FIELD TESTING OF WOOD PRESERVATIVES IN CANADA. X:

A REVIEW OF RESULTS

By

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Summary

Forintek generates data on the performance of wood preservatives and treated wood commodities at five terrestrial and three marine test sites across Canada. These data are reported to the Canadian Forest Service and appropriate standards authorities. Key information has been presented to the Canadian Wood Preservation Association in a series of nine publications. This paper summarises these results and brings some of the more topical material up to date. The material discussed includes stakes, marine samples, lumber exposed to termites, lumber in ground contact, round fence posts, veneer-based composites, field cut preservatives, shingles and shakes, decking and millwork. A review of the data shows that Canada's wood preservation standards are supported by performance data on a wide variety of treated commodities. These data can also be used to support marketing of Canadian treated wood products.

1 Introduction

The field testing program of Canada's Forest Products Laboratories has been generating performance data on wood preservatives and treated products since 1937. These laboratories were privatised as Forintek Canada Corp in 1979, and this work has continued to be funded by the Canadian Forest Service (CFS). In recent years, the work has been divided into three aspects: stake tests, marine tests and commodity tests, reported to CFS on a three-year rotation. Many of these reports, or sections of them, have also been provided to the Canadian Standards Association (CSA), the American Wood Preservation Association (AWPA) or overseas standards authorities to support listing of Canadian species in wood preservation standards. To ensure wider use of the results, these reports have been condensed and presented as papers to the Canadian Wood Preservation Association (CWPA), the AWPA or the International Research Group on Wood Preservation (IRG). This paper reviews results presented to CWPA, AWPA and IRG over the last ten years and brings the results of the more topical material up to date. Data tables presented in previous CWPA papers are not reproduced here.

2 Test Sites

Forintek Canada Corp. maintains a total of five terrestrial and three marine test sites in locations across Canada. The two main sites for both ground contact and above ground testing are situated at Petawawa ON and, until recently, at Westham Island BC. The Westham Island site was decommissioned in 1998 and a new western test site is under development at the Malcolm Knapp Research Forest (MKRF) of the University of British Columbia (UBC) at Haney BC. It is expected to be ready to receive above ground test material in 2001 and ground contact test material in 2003. Partial funding for the preparation of the new site has been provided by the Canadian Institute of Treated Wood. A third ground-contact site, set up specifically for termite testing, is situated at Kincardine ON in an area infested with the eastern subterranean termite. Two additional sites in BC are used for above ground testing. One is a small area at MKRF that has been used for exposure of shingles and shakes, which will be moved to the new site. The second is an area at the rear of Forintek's Vancouver Laboratory used for decking, millwork, finger-joined lumber and the AWPA round robin test of above-ground test methods. The three marine test sites are located at West Vancouver BC and Shediac Harbour and Whitehead Island NB.

3 Stake Tests

Morris and Ingram (1991) reported on a range of water-borne preservatives at the Westham Island test site. Chromated copper arsenate (CCA) and particularly ammoniacal copper arsenate (ACA) were not performing as well as expected, based on results from other sites. It was found that iron moving in from the soil was detoxifying the arsenic in treated wood (Morris 1992, 1993). *Leucogyrophana pinastri* Ginns and Weresub, a fungus capable of remaining dormant in soil as sclerotia (analagous to potato tubers), was able to take advantage of this phenomenon to cause rapid brown rot of CCA and ACA treated stakes. Data from both field tests and laboratory tests indicated that CCA retentions higher than 10 kg/m^3 would not be adversely affected by this phenomenon. ACA-treated wood was also found to be particularly susceptible to tunnelling bacteria.

Morris and Ingram (1998) brought up to date the preservative performance data from Westham Island and these tests have now been terminated. Long-term Performance data from Petawawa were also reported. The most effective water-borne preservative was the benchmark CCA. Of particular note was the excellent performance of CCA type B over 38 years at Petawawa. Another water-borne preservative that performed well was acid copper chromate (ACC). Contrary to expectations, wrapping ACA-treated stakes for 48 hours to retard loss of ammonia reduced the performance in ground contact.

Recognition of patterns in the relationship between decay rate and retention led to the development of a mathematical model to predict preservative performance (Morris and

Cook 1995). Such a model could be used to predict the effect on service life of increasing or reducing preservative retentions (Cook and Morris 1995). The progression of decay was also related to known characteristics of the preservative (Morris and Rae 1995). While well-fixed preservatives such as CCA continued to decay at a constant rate, poorly fixed preservatives showed increasing rates of decay, presumably as the preservative depletes. Biodegradeable preservatives showed several fold increases in decay rate, presumably because biodegradation increases as the preservative retention drops.

