# PROTECTING WOOD DECKS FROM BIODEGRADATION AND WEATHERING: EVALUATION OF DECK FINISH SYSTEMS

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## ABSTRACT

Mildew resistance, water repellency, and overall finish appearance were evaluated for 32 deck finishes on western redcedar (*Thuja plicata* D. Donn.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) after 12, 21, and 39 months of outdoor exposure in western Oregon. The finishes were either solvent-borne or waterborne; were either clear, tinted, or lightly pigmented; and were, in general, formulated to penetrate the wood surface. Mildew resistance was generally good for most of the finishes through the 21-month evaluation. Water repellency was fair at the 12-month evaluation, but in almost all cases had disappeared after 21 months. Overall appearance varied considerably for the finishes. Clear finishes generally were in only fair condition after 12 months; however, several tinted and lightly pigmented finishes were in good condition after 21 months. All finishes were in poor condition after 39 months. Service lives of these finish types can be extended to the 2-year range, but additional research and development is needed to achieve a longer service life. Given the low solids content and transparent nature of these finish types, a 2- to 3-year service life should be considered excellent in a fully exposed horizontal exposure.

Wood is widely used in aboveground exposures for decking (6). While many homeowners build decks using wood that has been pressure-treated with preservatives, others prefer using naturally durable wood species such as western redcedar or redwood (8, 10). However, other wood species, such as Douglas-fir, which have only moderate natural decay resistance, are also sometimes used in aboveground outdoor applications (7). The wood surfaces of decks are exposed to wetting by rain, dew, or snow; ultraviolet (UV) radiation from sunlight, and repeated abrasion from foot traffic and furniture (5). Water often forms pools on the surface, thus increasing the opportunity for water absorption, leaching of extractives, and microbial activity. These conditions lead to degradation of the wood by weathering and decay. Whether pressure-treated with preservatives or from a naturally durable species, the wood will last longer if it is regularly treated with finishes that increase water repellency, decrease cracking, splitting, and weathering, and inhibit microbial growth (6). Since the finishes are subjected to the same harsh conditions as the wood, the service life of clear or lightly tinted finishes has been only 1 to 2 years.

Finishes for use on decks have traditionally been formulated with mineral spirits or similar organic solvents, a preservative, a water repellent, and a small amount of drying oil as the binder. Such finishes are usually referred to as water-repellent preservatives (WRPs). WRPs lack a pigment, and their service lives are typically a year or less when used on fully exposed horizontal surfaces. These finishes increase the durability and appearance of the wood when used annually, but their limited service life has prompted many finish manufacturers to attempt to develop longer-lasting products.

Although finish service life could be increased to 4 to 5 years by adding inorganic pigments to the WRP formulation to give a solvent-borne semitransparent stain, this kind of finish largely obscures the natural characteristics of the wood. Therefore, during the late 1980s and

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*TABLE 1. - Sources and characteristics of finishes evaluated on western redcedar and Douglas-fir decks.*

