A Guide to the Spray Application of Waterborne Finishes

By
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Many people have difficulty when switching to a waterborne finishing system. I think this is because they approach it like they would a solvent based system, which will give mixed results at best. The first rule to remember when making the switch is that you are dealing with a water emulsion rather than a solvent solution so the entire chemistry dictates a different set of rules that you have to follow. I believe that with a better understanding of the fundamentals and how they relate to application techniques will help make the transition easier and less frustrating.

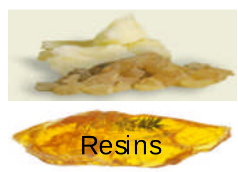
WATERBORNE FINISHES

Our discussion will center on waterborne finishes, and not water based finishes. Water based finishes are essentially latex paint without the pigment. While there are certain applications for water based finishes, most furniture and cabinetry products are better suited for waterborne finishes.

To understand waterborne finishes a little bit better let's look at solvent based finishes first.

Basic Solvent based Finish Components:

- Resins
- True or Active Solvents
- Diluent Solvents
- Latent Solvents

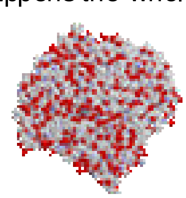


Various resins, both man made and natural, are selected for their particular performance characteristics; hardness, flexibility, scratch resistance, water resistance, cost, etc. They are mixed together in a ratio that will give the desired properties for the finish that is being formulated. There are three classes of solvents in a finish and each class can contain several different solvents. True solvents are solvents that will melt the resins into a liquid at room temperature. When added to the resins they melt into a thick syrupy liquid that is too thick for spray application. Diluent solvents do not melt resins at room temperature, however ever they do mix with the True solvents and reduce the viscosity of the resin / solvent mixture to a level that gives it the ability to be sprayed. The Latent solvents are solvents that on their own will not melt resins at room temperature, but are "activated" by the True solvents so that in combination they increase their potency. They are usually less expensive than the True solvents and thus help reduce the overall cost of the finish.

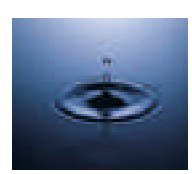
Once mixed the resins and solvents for a solution. This means that the resin is totally dissolved in the solvent, just like salt dissolves in water. When the finish is sprayed on to the wood the solvents start to evaporate. Every one of the individual solvents in the finish evaporates at a different rate. The faster evaporating solvents, generally the diluent and some latent solvents are the ones that "thin out" the finish so it can flow out on to the wood. As these evaporate out the slower solvents, usually the True solvents are left to melt the resins together into a smooth thin film. Although temperature and humidity effects how fast this all happens the whole scenario takes place in relatively short period of time.

Basic Waterborne Components:

- Polymer Emulsion - Acrylic or Polyurethane
- Coalescent Solvent – usually a Glycol Ether
- Water



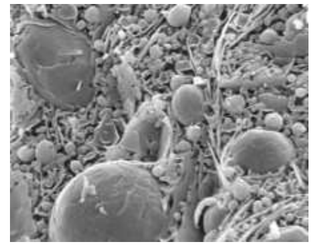
Polymer Emulsion



Water

There are several polymer formulations including acrylic, acrylic and polyurethane, polyurethane and acrylic, and finally straight polyurethane. The polymers are combined to take advantage of the non-yellowing characteristics of the acrylic and the increased wear characteristics of the poly. Obviously, the greater the amounts of polyurethane present the harder the finish, but then the greater the chance of yellowing.

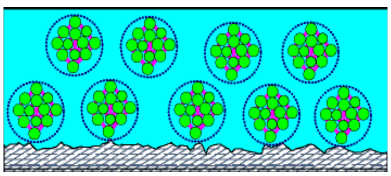
This sounds a little odd, but waterbased finishes are actually formulated on a solvent based platform. A glycol ether solvent is used because it is compatible with water and it will melt most acrylic and polyurethane resins. Another factor is that it evaporates more slowly than water. It importance of this will be shown later.



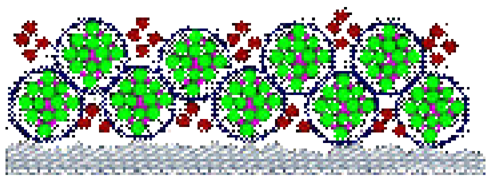
Water Emulsion

The basic waterborne finish can be defined fairly simply; the polymer resins are manipulated to form tiny droplets called latexes. They are dispersed in the water to create an emulsion. An emulsion is a liquid made up of unblendable substances. A good example of an emulsion is oil and vinegar. Then the coalescent solvent is added. Even though the process is relatively simple to explain, the chemistry involved is another matter. The polymers and water are not chemically compatible, so getting them to work together is quite complicated. Overcoming the issues of surface tension, ph, grain raise, and foaming are much more difficult than in their solvent-based cousins.

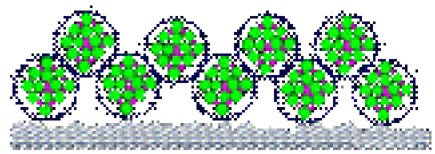
A simple explanation for the drying process is that the water evaporates and the polymers form a layer on the surface of the wood. At this point, the coalescent solvent is at a high enough concentration to dissolve or soften the polymers so that they melt together forming a thin smooth film on the wood.



