

# Wood Finishing Demonstration Project

## Final Report

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## **Wood Finishing Demonstration Project Results**

### **Introduction**

The Minnesota Pollution Control Agency's Small Business Assistance Program (SBAP) and the Minnesota Technical Assistance Program (MnTAP) received a two year Leadership Grant from the US Environmental Protection Agency (EPA) in 1995. The focus of the grant is to provide multi-media compliance and pollution prevention assistance to wood furniture manufacturers, cabinet manufacturers and millwork shops in Minnesota. The grant allows the MPCA and MnTAP a unique opportunity to provide compliance assistance to the wood finishers in the state and to work toward voluntary reductions to ensure that the ambient air quality standards for ozone are maintained.

The secondary wood products industry is an important industrial sector in Minnesota both economically and environmentally. Over 1,000 furniture, cabinet and millwork shops exist in Minnesota. These shops are a significant emission source of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). The secondary wood products industry is one which is receiving more regulatory scrutiny through the Wood Furniture Manufacturing National Emission Standard for Hazardous Air Pollutants (NESHAP) and in locations that do not meet the national ambient air quality standard for ozone.

This report documents the results of the pollution prevention demonstration project, which is one component of the grant.

### **Finding and Selecting a Candidate for the Project**

Fliers soliciting interest in the demonstration project were mailed to over 500 wood finishers in February 1996. Articles soliciting interest in the project were published in the MPCA's *AIR MAIL* newsletter and MnTAP's *SOURCE* newsletter. In addition, a list of seventeen companies which fit the targeted SIC codes and were significant emission sources of VOCs and HAPs was generated from the air quality permit application database. The companies from the database were contacted by SBAP staff regarding the demonstration project. Visits were set up at the fourteen receptive facilities to review their operations and discuss the project. These visits were conducted in February and March 1996. Second site visits were conducted at several of the facilities.

The Pine-Tique Furniture Company, located in Minnetonka, Minnesota, was selected for the pollution prevention demonstration project. The criteria used to select the demonstration company included:

- A project that would be transferable to other wood finishers.
- Support from management for the project.
- Willingness to allow the project to be documented.
- Flexibility in operations to try different pollution prevention options.

- Common spray coating equipment (to ensure the transferability of the information).
- Size of the facility. A small or medium shop was considered more desirable because the economic constraints it would face in exploring pollution prevention alternatives would apply to a large majority of the wood finishers in Minnesota.

A partnership agreement between Pine-Tique, SBAP and MnTAP for the demonstration project was signed in May 1996. The primary focus at Pine-Tique was to find a waterborne stain and lacquer whose finish quality would match their solvent-borne system. Viking Industries, located in St. Joseph, Minnesota, was also interested in finding a waterborne finishing system. In order to provide assistance to Viking and gain as much knowledge as possible on waterborne finishing systems, MnTAP placed a student from their summer internship program at Viking.

## **The Wood Finishing Process**

Many wood finishers use the traditional solvent-borne stains and nitrocellulose lacquers to finish their wood products. The solvent-borne coatings provide a durable, high quality finish at a reasonable cost. They are also easy to spray and problems with the finish are easier to fix because a compatible solvent can quickly strip off the finish.

Most wood finishers apply a wipe stain or a pigmented coating followed by a sealer and topcoat. Pieces are sanded between applying the sealer and topcoat so that the topcoat will adhere to the part. Steps vary between shops based on the type of wood being used, the type of product being manufactured and the desired finish. Some shops use toners (tints) in their lacquer to enhance the grain of the wood, others may be adding several layers of topcoat to achieve a deep, rich finish.

VOC and HAP emissions are associated with both the spraying and curing processes within the finishing area. Particulate matter (PM) emissions are generated during spraying and sanding operations. The sawing and milling operations also generate PM emissions.

### ***Process Considerations and Company Comparisons***

Both Pine-Tique and Viking currently use solvent-borne stains and nitrocellulose lacquers to finish their products. Stain is sprayed on and wiped off, followed with a sealer and topcoat. Scuff sanding is performed between applying the sealer and topcoat. Not all products are stained, some are sold with only a clear coat. Detailed descriptions of Pine-Tique's and Viking's finishing processes can be found in Appendix A and Appendix B respectively.

Pine-Tique and Viking each had unique concerns when searching for suitable waterborne coatings. Some of their concerns are compared as follows:

### **1. Wood species**

Viking's products are made primarily from pine while Pine-Tique's products are made from six different types of wood which include hard and soft woods. Applying waterborne finishes to soft woods such as pine often causes difficulties with grain raise as these woods are more porous. An even, smooth-to-the-touch surface is an industry standard for wood furniture manufacturers.

