PERFORMANCE OF PRESERVATIVE-TREATED WOOD SHINGLES AND SHAKES

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Preservative treatments can be applied to wood roofing before or after installation. In this paper, we briefly review treatment objectives, types of treatments, treating standards, quality control, technical factors that affect shake and shingle performance, environmental concerns, and disposal of spent or excess-treated wood products. A synopsis of research on alternative treatments for wood shakes and shingles being conducted at the USDA Forest Service, Forest Products Laboratory (FPL), is also presented.

KEYWORDS

Decay, preservative, roofing, shakes and shingles.

INTRODUCTION

Wood shakes and shingles are expected to remain durable (in-service) for lengthy periods. Traditionally, this long-term performance has been achieved by using the naturally durable heartwood of selected tree species to produce shakes and shingles. Other species are being considered as source materials for shakes and shingles.[1,2,3,4,5] Products manufactured from alternative species may be composed of both durable heartwood and nondurable sapwood or entirely of nondurable wood. When wood that is not naturally durable is used in the manufacture of shakes and shingles, preservative treatments are needed. Sapwood from all species is nondurable and requires protection. "Included sapwood" within the heartwood of western red cedar is also nondurable.[6,7,8,9,10] It has not been common to treat cedar. The main value of treated cedar is the chemical penetration on the ends of the cedar shake or shingle (the butt ends). Penetration of about ½ to ¾ in. (12.7 to 19.1 mm) can be attained on these ends. Cedar is labeled by the American Wood-Preservers' Association (AWPA) as a non-treatable species. However, the most moss or fungus occurs first on the butt ends where the most moisture is retained.

The durability of heartwood varies with tree species. A grouping of domestic woods according to approximate relative heartwood decay resistance is presented in the *Wood Handbook*.[11] Within the construction industry, some confusion about naturally durable woods occurs by inference that products produced from second-growth trees have the same durability as products produced from the naturally durable heartwood of old-growth trees from virgin stands. Bald cypress is a case in point. Heartwood from uniformly large, old trees of virgin timber is resistant to decay, but such trees are not readily available today. Products that are currently produced from second-growth cypress may contain sapwood as well as heartwood, which is less durable than heartwood in virgin growth.[12] Second-growth cedar is less durable than is old growth, but the dramatic instability (cupping, curling, splitting) of shakes and shingles manufactured from second-growth cedar is even more important.

The primary objective of pressure treatments with wood preservatives prior to installation is to impart or enhance durability. To extend the service life of wood roofing after installation, it is important to control growth of unsightly flora (molds, algae and moss) on the surface of wood roofing as well as on the underside of shakes and shingles. In addition, oils are applied to prevent or reduce checking in extremely dry situations. Lastly, an alteration of visual appearance may be a subordinate objective of treatments that contain a pigment.

Pressure treatments, prior to installation, have an initial effect on color of shakes and shingles, but this becomes less noticeable as roofing weathers. A greenish color is apparent on new CCA-treated shakes. Some treaters are now adding a dye to the treatment to impart a more natural brownish color to the new shakes.

Not included as an objective of a preservative treatment is improved fire performance. In an experimental apparatus that allowed us to evaluate the effect of preservative treatments (Table 1) on fire performance of wood shakes and shingles, we found no indication that preservative treatment improved fire performance (LeVan and De Groot, unpublished document). Indeed, treatment with preservatives that contain heavy metals, such as treatment with chromated copper arsenate (CCA), may contribute to glowing combustion of an ignited item after the flame has been extinguished. We are unaware of any record of this occurring in CCA-treated roofing, but the potential exists should that roofing be ignited.

Chemicals that have traditionally been used as fire-retardant treatments are not regarded as wood preservatives. However, some fire-retardant treatments appear to enhance decay resistance of shakes in service and slow the rate of corrosion on galvanized fasteners, compared to nontreated western red cedar. A patent has been issued for a one-step treatment that provides protection against both decay fungi and fire.[13]

TYPES OF TREATMENTS

Treatments can be classified according to the methodology used in applying chemical (pressure or nonpressure): time of treatment (before or after construction), whether water or a petroleum carrier is used, the active ingredient by class of compound, and allied function of the formulation (e.g., water repellency).