Polymers and coalescing solvent in water emulsion

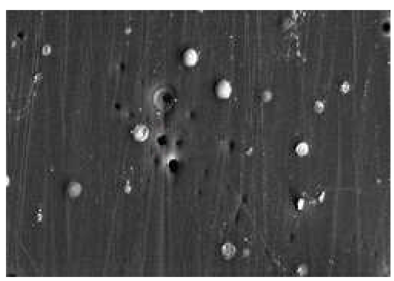


As water evaporates the concentration of coalescing solvent increases

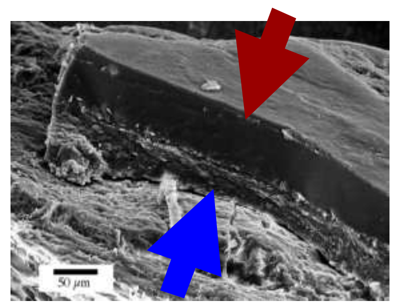


As the coalescing solvent evaporates it melts the polymers together to form a flat film

Finish right after spraying. Holes are atomizing air and solvents evaporating



Dried finish. Notice pin holes and sanding scratches. White dots are entrapped air bubbles



Cross section of dry finish. The blue arrow shows the sealer coat; the red arrow the top coat.

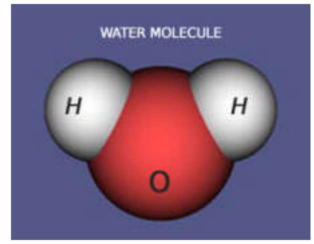
Waterborne finishes produce a coating that has excellent water and abrasion resistance, however their Achilles heel is solvent resistance – remember that a coalescing solvent is used to melt the resins together when they dry. Although they are not yet up to the caliber of the best catalyzed solvent based finishes the difference is becoming smaller with the introduction of Pre and Post catalyzed waterborne products.

Manufacturers are still working on a couple of issues that are keeping waterborne from becoming the standard in the industry. Clear waterborne finishes are almost perfectly clear. They also lay on the surface a little more than solvent-based finishes, so they tend to brighten the natural variations in the wood. This sometimes results in a slightly more harsh or plastic look, although they are getting much better. Solvent-based finishes tend to soften these variations resulting in a warmer look. Waterborne finishes are also are more weather sensitive, but this can be overcome with application technique. The sophisticated chemistry can add to waterborne finishes cost, but never use the dollar per gallon cost to be your main criteria for judging the acceptability of a finish. Increases in health, environmental, and safety regulations are fostering an increase in waterborne research and use.

Finishing Geek Speak

What you see when you spray out a finish are the atomized particles of finish form a wet spot on the surface of the wood and then as the solvents evaporate the coating lays out into a flat film. This observation is only a small part of what is actually going on, as the pictures above demonstrate. What happens between the time you pull the trigger and the coating dries is truly what finishing is all about.

The fundamentals of wood finishing involves principals that occur at a microscopic level. We can not see them with the naked eye so we tend to just accept the results without understanding why they happen. This leads to many of the common problems that we have and the frustrations that follow. Many of us react to the problem without really understanding the process that causes it. Because the physical properties of water are different than the solvents we are used to I feel it necessary to expand the description of the process.



Properties of Water

Water is a combination of two hydrogen atoms and one oxygen atom. The atoms are arrange in a triangular fashion. The oxygen atom has a slight negative charge and the hydrogen atoms have a slight positive charge. As with magnets positives and negatives, called dipoles, attract each other.

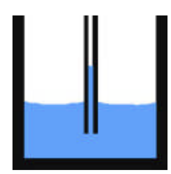
These are some of the physical properties of water as they relate to waterborne finishes:

Cohesion & Adhesion

- Cohesion - the attractive force between molecules. Water sticks very easily to itself. Due to the triangular arrangement of the hydrogen atoms and the dipolar attraction of the positive and negative charge on the hydrogen and oxygen atoms when one water molecule comes in contact with another water molecule they stick to each other. This is why water will bead up on the waxed surface of your car. This is also why waterbornes will not adhere to oily fingerprints on a piece of wood.
- Surface Tension - the force created by cohesion. Surface tension is defined as the attractive property of the surface of a liquid. It causes many liquids to behave as elastic sheets. This is what allows objects to float on liquid surfaces and causes liquids to form droplets. This is what makes the water drops round over causing them to cover only the smallest possible surface area. Water has a higher surface tension that most organic solvents. Only mercury has a higher surface tension than water. Surface Tension is the force that must be overcome when atomizing waterborne finishes.

Surface Tension

- Adhesion - the attractive force between molecules of different types. Water sticks very well to other surfaces. Again pour water on to the waxed surface of a car it will bead up and stick to the paint even on non horizontal surfaces. The adhesive forces are greater than the cohesive forces so the water sticks to the paint rather than to itself.
- Capillary Action - the ability to move up a narrow diameter tube. Capillary action is what allows water to move up the hollow fibers of plants and trees. The water adheres to the inside of the fiber, but surface tension tries to flatten it out. This makes the water rise and cohere to itself again. This process continues until it can no longer overcome the force of gravity. Capillary action also draws the water into the fibers of the wood you are trying to spray and causes grain raise.
- Specific Heat - the amount of heat energy that is required to raise the temperature of a liquid. Water has a very high specific heat so it takes a lot of energy to break the hydrogen bonding between molecules which allows it to evaporate. This is why waterborne dries slower than solvent based.