### **2. Color matching**

Waterborne finishes are water-clear whereas nitrocellulose lacquers have a amber tint to them and yellow over time. Walnut and cherry wood also gain a deep, oiled finish with nitrocellulose lacquer which can be difficult to match with a waterborne finish. Pine-Tique is concerned about being able to match the appearance of products which are in showrooms or customers homes. Pine-Tique's desire is to find one finishing product which is suitable for a large variety of woods as mixing special tints for different woods adds labor costs, equipment costs and/or scheduling difficulties.

### **3. Finished after assembly**

A larger percentage of Pine-Tique's products are finished after assembly. These three-dimensional pieces need special attention to minimize overspray onto finished areas. Dry waterborne overspray does not blend into a finish as well as lacquer and could cause finishing defects similar to dust. The cure time of a topcoat should also be slow enough to allow the wet edges to be blended together as the finisher completes the piece due to this same blending difficulty.

### **4. Dry time**

Viking has a shorter dry time requirement. Because of shipping schedules and promises to customers, an 8-hour dry time is required for some products. This can be an obstacle for waterborne finishes which generally do not dry as quickly as solvent-borne finishes.

### **5. Storage and transportation concerns**

Because they have unheated warehouses and often transport finished product by unheated truck, Viking is concerned about the affect of temperature changes on the finish. An acceptable finish will need to withstand ten extreme temperature cycles without visible signs of damage.

### **6. Sanding**

Viking does not sand their product as finely - leaving more surface area open to water absorption and grain raising difficulties. Sanding at 60 grit is considered "rough" by many wood finishers, but Viking is getting a satisfactory finish with this method and was not interested in investigating finer sanding methods. The finer grit paper would clog-up more often with pine pitch resulting in increased material and labor costs.

## **7. Spray Equipment**

Viking was also interested in alternative spray equipment such as high volume low pressure (HVLP), whereas Pine-Tique was utilizing HVLP already. Alternative equipment was tested at Viking and the production rate slowed with one of the alternative models tested.

## **Emissions and Wastes**

Many companies may be able to qualify for a simpler air quality permit or eliminate the need to complete a SARA Section 313 - Form R by switching to a waterborne finishing system. Companies have also eliminated or reduced the amount of hazardous waste they generate. Information from the demonstration projects can assist additional companies in achieving these goals.

Companies changing to waterborne finishing systems should evaluate their options for disposal of wastewater generated from spray equipment cleaning. The local publicly owned treatment works (POTW) tested rinsewater from equipment cleaning and allows sewerage this water in some cases. Check with the local POTW before sewerage finishing wastewater. Discharge of industrial wastewater to a septic system is prohibited. Companies on septic systems may consider collecting the wastewater and shipping it to a POTW for disposal.

Waterborne finishing overspray may collect differently than solvent-borne overspray on spray booth filters. Companies changing coatings may need to investigate alternative filters to obtain the best performance. For example, paper-type filters may not last as long as fiber-spun filters due to the slower evaporation rate of water in the overspray that is collected on the filter.

### ***At Pine-Tique***

#### **1. VOCs**

Pine-Tique is a low emitter of VOCs. They have applied for a registration permit with the MPCA . 1995 annual emissions of VOCs were 4.5 tons **based on product usage records**. The majority of the emissions are from the usage of lacquer as a sealer and topcoat. Nearly 1,300 gallons of finishing materials (paint, stain, and lacquer) were used in 1995.

#### **2. Rag waste**

Thermal underwear scraps are purchased for rags. They purchase 80 pounds a month at \$1.16 per pound. Scraps must be cut and the elastic trimmed from them before they are used for wiping. The wiping process is two-staged in that a used rag is utilized in the first wipe to remove excess stain and a cleaner or fresh rag is used as a final wipe. When the first rag does not pick up the stain it is discarded and the final wipe rag is used first. The rags have been tested to be non-hazardous and are disposed of as a non-hazardous industrial waste at a landfill. They accumulate one half drum per month. Annual cost of

disposal of rags is about \$115. This does not account for the cost of labeling, storing, and handling the wastes.

### **3. Hazardous waste**

Pine-Tique is a very small quantity generator (VSQG) of hazardous waste in Hennepin County. Waste solvent is accumulated from cleaning pressure pot systems, spray nozzles and mixing equipment. The fluid in the delivery lines recirculates and does not require flushing. The accumulation of waste solvent over the last 2.5 years is 8.7 gallons per month or approximately two drums per year. Annual hazardous waste disposal costs are \$300.

## ***At Viking***

### **1. VOCs**

Viking is primarily concerned with their organic air emissions released as a part of their wood finishing process and products. The VOCs are released from the stain, sealer, and topcoat as they are sprayed onto the products and while they are drying. The thinner, used to clean the equipment and lower the viscosity of the spray products, also releases some VOCs, though it is a small percentage of the total. In 1995, Viking released 20.7 tons of VOCs into the environment through its finishing process.

