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New Penetrating Barrier Treatment for Wood and Wood Composites

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ABSTRACT

A new treating system has been developed for protecting wood and wood-based composites from biological organisms including decay, mold and termites. The system is surface-applied but rapidly penetrates to the core of most lumber and wood composites including LVL and OSB. The treating solution is mixed on-site in a fully contained module and is applied by dip or in-line spray. Formulations can be customized to provide desired levels of protection. Unlike a pressure treating plant, the mixing and application equipment can be installed at the end of a planer or a panel manufacturing line. It can be easily taken off-line when not in use. The capital cost is generally less than that for a pressure treating plant. Penetrating Barrier preservative systems have been in commercial use in New Zealand for over two years. They are utilized in a number of mills to protect framing timber from decay and mold. The treatment meets New Zealand Specification 3640 for Hazard Class H1.2 and is being certified for use in Class H3.1. In the U.S., a major siding manufacturer is using a Penetrating Barrier treatment system to provide UC 3A decay and termite protection to its siding products. Additionally, the system has completed a successful plant trial at a U.S. OSB manufacturing facility. Treated OSB was shown in independent testing to be resistant to decay, mold, and Formosan termites, and it successfully passed an ASTM E84-05 flame spread test with a Class B rating. Mechanical properties and appearance of the OSB were not negatively affected by the treatment. Results of the OSB trial are presented in this report.

