

Integrating P2 into the Inspection Process

Wood Finishing Industry

Background

The wood finishing industry includes a diverse set of wood products such as household furniture, office furniture, kitchen cabinets, office and store fixtures, partitions, shelving, and lockers.

Wood furniture manufacturing and finishing involves the following processes:

Rough Milling. The purpose of rough milling is to remove defects and convert the dried rough lumber into "blanks" that will be used to make furniture components.

- *Gluing Operations.* Gluing is a value-added process. Companies may apply foam for cushions, veneers, and materials to the blanks, finished pieces, or in final assembly as product enhancements; or use it to assemble pieces.
- *Product dimensioning.* This step further shapes, cuts, and sands the pieces before they go to assembly. Wastes from product dimensioning processes are mostly solid wastes such as wood and sawdust, although sanding belts, machining tools, spent glue, volatile air emissions from the glue, bolts, nails, staples, and fabric or other covering trimmings are also generated.
- *Finishing Processes.* The finishing processes depends on the type and quality of furniture produced and may involve one or all of the following finishes:
 - stains to give color uniformity and develop wood grain
 - washcoat to seal the wood's surface and prevent further absorption of unwanted staining from the filler coat.
 - filler to fill large pores in the wood.
 - sealer to seal the wood before other coats are applied.



- glazes which will penetrate and adhere to the sealer.
- topcoats to provide a deep, clear, durable final finish.

Regulatory Issues

Wood finishing industry processes are mostly associated with air emissions and the generation of hazardous waste.

Air emissions are the most serious pollution problem, with VOCs and HAPs regulated by the Clean Air Act and a wood furniture National Emission Standard for Hazardous Air Pollutants (NESHAP). These emissions include methyl ethyl ketone (MEK), methyl isobutyl ketone (MIK), methylene chloride, toluene, and xylenes. In addition, some finishes require forced-air circulation from ovens to speed drying time, which may also involve permitting as an emission source.

Hazardous wastes result from line and gun cleaning solvents, cleaning wipes, and excess finishing materials. Disposable wipes are used to clean the wood, apply the stain or to wipe it into the wood grain after being sprayed on, to clean the wood surface between coatings to remove dust, and in the cleanup or stripping processes.

Solid waste is of considerable concern to this industry; shops may lose as much as 30%-50% of their incoming wood to waste. Local recycle opportunities for wood waste are few; transportation and increased handling costs to send waste to a remote recycle facility is usually not cost-effective. On-site recycle of wood waste can be cost-effective but usually requires large capital investments and man-hours to run.

Where Is the P2 Potential?

Change the Material

It may be possible to change to a less hazardous material to produce the product without affecting its quality or having to change major pieces of equipment in the processes. In some cases, this can be done by changing the *type* of material used to finish a piece, or by changing the type of solvent used for washoff operations.

Use an Alternative Glue

The seven general categories of contact adhesives used by the wood furniture industry are solvent-based, epoxy resin, urea-formaldehyde resin, hot melt, heat seal, aqueous-based, and polyvinyl acetates (PVA). The following options exist for glue alternatives:

- Use PVA glues. They are aqueous-based synthetic latex systems and are the primary glues for solid wood. PVA adhesives are widely used in furniture assembly, and their use in veneering and laminating is increasing.
- Use hot melt or heat seal adhesives. Hot melt will flow again if heated; heat seals use lower application temperatures and pressure to cure and do not re-flow when heated.

Use a Higher Solids Finish

High solid finishes can reduce VOC emissions by 50% to 100% (for ultraviolet UV or electron beam-cured coatings, which are covered under alternative technologies). High solid finishes such as polyurethanes and polyesters have half the VOC content but as much as two to four times the solids content of traditional nitrocellulose finishes. Because of this, these finishes reduce the amount of finishing material needed, require fewer applications, and are associated with a higher transfer efficiency. However, high solids coatings for the wood finishing industry have several disadvantages, such as higher cure temperatures, viscosity issues, and control issues with film thickness.

Use a Water-Borne or Hybrid System Coating System

Water-borne coatings also have higher solids and can easily contain less than one-fifth to one-third VOC content of traditional coating. Refinishing is more difficult with water-borne coatings because they form a harder, more durable coating. For these reasons, water-borne coatings are used less with higher end, and medium to high quality products. Some shops have found that a hybrid system can be used substituting the water-borne coating with one or more of the coating steps selectively to reduce VOC or HAP emissions. Advantages of waterborne coatings:

- reduced VOC emissions
- can be cleaned up with soap and water, greatly reducing hazardous waste generation from line and gun cleaning
- can use traditional spray equipment, although corrosion issues must be considered
- decreased fire hazards
- better impact and abrasion properties; very moisture resistant

Clean and Stripping

Methylene chloride, the active ingredient in many coating strippers, has come under increasing scrutiny for its potential damage to health and the environment. Alternative stripping materials have been developed that have less potential for damage. These materials utilize the following active ingredients that are biodegradable, nonflammable, lower in VOCs, and can be cleaned up with water:

- N-methyl pyrrolidone (NMP)
- Gamma - butyrolactone

Change the Process

Rough Milling

- Combine cutting of multiple long and short lengths on the same rough lumber board to improve yield.
- Finger-join two short sticks or boards end-to-end to form a longer one, resulting in less waste and better material utilization.
- Use wood with imperfections in new “natural” products, selling them at reduced prices.



