Pressure Treatment of Canadian SPF with Heated Borate Solutions

Cliff Baker[1], Craig Wilson[1], Shane McFarling[2] and Paul Morris[2]
[1]Timber Specialties Ltd, [2]Forintek Canada Corp.

Introduction

Borates have a history of use for wood treatment dating back to the early part of this century. They were first used as antisapstain treatments and fire-retardants (Hunt and Garrett 1938) but their efficacy against wood-rotting fungi was not widely recognised until the 1950s (Drysdale 1994). They have since been used continuously in New Zealand as a diffusion treatment to protect green framing and, during the 1960s and 70s in Canada for export to the UK (Byrne 1990). In the early 1990's attention shifted towards pressure treatment because of the shorter time frame and more contained processing (Byrne and Morris 1996). Borates gained increasing interest in Canada over the last 10 years (Morris 1999), because decay and termite problems have been on the rise inside buildings, the environment for which borates are uniquely suited.

The leaky building problems in BC (Morris 1997) and parts of the US have encouraged consideration of more treated wood use by builders. Canada's lumber industry has recognised that our export markets are increasingly in areas where termites are a threat to wood construction. One of the most aggressive termite species, the Formosan subterranean termite, spread from its natural range in southern China to invade Taiwan, southern Japan, and since WWII, the southern US. Since the late 80's, we have seen some of our most effective soil treatment and fumigant weapons in the battle against termites, withdrawn from the market. It is now recognised that multiple lines of defence are required against both decay (Hazleden and Morris 1999) and termites (Morris 2000) in buildings, and preservative treated wood is a key component in this defence.

Chromated copper arsenate (CCA) has been our mainstay preservative for all applications, but based on inaccurate adverse public perception, there is widespread reluctance to use it extensively inside buildings. By contrast, borates are perceived as low risk in terms of human health or environmental impact (Drysdale 1994). Like CCA, borates have been shown to provide resistance against both decay (Drysdale 1994) and termites (Grace *et al.* 2000, Tsunoda *et al.*2000). The limitation on the wider use of borates has been that they are not suitable for all end uses due to their leachability in contact with liquid water. Treaters, specifiers and users of treated wood have found it easier to use multi-purpose preservatives, such as CCA (Drysdale 1994). More recently, there has been a shift towards using preservatives and treatment levels targeted towards specific end uses, reflected in the development of hazard class, or use category, standards around the world (Morris 1996). Borates have consequently been recognised as effective preservatives for framing and sheathing.

While all these factors are important, the most important consideration is that borates provide better penetration than CCA into Canada's difficult to treat wood species and do not require incising which may affect marketability as framing lumber (Morris *et al.* 1996). Spruce-pine-fir is a particularly difficult species mix to treat. Nevertheless, it represents 88 % of Canada's exports to the USA (which takes 80% of Canada's production), 14% of which is used in new residential home construction in the US south, where Formosan termites are of concern.

Previous attempts to treat S-P-F with borates focussed on the use of a pressure treatment plus a diffusion storage period (Morris *et al.* 1996). Pre-steaming and the addition of surfactant produced improved results in some species, but the difficult to treat species still required an extended storage period, which seriously interrupts product flow. Furthermore the low heartwood moisture content of some species impeded diffusion. This paper describes how the ability to effectively treat SPF with an acceptable storage period has come about through the use of heated treating solutions and extended press times and a storage period.

The use of heat in treatment processes with Disodium Octaborate Tetrahydrate has a long history. Dip-diffusion treatments with heated solutions (around 50°C) have been used for 50 years in Australia and New Zealand (Cockroft and Levy 1973). Vinden, Fenton and Nasheri (1985) reviewed methods of accelerating boron treatment including thermal (hot and cold open tank), steam/cold quench, steam/evacuation/bethell, steam/APM and high-temperature diffusion treatment (60°C for one week). Lebow and Morrell (1993) found that pre-steaming Douglas-fir immediately prior to treatment enhanced uptake, but the effect was lost if the lumber was allowed to cool between steaming and pressure treatment. Barnes, Landers and Williams (1993) used the thermal process to treat southern pine lumber with borates. Van de Lagemaat (1994) found no improvement in penetration of green hem-fir using heated solution in a two-hour pressure period. Given this history, it is surprising that the use of heated solutions for pressure treatment of kiln-dried SPF with borates was not considered until very recently.

In September 1999, a cylinder located at Légaré Industries, St. Raymond, Quebec, was converted to a dual treatment Borate/CCA cylinder. During the conversion, an existing steam-heat exchanger was re-piped to allow the borate treating solutions to be heated. In September, four charges provided data that suggested small increases in the temperature of the treating solution would produce unexpectedly good results on eastern SPF. While the data from these charges was not conclusive, the heating of the treating solution to around 22°C (72°F) was thought to be a key factor.

