United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory

Research
Note
FPL-RN-0255

Delamination Rate of Acrylic-Latex-Finished Urea-Bonded Particleboard in Short-Term Exterior Exposure

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Abstract

Certain oil-based exterior finishes have been shown to protect urea-bonded particleboard for up to 8 years of exterior exposure. The work reported here was undertaken to determine if other currently used exterior finish systems, most notably those using acrylic-latex finishes, could likewise protect urea-bonded particleboard from early delamination. Four paint-finishing systems and two stain-finishing systems were evaluated. Finished panels varied in time to board failure, but none of the finishing systems completely prevented panel delamination and excessive thickness swelling in 3 years of exterior exposure in Madison, WI. Furthermore, all-latex finishing systems (paint systems using latex primer as well as topcoat and a latex stain system) usually resulted in excessive thickness swelling and delamination by 15 months of exposure.

Keywords: Exterior exposure, paint, stain, urea-formaldehyde, particleboard

September 1988

Carll, Charles G. 1988. Delamination rate of acrylic-latex-finished urea-bonded particleboard in short-term exterior exposure. Res. Note FPL-RN-0255. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 7 p.

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Introduction

Urea-bonded particleboard is generally considered unsuitable for exterior exposure because (1) cured urea-formaldehyde resin tends to hydrolyze when exposed to moisture and elevated temperature, and (2) cured urea-formaldehyde adhesive bonds are brittle and thus are unable to accommodate shrink-swell stresses (Dinwoodie 1981). Nevertheless, two studies have reported reasonable longevity of urea-bonded particleboard in exterior exposure. Jokerst (1968) reported that painted urea-bonded flakeboard remained intact and retained fair to high levels of bending strength after 8 years of exterior exposure. The specimens had been dipped in water repellent and painted with oil-based exterior paint; the paint coatings were renewed after 4 years of exposure. Meierhofer and Sell (1977) reported that urea-bonded particleboard maintained its integrity after 33 months of exterior exposure when edge-primed with polychloroprene primer and stained with a semitransparent water-repellent oil-based stain. These studies indicated that urea-bonded particleboard will survive numerous years of exterior exposure if carefully finished with certain finishing systems using oil-based topcoats.

The study reported here was undertaken to identify if acrylic-latex finishing systems, which are relatively easy to apply and remain extensible but are also relatively water-permeable (Feist et al. 1985), are capable of protecting commercial urea-bonded particleboards from early delamination in exterior exposure.

Procedure

Commercial panels graded 1-M-1 by ANSI Standard A208.1 (1979) were used in this study. Two 4- by 8-ft (122- by 244-cm) sheets were purchased at each of three retail outlets in December 1983.[1] Three sets of seven panels (21 panels) were cut from each sheet. Each panel measured 8 by 13 in (20 by 33 cm). One of the seven panels from each set was left unfinished. Each of the remaining six panels was finished with one of six paint- or stain-finishing systems.

Paint-Finishing Systems

Oil-Primed/Latex-Painted

1. Water repellent (wax, linseed oil, and mineral spirits) followed by oil-based, aluminum-flake-pigmented primer and two coats of white acrylic-latex exterior paint.[2]

2. Water repellent followed by oil-based, aluminum-flake-pigmented primer and two coats of dark-gray acrylic-latex exterior paint.

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[1] At this time, industrial efforts were underway in the United States to reduce the formaldehyde emission of this product, often by reducing the molar ratio of formaldehyde to urea in the adhesive resin (compared to the industrial practice prior to 1980).

[2] Formulation of the water repellent used for oil-primed/latex-painted and latex-primed/latex-painted systems is published in Feist and Mraz (1978).

Latex-Primed/Latex-Painted

1. Water repellent followed by acrylic-latex primer and one coat of white acrylic-latex exterior paint.

2. Commercially formulated, waterborne, water-repellent preservative followed by acrylic-latex primer and one coat acrylic-latex exterior paint.

Stain-Finishing Systems

Oil-Stained

Two coats of gray, semitransparent, water-repellent stain (linseed oil base with wax and pentachlorophenol).[3]

Latex-Stained

Waterborne water-repellent preservative followed by two coats of light-gray solid-color acrylic-latex stain.