| Carrier | Finish type[a] | Formulation | Source[b] | VOC[c] | %solids | %$H_2O$ | kg/L | Active ingredient[d] |
|---|---|---|---|---|---|---|---|---|
| Oil[e] | -;-;C | Benjamin-Moore CWP 1147-195E | a | 0 | 39.2 | < 0.5 | 0.86 | - - |
| Oil | -;-;- | Benjamin Moore 1152-187A (NonVac) | a | 0 | 33.3 | < 0.5 | 0.90 | - - |
| Oil | -;-;T | ISK Deck Care | b | - - | 96.1 | 0.8 | 0.88 | - - |
| Solvent[f] | R;P;T | Cuprinol #10 WP | c | 550 | 34.6 | 0 | 0.85 | CuNaph (2.2% as Cu) |
| Solvent | R;P;C | DAP Premium Woodlife | d | 686 | 1.3 | < 0.5 | 0.80 | 0.2% MBT, 0.2% TCMTB |
| Solvent | R;P;C | DAP Solvent WRP | d | - - | 9.9 | 0 | 0.78 | 0.25% propiconazole, 0.25% IPBC |
| Solvent | R;P;C | DAP Woodlife Preservative | d | 745 | 6.5 | < 0.5 | 0.78 | 0.5% IPBC |
| Solvent | R;P;C | DAP Woodlife WP | d | 740 | 0.6 | < 0.5 | 0.78 | 0.6% propiconazole |
| Solvent | R;P;C | Olympic Clear WP | e | - - | 9.6 | 0 | 0.79 | - - |
| Solvent | R;-;T | Penofin Cedar | f | - - | 25.0 | - - | - - | - - |
| Solvent | R;-;C | Penofin Clear | f | - - | 25.0 | - - | - - | - - |
| Solvent | R;P;C | Penta (5%) | - - | - - | 16.0 | < 0.5 | 0.90 | 5% pentachlorophenol |
| Solvent | -;-;- | PPG 51760 | e | > 400 | 10.5 | 0 | 0.79 | - - |
| Solvent | -;P;C | PPG 51787 | e | - - | 9.5 | < 0.5 | 0.80 | - - |
| Solvent | R;P;T | PPG 57619 | e | 550 | 39.1 | < 0.5 | 0.89 | - - |
| Solvent/oil | R;P;T | Amteco TWP 301 | g | 347 | 60.6 | < 0.5 | 0.93 | IPBC |
| Solvent/oil | -;-;- | Benjamin-Moore 1152-187B-550Vd | a | 550 | 42.9 | < 0.5 | 0.95 | - - |
| Solvent/oil | -;-;T | Benjamin-Moore 1152-187F | a | 350 | 65.2 | < 0.5 | 0.97 | - - |
| Solvent/oil | R;-;Pg | Cabot Stains 3000 | h | < 550 | 36.4 | 0 | 0.86 | - - |
| Solvent/oil | -;-;Pg | Cabot Stains 7433 | h | < 350 | 67.1 | < 0.5 | 0.95 | - - |
| Solvent/oil | R;P;T | ISK Wood Guard | b | < 350 | 79.9 | < 0.5 | 0.89 | 0.7% Cu-8 |
| Solvent/oil | -;-;Pg | Olympic Deck | e | 550 | 38.7 | < 0.5 | 0.88 | 0.5% TBTO, 0.5% folpet |
| Solvent/oil | R;P;Pg | Wolman CWF | i | 375 | 63.9 | 3.6 | 0.87 | 0.5% IPBC |
| Water | R;P;T | Burkes WB Deck Stain | j | - - | 7.1 | 97.4 | 0.98 | 1% TBTO |
| Water | R;P;T | Cuprinol CWP | c | 350 | 9.9 | 84.0 | 1.00 | 0.5% IPBC |
| Water | R;P;T | Cuprinol New Look WF | c | 380 | 12.2 | 81.6 | 1.01 | - - |
| Water | -;-;C | PPG 51775 | e | 0 | 15.6 | 81.0 | 1.01 | - - |
| Water | R;-;T | Rhinoguard | k | 0 | 28.6 | 71.1 | 0.98 | - - |
| Water | R;-;C | Thompsons WS Ultra | l | - - | 9.0 | 94.3 | 0.97 | - - |
| Water | -;-;C | Weather-Bos F1 Clear | m | 277 to 290 | 13.8 | 81.1 | 1.01 | - - |
| Water | -;-;T | Weather-Bas F1 Redcedar | m | 277 to 290 | 14.1 | 80.3 | 1.01 | - - |
| Water | R;P;C | Wolman Raincoat Clear WR | i | 375 | 9.0 | 84.8 | 1.00 | 0.5% IPBC |
| Water | R;P;T | Wolman Raincoat WR Toner | i | 300 | 12.5 | 81.6 | 1.01 | 0.5% IPBC |

[a] R = water repellent; P = preservative present; pigmentation is coded as clear (C), tinted (T), pigmented (Pg), or not listed on finish label (-).

[b] a = Benjamin Moore and Co., Newark, NJ; b = ISK Biosciences, Memphis, TN; c = Danworth Co., Avon, CT; d = DAP/Kop-Coat, Pittsburgh, PA; e = PPG Industries, Springdale, PA; f = Performance Coatings, Ukiah, CA; g = Amteco Inc., St. Louis, MO; h = Cabot Stain, Newburg, MA; i = KopCoat, Pittsburgh, PA; j = Burke's Protective Coatings; k = Silverton Products Inc., Ontario, CA, 1 = Thompson and Formby Inc., Memphis, TN; m = Weather Bos Stains and Paint, Reno, NV.

[c] Volatile organic compounds.

[d] IPBC = 3-iodo-2-propynyl butylcarbamate, CuNaph = coppernaphthenate; TBTO = Bis (tri-n-butyl tin) oxide; Cu-8 = copper-8-quinolinolate, MBT = methylene bisthiocyanate, and TCMTB = 3-(thiocyanomethylthio) benzothiazole.

[e] Oils may be drying oils, such as linseed oil or alkyds, or non-drying oils, such as mineral oil.

