Technology Profile

Value to Wood

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Factors Influencing the Performance of Exterior Finishes

Finished wood used outdoors can become unserviceable within a few years if not effectively protected against ultra-violet (UV) light and moisture deterioration. For exposed outdoor wood the finish is especially important, as it is the main defence against weathering. At the same time, extended service life, low-cost maintenance and, where possible, preserving the natural appearance of wood is increasingly demanded by customers.

When properly finished, exterior wood can last a long time. For example, latex paints have performed well for 10 years or longer. By comparison, improperly finished wood can fail due to flaking, cracking, erosion and discolouration after only one year of exposure. Finish lifespan depends on several principal factors including service conditions, wood substrate properties and finish type. Understanding these factors and how they link together is needed to maximize the performance of any finished wood product for exterior applications.

Service conditions

Exposure of the finished surface to sunlight, rain, condensation and high relative humidity leads to finish degradation, but the overall effect can vary widely depending on the severity of the local climate and the end-use of the product.

Weathering effects

Sunlight and wetness are the main agents responsible for reducing finish service life causing fading, cracking, peeling and blistering. Degradation is accelerated by surface wetting and drying cycles which cause the wood to alternately swell and contract, further stressing the finish. Prolonged contact with water can also foster fungal and algal growth on and underneath the finish leading to "mildew" (mold), stain and eventual wood rot. Reducing finish exposure to wetness and UV will extend service life.

Weathering effects are highly variable, depending on the climate. This is important for producers of pre-finished products to consider when marketing to different regions. For example, the warm, humid climate of many southern US states is more aggressive on finishes

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than most Canadian climates. Results from a recently completed study at Forintek compare finish performance on bevel siding in three different North American climates. In this study, a wide range of finished samples with different species and finish combinations were tested in Quebec, British Columbia and Mississippi. The average finish performance ratings showed that those in Quebec deteriorated at approximately 1/3 of the rate of those in Vancouver, and 1/6 the rate of those in Mississippi.

Product end-use

There are many different types of exterior finishing applications ranging from vertical-type house finishes such as siding, trim, fascia, windows and doors, to more exposed finishes for fences and flat decks. Decks and fences often get the full brunt of outdoor weather, which accelerates finish deterioration. Those structures which are more protected from rain and sunlight will last longer. An example of this is house siding, which generally has less UV exposure, and less prolonged surface wetness compared to the sloped or flat surfaces of decks and fences. Other examples are finished surfaces in building recesses which can receive even less UV and remain relatively dry. Finishes such as clear film formers that would otherwise fail under severe outdoor exposure conditions will last longer under less exposure. These facts are important to consider when choosing the right type of finish for the particular application.

Linking wood properties to finish performance

Wood is a naturally variable substrate and in this section the main wood properties that affect finish performance are discussed.

Grain orientation

On flat-grain surfaces, the latewood bands are more prominent and can cause problems with finish performance. Latewood is denser and smoother, and has lower permeability to water than earlywood. However, once the water gets inside, latewood suffers a higher volume change than earlywood. The differential expansion and contraction from wetness cycling can stress film-forming finishes. Latex paints have more flexibility than solvent-borne paints to withstand these stresses and therefore last longer. Finish adhesion is usually lower on the latewood grain and is also less permeable for penetrating finishes. On vertical-grain wood, the latewood bands are much narrower and pose less of a problem for most finishes. The most important method for improving finish performance on flat-grained wood is to use a saw-textured surface. Smooth surfaces can be improved with a 50-grit or rougher sandpaper.

Surface texture

Saw-textured wood has better finish adhesion and extended finish service life compared to smooth, planed surfaces. The Forintek finishing study (Groves 2002) compared the performance of finishes on saw-textured versus planed wood surfaces over a one-year span. Results showed that the finished saw-textured samples significantly outperformed the planed surface samples

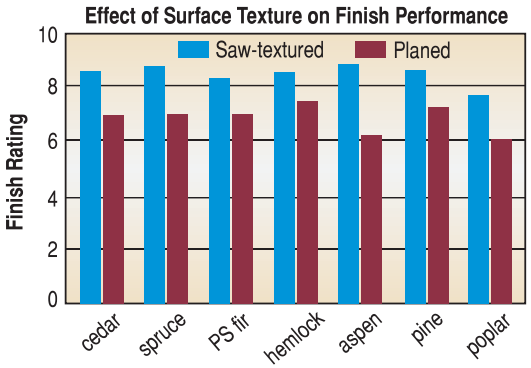


Figure 1. Comparison of finish ratings (1-10 scale; 1 = poor, 10 = excellent) for saw-textured and planed wood from exterior exposure tests

