

Service Life of Finishes on Smooth-Planed and Saw-Textured Western Redcedar Bevel Siding

by R. Sam Williams[†]—
USDA Forest Service, Forest
Products Laboratory*
and
William C. Feist—Retired

The performance of 35 finishes (clear water-repellent preservatives; lightly pigmented, water-repellent preservatives; semitransparent stains; solid-color stains; and paints) applied to newly planed, vertical grained; factory-planed, flat-grained; or saw textured, vertical-grained western redcedar bevel siding was evaluated for cracking, erosion, and general appearance over 14 years of outdoor exposure at two sites (Madison, WI, and Gulfport, MS). Service life was dependent on the wood surface and increased in the following order: clear water-repellent preservatives; highly pigmented, water-repellent preservatives; semitransparent stains; solid-color stains; and paints. The performance was about the same for both the flat-grained and vertical-grained smooth planed bevel siding but was greatly improved for almost all finish systems on the saw-textured western redcedar bevel siding.

INTRODUCTION

Previous information on the service life of finishes on western redcedar was obtained from studies of vertical grained lumber from old-growth forests using finishes that are no longer available. From previous studies at the USDA Forest Products Laboratory (Madison, WI), the performance of finishes formulated prior to 1990 on saw-textured and planed western redcedar (*Thuja plicata*), redwood (*Sequoia sempervirens*), Southern Pine (*Pinus sp.*),^{1,2} and aspen (*Populus tremuloides*)³ were reported. Others have compared the performance of paint systems on smooth and saw-textured plywood.³⁻⁶

All architectural finishes for use in the United States were reformulated in the early 1990s to lower their volatile organic compound (VOC) content to meet air quality legislation. At the time this study was started, little information was available on the long-term performance of these low-VOC finishes. Nor had any work been done to compare the performance of these new low-

*One Gifford Pinchot Drive, Madison, WI 53726.

[†]Author to whom correspondence should be addressed. Email: rswilliams@fs.fed.us.