[f] Solvent = organic solvent, such as mineral spirits, turpentine, or naphtha.

early 1990s, a large number of alternate finishes were developed. Many of these finishes contained chemicals to inhibit degradation by UV radiation or were lightly tinted to improve their service life without obscuring the character of the wood, or both. At the same time, waterborne finishes were also developed, and solvent amounts in many formulations were decreased to meet environmental regulations. Thus, a wide variety of finishes for decks is now available, but little comparative performance information is available concerning their efficacy (4,5,11). One recent survey did show that only a few finish products provided more than 1 year of protection to wood decks (3).

In this paper, we describe comparative field exposures of 32 commercially available deck finishes and a 5 percent pentachlorophenol/pararaffin water-repellent preservative formulation on western redcedar (*Thuja plicata* D. Donn.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco).

## MATERIALS AND METHODS

Defect-free western redcedar and Douglas-fir nominal heartwood lumber 50 by 100 mm was cut into 300- and 600-mm-long pieces. No attempt was made to select a particular grain angle, but most of the lumber was flat-grained.

These pieces were used to construct small (600 by 600 mm) deck units on hem-fir frames treated with chromated copper arsenate to a retention of 4 kg/m$^3$, as recommended by the American Wood Preserver's Association Standard C2 (2). Each deck contained three 600-mm-long pieces and six 300-mm-long pieces, which were staggered to give three butt joints on each deck. The pieces were attached to the frame using hot-dipped galvanized nails. Each deck was divided in half so that one half of the surface area was treated with one finish and the other half with a different finish. Each finish was replicated randomly on three decks per wood species.

The finishes used and their characteristics are listed in **Table 1.** The percentage of solids was determined according to American Society of Testing and Materials Standard D 2369-90 (1). All other information in **Table 1** was obtained from the finish label and data sheet supplied by the manufacturer. Finishes were applied by brush-flooding the top surface of the decking boards. After allowing the finish to absorb for about 20 seconds, the excess was brushed from the surface. Exposed end grains were painted twice in this manner. Finish spreading rates for each board were determined by weighing the brush and container before and after spreading each board. These data were later combined for each deck and averaged over the three deck sections for each species/treatment combination. The various commercial formulations were compared with untreated controls as well as a 5 percent pentachorophenol plus paraffin comparator.

The decks were conditioned outdoors under cover for 30 days prior to field exposure to allow residual solvent to evaporate.

The decks were exposed approximately 0.6 m above the ground at a site that receives approximately 1,050 mm of rainfall annually, with 8 1 percent falling between October and March. Average monthly temperature ranges from 4° to 30°C (39° to 86°F), with occasional frosts or temperatures above 32°C (90°F). The site has a Scheffer climate index of approximately 45 (9).

The condition of the decks and their respective finishes was assessed on a visual basis after 12, 21, 39, and 43 months of exposure. Mildew growth on the deck surface was evaluated on a scale from 10 (no evidence of mildew) to 0 (surface completely covered with mildew). Water repellency was assessed by spraying the deck surface with water and observing the extent of water beading. Beading was rated as 10 (rounded beads of water), 8 (convex bead), 5 (water flat on the surface), or 1 (complete wetting). While beading is just one measure of water repellency, it provided a rapid, field-practical method for assessing overall repellency. Water repellency was evaluated only when the decks had not been exposed to rainfall for at least 10 days. This restriction sometimes made it difficult to coordinate the mildew and general appearance evaluations with the water repellency evaluations, particularly during the wet winter months. The general appearance of the finish (general finish condition) was assessed using a scale from 10 (the finish was completely intact) to 0 (no evidence of the finish). A rating of 5 would indicate the condition of the finish when the deck should be refinished, or the useful service life of the finish.

## RESULTS AND DISCUSSION

Clear or lightly tinted or pigmented finishes generally do not last nearly as long as highly pigmented stains and paints when fully exposed to the weather. Many finish formulators are striving to improve the service life of these types of finishes; given the state of the technology when this study was started (1992), a service life of 2 years was considered acceptable. The mildew, water repellency, and general finish condition evaluations for the various finishes are listed for western redcedar (Table 2) and for Douglas-fir (Table 3). Correlations between formulation parameters such as carrier pigment, preservative, volatile organic compound (VOC) ratings, and deck appearance were generally poor ($r < 0.5$) (data not shown). These poor correlations may reflect the preponderance of so-called “inerts” in many formulations that can improve performance but have little to do with preservative efficacy.

