IMPROVING THE OUTDOOR PERFORMANCE OF FINISHES ON WOOD PANEL PRODUCTS

by W. C. Feist

U. S. Department of Agriculture, Forest Service,
Forest Products Laboratory*, Madison, Wisconsin

INTRODUCTION

The studies described in this report were conducted to study the mechanism of outdoor weathering and document the weathering performance of representative exterior finishing systems on various wood and wood-based substrates representing a selection of currently available traditional and newer siding materials. The effects of pretreatment/finish/substrate interactions and ultraviolet light-blocking characteristics were emphasized. These studies are currently in progress and these comments represent some early findings of long-range exposure tests.

Solid wood and wood-based (composite) panel products represent well over half of the exterior siding (cladding) material used for dwellings and other structures in the United States.

TABLE 1

Exterior Siding in the United States[1]

	Product Shipments--Surface Basis (million ft^2)				
	1982	1981	1980	1979	1978
Hardboard	987	976	963	1,213	1,282
Plywood	816	722	732	925	1,001
Redwood	130	119	135	148	150
Cedar	125	114	131	148	150
Others (Aluminum, Vinyl, Steel, Brick)	1,325	1,592	1,847	2,224	2,322
TOTAL	3,383	3,523	3,808	4,658	4,905

[1]Sources: American Hardboard Assoc., American Plywood Assoc., Western Wood Products Assoc., U. S. Dept. of Commerce

*The Forest Products Laboratory is maintained in cooperation with the University of Wisconsin

In 1982, 2,058,000,000 ft^2 of wood, hardboard, and plywood siding were used on exterior walls (Table 1). These two panel siding products have dominated the siding market for some years in the United States, while the use of solid wood siding has been slowly declining. Many new panel products made from reconstituted wood materials are being introduced in the United States and the world market.

Additional wood products used as exterior siding include solid lumber, waferboard, plywood composites, particleboard composites, and others. All these wood and panel siding materials are usually finished in some way (paint, stain, natural finish) for outdoor weathering protection and for aesthetic effects.

A wide variety of finishes are applied to wood and wood-based siding materials (1). Semitransparent penetrating stain finishes are designed to emphasize wood grain and texture characteristics. Solid color stains (also called opaque, hiding, or heavy-bodied stains) hide wood grain and color while letting texture show. These finishes perform essentially like paints. Two- and three-coat house paints form a highly durable coating in addition to hiding grain and most surface texture. These finish systems offer various degrees of protection for wood and wood panel products against outdoor weathering. Transparent film-forming finishes, such as varnish, provide only minimal protection to exposed wood surfaces.

The water repellents are well known as pretreatments for improving the weathering performance of wood and wood-based products (1,2). The value of the pretreatment of solid wood products with certain inorganic salts, notably those containing hexavalent chromium, has been clearly demonstrated (1). The review in reference (1) lists many publications describing the weathering performance of a range of finishes on reconstituted wood panel products such as plywood, hardboard, and particleboard. Other review papers on wood finishing and wood weathering are also listed.

Despite a relatively large research effort, a great deal of misunderstanding and many misconceptions still exist about the proper finish and the best finishing practices for the individual wood-based products. There is little comparative information about the performance of finish systems or about finish/substrate interactions. Additional complications are caused by the wide range of new finishing materials being applied to the wide range of new wood-based substrates. Problems with substrate/finish durability sometimes result with these new materials. Finish durability problems may also be further compounded by environmental and governmental restrictions on traditional paint and stain systems, as well as by restrictions on some paint additives such as certain heavy metals, mildewcides, and preservatives.

