Long-Term Performance of Preservative-Treated Shingles of Western Wood Species

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Abstract

The performance of western hemlock, sugar pine, and western larch as alternatives to western redcedar (WRC) for roof shingles was investigated on outdoor roof racks with and without an initial brush or dip treatment with either pentachlorophenol (penta) or chromated copper arsenate (CCA). Untreated shingles of all species experienced degradation over a 32-year exposure in western Oregon, but WRC provided the best performance. Penta treatments improved performance to some extent, but the best protection was provided by a dip treatment in CCA prior to installation. The results illustrate the benefits of even shallow surface protection in aboveground exposures.

Western redcedar (*Thuja plicata* Donn) has long been used for roof shingles and shakes because its heartwood has a well-known reputation for both durability and dimensional stability (Scheffer and Morrell 1998, US Department of Agriculture [USDA] 2010). In the late 1970s, concerns about the availability of more durable old growth cedar coupled with changes in import policies that threatened to sharply increase the cost of western redcedar from Canada encouraged a search for alternative wood species. A number of species that might produce useful shingles were considered (Peter 1971, Buchanan et al. 1990). For example, Miller (1983) noted that thick Douglas-fir shakes provided 22 years of service life in western Oregon. While this was promising, shingles of most alternative species would require some type of supplemental preservative treatment to provide performance similar to that produced by western redcedar. Pressure-treated shingles have been shown to provide excellent performance (Barnes et al. 1985, Morris et al. 2013), but many shingle producers lack the ability to pressure treat wood and would likely prefer dipping or some other less capital intensive treatment process. In response to these questions about the performance of alternative shingle species, a field trial was established using three potential western redcedar replacements. In this report, we describe the results of 32 years of field exposure of these materials at a site in western Oregon.

Materials and Methods

Western redcedar, western hemlock (*Tsuga heterophylla* (Raf.) Sarg), western larch (*Larix occidentalis* Nutt), and sugar pine (*Pinus lambertiana* Dougl.) shingles were prepared as previously described (Miller 1986; Table 1). Sugar pine has shrinkage properties that are similar to those for western redcedar, while both western hemlock and western larch shrinkage values are much greater and might make the woods less stable on a roof (USDA 2010). Each species was represented by five roof panels (0.9 m wide by 1.2 m long). Each panel was allocated to one of the following treatments.

1. No treatment (control).
2. Shingles dipped before assembly for 3 minutes in an ambient temperature solution of 5 percent pentachlorophenol (penta) in diesel oil.
3. Shingles similarly dipped in an aqueous solution of 9 percent chromated copper arsenate (CCA) Type B (oxide basis). This concentration was typically used for treating cuts to treated wood.

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Table 1.—Characteristics of shingles and shakes evaluated in the long-term field test.

Species	Shingle dimensions (mm)		Grade[a]	Appearance
	Length	Butt thickness		
Western redcedar	400	10	1[a]	Clear, all heartwood, edge, grain
Western hemlock	400	15–19	None	Clear, edge and flat grain, mixed heartwood/sapwood
Sugar pine	500	15	3 & 4[b]	A few knots, edge and flat grain, mixed heartwood/sapwood
Western larch	400	19	None	Clear, all heartwood, edge grain

[a] Redcedar Shingle and Handsplit Shake Bureau (1977–1978), Suite 275, 515 116th Ave. NE, Bellevue, WA 98004.
[b] See Miller (1986).

4. Shingles installed on the roof and then brushed with 5 percent penta in diesel oil.
5. Shingles installed on the roof and then brushed with 9 percent CCA Type B (oxide basis).

The shingles were attached to open sheathed boards spaced approximately 50 mm apart and attached to the roof panel. CCA treatments were stored under cover for 4 weeks prior to exposure to allow fixation reactions to proceed. Each wood species–treatment–water combination was replicated on 20 to 25 shingles of varying widths.