Pressure treatments involve applying the preservative chemical under pressure to force the chemical within the treated product. Various treating cycles may be used but will not be discussed here.

Active ingredient	Description of preservative
Ammonical copper zinc arsenate (ACZA)	An alkaline waterborne preservative that is commonly used in treatment of refractory western species such as Douglas-fir. This is similar to the previous formulation of ammonical copper arsenate (ACA), but with zinc substituted for some of the arsenic.
Ammoniacal copper citrate	A waterborne formulation containing copper equivalent to 4 moles of copper oxide (CuO) and 1 mole of citrate ($C_6H_4O_7$) appropriately dissolved in ammonia and CO_2.
Azoles	Two different azoles (Tebuconazole and Propiconazol) show potential as wood preservatives and are being developed and evaluated either individually or as components of a mixture of active ingredients.
Copper azole (CuAz)	Copper Azole wood preservatives contain copper and an azole biocide at a weight ration of 25:1. These are under development and covered by International Patent application PCT/GB92/01427.
Copper dimethyldithiocarbamate (CDDC)	CDDC is a chelate formed either by the reaction of copper sulfate plus sodium dimethyldithiocarbamate (SDDC) or copper complex with ethanolamine (2-aminoethanol) plus SDDC. This is a two-step treatment that is in the development stage.
Copper naphthenate (CuN)	Preservatives containing copper naphthenate as the active ingredient may be formulated as either a waterborne- or petroleum-based system. The organic component naphthenate is actually composed of a variety of acids that are collectively referred to as naphthenic acid.
Copper octoate (CuOct)	Preservatives containing copper octoate are formulated mostly in a petroleum carrier.
Copper/quaternary ammonium (CuO/ODAC)	Ammoniacal, waterborne preservatives.
	—The quaternary ammonium component is octyldecyldimenthylammonium chloride. The CuO:Quat ratio is 1:1.
(ACQ)	—The quaternary ammonium component is didecyldimethylammonium chloride (DDAC). The CuO:Quat ratio is 2:1.
Copper-8-quinolinolate	This active ingredient may be applied either as an oil-based system or as a waterborne system. Solution concentrations normally reflect the concentration of the entire preservative rather than just the copper, as metal, alone. This active ingredient is approved by the Food and Drug Administration for use on wood products that come in contact with food.
Didecyldimethylammonium chloride plus 3-iodo-2-propynyl butyl carbamate (DDAC/IPBC)	A patented aqueous mixture of DDAC and IBPC in a ratio of 8.5 to 1 (Ward 1990). This is used as an antistain treatment on freshly sawn lumber. Other applications are being explored.
Chlorothalonil	This is a broad spectrum fungicide that has been used in agriculture for many years to control plant diseases caused by fungi. It is now being evaluated for use as a wood preservative, either individually or in combination with other preservatives or insecticides. This is an oilborne preservative.
Zinc naphthenate (ZnN)	Zinc is formulated with napthenic acids. As with copper naphthenate, this preservative can be formulated as either a waterborne or petroleum-borne system. Zinc napthenate has a clear color. It does not impart a greenish color as do most copper-based preservatives.

Table 1. *Preservative chemicals that may be considered for use in wood roofing but are not yet included in standards.*

In contrast, nonpressure treatments entail applying the preservative chemical by spraying, short-term soaking (dipping), hot and cold bath treatments, as well as by methods designed to permit diffusion of the active ingredient into the wood. The installation of horizontal metal strips between courses of shakes or shingles is based upon the principle that metallic elements (copper or zinc) eluting from the metal strip will suppress biological growth on the roof surface below. In the wood roofing industry today, nonpressure treatments are employed mostly as spray applications of chemicals to shakes and shingles that are already installed.[14]

Some nonpressure treatments are being researched for use prior to construction. These will provide mostly an exterior shell of protection, but the degree to which preservatives penetrate into the cut ends of shakes and shingles is dependent upon both the wood species and the formulation. Sapwood of all species tends to be permeable, but that of heartwood varies with species. Little penetration of a nonpressure treatment will occur in impermeable wood. The heartwood of softwood groupings such as Southern Pine and Douglas Fir exemplify impermeable wood tissues, whereas the sapwood portion is permeable. It is to be anticipated that with nonpressure treatments in which a shake is immersed or flooded with an oilborne solution, some penetration of the treatment chemical into the exposed grain at cut ends of permeable wood tissues will occur.[15] Treatments with waterborne formulations will not penetrate either tissue very well.