Pretreatments and finishes were applied by brush to all panel surfaces (faces and edges). Application weights were monitored. A supplementary study was performed to compare brush application to dip application of solventborne water repellent. Brush application resulted in about 80 percent as much wet application weight as would have been obtained on specimens of the same material and size in a 10-s dip treatment (as practiced by Jokerst).

Three of the six replications of each combination of panel supplier and finish system were placed in north-facing vertical exposure on a test fence in Madison, WI. The other three replications were placed on the same fence facing south. A panel facing on the fence shaded north-facing panels from midday sun regardless of time of year. The purpose of this facing was to determine if the temperature history between shaded and unshaded panels would noticeably affect panel longevity. Two different topcoat colors (white and dark gray) were chosen for oil-primed/latex-painted panels to determine if a difference in temperature history resulting from topcoat color would noticeably affect panel longevity.

Panels were mounted with flathead wood screws to vertical wood standards that were in turn attached to the test fence. The screwholes and countersinks for the screwheads were drilled in the panels prior to finish application, and care was taken to apply finish to the tapered countersunk surface. The panels were placed in exterior exposure in June 1984 and were observed every 3 months thereafter for 3 years. Criteria for failure were edge delaminations that exceeded 1/32 in. in width and thickness swelling at the screwhole that exceeded 1/8 in.

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[3]The oil-based stain was the same material (except for color) as that used by Meierhofer and Sell (1977). This FPL-formula stain (Black et al. 1979) was included in the study reported here as a reference to Meierhofer and Sell's work.

Results

Some edge delamination was evident in most unfinished panels by 3 months. Some corner or edge swelling was evident in latex-stained panels by only 3 months of exposure; edge delamination usually occurred by 6 months of exposure. Corner swelling was evident in latex-primed/latex-painted panels by 6 to 9 months and delamination by 12 to 15 months. Of the latex-primed/latex-painted panels, those that were pretreated with the water repellent containing wax, linseed oil, and mineral spirits performed better than those that were pretreated with the waterborne water-repellent preservative. The unfinished panels, latex-stained panels, and latex-primed/latex-painted panels that faced north did not delaminate quite as quickly as similarly finished panels that faced south. A difference between north-facing and south-facing panels was evident at 6, 9, and 12 months of exposure, but this difference decreased after 9 months. By 15 months of exposure, most unfinished, latex-stained, and latex-primed/latex-painted panels had failed because of thickness swelling or edge delamination.

Panels primed with oil-based, aluminum-flake-pigmented paint and oil-stained panels were reasonably sound at 16 months of exposure. The oil-primed/latex-painted panels looked very sound, with the exception of four panels that had corner swelling, swelling at the screwhole, or the beginning of corner delamination. Topcoat color had no apparent effect on longevity of oil-primed/latex-painted panels. Furthermore, there was no apparent difference between the integrity of such panels facing north and those facing south. The oil-stained panels looked reasonably sound but had lost some surface particles, and a few showed corner swelling and the beginning of corner delamination. Oil-stained panels facing south showed slightly more loss of surface particles and corner thickness swelling than those facing north.

At 16 months of exposure, all failed panels and a few unfailed panels were removed from the test fence for side-by-side comparison of edge condition (fig. 1) and for evaluation of equilibrium moisture content at room temperature and 65-percent relative humidity (table 1). Panels finished with different finishing systems showed different equilibrium moisture content, indicating that the moisture content of some panels, particularly unfinished and latex-stained panels, reached a higher level during exposure, and because of hysteresis these panels did not reach as low a level of equilibrium moisture content upon conditioning as that of the other panels.

At 24 and 33 months of exposure, more failed panels were removed from the test fence. The percentage of failed panels at 15, 24, and 33 months of exposure (north and south exposures pooled) for the different finishing systems is shown in figure 2. Panels finished with systems that are recognized as being relatively more effective at moisture exclusion, that is, the water-repellent stain (Black et al. 1979) and the system including oil-based aluminum-flake-pigmented primer (Feist et al. 1985), showed longer times to substrate failure than panels finished with the other systems. Nevertheless, since substrate failure rates with even the most effective finishing systems used in this study exceeded 10 percent after 33 months, none of the systems are particularly dependable for short-term exterior exposure of urea-bonded particleboard panels in the midwestern United States.