The panels were mounted approximately 1.5 m aboveground at a slight angle to allow for water drainage at a test site in Corvallis, Oregon. This site is temperate and receives approximately 1.1 m of rainfall per year. The site has a Climate Index of 45, suggesting that the decay risk is moderate (Scheffer 1971). In order to accelerate decay, one-half of the panel from each treatment–species combination was sprinkled for 2 h/day during the dry summer months for the first 10 years of exposure, and then the supplemental watering was discontinued.

After 5 or 6 years of exposure, one-half of the surface on each panel was retreated with the same chemical initially applied to that section. The surfaces were first cleaned of debris, and then the preservative solution was liberally brushed on the surface with particular attention paid to the butts of the shingle as well as any joints between individual shingles. Areas retreated with CCA were covered with black plastic for 2 weeks after retreatment to allow fixation reactions to proceed.

Shingle condition was initially evaluated after 10 years of exposure by removing each shingle and assessing the location and extent of visible decay on the portions that were exposed and the area beneath the shingle above. The percentage of each zone that was decayed was then estimated and served as a measure of shingle condition. The shingles were then returned to their respective panels and exposed for an additional 22 years. At the end of 32 years of exposure, all of the shingles were again removed from the panels. Shingle condition was visually assessed on a scale from 0 to 10 as follows:

- 10: Sound, no evidence of biological degradation, some weathering allowed
- 9: Slight evidence of decay
- 7: Decay present, but shingle still serviceable
- 4: Advanced decay on more than 30 percent of the shingle
- 0: Advanced decay on more than 50 percent of the shingle

Shingles with ratings of 4 or lower were rejected and removed from the test. In some cases, the decay on a shingle receiving a higher rating (7) was in a location that precluded it from being capable of holding a fastener, and these shingles were also rejected. After evaluation, the remaining serviceable shingles were replaced on new panels for additional exposure.

Results and Discussion

The 10-year results indicated that shingles subjected to overhead watering in addition to natural rainfall tended to have higher levels of decay (Miller 1991). Western redcedar shingles were largely free of visible fungal decay. Western larch shingles also tended to be free of fungal attack except for the nontreated controls. Decay was far more prevalent in nontreated western hemlock and sugar pine shingles, reflecting the overall low natural resistance of these wood species to fungal attack. Preservative treatments generally reduced the incidence of decay. CCA tended to produce better protection than penta, and dipping tended to perform better than brushing. These CCA results were consistent with laboratory trials performed after the test was established (DeGroot et al. 1992).

Nontreated western redcedar shingles all contained visible fungal attack after 32 years of exposure, but the shingles were still largely serviceable (Table 2). Nontreated shingles of sugar pine, western larch, and western hemlock were all severely decayed and unserviceable. Western larch heartwood is classified as moderately durable, while western hemlock and sugar pine both have little natural resistance to fungal attack (Scheffer and Morrell 1998). The performance of the species is consistent with their reported durability. The results indicate that western hemlock and sugar pine would be poor substitutes for western redcedar without supplemental treatment. Western larch performed slightly better than the other two species, but not as well as western redcedar. This species might be suitable without treatment in drier climates where the decay risk was lower.

Penta tended to improve the performance of western redcedar only slightly, and there was no noticeable difference in performance between dipping or brushing, nor were there consistent differences with overhead watering versus natural rainfall. CCA treatment tended to produce marked improvements in performance. CCA-treated western redcedar shingles were largely still serviceable at the 32-year assessment and most were placed back in service. The differences in performance between penta- and CCA-treated shingles may reflect the modes of protection. Both systems are excellent fungicides, but chromium in CCA has the ability to limit ultraviolet light degradation, and this added protection may account for the improved protection afforded by this preservative system (Feist 1979, Johnstone and Bamber 1980).

Results with western larch were similar to those found with western redcedar. Shingles treated with penta were all still largely serviceable. Penta-treated shingles subjected to

Table 2.—Visual ratings of shingles of four species with various treatments after 32 years of field exposure in western Oregon.

