Weathering performance of painted wood pretreated with water-repellent preservatives

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Abstract

We evaluated the long-term effect of solvent-borne and waterborne water-repellent preservative pretreatments on the performance of various paint systems applied to different wood substrates. Results were compared to those obtained with untreated substrates. Six substrates were studied: Western redcedar bevel siding, redwood bevel siding, southern pine bevel siding, unprimed hardboard, Douglas-fir plywood, and southern pine plywood. The surfaces of these substrates were either smooth-planed, smooth-sanded, or scratch-sanded. The other variables were the type of paint system (all-latex, all-alkyd, or combined alkyd-latex) and number of paint coats (two or three). After 9 years of outdoor exposure in Madison, Wis., test panels were evaluated for degradation of substrate (checking and cracking) and finish (flaking, cracking, and discoloration), as well as for the presence of decay. The water-repellent preservative treatment helped improve paint performance of substrates with poor paint-holding characteristics; species like southern pine showed the greatest improvement, whether the wood was solid or in the form of plywood. Substrates with good paint-holding characteristics (Western redcedar, redwood, textured hardboard) did not benefit very much from water-repellent preservative pretreatments. Decay occurred in the southern pine test panels. Decay occurred to a lesser extent in panels brush-treated with solvent-borne water-repellent preservative; the waterborne water-repellent preservative was less effective. On the other hand, the paint performance of panels treated with the waterborne preservative was slightly better than that of panels treated with the solvent-borne preservative. Three-coat paint systems (one primer and two topcoats) performed much better than did two-coat systems (one primer and one topcoat). The study also showed that alkyd primer/latex topcoat and all-latex paint systems perform much better than the all-alkyd paint system, with or without water-repellent preservative pretreatment.

The primary objective of this study was to develop a better understanding of the weathering performance of painted wood siding products that had been pretreated with solvent-borne or waterborne water-repellent preservatives. We focused on the effects of pretreatment/primer/paint/substrate interactions on panels exposed outdoors in Madison, Wis.

A large proportion of damage to exterior woodwork (such as paint defects, deformations, decay, and leakage) is a direct result of moisture changes in the wood and subsequent dimensional instability (10,13). Water generally enters wood through open cracks, unprotected end-grain surfaces, and defects in surface treatments. Although the negative effects of such problems can be avoided or at least reduced by proper design or correct choice of materials, it is extremely difficult to stop checks or cracks from appearing when woodwork is subjected to harsh long-term exposure. Even a high quality coating often loses its protective characteristics because it cannot tolerate the stresses and strains of shrinkage and swelling, especially around joints. Eventually, the coating fails.

Because of these problems, researchers have often suggested that woodwork exposed outdoors be given a protective treatment that is both water repellent and resistant to decay fungi. Such a treatment could constitute the finish itself or be applied prior to the final finish. Materials developed for such purposes are termed water-repellent preservatives (WRP) (10). They are generally comprised of resin (10% to 20%), solvent, wax (as the water repellent), and preservative (fungicide, mildewcide).

A great store of information has been accumulated on the effectiveness of solvent-borne WRPS in protecting exterior wood (2,9,11). The treatments, which are applied before painting, improve the performance of the paint and

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TABLE 1. -- *Substrate characteristics for outdoor exposure performance study.*

Substrate	Surface texture	Thickness
		(in.)
Western redcedar bevel siding (WRC)	Smooth-planed	0.5
Redwood bevel siding (RW)	Smooth-planed	0.5
Southern pine bevel siding (SP)	Smooth-planed	0.5
Hardboard, unprimed (HB)	Simulated wood grain	0.375
Douglas-fir plywood (DFPLY)	Smooth-sanded	0.625
Southern pine plywood (SPPLY)	Scratch-sanded	0.625

TABLE 2. — *Characteristics of pretreatments and paints used to finish wood siding products.*