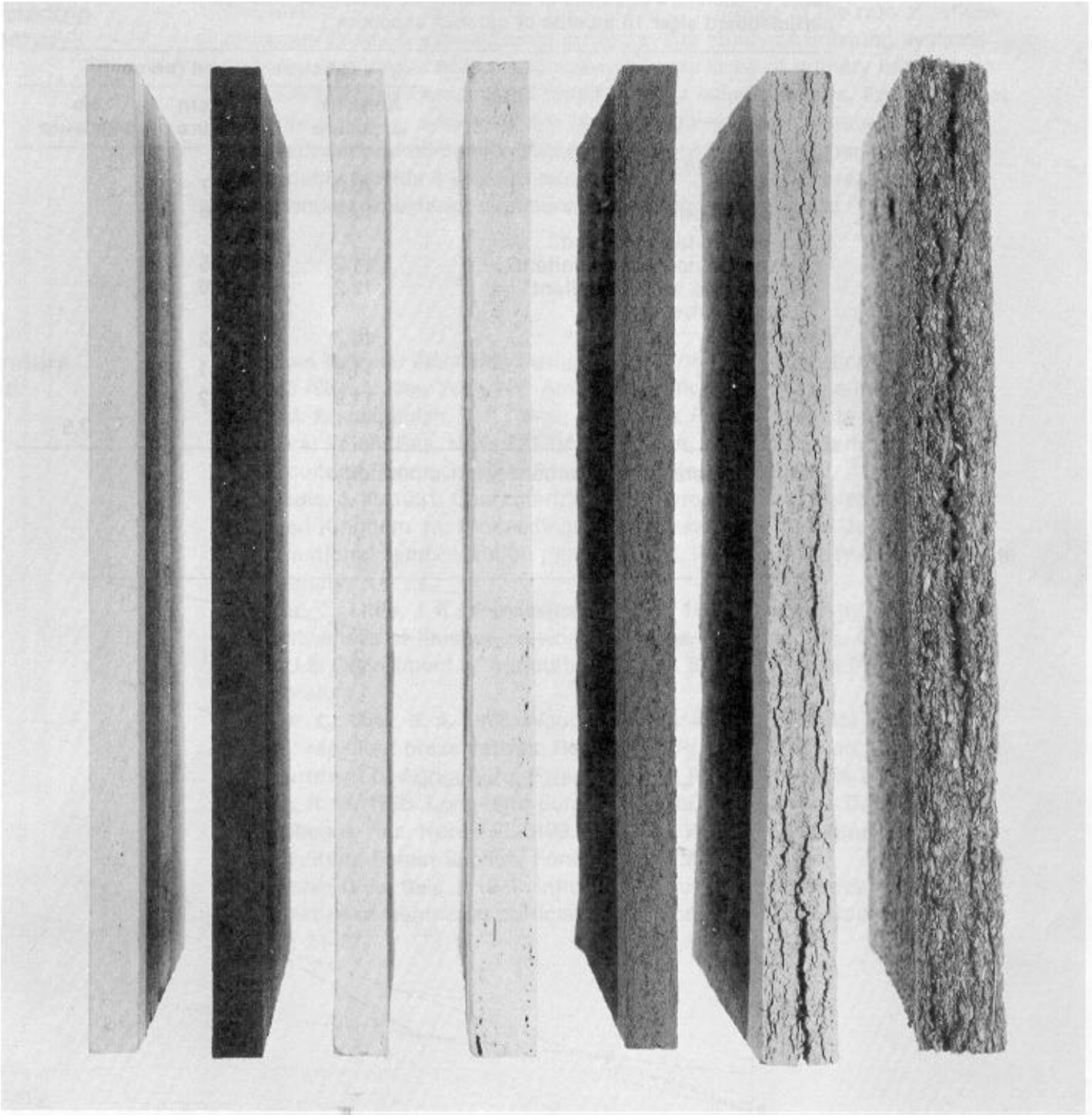

Figure 1—Edge appearance of 8- by 13-in panels removed from north-facing vertical exposure after 16 months of exposure. From left to right: Oil-primed/latex-painted, white paint; oil-primed/latex-painted, dark-gray paint; latex-primed/latex-painted plus water repellent; latex-primed/latex-painted plus waterborne, water-repellent preservative; oil stained; latex stained; and unfinished. (M 86 0069)

