Thickened Boron Treatments for Canadian Woods

by

Tony Byrne
Forintek Canada Corp.
Vancouver, B.C.

Summary

Boron treatments were formerly done on a commercial scale in Canada but were discontinued for various reasons. A major contributory factor was the inconvenience of using hot borate solutions. Recently thickened borates (Diffusol) have gained wide acceptance in New Zealand and offer a means of treating wood at ambient temperatures. There is also renewed interest in the use of borates as a preservative for Canadian woods in export markets. Work was therefore done on the applicability of Diffusol to hem-fir and alpine fir lumber. In a laboratory test these woods retained a liquid surface loading of approximately three times the amount retained in the traditional hot borate dip. The curcumin boron detecting reagent did not reliably indicate the level of treatment on hem-fir or alpine fir. However boron did appear to be diffusing towards the centre of the boards after three weeks and treatment was more or less complete after eight weeks. Overall this work indicates that the concept of using a cold thickened borate formulation is a potentially viable means of treating western Canadian woods prior to a diffusion period.

Introduction

In the 1960s the western Canadian wood species group hem-fir was treated on a limited commercial scale with borates. This was done at two British Columbia sawmills for a short time and at one for a period of about 10 years. The diffusion treated product was sold into the United Kingdom "System Builders" timber framing market. The process was, however, discontinued for reasons which are not easy to pin down 25 years later. I have asked several people who were involved with the process and the reasons for discontinuing can be put in three categories - market, chemical handling and production logistics.

The first reason is that the boron-treated wood was not aggressively marketed and as a result the market remained static. According to one man involved with the treatment the premium obtained covered the costs of doing the treatment but the margin was slim.

The second is basically a handling one. Sawmills like to produce wood and handling chemicals is not something they enjoy. The chemicals involved in the 1960 s were bags of Tim-Bor, a white powder which had to be dissolved in a dip tank together with a commercial liquid formulation of sodium tetrachlorophenate, added to control fungal stain and mould on the treated wood. In order to apply a sufficient chemical loading to the wood surface

the borate treating solution had to be concentrated and heated. It was hard to keep mill personnel enthused about the treatment involving as it did a hot, objectionable-smelling tank of chemicals which had to constantly be kept hot and topped up with sacks of dusty powder.

A third reason mentioned is of one sawmill not being able to accumulate enough of the correct material in suitable condition for treatment as mill production was diverted into other more profitable end uses. Surface drying of the wood occurred because of the time required to accumulate enough wood for batch treatment. This reason is really a local production problem.

Although these early treatments cannot be considered commercially successful they did show that hem-fir will treat readily with borate solutions, such as Tim-bor.

Several things have changed since the earlier borate treatments of B.C. lumber. One overriding factor is that borates conform with the recent "Greening of the Western World". In Vancouver, which is the birthplace of Greenpeace, we are constantly bombarded with literature which tells us to get rid of the "chemical" household cleaners and use borax and washing soda instead.

Other factors which have changed in the Canadian Wood Products industry are that there is a recognized need to diversify the forest products industry to produce more specialized products and increase the value of our exports. An additional factor is that, as anybody who has been involved with the sapstain control issue in Canada will testify, our sawmills have recognized that chemicals are a part of the modern wood product business. However there is an even greater need to handle chemicals safely in the workplace so that they pose a hazard neither to the environment or to the workers.

Awareness of potential markets for this environmentally acceptable product has renewed interest in treating western Canadian wood species with boron compounds. Forintek, together with the B.C. Council of Forest Industries, is actively encouraging the adoption of such treatments as a potential market niche to be developed.