Pretreatment or paint	Source	Color	Nonvolatile content	Weight
			(percentage of weight)	(lb./gal.)
Water-repellent preservative	Laboratory[a] (solvent-borne)	Transparent	16	6.8
Water-repellent preservative	Commercial[b] (waterborne)	Transparent	4	8.4
Alkyd primer paint A	Commercial	White	78	11.4
Alkyd primer paint B	Commercial	White	75	11.2
Latex primer paint	Commercial	White	52	9.8
Alkyd paint	Commercial	White	62	10.5
Acrylic latex house paint A	Commercial	White	52	11.3
Acrylic latex house paint B	Commercial	White	53	10.9

[a] Paraffin wax, varnish resin, mineral spirits, 5 percent pentachlorophenol preservative (reference 10).
[b] No formulation information available from manufacturer. Water emulsion system containing 0.5 percent 3-Iodo-2-propynyl butyl carbamate preservative, and proprietary water repelients.

add greatly to the durability of exposed wood. The WRP treatments give wood the ability to repel water, thus denying stain and decay fungi the moisture they need to live (12). The WRP reduces water damage to the wood and helps protect applied paint from the blistering, peeling, and cracking that often occurs when excessive water penetrates wood.

Solvent-borne WRPs have been used since the 1930s. Waterborne WRPs are relatively new, having appeared around 1980. Very little information has been published about the use of waterborne WRPs as pretreatments for wood before painting.

Materials and methods

Wood substrates

The wood materials for the exterior exposure studies were obtained from commercial sources. Substrate characteristics are described in Table 1. The unprimed hardboard (HB), Western redcedar *(Thuja plicata)* (WRC), redwood *(Sequoia sempervirens)* (RW), southern pine *(Pinus* sp.) (SP), and scratch-sanded southern pine plywood (SPPLY) represent materials currently used in large quantities for siding and other exterior wood surfaces such as soffits and fences. Douglas-fir *(Pseudotsuga menziesii)* (DFPLY) smooth plywood is commonly used for soffits and other protected exterior uses. The WRC and RW were vertical-grain heartwood; the SP was flat-grain sapwood. The scratch-sanded plywood surface was produced by sanding with a coarse paper. The resulting surface had a roughness in between that of smooth-sanded and rough-sawn plywood. The plywood panels were not grooved.

Exposure panels

Three randomly selected pieces of bevel siding (0.5 by 5 by 13.5 in.) or one piece of panel product (hardboard or Plywood, 13.5 by 15 in.) were assembled onto 16-inch-wide by 13.5-inch-long frames made from 0.25-inch exterior-grade plywood with 0.5-inch-wide by l-inch-deep side rails (5,7,8). The frames were dip-treated with a solvent-borne WRP and edge-coated with latex paint before substrates were attached with stainless steel nails. The framed exposure panels were randomly installed in groups of four horizontal rows of four panels each on vertical fences with southern exposure at Madison, Wis., in October 1979.

Pretreatments and paints

A variety of commercially available and laboratory-prepared paints and pretreatments were selected for the outdoor exposure study (Table 2). Paint systems were comprised of combinations of the individual paints with and without pretreatments. The materials selected represent paints currently available and recommended for application on wood used in outdoor exposure. The paints are of known durability on solid wood substrates, based on experience or research (7,8). The waterborne WRP represents a new class of pretreatment available at the time our study was initiated and was the only commercial product available.

All test specimens were conditioned to 65 percent relat ive humidity (RH) at 80°F before treating or painting. All surfaces were wiped with a soft cloth before finishing and between coats. No other special surface preparation was used. All pretreatments and paints were brushed on the clean and unweathered surface of the wood under ideal laboratory conditions and following all recommendations provided by the manufacturers, where applicable. All finishes were applied with the panels in a horizontal position. Top, side, and bottom edges of all panels were sealed as completely as possible with the pretreatment or paint itself,

Spreading rates for the pretreatments and paints (Table 3) were those usually recommended (5,6) and were determined by direct weighing. The finished exposure panels were stored indoors at 60 percent RH and 75°F for 1 week before being installed on the vertical exposure fences.

Paint performance ratings

We used different criteria to rate the effect of the various pretreatment/paint. systems on the wood substrates (Table 4). Most evaluation methods were based on American Society for Testing and Materials (ASTM) standards. The evaluations were based on paint performance and appearance. Discoloration (often influenced by mildew growth on the wood surface) is an indicator of paint performance because of its visual effect. Paint performance was evaluated for flaking and cracking. General appearance (subjective visual assessment) was used as a final overall criterion.

