Clear Coatings on Wood

HOME

Hello. I'm Steve Smith.

I'm a paint chemist.

My producer, the editor of this publication, tells me I have only a couple thousand words to cover the subject of how and why clear wood coatings fail, and what can be done about it.

No problem. I could do it in twice that.

The reason we are starting with how and why they fail is because you, as contractors, want to give your customer a clear finish that really lasts, and help them to understand what is within their budget. The customer may want a glossy finish, or low-sheen. The application may be interior or exterior. There are ways to do all this, and some products out-perform others. Independent publications such as The Practical Sailor or Consumer Reports have tested some few products, and those tests have been done in some more-or-less scientific manner and gave reasonably valuable side-by-side comparisons, but no discussion of the why of it all. All that is of value to you as a painting contractor but does not help you understand how to choose a better product, or how to get beyond the three-month-to-two-year life most clear coatings have.

Today, I want to talk to you about some of the fundamentals of coating design, with the goal of you becoming more able to produce for your

customer a clear coating that lasts long enough to satisfy them, and if I get really lucky someone will have a replacement cursor assembly for my 20" slide rule. It's related. Really.

We can understand how clear wood coatings exposed to the elements
can last for years by learning how and why such coatings fail. The "why" is three-fold: Water attacks the coating or the wood, ultraviolet light (which is an invisible part of both natural sunlight and interior fluorescent light) does the same, and the wood substrate moves .

These causes bring about different effects. The most obvious are yellowing, loss of gloss, tearing of the coating, cracking and finally flaking of the coating. Somewhere along the line the wood loses its originally attractive color and bleaches to gray.

Some of the above result from loss of flexibility, and this will manifest as a cracking, tearing, or peeling of the film. The main reason is degradation by ultraviolet light, which slowly breaks molecular chains in the coating [a polymer made of many molecules intertwined and connected]. When this happens the molecular fragments (called "free radicals", more about those later) will glue themselves onto neighboring polymer chains, making extra cross-links. These are extra branches in a chain, like rungs on a ladder. As more cross-links are made, the coating loses its elongation capability. That is to say, it becomes stiffer and cannot stretch as much as the natural expansion of the wood, and eventually cracks and tears and flakes. Polyurethanes, traditional varnish and, for that matter, any clear finish will get more brittle with age. The reason old, flaking varnish curls outwards is that the outer surface becomes shorter than the inner surface due to the extra surface cross-linking from the ultraviolet light.
There are special chemicals designed to trap and neutralize these free radicals before they can do

their damage. They are called antioxidants (something like vitamin-E, actually) and they work the same way your antioxidant vitamins work to keep you healthy.

Interestingly enough, conventional varnishes cure by a chemical reaction between the oil and the oxygen in the air. This is called oxidation, and the addition of antioxidants to a conventional varnish would poison the curing reaction. It is therefore impossible to add antioxidants to varnish and thus any varnish will lose its flexibility fairly rapidly with exposure to the sun. Some chemically cured coatings such as two-component polyurethanes are compatible with both ultraviolet absorbers and antioxidants, and those have the best maintenance of gloss and flexibility. Versions which are VOC-compliant are available for high-end applications. My company has been making such coatings for over fifteen years.

Evaporation of flexibilizing plasticizers is another reason coatings lose flexibility with age. Plasticizers are non-reactive chemicals which some manufacturers add to a resin to make it less brittle. Used correctly, this may be a good thing. If an incorrect [or cheap] plasticizer is used, it will evaporate with age, as it diffuses out of the material. I personally have experienced a significant loss due to exactly this kind of failure. The sliding part [cursor] on my twenty-inch slide rule was made with some plastic, which has shrunken and become brittle with age [my father bought it for me when I was in High School…I was the only kid with a 20-inch in a belt scabbard] and now the cursor is cracked in several pieces and does not glue back together well……and is very difficult to use. If you have one you would be willing to sell, please call me at 1-510-237-5986.

Incidentally, some epoxy products have volatile plasticizers, also called fugitive, because they go away. The MSDS may say they contain benzyl

alcohol or benzyl butyl phthalate…..these are two of the most common.

Where the coating was applied to two adjoining pieces of wood and bridged over them, relative motion may tear the film loose from the substrate without the film itself failing. The visual result of this is usually a whitish line appearing in the clear coating over the wood joint. As the coating lost its flexibility, it became stiffer, and stretched only with more difficulty. Eventually the force required to stretch the coating over the joint exceeded the shear strength of the wood or the peel strength of the coating's adhesive bond to the wood, and the coating tore loose some amount either side of the joint.

