Section VII:

Coating Your Finished Wood Product

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Process Overview

The finish of finely crafted wood furniture, cabinets and millwork is designed to provide a pleasing appearance, feeling of smoothness, and protection of the wood from physical and chemical damage, and natural degradation. The coating materials traditionally used by the wood products industry contain a substantial quantity of solvents that volatilize to the air within the plant and/or are directly vented to the outside, usually without treatment. The basic operations of the typical finishing process include:

- glue sizing or bleaching
- cleaning / stripping
- coating
- drying
- sanding
- rubbing / buffing
- equipment cleaning
- repair / touch-up

Potential Wastes: Solid and Hazardous

- volatile organic compound (VOC) emissions and hazardous air pollutants (HAP) emissions
- liquid wastes: spent stains, wash coats, fillers, sealers, glazes, topcoats, solvents, spray booth wastewater
- solid wastes: spray booth filters, overspray masking, paint solids, rags, solvent still bottoms
- energy

Waste Reduction Options/Case Studies/Checklists

Coating Formulations:

Waterborne

Water, instead of conventional solvents, is the major carrying medium for the coating solids in waterborne coatings. Using waterborne coatings, or "hybrid" coatings with a combination of water and conventional solvents can significantly reduce VOC air emissions and reduce associated wastes.

Benefits

- reduce air emissions and hazardous liquid and solid wastes
- finish resists moisture, chemicals, impact and abrasion well
- adaptable to a wide range of conventional application methods

New England Woodcraft Case Study
Forest Dale, Vermont

In 1987, New England Woodcraft, a manufacturer of bedroom and lounge furniture, installed a continuous finishing line that can apply clear water-based sealers and topcoats to their flat furniture pieces. Sealing steps include spraying, flash-off, infrared heating, followed by hand sanding . Pieces then make their way to the top coat spray booth, another set of flash-off and infrared ovens. After three years of testing water-based emulsion finishes with C. E. Bradley Laboratories of Brattleboro, VT, the company completely converted its finishing line to water based acrylic clear sealers and topcoats.

Results not only included a pleasing, high quality finish with excellent performance, but also the reduction of VOC emission rates by 80 percent and reduced costs by 25 percent. Even though the water-based formulations cost more than nitrocellulose, a Woodcraft representative states that they get "more mileage" from the water-based formulations because of the higher solids content.

Source: “Getting the Most from Water-based Finishes,” *Furniture Design & Manufacturing*, January 1991.

Madison Pre-Hung Doors and Pre-Finishing Case Study
Oregon, Wisconsin

The company switched from solvent-based to water-based finishes in both manual and automated spray applications of the wood products. VOC's were reduced from 115 tons/year to six tons/year while nearly doubling production.

Madison Pre-Hung Doors and Pre-Finishing experienced cost savings through reduced insurance premium costs, savings from avoiding purchasing an after-burner and elimination of waste disposal costs.

The major challenge lay in achieving a comparable quality to that of a solvent-based finish. The water-based finish was refined as they worked with their paint supplier.

Source: "Madison Pre-Hung Doors and Pre-Finishing Converting to a Water-based Wood Finish," Wisconsin Department of Natural Resouces, 1995.

The Shuttery of Nanik Case Study
Wausau, Wisconsin

The finishing and sanding departments of Shuttery of Nanik converted from solvent to waterborne coatings. Wood components are fogged with a primer, sanded twice and top-coated with the waterborne coatings.

As a result, the air emissions for this operation changed from a permitted air source to an exempt air pollution source. Hazardous Waste Generator status moved from Large to Very Small Quantity Generator (VSQG or conditionally-exempt).

While the custom-made shutter drying oven initally cost $70,000, the company saved $32,600 the first year from reduced or eliminated safety/DNR compliance programs and $13,000/year after for reduced administrative work.