For convenience and simplicity of presentation, the various performance criteria were combined into a single value called the overall performance rating (5,6). This rating is an average of the various elements of the rating system; each inspection criterion is evaluated on a scale of 10 to 1. Thus, an overall performance rating of 10 indicates no change from the original unweathered condition, 5 = the condition at which repainting would normally be required but without extensive preparation of the substrate surface, and 1 = total paint failure. The time required for paint checking or cracking to appear is a convenient measure of paint durability and the effectiveness of pretreatments.

Completely objective ratings are difficult to make. For consistency, observations were made by the same person on each occasion, and color transparencies were used to compare results from year to year. Panels were evaluated approximately every 12 months.

Results and discussion

The following results from the outdoor exposure study illustrate the performance of two pretreatments and three paint systems on six different wood substrates. The commercial paint systems chosen for this study represent a range of recognized durability (particularly on softwoods) that would be expected to protect solid wood surfaces for 6 to 10 years (2-4,7,8).

Spreading rate

The amount of finish applied to a wood surface affects overall performance (2-4). A lower spreading rate means more material has to be applied to the wood surface, and it usually reflects better penetration of the finish.

In our study, the WRP spreading rates were affected by substrate type (Table 3). The SP, HB, DFPLY, and SPPLY panels required more WRP (lower spreading rate) than the WRC and RW panels. Spreading rates for the waterborne WRPS were 15 to 45 percent lower than those for the solvent-borne WRPS.

Spreading rates for primer paints and the alkyd house paints were generally lower than the rates for the WRPS and the latex topcoat paints. In addition, the WRP pretreatment affected the spreading rates for primer paints. With alkyd primer paint A, spreading rates were generally increased after pretreatment; the solvent-borne WRP had the biggest effect on reducing the amount of primer paint that could be applied to the treated wood surface. Paint spreading rates also depended on the type of wood substrate. With alkyd primer paint B, spreading rates were often higher (less paint could be applied) for the wood surfaces pretreated with solvent-borne WRP compared to those treated with waterborne WRP, but there were exceptions to this observation.

TABLE 3. — *Spreading rates for pretreatments and paints applied to wood siding products.*[a]

Pretreatment or paint	Spreading rate					
	WRC	RW	SP	HB	DFPLY	SPPLY
	(ft.²/gal.)					
WRP solvent-borne	500	515	185	410	345	305
WRP waterborne	420	415	155	225	225	285
Alkyd primer paint A						
No pretreatment	280	275	235	250	255	265
WRP solvent-borne	280	325	240	280	285	290
WRP waterborne	295	290	200	295	315	280
Alkyd primer paint B						
No pretreatment	290	250	215	195	220	225
WRP solvent-borne	225	215	165	185	225	230
WRP waterborne	240	245	160	205	230	215
Latex primer paint						
No pretreatment	275	270	195	280	225	210
WRP solvent-borne	345	295	205	270	330	300
WRP waterborne	325	335	195	280	270	225
Alkyd house paint	270	315	230	270	310	295
Acrylic latex house paint A	490	485	408	410	490	475
Acrylic latex house paint B	515	535	435	440	520	425

[a] WRP = water-repellent preservative; WRC = Western redcedar bevel siding; RW = redwood bevel siding; SP = southern pine bevel siding; HB = hardboard (unprimed); DFPLY = Douglas-fir plywood; and SPPLY = southern pine plywood.

TABLE 4. — *Inspection criteria and evaluation methods for assessing the performance of pretreatment/paint systems on wood substrates.*

Inspection criterion	Evaluation method[a,b]
Nonvolatile content	ASTM D 2369-87
Paint	
Flaking	ASTM D 772-86
Cracking	ASTM D 661-86
Discoloration	Subjective visual assessment similar to ASTM D 3274-82 (mildew)
General appearance	Subjective visual assessment
Substrate checking or cracking	Similar to ASTM D 660-86 and ASTM D 661-86

[a] All evaluations used a scale of 10 (perfect) to 1 (complete failure). A value of 5 indicates the need for refinishing without major surface preparation.
[b] ASTM = American Society for Testing and Materials.