Table 1—Description of Finishes Used in Study 4-92 VOC

A	1	Product	Description	Pigment	Lb/Gal	Grams/cc	Solids %	Volatile %	Water %	VOC %
	1	Thompson Water Seal	Clear solventborne WRP	Ultr	6.06	0.796	14.6	85.4	0.1	85.3
	2	Thompson Wd. Prot.	Clear mineral oil WRP	Ultr	7.25	0.851	95.8	4.2	0.1	4.1
	3	X-100	Clear nollat oil based WRP	Ultr	7.10	0.850	92.6	7.4	0.1	7.3
	4	Carver Trap S Poly	Clear 10% solids WB WRP	Clear	8.04	1.075	30.4	59.6	49.6	41.2
	5	LifeTime Sealant	Clear 5% solids WB WRP	Clear	10.58	1.268	1.8	95.2	0.1	55.7
	6	Masterguard Wd. Sealer	Clear 70% solids WB WRP	Clear	8.44	1.211	19.5	80.5	80.4	0.5
	7	Nolmar WRP	Clear 67% solids oil-based SB WRP	Clear	7.25	0.869	66.3	33.2	2.9	31.1
		(New WRPs used May/96)								
B	8	Woodlife VOC Vaseboard	Clear 4% solids WB WRP	Clear	8.38	1.004	3.5	96.5	96.4	0.5
	9	Thompson Wd. Prot.	Clear mineral oil WRP	Clear	7.10	0.851	95.8	4.2	0.1	4.1
	10	X-100 Cedarstone	Tinted 45% solids WB WRP	Cedar	7.99	0.957	44.8	55.4	4.6	41.0
	11	Antico WRP 100 Ultr	Clear 14% solids SB WRP	Clear	6.85	0.822	13.8	84.2	0.6	6.1
	12	Cupinol WRP	Clear 10% solids WB WRP	Ultr	8.33	0.966	10.5	89.5	86.4	3.2
	13	Cupinol Upper Napth.	Tinted 55% solids oil-based SB WRP	Clear	7.22	0.851	55.4	44.6	0.1	44.3
	14	Wolmar WRP	Clear 67% solids oil-based SB WRP	Clear	7.25	0.869	66.8	33.2	2.9	31.1
B	1	Oly. Marathon Alk./Lat.	Redoxone 74% solids alkyl mod. acrylic WB STS	Redwood	9.09	1.089	25.6	76.4	75.1	4.6
	2	Oly. Marathon Acrylic Lat.	Redoxone 77% solids acrylic latex WB STS	Redwood	8.98	1.076	27.1	72.9	61.5	14.8
	3	L'Insey ST Oil Stain	Color 76% solids oil-based SB STS	Cedar Br.	7.63	0.917	75.9	24.1	0.2	71.9
	4	Duckback Oil ST Stain	Color 60% solids oil-based SB STS	Cedar	7.17	0.859	56.9	43.1	0.1	43.0
	5	Pratt+Lam. ST Lat. Stain	Pigmented 27% solids WB STS	RLatic	8.66	1.038	76.8	75.2	58.3	36.3
	6	Oly. WRP 5" Lat. Stain	Cedar 27% solids WB STS	Cedar	9.02	1.081	76.8	71.4	65.5	20.4
	7	LifeTime 5" Lat. Stain	Cedar 6% solids SB STS	Cedar	10.63	1.274	5.4	95.6	0.1	56.7
C	1	Pratt+Lam. SC Alkyd Stain	White 76% solids oil-based SB STS	White	12.29	1.473	11.8	99.2	0.2	22.4
	2	Pratt+Lam. SC Latex Stain	White 45% solids acrylic-based WB STS	White	10.43	1.250	44.9	55.1	51.4	10.4
	3	Nautz SC Oil 5" Stain	Tan 54% solids oil-based SB STS	Tan	9.97	1.111	54.5	45.5	0.6	45.2
	4	Nautz SC Latex Stain	Tan 50% solids acrylic-based WB STS	Tan	10.61	1.199	18.7	81.3	56.3	15.0
	5	Oly. SC Oil Stain	Red 54% solids oil-based SB STS	Red	8.66	1.038	55.4	44.6	0.1	44.5
	6	Oly. SC Latex Stain	Red 38% solids acrylic-based WB STS	Red	10.03	1.202	37.6	62.4	56.3	18.2
	7	Oly. SC Oil Lat. 5" Stain	Red 45% solids oil primer + 38% solids acrylic STS	Red	8.710	1.047	55.38	45.62	0.250.3	45.7.9
C	1	Oly. SC Oil Stain (2 cts.)	Red 50% solids oil-based STS (2 coats)	Red	8.7/8.7	1.047/1.047	55.4/55.4	44.6/44.6	0.1/0.1	44.5/44.5