Gluing

- The moisture content of wood should equal the surrounding air to prevent joint warping resulting in unusable pieces.
- Check for untrue and inactive surfaces (before gluing) that will weaken or reduce effectiveness of glue.
- Keep glue containers covered to prevent chemical vapors from escaping, to keep out moisture and oxygen, and to prolonging shelf life.
- Let glue completely set before removing the assembly from the press; otherwise, the glued joint becomes a weak point.

Product Dimensioning

- Recycle sawdust into composting, roof-felting materials, or wood pellet processes.
- Grind or shred wood pieces for animal bedding or mulch.
- Use wood waste to fuel a wood boiler for energy production or as a heat source.
- Use adequate dust collection systems to reduce worker exposures and to extend equipment life. Using a dust collection system also produces a cleaner sawdust that may promote reuse opportunities.
- Use in particle board, chip core, and laminates.
- Use in pulp and paper manufacturing.

Operator Training

Operator training is now a requirement for those regulated under the Wood Furniture NESHAP (NESHAP). Even if your business is not regulated, operator training can save companies money by:

- teaching proper spray techniques to reduce material waste and excessive emissions
- increasing product quality
- reducing reworks from operator error
- reducing equipment misuse and injuries

Throughout all training, emphasize the benefits of reduced waste and health and safety hazards, and encourage employees to protect themselves with personal protective equipment and to practice good housekeeping to prevent accidents.

Proper Spray Techniques

Use equipment in accordance with the manufacturer's specifications such as utilizing proper spray-gun air or fluid pressures, and adequate tip sizes to properly atomize coating, coating concentrations and viscosities, flow rates, and care and maintenance.

Use proper spray technique fundamentals such as:

- five percent overlap of the spray pattern
- spray-gun held six to eight inches away from the workpiece
- holding the spray gun perpendicular to the workpiece surface
- triggering the gun at the beginning and ending of each pass
- maintaining a consistent gun speed (general rule approximately 250 fpm)
- Select the appropriate spray gun attachments—needle, nozzle, air cap—for each coating utilized.

Train employees in safety and health hazards associated with the equipment and materials and how to protect themselves, and prevent accidents and environmental incidents.

Equipment Cleaning

- Establish an equipment cleaning and maintenance program. Regular care and maintenance must be performed on all equipment, especially spray equipment, to keep it in optimum working condition, and to prevent breakdowns or malfunctions and waste. Some fundamental measures include the following:
- Keep feed tanks free of contamination by keeping them covered whenever possible.
- Keep tanks agitated to prevent skin from forming and solids from settling.
- Maintain proper fluid and air pressures for minimum coating atomization.
- Use enclosed paint gun and delivery line cleaning units to control VOC emissions and reduce solvent use.
- Equipment should be cleaned as soon as possible after use before coating cures and is more difficult to remove.
- Minimize the number of cleanings of equipment by finishing with a light coating first, then progressively using darker coatings whenever possible to reduce amount of cleaning needed.
- Remove as much unused coating from the system as possible before flushing with solvent. Not only will this reduce solvent needed but it will be more suitable for recycling without all of the coating contaminants.
- Flush equipment first with dirty solvent, then with clean solvent.
- Reuse cleaning solvent until solvency is lost.
- Use clean solvent as final equipment cleaning, then use as coating reducer for next mix.
- Use air to blow lines free of coating back to pots or bubble injection and pigs to aid line flushing.
- Centralize solvent cleaning operations to reduce losses, and standardize cleaning methods and type of solvent used.
- Use mechanical cleaning such as scraping and wiping before solvent cleaning.
- Utilize Teflon-lined paint cups to improve drainage and minimize coating buildup.
- Recycle solvent on site to use for cleaning purposes.



