SAN JOAQUIN FINE WOODWORKERS ASSOCIATION

FINISHING - PART III

December 16, 2006

Presentation Introduction

- Today's presentation is the third part of a three-part series on finishing.
  - During the first part of this series, Howard Atamian provided an overall introduction to finishing, which included a brief history of finishing, how to eliminate the fear of finishing, what you need to know about different woods, and what factors go into choosing the right wood. Howard covered preparation of the wood, which included sanding, scraping, repairing, wood putties, fillers, and sealers. Howard also covered staining in great detail.
  - During part two of our series, John Snyder and Aaron Arnold addressed the different methods of applying finishes, which included using pads and cloths, brushing, and spraying.

- For part three, Howard, Chuck, Ben and I will be covering "film finishes".
  - I will present an overall introduction on film finishes and cover how finishes cure.
  - Ben will present some specific information on shellac, lacquer, & varnish.
  - Chuck will be covering water-based finishes.
  - Howard will explain how to "finish the finish"

  .
- We would like this to be an interactive presentation, so we encourage you to raise your hand if you have some knowledge or experience to share with the group.

  There is no one method that is best for everyone, and at least speaking for Ben and I, we do not claim to be experts on finishing.

- Most of the information being presented today can be found in Bob Flexner's book *"Understanding Wood Finishing".*

- The handout for today's presentation contains more information than we have time to cover and is intended to be a reference for the future.

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December 16, 2006

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Introduction to Film Finishes

- Finishes can be divided into two groups: ***penetrating and film***.
  - Penetrating finishes contain straight oil and don't cure hard, so they shouldn't be built up on the surface of the wood.
  - Film finishes cure hard and can be built up to any thickness you want.

- There are ***five*** common ***film finishes*** used in woodworking.
  - Shellac
  - Lacquer
  - Varnish (polyurethane is a type of varnish)
  - Water Base
  - Conversion (conversion varnish and catalyzed lacquer)
    - Due to time constraints, and the fact that conversion finishes are used primarily in the furniture industry, we will not be covering conversion finishes in today's program.

- Film finishes protect better than penetrating finishes because of their thickness on the surface of the wood.
  - The thicker the finish, the better it protects the wood from scratches, water, and humidity.
  - There are practical limits to film thickness, however, because if the finish is too thick it may develop cracks as a result of expansion and contraction of the wood underneath.

- Film finishes also offer more possibilities for decoration than penetrating finishes.
  - You build a finish film the way you make a sandwich - in layers.
    - The first coat is call the ***sealer coat*** which seals the pores of the wood.
    - Subsequent coats, called ***topcoats***, increase the thickness of the film, add decorative color, and increase or reduce the sheen if you choose.

How Finishes Cure

- All finishes fall into one of three types: ***evaporative, reactive, or coalescing***

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- Each type cures differently

- The way a finish cures, or changes from a liquid to a solid on the wood, tells you a lot about that finish.

Evaporative Finishes

- Evaporative finishes are made of solids that have been dissolved in a solvent.
    - The more solvent you put in, the thinner the solution, the less solvent, the thicker the solution
    - When all the solvent evaporates from the solution, only solids are left.
    - These solids are essentially the same as they were before they were dissolved, except they are now a film on the wood.

- The molecules in evaporative finishes are long and stringy like microscopic strands of spaghetti.
    - Just like spaghetti, the strands intertwine when they are softened and when they dry out, they harden, interlocking to form a continuous film.
    - Because nothing bonds the strands together, they will soften and separate when solvent is reintroduced.

- Evaporative finishes can change back and forth between liquid and solid by the introduction or evaporation of the solvent.
    - When you apply one coat of an evaporative finish on top of another, the solvent in the new coat partially dissolves the previous coat.
    - The solvent puts the spaghetti-like strands back into solution, so the coats interlock or fuse, making one thicker layer.

- Evaporative finishes cure from the bottom up.
    - The solvent at the bottom of the coat has to work its way through the film layer to get out, making the top the last part to cure.
    - This is the reason evaporative finishes don't skin over in the can.
    - You can apply coats of evaporative finish over coats that haven't totally cured or are still wet. It will just take longer for all the solvent to work its way out of the finish.
    - When the top is hard, you can be sure the film is hard all the way through.