The basic form of the model is as follows:

Condition of the wood = 100 - e^{A} $(\text{retention})^{B}$ $(\text{time})^{C}$

Where A, B, and C are derived by fitting curves to the depreciation data for a range o retentions. This model has provided a very good fit to data on a variety of water-borne preservatives tested at Westham Island. For the data to which the model has been applied so far, the value of B is such that increasing retention gives diminishing returns and the performance therefore tends to a maximum value. This agrees with the alternative data interpretation methods of Edlund (1998) and DeGroot (2000).

The model was further developed into a prototype tool for intepreting field data to suggest appropriate preservative retentions in standards (Morris 1998b). The model was used to estimate preservative retentions giving the same time to reach a log score of 70 as 6.4 kg/m^3 CCA type C. Some examples were: 6.7 kg/m^3 CCA type B, 8.5 kg/m^3 ACC, 199 kg/m^3 [*not a misprint*] of chromated copper borate (CCB), 7.1 kg/m^3 ACA (60:40 $CuO:As_2O_3$), and 14.2 kg/m^3 of ammoniacal copper borate (ACB). Further progress on this tool has been postponed due to other higher priorities.

It is anticipated that stakes treated with the next generation of preservatives will be installed at the Haney and Petawawa test sites starting in 2003.

4 Marine Tests

At the request of the CSA Technical Committee on Wood Preservation, marine tests of standard wood preservatives were set up on the west and east coasts of Canada between 1978 and 1984. The objective of these tests was to determine whether different retentions were required for water-borne preservatives in eastern and western waters and provide supporting data for the transition from gauge to assay retentions for marine applications.

While US standards specified 40 kg/m^3 CCA by assay, retentions as low as 15 kg/m^3 were found to provide excellent performance at the western and two eastern Canadian test sites after 14 and 8 years respectively (Morris and Doyle 1993). While ACA did not perform as well at these lower retentions, this was primarily due to very slow erosion of the surface by bacteria and soft-rot fungi, not attack by marine borers. Such erosion results in substantial reduction in the cross section of a thin wood coupon, but would not have such a dramatic effect on a wood pile. Preservative leaching would also be considerably greater from small test coupons with a high surface area to volume ratio. A Canadian formulation of Ammoniacal Zinc Copper Arsenate (ACZA) where zinc replaced copper performed very poorly. The US formulation of ACZA where zinc replaces arsenic has now supplanted ACA in Canada. A comparison among test sites showed there was no need to specify different retentions for western and eastern waters.

The results of these experiments were used to support substantial reductions in the retentions for creosote, ACA and CCA in CSA O80.18-97. Coincidentally, parallel work south of the border resulted in similar reductions in AWPA standards for northerly US waters.

Interestingly, while the galvanised steel racks supporting these test coupons had to be replaced after 15 years at the West Vancouver test site, treated wood samples at the new standard retentions are still in place after more than 20 years exposure.

Due to the decline in the volume of treated wood going into marine applications, the completion of the mandate of this work and the lack of new preservatives under development for marine applications, it is proposed to terminate these tests in 2003.

5 Commodity Tests

5.1 Termite Tests of Lumber in Ground Contact

To demonstrate the durability of preservative-treated wood against the eastern subterranean termite, *Reticulitermes flavipes* Kollar in southwestern Ontario a field test of commercially treated lumber was set up in 1988 at Kincardine ON. Results were reported to CWPA after 3-4 years (Doyle 1992) and 7-8 years (Morris and Motani 1997). Very little of the test material met CSA standards, nevertheless, two thirds of the lots of CCA-treated samples were performing well after 7-8 years with mean ratings of 1.0 (trace of attack) on the IUFRO scale, or less. The remaining one third, with mean ratings higher than 1.0, all had a very low percentage compliance with even a 5mm penetration requirement. All the ACA-treated lumber had mean ratings less than 0.7, possibly because every batch had 60% or more pieces with over 5mm penetration.

Where preservative penetrations and assay retentions were very low, termites had penetrated the outer treated shell. This often occurred where defects such as deep checks allowed the termites to bypass the treated zone. However, in several cases, termites had tunnelled directly through 2 or 3 mm of CCA-treated wood. A copper-naphthenate-based field cut preservative was quite effective against termite attack. There was no difference in performance between sets with an original pressure treated end or a cut and field treated end in the soil.

