Laboratory tests show which finishes work, which don't...

Protecting Wood from Humidity

by William Feist and Gary Peterson

Whether indoors and protected from weather, or outdoors and exposed to the elements, wood is always affected by moisture. It swells when it absorbs liquid from rain, dew, or moisture vapor in the air, and it shrinks as it dries.

Protecting wood from moisture is of no small importance. The more moisture that gets beyond the finish, the more grief you'll have with warped panels, joints that swell and break, drawers that stick, and wood that discolors. Of course, the ideal finish would seal the wood entirely against moisture and protect the surface against dirt and abrasion, all without obscuring the appeal of the grain that makes us appreciate wood, and fine woodworking, in the first place.

About a year and a half ago, the Forest Products Laboratory (FPL) completed a study that examined just how well finishes resist moisture vapor. And, while we didn't necessarily find that ideal finish, we did learn that wood coated with some types of finishes will be less affected than wood left completely unfinished. Our tests of 91 finishes showed that no coating entirely prevents wood from absorbing moisture. We also found great differences in the effectiveness of many finishes.

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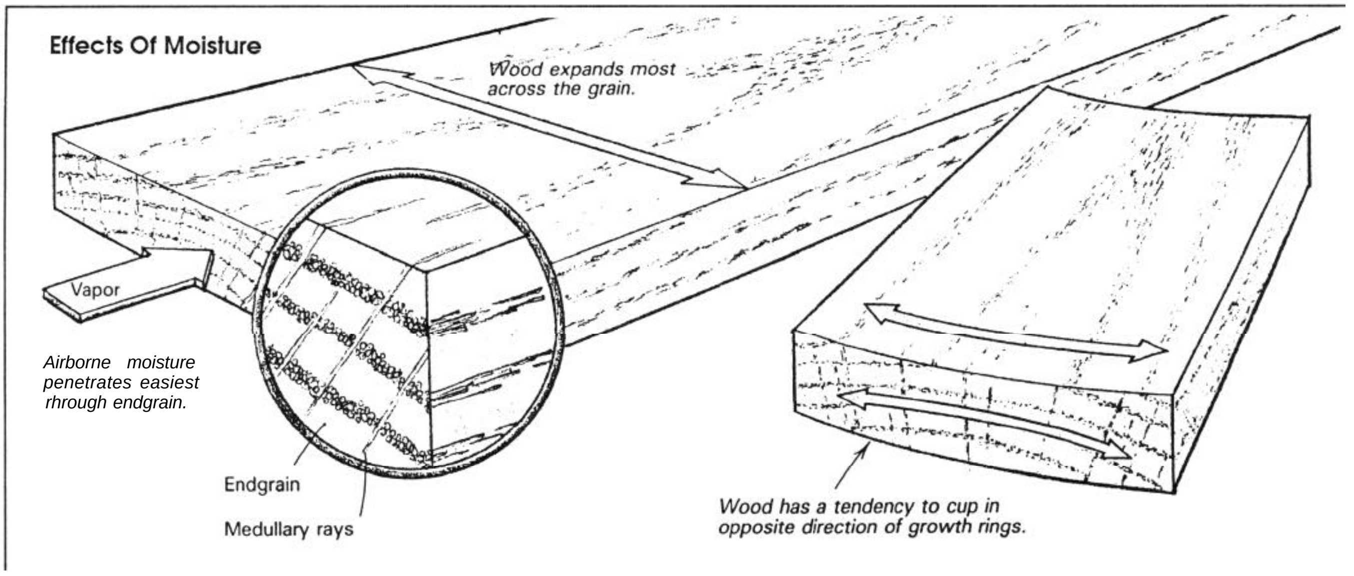

Some popular ones (linseed oil, tung oil, and lacquer for example) represent hardly any barriers to moisture vapor, while other materials that aren't even considered to be finishes (paraffin wax, for instance) sealed the wood almost completely.

The problem with protecting wood from moisture vapor lies in the material itself: it's literally full of holes. In fact, when seen under magnification, it would not be inaccurate to describe wood as mostly pores surrounded by smaller amounts of organic material. These pores provide lots of entry points for moisture vapor; and even the finish meant to seal them will be somewhat permeable. Ultimately, even the best moisture-resisting finishes only slow, but don't completely stop, the exchange of moisture vapor.