Reactive Finishes

- Reactive finishes change chemically when they cure.
    - As the thinner evaporates, the resin molecules come closer together and a chemical reaction occurs.
    - The molecules link together in a tinker-toy-like network that can't be broken by reapplying the thinner.
    - This chemical reaction is often referred to as ***crosslinking*** or ***polymerization***.

- Reactive finishes fall into two categories: those cured by reacting with oxygen and those that cure by reacting when a chemical catalyst is introduced, much like epoxy glue does.
    - Varnish is an oxygen-curing finish (linseed oil and tung oil also cure by reacting with oxygen, but they are penetrating, not film finishes).
    - Conversion finishes are catalyst-curing finishes, and again, we don't have time to cover those today.

- Varnish differs from all evaporative finishes in that when you apply an additional coat of finish, the thinner (mineral spirits) in it does not soften the existing cured coat.
    - The cured coat has cross-linked and can no longer be dissolved, so there is no bonding between coats.
    - If you want to remove the new coat before it has cured, you can do so easily and without affecting the existing coat by wiping it off with mineral spirits or naphtha.
    - Unlike evaporative finishes, you must remove all sanding dust, because it won't dissolve into the new coat of finish.
    - Since a new coat of varnish won't fuse to the previous coat, you have to sand the previous coat to make fine scratches for the new coat to lock onto mechanically.
    - Varnish can also be applied over other finishes, but again, it's necessary to sand the other finish first to achieve a mechanical bond.

- Since varnish cures by reacting with oxygen in the air, it cures from the top down.
    - Varnish that has skinned over in the can is an example of this reaction.
    - Oxygen makes contact with the top of the finish coat first and has to work its way through to cure the bottom of the coat.
    - That is why you should keep your coats of varnish thin.
    - Thick coats take much longer to cure all the way through.
    - You shouldn't apply a fresh coat of varnish until the underlying coat is thoroughly cured.
    - If you do, it will wrinkle the overlying coat when oxygen does finally work its way through to cure it.

Coalescing Finishes

- Coalescing finishes, typically water-based finishes, are more complex than evaporative or reactive finishes.
    - Coalescing finishes are actually a combination of evaporative and reactive finishes, and most finish chemists don't consider them a separate group.
    - Bob Flexner thinks they are easier to understand when treated separately.

- Coalescing finishes are tiny droplets of a cured reactive finish (**crosslinked** within the droplets) emulsified in water.
    - The water serves as the thinner.
    - A very slow evaporating solvent (usually glycol ether) is added so the droplets can cure as a film.
    - As the water evaporates, the droplets come closer together, or ***coalesce***.
    - The solvent, which evaporates more slowly than the water, softens the droplets so the outer molecules of each droplet relax and extend outward to become intertwined with the outer molecules of other droplets.
    - When the solvent evaporates, the droplets become interlocked much the same as evaporative molecules (remember the spaghetti), but they are not crosslinked.
    - Just like evaporative finishes, contact with solvents, such as alcohol or lacquer thinner, after the finish has cured, disconnects the droplets, putting the finish back into solution.

- The droplets in water-based finish take several weeks to achieve their maximum bond.
    - For a short time additional coats of finish will bond to the previous coats and no sanding is required.
    - The solvent softens the outer molecules of the droplets in the existing coat so they interlock with the outer molecules of the droplets in the new coat.
    - After a day or two the solvent may not adequately soften the existing coat and sanding may be necessary.

- Since the molecules in evaporative finishes and the outer molecules of the droplets in coalescing finishes interlock in the same way, you can apply an evaporative finish over a coalescing finish and achieve a good bond.
    - However, the solvent in coalescing finishes is usually not sufficient to make a strong bond with evaporative finishes after the evaporative finish has had time to cure.
    - Therefore, when applying a coalescing finish over an evaporative finish, it’s a good idea to scuff the surface with fine sandpaper to insure a good bond.

- Coalescing finishes cure like evaporative finishes - from the bottom up.
    - Enough water has to evaporate for the droplets to coalesce and interlock.
    - However, it's quite common for coalescing finishes to skim over a little near the tops of cans.
    - For this reason it's a good idea to strain a coalescing finish before using it.