### **2. Rag waste**

The rags that are used to wipe the wood after the stain is applied are an additional waste product from the finishing process. These rags are stored in thinner and reused. The thinner redissolves the stain in the rags, and then the rags can be reused up to a point when they wear thin and get holes in them. The number of rags that are disposed of each day varies widely with the products sprayed; if more products are sprayed that have more sides to be wiped, i.e., futon frames with many bars, then the rags wear more quickly. Approximately seven rags are disposed of each day. Excess solvent is hand wrung from them and they are put into the dumpster to be landfilled or incinerated.

### **3. Hazardous waste**

There is no liquid or hazardous waste created by Viking's finishing process. All of the remaining finish material left at the bottom of each used up barrel is rinsed out with lacquer thinner, and that mixture is poured into the new barrel. The thinner used to clean the rags can be mixed back into the stain barrel and sprayed as part of the wood stain. This small amount of used solvent does not affect the finish product performance and it reduces the amount of virgin thinner which needs to be added. Viking is also able to purchase finishes at a higher solids content and then reduce them in-house with waste solvents. This practice may be useful for other companies, but testing is recommended to assure finish quality is not compromised. Viking is concerned about the disposal of water used to clean equipment which applies waterborne finishes as it is doubtful that it can be added back into the finish.

## Use of Waterborne Finishes

Waterborne finishes use water instead of conventional solvents as the major carrying medium for the finish solids. The binder or solids in conventional nitrocellulose coatings are in solution. This is different in waterborne finishes where the binder is dispersed and tends to have a lower viscosity with higher solids concentrations. The same film thickness will be achieved with waterborne coatings using less material. Using a waterborne finish can significantly reduce the VOC air emissions. Appendix C contains a list of suppliers of low VOC and waterborne wood finishes.

### ***Finish Criteria and Process Considerations for Selecting Alternative Coatings***

Both of the companies have finish criteria which are subjective. They prioritize appearance criteria and their finished products must be smooth to the touch. Both companies were willing to consider slight changes in production processes but preferred to find finishes that did not require additional process steps or increase production time.

Pine-Tique's most important finish criteria is appearance. The nitrocellulose finish has a low gloss and the finished products are very smooth to the touch. Alternative products tested should not exhibit the grain raising characteristics after the topcoat.

The products tested should pass the Kitchen Cabinet Manufacturer's Association (KCMA) chemical resistance tests. The chemicals tested are listed in Appendix D. These tests simulate situations that the finish may see once it has been sold to the consumer. Pine-Tique does not perform these tests but asks potential vendors to certify that the finishing material passes these tests.

One production criteria includes the ability to touch or sand the material within time frames similar to the nitrocellulose product. Products usually have 45 minutes to an hour before they are sanded even though the finishes are dry in eight to 14 minutes.

The topcoat should be self sealing, that is the same material is used as a sealer and the topcoat. Preference is given to materials that would not require a duplicate system to apply two different products.

One advantage to the waterborne materials was that the finish does not yellow when exposed to UV light. This was considered to be an advantage; however, during the short-term, products will need to be finished to match furniture from previous customers.

Pine-Tique is interested in lowering the VOC content of their finish and they would like to use a material which has less than two pounds of VOCs per gallon. The nitrocellulose product being used contains 5.6 pounds of VOCs per gallon. Pine-Tique is currently undergoing an expansion and wants to keep their actual emissions within the limits of their air permit. Without switching to lower VOC content coatings, the increased



emissions from the expanded finishing department may require modifications to their permit.

Viking also prioritizes finish appearance. It must be glossy, have little or no grain raise and have a smooth, deep look. The first test that a finish needs to pass before being considered as a possible alternative is the appearance test.

The second most important characteristic in a finish for Viking is the cure time, the time it takes a finish to dry before it can be safely stacked on other finished surfaces without concern for sticking or finish damage to occur. Except on the most muggy days of the summer, Viking likes to be able to stack and pack their products within eight to ten hours after their final topcoat. The finish must be cured within six to eight hours at most.

The third most important characteristic for Viking is that the finish be able to withstand the temperature changes which a finished product may be subjected to. Finished products may sit in Viking's unheated warehouse during the winter, moved to a moving truck, moved into the cold and back into a warm area.

## **Testing, Modifications and Results**

Testing of waterborne finishes at Pine-Tique was handled by Mark Schultz, vice president and supervisor of the finishing department. The visual tests were most important to Pine-Tique and several modifications were tested to obtain improved appearance. Mark was able to compare colors of the topcoat and feel the amount of grain raise to determine acceptability.