New Zealand and Boron Treatment Technology

I want now to turn to technological changes which have occurred since the 1960s. Of course we tend to turn to New Zealand for knowledge about boron treatment of wood. New Zealand annually treats some 400,000 m^3 or about 25% of its sawnwood production with borates. Most of the treatment is done simply by dipping the wood in a tank of borates and storing the wood for 4 - 8 weeks under covers. Although this treatment is basically "low-tech", New Zealand, and particularly the Forest Research Institute in Rotorua, has been at the forefront of new developments in boron treatments some much more technically sophisticated such as vapour boron.
One New Zealand development has been the commercialization of "thickened" borates. Thickened boron treatments were jointly developed by Hicksons New Zealand and the Forest Research Institute. The concept is simply one of

artificially increasing the thickness of the film of liquid left on the wood surface after dipping or otherwise coating. Because the liquid uptake is higher than it would be from a simple solution the thickened solution can be at a lower concentration of borate salts (10 to 12% boric acid), to the point where this solution is stable at operating temperatures and there is therefore no requirement for heating. Other advantages of thickened borates became apparent during commercial trials involving Koppers-Hickson Timber Protection (New Zealand) Ltd. who subsequently commercialized the product Diffusol. This work is covered in a recent paper by Vinden, Drysdale and Spence (1).

Diffusol in New Zealand

Diffusol has created the largest change in the New Zealand industry since boron treatments first started there in the 1950s. On a recent Forintek/COFI trip to New Zealand I visited sawmills that were using both the traditional borate diffusion treatment method and sawmills which were using Diffusol. The big advantage seen by the sawmills of the Diffusol system is convenience: it is much less labour intensive than metering bags of dry salts and sapstain control products into a diptank. The paste-like Diffusol concentrate (38% w/w boric acid equivalent) is delivered in a tanker truck, in bulk bins or in drums ready for dilution into the sawmill's diptank. Once in the diptank the solution is stable down to 0°C and has no significant odour. The concentrate contains a sapstain control chemical so no additives to the diptank are required. For normal use the concentrate is diluted 1:2.4 (concentrate: water) giving a working solution of about 12% BAE. The normal uptake of this working solution is about 15 to 24 litres/m^3 for average roughsawn stock. A target chemical uptake of 5.6 litres of concentrate per m^3 is recommended.

When deliveries are received from a tanker truck the concentrate is automatically diluted through equipment supplied with the chemical. Also supplied are a storage tank and mixing/filtration equipment. Koppers-Hickson provides technical expertise and a system of treatment control (controlling under/over charge). By May, when I visited New Zealand, some 47 plants (approximately 30-40% of the market) were using the Diffusol system even though it had only been on the market for a little over one year.

Faster diffusion times are reported to be possible when using Diffusol rather than conventional hot-dip treatments. Variability of treatment is lower when using Diffusol because of a more even surface uptake of chemical during treatment. Overall, slightly lower boron loadings and slightly shorter diffusion times could therefore be required to attain the standard core retention. Some of the mills we visited had reduced the diffusion period required for treatment of radiata pine from 8 weeks using traditional hot borate salts to 6-6½ weeks using Diffusol.

An additional advantage of Diffusol is that it can be used on gauged (planed) timber because the wood surface has little effect on the uptake of solution. There is difficulty obtaining the borate loading on planed timber with simple borate salts because the wood surface is smooth and somewhat hydrophobic. Diffusol therefore permits the treatment of planed

timber but traditional New Zealand practice is to treat first and plane later.

Applicability of Diffusol on Canadian Woods

I mentioned the reluctance of Canadian sawmills to handle bulk chemicals. The Diffusol system appears to be one way to minimize chemical handling problems in a sawmill. In New Zealand Koppers-Hickson has moved the industry away from the concept of borates supplied as a bulk chemical commodity, in sacks, to that of a product delivered as a liquid in a tanker. Diffusol also has a sapstain/mould biocide incorporated; this chemical might have to be changed to suit the registration situation in Canada. Additionally despite the fact that most New Zealand wood treated is rough cut and despite the fact that the early Canadian experimental treatments of wood also involved rough material, I suggest that future treatments done in Canada will probably involve surfaced or planed wood. The reason is that planing treated wood results in loss of the wood with the highest chemical (including sapstain control product) content and chemically treated planer shavings are a disposal problem.