### MILDEW

Fungal (mildew), algal, or lichen growth on deck surfaces can diminish the appearance of finishes and is often the reason given for their failure. No algal or lichen growth was observed after 21 months of exposure, but there were varying amounts of mildew growth. Mildew growth generally does not indicate that the UV protection or water repellency of a finish has failed, but greatly affects the appearance rating of a finish system. Almost all finishes had mildew ratings of 5 or greater after 21 months; however, because of the importance of mildew to the appearance of decks, we considered 8 an acceptable rating. For western redcedar, 10 finishes had ratings of 8 or better after 21 months, whereas only 6 finishes had this rating on Douglas-fir. Those finishes that had mildew ratings of 8 or more after 21 months also tended to have good general finish condition ratings, reflecting the tendency for mildew to dominate that assessment.

In general, mildew ratings were higher on western redcedar than on Douglas-fir. We do not have an explanation for this difference. However, the results of this study suggest that Douglas-fir requires slightly more effort to keep it free of mildew than does western redcedar in the wet climate of western Oregon.

### WATER REPELLENCY

Water repellency is an important characteristic for deck finishes. Wood that remains dry or that dries quickly after it becomes wet is less likely to develop decay or mildew (12). In addition, water repellents decrease the amount of water absorbed by wood, thus decreasing surface checking, splitting, and warping. We considered a rating of 5 a minimum water repellency value on exposed wood surfaces. About half of the finishes provided this level of protection for 12 months (16 finishes on western redcedar and 14 on Douglas-fir), but very few finishes showed any water repellency after 21 months. There appeared to be little difference in water repellent performance between the two wood species. The absence of differences probably reflects the tendency for water repellency to be a surface characteristic of a finish. Thus, anatomical differences between the two wood species that might affect other performance features are probably of less importance to water repellency.

One of the surprising results was the inconsistency between water repellency at 12 months and the overall performance of the finish. Loss of water repellency did not necessarily mean that the finish had lost its ability to protect against UV degradation. For example,

*TABLE 2. - Condition of western redcedar decks treated with selected deck finishes and exposed aboveground in western Oregon for 43 months*[a]