Keywords: wood preservative, surface-applied, penetrating, lumber, OSB

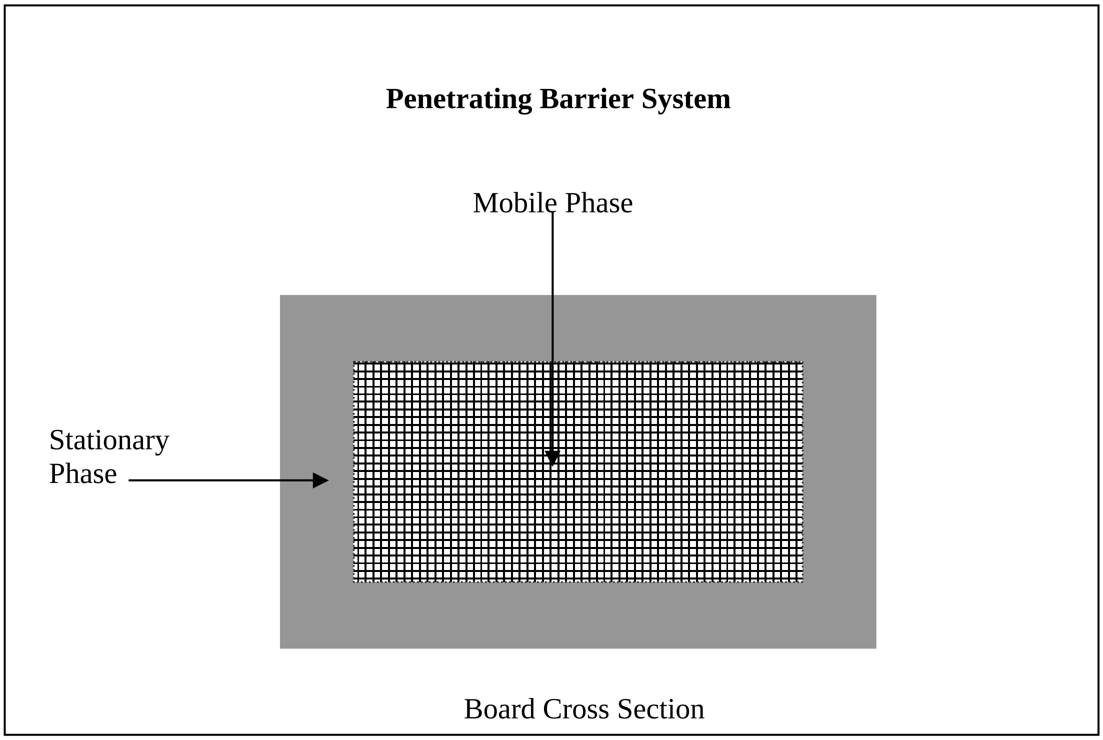
INTRODUCTION

This paper describes a new type of treatment system which has been developed for the protection of solid wood and wood composites such as LVL and OSB. The most unique feature of this system is that it is applied as a surface treatment by dip, flood coat or spray but it rapidly penetrates to the core of most substrates. While the treatment employs the use of borates (along with other preservatives and insecticides), it is not a diffusion system in that it can be applied to substrates with the addition of as little as 2-3% to the moisture content, and it does not require the presence of large amounts of moisture to affect penetration. Unlike diffusion systems which typically require several weeks of conditioning for complete preservative distribution, the Penetrating Barrier system requires only about 24-36 hours of conditioning for penetration to the core. Another important feature of this system is that it is dual phase. The Stationary Phase provides a fixed outer envelope of protection to the substrate while the Mobile Phase penetrates to the core, providing protection throughout the entire component (figure 1). The preservative system can be designed to make optimal use of the dual phases. For example, the Stationary Phase can contain components which are more important for protecting against surface issues such as mold and water damage, while the Mobile Phase can contain components most useful below the surface, protecting against decay and termite attack. The technology of the Penetrating Barrier system is protected by a number of patents and pending patents around the world.

ADVANTAGES

Following are some of the advantages of the Penetrating Barrier treatment system compared to traditional methods of treating lumber and wood composites:

Figure 1



SURFACE APPLICATION

- Preservatives are applied to the surfaces of substrates using dip, flood coat or spray. This eliminates the need for heavily capital intensive treating equipment such as pressure cylinders for lumber or strand blenders for OSB.
- Preservatives can be applied in-line rather than in batch processes. This provides more rapid treating and eliminates several drying and handling steps associated with pressure treatments.
- The mixing and application equipment easily adapts to the high speed, continuous processes associated with forest products manufacturing facilities (i.e., lumber mills or panel manufacturing plants). Thus, forest products manufacturers can treat on-site, eliminating the need for separate treating services.

DUAL PHASE SYSTEM

- As noted above, the preservative system is composed of a number of different types of active ingredients. Some of the actives remain in the Stationary Phase at the surface of the substrate. These can be designed to target organisms and issues which mainly affect the surface (i.e., mold, water intrusion, surface decay, etc.). Additionally, colorants and repellant insecticides can be incorporated in the Stationary Phase. The repellant insecticides help prevent surface grazing on the substrate. Preservatives and insecticides in the Stationary Phase are generally fixed to the wood or wood components and do not migrate or easily leach out.
- Preservatives and insecticides in the Mobile Phase are designed to penetrate below the surfaces of treated substrates. Some of these penetrate part way through the substrate, while others penetrate rapidly to the core. Active ingredients in the Mobile Phase are designed to protect against those organisms which are a threat throughout the entire thickness of the component (i.e., decay fungi and termites). Although these ingredients are designed to be more mobile than those of the Stationary Phase, they do not readily leach out of treated lumber or wood composites.

RAPID PENETRATION

- As noted previously, the Penetrating Barrier treatment system utilizes borates. Borates are widely used in diffusion treatments; however, in this system the borates do not behave as classical diffusion preservatives. Unlike diffusion treatment systems, the Penetrating Barrier system allows for rapid penetration of active ingredients to the core, usually in a matter of hours rather than the days to weeks required for diffusion systems. Moreover, this system, unlike diffusion systems, adds minimal amounts of water to the moisture content of the substrate (2-3% in most cases). This eliminates the need for post-treatment drying, and it significantly reduces the negative effects of water on the substrates such as checking and grain raising in solid wood or swelling and fiber popping in OSB.
- Conditioning is carried out by storing under plastic wraps for 24-36 hours, or by placing in a conditioning chamber with specific temperature and humidity settings. A dry kiln can be used as the conditioning chamber, but the settings are different than those used for a typical drying operation.