For reasons mentioned above thickened borate formulations appear to be a feasible treatment method when Canadian producers adopt boron diffusion treatments and Forintek has therefore done laboratory work with Diffusol on western Canadian wood species. While we acknowledge that much research work has already been done in New Zealand on Diffusol, Hickson World Timber Ltd. agreed that work must also be done on Canadian wood species for our particular circumstances and have funded this work. Some laboratory and field work had been done with borates at the Western Forest Products Laboratory (the predecessor to Forintek's Western Laboratory) prior to the commercial use of borates discussed earlier (2) and the work with Diffusol was based on some of the earlier experiences.

Forintek Work with Diffusol

The objective of this work was to produce information on the treatability with Diffusol of two Canadian woods so that commercial treatment schedules can be designed for those wood species. Western Canadian hem-fir and alpine fir which are naturally very wet wood species, are known to lend themselves particularly well to diffusion treatments and these were the species used in this work.

The first parameter to check was the uptake of Diffusol by surfaced wood. At Forintek we measure uptake of liquids in dip or spray systems in terms of weight (grams) of treating solution per unit (m^2) of wood surface area rather than per unit of wood volume. The wood volume measure depends on the surface area to volume ratio which varies with different sizes of material.

The second part of the work was designed to produce information to enable commercial treatment schedules to be designed. This was done testing diffusion of two wood species, at three different moisture contents after three, five and eight weeks of storage at two temperatures - 10°C or 25°C.

Boron analytical data for this second part requires to be completed before the results can be reported.

Experimental Work

The Diffusol concentrate was diluted 2.4 volumes water: 1 volume concentrate to give a clear slightly "thick" working solution of 12.6% boric acid equivalent (BAE) by analysis. Viscosity measurements on the working solution gave a reading of 145 centipoise (cps) at 10°C and 120 cps at 20°C using a #2 spindle at 30 rpm on the Brookfield Viscometer. The different viscosities at 10 and 20°C indicates that the temperature of the treating solution would affect the thickness of the film retained on a wood surface.

The wood used was freshly sawn and planed, unseasoned, ungraded, untreated 1 9/16 x 3 9/16-in. (40 x 90 mm) alpine fir or hem-fir lumber. The wood was cut into 4 ft. (1220 mm) pieces sorted according to the weights of the boards as estimates of the moisture content. The samples were divided into three groups of high, medium and low moisture contents (MC s) and within each group, the samples were randomly distributed among the treatments. Before treatment, to reduce the influence of the end grain on the treatment, the samples were end-sealed with two coats of polyvinylacetate glue. During each handling of the wood the wood surfaces were covered as far as possible to prevent drying.

To approximate the range of winter/summer temperatures at which treatment might be done wood samples were treated with 12.6% BAE Diffusol at two different temperatures: 10°C or 25°C. The temperature of the wood was approximately 10°C for the former and 20°C for the latter treatment. Using a replication of 16 pieces per wood species group per moisture content per treatment temperature, test boards were immersed in the treating solution for one minute followed by a draining period of 30 seconds. The pieces were weighed before and after treatment to determine the uptake of Diffusol. They were then close-piled with the other pieces in the treatment group, wrapped in plastic and stored at temperatures approximately the same as the treatment temperatures. Inspection and assessment of the diffusion process was done by sampling the pieces after three, five and eight weeks. At the final inspection the moisture content of the sample was also determined gravimetrically. The intention was to use a curcumin boron-detecting reagent to indicate the level of diffusion of the boron treatment in the samples and follow up this assessment by a limited number of chemical analyses. These results will be discussed in another paper when the analytical data has been finalized.

Results and Discussion

Table 1 summarizes the uptake of Diffusol (calculated in g working solution/m^2 of western hem-fir and alpine fir wood surface) based on the weight gains measured during treatment.