FINISH PERFORMANCE STUDIES

In previous papers (3,4), we studied a number of commercial finishes on several representative wood siding products. The outdoor exposure studies in Madison, Wisconsin, on the performance of several finish systems on four wood-based panel products and one solid wood substrate (4) showed that two- and three-coat finish systems have enhanced protection. The four panel products evaluated (hardboard siding, roughsawn redwood plywood, smooth

Douglas-fir plywood, and aspen waferboard) exhibited different degrees of overall performance. Aspen waferboard had the poorest overall performance, primarily because of particle delamination and the presence of white-rot decay organisms. The best overall performance was found for hardboard siding, especially for opaque paint finish systems. A semitransparent oil stain offered the least protection of all finish systems studied because of its partial transparency to ultraviolet light. Good overall performance of all-acrylic latex finish systems on all substrates was clearly demonstrated. This earlier study was preliminary and prompted many of the studies currently underway (3).

At the Forest Products Laboratory, we have initiated a series of outdoor exposure studies. A wide variety of wood substrates were chosen for these studies (Table 2).

TABLE 2

Substrate Characteristics for Outdoor Exposure Performance Studies

Substrate	Surface Texture	Thickness cm
Western redcedar bevel siding	Smooth planed	1.3
Southern pine bevel siding	Smooth planed	1.3
Aspen waferboard	Smooth	1.1
Hardboard, unprimed	Simulated wood grain	1.0
Douglas-fir plywood	Roughsawn	1.6
Douglas-fir plywood	Smooth sanded	1.6
Southern pine plywood	Roughsawn	1.6
Southern pine plywood	Scratch sanded	1.6
Western redcedar plywood	Roughsawn	1.3
Sweetgum plywood	Roughsawn	1.6

All wood substrates were fastened to panels and exposed vertically on test fences facing south at Madison, Wisconsin (latitude 43°N).

We selected a wide range of commercially available and laboratory prepared finishes and pretreatments for these studies (Table 3). Finish systems comprised of combinations of the individual finishes and/or pretreatments were used as well as individual materials. The materials selected represent finishes currently available (or recommended) for application on wood used in outdoor exposures.

All finishes and pretreatments were brushed on the surface of the wood substrate under ideal laboratory conditions and following all the recommendations provided by the manufacturers, where applicable. Top, side, and bottom edges of all test panels were sealed with the finish or pretreatment itself. Spreading rates were those usually recommended and were determined by direct weighing. All substrate surfaces were wiped with a soft cloth before finishing and between coats. No other special surface preparation was used. All surfaces represented new, unexposed wood.

TABLE 3

Finishes and Pretreatments Used in Outdoor Exposure Studies

Finish or Pretreatment	Source	Color	Solids Content %
Tung oil	Commercial	Transparent	50
Linseed oil	Commercial	Transparent	50
Oiticica oil	Commercial	Transparent	28
Linseed oil + tung oil + phenolic resin	Commercial	Transparent	25
Polyurethane varnish	Commercial	Transparent	53
Water repellent	Laboratory	Transparent	13
Water-repellent preservative (solvent-borne)	Laboratory	Transparent	16
Water-repellent preservative (water-borne)	Commercial	Transparent	4
Pigmented shellac primer (alcohol-borne)	Commercial	White	54
Pigmented shellac primer (water-borne)	Commercial	White	52
Alkyd primer paint	Commercial	White	78
Acrylic latex primer paint	Commercial	White	52
Acrylic latex house paint	Commercial	White	52
Alkyd house paint	Commercial	White	62
Semitransparent oil stain	Labortory	Brown	75
Semitransparent latex stain	Laboratory	Brown	25
Solid color oil stain	Commercial	Lt.brown	60
Solid color latex stain	Commercial	Lt.brown	45
Chromium trioxide	Laboratory	Orange	5
Organochrome complex	Commercial	Green	12

We used different criteria to determine the overall performance ratings of the various pretreatment/finish/substrate systems (3,4). Most of the evaluation methods were based on American Society for Testing and Materials Standards. Both substrate and finish performance were considered. The performance criteria used depended on the substrate type or finish type. Overall performance rating was based on an average of the various elements of discoloration, mildew, substrate performance, finish performance, and general appearance of the system, each evaluated on a 10 to 1 scale. A value of 10 indicated no change from the original unweathered condition, 5 represented an overall condition at which refinishing would be required but without extensive preparation of the substrate surface, and 1 represented total failure.