TREATS MOST WOOD OR WOOD COMPOSITES

- Kiln-dried Lumber – Most pressure treating systems can deal with dry lumber; however, they require a re-drying step which the Penetrating Barrier system does not.
- Green Lumber – Most pressure treating systems (with the exception of borates) are not able to treat green lumber. The Penetrating Barrier system works well on green lumber.
- LVL – Laminated Veneer Lumber is most often treated with solvent-based pressure treatments or by adding preservatives or insecticides to the glue line before pressing. The Penetrating Barrier system has been demonstrated to penetrate the glue lines of LVL.
- OSB – Oriented strand board is treated commercially by combining the lumber strands with a preservative such as zinc borate prior to fabrication of the board. This process works well but is costly. The Penetrating Barrier system can treat OSB panels after fabrication. This is best carried out by spraying hot panels as they come out of the press before they are stacked. This provides treatment throughout the thickness of the panel and is much more cost effective than strand treatment.
- Western Species of Lumber – Many western wood species are difficult to pressure treat with conventional preservatives such as ACQ, copper azole or CCA. Pressure treatment with borates achieves penetration; however, the treated wood has a high moisture content and requires post treatment drying. The Penetrating Barrier system achieves excellent penetration on most western species such as Douglas fir or spruce.

SELF-CONTAINED MIXING SYSTEM

- Computer-controlled mixing equipment weighs and combines powders and liquids to achieve formulated treating solutions.
- Mixes are scaled to application rates to achieve a continuous mode of operation.
- Treating compositions can be adapted for specific performance needs.
- Highly automated system requires minimal manpower to operate.

EXCELLENT HEALTH, SAFETY, ENVIRONMENTAL PROFILE

- All active ingredients are EPA registered.
- Active ingredients are those typically used in the Personal Care or Crop Protection industries.
- No heavy metals or other persistent ingredients are present.
- No ingredients included on California Proposition 65 list are present.
- No volatile organic compounds (VOCs) are present.

COMMERCIALLY PROVEN TECHNOLOGY

- Eleven operating licensees in NZ.
- One operating licensee in U. S. (September 2006).

LIMITATIONS

Following are some limitations of the Penetrating Barrier system at this time:

- Not recommended for applications beyond AWPA Use Category 3A
  - * Not recommended for ground contact applications.
  - * Not recommended for above ground outdoor exposures unless protected with a cladding or coating.
- Specialized Equipment
  - * Mixing and application equipment is customized to requirements of each facility.
  - * Specialized service is required to maintain and operate the equipment.
  - * The Penetrating Barrier system is only available through licensed programs at this time.

APPLICATIONS

New Zealand

The Penetrating Barrier system is in commercial use at eleven operating licensees in New Zealand (as of May 2006). One of its main uses is to treat radiata pine framing timber for the New Zealand home construction market. In New Zealand, framing timber is required to have a minimum 50 year service life under the 2004 Building Code. Following a number of instances of decay in residential buildings, framing timber is now required to incorporate fungicidal protection in the event of exposure to dampness. The protection may be short term (i.e. two years) but would allow a reasonable time for the homeowner to recognize the problem and take remedial action to eliminate the source of moisture.

The preservative treatment specification for framing is given in New Zealand Standard 3640:2003 *Chemical Preservation of Round and Sawn Timber.* Hazard class 1.1 applies to timber used in situations protected from the weather, dry in service (less than 18% moisture content), and where resistance to the borer *Anobium punctatum* is required. Hazard class 1.2 applies to timber used in situations protected from the weather, but where there is a risk of moisture conducive to decay. Borate treated timber is required to have the sapwood completely penetrated and a concentration of 0.40% boric acid equivalent (BAE) in the sapwood cross section. In addition, boron penetration must be demonstrated in the central ninth core of the sapwood cross section. Hazard class 3.1 applies to lumber products used outdoors, out of ground contact, where there is no possibility of water entrapment. Typical applications include fascia and weatherboard.

North America

A United States siding manufacturer is using a Penetrating Barrier treatment to protect trim and fascia board from decay and termite attack. Treated boards are coated with a special primer prior to shipment. This provides protection equivalent to that specified in AWPA Use Category 3A (aboveground, outdoors, protected from the weather).

A plant trial using the Penetrating Barrier treatment was conducted at a U.S. OSB manufacturing facility. The treated OSB was then subjected to third-party testing for durability and physical properties. A description of the trial and the test result follows.