	2	Pratt+Lam. SC Oil/AC Lat.	White 78% solids oil-based STS + 45% solids acrylic STS	White	12.3/10.4	1.47/1.25	78/45	22.2	0.2/52.4	22.1/10.4
	3	Pratt+Lam. Oil pr+40% Lat.	White 80% solids alkyl primer + 77% solids alkyl TC	White	11.8/9.7	1.42/1.16	80.5/71.2	19.5/28.8	0.4/0.1	19.2/28.7
	4	Pratt+Lam. Lat.pr+40% Lat.	White 38% solids latex primer + 46% solids latex TC	White	9.7/6.33	1.17/1.19	38.3/46.1	61.7/53.9	0.2/1.22.1	38.8/43.2
	5	Lucite Lat.pr+40% Lat. Topcoat	White 48% solids acrylic primer + 57% solids acrylic TC	White	10.0/11.0	1.20/1.31	48.3/57.0	51.7/43.0	0.9/40.4	2.0/5.6
	6	Lucite Oil.pr+40% Lat. Topcoat	White 44% solids alkyl primer + 57% solids acrylic TC	White	11.6/11.0	1.39/1.32	77.4/57.0	22.6/43.0	0.2/40.4	22.7/5.6
	7	S/W A-100 Oil pr+40% Lat. Top.	White 44% solids alkyl primer + 57% solids acrylic TC	White	11.0/11.1	1.32/1.33	74.6/56.8	25.5/43.2	0.3/45.2	25.3/5.1
D	1	Woodlife Wood Preserv. +	SB WRP + White 76% solids oil-based SB STS	Clear	6.05	0.797	6.2	93.6	0.7	93.5
	2	Pratt+Lam. SC Alkyd Stain	SB WRP + White 45% solids acrylic-based WB STS	White	12.29	1.473	77.8	22.2	0.7	22.1
	3	Pratt+Lam. SC Latex Stain	SB WRP + White 50% solids oil-based SB STS	White	10.43	1.250	44.9	55.1	51.4	10.4
	4	Nautz SC Oil Stain	SB WRP + Tan 54% solids oil-based SB STS	Tan	9.97	1.111	54.5	45.5	0.6	45.2
	5	Nautz SC Latex Stain	SB WRP + Tan 50% solids acrylic-based WB STS	Tan	10.61	1.199	18.7	81.3	56.3	15.0
	6	Oly. SC Oil Stain	SB WRP + Red 54% solids oil-based SB STS	Red	8.66	1.038	55.4	44.6	0.1	44.5
	7	Oly. SC Latex Stain	SB WRP + Red 38% solids acrylic-based WB STS	Red	10.03	1.202	37.6	62.4	56.3	18.2
	WRP+	SB WRP + Red 45% solids oil primer + 38% solids acrylic STS	Red	8.7/10	1.047/1.2	55/38	45/32	0.1/56.3	25/19	
E	1	Oly. SC Oil Stain (2 cts.)	SB WRP + Red 55% solids oil-based STS (2 coats)	Red	8.7/8.7	1.047/1.047	55.4/55.4	44.6/44.6	0.1/0.1	44.5/44.5
	2	Pratt+Lam. SC Oil/AC Lat.	SB WRP + White 78% solids oil-based STS + 45% solids acrylic STS	White	12.3/10.4	1.47/1.25	78/45	22.2	0.2/52.4	22.1/10.4
	3	Pratt+Lam. Oil pr+40% Lat.	SB WRP + White 80% solids alkyl primer + 77% solids alkyl TC	White	11.8/9.7	1.42/1.16	80.5/71.2	19.5/28.8	0.4/0.1	19.2/28.7
	4	Pratt+Lam. Lat.pr+40% Lat.	SB WRP + White 38% solids latex primer + 46% solids latex TC	White	9.7/6.33	1.17/1.19	38.3/46.1	61.7/53.9	0.2/1.22.1	38.8/43.2
	5	Lucite Lat.pr+40% Lat. Topcoat	SB WRP + White 48% solids acrylic primer + 57% solids acrylic TC	White	10.0/11.0	1.20/1.31	48.3/57.0	51.7/43.0	0.9/40.4	2.0/5.6
	6	Lucite Oil.pr+40% Lat. Topcoat	SB WRP + White 44% solids alkyl primer + 57% solids acrylic TC	White	11.6/11.0	1.39/1.32	77.4/57.0	22.6/43.0	0.2/40.4	22.7/5.6
	7	S/W A-100 Oil pr+40% Lat. Top.	SB WRP + White 44% solids alkyl primer + 57% solids acrylic TC	White	11.0/11.1	1.32/1.33	74.6/56.8	25.5/43.2	0.3/45.2	25.3/5.1