Table 1—Moisture contents of reconditioned panels of finished particleboard after 16 months of outdoor exposure

Panels	Moisture content (percent)[1]		
	Northern exposure	Southern exposure	No exposure
Oil-primed/latex-painted			
White paint	10.8	10.7	
Dark-gray paint	10.4	9.8	
Latex-primed/latex-painted			
Solventborne water repellent	11.2	11.5	
Waterborne water-repellent preservative	12.2	12.6	
Oil-stained	10.7	10.2	
Latex-stained	11.9	12.1	
Unfinished	11.9	12.2	
Controls			9.6

[1]Room temperature, 65-percent relative humidity.

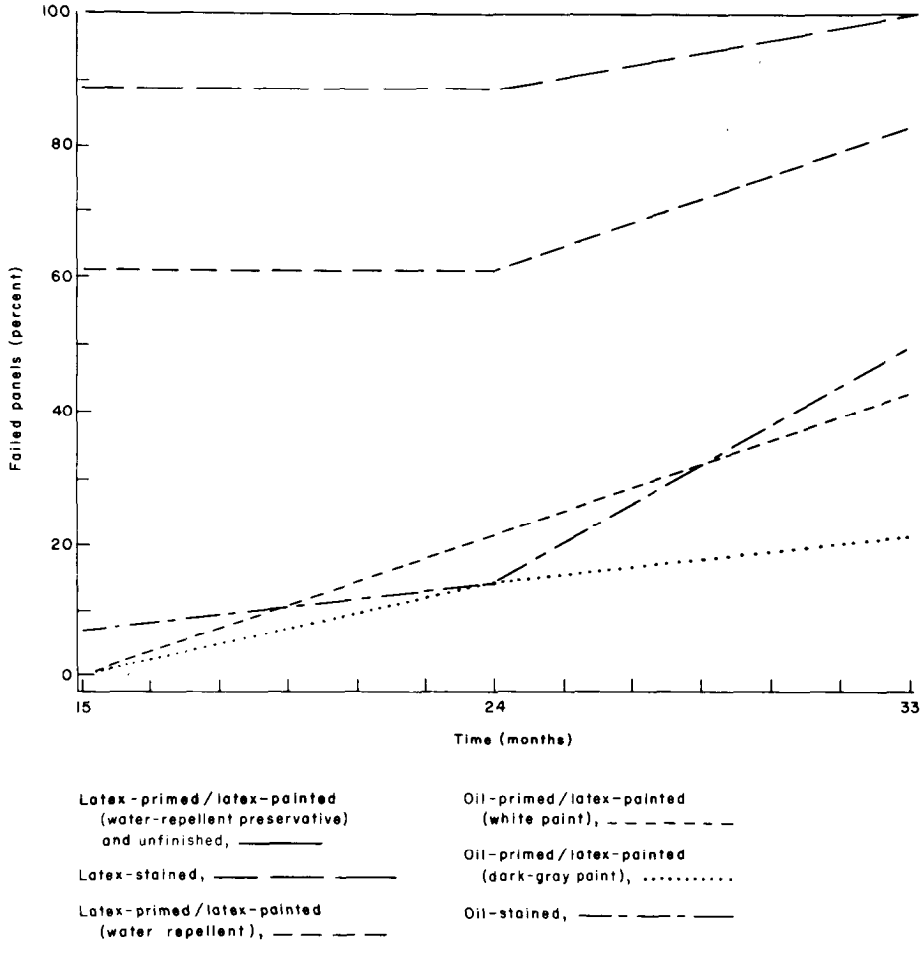

Figure 2—Failure rate for panels (all suppliers; north and south exposures pooled) at 15, 24, and 33 months of exterior exposure. (ML88 5451)

Concluding Remarks

The results of this study show substantial differences in the rate of failure of panels finished with different systems. The ability of finishing systems to seal panel edges from liquid water appears to be of primary importance and overshadows variations in finish color or solar exposure. Even the most effective finishing system (which included solventborne water-repellent pretreatment and oil-based, aluminum-flake-pigmented primer) did not dependably provide 3 years of service life for commercial urea-bonded particleboard in exterior exposure in the midwestern United States.

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