Capillary Action

- Solvent - water is a strong solvent, considered to be a universal solvent. It will dissolve many types of substances and turn them into a solution. Unfortunately water does not dissolve the polymer resins I waterborne finishes.
- Miscible - the ability to mix with another liquid, in any proportion and form a single homogenous liquid. Water is mixed with ethyl glycol, another solvent to form the solvent base of waterborne finishes, which is a good thing. Water is completely miscible with air and that often can lead to problems in the finishing world.
- Positive Azeotrope - water mixed with certain liquids creating a solution that has a lower boiling point than either of the two original liquids. For waterborne finishes this is the coalescing solvent. The reduction in the boiling point reduces the minimum film forming temperature of the polymer in the finish and helps decrease dry time
- Water is transparent and in small quantities appears to be clear. In reality water is a very light blue

It's all About the Water

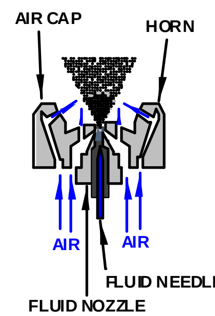
When you pull the trigger on your spray gun a stream of material exits the nozzle. The pressure behind the fluid, as well as the tiny holes next to the large center hole in the air cap flatten the stream into a sheet. As the liquid continues to move forward the sheet disintegrates into spaghetti like ligaments. The forward momentum finally overcomes the surface tension of the liquid and droplets form. As the droplets move forward they fan out in a cone shape. The air coming out of the air cap horns controls the final shape and size of the fan.

Beginning of Atomization

This process is a balancing act between:

- The amount of fluid that you set to come out of the gun
- The amount of air pressure that you supply
- The size of the nozzle
- The size and placement of the holes in the air cap
- The viscosity of the finish
- The surface tension of the liquid you are spraying.

We can control the viscosity of the finish and the settings on the gun and do so to accommodate the nozzle/ air cap combination that we have to give us the desired atomization.



When thinking about waterborne finishes you have to remember that the major component in the finish is water, usually 60% or more. Solvent based finishes contain typically 60% to 80% organic solvent. Since water has a higher surface tension that most organic solvents we need to adjust our settings and/or reconfigure our equipment to overcome the surface tension of the water. This difference in molecular attraction is what causes a lot of problems when people switch from solvent based to waterborne products. Reaction to temperature, viscosity, reduction, and application techniques are all just a little bit different than what most finishers are used to. The solutions are not difficult; they just require a different mindset, a "waterborne mentality", so to speak.

After the finish is applied to the wood the water and coalescing solvents are removed from the pool of liquid by evaporation. Since the coalescing solvent in the finish is selected because it evaporates slower than water the water will evaporate first. As it evaporates the water below the surface migrates to the surface by diffusion. Diffusion is defined as "the spontaneous migration of substances from regions where their concentration is high to regions where their concentrations are low". When you bake cookies in the kitchen the smell travels all over the house is a simple example of diffusion.

This flow of water to the surface continues until it is evaporated. The time that it takes for the water to evaporate is based on:

- The thickness of the coating
- The percentage of water in it

The evaporation rate is determined by:

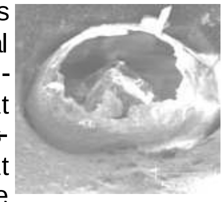
- The type and amount of coalescing solvent
- The temperature of the air
- The humidity of the air
- The velocity of the air moving over the surface
- The temperature of the coating.

Temperature

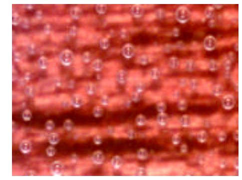
The acceptable temperature and humidity range for the application of waterborne finishes is a little a narrower than solvent based finishes.

The air, wood and finish should all be above 65 degrees when spraying. Low temperatures increase dry time and increase the potential for trapping dust. They also raise the viscosity of the finish which raises surface tension.
This increase in surface tension accentuates the pores of open grained woods because the finish clings to itself and won't flow onto the pore.
Temperatures that are too low or too high can cause an increase in pinholes. You have to remember that the air that

atomizes the liquid finish and the solvents that if contains have to go somewhere when the finish is sprayed on the wood. Microscopically they form tiny bubbles and float to the surface. In an ideal condition the bubbles pop at the surface and the liquid simply flows back and fills in the little pinholes. When the temperature is low and the viscosity is high the bubbles take a lot longer to float to the surface. When they finally get to the surface and pop the liquid is so thick that it often doesn't flow back into the hole causing the pinhole. This problem is often exacerbated by the fact that the common reaction is to increase the air pressure to help with atomizing, thus creating more bubbles. The solution to this problem is simple, either increase the temperature, water to reduce the viscosity, or apply less wet mils.


Pin Hole

When temperatures are too low and the coalescent solvent evaporates before the resin levels, and hardens. This results in orange peel. There are flow agents that can be added to the finish that can help with this problem.

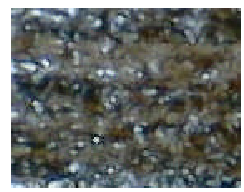

Bubbles in Finish

High temperatures also can cause pinhole problems. The bubbles move quickly to the surface after being sprayed, but the higher temperatures also cause the surface of the finish to dry quickly. This raises the viscosity at the surface which impedes the flow of the liquid back into the hole; again pinholes are the result. The solution is to add some flow agent which will keep the surface wet longer and allow the pinholes heal.


Orange Peel

Another problem in high temperature conditions is that if the finish dries too fast and traps the water. The result is that the finish looks hazy especially over dark stains. Because the water in the coating must evaporate before the film can form.