As wood takes on moisture vapor, it expands, which explains why a door that closes just so in the winter sticks annoyingly when humid summer weather arrives. As the drawing above shows, most of the expansion (and when the wood dries, contraction) occurs across a board's width rather than along its length. More shrinking and swelling will take place parallel to the growth than perpendicular to them. Thus, a board sawn so its growth rings are parallel to its face (plainsawn) will shrink and swell much more than a board sawn with rings perpendicular to its face (quartersawn).

This bit of wood lore is useful to know for two reasons. First of all, a quartersawn board will be less likely to warp because it expands less across its face. Secondly, to reduce warpage in any wood, moisture exchange must occur evenly on all sides and edges of the board. So, if you coat only one side with a finish, the face you skip will pick up or lose moisture faster than the coated side. This uneven exchange promotes warping. It's imperative, therefore, that the same number of finish coats be applied to both sides of the board. And don't forget the endgrain, either. A great deal of moisture exchange occurs through the exposed pores of the endgrain.

In our tests, we refer to the effectiveness of a finish in terms of moisture-excluding effectiveness (MEE). To make it easier to understand the results, we used a numeric rating for each finish. This is a relative value, based on thenumber of coats applied to the clear Ponderosa pine samples we used in our tests. To get this rating, we took a piece of smooth pine, cut it in half, and completely finished one half while the other half was left uncoated. To establish a reference point, we exposed both samples to 80" F temperatures at 30% humidity until both would absorb no more water vapor. Then, both samples were exposed for one, seven and 14 days at 80' F and 90% relative humidity. (This exposure to controlled atmospheres of higher humidity imitated a "real world" situation, similar to going from low humidity in the winter to high humidity in the summer.) To arrive at the MEE, we simply weighed the pieces before and after exposing them to the higher humidity.

Perfect protection by the coating — or no gain of water vapor -would be represented by 100% effectiveness; complete lack of protection (as with unfinished wood) by 0%. Most of the coatings were brushed on; a few were dipped. We kept the more moisture-resistant finishes in the test longer (up to 150 days). Also, all test samples were completely coated with the finish.

As the chart shows, most clear and pigmented coatings that form some sort of film and are not latex-based will slow the rate at which water vapor enters wood. In

MOISTURE-EXCLUDING EFFECTIVENESS

This chart shows the moisfure-excluding effectiveness (MEE) of a variety of finishes and other materials. Of fhe 91 finishes tested, thesefigures are the best for each finish type. The chart is arranged from the highest MEE to lowest. Ratings are given for one, fwo and three coats after 24 days of exposure at 80" F and 90% relative humidify. Negative numbers indicate that the finish itself absorbed water. (N.A. = not applicable)

	NUMBER OF COATS		
MATERIAL	1	2	3
Melted paraffin wax (dip coat)	95	N.A.	N.A.
Melted paraffin wax (brush coat)	69	N.A.	N.A.
Two-part epoxy sheathing	54	88	91
Two-part epoxy polyamide sheathing gloss (paint)	53	82	87
Aluminum-flake-pigmented polyurethane gloss varnish	41	77	84
Soya-tung alkyd satin enamel	50	70	80
Two-part polyurethane gloss varnish	0	46	66
Epoxy gloss varnish	3	34	50
Orange shellac	2	25	46
Polyurethane gloss varnish	11	36	44
Alkyd satin wood finish	8	29	43
Polyurethane satin varnish	8	27	41
Nitrocellulose alkyd lacquer	7	24	40
Phenolic tung floor sealer	-1	18	35
Soya epoxy gloss and trim sealer	1	13	31
Soya alkyd phenolic/tung gloss spar varnish	0	15	30
Acrylic gloss latex varnish	-1	6	10
Tung oil	-1	-1	2
Brazilian carnauba paste wax	0	0	1
Linseed oil	-5	-4	0
Spray furniture polish lemon oil/silicone	0	0	0

general, solvent-based, pigmented coatings such as paints, are more effective in slowing moisture exchange than clear coatings, such as varnish or shellac, since pigments (the fine solid particles used to color finishes) increase the barrier against moisture vapor. Within practical limits, the more coats applied, the greater the barrier to moisture vapor penetration and the slower the moisture level will change.

The finishes shown in the chart illustrate the range of our tests results. Although not generally considered a finish, paraffin still proved to be the most effective, with an MEE rating of 95% after a dip-coated sample was exposed for 14 days, We had good results brushing it on as well: a one-coat, molten paraffin wax brush treatment topped the ratings for one-coat, brush-applied finishes, with an MEE of 69%.