Nonpressure, water repellent, preservative treatments are quite effective in above-ground construction exposed to intermittent wetting and are designed to be drip free.[15] The utility of these types of treatments for protecting wood roofing requires demonstration. With wood roofing, water can be retained for considerable periods between overlapping shakes. Water-repellent treatments were ineffective in reducing moisture content of wood packaging exposed to three continuous days of wetting in a jungle environment.[16]

In-depth treatment of wood can be achieved by diffusion of some preservatives such as borates, but the potential limitation for this type of treatment is the egress of the diffusible chemical and subsequent loss of protection when the product is rewetted in service. For leaching of a diffusible preservative to occur, water must penetrate the wood product to dissolve the preservative and form a continuous pathway for removing the preservative by diffusion. Typically this occurs in wood products that are in continuous contact with the soil or exposed to a continuum of water running off the surface of the product.[17]

Preservative treatments are also distinguished by the type of carrier used, i.e. whether water or a petroleum oil is used as the solvent for the active ingredient. Most nonpressure treatments for shakes that are already installed on roofs are waterborne systems. An oilborne formulation that might be developed for this application would have to meet applicable regulations about volatile organic compounds (VOCs). The waterborne preservative CCA is currently used for treatment of wood shakes. Additional waterborne and oilborne preservatives are being evaluated for this use.

Treatments may also be classified according to the chemical that functions as the biocide, i.e., the active ingredient. Within that grouping, treatments may be further categorized according to the intended exposure, e.g., ground contact, not in ground contact, exterior applications, interior applications subjected to frequent wetting, or interior applications without exposure to water. For active ingredients that are accepted for use in the entire array of exposures, different requirements for retention (amount of chemical within a given volume of wood) and penetration (depth to which the chemical penetrates into the product) might be required for one or more use applications.

STANDARDS

Wood preservative standards describe the formulation chemistry of the wood preservative, method of analysis, minimum quantity and penetration of chemical required for specific commodities, procedure to ensure quality control, and related information on processing, handling procedure, and third-party inspection labels.

				Retention[a]				
Preservative	Code[b]	Deck	Wood[c]	Target (lb/ft^3)	Analyzed (lb/ft^3)	Weight loss[d] (%)	Mean decay rating[e]	Decay rating for shakes
Weight loss in cross sections of preservative-treated shakes during 16-week laboratory decay test								
CuOct	25		WH	0.04	0.02	53.24		
Ctrl	16		WH	—	—	44.29		
Shake condition in experimental modules after 54 months in an open field in southern Mississippi								
CuOct	25		PSF	0.004	0.003		1.4	
CuOct	25		PSF	0.01	0.004		1.4	
CuOct	25		PSF	0.02	0.015		1.0	
CuOct	25		PSF	0.04	0.023		1.0	
CuOct	25		PSF	0.06	0.04		1.0	
Ctrl	16		WH	—	—		4.7	
Ctrl	16		PSF	—	—		4.2	
Shake condition exposed on a simulated roof deck after 54 months in an open field in southern Mississippi								
CuOct	25	4083	WH	0.04	0.02			1
CuOct	25	4084	PSF	0.04	0.03			1
Control	16	4088	WH	—	—			1
Control	16	4989	PSF	—	—			2

[a] Retention is computed on the basis of metal ion (Cu) in the treated product. ($1 lb/ft^3 = 16 kg/m^3$).

[b] The same code number is used for each preservative in a series of experiments. Code numbers are included here, out of sequence, to aid the reader cross referencing with other reports that are published elsewhere.

[c] ALD = red alder; PSF = Pacific silver fir; WH = western hemlock; WP = western white pine.

[d] Average of 10 observations.

[e] Average of 10 observations. Each observation represents the most advanced decay observed in any of four shakes in each replicate stack. See Appendix for explanation of decay rating.

Table 2. *Performance of western hemlock and Pacific silver fir shakes treated with copper octoate in a light naphthenic distillate.*

Within the United States, preservatives are accepted for standard by two major organizations: the American Wood-Preservers' Association (AWPA) and the American Society for Testing and Materials (ASTM). Preservatives are also approved for use by various building code authorities. Within these organizations, new preservatives are generally brought forward for application in commodities other than wood roofing prior to their consideration for use in wood roofing. The wood roofing market tends not to be large enough to support the development of new preservatives for this unique purpose. Consequently, preservative chemicals that are proposed for pressure treatment of wood roofing often have a substantial developmental history.