Source: "The Shuttery Of Nanik: Conversion from solvent to waterborne coatings for wood finishing," Wisconsin Department of Natural Resources, 1995

! clean equipment with soap and water (in some cases)
! potential reduction in fire insurance when converting from solvent coatings to waterborne
! reduce toxicity and odor (in some cases)

Cautions

! increase drying times, larger drying air requirements or higher oven temperatures as water takes more time than VOCs to evaporate, especially in high humidity
! store at room temperature for proper solubility and freeze protection
! clean equipment immediately after use (in some cases)
! use corrosion resistant equipment; costs of conversion can be significant
! control moisture content of substrate and finish room humidity
! raising of wood grain possible
! wood surface must be free of oils and dust for good adherence properties
! high gloss finish sometimes difficult to obtain; increased rubbing effort needed
! some atomization difficulties, increased runs and sags, tendency to foam
! refinishing is sometimes difficult

High-Solids Solvent-Based

These solvent-based coatings have a high-solids concentration in the range of 35-40 percent solids which results in an increased application of coating with less VOC emissions and solvent waste. There are three basic types of high solids coatings - two component ambient temperature cured, one component heat converted, and high solids thermoplastic solvent borne coatings.

Benefits

- reduce air emissions, and liquid and solid wastes
- realize less compliance and disposal costs
- less material required to coat, reduce solvent usage and costs
- reduce number of spray applications to achieve the same coating thickness
- high transfer efficiency
- reduce inventory, less handling and shipping costs, additional available floor space
- less fire risk, potential reduction in fire (in some cases)

Cautions

- cannot use effectively in dip or flow coating applications
- wood surface must be clean
- may require high temperature curing with narrow "time/temperature/cure window"
- difficult to control film thickness and sagging; may require heater
- sensitive to ambient temperature and humidity
- finished piece difficult to repair
- overspray is tacky and difficult to clean
- reduce shelf life, short pot life for two component coating
- odor and slow flash-off require use of vented flash-off zones

Polyester-/Polyurethane-Based

Polyester-based and polyurethane-based coatings are used significantly outside the U.S. Use of these coatings can result in a reduction of VOC air emissions over nitrocellulose solvent-based coatings. Polyester-based coatings include styrene derived polyester of 100 percent solids which is cured by ultraviolet (UV) radiation, and acrylic polyesters (30-50 percent solids) which are cured by catalytic reaction or UV radiation. 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.

Benefits

- reduce solvent usage and associated costs
- reduce air emissions, solvent wastes and associated compliance and disposal costs
- fast drying, less floor space needed
- durable finish
- resistant to heat, chemicals, impact
- high gloss with polyurethane
- multiple application methods

Pennsylvania House Case Study,
White Deer, Pennsylvania

The Pennsylvania House manufacturing facility in White Deer, PA is applying the UNICARB™ spray finishing system full time for lacquer topcoats on chairs. Starting in spring 1990, Pennsylvania House worked with Union Carbide (licenser of UNICARB™ system), Nordson (developer of the spray equipment) and Guardsman Product Inc. (formulator of the top coat lacquer) in the development of the system, which was installed on the chair finishing line, July, 1991.

Results include a topcoat finish of equivalent quality and integrity to the finish previously provided by the air assisted airless spray guns, however with only about half as many gallons of finish used. VOC emissions have been reduced by approximately 70 percent.

Cautions

- may require a clean room
- coated piece is difficult to repair
- polyester is chemically incompatible with nitrocellulose materials, can not be used in the same system or on the same piece - potentially explosive
- short 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"
- some users report "plastic" looking finish

Carbon Dioxide System

In this system, super critical carbon dioxide is used to decrease viscosity and enhance atomization and replaces all or a substantial amount of the solvents used in the conventional spray application of coatings. The system's specially designed spray guns and nozzles enable the resin concentrate to be mixed with the carbon dioxide. The coating cures by air or baking. The use of carbon dioxide (CO_2) based coatings can reduce VOC emissions by 50 percent over nitrocellulose solvent-based coatings.

