. The site has a high soft rot activity and a moderate activity of soil-inhabiting strand-forming, wood-rotting basidiomycetes including *Antrodia serialis*, *Paxillus panuoides* and *Leucogyrophana pinastri*. This site has an updated Scheffer Index of 63 (Morris and Wang 2008).

The material was inspected annually periodically up to the 15 year mark. Since being moved to the field test site, it has been inspected annually. The reason for this was a concern that the horticultural loam, while being a good medium for soft rot, did not appear to harbour soil-inhabiting wood rotting basidiomycetes. Continued monitoring at Maple Ridge was intended to confirm that the heated soil bed was sufficiently aggressive to detect any weakness in the treated wood. After 15 years in the soil bed, the mean ratings on the AWPA 10 to 0 scale were 9.4 and higher, for both needle and conventional incised lodgepole pine and white spruce. There was no difference in performance between needle and conventionally incised, or between lodgepole pine and white spruce. After a further three years in the field site the ratings had dropped to between 9.1 and 9.5 but the material is all still in very good condition.

Table 6 AWPA Ratings of Needle (N)- and Conventionally(C)-incised CCA-Treated Lodgepole Pine and White Spruce nominal 2 x 4 inch Lumber

Preservative	Incising	Species	Retention (kg/m³)	% ≥10mm Penetration	Year of Installation	Mean Rating >15 yr*	Mean Rating >18yr*
CCA-C	Conventional	Pine	5.0	20	1985	9.6	9.1
CCA-C	Needle	Pine	7.0	93	1985	9.4	9.2
None	None	Pine	0.0	0	1985	0.0	-
CCA-C	Conventional	Spruce	5.7	10	1985	9.6	9.5
CCA-C	Needle	Spruce	7.9	33	1985	9.7	9.4
None	None	Spruce	0.0	0	1985	0.0	-

* Equivalent to more than 15 and 18 years due to acceleration from heating the soil bed.

2. General Discussion

Previous estimates of the benefits of wood preservation, based on earlier field test data, have estimated increases in service life of between five and ten times (Stephens *et al.* 1994). The data reported here suggest that the true multiplier is between ten and twenty times for wood products treated with effective preservatives to CSA standards. These results should demonstrate the benefits of these industrial preservatives in terms of resource conservation and support their continued registration by Canada's Pest Management Regulatory Agency.

The Petawawa test site continues in operation and there are plans to expand the site to accommodate more test material.

3. Conclusions

Creosote, pentachlorophenol in P9 type A oil, CCA, and ACZA are fully effective in Canadian wood species.

Effective preservatives can give service lives upwards of 50 years in commodities treated to meet CSA standards. This is commonly ten to twenty times the life of untreated wood.

4. References

American Wood Protection Association 2010 E7-09 Standard method of evaluating wood preservatives by field tests with stakes. p367 – 375 in the AWPA Book of Standards, AWPA, Birmingham AL.

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