OSB TREATMENT PLANT TRIAL

Description of the Trial

A spray application system was installed on the production line of an OSB manufacturing plant so that the preservative treatment was applied to the panels between the forming press and the stacker. The panels measured 122cm by 244cm by 11.1mm (4 ft. by 8 ft. by 7/16 in). They were prepared from oriented strands of southern yellow pine (SYP) bound with a phenol-formaldehyde resin. At the point of application, after the press and the trimmer, the panel surface temperature was approximately 120° C. Panels were sprayed on both top and bottom surfaces in a one foot wide strip running along the center portion of each board as it passed along the production line. A red dye was added to the treatment to help visualize the area of application. The line speed at the point of application was approximately 370 lineal feet per minute. After treatment, panels were hot-stacked for conditioning and final curing of the resin. Panels were examined 24-36 hours later. They were found to be completely dry to the touch. The treated areas were cut out of each panel and sent off for testing and analysis.

PERFORMANCE

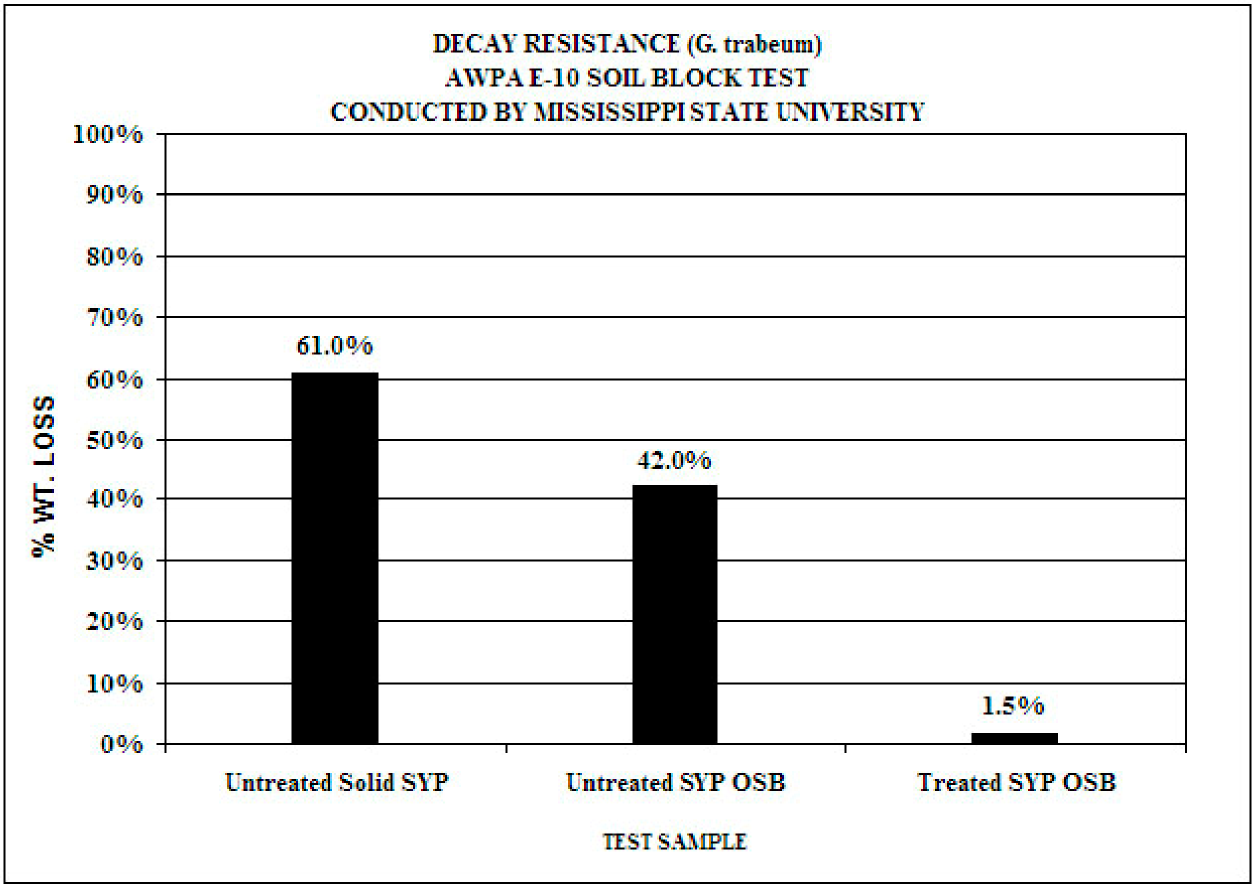
Decay Resistance

A soil block test was conducted on treated OSB from the trial described above. Test blocks were cut into rectangles measuring 19mm by 19mm (0.75 in. by 0.75 in.) by the thickness of the treated OSB panel. Control blocks of the same size were cut from untreated panels produced at the same plant. Untreated solid SYP was also used as a control. The test was conducted by Mississippi State University following the method of AWPA E10-01 using G. trabeum as the test fungus. Results are presented in Figure 2. The untreated solid SYP control lost 61% weight; the untreated SYP OSB lost 42% weight; and the Penetrating Barrier treated SYP OSB lost only 1.6% weight, which is statistically insignificant.

Formosan Termite Resistance

A laboratory termite test was conducted by Louisiana State University following the method of AWPA E1-97 for single choice testing. Test blocks were cut from the treated OSB into rectangles measuring 19mm by 19mm (0.75 in. by 0.75 in.) by the thickness of the OSB panel. Control blocks of the same size were cut from untreated SYP OSB panels produced at the same plant. Solid untreated SYP blocks were also used as a control. Performance was measured in terms of Percent Mortality, Percent Weight Loss and Visual Rating. Percent Mortality was obtained by counting all live termites remaining in each jar at the conclusion of the test (28 days) and dividing by the