Subsequent experimental work by Forintek, funded by Timber Specialties, showed that the effect was reproducible under controlled conditions. At a solution temperature of 10°C (50°F) (typical water main temperature in Canada), eastern SPF reached refusal after 2 hours at pressure. At 35°C (95°F) the uptake was still increasing after 2 hours and at 60°C (140°F) it was still increasing rapidly. It was suggested that increasing the pressure period to 4 to 6 hours should meet the CSA O80.34 standard for penetration and retention. Given these results, a plant trial was undertaken to determine whether eastern SPF could be commercially pressure treated to meet CSA O80.34 without incising.

Materials and Methods

The work plan followed the protocol outlined in AWPA Standard, Appendix E, Recommended Method for Determining the Treatability of a Species for Inclusion in the AWPA Commodity Standards for Sawn Material.

Lumber Sources

Lumber sources were selected to represent Western Spruce-Pine-Fir (SPF-W) from British Columbia and Alberta, Eastern Spruce-Pine-Fir (SPF-E) from the boreal forest and, Spruce-Pine-Fir South (SPF-S) from the Northeastern USA (Table 1). SPF-W was provided by three mills. SPF-E and SPF-S were provided by nine mills. All the material was graded and kiln dried. Most of the material was #2 and better, but some machine stress rated (MSR) material was supplied.

Table 1 Common and Latin names of species in Western SPF, Eastern SPF and SPF-South

SPF-W		SPF-E		SPF-S	
Common name	Latin name	Common name	Latin name	Common name	Latin name
Subalpine fir	Abies lasiocarpa	Balsam fir	Abies balsamea	Balsam fir	Abies balsamea
White spruce	*Picea glauca*	White spruce	*Picea glauca*	White spruce	*Picea glauca*
Black spruce	*Picea mariana*	Black spruce	*Picea mariana*	Black spruce	*Picea mariana -*
Engelmann spruce	*Picea Engelmanii*	Red spruce	*Picea rubens*	Red spruce	*Picea rubens*
Lodgepole pine	*Pinus contorta*	Jack pine	*Pinus banksiana*	Jack pine	*Pinus banksiana*
				Red pine	*Pinus resinosa*

Species Identification and Moisture Content

As the product was received at the treating plant it was held in a segregated area until all inventory required was on location. Quebéc Lumber Manufacturers Association staff, under the supervision of their Chief Lumber Grader then identified the species. Each bundle was dismantled and identified by species and color-coded. A minimum of ten moisture content readings were recorded and averaged. The lumber was re-bundled for treatment.

Treatment Process

The Full-Cell pressure process method was used for all charges. A 5.4% (6.5% BAE) Timbor solution was heated to a temperature of 140°F (60°C) to 150°F (65°C) prior to treatment. No additional heat was added during the treatment cycle. The treating schedule was as follows:

Vacuum – 30 minutes vacuum at 22 in. Hg (-77kPa)
Fill retort under vacuum
Bring to pressure and maintain 150 PSI for 4-10 hours.
Relieve pressure & pull a 15-minute final vacuum at 22 in. Hg (-77kPa)Each bundle was weighed before and after treatment to monitor uptake. All treated material was wrapped immediately to retain heat and moisture.

Treating Charges

A total of 100,000 FBM were treated in 12 charges as shown in Table 2.

Table 2 Species Composition of Treating Charges

Chg.	lodge -pole pine	jack pine	red pine	W white spruce	E white spruce	red spruce	black spruce	balsam fir	SPF W	SPF-E	SPF-S
1	✓		✓				✓			✓	
2				✓	✓	✓	✓			✓	✓
3					✓	✓	✓			✓	✓
4	✓			✓	✓		✓			✓	
5	✓			✓	✓	✓	✓	✓		✓	✓
6	✓	✓	✓						✓	✓	✓
7				✓	✓			✓	✓	✓	
8		✓		✓	✓		✓	✓	✓	✓	
9		✓					✓	✓		✓	
10							✓			✓	
11					✓	✓		✓		✓	2✓
12					✓	✓		✓		✓	2✓

Inspection and assay for Penetration and Retention

Immediately after treatment core borings were taken in the middle of the length, on a total of 20 samples from each species plus a random selection of SPF from each bundle under the supervision of Timber Products Inspection. Two sets of borings were taken for SPF-S from charges 11 and 12. Only the results from the SPF mixes will be presented here.

Borings were dried and split. Timber Products Inspection witnessed the spraying of one set of half borings for each species plus random SPF mix from each charge and then measured and recorded the penetration. The other half borings from each set of samples was ground and packaged for shipment to Timber Products Inspection Laboratory for borate analysis.