Pine-Tique has been growing over the last few years and decided to expand its finishing department. This expansion began in November 1996. The equipment ordered was chosen with the intention of converting the finishes to waterborne products. Modifications have been made to all fluid passages of the pumps, lines and spray guns to ensure usage of corrosion resistant materials such as stainless steel or plastic. Coating vendors have cautioned wood finishers of production problems when corrosion occurs in fluid delivery systems in which waterborne coatings are used. Corrosion can cause finish defects and plug spray equipment.

Testing at Viking was done by a MnTAP intern. Pine boards were used following the production sanding and finishing steps previously mentioned. That means using 60 grit sanding before sealer and 180 grit between coats. The appearance test is done by comparing the color, grain raise, and gloss of the waterborne relative to that of the nitrocellulose. Most of these comparisons are done visually, however, the grain raise comparison is also done by touch.

The intern tested products from eleven coating manufacturers. A supplier's list of low VOC and waterborne wood finishes is included in Appendix D. The methods used to test the alternatives were designed to simulate the production process. Samples were sanded and finished as in production with waterborne sealers and topcoats replacing the nitrocellulose sealer and topcoat. All of the original samples tested showed signs of grain raising. Modifications were tried based on recommendations from the vendors. These modifications include sanding with finer grit paper and using solvent-borne sealers.

## ***Appearance***

### **Grain raise**

Pine-Tique has successfully tested a waterborne, self-sealing lacquer on four of the six species of wood used for their products (pine, birch, maple and oak). This material has only been tested as a clear finish on unstained products.

Finishing steps were modified over the course of the project based on recommendations by suppliers and information gained in trade publications. One trial was done with a light "mist coat" which was intended to minimize grain raise and seal the pores for future coats. This step did not have noticeable affects on the appearance of Pine-Tique's finish.

A third full coat of the waterborne topcoat was added to achieve a smoothness comparable to that of the nitrocellulose lacquer. This step also required an additional sanding step. Although these steps increase the labor cost per piece and use additional floor space, Pine-Tique is still considering this option.

Viking was not able to find a waterborne system which was able to match their appearance criteria. Defined growth rings in the pine swelled from the waterborne sealer and could not be overcome in the topcoat step. Some finishes were tested with modified sanding procedures. Pre-finished wood which was sanded with a finer grit paper reduced grain raising. Viking was not interested in changing this production step due to the increased labor and replacement costs for the finer grit sanding belts which would plug faster from the pitch of the pine wood.

Two types of nonwaterborne sealers were tested: nitrocellulose and vinyl. They seemed to seal the wood fibers better than the waterborne sealers and minimized grain raise. Two brands of waterborne topcoats had acceptable appearance when used with a vinyl sealer. A bed frame set was sprayed with each of these vinyl sealer / waterborne topcoat systems and shipped as acceptable product. Although the appearance criteria were met, these systems did not cure within the eight-hour cure time requirement. These bed frames were sprayed late one Friday and allowed to dry over a weekend due to concerns with the longer dry times. Due to this production constraint, this system was unacceptable.

## **Color**

Matching the amber finish appearance of the nitrocellulose lacquer was necessary in order to match the amber that exists on previously sold products by Pine-Tique. Dyes were added to the finish and tested for color match. Dyes were tried in the seal coat only and in all coats. Having a slight amount of tint in each coat would allow Pine-Tique to continue to use the same product as a sealer and a topcoat. This procedure yielded an acceptable finish for clear-coated products made of pine, birch, oak and maple.

An acceptable waterborne clearcoat has not been found for the walnut or cherry pieces. Even with dye added to the material, the deep color of the nitrocellulose finished wood has not been matched. The appearance of the walnut and cherry seems washed out and the wood grain is not as defined when the waterborne material is used. This material has only been tested on unstained products. Even if an additional dye mixture yields an acceptable finish for walnut and cherry pieces, Pine-Tique is concerned that a separate clearcoat mixture will be required for each wood species. This would potentially add cost for three dedicated clearcoat systems or add time to change materials in pressure pots and clean the equipment. One vender suggests a dye stain to be applied to the wood before sealing, but this has not been tried at this time.

Color matching was not a selection criteria for a waterborne coating for Viking.

## **Cure time**

Pine-Tique's testing has not needed to be modified for cure time differences. They allow all finished products time to dry over night before any hardware is attached and then allow an additional day before a product is packaged or shipped.

Along with Viking's difficulties in achieving an acceptable, smooth surface, production schedules could not accommodate the longer dry time associated with waterborne materials. A stacking test was performed to simulate packaging a product with a short cure time. Finished boards were clamped together at set times such as six or eight hours and allowed to sit over night. The next day the clamps were removed. If the boards could be separated with no visual damage the finish passed the test. No samples were able to meet the appearance and cure time criteria.