| Carrier | Formulation | Initial solution uptake | Mildew[b] | | Water repellency[c] | | | General finish condition[d] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 12 mo. | 21 mo. | 0 mo. | 12 mo. | 21 mo. | 43 mo. | 12 mo. | 21 mo. | 39 mo. |
| | | ($g/m^2$) | | | | | | | | | |
| Oil[e] | Benjamin-Moore CWP 1147-195E | 122.6 (10.0) | 5 (1) | 7 (0) | 8 (0) | 1 (0) | 1 (0) | 1 (0) | 4 (1) | 5 (1) | 1 (1) |
| Oil | Benjamin Moore 1152-187A (NonVac) | 150.7 (3.0) | 10 (0) | 7 (1) | 5 (0) | 1 (0) | 1 (0) | 1 (0) | 9 (0) | 6 (1) | 2 (0) |
| Oil | ISK Deck Care | 202.3 (10.6) | 7 (1) | 6 (1) | 7 (1) | 7 (1) | 1 (0) | 1 (0) | 5 (1) | 3 (1) | 2 (1) |
| Solvent[f] | Cuprinol #10 WP | 217.9 (34.4) | 9 (1) | 9 (1) | 9 (1) | 5 (0) | 1 (0) | 1 (0) | 6 (0) | 7 (0) | 1 (0) |
| Solvent | DAP Premium Woodlife | 205.0 (24.2) | 9 (0) | 6 (1) | 9 (0) | 1 (0) | 1 (0) | 1 (0) | 5 (0) | 5 (2) | 0 (0) |
| Solvent | DAP Solvent WRP | 188.8 (15.2) | 9 (0) | 7 (0) | 5 (3) | 2 (2) | 1 (0) | 1 (0) | 5 (0) | 6 (1) | 1 (1) |
| Solvent | DAP Woodlife Preservative | 184.9 (14.8) | 7 (1) | 7 (1) | 7 (1) | 2 (2) | 1 (0) | 1 (0) | 4 (0) | 6 (1) | 1 (0) |
| Solvent | DAP Woodlife WP | 217.3 (26.5) | 9 (0) | 8 (1) | 5 (3) | 1 (0) | 1 (0) | 1 (0) | 5 (0) | 5 (1) | 0 (0) |
| Solvent | Olympic Clear WP | 139.7 (10.4) | 4 (0) | 5 (1) | 10 (0) | 5 (0) | 1 (0) | 1 (0) | 4 (0) | 5 (1) | 1 (1) |
| Solvent | Penofin Cedar | 142.6 (9.7) | 7 (1) | 7 (1) | 4 (2) | 1 (0) | 1 (0) | 1 (0) | 7 (1) | 5 (1) | 2 (1) |
| Solvent | Penofin Clear | 176.8 (33.7) | 2 (0) | 4 (1) | 1 (0) | 1 (0) | 1 (0) | 1 (0) | 2 (0) | 3 (1) | 1 (1) |
| Solvent | Penta (5%) | 201.3 (7.5) | 9 (1) | 7 (1) | 10 (0) | 9 (1) | 1 (0) | 1 (0) | 6 (0) | 6 (1) | 0 (0) |
| Solvent | PPG 51760 | 162.3 (26.0) | 9 (0) | 8 (1) | 10 (0) | 6 (4) | 9 (1) | 1 (0) | 5 (0) | 8 (1) | 1 (0) |
| Solvent | PPG 51787 | 209.6 (9.4) | 9 (1) | 8 (1) | 10 (0) | 9 (1) | 1 (0) | 1 (0) | 5 (0) | 8 (1) | 1 (1) |
| Solvent | PPG 57619 | 165.9 (5.4) | 10 (0) | 8 (1) | 9 (1) | 7 (2) | 1 (0) | 1 (0) | 9 (0) | 8 (1) | 3 (1) |
| Solvent/oil | Amteco TWP 301 | 170.1 (3.6) | 9 (1) | 9 (0) | 9 (1) | 5 (0) | 1 (0) | 1 (0) | 7 (0) | 8 (1) | 2 (1) |
| Solvent/oil | Benjamin-Moore 1152-187B-550Vd | 156.0 (16.1) | 10 (0) | 8 (1) | 6 (1) | 4 (2) | 1 (0) | 1 (0) | 9 (2) | 7 (1) | 3 (1) |
| Solvent/oil | Benjamin-Moore 1152-187F | 140.4 (37.4) | 10 (0) | 8 (0) | 4 (2) | 2 (2) | 1 (0) | 1 (0) | 9 (0) | 7 (1) | 2 (1) |
| Solvent/oil | Cabot Stains 3000 | 177.4 (8.3) | 7 (0) | 7 (1) | 10 (0) | 1 (0) | 1 (0) | 1 (0) | 6 (1) | 4 (2) | 1 (0) |
| Solvent/oil | Cabot Stains 7433 | 150.2 (5.8) | 8 (0) | 7 (1) | 10 (0) | 1 (0) | 1 (0) | 1 (0) | 7 (1) | 4 (1) | 1 (1) |
| Solvent/oil | ISK Wood Guard | 199.2 (4.9) | 9 (0) | 7 (1) | 8 (0) | 6 (1) | 1 (0) | 1 (0) | 6 (0) | 3 (0) | 1 (0) |
| Solvent/oil | Olympic Deck | 155.9 (3.6) | 9 (1) | 7 (1) | 9 (1) | 1 (0) | 1 (0) | 1 (0) | 8 (0) | 7 (1) | 1 (1) |
| Solvent/oil | Wolman CWF | 160.0 (19.5) | 9 (0) | 5 (1) | 9 (1) | 8 (0) | 1 (0) | 1 (0) | 7 (0) | 3 (1) | 0 (0) |
| Water | Burkes WB Deck Stain | 153.4 (23.2) | 8 (1) | 6 (1) | 9 (1) | 2 (2) | 1 (0) | 1 (0) | 5 (0) | 5 (1) | 1 (1) |
| Water | Cuprinol CWP | 222.5 (26.7) | 7 (0) | 7 (1) | 9 (1) | 8 (0) | 1 (0) | 1 (0) | 4 (0) | 6 (1) | 0 (0) |
| Water | Cuprinol New Look WF | 177.0 (15.2) | 10 (0) | 9 (1) | 6 (1) | 8 (0) | 5 (3) | 1 (0) | 6 (0) | 8 (1) | 2 (1) |
| Water | PPG 51775 | 210.7 (8.9) | 6 (1) | 5 (1) | 10 (0) | 8 (0) | 1 (0) | 1 (0) | 4 (0) | 4 (1) | 1 (1) |
| Water | Rhinoguard | 176.3 (13.2) | 7 (0) | 6 (1) | 1 (0) | 1 (0) | 1 (0) | 1 (0) | 8 (0) | 6 (1) | 1 (1) |
| Water | Thompsons WS Ultra | 156.2 (9.7) | 8 (1) | 5 (1) | 9 (1) | 9 (1) | 9 (1) | 1 (0) | 5 (1) | 5 (1) | 2 (1) |
| Water | Weather-Bos F1 Clear | 180.7 (7.6) | 4 (1) | 6 (0) | 2 (2) | 1 (0) | 1 (0) | 1 (0) | 4 (0) | 4 (1) | 1 (0) |
| Water | Weather-Bos F1 Redcedar | 188.9 (4.8) | 6 (0) | 7 (1) | 2 (2) | 1 (0) | 1 (0) | 1 (0) | 5 (2) | 4 (1) | 1 (0) |
| Water | Wolman Raincoat Clear WR | 157.4 (8.9) | 4 (0) | 5 (1) | 9 (1) | 9 (1) | 1 (0) | 1 (0) | 4 (0) | 4 (1) | 0 (0) |