Table 2---Spreading Rates of Applied Finishes in Square Feet Per Gallon [Sq Ft/gal (m²/l)]

Gulfport											
	NP VG Sq ft./gal.	NP VG m ² /l	NP VG Sq ft./gal.	ST VG m ² /l	ST VG Sq ft./gal.	FP FG m ² /l	FP FG Sq ft./gal.	NP VG m ² /l	NP VG Sq ft./gal.	ST VG m ² /l	FP FG m ² /l
A 1	530	13.0	210	5.1	550	13.5	635	15.6	260	6.4	505
2	440	10.8	185	4.5	510	12.5	480	11.8	240	5.9	450
3	545	13.4	185	4.5	505	12.4	525	12.9	225	5.5	445
4	395	9.7	195	4.8	395	8.7	390	9.6	210	5.1	375
5	310	7.6	155	3.8	315	7.7	325	8.0	160	3.9	285
6	370	9.1	175	4.3	355	8.7	345	8.5	185	4.5	345
7	510	12.5	225	5.5	490	12.0	550	13.5	205	5.0	465
B 1	500	12.3	225	5.5	470	11.5	445	10.9	175	4.3	440
2	485	11.9	195	4.8	550	13.5	465	11.4	190	4.7	555
3	490	12.0	190	4.7	500	12.3	515	12.6	205	5.0	555
4	470	11.5	200	4.9	450	11.0	405	9.9	205	5.0	475
5	475	11.6	185	4.5	510	12.5	450	11.0	195	4.8	410
6	435	11.2	185	4.0	535	13.1	450	11.0	205	5.0	435
7	270	6.6	120	2.9	245	6.0	235	5.8	125	3.1	255
C 1	460	11.3	250	6.1	460	11.3	435	10.7	230	5.6	430
2	395	9.7	230	5.6	485	11.9	420	10.3	230	5.6	460
3	480	11.8	220	5.4	465	11.4	515	12.6	240	5.9	480
4	420	10.3	215	5.3	445	10.9	305	9.7	215	5.3	465
5	520	12.7	215	5.3	520	12.7	610	14.9	240	5.9	450
6	395	9.7	175	4.3	415	10.2	360	8.8	205	5.0	375
7	575	14.1	250	6.1	620	15.2	630	15.4	280	6.9	700
	635	15.6	390	9.6	665	16.3	680	16.7	395	9.7	730
D 1	425	10.4	225	5.5	410	10.0	460	11.3	200	4.9	435
2	660	16.2	595	14.6	660	16.2	625	15.8	595	14.6	585
3	410	10.0	235	5.8	465	11.4	460	11.3	230	5.6	430
4	760	18.6	645	15.8	895	20.7	845	20.7	645	15.8	745
5	445	10.9	240	5.9	470	11.5	455	11.1	240	5.9	425
6	625	15.3	370	9.1	610	14.9	565	13.8	405	9.9	580
7	380	9.3	180	4.4	370	9.1	360	8.8	185	4.5	365
	840	20.6	445	10.9	1025	25.1	950	23.3	450	11.0	950
	375	9.2	200	4.9	450	11.0	405	9.9	205	5.0	425
	715	17.5	465	11.4	730	17.9	705	17.3	500	12.3	650
	415	10.2	195	4.8	370	9.1	355	8.7	205	5.0	345
	800	19.6	515	12.6	740	18.1	850	20.8	525	12.9	715
	425	10.4	225	5.5	395	9.7	430	10.5	230	5.6	390
	475	11.6	335	8.2	490	12.0	510	12.5	340	8.3	465

Table 2 continued on next page.

Table 2—cont'd

SP	Madison						Gulfport					
	NP VG Sq ft/gal	NP VG m ² /A	ST VG Sq ft/gal	ST VG m ² /A	FP FG Sq ft/gal	FP FG m ² /A	NP VG Sq ft/gal	NP VG m ² /A	ST VG Sq ft/gal	ST VG m ² /A	FP FG Sq ft/gal	FP FG m ² /A
WRP	130	3.2	65	1.6	125	3.1	145	3.6	65	1.6	120	2.9
E 1	460	11.3	250	6.1	500	12.3	435	10.7	255	6.2	435	10.7
2	595	14.6	340	8.3	570	14.0	580	14.2	310	7.0	500	12.3
3	595	14.6	315	7.7	605	14.3	565	13.8	335	8.2	575	14.1
4	550	13.5	320	7.8	555	13.6	540	13.2	315	7.7	610	14.9
5	660	16.2	280	6.9	645	15.8	660	16.2	270	6.6	645	15.8
6	490	12.0	290	7.1	510	12.5	500	12.3	295	7.2	505	12.4
7	950	23.3	335	8.2	870	21.3	850	20.8	350	8.6	850	20.8
	720	17.6	460	11.3	745	18.3	690	16.9	465	11.4	780	19.1
SB												
WRP	85	2.1	50	1.2	105	2.6	100	2.5	45	1.1	100	2.5
F 1	535	13.1	270	6.6	595	14.6	520	12.7	275	6.7	610	14.9
2	685	16.8	585	14.3	700	17.2	660	16.2	585	14.3	750	18.4
	520	12.7	300	7.4	580	14.2	545	13.4	280	6.9	570	14.0
3	705	17.3	595	14.6	745	18.3	720	17.6	605	14.8	705	17.3
	480	11.8	295	7.2	500	12.3	430	10.5	280	6.9	520	12.7
4	465	11.4	435	10.7	510	12.5	510	12.5	400	9.8	500	12.3
	420	10.3	265	6.5	420	10.3	400	9.8	260	6.4	405	9.9
5	950	23.3	605	14.8	1055	25.8	925	22.7	595	14.6	900	22.1
	535	13.1	290	7.1	465	11.4	435	10.7	275	6.7	425	10.4
6	670	16.4	660	16.2	650	15.9	740	18.1	525	12.9	715	17.5
	420	10.3	240	5.9	400	9.8	370	9.1	235	5.8	395	9.7
7	770	18.9	590	14.5	755	18.5	770	18.9	565	13.8	800	19.6
	465	11.4	250	6.1	430	10.5	435	10.7	260	6.4	430	10.5
	485	11.4	340	8.3	460	11.3	525	12.9	330	8.1	440	10.8

VOC finishes on flat-grained bevel siding from second- and third-growth forests.