Another unusual finish we tested was a two-part (resin and hardener) epoxy coating, Chem Tech's L-26. It had a rating of 91% for three coats and 88% for two coats. Conventional two-part epoxy paints, often intended for marine use, were also very effective, especially with three coats.

The degree of moisture vapor protection afforded by a coating or finish depends on several factors. Among these are how thick a film the finish leaves; whether it contains pigments; the type of binder (the non-volatile, solid portion of the finish that holds the pigment particles together after the film is dry); the kind of resin (a film-forming solid or semi-solid organic substance, usually derived from chemical or natural products); and how long the wood is exposed to high or low humidity

We found the wood samples absorbed more water vapor as time went on. The longer the finished pieces were exposed to high humidity, the poorer their vapor retardance; eventually, moisture vapor finds its way in.

The chart shows that penetrating finishes like linseed oil, tung oil and furniture polishes are at the bottom of the scale, offering minimal or no protection even after three heavy brush coats. Because penetrating finishes don't form a film, they're usually not effective for controlling water vapor, even though they may be good at protecting against liquid water and staining from dirt. Latex- or water-based varnishes are also not very effective (although not shown, neither are latex paints). When these coatings dry, they leave small openings that allow water vapor to penetrate.

While penetrating oils, such as linseed and tung, are notveryeffective-even when three coats are applied-their effectiveness is greatly increased by blending them with other resins (making varnishes), or by adding both resins and pigments (paints). The more resin or pigment incorporated, within practical limits, the greater the effectiveness. As a rule, oil-based paints are more effective than varnishes; enamels (essentially paints with finer-ground pigments) are even more so.

The use of fillers to "plug" wood pores will indirectly contribute to improving the MEE, and will also provide a smooth surface on which to build a uniform top coat. Woods with large pores, such as oak and mahogany, will be more difficult to coat effectively than, say, cherry. Thinning a finish so it acts as a "sealer" may indirectly help in the same way, but it will probably do more to improve the appearance and durability of the final finish, than to enhance the MEE.

The first coat of any finish may "seal" the wood, but it won't provide a totally defect-free, uniform film coating. The second coat covers any defects in the first coat and doubles the film thickness. Each succeeding coat will increase the MEE, but when compared to the MEE produced by the first and second coats, the gains will be relatively small — even when up to six coats are applied. This is because the film thickness is doubled for the second coat, but is increased only by a third for the third coat, a fourth for the fourth coat, and so on.

A coating that is effective at keeping water vapor out is also effective at keeping it in. It took as long-or longer -for a coated specimen to lose water when the humidity was decreased. In fact, it took nearly a year for specimens with the most effective finishes to lose all their moisture after they were exposed at 90% relative humidity for six months.

The information in our studies relates to coatings that are only a few weeks old and not exposed to prolonged aging or severe conditions, such as outdoor weathering (which will quickly damage most coatings, causing them to lose effectiveness).

The moisture resistance of finishes also depends on the type of exposure. For example, water-repellent treatments are quite ineffective against water vapor, but because they cause water to bead on the surface, they're fairly effective against liquid water. So, this type of sealer finish would protect outdoor wood against rain and dew for some time, but not for very long against humidity.

Most of our studies dealt with brush-applied finishes, although we also compared the effectiveness of dipping. With a conventional finish like gloss polyurethane varnish, we found that one dip coat was equal in moisture-excluding effectiveness to two brush coats. One dip coat of a soya alkyd gloss enamel paint was equal to three brush coats. The better MEE from dipping occurs because more finish is applied over the wood surface and because dipping for some time (we used 30 seconds) increased penetration and provides greater sealing of the end grain pores, where most moisture enters.

Protecting wood against humidity is important whether the wood will be outdoors or in. The information shown here should help you determine which finish to use. Perhaps, as well, we have dispelled a few old wives' tales on how to control the effect water vapor has on wood. Among them, that penetrating oils are effective in reducing the absorption of water vapor. Similarly, thinning a finish so the first coat acts as a sealer may help improve the appearance and durability of the final finish, but it won't do much to protect against humidity.

The most important criteria then, for protecting against humidity, are film thickness and impermeability. But no matter how effective your finish, some vapor still gets through and is absorbed by the wood. Although it happens too slowly to watch, this means your wood (solid wood, anyway) is always on the move. ■

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