Benefits

- reduce solvent usage and associated costs
- reduce VOC air emissions, solvent wastes and associated compliance and disposal costs
- reduce worker exposure
- high quality finish
- high solids content
- nitrocellulose resins can be used and do not need reformulation
- fewer coating applications needed
- high transfer efficiency
- sometimes reduces sanding requirements
- easy to repair

Cautions

- limited suppliers of system equipment
- technology still in the developmental stage with limited experience
- lower fluid delivery rates than air spray guns
- gun and tubing is bulky
- royalty costs
- use of equipment requires training

Radiant Cured

The physical and chemical properties of a coating are altered by ultraviolet (UV), electron beam (EB), or infrared (IR) radiation so that a rapid polymerization takes place. In general, radiation cured coatings require less energy, less time to cure, and contain less VOCs than conventional coatings. Common radiation cured coatings include acrylate based materials and epoxies.

Lowenstein Case Study
Pompano Beach, Florida

Loewenstein is a seating manufacturer that finishes over 250 varieties of chairs. Late in 1987, it was ordered to reduce its annual VOC emissions (290,000 lbs.) by 31 percent with a deadline of February 1, 1989. By April of 1989 Loewenstein had reduced its annual emissions to 165,000 lbs, and as of March 1993, they were down to 75,000 lbs. per year.

This reduction is a result of changing from their previous sealer and with 16 percent solids to a epoxy acrylate UV sealer and 68 percent solids.

They have also switched to non-electrostatic guns for stain touch up and guns for sealer and topcoat applications.

Other benefits included improved film properties and appearance, less coatings to achieve the desired film thickness, early sealer film hardness that permits extensive without wearing through the coating.

Source: “Lowenstein VOC Dip Continues,” *Industrial Finishing*, May 1993.

Benefits

- very high solids content
- reduce solvent usage and associated costs
- reduce air emissions, solvent wastes and associated disposal costs
- reduce energy costs
- high film thickness, fewer coats needed
- durable and glossy finish
- increase production rates, short curing times
- small ovens
- UV systems are easily installed / retrofitted
- low air movement reduces dust contamination

Cautions

- necessity of automation
- design changes usually require significant modification
- finished pieces difficult to repair
- not applicable to coatings which contain pigments (e.g., stain)
- higher capital investment than conventional ovens
- higher cost for UV and EB coatings
- potential toxicity of coating constituents, dermatitis
- shrinkage / adhesion problems with acrylate
- curing three dimensional pieces is difficult
- may require a clean room
- some "plastic" looking finishes reported by users

Coating Application Technology:

Summary of Spray Application Methods

Spray Application Method	Comparable Transfer Efficiency	Atomization Quality	Categories of Coating Applied
Conventional Air	**low**	**very fine**	**solvent borne waterborne**
High Volume, Low Pressure	**medium to high**	**fine**	**UV-curable solvent borne waterborne high solids**
Airless	**low**	**coarse**	**solvent borne waterborne**
Air Assisted Airless	**low to medium**	**fine**	**solvent borne waterborne high solids**
Electrostatic	**high**	**fine**	**solvent borne high solids powder coat waterborne UV-curable**

High Volume, Low Pressure (HVLP) Spray

HVLP spray guns atomize materials with warm, dry air between 0.1 and 10 psi, while conventional spray guns usually atomize materials at 60 to 100 psi. The low pressure air of HVLP systems transfers the coating to the substrate with low velocity and prevents the rapid expansion of spray caused by higher pressure guns, resulting in less overspray, less bounce back, and better transfer efficiency (40 -70 percent).

Benefits

- increase transfer efficiency, reduced overspray
- reduce worker exposure from bounce back
- reduce VOC air emissions
- lower booth clean-up costs
- reduce filter replacement costs
- decrease booth wastewater treatment costs
- sprays well into cavities and recesses
- can be used for a variety of coatings (e.g., waterborne, high solids)
- finish as good as conventional spray guns with low to medium viscosity coatings

Cautions

- less complete atomization, atomization may not be sufficient for fine finishes
- slower application rate may affect high production rates
- worker training is a must for success

Airless Spray

Airless spray systems atomize the coating by increasing the coating's fluid pressure (ranges from 500 to 6500 psi) without introducing a pressurized air flow.

Benefits

- high transfer efficiency (35-65 percent)
- reduce coating usage
- reduce air emissions and wastes
- high rates of paint flow, can move gun faster
- greater productivity, less operator fatigue
- ability to apply highly viscous fluids
- no air hose providing increased gun handling versatility

Ethan Allen Inc. Case Study
Old Fort, North Carolina

Ethan Allen, who manufactures dining and bedroom furniture, replaced air assisted spray guns with HVLP equipment. Each operator is required to attend annual technical training provided by the spray gun manufacturer.