- There are three significant differences between evaporative and coalescing finishes.
    - Evaporative finishes have a lot of solvent, so new coats can redissolve the existing finish all the way through while coalescing finishes have very little solvent , so only the surface of the existing finish is redissolved.

- Evaporative finishes cure rapidly while coalescing finishes become gummy as soon as the water evaporates and then remains that way some time until the solvent evaporates.
- You must wait until a water base coat is hardened (several hours) before applying another coat or you may trap water in the existing coat.

A Discussion of Film Finishes

Shellac (*Evaporative Finish*)

Background

- Shellac is a natural resin secreted by insects, called lac bugs, which attach themselves to certain trees in and around northern India and Thailand,
    - The word "***lac***" means "one hundred thousand", referring to the number of insects found on a single branch.
    - Approximately 1.5 million bugs must be harvested to make one pound of shellac.
    - The resin is scrapped from the twigs and branches of the trees, melted, strained to remove bug parts and other foreign matter, and formed into large thin sheets that are broken up into flakes.

- Shellac has a long history, and the system for measuring it, called the "***pound cut***", is also old.
    - A 1-pound cut is the ratio of 1 pound of shellac flakes dissolved in I gallon of alcohol.
    - A 2-pound cut is the ratio of 2 pounds of shellac flakes in 1 gallon of alcohol.
    - A 4-pound cut is the ration of 1 pound of flakes in 1 quart of alcohol.
    - For those that don't want to bother with mixing their own shellac from flakes, supplier-dissolved shellac is available, usually in a 3-pound cut.

- In its natural form, shellac is orange in color and contains about 5% wax.
    - The orange color can be used to advantage when you want to add warmth to the wood.
    - It can be a disadvantage if you want to maintain the color of a pickling stain or light-colored woods, such as maple, birch, or poplar.
    - Most suppliers provide a bleached shellac that has the orange color removed.
    - Bleached shellacs are called "white", "clear", or "super blond" and are virtually colorless.
    - You can mix orange and bleached shellac to achieve an in-between color.

- For at least 100 years prior to the introduction of lacquer in the 1920s, shellac was the primary finish used in furniture and small woodworking shops and almost all high-quality furniture made in the United States and Europe was finished in shellac.

- Before the availability of polyurethane, shellac was one of the most popular finishes used on wood trim and floors in houses

Application

- The naturally occurring wax causes shellac to appear cloudy and reduces the transparency and water resistance of the cured film.
    - For most situations where you are using shellac as the entire finish, the wax makes little difference in performance.
    - It can prevent good bonding when used under varnish, polyurethane, or water-based finishes.
    - Some suppliers remove the wax from the flake form, and Zinsser, makers of Bulls Eye Seal Coat, which is a 2-pound cut premixed shellac, guarantees it to be 100% wax free.
    - You can make your own dewaxed shellac from a can of shellac by allowing the wax to settle in the container and then decanting the liquid.

- The 3-pound cut ratio provided by suppliers already dissolved in cans is a little too thick for brushing and much too thick for spraying.
    - For easy brushing, reduce the 3-pound cut shellac with nearly an equal amount of denatured alcohol.
    - For easy spraying, reduce 1 part of the 3-pound-cut shellac with 2 parts alcohol.
    - You may need to make adjustments from there to reach the thickness, or pound cut, you feel most comfortable with.

Advantages
- Excellent resistance to water-vapor exchange.
- Excellent barrier to stain and silicone penetration.
- Dewaxed variety has excellent clarity and depth.
- Orange variety adds warmth to dark and dark-stained woods.
- Good rubbing properties.
- Denatured-alcohol solvent is less harmful to breathe and less harmful to the environment than most other solvents.

Disadvantages
- Weak resistance to heat, water, solvents, and chemicals.
- Only moderate resistance to wear.
- Short shelf life.

Safety
- In this era of concern for health and the environment, it's important to note that the denatured-alcohol solvent used in shellac is relatively benign.
    - As long as you use denatured ethyl alcohol (also called shellac thinner) and not methyl alcohol, which is quite toxic, inhaling the fumes is not particularly harmful.
    - Nevertheless, as when using any finish, you should still arrange for cross ventilation in your finishing area to protect yourself.
    - Shellac is not listed as a pollutant or ozone-depleting solvent by EPA.