There was no significant difference between the uptake for the three moisture content groups and for the two wood species groups but there was

a significant difference between uptakes at the two treatment temperatures: averages of 221-263 g/m^2 at 10° and 133-198 g/m^2 at 25°C. This probably reflects the decrease in viscosity with increasing temperature and indicates that the treatment temperature would be a factor in determining the appropriate surface loading with the current Diffusol formulation. For the 10°C treatment the range of Diffusol uptakes, illustrated by the standard deviations was relatively low (6 - 11% of the means) and the means within a species group were very similar. This indicates that at cooler temperatures irregularities in the wood surface and variations in moisture content in the wood do not appear to be strongly influencing the uptake of liquid. This contrasts with uptakes of solution from hot borate solutions where we have seen larger proportional ranges of uptake and where there are indications that the moisture content of the wood can influence the uptake (illustrated by data in Figure 1).

For the treatment at 25°C variation between the uptake means and about the means was much higher than at 10°C. This coincided with a problem of dripping from the pieces leading to inaccurate determinations of the uptake. It should be stated that 25°C is above the range in temperature which the product was designed to work at and presumably the viscosity could be adjusted by changing the thickening system.

Overall the average uptake of Diffusol was about three times the uptake of hot Timbor solutions recorded in other work at Forintek. This indicates that a Diffusol solution of approximately one third boron concentration should give similar surface loadings of borates from a hot dip treatment.

The data enables calculation of the concentration of borates in the treating solution to meet the required loading. The British Standard (3) suggests a cross section loading of 5.3kg boric acid/m^3 (equivalent to approx. 1% BAE) but it is the required core loading of 0.1% BAE (boric acid equivalent) on a dry weight basis which is the critical determinant of whether the standard has been met; this Standard requires 8 out of 10 samples to exceed 0.1% BAE. Based upon New Zealand experience it is probable that the cross section loading recommended in this standard is considerably higher than that required to reach the core loading of 0.1% BAE. For radiata pine target cross-section loadings of about 2.5-4 kg/m^3 are normal to achieve the required core loading.

Based on the uptake of Diffusol, and assuming all the chemical initially picked up would diffuse into the wood, theoretical average cross-section loadings of 0.44% BAE (treatment at 10°C) and 0.33% BAE (treatment at 25°C) were obtained for hem-fir and 0.63% BAE (10°C) and 0.36% BAE (25°C) for alpine fir (Table 1). Despite similar uptakes of Diffusol on an area basis for a given temperature the % BAE for alpine fir is higher than for hem-fir because of the lower density of alpine fir.

The mean moisture contents, determined gravimetrically for each moisture content group are shown, together with standard deviations in Table 1. These were generally lower than the estimated moisture contents previously calculated determined by weighing the wet boards and using book densities.

After eight weeks there was no trace of visible growth of moulds or staining fungi on the treated boards indicating that the antisapstain agent included in Diffusol was effective.

The cross sections of treated wood after the 3, 5 and 8 week storage periods and sprayed with the curcumin boron-detecting reagent were assessed for the indicative colour reaction. The boards generally showed a red coloration around the outside of the cross section and a yellow-orange coloration in the core but despite reports in the literature it was not usually possible to define a boundary between a treated zone and an untreated zone. This confounded estimation of the area adequately treated with boron. Both wood species groups have variable background colour ranging from buff to grey to brown. This background colour may affect the colour of the indicator.

Figures 2 and 3 (colour slides not available for publication) illustrate typical results with the colour indicator in the case of hem-fir after three and eight weeks of storage. Diffusion appears to be well advanced after three and close to complete after eight weeks. However it is difficult to define the difference between the red/brown and yellow/brown colorations mentioned by MacLean (3) in these figures. Subsequent chemical analyses confirmed the unreliability of using this colour indicator method on these two wood species. There was no correlation of intensity of red coloration with %BAE by analysis.