We report here the performance of 35 finishes used in 49 finish systems on newly planed vertical-grained; factory-planed flat-grained; or saw-textured vertical-grained western red-cedar bevel siding. Finishes included clear water-repellent preservatives, lightly pigmented water-repellent preservatives, semitransparent stains, solid-color stains (also called full-bodied stains or opaque stains), and acrylic and alkyd paints. All finishes were readily available commercial finishes and were applied under laboratory conditions. It is not the intent of the study to compare the performance of the various brands of finish, but rather to obtain general performance information for various types of finish on the different substrates (for example, to determine the expected service life of a typical semitransparent stain on saw-textured and smooth-planed bevel siding). The effect of a water-repellent preservative (WRP) pretreatment on the performance of several paint and solid-color stains is also evaluated.

EXPERIMENTAL

Materials

Western redcedar bevel siding was obtained from lumber dealers in Madison, WI. Bevel siding was nominal 6 in. (150 mm) and was obtained in 12-ft (3.66 m) lengths. The vertical-grained siding was an all-heartwood clear grade having growth rates in the range of 26–28 growth rings per inch (10–11 per cm). As received, the siding had one side smooth-planed and one side saw-textured. The factory-planed surface was planed again in our laboratory several days prior to finishing and stored in one of our controlled-humidity rooms (65% relative humidity (RH) and 27°C) until it was finished. Approximately 1 mm was removed from the surface. The flat-grained

Figure 1—Paints and two-coat solid-color stains (Group D) after 10 years outdoor exposure near Gulfport, MS.



Figure 2—General appearance evaluations for a red 55% solids oil-based solid-color stain (SCS, C 5, Table 1) exposed near Madison, WI (NP VG: newly planed vertical-grained; FP FG: factory-planed flat-grained; ST VG: saw-textured vertical-grained).

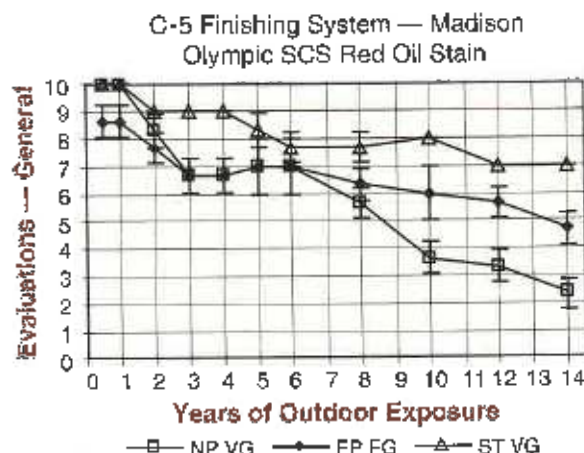
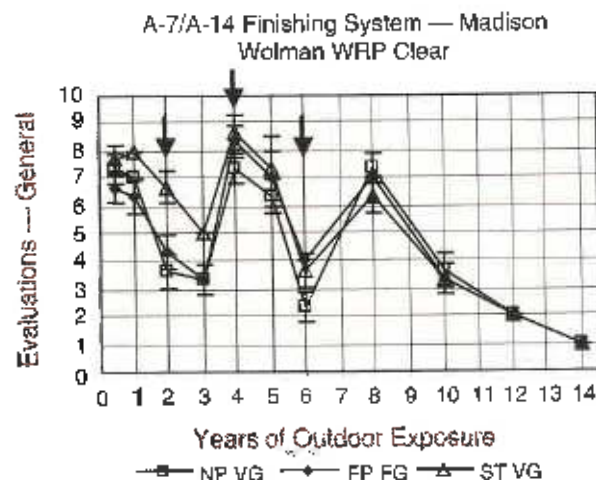


Figure 3—General appearance evaluations for a clear 67% solids repellent-preservative (WRP, A-7, Table 1) exposed near Madison (NP VG: newly planed vertical-grained; FP FG: factory-planed flat-grained; ST VG: saw-textured vertical-grained). Boards were refinished after 2, 4, and 6 years (arrows).



bevel siding was all heartwood select-knotty grade with small tight knots having approximately two to three growth rings per cm. This siding was also stored in our controlled-humidity room prior to being finished. Siding was cut to 47.75 in. (1.21 m) lengths (henceforth referred to as 4-ft boards) and each board was marked with a pencil with seven 6-in. (150 mm) sections for the various finishes, with approximately 3 in. (76 mm) on each end to remain unfinished.