Historically, nonpressure treatments have not benefited from the review given pressure treatments, but this is changing with an expansion in the scope of AWPA to include nonpressure preservative treatments. Thus, avenues for formal acceptance to standard within the AWPA exist for new treatments, either pressure or nonpressure.

One problem that continues to perplex standard-setting authorities is the difficulty of predicting future long-term performance of candidate treatments on the basis of short-term laboratory tests. For example, soil contact decay laboratory tests provide a more severe challenge to treated shakes than five years of field exposure on simulated decks of treated shakes or in modules of overlapping shakes exposed in an open field in southern Mississippi. In comparative laboratory and field studies using the preservative-treated shakes from the same treatment, even preservative treatments that showed no efficacy in laboratory soil-jar tests prevented decay in shakes during the first five years of field exposure in an open field in southern Mississippi (Table 2).[18] Indeed, it was not until after 6.5 years of exposure that we saw the first evidence of decay in shakes that were treated with copper octoate (Table 3). With a lack of direct linkages between accelerated tests and actual field performance, it is not surprising that standard-setting authorities are conservative in accepting new products to standard.

PRESERVATIVES ACCEPTED IN STANDARDS

Currently, the only treatment included within the standards published by AWPA for use in wood roofing[19] is a pressure treatment using CCA. Only wood shakes that are manufactured from Southern Pine are referenced in this standard. The retention of CCA that is specified by AWPA for Southern Pine shakes and shingles is 0.4 pounds per cubic foot (0.4 $lb/ft^3 = 6.4\ kg/m^3$). This is the retention specified for wood used in ground contact and is greater than that required in Southern Pine lumber that is used above ground in decks.

The CERTI-LAST* program developed by the Cedar Shake & Shingle Bureau (Bellevue, Wash.) is based on pressure-treatment requirements that function in the same manner as a standard (Figure 1). (The Cedar Shake and Shingle Bureau's [C.S.S.B.] Certi-last program was formulated in 1988-1990. Some treated products were previously available, particularly in Hawaii around 1985.) Specified are the commodity (No. 1 Grade western red cedar shakes and shingles), the preservative (CCA), the method of treating, the minimum penetration and preservative retention, and quality control standards. The goal of this program is to attain a minimum of ⅜ in. (9.5 mm) preservative penetration at the butt ends of the shakes and shingles.

CERTI-LAST®
CEDAR SHAKE & SHINGLE BUREAU

Figure 1. Example of inspection label that indicates compliance with minimum treating criteria defined in the Cedar Shake & Shingle Bureau's CERTI-LAST program.

CCA has a lengthy history of performance[20] and it is included with AWPA standards for treatment of a variety of commodities. Three major formulations of CCA are included within the standard that describes the chemical formulations of wood preservatives,[21] but all wood that is currently treated with CCA is treated with only one formulation, Type C. Stakes of Southern Pine sapwood that were treated with a closely related formulation of CCA Type B at a retention of 0.37 lb/ft^3 and exposed in ground contact at the FPL's field plot in southern Mississippi show no failures after 40 years of exposure. This retention corresponds with the 0.4 lb/ft^3 requirement for CCA Type C in wood shakes. This attests to the durability of CCA-treated Southern Pine sapwood. Stakes of Southern Pine heartwood, treated with CCA Type C, have been exposed in field plots for only 15 years with no failure at any of the retention levels used.

With regards to potential durability of shakes that are treated with CCA in accordance with AWPA standards, the ultimate durability of the treated shakes probably would be more dependent on quality of treatment than efficacy of the preservative. Compliance of the treatment with referenced standards or specific marketing programs can be verified by third-party inspections. Obviously, every bundle of shakes cannot be inspected, but representative sampling of the production of pressure-treated shakes is conducted. Bundles of shakes that are produced within programs that, according to the third-party inspection routines, are meeting minimum treating requirements will be tagged or labeled so that the purchaser can recognize that the shakes were inspected and did pass the standard identified on the tag or label (Figure 1).