An alternative reagent for boron used in New Zealand based on pyrocatechol violet was also investigated but was found to give similarly indistinct results.

Therefore no firm conclusions could be drawn about the rate of diffusion, the effect of moisture content or the wood species from the colour indicator method, except to indicate that boron did appear to be diffusing towards the centre of the boards and that significant diffusion had occurred after three weeks. Chemical analyses on these samples are being done to verify the treatment levels and the required period for full diffusion to occur.

Conclusions

Borates are being universally acknowledged as a viable wood preservatives for certain end uses and there is renewed interest in their use on Canadian woods. One of the reasons commercial treatments with borates in the 1960s in British Columbia sawmills were discontinued was the problem of handling chemicals around a sawmill. Treating Canadian woods with borates today would require a preservative system which is safe and as convenient to handle as possible. Diffusol, a thickened borate currently sold in New Zealand as a method of treating radiata pine, is one approach to this problem. Several other advantages of thickened borates are that they reduce the need for heating liquids during treatment, treatment of planed lumber is more easily done and more even diffusion is probably possible. This might lead to slight reduction of the diffusion period required.

In a laboratory test hem-fir and alpine fir boards retained a liquid surface loading of approximately three times the amount retained in the traditional hot borate dip. The viscosity of the Diffusol treating solution decreased with increasing temperature, and subsequently higher uptakes, determined by weighing, were calculated at 10°C than at 25°C.

The curcumin boron detecting reagent does not appear to be a fully reliable indicator of the level of treatment on hem-fir or alpine fir. However boron did appear to be diffusing towards the centre of the boards and significant diffusion had occurred after three weeks.

The antisapstain agent included in Diffusol was effective in preventing the growth of moulds and staining fungi on the wood.

Overall this work indicates that the concept of using a cold thickened borate formulation is a potentially viable means of treating western Canadian woods prior to a diffusion period.

Literature Cited

1. Vinden, P., J. Drysdale and M.Spence. 1990. Thickened boron treatment. International Research Group on Wood Preservation Working Group III Document No: IRG/WP/3632. Paper prepared for 21st Annual Meeting, Rotorua, New Zealand, May 1990.

2. MacLean, H. 1962. Diffusion Impregnation of Western Hemlock with Boron. Report No. V-1029. Forest Products Research Branch Vancouver Laboratory, B.C. Canada.

3. Princes Risborough Laboratory. 1969. Preservation of Building Timbers by Boron Diffusion Treatment. Technical Note No. 41. Prices Risborough Laboratory, Aylesbury Bucks, England.

Table 1

Average Percent Moisture Contents, Uptake of Diffusol and Theoretical Overall Boric Acid Equivalent of Test Samples.

Moisture Content Group	% Moisture Content		Uptake g Diffusol/m^2		Calculated Cross-section loading % BAE w/w	
	Mean	SD	Mean	SD	Mean	SD
Hem-fir treated at 10°C						
Low	70	18	221	19	0.44	0.04
Medium	92	21	221	19	0.44	0.04
High	133	29	223	14	0.45	0.03
Hem-fir treated at 25°C						
Low	75	19	198	51	0.39	0.10
Medium	88	26	133	46	0.26	0.09
High	133	34	169	35	0.33	0.07
Alpine fir treated at 10°C						
Low	61	15	263	23	0.67	0.06
Medium	70	18	238	22	0.61	0.06
High	101	24	236	16	0.60	0.04
Alpine fir treated at 25°C						
Low	59	18	142	38	0.36	0.10
Medium	68	21	140	53	0.36	0.14
High	103	27	139	33	0.35	0.09