TABLE 5. — *Performance of all-latex paint system on Western redcedar and redwood bevel siding after 9 years of outdoor exposure.*

Substrate and pretreatment	Paint coats	Substrate rating[a]	Paint rating			Overall performance rating	Presence of decay
			Flaking	Cracking	Discoloration		
	(no.)						
Western redcedar							
No pretreatment	2	10	10	10	<5	8.5	No
	3	10	10	10	7	9.3	No
WRP solvent-borne	2	9	9	6	<5	7.0	No
	3	10	10	10	7	9.3	No
WRP waterborne	2	8	8	6	<5	6.5	No
	3	10	10	10	7	9.3	No
Redwood							
No pretreatment	2	9	9	8	<5	7.5	No
	3	10	10	10	6	9.0	No
WRP solvent-borne	2	8	9	6	<5	6.8	No
	3	10	10	10	7	9.3	No
WRP waterborne	2	8	8	6	<5	6.5	No
	3	10	10	9	6	8.8	No

[a] Checking or cracking.

Overall paint performance

This study was primarily concerned with the performance of different paints on wood substrates that had been pretreated with a solvent-borne or waterborne WRP. Construction aspects or the performance of the wood substrate with regard to such properties as dimensional stability and nail-holding characteristics were not addressed in this study.

A convenient indicator of paint performance is the overall performance rating described in the **Materials and methods** section. This rating includes consideration of any discoloration or staining of the paint as well as performance characteristics of the substrate (checking or face-checking) and the finish (cracking and flaking).

Effect of paint system

Overall paint performance for the WRC and RW siding was excellent for the two- and three-coat paint systems with alkyd primers. These paint systems were so effective for WRC that no differences could be detected between

TABLE 6. — *Performance of latex house paint with different primers on various substrates after 9 years of outdoor exposure.*

Paint system and pretreatment	Paint coats	Substrate rating[a]	Paint rating			Overall performance rating	Presence of decay
			Flaking	Cracking	Discoloration		
	(no.)						
Southern pine smooth bevel siding (SP)							
Alkyd primer A and latex house paint A							
No pretreatment	2	<5	<5	<5	<5	<5	No
	3	<5	<5	<5	<5	<5	No
WRP solvent-borne	2	7	7	<5	<5	5.5	No
	3	9	10	8	5	8.0	No
WRP waterborne	2	8	8	6	<5	6.5	Yes
	3	9	9	8	5	7.8	Yes
Latex primer and latex house paint B							
No pretreatment	2	<5	<5	<5	<5	<5	Yes
	3	<5	<5	<5	<5	<5	Yes
WRP solvent-borne	2	7	7	<5	<5	5.5	No
	3	9	9	8	6	8.0	No
WRP waterborne	2	<5	6	<5	<5	<5	Yes
	3	9	9	7	5	7.5	Yes
Textured hardboard (HB)							
Alkyd primer A and latex house paint A							
No pretreatment	2	10	10	10	<5	8.5	No
	3	10	10	10	8	9.5	No
WRP solvent-borne	2	10	10	10	6	9.0	No
	3	10	10	10	8	9.5	No
WRP waterborne	2	10	10	10	<5	8.5	No
	3	10	10	10	6	9.0	No
Latex primer and latex house paint B							
No pretreatment	2	10	9	9	8	9.3	No
	3	10	10	10	9	9.8	No
WRP solvent-borne	2	10	10	10	8	9.5	No
	3	10	10	10	8	9.5	No
WRP waterborne	2	10	9	9	6	8.5	No
	3	10	10	10	8	9.5	No
Douglas-fir plywood (DFPLY)							
Alkyd primer A and latex house paint A							
No pretreatment	2	<5	9	<5	<5	5.3	No
	3	6	10	5	5	6.8	No
WRP solvent-borne	2	7	9	6	6	7.3	No
	3	9	10	8	8	9.0	No
WRP waterborne	2	<5	9	<5	<5	5.3	No
	3	7	10	6	6	7.3	No
Latex primer and latex house paint B							
No pretreatment	2	8	9	7	6	7.5	No
	3	9	10	9	8	9.0	No
WRP solvent-borne	2	5	7	<5	<5	5.0	No
	3	9	10	9	9	9.3	No
WRP waterborne	2	7	9	7	6	7.3	No
	3	9	10	9	8	9.0	No
Southern pine plywood (SPPLY)							
Alkyd primer A and latex house paint A							
No pretreatment	2	<5	8	<5	<5	5.0	Yes
	3	8	9	6	5	7.0	Yes
WRP solvent-borne	2	6	9	<5	<5	5.8	No
	3	9	10	8	7	8.5	No
WRP waterborne	2	7	9	<5	<5	6.0	Yes
	3	8	10	7	6	7.8	Yes
Latex primer and latex house paint B							
No pretreatment	2	8	9	7	<5	7.0	Yes
	3	10	10	9	7	9.0	Yes
WRP solvent-borne	2	9	9	9	6	8.3	No
	3	10	10	10	8	9.5	No
WRP waterborne	2	8	9	7	5	7.3	Yes
	3	10	10	8	7	8.8	Yes