The potential of metal fasteners to corrode in moist wood is well documented.[22,23] Note the potential for galvanic cells to form whenever metal fasteners are in contact with CCA-treated wood under conditions of long-term wetting. The relative susceptibility of nails to corrosion in CCA-treated wood can be predicted by comparing the position of the metals, coatings and base metal in a galvanic series of metals referred to sea water.[24] When lengthy service life is desired, metals that are cathodic to copper in the galvanic series should be chosen for use in contact with CCA-treated wood in moist conditions.[25] Results from experiments designed to simulate conditions in wood foundations showed that type 304 and 316 stainless steel, silicon bronze, copper and monel nails were suitable for those conditions.[25] The minimum retention of CCA in wood foundations is greater than in wood shakes (0.6 lb/ft^3 compared with 0.4 lb/ft^3). Nevertheless, the potential for galvanic cells to form under conditions of continued wet-

** The use of trade names is for information only and is not intended to be an endorsement by the USDAFS Forest Products Laboratory.*

				Southern Mississippi[b]				Eastern Texas[3]		
Code[d]	Preservative	Target Retention (lb/ft³)[e]	Wood	Wood decay	Cup/ curl	Check	Split	Wood decay	Cup/ curl	Check
26	ACZA	0.30	WH	1	1	4	4			
26	ACZA	0.30	PSF	1	1	5	3			
1	CCA	0.30	WP	1	1	2	2			
1	CCA	0.30	WP	3	1	1	2			
1	CCA	0.30	GF	1	1	1	2			
1	CCA	0.30	GF	1	1	2	2			
3	DDAC/IPBC	0.45	WP	1	1	1	2			
3	DDAC/IPBC	0.30	WP	3	1	1	2			
3	DDAC/IPBC	0.30	WP	1	1	1	1			
3	DDAC/IPBC	0.30	GF	1	1	1	3			
3	DDAC/IPBC	0.30	GF	1	1	1	2			
3	DDAC/IPBC	0.30	GF	2	1	2	4			
6	CuN	0.06	WP	3	1	1	1			
6	CuN	0.04	WP	2	1	1	1			
6	CuN	0.09	WP	1	1	1	2			
6	CuN	0.06	GF	1	1	1	2			
6	CuN	0.06	GF	1	1	1	3			
15	CuN	0.04	WH	1	1	3	2	1,1	1,2	3,3
15	CuN	0.04	PSF	1	1	3	2			
15	CuN	0.04	WP	1	1	2	1			
15	CuN	0.04	GF	1	1	1	2			
17	CuN	0.04	PSF	1	1	1	2			
17	CuN	0.04	WH	1,1	1,1	3,3				
23	CuN	0.04	WH	1	1	2	2	0,0	1,1	3,1
23	CuN	0.04	PSF	1	1	5	2			
23	CuN	0.04	WP	1	1	2	2			
23	CuN	0.04	WP	1	1	1	2			
23	CuN	0.04	GF	1	1	1	2			
23	CuN	0.04	GF	1	1	1	2			
22	CuN	0.04	PSF	1	1	2	2			
22	CuN	0.04	WH	0,0	1,1	1,3				
10	ZnN	0.05	WP	3	1	1	1			
10	ZnN	0.06	WP	1	1	1	2			
10	ZnN	0.06	GF	1	1	1	2			
18	ZnN	0.06	WH	1	1	1	2	1,	1,	1,
19	ZnN	0.06	PSF	1	1	1	2			
21	ZnN	0.06	WP	3	1	1	2			
20	Znn	0.06	GF	1	1	1	1			
19	ZnN	0.06	PSF	1	1	1	1			
19	ZnN	0.06	WH	1,1	1,1	2,2				
21	ZnN	0.06	WH	1	1	2	3	1,	1,	2,
21	ZnN	0.06	PSF	1	1	1	2			
21	ZnN	0.06	WP	1	1	1	2			
21	ZnN	0.06	GF	1	1	1	2			
20	ZnN	0.06	PSF	1	1	2	1			

Table 3. Condition of pressure-treated shakes on roof decking after 6.5 years exposure in southern Mississippi and after 6.25 years exposure in eastern Texas[a].

ting still exist and need to be considered when choosing fasteners and flashing for use with CCA-treated shakes.