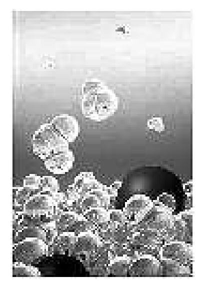
Some waterborne finishes are not tolerant of freezing which can cause resins to coagulate causing the finish to no longer be an emulsion. For this reason it is important that waterbornes be stored in heated buildings. This can also become problematic when shipping certain products to the northern part of the country or Canada, in the wintertime. Some manufacturers ship their products in temperature controlled trucks.


Water Entrapment Resulting in Haze

Humidity

In order for the finish to dry and form a film the water in the finish must evaporate into the air. As stated earlier, temperature and relative humidity are two of the major factors that influence the evaporation rate. Relative humidity is a measure of how much water vapor is in the air at a given temperature.

The relative humidity fluctuates with air temperature. As the temperature increases so does the water holding capacity of the air. For example going from 77°F and 50% relative humidity a 10% rise in temperature will increase the potential water capacity of the air by about 40%. Increased temperature increases evaporation and the increased potential for the air to absorb water vapor results in shorter dry times. That is the good part. The bad part is that at higher temperatures the ambient air may already be heavily loaded with water vapor due to the environmental conditions at the time.


Evaporation

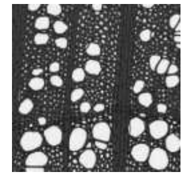
The quality of your compressed air is especially important with waterbornes. When the relative humidity is high it is very important to monitor your air filters and compressor for excessive water. Draining your compressor and filters regularly will keep the water from being passed on and contaminating your finish.

Grain Raise

Waterborne does raise the grain when applied; this goes back to the capillary properties of water. This is often addressed by sanding the surfaces to finer grits, almost burnishing the wood. Wood that is sanded to a 120 grit will has more surface area of wood fiber exposed to the liquid than wood sanded to 240 grit. I have tried lightly wetting the wood surface before sanding and then knocking down the raised grain but I have gotten mixed results that did not seem to warrant the extra step.

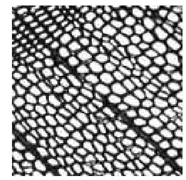
If you apply a heavy seal coat it will stay wet on the surface longer and increase the chances of grain raise. Heavy coats can also trap water below the surface of the film as it dries resulting in a hazy appearance. This is particularly noticeable over dark stains. Apply several light coats before sanding the sealer coat. To avoid intercoat adhesion problem a wet on wet application requires that the successive coats be applied within minutes of each other, especially in warm weather when dry time is shortened. This procedure will not only reduce overall dry time, but reduce grain raise as well. The application of two light coats before sanding will reduce the risk of burn thrus.

Make sure that the wood is warm when the finish is applied. If the wood is cool - again, it will slow down evaporation and allow the surface to be wet longer which increases grain raise. If the finish is warm and the wood is cool there is the chance for water entrapment in the dry film which will result in a hazy finish.



Cherry

I have found it very difficult to use waterborne primers on MDF. It seems no matter how fine I sanded the bare MDF or how lightly I applied the primer the fibers of the MDF keep popping up. When you sand the primer you re-expose the raised fiber and it again expands when re-wetted with the next coat. The best solution would be to apply a shellac based primer followed by a waterborne paint.



Pine

Softwoods such as pine can also be problematic. Their grain structure is very different than that of most hardwoods. Most pines have a larger open cell structure so they are much more porous, thus they will absorb more water which results in increased grain raise.

PH

PH levels of the wood are important. If the wood is too acidic, it will impede film formation and lower hardness and chemical resistance. Occasionally this can be a problem with woods that have high tannic acid content like oak. On painted wood the tannins can bleed through the paint and discolor it. Wood that has been stripped with an alkaline based stripper can also cause these problems.

Tannin Bleed

Rust

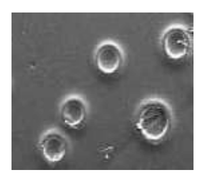
The water in waterborne finishes will cause ferrous metals such as steel to rust. It can also make aluminum oxidize. Most professional spray guns have their wetted parts fabricated from stainless steel or plastic to eliminate this problem. If you are using a pressure pot that is not stainless steel use a plastic liner and be sure that your pick-up tube is stainless steel. Waterborne products should also be stored in stainless steel or plastic containers.

Never use steel wool on the wood or finish. Any leftover particles will react with the water and will cause black stains in the wood or finish.

Finishing Environment

Contamination

In any finish room cleanliness is the rule. A clean environment and clean hands are a must. Clean compressed air is imperative. As the saying goes, oil and water don't mix. Check or replace your filters and elements. If your compressor is passing oil determine the cause and fix it. Ignoring these precautions will result in fish eyes or craters.



Fish Eyes

Avoid the use of tack cloths. Some can leave an oily residue that the finish will not stick to or can cause fish eyes. It is better to wipe the surface with a dry or slightly damp rag.

Health and Safety

Though not very flammable, air quality is still an issue. Spray finishing produces mists and these mists contain resins that can clog or irritate the lungs. Waterborne finishes also contain 2-10% organic solvents - the coalescing solvents. Depending on the solvent, they may or may not be on the EPA's Hazardous Air Pollutants (HAPS) list. While the solvents may be encapsulated in water when they evaporate (theoretically making them less harmful), a solvent is a solvent. What may not be on a list today may be on one tomorrow. Wear a respirator and have adequate ventilation. Remember too that the overspray is flammable, so be sure to practice good housekeeping practices. Do not be lulled into complacency when it comes to your health. Contact your finish manufacturer for specifics about their products.