Prepare Coatings Properly

Proper coating material preparation can impact the amounts of material used and wasted. For example, too much thinner can cause running and sagging, while too little can cause defects such as orange peeling. These defects can result in rejects

and in wasted raw materials and labor. Proper coatings preparation includes the following:

- Always add reducer to the material versus material to the reducer.
- Add reducer to the material slowly and test often to determine when you have reached the desired viscosity.
- Mix materials thoroughly before and during use to maintain the desired uniformity. Keep tanks covered to prevent evaporative losses and contamination of the contents.
- Practice sound inventory and scheduling controls and practices. Scheduling is very important in the coatings industries as more color/finish changes create an excessive amount of cleaning solvent-related waste and labor costs.
- Use Heat to Obtain Desired Coating Viscosity

Change the Technology

Technology changes for the wood finishing industry primarily consist of changes in the finishing processes, and the addition of automated equipment and processes that has been covered in a previous section.

Application equipment

Application equipment choices are dependent upon the part configuration, line speed, product quality and customer acceptance, operator ability, and available capital for equipment investment. The following application technologies are available to help reduce material use and wastes:

- High-volume low-pressure (HVLP) spray systems use large volumes of dry air at very low pressures (1-10 psi) to atomize the coating, as compared to conventional spray guns that atomize at 60-80 psi. Because of these low pressures, there is less “bounce-back” and less expansion of the sprayed material, resulting in less loss to overspray and bounce-back or bounce-off. Transfer efficiency of 40%-70% is possible and results in reduced VOC emissions, and lower booth cleanup and filter replacement costs and labor; they can be used with most coatings. HVLP systems may not be suitable for very fine finishes which require more complete atomization. These may involve slower application rates, thus affecting line speeds. Operator training and acceptance is a must for technology to succeed.
- Airless and air-assisted airless spray systems atomize the coating by increasing its fluid pressure. Airless systems use pressures of 500 to 6500 psi and the air-assisted airless uses fluid pressures of 150 to 800 psi with as little as 15 percent of the atomization accomplished by air pressure of 5-30 psi at the nozzle to help shape the spray pattern. These systems are well suited to high solids, high viscosity coatings, and high production rates. They have high transfer efficiencies and result in raw material savings. Airless and air-assisted systems can be very hazardous to operators because of the possibility of “injections” under the skin. This can create a very painful condition and should be attended to by a doctor immediately, no matter how small the opening.
- Electrostatic coating involves coating particles that are given a negative electric charge and the piece to be finished is either grounded or given a positive charge. This electrostatic action causes the coating particle to be drawn to the piece, creating a high transfer efficiency of 35-70% for spray guns and 60-90% for

rotary disk (centrifugal force) applicators. This allows each piece to be coated with fewer passes, and with less coating material used and less associated waste. The particle velocity and electrostatic charge must be balanced to achieve optimum coating. Advantages of this system include high transfer efficiency, reduced material usage and associated VOC emissions and waste, uniform film thickness, good wrap-around coating and edge cover, and an ability to apply a variety of coatings (e.g. solvent-/water-based, high solids, radiation curable). This technology may involve a coating of a humidity-sensitizing agent as pieces must be conductive.

The following coating technologies are used in applications that are more automated with high production rates and low finish quality requirements. Each is associated with excellent transfer efficiency, as well as waste and emissions reductions. Most methods are dependent on viscosity control to some degree.

- Dip Coating. Parts are dipped into a tank of coating material. Excess coating drips off the piece and drains back into the tank.
- Flow Coating. This involves many individual streams (10-80) of coating directed at the surfaces of the piece as it passes through the flowcoating chamber.
- Curtain Coating. Curtain coating coats flat pieces by moving them through a continuous flowing "waterfall" of coating material. The coating material flows at a controlled rate from a reservoir onto the pieces, which are conveyed through the stream at high rates of speed. The excess coating material is trapped in a reservoir and re-circulated with minimal waste.

Coating Delivery Systems

Direct delivery of the coating material to the spray gun or application device, instead of indirect transfer, can provide *big* benefits and savings. There are three types of direct transfer systems:

- Dead-end delivery supplies materials that do not have settling problems to the application, without a return line.
- Simple flow delivery through hard piped coating delivery lines provides continuous circulation back to the storage tank through a return line which prevents settling in the storage tank.
- Recirculating delivery circulates the material throughout the system, including in the hose of the spray gun, to prevent settling of materials with high settling rates. This is especially useful when using pre-heaters with high solid coatings in order to maintain viscosity level.

In addition to direct transfer, there are also two and three component delivery systems which will mix the individual components a short distance before the gun. Since the coating components are mixed at the gun, the delivery lines can remain filled with coating, reducing coating waste and line washing.

Radiation Cured Coatings

Ultraviolet and electron beam coatings are radiation-cured coatings and thermosetting conversion coatings that form a durable surface. The curing reaction is initiated by exposure to intense ultraviolet light or accelerated electrons which begin a rapid polymerization. This is completed in a matter of a few seconds or less.

In general, these materials *may* require less energy and less time to cure, and contain less volatile materials than conventional products. Use of these coatings can result in a reduction of VOC air emissions over nitrocellulose solvent-based coatings. These coatings are typically applied by conventional spray guns or flat-line applicators. Curing may require an initiator such as organic peroxide or UV radiation.