All finishes were purchased from paint stores in Madison, WI. Their description and general characteristics are given in Table 1. The description includes the type of color, binder, solids content, volatile content, water content, VOCs, and preservatives/mildewicides. Solids content was determined using the ASTM D 2832-83 procedure. Finishes are grouped in six general categories: clear and lightly pigmented water-repellent preservatives (Group A), semitransparent stains (Group B), solid-color stains (Group C), paints (Group D), solid-color stains with a WRP pretreatment (Group E), and paints with a WRP pretreatment (Group F). Within each group are seven finishes except in Group A, which has 14 finishes. Hereafter, when the finish groups are mentioned, the reader can refer to Table 1. Seven Group A (1 to 7) finishes were laboratory-applied at the beginning of the study. These finishes lasted less than two years and were subsequently reapplied in the field (first refinish). Note that finish A-2 is the same as A-9 and A-7 is the same as A-14. For all other Group A finishes (A1, A3, A4, A5, and A6), a different finish was used in subsequent years for the second and third refinish. Some of the original seven finishes were no longer manufactured.

Figure 4—General appearance ratings for a redwood color 24% solids alkyd-modified acrylic waterborne semitransparent stain (STS, B-1, Table 1) exposed near Madison (NP VG: newly planed, vertical-grained; FP FG: factory-planed flat-grained; ST VG: saw-textured vertical-grained).

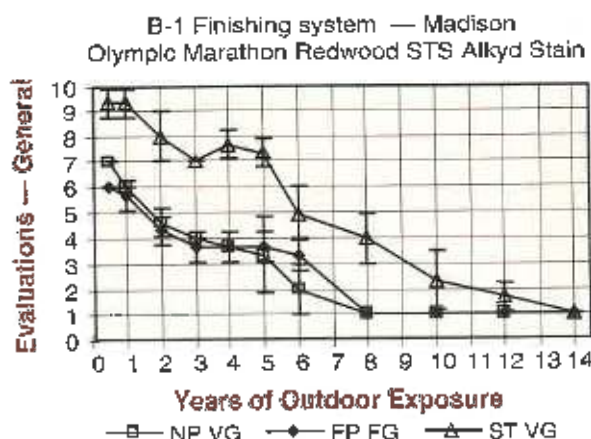
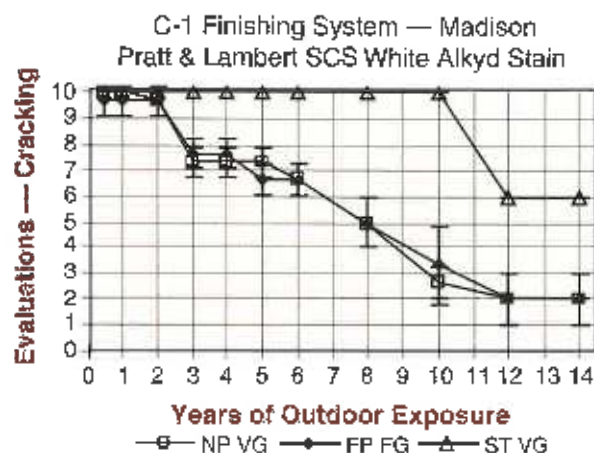


Figure 5—Finish cracking ratings for a white 78% solids oil-based, solventborne solid-color stain (SCS, C-1, Table 1) exposed near Madison (NP VG: newly planed vertical-grained; FP FG: factory-planed flat-grained; ST VG: saw-textured vertical-grained).



Cleaning solution was one part household bleach (5% sodium hypochlorite), three parts water, and a small amount of powdered detergent.

Methods

FINISHING—Within each type of bevel siding (factory-planed flat-grained; newly planed vertical-grained; and saw-textured vertical-grained), the 4-ft boards were randomized, and three boards were used for each finish system. Six general categories of finish were applied to each of these three-board sets. Each category of finish had seven finishes—one for each section within each of the 4 ft boards. This gave a total of 54 4-ft boards for each outdoor exposure site. One site is located approximately 5 km west of Madison, WI, and the other site is located approximately 15 km north of Gulfport, MS. These sites have distinctly different climates. The Madison site has four seasons with rather severe winters, and the Gulfport site is a maritime climate with hot humid summers and mild winters.