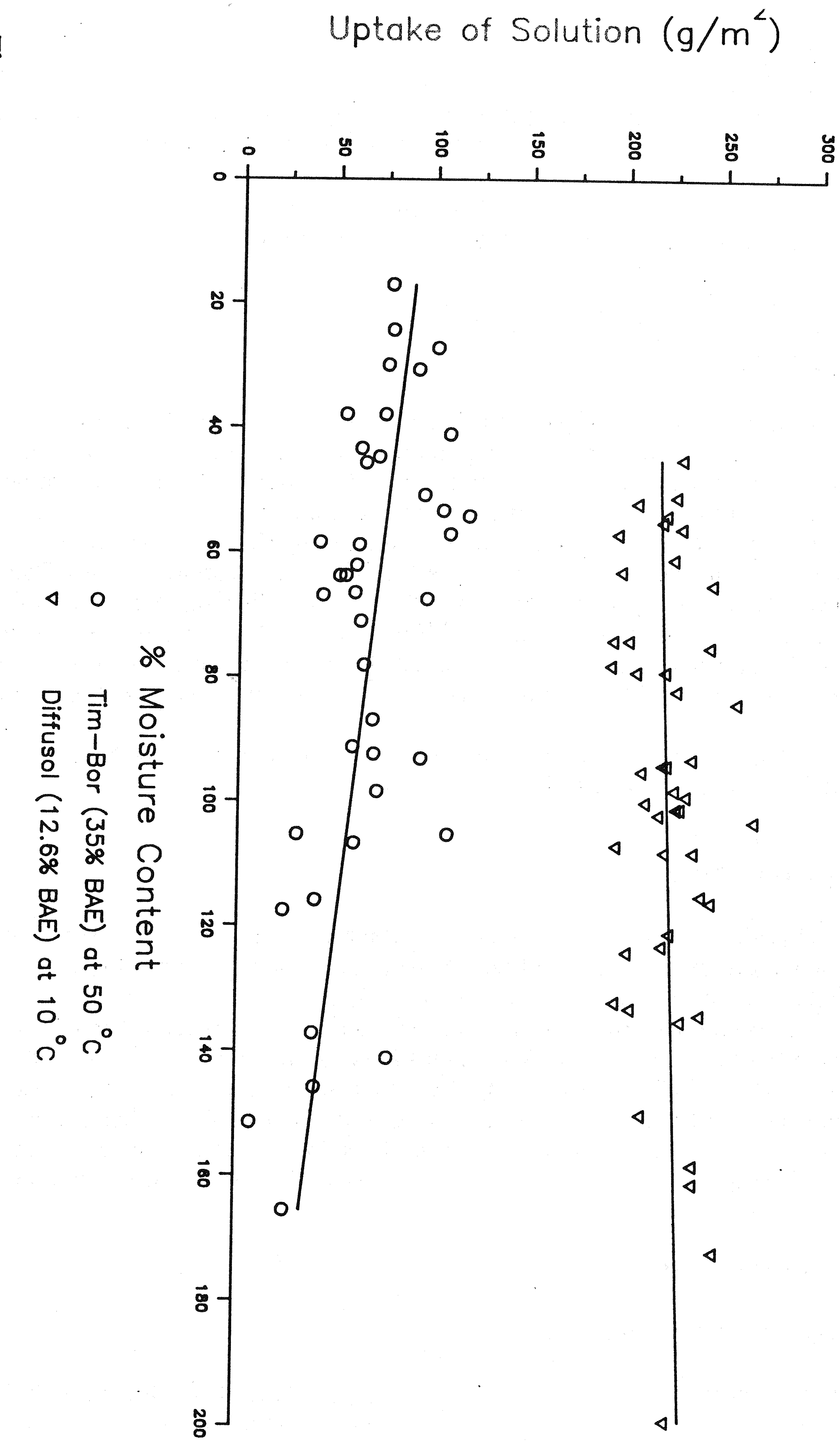

Figure 1. Uptake of treating solution by surfaced hem-fir lumber treated with Diffusol at 10°C or Tim-Bor solution at 50°C.