Treated-wood materials should be handled in accordance with instructions given in the Consumer Information Sheets that are available from suppliers of treated-wood products. Cutting and sawing should be done while wearing a dust mask and appropriate eye protection. CCA-treated shakes and shingles should be disposed only in an approved landfill. They should not be burned within a dwelling or in an open fire at the construction/demolition site.

It also seems advisable to not install shakes prior to completion of the chemical reaction that occurs within CCA-treated wood soon after treatment. Various reactions among the chemical components and between the chemical components of the treating solution and the lignin and cellulose in wood occur within treated wood immediately after treatment as stable components are formed within wood. This is sometimes referred to as "fixation." In the treating solution, chromium is in the hexavalent state. The primary reaction that governs all reactions during the main precipitation fixation period after treatment is the chromic acid reduction to trivalent chrome.[26] Standard methods have been developed to test for the presence of hexavalent chromium in treated wood.[27] This method indicates, by the absence of a colored chronotropic acid complex, the presence of 15 ppm or less chromium (VI). In practical terms, this is taken as evidence that fixation is virtually complete. Attention to this fixation reaction in CCA-treated shakes may be important with respect to leaching. An analysis of rainwater collected from CCA-treated shakes exposed in British Columbia indicates that the level of leaching decreased to a very low level after six- to eight-months exposure.[28] A study using marine piling treated to retention levels almost six times greater than that used in shakes showed that the leaching of copper, chromium, and arsenic from properly treated and fixed CCA-C treated wood does not occur at a concentration that would significantly affect water quality (around those pilings).[29] If shakes were to be installed prior to completion of this reaction, it seems likely that the soluble chemicals within the wood would be subject to leaching by rain.

CURRENT PRESERVATIVE RESEARCH

Public concerns about the environment and a growing recognition of the need to manage treated-wood products throughout their life-cycle, from manufacture through disposal or reuse, are two of the stimuli driving a search for additional preservatives. Some preservatives that are receiving current attention are listed in Table 1.

The C.S.S.B. in cooperation with Chemical Specialties Inc. has 16 test decks in Hilo, Hawaii. Shakes were treated with CCA, ACQ or Bardac 22. After four years, the most stable flat-grain shakes are those treated with Bardac 22. The least stable flat-grain shakes are those treated with CCA.

In recent research at the FPL, we have explored the potential to produce durable shakes from alternative wood species with nondurable heartwood.** Shakes manufactured from western hemlock (Tsuga heterophylla), Pacific silver fir (Abies amabilis), grand fir (A. grandis), and red alder (Alnus rubra) were pressure treated with alternative, new preservatives or combinations of preservatives and fire retardants. Shakes manufactured from Southern Pine are also being evaluated with our combined wood preservative and fire retardant system. [3,4,18,30,31] Results from our most recent observations on simulated decks of shakes made of preservative treated wood are presented in Tables 3 and 4 and discussed in the following paragraphs.

Part of our evaluation program included field exposure of treated shakes on small decks that simulated actual roof exposure. These were exposed in open fields in the Harrison Experimental Forest in southern Mississippi and near Lufkin, Texas.*** These roof decks were 40-in. wide x 52-in. long (1.0-m wide x 1.3-m long). Construction details are those described in paragraph 5 of ASTM E 108, Fire Tests of Roof Coverings[32] with the following variations. Southern Pine lumber, pressure treated with CCA was substituted for No. 1 White Pine lumber as framing material; decks were constructed of nominal 1-in. x 4-in. (25-mm x 100-mm) lumber, spaced a minimum of 1 to 5 inches (25 to 125 mm) apart. Shakes were fastened to the decks with stainless steel, power-driven staples. Shakes were installed with weather exposures of 5½ or 7½ inches (140 or 190 mm). Shakes with the shorter weather exposure were applied without felt interlayment. Felt interlayment was used with all other installations in accordance with standard construction practices. Test roof decks at both locations were positioned in the field with a 4-in-12 (33 percent) slope, facing south, exposed to full sunlight. At time of inspection, decks were checked for wood decay, tendency of shakes to check or split, and stability of shakes following criteria described in the Appendix. After nearly seven years of exposure at both locations, one general observation is that this type of field exposure is neither finely tuned nor accelerated. Nevertheless, some general trends are becoming evident. For example, the checking of shakes treated with CuO/ODAC is more severe than that observed with other treatments (Table 4). This apparently reflects a treatment-dependent phenomenon. Evidence of decay is now seen in shakes manufactured from western white pine that were treated with a variety of preservatives (Table 3). This appears to be a wood species-related result, perhaps reflecting some nonuniform penetration or evidence of preexisting decay present in small pockets in the insect-killed trees when they were harvested. The uniformity of preservative penetration in these shakes was questioned in our original study of treatability.[3]