Extractives

The content and nature of extractives depend on species, age, growing conditions, season of felling and heartwood content. Extractives determine the colour, odour, decay- and insect-resistance, and moisture uptake/release of the heartwood. Water soluble extractives produce problems, especially with light-coloured water-based stains and paints, which can become irregularly discoloured. Extractives can bleed through the finish anywhere, though it occurs more in live-knots and in the heartwood core (near the pith). Oil-based primers are recommended to help lock-in water soluble extractives. Non-water soluble exudates (resin or pitch) can be characterized as a mixture of rosin (brittle solid) and turpentine (liquid) and they form most abundantly in the live-knot area. They can be a particular problem in strong sunlight, causing blistering of the coating. These oily products can be solubilized by the solvents or binders in oil-based or alkyd paints and thereby discolor the paint. High-temperature kiln drying schedules help eliminate the lower boiling point liquids which carry the rosin out. The "setting" of the pitch during a kiln drying schedule is usually accomplished by using higher temperatures in the early stages of the drying process.

Wood durability

Finishes can protect wood from UV degradation, but most allow water through to the underlying wood. When wood moisture contents reach 25% or higher, the substrate is susceptible to fungal attack which can result in staining and decay (Figure 2). Outdoor wood is commonly attacked by a group of fungi called black yeasts, which can penetrate paint films and grow between the film and the wood. This disrupts the adhesion of the film. Some species are more naturally-durable than others, which make them better suited for exterior applications. These species are Western red cedar and yellow cypress (yellow cedar), which have the highest durability, followed by moderately- durable species, including Douglas-fir heartwood. Most other Canadian species are more vulnerable to decay under high moisture content situations unless pre-treated with preservatives.

Figure 2. Decay on trembling aspen

Surface preparation

A fresh surface that is free of dirt and dust gives the best finish adhesion. Between manufacturing and finishing, the wood product should be kept clean, dry (<20% moisture content), and away from even short-term weathering exposure. Research has shown that UV starts to degrade lignin in the wood after about four hours of exposure to sun. Lignin is critical because it is the matrix which binds the cellulose. With as little as one week of outdoor exposure, sunlight will cause sufficient degradation that the finish adhesion is considerably reduced and premature finish failure is likely to occur. Surface inactivation of the wood surface also occurs in storage. This is a natural process in which freshly cut surfaces become increasingly enriched with low molecular weight substances, which lower the surface "wetability". This can interfere with finish penetration or the anchoring ability of a finish to the wood substrate. Finishing should preferably take place within 2 to 3 days after milling to avoid natural surface inactivation.