Spraying efficiency has increased and the quantity of material to be filtered has been reduced. The investment was $3000 (12 guns @ $250). Raw materials were reduced by $15,000 to $20,000 per year, and costs associated with waste management and disposal were reduced.

Source: Case Study: Ethan Allen, Inc., North Carolina Waste Reduction Resource Center, December 1993.

Tiz's Door Sales (TDS) Case Study
Everett, Washington

TDS manufactures interior and exterior doors and frames, window and base moldings, and stained railings. HVLP spray guns were purchased to replace 20 percent efficient conventional spray guns on manual spray lines. Along with the conversion to HVLP, TDS also installed automated flat line spray equipment which increased application efficiency, recycled overspray, switched from toluene-based coatings to less hazardous coatings, uses heat instead of solvents to thin coatings, uses dedicated pumps and lines for each type of coating, blocks gun nozzles and blows air back through guns and delivery systems to reduce waste during cleaning.

TDS has reduced coating use by one-half (1991 - 18,000 gallons saved ~ $180,000) and experienced significant savings in labor and waste disposal costs.

Cautions

- reduce spray pattern
- relatively poor atomization
- expensive nozzles
- coatings limitation
- tip plugging
- danger of skin injection
- increase training and maintenance

Air-Assisted Airless Spray

Air-assisted airless spraying combines compressed air atomization with airless atomization. About 85 percent of the atomization of the coating is provided by fluid pressure (150-800 psi) as in airless, and the remaining 15 percent is provided by air pressure (5-30 psi) supplied at the nozzle.

Benefits

- high transfer efficiency relative to conventional (40-70 percent)
- finish comparable to conventional spray
- reduce material usage
- less overspray and bounce back

Cautions

- not compatible with some coatings
- risk of skin injection
- increase maintenance
- increase operator training
- capital cost

Electrostatic Technology

During electrostatic coating, coating particles are given a negative electric charge and the piece to be finished is either grounded or is 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 percent for spray guns, and 60-90 percent for rotary disk (centrifugal force) applicators. This allows each piece to be coated with fewer passes and less coating material and associated waste. The particle velocity and electrostatic charge must be balanced to achieve optimum coating.

Benefits

- high transfer efficiency
- reduce material usage and associated VOC emissions and waste
- uniform film thickness

Henredon Furniture Case Study

Morgantown, North Carolina

Henredon converted from Spray guns to HVLP equipment (7-10 psi) for applying lacquers, sealers, and stains to chairs and benches. Spray operators received on-site training.

The company realized a $120,000 annual savings from a 15 percent reduction in coating usage. Product quality improved without impact to line speed and VOC emissions were reduced by over 126,000 lbs. Spray gun purchase and installation ranged from $350-$500 per gun. Payback period was 3.5 months.

Source: D.B. Williams, "Incentives and Techniques for Pollution Prevention in Furniture Coating Operations," presented at The Furniture Industry and the Environment, Hickory, N.C., November 19, 1992.

Thomson Crown Wood Products Case Study

Mocksville, North Carolina

Wood and wood finished television cabinets are manufactured by Thomson Crown. Parts of these cabinets were coated with air-assisted airless spray guns (high air pressure up to 55 psi) with a poor transfer efficiency and a high generation rate of VOC emissions and coating waste. HVLP spray guns were purchased to replace the existing guns.

Material reductions of 65 percent for equalizer, 65 percent for toner, 35 percent for glaze, 35 percent for no-wipe, and 53 percent for water-based black finishes that total 13,300 gallons per year have been realized with an estimated savings of $137,000. The cost of the project was $21,000.

Source: *Pollution Prevention for the Wood Finishing Industry*, U.S. EPA/SEDESOL Pollution Prevention Workgroup, May 1994.