5.2 Decay tests of Lumber in Ground Contact

Forintek's performance data on lumber in ground contact was reported to the CWPA last year (Morris 1999). In the absence of termites, (or a bolt-hole below ground) a thin shell of preservative treatment (5mm or less) provided a minimum 10 year life in ground contact at Petawawa and Westham Island. In nominal 4 x 4 inch posts, 10 kg/m^3 in a 10mm treated zone (6.4 kg/m^3 in a 16mm assay zone) was sufficient to resist the aggressive decay conditions at the Westham Island site. In contrast over 50% of untreated posts failed after only 4 years.

5.3 Round Fence Posts

As with the data for lumber, the most recent report to CWPA was presented last year (Morris 1999). Generally, the service life of round-wood fence posts was determined by the quality of treatment, not the natural durability of the wood used. Pressure treatment using standard water-borne and oil-borne preservatives provided excellent protection with average service lives over 30 years. For example, CCA-treated jack pine and white spruce fence posts at retentions around 8 kg/m^3 had mean service lives over 36 years. Full-length thermal treatment with creosote provided twice the life of butt-only treatments with many wood species averaging over 60 years service life to date. These data should be taken into account by utilities considering moving back to butt-only treatments. Organo-copper complexes in pole oil applied using empty cell processes showed good potential as treatments for posts. Mechanical barriers to decay gave variable results.

5.4 Veneer-based Composites

The performance of a variety of veneer-based composite products was reported by Morris and Ingram (1994). Key findings related to the effect on performance of small areas of untreated wood in CCA-treated plywood. The penetration requirements in the outer veneers of permanent wood foundation standard (CSA O80.15) were slightly relaxed, based partly on earlier data from this field test. Results after 14 years exposure confirmed that incomplete penetration of hem-fir plywood did not promote decay compared to completely penetrated solid wood stakes at similar retentions. Furthermore, plywood with lodgepole pine heartwood face veneers CCA-treated to CSA O80.15-97 and edge-treated with copper naphthenate performed as well as hem-fir plywood treated to the same level. Pine plywood with sapwood face veneers did not perform as well despite better preservative penetration. Aspen laminated veneer lumber, CCA treated to

16.6 kg/m3 remained in reasonable condition after 11 years. Lower retentions decayed rapidly.

5.5 Field Cut Preservatives

At the request of the CSA Technical Committee on Wood Preservation, a test of field-cut preservatives was set up in 1987. Short lengths of nominal 2 x 6 inch lumber CCA-treated to PWF specifications were field treated with a variety of preservatives, then half buried on edge in the Westham Island field test site. After ten years of exposure, CCA, ACC and copper naphthenate provided excellent protection with less than 10% of ends showing any signs of decay (Table 1). ACA and creosote were intermediate in performance while zinc naphthenate and penta contributed essentially no protection. Untreated controls had 100% of ends with decay after 10 years. A three-minute dip and a double brush coat of copper naphthenate provided the same excellent level of protection.

Table 1: Performance of field-cut treatments at Westham Island, BC

Treatment	% of ends with decay
Untreated	100
CCA-C	10
Cu naph	2
Zn naph	92
creosote	25
PCP	81
ACC	8
ACA	26
Cu naph, dip	8

CCA, ACC, ACA and penta are no longer registered as field-cut preservatives. Zinc naphthenate formulations that can be colour matched to CCA are desirable for more visible end uses. However, based on these data we recommend use of zinc naphthenate-based field-cut preservatives be restricted to above ground applications. While the dark green colour of copper naphthenate does fade in one or two years, it is objectionable to some homeowners. This test method could be used in the development of alternative colour-matched ground contact field-cut preservatives.

5.6 Shingles and Shakes

Results of field tests of untreated and preservative treated western red cedar shingles and shakes, set up at the UBC Malcolm Knapp Research Forest between 1973 and 1983, were reported by Morris, Byrne and Ingram (1995). These data were used to support the introduction of the CSA O80.35-99 standard for preservative treatment of shingles and shakes.

Table 2: Rating Criteria for Shingles and Shakes

Rating	Decay	Erosion	Splitting
0	none	none	none
1	trace	< 1 mm	0-10 mm
2	moderate	1-3 mm	10-50 mm
3	advanced	3-5 mm	50 mm full length
4	failure	> 5 mm	full length

Recent inspections have updated these results to 25 years for shakes (

Table 3) and 20 years for shingles (Table 4). At this high hazard site, untreated shake panels would have required repair after 15 years and replacement after 20 years. CCA-treated material was still in excellent condition after 25 years. Surprisingly, considering the increased leaching potential from cut fibres, untreated shingles seem to have fared better than shakes with repair required only after 20 years. Again, CCA-treated material was in excellent condition after 20 years exposure. CCA also continued to provide protection against erosion caused by ultra-violet light. ACC-treated shakes also performed very well with no decay after 20 years exposure.