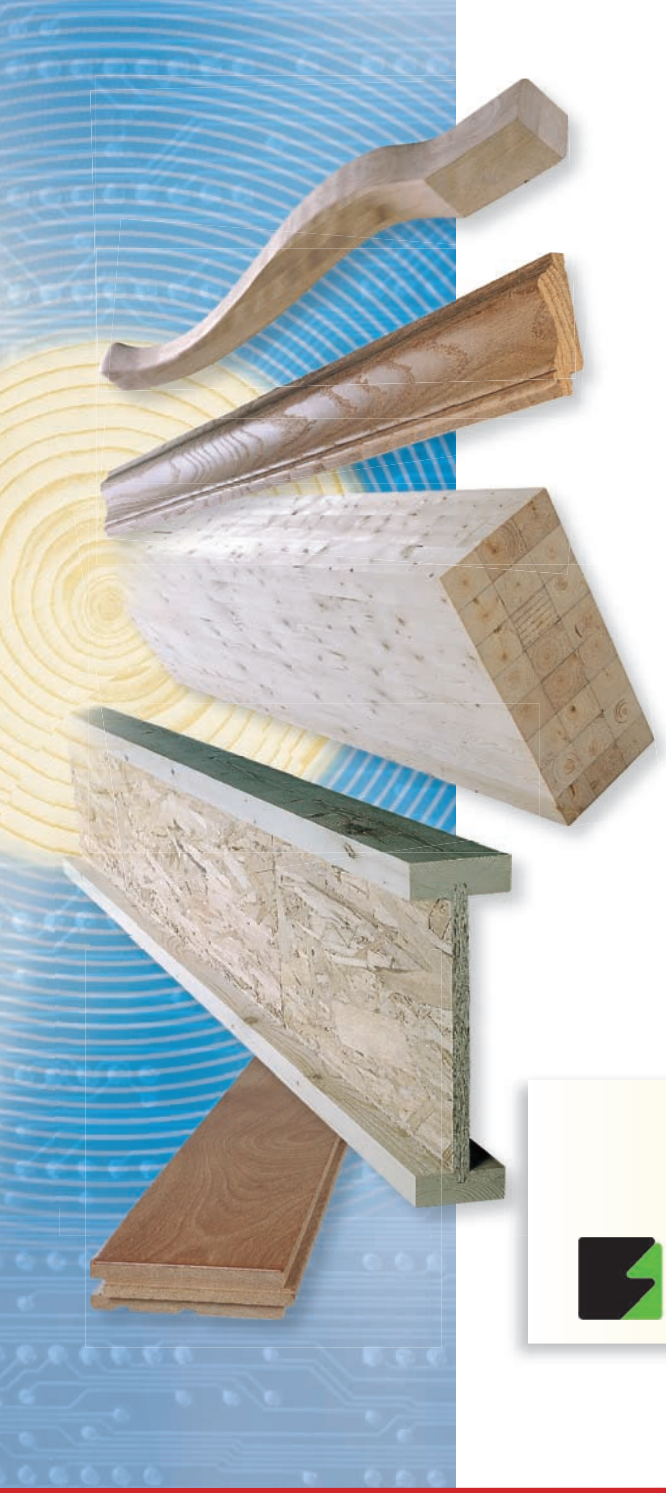
Finish types and application

There are many different types of finish that can either be applied on their own or more commonly, as part of a finishing system where multiple coatings are applied to the wood surface. Depending on the particular finish, service life can range from as little as 1 to 2 years for clear film coatings, all the way up to 15 years or longer for primer/paint systems. This is why selection of the particular finish is very important. Table 1 illustrates how the service life of wood siding varies depending on the finish system used. Ratings in Table 1 are calculated according to average lifespan, which depends upon the degree of exposure to sunlight and moisture, the quality of the coating, the fade resistance of the colour used, the thoroughness of the surface preparation before painting, and proper application.

Table 1. Finish System and Lifespan

Finish system	Lifespan (for wood siding)	Description
Primer +paint Topcoat* (acrylic latex)	10+ yrs	• longest lasting and best for siding, house trim & fascia
Primer + Paint Topcoat* (alkyd)	5-10 yrs	• primers help anchor topcoat to substrate and prevent extractive staining
Solid Colour Stains*	3-8 yrs	• similar to paints but allow more grain figure & surface texture to show
Semi-Transparent Stains	1-5 yrs	• best for decks & fencing
Water Repellants/Water Repellant Preservatives (WRP's)	1-4 yrs	• helps prevent water penetration into the wood to prevent cracking and checking in such applications as decking
Clear Films (varnishes etc.)	<2 yrs	• very attractive but short lifespan

* 2 coats can extend service life up to 2x compared to single coat application



Because of these factors, the years of service experienced from these products may be greater or less than the average lifespan indicated.

Finish application

To function properly, a finish needs to be applied correctly. Most finishes applied to wood are done by homeowners or building contractors. However, factory finishes, particularly for siding, are increasing in popularity. Some principles apply to both. Generally speaking, finishes should only be applied at temperatures above 15°C and indoors where both substrate and finish are at consistent temperature. This allows better control over finish viscosity and film thickness uniformity. For optimum finish adhesion, a coating must adequately wet the wood surface. Spray application over rough or porous surfaces often does not result in an even, thorough coverage. Brushing is the best and most simple method to achieve full contact between the finish and the substrate. If the finish is spray applied, back brushing is recommended to work the finish into the wood fibres to maximize adhesion.

For information on the 2003-2004 ***Value to Wood*** research program,
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*This **Technology Profile** has been edited by*
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*Ce **Profil technologique** est également disponible en français.*

Value to Wood

As part of the ***Value to Wood*** program, funded by Natural Resources Canada, Forintek's Industry Advisors are providing technical services to value-added wood product manufacturers in all regions of Canada. If you need information on any technical issue related to wood product manufacturing, you can:

- Send a request via *valuetowood.ca* (Help Desk).
- Contact a *Value to Wood* co-ordinator at one of the following locations:

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