[a]Values represent means of 12 to 15 boards on each of three decks per treatment. Numbers in parentheses represent one standard deviation.
[b]Ratings range from 10 (no evidence of fungal growth) to 0 (complete fungal coverage).
[c]Ratings range from 10 (high repellency) to 1 (none).
[d]Ratings range from 10 (excellent condition) to 0 (completely discolored).
[e]Oils may be drying oils, such as linseed oil or alkyds, or non-drying oils, such as mineral oil.
[f]Solvent = organic solvent, such as mineral spirits, turpentine, or naphtha.

Rhinoguard and Benjamin Moore Deck Stains 1152-187A, B, and F had little water repellency, but showed very good general performance (8 or better) after 12 months of exposure. These formulations contained higher solids contents that apparently improved their resistance to UV degradation. In contrast, some formulations that gave very good water repellency did not provide much protection against UV degradation. A few formulations gave excellent water repellency (8 to 9 rating) after 12 months of exposure, but were at the limit of their service life (4 to 5 rating for general appearance) after the same exposure (Wolman Raincoat Clear WR, Thompsons WS Ultra, and PPG 51775). All were clear formulations with low solids contents. Obviously, water repellency is but one component of outdoor finish performance. Service life depends on protection against UV radiation as well as water repellency.

#### GENERAL FINISH CONDITION

We considered a rating of 5 for the general finish condition to indicate the useful service life of the finish; after 12 months, 25 of the 32 finishes were rated 5 or better for western redcedar and 26 were so rated for Douglas-fir. After 21 months, 23 of the 32 finishes were rated 5 or better for western redcedar and 12 were so rated for Douglas-fir. A few finishes were still in very good condition (8 or better) after 21 months: 5 on western

***TABLE 3. —*** *Condition of Douglas-fir decks treated with selected deck finishes and exposed aboveground in western Oregon for 43 months.*[a]