The difference between locations seems most apparent from the extent of checking that was observed (Tables 3 and 4). Checking was generally more severe at the Mississippi location than in Texas. A comparison of the rate at which decay developed is less meaningful, because only one untreated (control) deck was evaluated in Mississippi, but again, decay was a bit more extensive in Mississippi than in Texas. This pattern of decay development is consistent with the climate index concept by Scheffer.[33] At both locations, shakes of the western softwood species laid quite flat. Neither location showed a tendency to cup or curl that was greater than that of the reference species. In contrast, shakes made from the hardwood red alder were very unstable.

As previously mentioned, we developed a one-step wood preservative-fire retardant treatment during the course of this research at FPL. Shakes of several wood species were treated with this combined system and exposed on a test rack in southern Mississippi. Short lengths of Southern Pine sapwood were also treated with this combined system and exposed vertically in the ground as stakes. In June 1995, these stakes will have been exposed for five years. A full report of field performance of materials that were exposed above ground and in ground contact will be given at that time. To date, wood decay has developed in all untreated shakes, but not in shakes treated with the combined system.

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*** *Field exposures in Texas were done in cooperation with the Texas Forest Products Laboratory, Lufkin, TX.*

				Saucier, MS[b]				Lufkin, Texas[c]		
Code[d]	Preservative	Target Retention (lb/ft^3)[e]	Wood	Wood decay	Cup/ curl	Check	Split	Wood decay	Cup/ curl	Check
13	CuOCT	0.06	WH	1	1	2	2			
13	CuOCT	0.04	WH	3	1	2	2	1,1	1,2	2,3
13	CuOCT	0.04	PSF	1	1	2	2			
13	CuOCT	0.04	WP	1	1	2	2			
14	CuOCT	0.06	WH	1	1	3	2			
14	CuOCT	0.04	WH	1	1	2	2	1,	2,	3,
25	CuOCT	0.06	WH	1	1	3	2			
25	CuOCT	0.04	WH	1	1	3	2	1,1	1,1	3,3
25	CuOCT	0.04	PSF	1	1	4	2			
25	CuOCT	0.04	WP	1	1	3	3			
24	CuOCT	0.06	WH	1	1	4	2			
24	CuOCT	0.04	WH	1	1	3	2	0,	1,	3,
—	Control		WH	4	1	1	4			
—	Control		PSF	1	1	4	3			
—	Control		WP	3	1	1	2			
3	Control		GF	5	1	4	3			
—	Control		GF	6	1	2	3			
—	Control		ALD	7	3	1	5			
1	CCA	0.60	ALD	1	4	4	4			
26	ACZA	0.60	ALD	1	5	4	4			
3	DDAC/IPBC	0.66	ALD	1	3	2	3			

[a] Decks were installed in an open field on the Harrison Experimental Forest in southern Mississippi June 1988. They were inspected January 1995. Decks were installed in an open field near Lufkin, Texas, in August 1988 and inspected November 1994.

[b] Only tapersawn shakes were exposed in Mississippi. See Appendix for an explanation of ratings.

[c] Both tapersawn and handsplit resawn shakes were exposed in Texas. The number preceding the comma describes the condition of tapersawn shakes; the number following the comma describes the condition of handsplit resawn shakes. See Appendix for explanation of ratings.

[d] The same code number is used for the same preservative treatments at both locations.

[e] 1 lb/ft^3 = 16 kg/m^3. Values are rounded to two decimal places.

Table 4. Condition of pressure-treated shakes on roof decking after 6.5 years exposure in southern Mississippi and after 6.25 years exposure in eastern Texas[a].