To improve the cure time, several steps were taken. Fans were placed near the finished boards to improve the air circulation to reduce cure time, but the samples could not consistently meet the eight-hour time goal under different humidity conditions. Several product samples were cured in the air-conditioned production office. The cure time was shortened with air conditioning, but samples did not consistently pass both the appearance and cure time tests.

## ***Cold-cracking***

Viking tests for cold-cracking, small finishing flaws shaped like spider webs that appears a result of cold stress. A finish is tested by placing a finished sample in a cooler with dry ice then warming it to simulate the dramatic temperature changes product could see moving from unheated storage to trucks to showrooms or homes. The finish should not show any signs of cold-cracking after the sample has been subjected to ten cold - warm cycles.

One waterborne topcoat sample sealed with the vinyl sealer passed a modified cold cracking test. The sample boards were cycled seven times until the supply of dry ice was depleted. No cracks were evident on the sample tested; however, the coating did not cure within eight hours.

## **Future plans**

Three vendors of waterborne materials continue to work toward a material which will be acceptable to Pine-Tique. New material samples are currently awaiting scheduling time to be tested at Pine-Tique. These samples are planned to be evaluated during the first quarter of 1997. The growing pains of the expansion have limited production time and the ability to test new finishes. It is hoped that the addition of a second spray booth will allow for testing of these new finishes and a suitable alternative finish or finishes can be found.

At the time of this report, Viking has not continued testing of waterborne finishes. Additional testing of the most promising **coatings** may occur later this winter while the ambient humidity remains low. One option would be to use the vinyl sealer / waterborne topcoat system during the winter months and use a higher solids solvent-borne material during the humid summer months. Another option would be to use alternative coatings for products which do not need to be shipped eight hours after they are finished. Several coating manufacturers plan to continue improvements to their products and continue to work with Viking.

## **Other Pollution Prevention Options**

### ***Laundering Staining Rags***

Industrial laundry services and uniform leasing companies also lease towels which can be used for staining operations. One service contacted could offer towel laundering at a cost of six to eight cents a towel depending on the amount ordered. During the laundering process solvent washwaters may be generated and are difficult to manage. Reputable laundry services have industrial wastewater permits and properly manage these problem waste streams. At the time of this report, Pine-Tique is still considering the use of reusable rags. A list of industrial laundries accepting staining rags is in Appendix E.

### ***Optimizing Cleaning Solvents***

Pine-Tique reuses the solvent used to clean mixing equipment but disposes of it when the solids content becomes high. Currently fresh solvent is used to flush pressure pots, lines and guns when necessary because the solids would plug the in-line strainer on the spray gun. We tested the ability of a paint strainer to remove solids from the old cleaning solvent to be used as a first wash. The strained cleaning solvent was pumped through the equipment and no solids were detected in the gun screen. This practice could cut their solvent waste stream in half with a few modifications to solvent collection and use. This could be combined with the practice of allowing the solids to settle before straining the rest thus minimizing the clogging of the paint strainer. Reusable strainers could also be fabricated and then back washed into the solids container. With the planned conversion to the waterborne finishes and reduction of solvent needs, Pine-Tique was not planning to implement the modifications.

### ***Improving Transfer Efficiency***

Companies should also consider purchasing equipment that improves transfer efficiency. Improving the transfer efficiency not only saves money by reducing the cost of raw materials it can save time by minimizing the amount of oversprayed material which needs to be cleaned up. Spray equipment should be tested with the coating materials that will be used as the atomization of the coating and the transfer efficiency will vary with different materials.

Viking has purchased and is using a HVLP spray gun for applying the sealer coat. The estimated material savings are 1,300 gallons of sealer per year. This translates into an annual material savings of \$10,530. Approximately four tons of VOC emissions and two tons of HAPs will be prevented annually.

Viking has also purchased and is using an air-assisted airless spray gun to apply the dark stain. Cost savings and emissions reduction data have not been collected on this staining process; however, employees at Viking notice reduced overspray. Improving transfer efficiency of sprayed stains may translate into increased rag use and more stain needing to be wiped off if changes are not made in spray techniques or equipment tip sizes to ensure the correct wet film application.

### ***Adjusting Spray Systems***

One item which companies need to watch closely when changing to higher solids finishes is the size of the spray tip. Reducing the tip size will allow the operator to maintain familiar spray speeds and patterns while spraying a thinner wet coat. This helps to achieve the recommended dry film thickness of the new coating. Pine-Tique has experimented with smaller tip sizes for the waterborne finishes. Other settings such as fluid pressure and air pressure should also be monitored and adjusted with any changes to coatings.