| Carrier | Formulation | Initial solution uptake | Mildew[b] | | Water repellency[c] | | | General finish condition[d] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 12 mo. | 21 mo. | 0 mo. | 12 mo. | 21 mo. | 43 mo. | 12 mo. | 21 mo. | 39 mo. |
| | | ($g/m^2$) | | | | | | | | | |
| Oil[e] | Benjamin-Moore CWP 1147-195E | 149.1(11.0) | 4(1) | 7(1) | 8(0) | 1(0) | 1(0) | 1(0) | 4(0) | 4(0) | 0(0) |
| Oil | Benjamin Moore 1152-187A (NonVac) | 156.6(29.4) | 9(0) | 7(1) | 5(0) | 2(2) | 1(0) | 1(0) | 8(0) | 4(1) | 3(1) |
| Oil | ISK Deck Care | 210.4(15.0) | 7(0) | 7(1) | 7(1) | 5(0) | 1(0) | 1(0) | 6(0) | 4(1) | 1(1) |
| Solvent[f] | Cuprinol #10 WP | 222.5(33.1) | 9(0) | 7(1) | 6(4) | 4(2) | 1(0) | 1(0) | 6(0) | 5(1) | 3(1) |
| Solvent | DAP Premium Woodlife | 212.6(28.2) | 8(0) | 6(1) | 8(0) | 1(0) | 1(0) | 1(0) | 5(0) | 3(1) | 1(1) |
| Solvent | DAP Solvent WRP | 169.8(34.3) | 8(1) | 7(1) | 5(3) | 1(0) | 1(0) | 1(0) | 5(0) | 3(1) | 1(1) |
| Solvent | DAP Woodlife Preservative | 241.1(17.4) | 7(0) | 8(0) | 5(0) | 1(0) | 1(0) | 1(0) | 4(0) | 5(1) | 0(0) |
| Solvent | DAP Woodlife WP | 225.3(3.8) | 9(0) | 7(1) | 5(3) | 1(0) | 1(0) | 1(0) | 5(0) | 4(1) | 0(0) |
| Solvent | Olympic Clear WP | 181.7(11.7) | 5(0) | 5(1) | 9(1) | 7(1) | 1(0) | 1(0) | 4(0) | 2(1) | 0(0) |
| Solvent | Penofin Cedar | 181.3(48.6) | 8(1) | 6(0) | 4(2) | 1(0) | 1(0) | 1(0) | 8(0) | 4(1) | 1(1) |
| Solvent | Penofin Clear | 179.2(12.9) | 2(1) | 2(1) | 4(2) | 1(0) | 1(0) | 1(0) | 2(1) | 1(1) | 0(0) |
| Solvent | Penta (5%) | 213.4(3.7) | 9(0) | 7(1) | 9(1) | 9(1) | 3(3) | 1(0) | 5(0) | 6(1) | 1(0) |
| Solvent | PPG 51760 | 163.1(20.0) | 7(2) | 6(1) | 10(0) | 10(0) | 3(3) | 1(0) | 5(1) | 3(1) | 0(0) |
| Solvent | PPG 51787 | 176.8(18.0) | 9(0) | 7(2) | 10(0) | 9(1) | 1(0) | 1(0) | 5(0) | 3(1) | 1(1) |
| Solvent | PPG 57619 | 172.5(5.6) | 10(0) | 8(1) | 9(1) | 2(2) | 1(0) | 1(0) | 9(0) | 7(1) | 2(1) |
| Solvent/oil | Amteco TWP 301 | 192.9(7.7) | 9(1) | 9(1) | 9(1) | 5(0) | 1(0) | 1(0) | 8(1) | 8(1) | 2(1) |
| Solvent/oil | Benjamin-Moore 1152-187B-550Vd | 162.1(29.1) | 9(0) | 8(0) | 8(2) | 4(2) | 1(0) | 1(0) | 8(0) | 6(1) | 3(1) |
| Solvent/oil | Benjamin-Moore 1152-187F | 151.8(15.1) | 10(0) | 8(0) | 4(2) | 2(2) | 1(0) | 1(0) | 8(0) | 7(1) | 2(1) |
| Solvent/oil | Cabot Stains 3000 | 183.1(20.7) | 8(1) | 5(2) | 8(2) | 4(2) | 1(0) | 1(0) | 7(1) | 3(1) | 0(0) |
| Solvent/oil | Cabot Stains 7433 | 172.8(31.4) | 8(0) | 4(1) | 7(4) | 4(2) | 1(0) | 1(0) | 7(1) | 3(1) | 1(1) |
| Solvent/oil | ISK Wood Guard | 212.0(22.2) | 6(1) | 7(1) | 7(1) | 1(0) | 1(0) | 1(0) | 5(0) | 3(1) | 1(1) |
| Solvent/oil | Olympic Deck | 163.9(5.3) | 9(0) | 7(1) | 10(0) | 4(2) | 1(0) | 1(0) | 8(1) | 7(1) | 2(1) |
| Solvent/oil | Wolman CWF | 185.8(23.4) | 8(0) | 6(1) | 9(1) | 8(0) | 1(0) | 1(0) | 7(1) | 3(1) | 0(0) |
| Water | Burkes WB Deck Stain | 133.0(11.9) | 7(2) | 5(2) | 9(1) | 5(0) | 1(0) | 1(0) | 6(2) | 4(2) | 0(0) |
| Water | Cuprinol CWP | 232.7(12.0) | 8(0) | 6(1) | 9(1) | 9(1) | 1(0) | 1(0) | 5(0) | 5(1) | 0(0) |
| Water | Cuprinol New Look WF | 200.6(9.6) | 9(0) | 8(1) | 8(2) | 9(1) | 1(0) | 1(0) | 8(0) | 6(1) | 3(1) |
| Water | PPG 51775 | 227.9(3.0) | 7(1) | 5(1) | 10(0) | 9(1) | 1(0) | 1(0) | 4(0) | 3(2) | 0(0) |
| Water | Rhinoguard | 194.5(16.0) | 6(1) | 6(1) | 1(0) | 2(2) | 1(0) | 1(0) | 7(0) | 5(1) | 0(0) |
| Water | Thompsons WS Ultra | 168.1(11.0) | 6(2) | 3(9) | 9(1) | 10(0) | 6(4) | 1(0) | 4(1) | 2(1) | 0(0) |
| Water | Weather-Bos F1 Clear | 182.1(12.2) | 6(1) | 4(1) | 1(0) | 1(0) | 1(0) | 1(0) | 4(0) | 4(1) | 0(0) |
| Water | Weather-Bos F1 Redcedar | 193.4(22.0) | 7(1) | 7(1) | 7(4) | 1(0) | 1(0) | 1(0) | 6(1) | 4(1) | 0(0) |
| Water | Wolman Raincoat Clear WR | 136.6(8.0) | 6(0) | 5(1) | 10(0) | 9(1) | 1(0) | 1(0) | 5(1) | 3(1) | 0(0) |
| Water | Wolman Raincoat WR Toner | 243.8 (27.5) | 8(0) | 7(1) | 10(0) | 10(0) | 9(1) | 1(0) | 8(0) | 5(1) | 2(0) |