- good wrap around coating and edge cover
- can apply a variety of coatings (e.g. solvent-/water-based, high solids, radiation curable)

Cautions

- pieces sometimes need to be coated by humidity sensitizing agent as pieces must be conductive
- safety/fire risk
- extra cleanliness essential
- touch up coating buildup at high points and skips (uncoated areas) in corners caused by Faraday effect
- bulky and delicate spray guns
- relatively high cost
- wrap-around may overcoat rear edges

Vacuum Coating

Pieces are passed through a coating chamber under

Thomasville Furniture Case Study
Thomasville, North Carolina

Thomasville Furniture was realizing an 80 percent loss of finishing materials (20 percent transfer efficiency) from their conventional air spray guns on their chair finishing line. In 1979, the company installed five hand-held airless electrostatic sprayers in an effort to reduce the amount of coating material wasted.

Clean up of the spray booth is now conducted once a week instead of once per day. Material waste was reduced by 30-40 percent and associated wastes and VOC emissions were reduced. The walls of the spray booth are grounded so that overspray is attracted to the walls keeping the remainder of the area clean. The greatest savings occurred in the lines wiping stain where stain usage was reduced from 12 ounces per chair (dipping process) to three ounces per chair. In spite of some difficulties with humidity problems and higher coating prices, a payback period of one year was realized.

Larson Juhl, Inc. Case Study
Ashland, Wisconsin

Larson Juhl used Air Assisted Airless sprayers to apply the finish onto milled mouldlings. They switched to High Volume Low Pressure spray guns in seven of its nine finishing processes, resulting in a 45 percent decrease in acrylic- and nitrocellulose-based paints.

Payback was immediate as the decrease in maintenance, parts inventory, and waste disposal outweighed the cost for purchasing the HVLP systems--enough to realize an $18,000 payback the first year with just one system.

Source: "Larson Juhl, Inc.: Replacing AAAL (Air Assisted Air Less) spray guns with HVLP (High Volume Low Pressure) spray guns," Wisconsin Department of Natural Resources, 1995.

Sun Tui Case Study
St. Paul, Minnesota

In 1992, Sun Tui, which manufactures futon frames, installed an automated electrostatic spray line that applies waterborne coatings to futon frames. The system replaced conventional air spray that applied water based coatings. The system includes a conveyor line, a photosensitive light curtain that communicates piece size information to the spray guns, water spray guns to add humidity to the piece for better conductivity, electrostatic bells which apply the coating, and an infrared oven.

Results have included increasing transfer efficiency 30-35 percent over the conventional system, less overspray and wasted material, and less VOC emissions.

Source: "Futon Maker Plugs into Electorstatic Finishing System," *Wood & Wood Products*, January 1993.

a vacuum. Coating material fills the chamber, coating the piece as it proceeds through the chamber. An air jet removes excess finish. Film thickness is controlled by varying the coating viscosity, vacuum magnitude, and air jet velocity. The technology is limited to pieces with the same silhouette along its entire length. In theory, there is no wasted material as the chamber recycles excess material. Water-based coatings can build up solid coating on reservoir walls and other parts that require cleaning.

Benefits

- excellent transfer efficiency (~ 100 percent)
- waste coating and VOC emissions essentially eliminated
- high production rates
- low labor costs

Cautions

- piece must have uniform silhouette
- primary use for waterborne coatings
- thinners and water can be removed from the coating by the vacuum causing viscosity adjustments
- some tendency to foam

Dip Coating

Parts are dipped into a tank of coating material. This provides better coverage and causes less waste than conventional air spray systems. Dipping can be manual or pieces can be loaded onto a conveyor that dips the piece into the tank. Excess coating drips off the piece and drains back into the tank. Optimize viscosity for desired coating thickness. If solvent-based coatings are being applied, the system should be enclosed to prevent VOC emissions from escaping the tank.

Benefits

- excellent transfer efficiency
- reduce wastes
- low labor requirements
- high production rates

Cautions

- finish is viscosity sensitive
- not suitable for pieces with hollows or cavities
- color change is difficult and slow
- appearance is poor to fair compared to spray finishes

Flow Coating

In flow coating, many individual streams (10-80) of coating are directed at the surfaces of the piece as it passes through the flow coating chamber.