All 4-ft boards were initially finished under ambient laboratory conditions; the spread rates are given in Table 2. Finishes in Group A were reapplied in the field and field-applied spread rates were not determined. Prior to field application (refinishing) of the boards in Group A, the boards were cleaned with a mild household bleach and detergent mixture. Bleach solution was applied using a soft-bristle brush and thoroughly rinsed with water after 15 min. Boards were refinished after they dried, usually the next day. All other finishes (Groups B to F) were applied only once at the beginning of the study. All finishes were brush applied.

The 4-ft boards were attached to a vertical test fence facing south with a single screw at each end and there

was a 1/4-in. (6 mm) gap between each board. Nine boards were placed in each section of the fence (Figure 1).

EVALUATION—With the exception of Group A each of the finish systems was evaluated once a year over 12 to 14 years. The finishes in Group A were evaluated more often (approximately every six months). The service life of the clear and lightly pigmented finishes (Group A) was determined from the general appearance evaluations (listed as "General" in the tables and figures). Semitransparent stains were evaluated for "erosion," and the solid-color stains and paints were evaluated for "cracking" and "general appearance." Evaluations for erosion, cracking, and general appearance were in accordance with ASTM D 662-93, D 661-93, and D 3274-88, respectively. A rating of "10" indicates no degradation, and "1" indicates total failure of the coating system. A rating of "5" indicates a condition at which the coating should be refinished without having to do excessive surface preparation (in other words, the approximate service life).

DATA REDUCTION—The data for each of the finish systems were plotted to show performance over the 14-year exposure on each of the three different surfaces (newly planed vertical-grained (NP VG); factory-planed flat-grained (FP FG); and saw-textured vertical-grained (ST VG)). The plots showed the average and standard deviation of the three observations for each of the finish systems on each of the surfaces. For example, the general-appearance ratings over 14 years for a red 55% solids oil-based solid-color stain (Group C, finish C-5) exposed near Madison is shown in Figure 2. The standard deviations are the bars at each average point in the plots.

Most finishes had four plots ("General Appearance" and "Cracking" for Madison and Gulfport), which to-

Figure 6—Paint cracking ratings for a white 77% solids alkyd primer and 57% solids acrylic topcoat (D-6) exposed near Madison (NP VG: newly planed vertical-grained; FP FG: factory-planed flat-grained; ST VG: saw-textured vertical-grained).

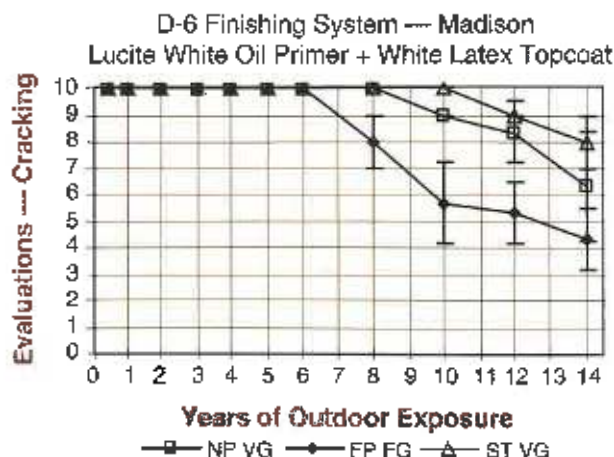
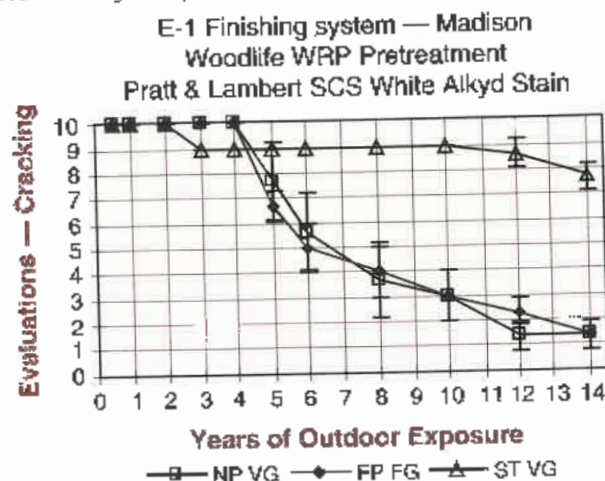
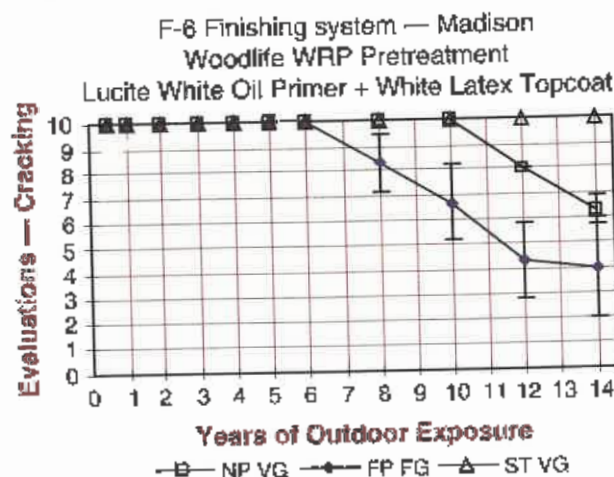