### ***Training Operators***

All finishing companies can improve finishing material transfer efficiencies by focusing on training operators. Often the production push conflicts with the pace necessary to do the job right. The result is often lower material transfer efficiencies. Training on good spray techniques should be given to both veteran and new spray operators on a periodic basis. Often one spray operator will have improvements on the techniques or “tricks” in spraying one piece over another. Many times these advantages are not shared between shifts. It may help to videotape the spray operators so they can see how they can improve their spraying techniques. Good spray techniques include the following:

- Hold the spray gun perpendicular to the surface of the part being sprayed. This reduces the chance of the coating coverage being uneven.
- Trigger the gun slightly before and after each pass to minimize overspray.
- Overlap each stroke by 50 percent to achieve a uniform coating thickness.
- Maintain a constant distance between the gun tip and the part. This ensures the best spray pattern. The distance is dependent on the spray equipment, coating and operating pressures.

- Spray with a suitable speed to give a full, wet coat with each stroke, without causing the coating to “sag.”
- Adjust the air and fluid pressures, and select the correct tip size for the coating and gun being used. This minimizes overspray and avoids wasted material.

Uniform coating thickness is stressed because applying too much coating wastes material and may pose quality problems while too little finish may also cause a reject part creating waste in time or refinishing costs.

Investigating waterborne finishes and high transfer efficient spray equipment is a priority for Pine-Tique. Preparing to expand the finishing department has minimized the time available to improve training. Training will be necessary to incorporate the techniques used when handling and finishing with waterborne materials.

## **Conclusions:**

The process of finding and converting over to alternative coatings takes time. Drop-in substitutes are not available at this time. The facility must be willing to alter their processes to successfully implement an alternative coating system.

Steps which may need to be modified to have the alternative finishes work include:

- Allowing for a longer drying time or investing in equipment that will speed up the drying process.
- Converting all fittings, hoses and valves to materials compatible with waterborne coatings.
- Purchasing new spray equipment that has the highest transfer efficiency for the coatings being applied.
- Allowing time to get all the problems worked out of the process.
- Training operators on the techniques to properly spray the alternative coatings.
- Looking at all the options such as using a solvent-borne sealer with waterborne stains and topcoats.
- Finding vendors that are willing to help with trouble shooting problems.

Although neither company has successfully converted to a waterborne finishing system at the time of this report, each has gained valuable information about criteria they have set for their finish and finishing process. It is hoped that this information is not only useful in their search for alternative finishes, but will assist other wood finishing companies decide what modifications they are able to make to reduce VOC emissions.

## **Appendix A: Finishing Process at Pine-Tique**

Pine-Tique's products are manufactured from a variety of woods and finished with a variety of coatings. Wood species include knotty pine, white birch, cherry, bird's eye maple, oak and walnut. About half of the products sold are finished with a sealer and clear coat only. Approximately ten percent of production is sealed, painted and clear coated. The remaining forty percent is stained, sealed and top coated. The type of sanding is dependent on the type of finish the product will receive. Products to be stained will be sanded with 180 or 220 grit sand paper while other products can be sanded with 150 grit paper.

### **Clear Finish only:**

#### **1. Sanding.**

Lumber is prepared by running it through a wide belt sander with 150 grit paper. The furniture may be sent to the finishing room as pieces (such as table tops, shelves and cabinet doors) or as assembled product (such as blanket chests, entertainment cabinets, chairs and armoires). Pieces are then manually sanded with a dual action sander with 150 grit paper before moving to the spray booth.

#### **2. Preparation.**

Sawdust is blown off the pieces with compressed air in the spray booth. A few pieces are wiped off with a cloth (a dining room table top may be wiped off to minimize the chance of finish defects caused by dust.)

#### **3. Seal.**

One coat of a Sherwin Williams self-sealing lacquer (5.6 lbs. VOC / gal. - 16.5% solids by volume) is applied approximately 5 mils wet. The lacquer is pumped from a drum through the recirculating delivery system and heated to 100 degrees F and sprayed with a HVLP spray gun.

#### **4. Sanding.**

The seal coat is allowed to air dry 45 minutes to an hour before sanding with 320 grit DAS. The pieces then return to the spray booth for the topcoat.

#### **5. Topcoat.**

The dust is blown off again and the topcoat is applied at 5 mils wet.

#### **6. Drying.**

After air drying overnight, the piece can go to hardware and final assembly attaching doors, knobs, mirrors, etc. Products are allowed to cure one day before storing within a heated area or shipping to a store or customer.



**Stained finishes:**

Pieces which are stained follow similar steps but are sanded with finer grit paper during the first step. The stain is applied immediately before the sanding sealer is applied.

Pieces are sanded with 180 or 220 grit paper before entering the finishing booth to be stained. This minimizes the chance for scuffs showing up when the pigment fills in a scratch. The slight scratches will not show when only a clear coat is applied.