[a]Values represent means of 12 to 15 boards on each of three decks per treatment. Numbers in parentheses represent one standard deviation.
[b]Ratings range from 10 (no evidence of fungal growth) to 0 (complete fungal coverage).
[c]Ratings range from 10 (high repellency) to 1 (none).
[d]Ratings range from 10 (excellent condition) to 0 (completely discolored).
[e] Oils may be drying oils, such as linseed oil or alkyds, or non-drying oils, such as mineral oil.
[f]Solvent = organic solvent, such as mineral spirits, turpentine, or naphtha.

redcedar and 1 on Douglas-fir. All of the finishes had failed after 39 months.

Finish performance after the 12 months of exposure appeared to be similar for western redcedar and Douglas-fir; however, after 21 months of exposure, western redcedar seemed to give better performance than Douglas-fir (23 finishes were rated 5 or better for western redcedar, versus 12 finishes for Douglas-fir). The lower evaluations for the Douglas-fir reflect the greater tendency of this species to weather and develop surface checking.

Evaluations after 12 and 21 months provide a good indication of the refinishing cycle. Finishes rated as 7 to 8 after 21 months probably will not last an additional year, given the low ratings at 39 months. Almost all finishes provided at least 1 year of service, and many provided 2 years.

Performance differences were primarily associated with the amount of solids in the finish and the wood species. Two years did appear to be the limit of the service life for the majority of the finishes on western redcedar; a 2-year service life was more difficult to obtain on Douglas-fir. Tinted or pigmented finishes lasted longer than untinted formulations.

## EFFECT OF SPREAD RATE ON SERVICE LIFE

The amount of finish applied to each deck was measured on a basis of weight

per unit area to determine whether the amount of finish absorbed affected service life. There appeared to be no consistent relationship between the amount of finish applied and the service life. Much of this inconsistency was caused by the different solids content of the various finishes. Performance depended on the amount of solids and pigment content remaining on the boards after the solvents or water evaporated, not the amount of finish applied.

### EFFECT OF VOC LEVEL ON SERVICE LIFE

In recent years, VOC levels in most finishes have been decreased to meet U.S. Environmental Protection Agency regulations. At the time this study was initiated, a variety of products containing different organic solvents were available. Some of the low-VOC finishes were water-based formulations, while others achieved low VOC levels by using non-VOC solvents or non-volatile oils (these finishes are identified by low values for both VOC and % water). Ten water-based formulations were included in this study, of which six had ratings of 5 or greater on western redcedar and seven had such ratings on Douglas-fir after 12 months of exposure. Six finishes for western redcedar and four for Douglas-fir had ratings of 5 or greater after 21 months of exposure. The proportion of finishes giving acceptable performance after 12 and 21 months was about the same for both water-based and solvent-based formulations. However, the solvent-based formulations gave slightly better service life on both wood species. Only solvent-based formulations had ratings of 7 to 8 after 21 months of exposure. Thus, a move toward water-based formulations, while attractive from an environmental perspective, may have some performance drawbacks.

## CONCLUSIONS

The protection provided by deck finishes varied from about 1 year for clear finishes to about 2 years for some tinted or lightly pigmented finishes. Mildew resistance of most finishes was fair to good after 21 months; however, most finishes performed slightly better on western redcedar than on Douglas-fir. Water repellency was marginal for most finishes after 12 months. Although water repellency is an important quality for these finishes, good water repellency did not guarantee long service life. The type and amount of pigment or other UV stabilizer seemed to have a greater influence on performance. General finish appearance was good at 12 months and fair at 21 months for many finishes. A few finishes were in very good condition after 21 months, particularly on western redcedar, but all finishes had failed by 39 months. Solvent-borne formulations seemed to give slightly better service life than water-borne formulations. There is considerable opportunity to improve deck finishes by identifying more suitable UV stabilizers for wood surfaces and transparent pigment for the finish.

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