Figure 7—Paint cracking ratings for white 78% solids oil-based solid-color stain (E-1) with a solventborne water-repellent preservative (WRP) pretreatment exposed near Madison (NP VG: newly planed vertical-grained; FP FG: (factory-planed flat-grained); ST VG: saw-textured vertical-grained).



talled almost 200 plots for all the finish wood combinations. Only a few representative plots are included. The service life was determined as the time it took for the average rating to reach "5" on the evaluation scale. The service life (time on the abscissa) of each finish is the intersection of the performance line with the five-year line (ordinate). For example, the service life of finish C-5 (solid-color oil stain, Figure 2) was about nine years on newly planed vertical-grained, 13 years on factory-planed flat-grained boards, and more than 14

Figure 8—Paint cracking ratings for a white 77% solids alkyd primer and 57% solids acrylic topcoat (F-6) with a solventborne water-repellent preservative (WRP) pretreatment exposed near Madison (NP VG: newly planed vertical-grained; FP FG: factory-planed flat-grained; ST VG: saw-textured vertical-grained).



years on saw-textured vertical grained lumber. The service life for each finish is tabulated in the various tables. The performance line often intersected the five-year line between years. The closest year was listed in the tables: clear penetrating finishes (Table 3A,B), semitransparent finishes (Table 4), solid-color stains (Table 5 and 7), and paints (Table 6 and 8). Tables include the service life for both the Madison and Gulfport field sites.

RESULTS AND DISCUSSION

The performance of the various finish systems on the three different substrates varied greatly. Many of the clear and lightly pigmented finishes (Group A) lasted less than six months, whereas some of the solid color stains and paints were in excellent condition after 14 years. The most important factor in determining the service life was the type of finish. In general, the ranking in decreasing order of service life was as follows: paints, solid color-stains, oil-based semitransparent stains, water-based semitransparent stains, lightly pigmented WRPs, and clear WRPs.

After the type of finish, next in importance is the wood surface. In general, each of the finish systems had longer service life on the saw-textured vertical-grained bevel siding. The vertical grain surface is primarily comprised of early wood, which absorbs the finish better than latewood. The saw-textured surface has no planer-induced surface stresses, which can place stress on subsequently applied coatings.⁸ The saw-textured surface accepts more finish, which gives a greater film thickness than smooth-planed surfaces. In general, we found little difference between the newly planed vertical-grained surface and the factory-planed flat-grained surface with some exceptions noted in the following subsections. The service lives for finishes within each of the six finish systems (Group A to F) are given in the following subsections.

Clear and Lightly Pigmented WRPs (Group A)

General appearance ratings for finish system A-7 (A-14) show considerable difference over the 14 years (Figure 3). The initial finish application lasted less than 18 months, and the boards were refinished after two, four, and six years. The finish was not evaluated after refinishing at two years. Not evaluating the finish systems immediately after they were refinished was an oversight because in many cases the ratings fell below "5" within six months of refinishing. To compare the ratings among the various finish systems, the information on the various plots (such as shown in Figure 3) is tabulated for each of the finishes on each of the substrates. The times (years) that it took for the rating to drop below "5" are tabulated (Table 3A (Madison) and