Lacquer (*Evaporative Finish*)

Background

- When lacquer became available in the 1920s, it was widely believed to be the ultimate finish.
    - Lacquer had all the superior application and repair qualities of shellac, but it was more resistant to water, heat, alcohol, and alkalis.
    - In addition, Lacquer was a synthetic, so supply didn't depend on exotic natural materials (lac bug resin) and was easily manufactured.

- There are two commonly available lacquers: ***nitrocellulose***, and ***cellulose acetate butyrate*** (also called "CAB", "water-white", or simply "butyrate").
    - Nitrocellulose lacquer has been the most widely used finish in furniture factories and professional refinishing shops for the last 70 years.
    - CAB lacquer doesn't yellow over time as much, but is more expensive.
    - With the introduction of water-based finishes, which don't yellow at all, CAB lacquer is losing its appeal and from this point forward we will just address nitrocellulose lacquer.

- Lacquer consists mostly of resin, usually an ***alkyd*** or a ***mastic***.
    - Nitrocellulose, made by treating the cellulose fibers of cotton or wood with nitric and sulphuric acid, gives the finish its fast-drying properties.
    - By itself, though, nitrocellulose has poor build quality and flexibility, so resin is added to improve these characteristics, and oily chemicals, called plasticizers, are added to further improve flexibility.
    - Manufacturers vary the amounts and types of these resins and plasticizers to produce lacquers with varying degrees of elasticity, color, and resistance to water, solvents, acids, and alkalis.
    - Generally, the more elastic, colorless, and resistant the lacquer is, the more it costs.

- Lacquer is more protective and durable than shellac, roughly the same as water-based finishes, and less so than varnish.

Application

- Brushing Lacquer
    - Most lacquers are made to be sprayed and dry too fast for brushing.
    - To brush lacquer you must thin it with lacquer retardant or purchase a brushing lacquer which has slower-evaporating solvents added by the manufacturer.
    - You must work quickly and avoid rebrushing the same area to keep from dragging the lacquer.
    - If you don't have spray equipment, brushing lacquer is a good substitute for shellac or varnish.
    - Brushing lacquer is more durable than shellac but just as forgiving, and it doesn't have the inherent dust problems of varnish.

- Spraying Lacquer
    - Use a sealer coat before applying lacquer of either shellac (1 lb cut) or sanding sealer.

- Once dry, lightly sand with 320 grit stearated sandpaper.
- Reapply sealer if necessary to obtain a smooth surface.
- Use gloss spray lacquer for the buildup coats, thinned about 25% (apply enough to just wet the surface).
- Let dry about 1 hour between coats then sand with 320 grit sandpaper if needed to correct imperfections or level surfaces.
- Apply the final coat full strength.
- The final coat can be semi-gloss if you are not going to rub out the finish and don't want a gloss finish.

Advantages

- Very fast curing.
- With the addition of slower- or faster-evaporating thinners, can be applied in all types of weather.
- Excellent clarity and depth.
- Excellent rubbing properties.

Disadvantages

- High solvent content, which is toxic, flammable, and air-polluting.
- Only moderate heat, wear, solvent, acid, and alkali resistance.
- Only moderate water and water-vapor resistance.

Safety

- The problem with lacquer is the high percentage of thinner required to put the lacquer into solution.
  - Not only does the lacquer thinner cause pollution, which is leading to lacquer being restricted in some parts of the country, but it is also highly flammable and bad for your health.
  - The fumes from lacquer thinner can damage your central nervous system, liver, and kidneys and make you irritable, euphoric, or nauseous.
  - Avoid using lacquer near any source of flame or spark, and protect yourself from breathing the lacquer thinner fumes.

Varnish - (*Reactive Finish*)

Background

- Varnish is made by cooking an oil such as linseed oil, tung oil, or modified soybean oil, with a resin.
    - Natural resins such as copol, kauri, and amber, which are fossilized sap, were once used.
    - The resins used in varnishes today are synthetic alkyds, phenolics, and polyurethanes, and the name on the can indicates what you are getting

- Varnishes with polyurethane resin are the most commonly available and the most popular.
    - These products are usually referred to simply as "***polyurethane***", but in fact they are a type of varnish.
    - The polyurethane resins make this type of varnish a little more protective and durable than the others.