One cross-cut section (4" sub-sample) was taken following treatment from 20 boards for each species in each charge. The 4" sub-samples were taken approximately 23" from the end of the piece. Sub-samples were oven dried and ½" wafers cut from the center of each sub-sample, sprayed with curcumin reagent to show preservative penetration and photographed.

After one week, the inspection agency took and/or witnessed the taking of core in the middle of the length, on a total of 20 samples from each species in a charge that had not passed penetration requirements immediately following treatment. Borings were dried, split and one set of half borings was sprayed with curcumin reagent and results recorded and photographed. The other half borings from each set of samples was ground and packaged for shipment to Timber Products Inspection Laboratory for borate analysis as per CSA Standards.

Results and Discussion

Immediately after treatment, eight of twelve commercial charges of SPF-E met CSA O80.34 penetration requirements (Table 3). The remaining four charges passed after one week of storage. All charges met or exceeded the CSA O80.34 Retention Level – 2.7 kg/m^3 B_2O_3 by assay. In addition, eight of the twelve charges met the retention required for Formosan termites – 4.5 kg/m^3 B_2O_3 (AWPA 2000) and one came very close at 4.3 kg/m^3. The variability in retention can be largely explained by the differences in the mixture of species in the different samples and would not be a major problem in practice. Owing to the constraints of this study, it was not possible to adjust the solution strength for each charge. With the information generated on the individual species (not published here) it should be relatively easy for a commercial treater to adjust the solution strength for the species mix being treated.

Immediately after treatment, all three commercial charges of SPF-W met CSA O80.34 penetration requirements (Table 3). All charges met or exceeded the CSA O80.34 Retention Level. In addition, two of the three charges met the retention required for Formosan termites and one came very close at 4.2 kg/m^3.

Immediately after treatment, four of eight commercial charges of SPF-S met CSA O80.34 penetration requirements (Table 3). Three more charges passed after one-week storage and the remaining charge passed after two weeks storage. All charges met or exceeded the

CSA O80.34 Retention Level. Seven of the eight also passed the Formosan retention requirement.

The effect of heating the solution in increasing uptake during pressure treatment is not fully understood, but it may involve loosening of aspirated pits and/or reduction in surface tension of the solution. Further increases in penetration after pressure treatment may be due to contraction of the air inside the lumber creating a vacuum and to a capillary wetting effect. Unlike CCA, borates do not fix to the wood and are therefore able to keep moving with the water as it soaks into the wood. The process is, in effect, a combination of pressure treatment, and thermal treatment. It is not strictly a diffusion treatment, since there is insufficient moisture in kiln dried lumber to permit diffusion beyond the penetration depth of the treating solution. It seems likely that the improved penetration resulting from pre-steaming lumber seen by Lebow and Morrell (1993) and Morris *et al* (1996) may have been due partly to the hot wood heating the solution. Lebow and Morrell (1993) noted that the effect disappeared if the lumber was allowed to cool between steaming and pressure treatment. The failure of van de Lagemaat (1994) to show any improvement in penetration using heated solutions on green hem-fir may have been due to the cooling effect of the thermal mass of green lumber or the relatively short press time.

Some washboarding was observed in the early wood of some Balsam fir and Red spruce. This problem should be eliminated through minor modifications to the treating process. Furthermore, these species account for very small percentages of the eastern S-P-F mix, and in many cases are sorted out at the mill.

Conclusions

The results of twelve commercial charges demonstrate that kiln dried Spruce-Pine-Fir from across Canada can be consistently treated to the CSA O80.34 Standard without incising.

For some sources of lumber, the use of heated solution, extended press times and up to two weeks storage after pressure treatment was required to meet penetration requirements.

Acknowledgements

This study on which this report is based, was funded by Timber Specialties Ltd, Forest Renewal BC, Alberta Innovation and Science, ministry of Natural Resources of Quebec and Forintek's core budget. The authors would like to acknowledge the support of twelve sawmills in Quebec, Ontario and British Columbia, and the participation of Quebec Wood Export Bureau, Quebec Lumber Manufacturers Association, and Légaré Industries. Forintek Canada Corp. would like to thank its industry members, Natural Resources Canada, and the Provinces of British Columbia, Alberta, Quebec, Nova Scotia, New Brunswick and Saskatchewan, for their guidance and financial support for this research.