Water causes a loss of film strength….it will tear more easily, and stretch less before it fails. The reasons are technical, and have to do with chemical reactions between water and some kinds of plastics, acrylics and some others, which lead to decomposition of the material. The chemist who formulates the coating would use better-quality materials to make a coating more resistant to this sort of degradation. Some urethanes, some epoxides, and the reaction products of certain natural oils (such as linseed oil or tung oil) or other kinds of resins called alkyds are more resistant to water than some other materials such as acrylic resins or some polyester resins. Fiberglass boats develop gel-coat blisters which are a result of water attacking that polyester resin.

Water may cause a chemical decomposition or swelling of the wood beneath the coating, allowing the bond between the wood and the coating to fail. Ultraviolet light also causes chemical decomposition of wood.

A chain is only as strong as its weakest link, and so it is necessary to not only improve the varnish or other clear coating to obtain a longer life, but to

improve the stability of the wood surface. This gives any topcoat something better to stick to.

There are many different definitions of the word "primer", depending on the specific functions being performed. Manufacturers of clear coatings usually design some sealer-primer, adhesion-enhancing primer or wood-stabilizing primer for use with their coating products. The oldest and simplest of these, used with any varnish, was to thin the first coat of varnish with mineral spirits and allow it to soak into the wood. This is commonly done today.

Whatever the recommendation of the topcoat manufacturer for surface prep or primer, follow it.

My company manufactures a primer for wood which is compatible with not only our clear finish, but other manufacturers' alkyd or latex paints or clear coatings or varnishes. It is called Clear Penetrating Epoxy Sealer™ and also MultiWoodPrime™, and impregnates the wood substrate with a water-repellent resin system made largely from the natural resins of wood itself. It bonds the wood surface fibers together and into the wood substrate, where there was open porosity. This gives a stronger surface, better attached to the bulk of the wood itself, and thus creates better water resistance of the wood substrate as well as better topcoat adhesion. It bonds the coating to the wood with a tough, flexible adhesive , and this bond is stronger than the bond of varnish or other finishes directly to bare wood. Thus, the sealer glues down the topcoat, while the ultraviolet absorbers in the topcoat protect both wood and sealer from the sunlight. You can learn more about Clear Penetrating Epoxy Sealer or MultiWoodPrime by clicking on the link.

Wood consists of hollow fibers of cellulose (a kind of sugar, very tasty to fungus and termites) glued together by a material called lignin. Lignin is a

very hard, strong resin (a phenolic resin, chemically a half-brother to the resorcinol glue used to make plywood) which is very resistant to water, but is decomposed very quickly by ultraviolet light.

Ultraviolet light attacks almost everything. All organic compounds, whether synthetic or natural, will eventually be attacked and broken down by ultraviolet light. Even some of the best urethane paints will lose about half their gloss in two years of outdoor exposure. It is not enough to make a clear coating which is not much degraded by ultraviolet light, as such a coating would simply transmit the ultraviolet light through to the wood underneath.

Therefore, ultraviolet absorbers were invented. The most effective are chemical compounds, which act as magnets for ultraviolet light. When a molecule of this absorber material captures a photon (light comes in small units; they are called photons) it converts the energy of the ultraviolet photon into heat. When it does this, the molecule vibrates. The phenomenon is very much like ringing a bell. We know that if you strike a bell often enough, the bell will crack. The molecules of ultraviolet absorber wear out in the same way. Eventually they will die and no longer absorb ultraviolet light. The more ultraviolet absorbers the manufacturer puts in the clear coatings, the longer the coatings will last, assuming that high-quality ingredients are used and the coating itself is correctly designed.

Clear coatings containing ultraviolet absorbers must be applied to some minimum predictable film thickness, so that there is enough ultraviolet absorber chemicals over the wood to afford enough protection to the wood to obtain good life and color stability for the wood. When the ultraviolet absorbers burn out, the wood will lose its color, becoming gray.

Besides absorbers, another kind of ultraviolet protection is small particles of some minerals. They are small enough to pass most visible light but big enough to scatter and reflect most of the shorter-wavelength ultraviolet light. They never burn out, but they have the disadvantage that as one adds more or makes a thicker film, there is a noticeable haziness or blurring of the wood underneath.

Sometimes it is desirable to stain wood before a clear coating is applied. In general, waterborne stains are compatible with waterborne clear finishes, whereas solvent-borne stains must be used with solvent-borne topcoats.

Well, I see by the bulging red veins on my editor's neck that I'm about at the word limit, so I want to thank you for your attention and I trust this has been useful for you.

One last thing, in case you are wondering…….you may have noticed I did not say how manufacturers keep coatings from losing their gloss. It's true. I didn't. I'm a paint chemist. We have our secrets.