- More oil and less resin results in "***spar***" varnish, which is softer and more flexible.
    - Spar varnish is best for exterior use because it flexes to accommodate the greater wood movement outdoors.
    - The best spar varnishes are made with tung oil and phenolic resin because these ingredients combine to produce the best water resistance.

- Varnish can be thinned with any amount of paint thinner (mineral spirits).
    - When varnish is thinned by about half with paint thinner, it becomes easy to wipe on wood and is called "***wiping varnish***".
    - Wiping varnish provides excellent protection and durability, just like full-strength varnish, but it takes more coats to achieve the same thickness.
    - Unfortunately, many manufacturers label their wiping varnish "tung oil", or imply in their marketing that the finish is tung oil, and this causes confusion.
    - In fact, varnish and tung oil are two entirely different finishes.

- Varnish comes in sheens that range from gloss to flat.
    - Satin is probably the most popular sheen, because it imitates the appearance of a finish rubbed with steel wool.
    - Since the flatting agent that creates the sheen settles to the bottom of the can, you should stir this type of varnish before using it.

Application

- Varnish takes a long time to cure.
    - It takes an hour or more to cure enough for dust not to stick to it, and it takes at least overnight to cure enough to apply another coat.
    - For this reason, varnish is seldom used in factories or by professional finishers.
    - It is primarily used by amateurs who don't own spray equipment.
    - Many amateurs erroneously believe they are using an inferior product because it's not used by professionals.

- Varnish is a joy to brush and a misery to spray.
    - It brushes well because you have plenty of time to spread it out evenly on the wood.
    - It's troublesome to spray because small particles of uncured varnish float around in the air and when they settle, they make everything sticky, including you.

- It takes very few coats of full-strength varnish to build a significant thickness of film.
    - Varnish has a high solids content.
    - Two or three coats of varnish after the first "sealer" coat is almost always enough.

- The weather affects the speed at which varnish cures.
    - Cold and damp weather slows the curing significantly.
    - Don't apply varnish in temperatures below 60 degrees Fahrenheit as it may takes days to cure.
    - Hot weather speeds the curing because the thinner evaporates more quickly, and the varnish reacts more quickly with oxygen.
    - You may find it difficult to brush varnish on a large surface if the temperature is 90 degrees or higher.
    - Brush marks may not have time to smooth out, and air bubbles in the varnish film may not have time to pop out before the varnish cures.
    - There's nothing you can do to speed up the curing on cold or damp days except raise the temperature in the area you are working in.
    - You can slow the curing somewhat on hot days by adding 10 to 20 percent mineral spirits (paint thinner) to the varnish, but the downside is the coats are thinner and more coats may be required.

Advantages
- Excellent heat, wear, solvent, and alkali resistance.
- Excellent water and water-vapor resistance.
- Brushes well.

Disadvantages
- Very slow curing, causing severe dust problems.
- Tends to yellow over time.

Safety
- Similar to shellac, varnish is a relatively safe finish, but it is still a good idea to:
    - Apply varnish in a well ventilated area.
    - Wear appropriate gloves.

Water-Based (*Coalescing Finish*)

Background

- What's commonly called water-based finish is really a solvent-based finish, usually acrylic or polyurethane, that is dispersed in water.
    - Calling it water-based distinguishes it from those finishes known as solvent-based finishes (shellac, lacquer, and varnish) which don't use water.
    - A true water-based finish would be impractical for use on household objects, since it would redissolve in water.
    - Though water-based finishes still do contain organic solvents, they use less than most other finishes.
    - Water-based finishes are often marketed as "varnish", "polyurethane", or "lacquer", which confuses them with solvent based products of the same names.
    - Water-based finishes are always identifiable by some mention of water cleanup on the can.

- The only significant difference between brands of water-based finishes is the resin used.
    - Some are made with acrylic resin, some with polyurethane resin, and some with a combination of the two.
    - While the type of resin makes no significant difference in protection or ease of application, the polyurethane is more scratch resistant and the acrylic is totally non-yellowing.

- Water-based finishes are more complex to produce than either lacquer or varnish, which makes them more expensive.