Completely objective rating observations are difficult to make. For consistency, observations were made by the same person on each occasion, and photographs were used to compare results from year to year. Evaluations were made annually.

SUMMARY AND CONCLUSIONS

The results (3) from our outdoor exposure studies illustrate the performance of a wide range of commercially available finishes on a number of wood siding products currently used in the United States. The effectiveness of commercial pretreatments (primarily water-repellent preservatives) and some laboratory pretreatments in improving finish and substrate performance are described. The finish systems chosen for these studies represent a range of systems of recognized low durability or long-term durability (i.e., systems that are known to last on solid wood only a year or two to those known to last up to 10 years).

These ongoing outdoor exposure studies of the performance of various finish systems on a variety of wood-based panel products and on some representative solid wood substrates clearly illustrate the enhanced protection found with two- and three-coat paint systems. Semitransparent pigmented stains, whether oil or latex, are partially ultraviolet light-transparent and provide less protection to the wood substrate surface than do the paint systems. Solid color stains give a protection and performance intermediate between paints and semitransparent stains. Unpigmented finishes (oils, water-repellent preservatives) give the least protection to the wood surfaces of all the finishes investigated. These unpigmented finishes are not suitable for use on wood panel products because of the small amount of protection they provide.

Two-coat systems, comprised of acrylic latex finishes, exhibit better performance than do alkyd (oil) primer/acrylic latex paint systems. Three-coat systems (one primer plus two topcoats) always gave the best overall performance and provided the greatest degree of protection for the substrate. The acrylic latex primer/acrylic latex topcoat paint systems represent the best overall finish system currently available for use on all the variety of wood substrates included in these studies.

The water repellent and water-repellent preservative pretreatments produce variable results depending upon the substrate, the primer, and the topcoat. Except when used as a pretreatment for a pigmented shellac primer, these water repellents improve the performance of paints on solid wood. Results are variable on plywood and hardboard. The water repellent and water-repellent preservative pretreatments appear to be of some value when used on aspen waferboard.

The chromium-based pretreatments enhance panel properties and weathering performance of semitransparent pigmented stains, oil or latex. The pretreatments stabilize the wood surface against ultraviolet light degradation and also provide a degree of water repellency and inhibition of staining fungi. The pretreatments do not seem to have any marked effect on paint performance.

The commonly used siding products, hardboard and roughsawn plywood, can be finished in ways similar to those used for solid wood. The best performance can be expected by using sufficient coats of quality pigmented finish products. Semitransparent finishes are not very good for these substrates. Less durable substrates such as aspen waferboard may require pretreatment and careful application of quality paint systems. All these results assume that

the siding products will be installed using currently recommended procedures for best performance.

These ongoing outdoor exposure studies show the wide range of performance that will be found for a number of wood and wood-based panel products depending on which pretreatment/primer/finish systems are used. Many new finish materials are being introduced into the commercial market and many new wood composite materials are appearing. These studies emphasize the great range of materials available and used for outdoor siding.

REFERENCES

1. Feist, W. C., and Hon, D. N. -S. 1984. "Chemistry of weathering and protection," In: Chemistry of Solid Wood, R. M. Rowell, Ed. Advances in Chemistry Series No. 207, American Chemical Society, Washington, D.C. pp 401-451.

2. U. S. Department of Agriculture, Forest Service, Forest Products Laboratory. 1974. Wood Handbook: Wood as an Engineering Material. U. S. Department of Agriculture Handbook, No. 72, Washington, D. C.

3. Feist, W. C. 1984. "Weathering interactions on treated and untreated wood surfaces," Proceedings of the Annual Convention of the British Wood Preserving Association, 13-23.

4. Feist, W. C. 1982. "Weathering characteristics of finished wood panel products," Journal of Coating Technology, 54(686):43-50.