Table 3 Summary of Results of Treatment

Species Group	Charge #	Retention Kg/m^3	%≥10mm		
			Immediate	1 Week	2 Weeks
SPF-W	1	8.7	80		
	2	4.2	90		
	3	8.5	100		
SPF-E	1	8.8	100		
	2	3.2	65	95	
	3	3.0	55		
	4	5.1	90	95	
	5	6.1	85		
	6	9.9	100		
	7	4.6	85		
	8	7.7	85		
	9	4.6	35	95	
	10	2.9	95		
	11	7.2	80		
	12	4.3	55	80	
SPF-S	1	5.1	45	95	
	2	6.9	80		
	3	8.2	95		
	4	3.2	60	85	
	5	8.8	15	55	85
	6	8.0	85		
	7	6.6	90		
	8	6.1	60	85	

References

American Wood Preservers' Association. 2000. Minutes of the AWPA Subcommittee T2 Lumber and Timber meeting held on Wednesday, September 20, 2000 – Salt Lake City, Utah. 7p. (www.awpa.com)

Barnes, H.M., R.W. Landers, and L.H. Williams. 1993. Thermal treatment of southern pine with borates. For. Prod. J. 43(3):31-34

Byrne, A. 1990. Recent research in boron treatment of Canadian wood species: stain and mould preventives. P 65-67 In: Proc. 1st International Conference on Wood Protection with Diffusible Preservatives and Pesticides. Forest Products Society Madison WI.

Byrne, A. and P.I. Morris. 1996. Recent research in boron treatment of Canadian wood species. P55-61 in Proc. 2nd International Conference on Wood Protection with Diffusible Preservatives and Pesticides. Forest Products Society Madison WI.

Canadian Standards Association 1997. CSA O80.34-97 Pressure preservative treatment of lumber and timber with borates for use out of ground contact and continuously protected from liquid water. 2p. Canadian Standards Association, Etobicoke ON.

Cockcroft, R. and J.F. Levy. 1973. Bibliography on the use of boron compounds in the preservation of wood. J. Inst. Wood Sci. 6 (3): 28-37

Drysdale, J.A. 1994. Boron treatments for the preservation of wood – a review of efficacy data for fungi and termites. Int. Res. Group on Wood Preservation. Document No. IRG/WP/ 94-30037. 21p.

Grace, J. K., R.J. Oshiro, A. Byrne, P. Morris and K. Tsunoda. 2000 Termite resistance of borate-treated lumber in a three-year above-ground field test in Hawaii. . Int. Res Group on Wood Preservation. Document No. IRG/WP/30236. 5p.

Hazleden, D.G., and P.I.. Morris 1999. Designing for durable wood construction: the four Ds. Durability of Building Materials and Components. 8(1) Lacasse and Vanier Eds. NRC Research Press, Ottawa, Canada. 12p.

Hunt, G.M. and G.A. Garrett. 1938. Wood Preservation. McGraw-Hill, New York.

Lebow, S and J.J. Morrell, 1993. Effect of steaming on treatability of Douglas-fir heartwood with sodium octaborate tetrahydrate. For. Prod. J. 43(4): 35-38

Morris, P.I. 1996. Towards a unified international hazard class system. IRG/WP/96-20081. 16p.

Morris, P.I. 1997. Moisture Problems in Vancouver Condominiums. in: Proc. Structural Board Assoc. Technical Forum 14p.

Morris, P. I. 1999. Wood Preservation in Canada 1999. Mokuzai Hozon. 25(4) 2-12 (paper in Japanese. English version available at www.durable-wood.com)

Morris, P.I. 2000. Integrated control of subterranean termites: the 6S approach. Proc. American Wood Preservers' Assoc. 96. In press.

Morris, P.I., S. McFarling and A. Byrne. 1996. Treatability of Canadian wood species with borates. Proc. a Conv. Cdn. Wood Preservation Assoc. 17: 97 - 122.

Tsunoda, K., A. Adachi, T. Yoshimura, A. Byrne, P. I. Morris, and J. K. Grace. 2000. Resistance of borate-treated lumber to subterranean termites under protected, above ground conditions. International Research Group on Wood Preservation. Document No. IRG/WP/30239. 6p.

Van de Lagamaat. 1994. The effect of variation in pressure-treatment process variables. Unpublished internal report. Forintek Canada Corp., Vancouver BC.

Vinden, P., T. Fenton and K. Nasheri. 1985. Options for accelerated boron treatment: A practical review of alternatives. International Research Group on Wood Preservation. Document Number IRG/WP/3329. 21p.

Table 3 Summary of Results of Treatment

Species Group	Charge #	Retention Kg/m^3	%≥10mm		
			Immediate	1 Week	2 Weeks
SPF-W	1	8.7	80		
	2	4.2	90		
	3	8.5	100		
SPF-E	1	8.8	100		
	2	3.2	65	95	
	3	3.0	55		
	4	5.1	90	95	
	5	6.1	85		
	6	9.9	100		
	7	4.6	85		
	8	7.7	85		
	9	4.6	35	95	
	10	2.9	95		
	11	7.2	80		
	12	4.3	55	80	
SPF-S	1	5.1	45	95	
	2	6.9	80		
	3	8.2	95		
	4	3.2	60	85	
	5	8.8	15	55	85
	6	8.0	85		
	7	6.6	90		
	8	6.1	60	85	