[a] Checking or cracking.

TABLE 7. — *Time before start of cracking and flaking of paint systems on various wood products.*

Paint system and pretreatment	Coats	Time before paint degradation for various substrates[a]											
		WRC		RW		SP		HB		DFPLY		SPPLY	
		Cr	Fl	Cr	Fl	Cr	Fl	Cr	Fl	Cr	Fl	Cr	Fl
	(no.)	(yr.)											
Alkyd primer B and alkyd house paint													
No pretreatment	2	--	--	5	--	2	2	7	--	2	7	2	4
	3	--	--	7	--	2	2	7	--	2	--	2	4
WRP solvent-borne	2	--	--	5	--	3	5	--	--	3	9	4	5
	3	--	--	5	--	3	5	--	--	3	--	4	5
WRP waterborne	2	6	--	2	--	2	3	8	--	2	7	2	4
	3	6	--	5	--	2	3	8	--	2	8	2	4
Alkyd primer A and latex house paint A													
No pretreatment	2	--	--	9	--	2	3	--	--	2	--	2	5
	3	--	--	9	--	2	3	--	--	2	--	2	6
WRP solvent-borne	2	--	--	9	--	2	6	--	--	2	7	2	5
	3	--	--	--	--	2	7	--	--	2	--	2	6
WRP waterborne	2	--	--	9	--	2	6	--	--	1	--	2	8
	3	--	--	--	--	2	7	--	--	1	--	2	--
Latex primer and latex house paint B													
No pretreatment	2	6	--	5	--	4	7	7	--	4	9	2	8
	3	--	--	--	--	5	7	--	--	5	--	2	--
WRP solvent-borne	2	6	7	5	8	5	7	--	--	2	7	5	7
	3	--	--	--	--	6	9	--	--	3	--	8	--
WRP waterborne	2	6	--	6	8	4	6	7	6	4	9	4	8
	3	--	--	7	--	5	7	--	--	6	--	8	--

[a] Cr = cracking; Fl = flaking.

the different WRP pretreatments. For RW, the paint performance of wood pretreated with solvent-borne WRP was somewhat improved by three coats of paint (one primer and two topcoats). The two-coat latex primer/latex topcoat paint system did not perform as well as the three-coat system (Table 5). The three-coat all-latex paint system generally gave excellent results.

With SP, paint performance was very poor with the alkyd primer/alkyd topcoat system regardless of the number of coats, and all substrate/paint ratings were < 5. However, in the early stages of exposure, paint performance of this system was better for wood that had been pretreated with WRP (data not shown). The alkyd primer/latex topcoat and all-latex paint systems performed fairly well, especially with three coats (Table 6), and they performed considerably better than the all-alkyd paint system (which had ratings all < 5). The WRP treatment significantly improved overall paint performance, demonstrating that pretreatment can improve wood with poor paint-holding characteristics.