Advantages of these coatings are:

- high solids content
- greatly reduced solvent usage, consequent air emissions, and disposal costs
- high film thickness with fewer coats
- very durable finish
- small ovens that can be easy to install or retrofit
- low air movement reduces dust contamination
- fast drying, less floor space needed
- resistant to heat, chemicals, impact
- high gloss with polyurethane
- multiple application methods

Disadvantages are:

- may require a clean room
- coated piece is difficult to repair
- polyester is chemically incompatible with nitrocellulose materials; cannot be used in the same system or on the same piece—potentially explosive
- short pot life potential (1-6 hours)
- respiratory protection may be required (potential exposure to isocyanates)
- UV radiation curing may be difficult for non-flat surfaces since energy transfer is along "line of sight"; 3D set ups are not easily re-configured
- some users report "plastic" looking finish
- higher capital costs than conventional ovens
- exacting process to achieve acceptable results

Woodfinishing Industry P2 Checklist

Wood Waste

- Use automated equipment to utilize smaller pieces of wood and protect personnel.
- Utilize imperfect woods for other products.
- Collect sawdust for reuse in composting or other opportunities.
- Collect wood waste for reuse in mulches or animal bedding.
- Inspect wood blanks before gluing for evenness and trueness; once glued, the whole part may become waste.

Coatings Waste

- Train finishing operators periodically on application techniques to reduce overspray.
- Use high transfer efficiency equipment, such as HVLP spray guns.
- Reduce color/finish changes to reduce coatings waste.
- Track material usage per part to establish a usage guidelines per part.
- Schedule product throughput from light to dark colors to reduce line flushing.
- Control viscosity to ensure proper coating thickness – use heaters to reduce viscosity.
- Use high solids coatings to reduce amount and number of coatings required.
- Use direct delivery systems to reduce coating waste.
- Use air to blow coating out of lines for re-use.
- Use hand wipes to apply stains, if possible.

Solvent Waste

- Reduce color changes to reduce cleaning needs.
- Remove as much finishing material from the system before running solvent through.
- Use a two-stage cleaning system: use first-pass solvent as long as possible, then a cleaner solvent for final clean.
- Recycle solvent on site.
- Use direct delivery systems to reduce long line cleaning.

VOC and HAP Reductions:

- Use recommended P2 cleaning methods
- Use high solids or water-based coatings.
- Use high transfer efficiency equipment.
- Use hand wipes to apply stains, if possible.
- Use low HAP, VOC cleaners.
- Use heat to reduce viscosity.
- Use water-based glue or hot melt adhesives.

Case Studies

Larson Juhl, Inc., Ashland, Wisconsin

Larson Juhl, in its finishing operations for wood picture frame mouldings, was using eight to ten gallons of xylene/day to clean out its paint piping/gun system. In addition, paint color changes occurred 30-45 times a day, sometimes with lighter colors following the dark.

To reduce disposal costs, which had increased 400 percent, the company removed paint distribution manifolds and excess piping. Additional valving was installed for a closed loop dedicated line delivery system. Colors now run from lighter to darker as the day progresses, as well.

The payback was immediate, resulting in \$50,000 savings /year.

Halworth, Holland, Michigan

Halworth is a large manufacturer of all types of office furniture. Halworth switched to a two-component, aqueous-based, formaldehyde-free contact adhesive for the manufacture of fabric-wrapped flipper doors for overhead storage compartments. Halworth had to purchase new spray equipment to apply the two-part adhesive. The new adhesives instantly bond a variety of fabrics. Halworth believes the new adhesive system produces a more consistent quality product.

Drying ovens are no longer needed, and spray booth exhaust is now filtered and directed back into the plant. Combined, these greatly reduce utility requirements. In addition, removing ovens and exhaust stacks has freed up roughly 600 square feet of floor space and allowed easier layout changes.

The new system has many benefits. Halworth realized an 88% reduction in VOC emissions and a 33% reduction in adhesive use. Utility savings are estimated at \$16,000 per year. Quality improvements result in approximately \$18,000 in savings per year.

Additional Resources

Kansas SBEAP's technical documents for wood finishing: *Pollution Prevention for the Wood Manufacturing and Wood Finishing Industry*; or call the environmental hotline for personal assistance at 800-578-8898.

Sector Resources - Wood Manufacturing can be found at the following Web site from the Western Region Pollution Prevention Network:
<http://www.westp2net.org/Sector/wood.htm>.

Most of the resources listed are available on the Web for downloading. Includes case studies, P2 manuals, EPA sector notebook, and regulatory guidelines.

NEWMOA publications. Documents available via the Web are linked. For more information on these documents visit <http://www.newmoa.org/publications/>.