original number of termites placed in that jar (approximately 400). Percent Weight Loss was obtained by dividing the final oven dry weight of each test block by the original oven dry weight of that block. Visual Rating was conducted by estimating the extent of damage done to each block using a scale of 0 to 10 with 0 being complete failure and 10 being sound with nibbles allowed. Results are presented in Table 1. The Penetrating Barrier treated OSB had a termite mortality of 43.62% compared to 16.52% for the untreated OSB and 10.99% for the untreated SYP control. The untreated solid SYP control lost 26.85% of its weight compared to 8.65% for the untreated OSB control and 0.89% for the Penetrating Barrier treated OSB. In terms of Visual Rating, using the 0 (worst) to 10 (best) scale, the untreated solid SYP had an average rating of 1.6; the untreated SYP OSB had an average rating of 5.1; and the Penetrating Barrier treated OSB had an average rating of 9.8.

Figure 2



Mold Resistance

This test was conducted by Louisiana State University in a Mold Chamber following the method of the AWPA Mold Chamber Test currently working its way to standardization by Subcommittee P6. Test samples were 7.62cm by 12.70cm (3 in. by 5 in.) by the thickness of the OSB. They were suspended in the Mold Chamber for a period of eight weeks. Evaluations were conducted every two weeks using a visual rating scale of 0 (best) to 5 (worst). Results are presented in Table 2. At the end of the test period the Penetrating Barrier treated SYP OSB had a rating of 1.4 (minimal mold attack). All control samples were completely mold covered with ratings of 5.0.

Flame Spread

This test was conducted by Intertek Testing Services following the method of ASTM E84-05. The sample material tested consisted of three 243cm by 51cm by 1.27cm (8ft. by 20 in. by 0.5 in.) panels of treated OSB. The control sample material was untreated OSB, from the same manufacturing facility, of the same size and mounted in the same manner. For each trial run the three 8-ft. panels were placed on the upper edge of the flame spread tunnel and butted together to form the required 24 ft. sample length. A layer of 6 mm reinforced cement board was placed over top of the samples, the lid was lowered onto place, and then tested in accordance with ASTM E84-05. The flame spread of the Penetrating Barrier treated OSB was determined to be 72 while that of the untreated OSB was 109. Using the traditional ratings system, the treated OSB would have a Class B flame spread rating, while the untreated OSB would have a Class C flame spread rating.