The WRP pretreatments had very little effect on the performance of paint systems over HB siding (Table 6). The paint systems with acrylic latex topcoats gave the best overall performance. Cracking was observed with the all-alkyd paint system, suggesting the initiation of more drastic paint failure.

For DFPLY and SPPLY, paint performance was very poor for the all-alkyd paint system. The alkyd primer/latex topcoat system performed better than the all-alkyd system, and pretreatment with the solvent-borne WRP apparently had a beneficial effect (Table 6). The all-latex paint system gave very good results with DFPLY and SPPLY substrates compared to those found for WRC and RW. This paint system resulted in less face checking compared to the all-alkyd or alkyd primer/latex topcoat systems.

Effect of substrate

Paint performance was markedly affected by the wood substrate. The overall performance ratings were averaged for the different substrates. The following ranking was observed:

Substrate	Average overall performance rating
Hardboard (HB)	8.77
Western redcedar bevel siding (WRC)	8.44
Redwood bevel siding (RW)	8.23
Southern pine plywood (SPPLY)	6.33
Douglas-fir plywood (DFPLY)	6.17
Southern pine bevel siding (SP)	5.16

As the ratings indicate, the paint performed best on HB and poorest on SP. There was considerable difference between the very good performance of paint on HB, WRC, and RW compared to that on SPPLY, DFPLY, and SP, confirming earlier observations (3,5,13).

Cracking and flaking

Paint cracking and flaking had a significant impact on overall paint performance. Cracking occurred after only 2 to 3 years for the all-alkyd paint system for SP, DFPLY, and SPPLY (Table 7). Cracking generally occurred several years before flaking was observed. The WRP pretreatment did not have much influence on cracking and flaking of this paint system for most substrates; however, there was substantially less flaking on SP pretreated with solvent-borne WRP. For SP, DFPLY, and SPPLY, the alkyd primer/latex topcoat paint system also developed cracking after only 2 to 3 years, but flaking did not occur for 3 to 8 years. The WRP pretreatment again prevented some flaking on SP. Cracking occurred to a much lesser extent for the all-latex paint system for SP, DFPLY, and SPPLY. For SPPLY, WRP treatment helped reduce cracking. Cracking did not occur until at least 5 years of exposure for WRC, RW, and HB. These three substrates had very little flaking.

Overall effects

The three paint systems in this study had very different overall performance. The average overall performance rating for each system was as follows:

TABLE 8. — *Effect of pretreatment on average overall performance for all substrates after 9 years of exposure.*

Pretreatment	WRC	RW	SP	HB	DFPLY	SPPLY
No pretreatment	8.63	8.28	4.00	8.78	6.10	6.00
WRP solvent-borne	8.38	8.33	5.83	9.05	6.43	6.68
WRP waterborne	8.30	8.08	5.63	8.47	6.15	6.32

Paint system	Average overall performance rating
Latex primer paint + latex house paint B	7.78
Alkyd primer paint A + latex house paint A	7.57
Alkyd primer paint B + alkyd house paint	5.91

As indicated, the more brittle all-alkyd paint system did not perform nearly as well as the alkyd primer/latex topcoat system, which, in turn, did not perform as well as the all-latex paint system. The difference between the performance of the two latex topcoat paint systems was considerably less than that between the latex and the all-alkyd systems.

The overall performance ratings were averaged for the untreated and WRP-treated wood substrates for all the paint systems (Table 8). The biggest improvement in overall paint performance resulting from WRP pretreatment was found for SP. This wood is known to have poor paint-holding characteristics (1,13), and WRP pretreatment helped improve paint performance on the flat-grained boards. Paint performance was also improved with WRP pretreatment for the flat-grained, scratch-sanded southern pine plywood (SPPLY). Only small effects, both positive and negative, were observed for WRP pretreatment of the other substrates. Average combined overall performance ratings for all substrates were as follow:

Pretreatment	Average overall performance rating
Solvent-borne WRP	7.43
Waterborne WRP	7.16
No pretreatment	7.02

The combined average overall performance ratings suggest that the solvent-borne WRP pretreatment is somewhat better than the waterborne WRP and that both will be of some benefit in improving paint performance of pretreated wood compared to that of untreated wood. As shown previously, WRP pretreatment results in the better performance of flat-grained samples of wood with poor paint-holding characteristics (1,13).