Advantages
- Minimal solvent fumes.
- Not a fire hazard.
- Easy cleanup.
- Non-yellowing.
- Very scuff-resistant.

Disadvantages
- Produces bland, washed-out appearance on dark woods.
- Very weather-sensitive during application.
- Raises the grain of the wood.
- Only moderate heat, solvent, acid, alkali, water, and water-vapor resistance (same as lacquer).

Safety
- Water-based finishes contain very little solvent compared to solvent-based finishes and are safer than most other finishes, but not totally safe.
    - The solvents in water-based finishes are similar to those in latex paint and can cause dizziness.
    - Again, it’s a good idea to apply these finishes in a well ventilated area.

Finishing the Finish

- Why rub a finish?
    - Rubbing a finish is the final process after brushing or spraying. The finish will be much smoother and will have a softer appearance.

- Factors to consider.
    - Type of finish you are rubbing.
    - Open or closed grain wood? Are the pores filled or not filled?
    - What is the thickness of the finish?
    - How thoroughly has the finish cured? At least a week for lacquer and two weeks for varnish.
    - What type of sheen desired? Gloss, semi gloss, satin, or flat,

- Controlling the sheen
    - Additives such as silica can be added to give a satin finish.
    - The angle of incidence is equal to the angle of reflection.

- Six types of abrasives used for rubbing.
    - Sandpaper (300 to 1,500 grit)
    - Steel wool (0000)
    - Synthetic steel wool (maroon 0, green 00, gray 000, or white 0000)
    - Pumice-volcanic ash (F – FFFF fine)
    - Rottenstone (decomposed limestone)
    - Commercial compounds

- Lubricants
    - Water and soap
    - Mineral oil
    - Mineral oil and paint thinner
    - Paint thinner or naphtha

- Evaporative finishes such as lacquer, shellac, water based lacquers, when applied in layers, melt together and form a single film and are easier to rub out.

- Reactive finishes such as oil based varnishes, polyurethanes ,etc. dry as individual layers and rubbing out can result in “witness lines” or “ghosting” where you rub through the top layer and the layer under the top layer will show up as a circle.

- Soft finishes such as tung oil, linseed oil, and Danish oil, can be waxed or burnished, but they can’t be rubbed out.

- Do not rub out semi-gloss, satin, or flat finishes. If surface is rough, use some 0000 steel wool.

- Leveling
    - Start with 400 grit wet/dry sandpaper using a cork backed sanding block with a lubricant.
    - Graduate to 600 grit using the same process.
    - CAUTION!! Be careful that you don’t sand the finish through at the edges of the finish.

    - When the finish is a liquid, the surface tension will pull the finish away from the corners which makes the finish thinner at the edge of a project.

- For a satin finish after leveling, use 0000 steel wool, water and soap lubricant. If you are rubbing out a water-based finish, use scotch brite gray and white .

- For a gloss finish after leveling, use sandpaper through 1200 grit or use pumice and rottenstone with mineral oil and thinner lubricant.
    - Pure mineral oil lubricant cuts slower than 50/50 mix of mineral oil and thinner.
    - Do not use pumice on open grain woods as the white pumice will remain in the open grain.

- For a gloss finish with a machine, use Abralon pads 1000-4000 grit and a random orbital sander with water and soap lubricant.

- To polish, use automotive polishing compound and lambs wool bonnet power buffer.

- Wax, which is made from paraffin, beeswax, and carnauba wax, may be used to protect the finish.
    - There is a difference of opinions on whether or not to use wax on hard surfaces such as epoxy, lacquer, or polyurethane, which need little help.
    - Wax does not feed or replenish the wood oils, but it does provide some desirable qualities such as:
        - Dust and dirt won't stick to the surface
        - It is a barrier to moisture and spills
        - It fills tiny scratches on the surface

- Trouble shooting hints
    - To avoid blushing in cold weather when spraying, warm your project, heat the spray material to about 75 degrees, bring up the temperature in you shop to about 65 degrees, lower your air pressure, and install a water trap about mid way into your spray hose.
    - On your final coat, sand to 600, thin your lacquer three parts thinner to one part lacquer and spray a wet coat. This will give you a very smooth surface.

Good luck!! Let me know how these hints work out for you.