The stain is applied using a spray gun. Two of the main colors are pumped from the paint kitchen. The excess stain is then wiped off using a rag. This first wipe is often done with a rag which has been used a few times already as the purpose of the first wipe is to soak up the excess stain. A second wipe is then made with a cleaner cloth in order to blend the color and remove the residual stain. If the back side of the piece is to be stained, the piece is flipped over and stained immediately. Once the piece is stained and wiped, it can be immediately sealed and allowed to dry before continuing in the same process as the clear-finish-only pieces.

A few products have tinted finishes and/or extra seal coats (cherry finish on pine.) One product is stained and given four clear finishes with sanding steps in-between clear coats.

## **Appendix B: Finishing Process at Viking**

Viking uses primarily (90%) yellow pine, and small amounts of red elm (8%), and oak (2%) to make bedroom and indoor furniture such as waterbed and futon frames, tables, chairs and dressers. Their process follows these steps:

### **1. Sanding.**

After the wood is cut to the desired size and shape, it is rough sanded through a wide-belt sanding machine. Most of the wood pieces (80%) are sanded at 60 grit, including bed frame pieces and thin pieces that make up the less noticeable parts of furniture such as chair or futon bars. For the large flat pieces of wood used in more noticeable areas of furniture such as on dressers, table tops, or smaller pieces of shaped wood used as mirror frames or designed bed posts, the wood (15% of the total) is sanded at 100 grit, and then sanded with an oscillating sander at 100 grit. Occasionally, when parts are sanded across the grain on the wide-belt sander, 120 grit or 150 grit paper is used. The wood is then sanded with an oscillating sander at 120 grit to remove any grit marks before the wood is finished.

### **2. Staining.**

Parts are brought to the finishing room and sawdust is blown off them with compressed air in the first finishing booth. Most of the wood is sprayed with stain on one side, wiped quickly with a rag, flipped, and immediately sprayed with stain and wiped on the opposite side. A small percentage of the total wood products is not stained and will go straight to the sealing booth (step 3) so it can have a natural wood color.

### **3. Sealing.**

After 10-15 minutes, the wood is sealed on one side with about 4-5 mils wet of sanding sealer. When it is dry to the touch in about 20 to 30 minutes, the other side can be sealed if required.

### **4. Sanding.**

Once the wood is completely dry on both sides, the wood is sanded on all sides with 180 grit paper. The shaped parts of the wood and the edges are sanded by hand; the large flat areas of the wood are sanded with an air-powered oscillating sander or with a sanding block.

### **5. Topcoat.**

The wood pieces return to the sealer and topcoat booth, the dust is blown off, and the wood is given a topcoat (about 4-5 mils wet). After the wood dries for one to two hours it is flipped and given the same amount of topcoat on the other side.

#### **6. Optional second topcoat.**

Most of the wood products have only one topcoat of finish; however, wood products that are more for show, like bedposts, bed headboards, dressers, and tables, are given one or two more topcoats. The wood waits between 45 minutes and one hour before getting additional coats.

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#### **7. Drying.**

The wood air dries a minimum of eight hours. As a service to their customers, Viking is able to build, finish, and deliver a product the day after it is requested. However, most of the products do sit for longer than eight hours, sometimes sitting as much as three days.

#### **8. Packaging.**

After the product's finish has dried it is brought to the assembly room where it is packaged in cardboard. Though the cardboard keeps the pieces securely packaged, the individual pieces inside the box can move around and rub against each other a little. Depending on the product, the wood can sit in Viking's unheated warehouse for a few months or be shipped immediately to a store.

Viking uses two main stains, a dark stain and a honey pine stain, applied with an air-assisted airless spray gun in a stain booth. Occasionally, some different colored stains are applied with a cup gun. The sealer and the high gloss nitrocellulose topcoat are both sprayed with an airless spray gun in the other spray booth. The setup at Viking includes two spray booths and five handheld spray guns. Only one gun may be used at a time in each booth. There is a spray gun for each of the topcoat, the sealer, the dark and honey pine stains, and a cup gun to be used for other colors of stains.

## Appendix C: Suppliers of Low VOC and Waterborne Wood Finishes

SUPPLIER	LOCAL REPRESENTATIVE
Benjamin Moore Paints Montvale, NJ	Al Nielsen St. Paul, MN (612) 698-5578
Parks Corporation PO Box 5 Summerset, MA 02726 (800) 225-8543	
Ceramic Industrial Coatings 325 Highway 81 Osseo, MN 55369	Bob Thayer (612) 424-2044
Chemcraft International 55 Rose Glen Road North PO Box 458 Port Hope, Ontario L1A323 (800) 263-7951	Power Process Equipment Del Lafky 7630 Commerce Way Eden Prairie, MN 55344 (612) 937-1000
Davis Frost Inc. 1209 Tyler Street NE Minneapolis, MN 55413	David Boie (612) 789-8871
Delta Laboratories, Inc. 640 W 18th Street Hialeah, FL 33010 George Kraus (800) 432-5507	
Diamond Vogel Paints 2100 N 2nd Street Minneapolis, MN 55411 (612) 521-4700	Randy Porter (612) 521-4707
FSM Corporation 216 Linn Street Brookfield, MO 64628 Sean Curns (800) 558-7437	Lee Tufto 7820 Long Lake Rd. Willmar, MN 56201 (320) 235-3630