Table 3: Shake ratings after 20 and 25 years' exposure in a field test[a]

Preservative	No. of replicates	Mean rating					
		Decay		Erosion		Splitting	
		20-yr	25-yr	20-yr	25-yr	20-yr	25-yr
Control	49	1.7 (0.9)	2.3 (0.6)	2.4 (0.4)	2.7 (0.5)	1.5 (1.5)	1.8 (1.5)
CCA-C	43	0.05(0.2)	0.05(0.2)	1.2 (0.4)	1.6 (0.5)	1.7 (1.6)	2.2 (1.4)
CCA-B	46	0.0 (0.0)	0.1 (0.3)	1.3 (1.3)	1.9 (1.4)	1.2 (1.5)	1.5 (1.4)
ACA	39	0.0 (0.0)	0.3 (0.5)	1.4 (0.6)	2.0 (0.2)	2.0 (1.3)	2.3 (1.2)
Modifed ACA	43	0.0 (0.0)	0.1 (0.3)	1.3 (0.5)	2.0 (0.2)	1.6 (1.4)	1.9 (1.2)

Table 4: Shingle ratings after 20 years' exposure at Westham Island / Vancouver and Haney, BC[a]

Preservative	Panel	Mean rating		
		Decay	Erosion	Splitting
Vancouver				
Control	1	0.9 (0.8)	1.9 (0.2)	1.0 (1.5)
	2	1.0 (0.9)	1.9 (0.3)	0.6 (1.2)
CCA-C	1	0.0 (0.0)	0.8 (0.4)	1.6 (1.7)
	2	0.0 (0.0)	0.7 (0.5)	1.8 (1.7)
ACC	1	0.0 (0.0)	0.9 (0.2)	2.3 (1.8)
	2	0.0 (0.0)	0.6 (0.5)	1.6 (1.7)
Modified ACA	1	0.0 (0.0)	1.0 (0.2)	0.8 (1.3)
	2	0.0 (0.0)	1.0 (0.0)	2.1 (1.5)
Haney				
Control	Sun	0.0 (0.0)	3.0 (0.0)	0.2 (0.8)
	Shade	0.7 (0.8)	2.1 (0.3)	0.2 (0.7)
CCA-C	Sun	0.1 (0.3)	1.0 (0.0)	1.4 (1.7)
	Shade	0.0 (0.0)	1.0 (0.0)	1.3 (1.6)
ACC	Sun	0.0 (0.0)	1.0 (0.2)	1.8 (1.7)
	Shade	0.0 (0.0)	1.0 (0.2)	0.7 (1.4)
Modifed ACA	Sun 1	0.0 (0.2)	1.2 (0.4)	1.3 (1.5)
	Sun 2	0.0 (0.0)	1.3 (0.5)	1.6 (1.8)

[a] Standard deviations are given in parentheses.

5.7 Decking

A variety of treated and untreated decking has been exposed at Forintek's Westham Island and Vancouver test sites for between 15 and 19 years. Earlier results from this work (Morris and Ruddick 1993) were used to support the introduction of CSA O80.32, the decking standard with a 5mm penetration requirement. Updated results have recently been reported to the T2 committee of the American Wood Preservers' Association to support a similar standard for the USA. While untreated hem-fir decking would have required 23% of the boards to be replaced after only 7 years, unincised CCA-treated decking that failed to meet the new CSA O80.32-97 was still in good condition after 19 years (Table 5). Material that would have met this standard, installed in 1984, was also in good condition after 16 years while material that would have failed the penetration requirement showed only limited signs of decay. The decay resistance of both sets of CCA-treated unincised hem-fir was superior to western red cedar decking exposed for 18 years.

Table 5: Performance of non-incised decking

Yrs In test	Species	Preser-vative	Process	Ret'n[a] Kg/m^3	Pene-tration % ≥ 5mm	Finish	Mean 2000 Rating	% Boards rated 3 or 4	Overall Rating
19	Hem-fir	None	-	-	-	-	2.3	41	4
19	Hem-fir	None	-	-	-	stain	1.4	25	3
19	Hem-fir	CCA-C	pressure	2.3	65	-	0.1	0	2
19	Hem-fir	CCA-C	pressure	1.6	35	stain	0.1	0	2
18	Hem-fir	None	-	-	-	-	2.5	47	4
18	WRC	None	-	-	-	-	1.5	7	3
18	Pine	None	-	-	-	-	0.4	7	3
16	Hem-fir	CCA-C	pressure	3.7[b]	80[b]	Sunwood	0.1	0	2
16	Hem-fir	CCA-C	pressure	5.3[b]	40[b]	Cedartone	0.6	0	2

[a] Ret'n = Retention, in a 16 mm assay zone [b] Five samples only.