The Waterborne Finishing System

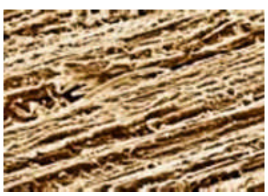
In any coating system every process in the finishing chain has an effect on the appearance and quality of the final product. Because of the unique properties of a waterborne finish we will look at other processes in the system to see how they differ from a solvent based system. It is often the lack of understanding of these processes that leads to poor results with waterborne finishes and not the finish itself.

Sanding

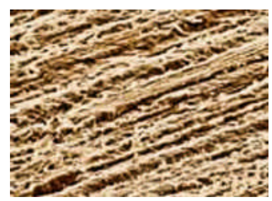
White Wood Sanding

When it comes to sanding bare wood you will find that depending on the species and the stain system you may have to follow different sanding schedules. Grain raise in a waterborne system is always an issue as we discussed earlier. If you use a water based stain it will further add to the grain raise issue. The best solution is to use an aluminum oxide sandpaper and experiment to determine what sanding schedule works best for your particular application. In many cases it is not uncommon to use 220 - 280 as your final grit.

When using wiping stains with any finishing system you know that the stain color is affected by your sanding schedule. Courser sanding grits normally produce darker colors; the exception are stains that contains a lot of dye. These types of stains will actually produce darker colors with finer sanding grits. The key with a waterborne finish is to find the balance between color and grain raise.

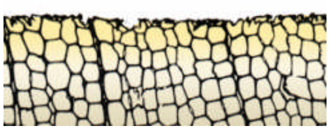


Wood sanded with Aluminum Oxide Sandpaper*

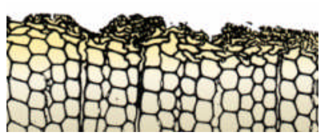


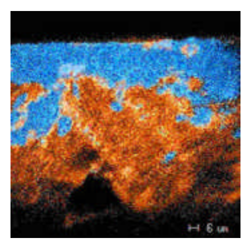
Wood sanded with Silicon Carbide Sandpaper*

Sanded with 240-grit paper



Sanded with 120-grit paper



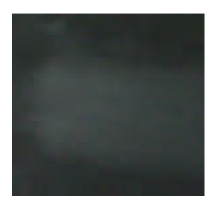


Cross section of coating (blue) on wood

* Photos: Mirka Abrasives

Sanding Between Coats

Once dry there is no chemical burn-in between coats of waterborne finishes, so the dry finish must be sanded before recoating; the sanding scratches provide a mechanical bond for the new coat to adhere to. Waterborne finishes are very hard and can be tough to sand. It is best to sand between coats with 220-320 silicon carbide sandpaper. Be careful to avoid sand thrus when sanding between coats as they can cause wrinkles or show a halo at the sand thru location. For best adhesion recoat the day you sand and be sure to blow or wipe the surface clean before recoating because the sanding dust does not re-melt. On open grain woods make sure that you get sanding dust out of the pores.



Halo Caused by Sand Thru

Staining

The stain system chosen has a large impact on the overall success of system. Avoid using waterborne finishes over oil-based stains. If you must, make sure the stain is completely dry. This could take as long as a couple of days.

As stated earlier, waterborne finishes generally produce a much clearer film than solvent based finishes, especially lacquers. Matching an existing color sample can sometimes be difficult especially dark colors. One of the first thing you might notice is that woods like cherry and walnut lack the glow obtained with solvent based finishes and look rather “dead”.

Waterborne Finish

Solvent Based Finish

Waterborne Stains

Water based stains produce a different “look” than solvent based stains. They can produce a greater variation between early wood and late wood. This is due to the difference in absorption caused by the difference in wood density. As with solvent base stains water based stains are prone to blotching. With both stain systems wiping on a clear stain base, letting it set for a bit and then wiping it off before applying the pigmented wiping stain will help. The key is to let the clear base dry completely before applying the color. I find that this technique provides more consistent results than applying a washcoat then scuff sanding before staining. It also eliminates the scuff sanding step. Water based stains are non-flammable and VOC compliant. They also raise the grain and dry quickly.

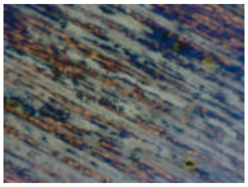
Grain Raise

Their short open time can make it difficult to stain large or complex pieces. After applying the stain, one trick is to wipe the stain off with a damp rag before using a dry rag to remove the excess. The stained wood may need a swipe with a fine sandpaper to remove excess raised grain. Sanding with a heavy hand will remove color.

It can be hard to make toners with waterborne finishes since they usually require heavy reduction to avoid excess film build. Over reducing waterbornes can lead to cratering and runs on vertical surfaces.

Solvent Based Stains

Hybrid systems using solvent based stains with waterborne finishes can simplify the finishing process. They produce minimal grain raise, have longer open times and many have relatively short dry times. Although they are flammable there are VOC compliant formulas available. Many use the same colorants and stain formulas that the standard solvent based stains use. When using solvent based stains you should always make sure that the stain is totally dry, especially when used on deep grained woods. If you use solvent based stains stain and seal on the day you sand for best adhesion.