Gemini Lacquers, Inc. PO Box 699 El Reno, Oklahoma 73036 Don Hallett (405) 262-5710 (factory)	
Guardsman Products Inc. 1350 Steele St Grand Rapids, MI 49507 (616) 452-5781	Mike McColley (612) 747-3298
Gilbert Spruance Company Richmond & Tioga St Philadelphia, PA 19134 (215) 739-6172	
Hirshfield's 4450 Lyndale Avenue North Minneapolis, MN (612) 522-6621	Steve Bloomberg (612) 377-3910
ICI Paints Euclid, OH	Denny Ault Golden Valley, MN (612) 522-6520
James B. Day and Co. Day Lane Carpentersville, IL 60110 (708) 428-2651	C.C. Mantenfel & Son Michael J Arndt W 12455 -851st Ave. River Falls, WI 54022 (800) 545-0025
Lilly Industries, Inc. High Point, NC (910) 889-2157	David Kennedy Indianapolis, IN (317) 687-6700
McCloskey Corporation 1191 S. Wheeling Rd Wheeling, IL 60090	Roy Suttles (800)345-4530 ext: 8543
Midwest Industrial Coatings, Inc. 6667 W Old Shakopee Rd #101 Bloomington, MN 55438	David Hirsch (612) 942-1840
Mohawk Finishing Products, Inc. 4715 St. Hwy 30 Amsterdam, NY 12010 (800) 545-0047	Jerry Behrens (612) 448-2127

Pratt & Lambert Inc. 31 Greenstone Lane Waite Park, MN 56387	Chuck Schneider (708) 850-8055 (800) 876-7220 ext. 651
Sheboygan Paint Company 1439 N 25th St Sheboygan, WI 53082 (414)-458-2157	Jon Gilbertson & Scott Berg Dassel, MN (320) 275-3975
Sherwin Williams 11541 S Champlain Chicago, IL 60628 (312) 821-3416	Dan Zeller & Chad Frank 7697 Washington Ave S. Edina, MN 55439 (612) 941-6070
Sierra Corporation 11400 47th St W Minnetonka, MN 55343	Craig Wurzinger (612) 938-7223
Star Bronze Company PO Box 2206 Alliance, OH 44601-0206 (330) 823-1550	
Star Finishing Products, Inc. 360 Shore Dr Hinsdale, IL 60521-5822 (630) 654-8654	Jim Kleis Rosemount, MN (612) 438-9896
Ti-Kromatic Paints Inc. 2492 Doswell Ave St. Paul, MN 55108	Larry Bonaventura (612) 644-4477
Valspar Corporation Minneapolis, MN	Terry Miller St. Paul, MN (612) 222-8435
Van Technologies Inc. 5791 Bergquest Rd Duluth, MN 55804	Lawrence C. Van Iseghem (218) 525-9424
Warner Industry Supply 2211 E Hennepin Minneapolis, MN 55413	Dick Cable (612) 378-7300

## **Appendix D: Chemical Resistance Tests**

Kitchen Cabinet Manufacturer's Association (KCMA) chemical resistance test procedure:

After the coating has aged at least 10 days, place 3 ml of each of the following chemicals individually on the coated surface for 24 hours:

- vinegar
- lemon juice
- orange juice
- grape juice
- tomato catsup
- coffee @ 115 F
- olive oil
- 100 proof alcohol
- detergent and water
- mustard (1 hour)

The chemical should not damage the coating.

KCMA also has tests for:

- shrinkage & heat resistance,
- hot & cold check resistance, and
- detergent & water resistance

## **Appendix E: Industrial Laundry Services**

The following is a partial listing of facilities for industrial laundering of reusable wood finishing towels:

G & K Services  
Mic Klaith  
2108 Washington Avenue North  
Minneapolis, MN 55441  
(612) 521-4771  
(612) 521-8271 (Fax)

American Linen Supply Co  
Scott Reppert  
700 Industrial Blvd  
Minneapolis, MN 55413  
(612) 362-0303

Leef Brothers, Inc.  
Mark Lamp  
212 James Avenue N.  
Minneapolis, MN 55405  
(612) 374-3880 or (888) 445-5333  
(612) 374-1827 (Fax)