Checks developing in unincised CCA-treated hem-fir deck boards should have penetrated the treated zone and permitted access to untreated wood by decay fungi. Smith (1986 R.S. Smith, personal communication) has proposed the hypothesis that low levels of mobile CCA components wash into checks and prevent germination of the spores of wood rotting basidiomycetes. Experiments to investigate this hypothesis have been set up at Forintek and we are currently working with a graduate student under the supervision of Prof J.N.R. Ruddick.

5.8 Finger-Joined lumber

A field test of CCA-treated finger-joined SPF was set up in 1980 and reported in detail by Morris and Troughton (1993). This material was recently inspected after 20 years exposure (Table 6) and reported to AWPA to support the proposed decking standard. The untreated material was severely decayed with 63% of the samples failed (rated 3 or 4 on the IUFRO 0-4 scale). In contrast, the CCA treated material, which would have met the retention but failed penetration requirements or above ground applications in CSA O80.2-97 and CSA O80.32-97, was completely free from decay.

Table 6: Performance of finger-joined SPF lumber after 20 years' exposure

Treatment	Retention (kg/m^3)	Mean penetration (mm)	% with ≥ 5 mm penetration	Decay rating
				20-year
None	-	-	-	2.9 (0.9)
CCA-C	4.5	4.3 (5.0)	30	0.0 (0.0)

Standard deviations are given in parentheses

5.9 Millwork

A post and rail test of millwork preservatives was set up at the Petawawa test site in 1978. After 20 years exposure (unpublished report), samples treated with 5% penta and a commercial formulation of phenyl mercury oleate were still performing well with log scores on the AWPA (100-0 scale) of 90 or higher in white pine and 80 or higher in white spruce (Table 7). Both of these preservatives are no longer registered for millwork applications. The only preservative tested that gave similarly good performance was oxine copper at 0.08 kg/m^3 in white pine and 0.05 kg/m^3 in white spruce.

Table 7: Preservative retention and Mean logscores after 20 years' exposure

Treatment	Pine		Spruce	
	a.i. Retention by uptake (kg/m^3)	Logscore	a.i. Retention by uptake (kg/m^3)	Logscore
None		66.0		37.1*
5% PCP	0.61	91.0	0.43	88.9
1% Cu-N	0.12	81.0	0.09	60.0
0.4% TBTO	0.04	78.0	0.03	64.4
0.8% TBTO	0.09	80.0	0.06	62.2
phenyl mercury oleate	-	94.0	-	82.2
0.38% oxine copper	0.04	83.0	0.03	56.0
0.75% oxine copper	0.08	93.0	0.05	86.0

* Replicates had been lost

Tests of millwork preservatives using the newer L-joint test were set up between 1990 and 1991 mostly under contract to chemical suppliers. With the permission of the clients, the data after 5 and 6 years exposure were published by Morris and Ingram (1996). Formulations containing 1.0% TCMTB or 50:50 TCMTB/IPBC gave equivalent performance to 5% penta after 5 years and 1.0% propiconazole and 3.0% zinc neodecanoate gave equivalent performance after six years when applied by the double vacuum process. A 1.0% TBTO formulation gave equivalent performance to 5% penta when applied by dip, but not by double vacuum.

Despite considerable loss of active ingredient from the joint region after 5 years exposure (Morris and Ingram 1996) borate-treated material was still performing well with a mean rating of 0.1 on the IUFRO scale after 10 years exposure (Morris 2000). By contrast, the untreated material had a mean rating of 3.4 (Table 8).

Table 8: Performance of borate-treated and untreated hem-fir L-Joints after 10 years exposure

Treatment	Decay Rating
None	0.1
Borate	3.4

6 Conclusions

Observations and data derived from field testing can increase our understanding of the factors limiting the performance of treated wood products and assist in the development of new products and preservatives.

Canada's wood preservation standards are supported by performance data on a wide variety of treated commodities.

These data can also be used to support marketing of Canadian treated wood products

Note:

To support your performance claims on treated wood products, you can direct customers to our web site jointly developed with the Canadian Wood Council:

durable-wood.com

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