Physical Property Testing

Panels of treated and untreated OSB were tested for physical and water absorption properties by Timber Products Inspection following the methods of ASTM D1037-99. Specific tests run included static bending, tensile strength perpendicular to the surface, water absorption and thickness swelling. Results are outlined in Tables 3, 4 and 5. The Penetrating Barrier treatment had no detrimental effects on the physical properties of the OSB.

CONCLUSIONS

The Penetrating Barrier system is a unique, proprietary treatment for solid wood and wood composites. Although it is surface-applied, it is capable of penetrating most substrates to the core after a brief (24-36 hour) activation period. It treats green lumber, dry lumber and wood composites including LVL and OSB. Although the system utilizes borates, along with other fungicides and insecticides, it is not a classical diffusion system in that it adds very little moisture to the treated substrate (2-3%), and it requires only a matter of hours for complete penetration rather than the days to weeks associated with diffusion systems. The treatment components are mixed on-site in a computer-controlled, modular, automated system. Application is in-line and can be coupled to a planer line at a sawmill or an OSB manufacturing line, thus bypassing the need for a treating service. The system is easily adaptable to specific performance needs such as decay resistance, mold resistance and termite resistance. All materials used have an excellent health, safety and environmental profile with zero volatile organic compounds (VOCs) emitted.

On OSB, the Penetrating Barrier system was shown via third party testing to protect against decay fungi, Formosan termites and mold. In addition, it reduced the flame spread rating from a Class C to a Class B. The treatment had no deleterious effects on the physical properties of the OSB, as demonstrated in third party testing.

The Penetrating Barrier system is in commercial use in New Zealand on framing lumber where it meets the New Zealand standard for timber framing protection. It is also being introduced in commercial use in the U.S. for the protection of exterior, painted trim board and fascia.

New opportunities for the Penetrating Barrier system include interior uses on OSB, LVL, I-joists and framing (U.S.). Opportunities for exterior uses include siding, fascia, trim board, windows, doors and fencing. Opportunities in the reduction of flame spread are promising but require further investigation.

Table 1
Formosan Termite Resistance
Test Method: AWPA E-1 (No Choice)
conducted by Louisiana State University

	Mortality %	Weight Loss %	Avg. Rating (1-10)
Untreated OSB	16.52	8.65	5.1
Treated OSB	43.62	0.89	9.8
SYP Control	10.99	26.85	1.6

Table 2
Mold Resistance
Test Method: AWPA Mold Chamber
conducted by Louisiana State University

	Avg. Rating (0 – 5)			
	2 Weeks	4 Weeks	6 Weeks	8 Weeks
Untreated OSB	3.3	4.9	5.0	--
Treated OSB	0.0	0.1	0.3	1.4
SYP Control	1.5	5.0	--	--

Table 3
Test Method: ASTM D1037
conducted by Timber Products Inspection
Summary of Static Bending Test Results

Condition	Treatment	Strand Orientation		MOR (psi)	MOE ($x10^6$ psi)	MC (%)
Dry	Untreated	Perpendicular		2612	0.256	11
		Parallel		3958	0.582	12
	Treated	Perpendicular		2061	0.218	10
		Parallel		4274	0.695	11
Wet	Untreated	Perpendicular		956	0.095	10
		Parallel		1558	0.383	10
	Treated	Perpendicular		774	0.070	11
		Parallel		1307	0.223	11

Table 4
Test Method: ASTM D1037
conducted by Timber Products Inspection
Summary of Tensile Strength Perpendicular Test Results

Treatment	Tensile strength (psi)	MC (%)
Untreated	25	11
Treated	45	11

Table 5
Test Method: ASTM D1037
conducted by Timber Products Inspection
Summary of Water Absorption and Thickness Swelling Results

Treatment	Water Absorption			Thickness Swelling (%)	Moisture Content (%)	
	Amount (g)	by volume (%)	by weight (%)		Initial/Dry	After 2+22H submersion
Untreated	43	31	22	8	11	35
Treated	60	43	30	11	11	44