Species	Treatment[a]	Brush or dip	Average condition[a] Watered	No water
Western redcedar	Penta	Dip	5.5 (1.9)	6.5 (1.2)
		Brush	6.0 (1.5)	5.7 (1.5)
	CCA	Dip	9.8 (0.0)	9.0 (2.5)
		Brush	8.9 (0.5)	5.8 (2.5)
	None	—	5.8 (2.4)	4.1 (2.8)
Sugar pine	Penta	Dip	2.8 (2.1)	1.7 (2.1)
		Brush	1.6 (2.2)	0.9 (1.7)
	CCA	Dip	9.7 (0.4)	9.8 (0.9)
		Brush	5.9 (2.4)	4.4 (2.6)
	None	—	0.2 (0.9)	1.7 (2.1)
Western larch	Penta	Dip	7.5 (0.9)	0.9 (1.7)
		Brush	7.7 (1.0)	5.3 (2.0)
	CCA	Dip	9.8 (0.0)	10.0 (0.0)
		Brush	8.8 (1.5)	8.2 (1.0)
	None	—	2.7 (2.7)	2.0 (3.0)
Western hemlock	Penta	Dip	5.7 (1.5)	7.3 (1.2)
		Brush	3.3 (3.1)	5.8 (1.9)
	CCA	Dip	9.1 (1.5)	9.6 (0.9)
		Brush	5.2 (2.8)	7.7 (2.0)
	None	—	1.1 (2.4)	3.0 (2.9)

[a] Penta = pentachlorophenol; CCA = chromated copper arsenate.
[b] Values represent means of 20 to 25 samples, while figures in parentheses represent one standard deviation.

overhead watering tended to be in better condition than those receiving only natural rainfall. The extra water should have enhanced fungal attack, and it is unclear why that did not occur. Shingles that were dipped or brushed with CCA were all in excellent condition. Most had only small decay pockets. Shingles dip treated with CCA were virtually free of decay; most were only slightly weathered, and there was no noticeable difference between shingles exposed to artificial or natural watering.

Sugar pine shingles treated with penta were in slightly better condition than the nontreated controls, but most were largely unserviceable and could not be replaced on the roof. The reduced protective effect on sugar pine may have reflected the presence of impermeable heartwood. While the treatment solution would penetrate into the sapwood, heartwood penetration would be limited, and this, coupled with subsequent weathering, may have reduced the protective effects of the shallow surface treatment. Shingles treated with CCA tended to be in much better condition than those treated with penta. Shingles dip treated with CCA were in excellent condition, and most had only slight weathering. Shingles that were brush treated with CCA tended to be in poorer condition than those that were dip treated, but most were still serviceable. Exposure to supplemental rainfall had little effect on condition at the 32-year mark. The differential performance of CCA, even on heartwood, likely reflects the protective effect of chromium against weathering that limited loss of the surface barrier.

As with the other species, western hemlock shingles that were dip treated with CCA tended to be in excellent condition. Shingles that were brush treated with CCA were still serviceable but contained more decay. Dipping in penta also improved shingle performance, but not to the same extent as dipping in CCA. Brush treatment with penta produced even lower levels of protection.

The results suggest that CCA treatment produced consistently better protection than penta regardless of wood species and that dipping generally performed better than brushing. Supplemental watering had inconsistent effects on performance, and this may be because of the discontinuation of watering at the 10-year point. The test site is characterized by an extensive overhead canopy that limits the rate of drying and creates excellent conditions for fungal attack. Lichens and other debris also rain down on the roofs, providing additional organic materials that can support microbial growth.

Conclusions

While neither CCA nor penta are currently labeled by the US Environmental Protection Agency for brush-on application, their performance illustrates the benefits of treatment barriers for limiting decay aboveground. These treatments generally penetrate only a few millimeters into the wood but remain effective for prolonged periods out of soil contact. The treatments also demonstrate that these alternative species can perform well in these applications when they receive supplemental treatments.

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