Decay

Southern pine is a wood species described as slightly resistant or nonresistant to decay (13). This means that decay is always possible if the moisture content of the wood is sufficiently high. The design of our outdoor exposure panels was such that the vertical edges of the test specimens were butted against a wood strip; completely sealing the end grain was not normally possible. Also, water could enter at the top of the test specimen and could move between the specimen and plywood backing on the exposure panel. This design increases the possibility for decay because water is so easily trapped and retained.

A white-rot fungus, *Schyzophyllum commune,* was found growing through paint cracks on painted SP and SPPLY panels as early as 2 years after initial outdoor exposure. There was no consistent pattern of decay relative to WRP pretreatment. Solvent-borne WRP pretreatment helped prevent decay with the alkyd primer/latex topcoat and all-latex paint systems on both SP and SPPLY substrates, but the waterborne WRP was effective only with the all-alkyd paint system.

Concluding remarks

This outdoor exposure study of various paint systems on different wood substrates demonstrates that water-repellent preservative pretreatment will help improve paint performance on substrates with poor paint-holding characteristics, such as southern pine. Such species will benefit the most from pretreatment, whether the wood is solid or in the form of plywood. On the other hand, substrates with good paint-holding characteristics, such as Western redcedar, redwood, and textured hardboard, will not benefit very much from pretreatment.

Brush treatment with water-repellent preservative will help prevent decay of treated wood. Solvent-borne water-repellent preservatives will help control decay better than will waterborne water-repellent preservatives; paint performance of wood treated with solvent-borne water-repellent preservative will also be slightly better than that of wood treated with waterborne water-repellent preservative.

In our study, three-coat paint systems (one primer and two topcoats) performed much better than did two-coat systems (one primer and one topcoat). Our study also showed that alkyd primer/latex topcoat and all-latex paint systems perform much better than an all-alkyd paint system, with or without water-repellent preservative pretreatment.

Literature cited

1. Anderson, L.O. 1963. Water repellents improve performance of drop siding. Res. Pap. FPL 4. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.
2. Cassens, D.L. and W.C. Feist. 1986. Finishing wood exteriors — Selection, application, and maintenance. Agri. Handb. 647. U.S. Gov. Print. Office, Washington, D.C.
3. Emery, J.A. 1980. Exterior finishes on plywood composite panels. Research Report 140. American Plywood Assoc., Tacoma, Wash.
4. ________. 1981. Comparison of the ability of selected house paints to retard face checking in plywood. J. Coatings Tech. 53(673):61-67.
5. Feist, W.C. 1982. Weathering characteristics of finished wood panel products. J. Coatings Tech. 54(686):43-50.
6. ________. 1984. Weathering interactions on treated and untreated wood surfaces. Record of the annual convention of the British Wood Preserving Assoc. pp. 13-23.
7. ________. 1987. Weathering performance of finished yellow-poplar siding. Forest Prod. J. 37(3):15-22.
8. ________. 1988. Weathering performance of finished southern pine plywood siding. Forest Prod. J. 38(3):22-28.
9. ________ and D.N.-S. Hon. 1984. Chemistry of weathering and protection. *In:* Chemistry of Solid Wood. R.M. Rowell, ed. Advances in Chemistry Series 207. American Chem. Soc. pp. 401-451.
10. ________ and E.A. Mraz. 1978. Wood finishing: Water repellents and water-repellent preservatives. Res. Note FPL-0124. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.
11. Gorman, T.M. and W.C. Feist. 1989. Chronicle of 65 years of wood finishing research at the Forest Products Laboratory. Gen. Tech. Rept. 60. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.
12. Rowell, R.M. and W.B. Banks. 1985. Water repellency and dimensional stability of wood. Gen. Tech. Rept. 50. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.
13. U.S. Department of Agriculture, Forest Service. 1987. Wood Handbook. Wood as an Engineering Material. Agri. Handb. 72, rev. U.S. Gov. Print. Office, Washington, D.C. pp. 16-1 to 16-13.