ENVIRONMENTAL CONSIDERATIONS

The concept that potential for decay is influenced by climate seems well recognized. Scheffer[33] developed a decay hazard index that is referenced by model codes. Scheffer's index quantifies the influence of climate on potential for decay in wood used above ground within the United States. Major regional differences in potential for deterioration of wood used in contact with the ground are recognized by AWPA Standard C4.[34] In other commodities, only one retention level is specified for use conditions, i.e., in ground contact, above ground, etc. Thus, it would seem likely that new preservative options could be tailored for specific use environments. However, this concept is difficult to incorporate into the marketplace when the argument is made that treated products are routinely sold in a variety of climates, and standards should identify minimum treatment criteria that will ensure good performance in all environments.

The AWPA generally does not accord recognition to climatic influence on potentials for decay in the definition of minimum preservative retention levels for commodities. This occurs only with utility poles where different retention levels are specified for some preservatives. With those specific preservatives, the user may select a desired retention for poles based upon the anticipated hazard for wood decay in the region where the poles will be installed. Whether this concept will prevail with high profile, treated-wood products such as decking and roofing that are used by an increasingly knowledgeable and environmentally aware consumer group remains to be determined.

The technical challenge for manufacturers who are developing environmentally preferable preservatives is to define the minimum amount of preservative that is need to ensure prescribed performance (i.e., service life) of a treated product in a specified environment. The administrative challenge is to affect changes in prevailing standards that will have greater opportunity for targeting designed products for specific use applications.

CONCLUDING REMARKS

The primary objective of preservative treatments for wood shakes is to enhance durability. Pressure treatment with approved preservatives can add to the performance of durable roofing materials and may offer new opportunities to nondurable wood for the manufacturer of shakes and shingles.

Quality control for pressure treatments can be ensured through independent inspection for compliance with a published standard. Less opportunity for independent verification of quality control exists with nonpressure treatments. A variety of wood species and new preservatives is being investigated for their potential in producing alternative wood roofing. It is difficult to predict the total complement of long-term, future physical and biological performance attributes of candidate combinations of wood species and preservatives on the basis of results from individual short-term tests. Therefore, it seems prudent that assessments of new combinations of woods and preservatives for roofing be based on a complement of tests that will address both durability and physical performance characteristics.

With new products coming into the building industry and consumer and environmental demands becoming more exacting, where do homeowners, builders and contractors find guidance? With pressure treatments applied prior to construction, the building codes identify products that have met a structural review process. In addition, standard-setting bodies such as AWPA or associations such as the C.S.S.B. develop performance on recommended standards that identify products that meet criteria of that group. Research with new preservatives and alternative wood species continues. New combinations of preservatives and wood roofing material will be accepted by codes and standards as acceptable performance is demonstrated and quality control criteria are identified.

Best management practices are being developed to define the manufacturer's steps for some timber products in even greater detail than is included in codes and standards. This affords opportunities to address sensitive environmental issues.

Nonpressure treatments have historically not benefited from structural review processes that were available to pressure treatment processes. However, recently the AWPA broadened its scope of interests to include nonpressure treatments. Thus, AWPA standards may in the future provide guidance in identifying appropriate nonpressure treatments for wood roofing, after installation.

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APPENDIX

The following criteria are used to rate the extent of wood decay in shakes, stability of shakes, and tendency of shakes to check or split.

Wood Decay

Rating	Extent of Decay
0	Wood bright (at least near original color, if treated product), no discoloration or suspicion of decay
1	No decay suspected, wood discolored from mold or weather.
2	Decay suspected
3	Evidence of decay, but percentage of destroyed wood impossible to determine. Decay evidenced by fruiting bodies on wood or mycelium over surface of wood. Decay may also be evidenced by small spots of decayed wood.
4	At least 10 percent, but less than 50 percent of wood decayed.
5	At least 50 percent, but less than 75 percent of wood decayed.
6	At least 75 percent of wood decayed
7	Item destroyed by decay, can be broken easily

Checking and Splitting

Rating	Checking	Splitting
1	Occasional	None
2	Moderate	Occasional
3	Considerable	Moderate
4	General	Considerable
5	Omnipresent	General

Cupping and Curling

Rating	Frequency of Shakes with Cupping or Curling of ½ inch or more
1	None
2	Occasional (At least one)
3	More than occasional, but < ⅓ of all shakes
4	⅓ > < ⅔ of all shakes
5	> ⅔ of all shakes