Loss of Adhesion due to Wet Stain in Pore

Finish Application

Here are some basic waterborne application rules that should help eliminate problems:

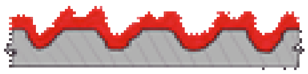
- Generally use a larger size needle/nozzle/air cap combo in spray guns
  - The larger the nozzle size the more air needed to atomize the fluid stream
  - I personally prefer Reduced Pressure spray guns over HVLP. They have the same transfer efficiency but have finer atomization and use less air.
  - If you use a turbine unit a three or four stage system will give the best atomization
- If the gun was used previously for a solvent based finish run some clean water thru it before adding the waterborne
- Stir material very well – especially paint
  - Re-emulsify the water with the resins and pigments
  - Paint will sometimes crater if not stirred well
  - Avoid vigorous shaking of the product as this will encapsulate air bubbles into the mixture
  - Good results can be obtained with an inexpensive paint stirring attachment used on an air drill
  - Agitators are highly recommended when using a pigmented finish in a pressure pot or with an air assisted airless system
  - Run agitators slowly to avoid whipping air into the finish
- Spray light coats – 2 to 3 wet mils

- Faster dry
- Waterborne has a higher specific gravity than solvent-based products; this, combined with a sometimes slower dry time, can lead to increased sagging on vertical surfaces.
- Eliminates cloudiness when applied over dark stains
- Higher wet mil thickness increases surface tension which exaggerates the pore on open grained woods. Lower wet mil thickness gives a crisper pore
- When spraying sealer on stained woods ,to avoid burn thrus, apply two light coats wet on wet and then sand.

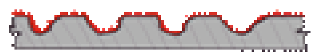
Runs

Cloudy Finish

- Do not over reduce material
  - Check with the manufacturer about using water to reduce viscosity
  - More water means higher surface tension which can create craters and pinholes
  - Increased sagging and runs on vertical surfaces
- If performing wet on wet application do not wait too long before recoating
- Total finish system requirements
  - Minimum 3 dry mils
  - Maximum 5 dry mils



High Wet Mil Thickness



Reduced Wet Mil Thickness

Wet Mil Gauge

Drying

Lower Wet Mil Thickness
So far we have pressed the subject that waterborne is temperamental when it come to drying. This fact may seem to have a significant impact on production if you do not use ovens to dry the finish. Quite simply the dry time can be overcome by applying fewer wet mils per coat, although this may require additional coats to bring you up to the desired dry mil thickness. Waterbornes typically have a high percent of solids by volume. If you are using a pre-catalyzed lacquer this might not even be an issue. For instance, three coats of a 33% solids by volume waterborne, applied at three wet mils will give a system total dry mil thickness of 3 dry mils. Thee coats of a 25% solids by volume precatalyzed lacquer applied at five wet mils will give a system total dry mil thickness of 3.75 dry mils. Both scenarios will meet most finish manufacturers requirements for minimum system dry mil thickness.

Increase Temperature
Heated air not only increases the evaporation rate of water, but as we stated in the humidity section, as the temperature increases so does the water holding capacity of the air. In large production facilities they use ovens. In a small shop the solution might be as simple as turning up the thermostat.

Air Movement
Air movement through the use of fans can also speed drying, even at higher relative humidity levels. If you can imagine a typical vertical door rack where each door becomes a ceiling for the door below, As the water evaporates off of the finish a little micro-climate of water laden air forms across the surface of the finish effectively held in place by the door above. There gets to be a point where the air becomes saturated and the transfer of water in the finish to air becomes slowed. Air moving across the surface of the coating allows the airborne water particles to be swept away and replaced with air that is at a lower moisture content, thus speeding the water transfer process. When the humidity is high this same principal holds true. Although the dry times will not be as fast as in low humidity conditions it will be faster than if no air movement was involved. An important point to remember is to allow the freshly sprayed product some time to flash off before moving it in front of a fan or else you will have pinhole problems.

There is one final consideration to be made when employing the previously mentioned methods; in an enclosed environment eventually all of the air will become heavily laden with water vapor and the drying process will slow. Running your spray booth will help exhaust the moisture rich air. Cycling the booth on and off after you are finished spraying may help conserve heat in the winter, but you must be careful of air quality levels.

Dehumidification

Dehumidification is a rather new approach to the subject of drying waterborne finishes. The concept is brilliantly simple. As stated earlier water moves to the surface of the pool of finish by diffusion, followed by evaporation from the surface and then dispersion into the air. By supplying air that is at a very low relative humidity level the rate of this processed is increased without the addition of heat. Heat can not only increase the possibility of pin holes and water entrapment, but it is expensive. Heated air systems are an open loop system, eventually the warm air will saturate with water and must be exhausted. The expensive heat goes up the stack, so to speak. The dehumidification process is a closed loop system. It typically operates in an enclosed room or chamber. The air is moved across the wet parts and is sucked into a filtered two stage dehumidifier. The first stage employs a desiccant or moisture absorbent material like silica gel which removes a portion of the water. The second stage is a refrigerated coil dehumidifier. As the reduced moisture air moves across a refrigerated coil it is cooled and the remaining moisture condenses, is collected and drained. The compressor used to cool the coil generates heat. This heat is used to re-warm the now dry air then it is blown back into the room and the cycle begins all over. Not only do these dehumidifying systems require less energy to operate they don't require more that the ambient heat supplied to the building to operate efficiently. Right now these systems are designed for large production plants, but I am sure that in time smaller scale systems will be available.

Pack & Stack

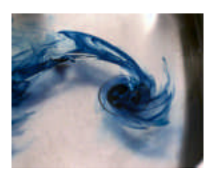
While a finish may feel dry to the touch in a matter of hours, this does not mean that it is ready to travel.

- Finish should be dry for a minimum of 48 hours before being packed and stacked
  - Longer in humid weather
  - Longer for glazed & full-fill finishes
  - Most wood finishes take 30 days to fully cure and harden
- Never stack pieces "finish to finish" without a protective layer between
  - Always use plain paper or a closed cell foam between layers when bundling multiple shelves, doors or panels
  - Never use corrugated cardboard between layers – it will leave an imprint
  - Never use newspaper between layers as the ink may transfer onto the finished piece
- Whenever possible ship bundles of shelves, doors or panels on edge rather than laying flat
- Never leave newly finished products in a truck for an extended period of time
  - Summer heat can cause freshly finished pieces to stick together or to leave an imprint from their wrapper
  - Winter cold can cause freshly finished pieces to cold check and crack
- Store shelves, doors or panels standing on end at the jobsite rather than laying flat.
  - Cut the tape or wrapper on bundles as soon as possible after the product is delivered to relieve pressure
- Make sure moving pads and blankets are clean and free of debris

Printing

Clean Up

Clean equipment right after use. Once dry waterborne finishes do not re-dissolve in water and solvents turn them into a rubbery gooey substance – the technical term is snot. Guns must have their needle, nozzle and air cap removed and scrubbed with warm soapy water and a brush. You can also add a little ammonia to the solution. You cannot clean guns by just blowing water through them; I have tried and have regretted it afterwards. If a gun is going to be reused later for a solvent based finish after washing with the water solution you should run denatured alcohol through it to remove any remaining moisture. Denatured alcohol is miscible in water. Ite remaining water will go into solution with the alcohol and be cleared out of the gun.



One final thought, be environmentally responsible with the disposal of your unused product. Just because it is mostly water doesn't mean that you can simply pour it down the drain. Check with local authorities or a licensed waste hauler to make sure that your disposal methods are in compliance.

Business Issues

The non-flammability feature of waterborne has several financial benefits. Insurance rates may be lowered not only because of the elimination of highly flammable solvents, but also because the lower VOC's decrease potential health liability.

Waterborne coatings eliminate or reduced the need for flammable storage rooms and cabinets. Zoning and permitting can also be easier to obtain plus there are reduced regulatory compliance issues. Many localities place a restriction on the amount of flammable liquids that can be stored on site; there are usually no restrictions for waterbornes.

While waterborne finishes may have a higher cost per gallon they usually have a high solids by volume content and may actually reduce the amount of material needed to complete a job. This is particularly true if you use precatalyzed lacquers. Consider also the elimination of solvents necessary for clean up and their disposal fees, which can often cost twice the original cost of the solvent itself.

Many waterborne finishes can qualify for LEED's and Green Projects which can put you ahead of the competition. There is also the potential marketing aspect of being part of the green movement.

Most importantly a safer healthier workplace is the largest benefit by far. The improved air quality may lead to higher production rates and improved employee morale.

Aside from the increase in material costs waterbornes can have some increased labor costs as well. There is often an increase in production time compared to solvent based finishes and is often weather related. They can include:

- More coats
- More material handling - more cycles through the booth
- More sanding
- Seasonally slower dry times
- May require more heat in cold months
- Waterbornes can be harder to sand which will increase sanding times
- Longer equipment clean up times.
- In general, the waterborne coatings are more sensitive to changes or operator error than the solvent based coatings.

Material Coverage per Square Foot per Coat

Use this chart to calculate coating coverage.

Coverage per coat - Large Flat Panels

TE - Transfer Efficiency	3 mils wet	5 mils wet
100% (Brush)	534 sq ft.	320 sq ft.
80% (Air Assisted Airless)	428 sq ft.	257 sq ft.
65% (HVLP)	348 sq ft.	208 sq ft.
40% (Conventional)	214 sq ft.	128 sq ft.

Things to Consider when Using this Chart

- Transfer efficiency is not only a function of the spraygun, but also the type of part being sprayed and the application technique of the finisher.
- The application technique of the finisher has a greater effect on the Transfer Efficiency than either the type of spraygun or the type of part being sprayed.
- You will get less coverage on mouldings or parts that you have to spray edges than you will on the faces of large flat panels.
- Lower solids (often less expensive) materials or lighter coats may take more coats to achieve a desired dry film build.
- Labor is always more expensive than material.

Square Foot Cost of Coatings

This chart will help calculate you cost of material per square foot per coat. It can be used for both waterborne and solvent based finishes. The two tables show both a 3 and a 5 wet mil application. A 3 wet mil application rate which is typical for waterbased finishes which are usually applied in a lighter coat.

I have highlighted the 65% TE (***Transfer Efficiency)*** which is typical for most HVLP and Reduced Pressure sprayguns. 40% TE is typical of conventional guns and 80% is for Air Assisted Airless equipment.

Simply go across the row that is closest to the price per gallon that you pay to where it intersects with the TE column of your spray gun and that is your cost of material per square foot per coat. Multiply that number by the number of coats that you will apply and you will have your cost of material per square foot.

Finish is applied at 3 wet mils

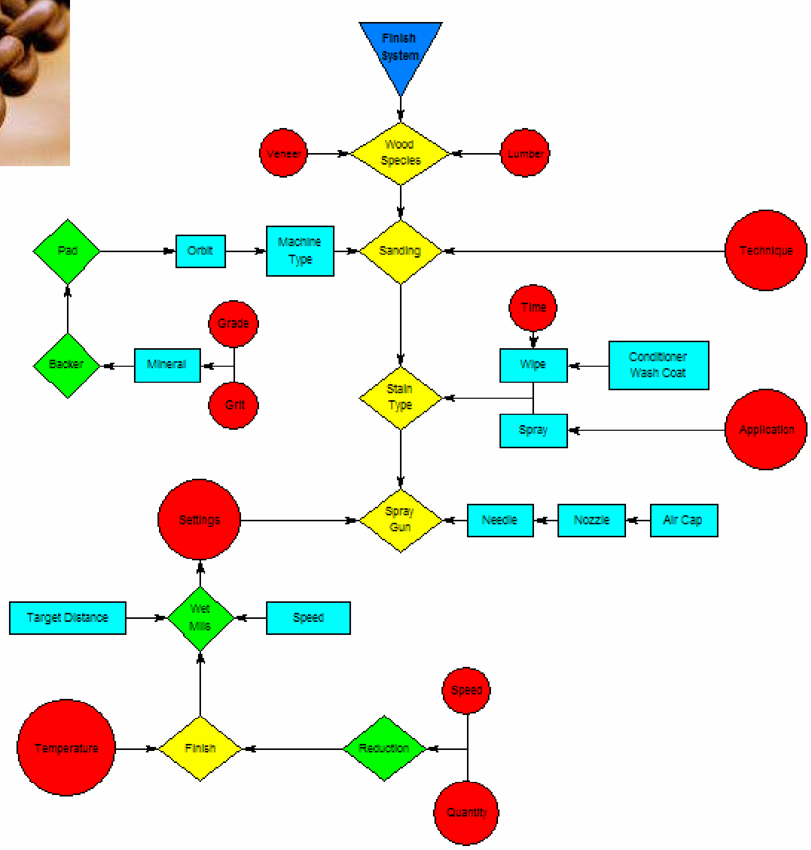
	80% TE	65% TE	40% TE
$ PER GALLON	SQ FT COST PER COAT	SQ FT COST PER COAT	SQ FT COST PER COAT
$10	$0.02	$0.03	$0.05
$12	$0.03	$0.035	$0.06
$15	$0.04	$0.04	$0.07
$18	$0.045	$0.05	$0.08
$20	$0.05	$0.06	$0.09
$23	$0.055	$0.07	$0.11
$25	$0.06	$0.075	$0.12
$28	$0.07	$0.08	$0.13
$30	$0.075	$0.09	$0.14
$33	$0.08	$0.095	$0.15
$35	$0.085	$0.10	$0.16
$38	$0.09	$0.11	$0.18
$40	$0.10	$0.115	$0.19
$43	$0.105	$0.12	$0.20
$45	$0.11	$0.13	$0.21
$48	$0.115	$0.14	$0.22
$50	$0.12	$0.145	$0.23

Finish is applied at 5 wet mils

	80% TE	65% TE	40% TE
$ PER GALLON	SQ FT COST PER COAT	SQ FT COST PER COAT	SQ FT COST PER COAT
$10	$0.04	$0.06	$0.08
$12	$0.05	$0.06	$0.09
$15	$0.06	$0.07	$0.12
$18	$0.07	$0.09	$014
$20	$0.08	$0.10	$0.16
$23	$0.09	$0.11	$0.118
$25	$0.10	$0.12	$0.20
$28	$0.11	$0.13	$0.22
$30	$0.12	$0.14	$0.23
$33	$0.13	$0.16	$0.26
$35	$0.14	$0.17	$0.27
$38	$0.15	$0.18	$0.30
$40	$0.16	$0.19	$0.30
$43	$0.17	$0.21	$0.34
$45	$0.18	$0.22	$0.35
$48	$0.19	$0.23	$0.38
$50	$0.20	$0.24	$0.39

Conclusion

Waterborne stains and finishes are here to stay. Finish manufacturers are constantly making improvements and as usage increases prices go down. Waterborne systems can provide your company many health and economic benefits, but I suggest that before you make the switch do your homework.

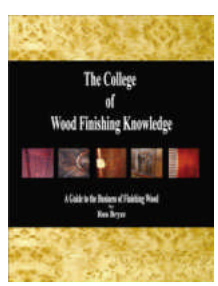


Wood finishing is a system because the success of every process is dependant on the success of the process that preceded it. This string of processes is often compared to a chain and usually implies the premise that the system is only as strong as it's weakest link.

In part that premise is true, however in real life there are many procedures within a link that effects its performance. For instance, there is the fact that finishers often compensate for abnormalities. If they do not have the right size needle for their gun they might adjust the amount of reducer they use, or how fast they move the gun over the surface. This may require more material or labor, but I does get the job and many accept this as a fact of life in the finishing world.

I like to think of the finishing system as a Mobile. There is a balance in the system. As something goes out of balance there is the chance that it can be compensated for without the system totally crashing. There are some items that carry more weight than others and would require more adjustments to fix. Most of these critical factors are application and technique related, which goes to show that the person behind the tool is often more important than the tool itself. This observation goes a long way in stressing the need for training and education.

Optimal performance is achieved by obtaining balance in each of the arms of the finishing mobile so that nothing else must compensate for it. It is the balance of man, material and equipment equals profitability



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