Broyhill Furniture Industries Case Study
Conover Plant

In December 1983, Broyhill installed an electrostatic system in their Conover chair plant in order to obtain a better quality finish and reduce material and labor costs. The new system, which uses five electrostatic high speed reciprocating turbo-disks, replaced a conventional spray system. The system also includes a flow coater that applies a sensitizer to make the surface of the chairs stain-conductive, and two non-grain raising stain spray booths.

After the system had been operating for two years, it was determined that material costs were reduced by 25 percent and the new system eliminated the need for six employees, who were relocated into different jobs at the plant. Associated wastes were also reduced and the payback period for the system was less than two years.

Steelcase Inc. Case Study
Fletcher, North Carolina

Steelcase installed a flatline roller coating system in 1985 in order to increase productivity, maintain consistent high quality, and reduce VOC emissions.

Paint was saved through an increased transfer efficiency and by converting to a high solids paint. A 30- 50 percent decrease in rejects and associated touch-up work was achieved, and overall VOC emissions were reduced by 25 percent.

Benefits
- high transfer efficiency
- reduce wastes
- high production rates
- low labor requirements
- low installation costs

Cautions
- poor to fair finish appearance
- coating controls film thickness

Curtain Coating
Curtain coating coats flat pieces by moving the pieces 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 recirculated with minimal waste.

Benefits
- excellent transfer efficiency
- reduce wastes
- very high production rates
- uniform coating thickness
- lends itself to UV / EB curing

Cautions
- suitable for flat work only
- may require clean room
- foaming and curtain breaks are sometimes associated with waterborne coatings

Roll Coating
In roll coating, coatings are applied by rollers to a flat surface of the piece. The roll coaters that apply the coating are often times engraved so as to produce a wood grain effect onto the piece if fiberboard or plywood.

Benefits
- high transfer efficiency
- reduce material waste
- high production rates
- allows the use of high solids coatings
- lends itself to UV / EB curing

Cautions
- limited to flat work
- for solvent-based coatings, potentially large amounts of VOC emissions as the rollers have to stay wet
- will not coat cavities or hard to reach areas
- "ribs" resulting from poor flow of the coating are sometimes created on the substrate

Dry Coating

Dry coating can be achieved with a formulated granular wax that is tumbled with the parts needing to be coated. This allows for reduction in amount of VOC's generated while giving adequate coverage on the parts. The pieces actually rub the surfaces of one another to create adequate coating. Great for coating small pieces such as wood buttons, napkin rings, and balls.

Benefits

- reduce material waste
- no VOC's

Cautions

- parts must be uniform in size with no sharp edges or irregularities in shape.

> ***Gerry Wood Products Case Study***
> *Suring, Wisconsin*
>
> **This company which produces wooden juvenile furniture and expansion gates converted to a dry application of a formulated wax coating for selected parts in lieu of a laquer coating. The process remained the same: using a tumbling process, mixing the wax and parts in a barrel before rotating.**
>
> **Payback was immediate with an annual savings of over $200,000 based on drastically reduced VOC emissions and hazardous wastes from daily clean-up.**

<u>Cleaning/Stripping:</u>

Alternatives to Methylene Chloride

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 active ingredients:

- N - methyl pyrrolidone (NMP), a water soluble, biodegradable solvent that has relatively low toxicity, is nonflammable and noncarcinogenic (but may need to be reported to EPA).
- Gamma - Butyrolactone, a water soluble, biodegradable solvent that is FDA approved and has tested noncarcinogenic in rats and mice

Benefits

- biodegradable
- nonflammable
- no offensive vapors
- soap and water cleanup
- less VOC emissions

Cautions

- hazardous waste may still be generated when using non-hazardous strippers because of the characteristics of the materials being stripped

> ***Larson Juhl, Inc. Case Study***
> *Ashland, Wisconsin*
>
> **Larson Juhl, in its finishing operations for wood picture frame mouldings, was using 8-10 gallons of xylene/day to clean out the 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 system. Colors now run from lighter to darker as the day progresses, as well.**
>
> **The payback was immediate, resulting in $50,000 savings /year.**

Operation And Maintenance:

Train Equipment Operators

Formal operator training is essential to successful waste reduction and should include:

- communication of safety and health, quality, productivity, waste reduction and energy conservation goals and expectations, and how this will help the company and the operators
- use of equipment in accordance with the manufacturer's specifications such as utilizing proper spray gun air or fluid pressures, coating concentrations and flow rates, care and maintenance
- proper spray technique fundamentals such as:
  - 50 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)
- safety and health hazards associated with the equipment and materials and how to protect themselves, prevent accidents and environmental incidents

Some companies periodically videotape their operators so that the operators can critique themselves and point out where improvements are necessary (see the Case Study below).

Benefits

When finishing operators are properly trained, they can:

- reduce material costs
- achieve a higher quality finish
- reduce wastes and VOC emissions
- improve productivity
- improve work place safety
- reduce incidence of injury (e.g., carpal tunnel syndrome) through ergonomic improvements

Cautions

- informal training by other operators can continue bad habits
- infrequent or inappropriate training for the equipment or the coating type will not help

Prepare Coatings Properly

Proper coating material preparation can impact the amounts of material used and wasted. For example, too much thinning or reduction can cause running and sagging, while too little reduction can cause defects such as orange

Ethan Allen Furniture Case Study
Old Fort, North Carolina

Ethan Allen has a training program for spray operators that utilizes video taping as a operator training tool. The training consists of three stages:

1-Operators are video taped while performing their job (it is important to communicate the purpose of the taping to the operators before video taping starts so that there are no misunderstandings).

2-The operators in groups of three along with their supervisors and technical personnel, review the tapes in one hour sessions in order to identify ways to improve. Instruction on spray techniques is provided during the session and follow-up is provided during production on the manufacturing floor.

3-The operators are taped again and given a chance to compare the tapes and observe the improvements.

The training is conducted twice a year and equipment and coating suppliers provide technical assistance. The company projects saving $50,000 to $70,000 annually as a result of 8 - 10 percent savings in material usage. Wastes and VOC emissions are also reduced.

Source: Case Study: Ethan Allen, Inc., North Carolina Waste Reduction Resource Center, December 1993.

peeling. These defects can result in rejects and waste. Proper coatings preparation includes:

- always adding 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 mixture
- test for complete mixing by sampling the top and the bottom layers of the mixture and placing each on separate pieces of glass to observe and compare color and rate of flow
- mix materials thoroughly before use and during use to maintain the desired uniformity
- keep tanks covered to prevent evaporative losses and contamination of the contents
- for continuous coating systems, monitor the viscosity of the coating in the reservoir so that the amount of solvent added is not excessive

Direct Delivery of Coating to Spray Gun

Direct delivery of the coating material to the spray gun or application device instead of indirect transfer (e.g., filling an interim container from a drum or tank, transporting the container to the work area, transferring the coating material from the interim container to the spray gun or application device reservoir) can provide benefits and savings.

There are three types of direct transfer systems:

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

Benefits

- volume cost discounts for bulk coating purchases
- less waste from: spills during transfer, container residues, and evaporative losses
- less employee exposure to hazardous chemicals
- better finish quality through uniform material consistency

Ethan Allen Furniture Case Study
Old Fort, North Carolina

1-Cardboard filters that were used for all coating operations were replaced with metal filters. The cardboard filters were disposed of as waste, while the metal filters are cleaned in a solvent tank. The waste solvent / coating mix is distilled and the overspray is drummed for disposal, while the solvent is reused. The metal filters used for capturing lacquer and sealer overspray are wiped by hand and the dust is sent off-site for recycling.

Cost: $57,000, Waste Reduction: 10,000 lbs. per year, Savings: $48,125.

2-A fabricated, sloped polyethylene trough replaced absorbent and wood shavings to catch coating. The overspray is squeegeed from the trough into a pan for disposal eliminating the absorbent as a waste material.

Cost: $400, Waste Reduction: 6100 lbs. per year, Savings: $38,430.

3-Polyethylene covers replaced cardboard covers for the pallets that transferred products through coating operations. The overspray is peeled off the pallet cover and drummed for disposal and the covers reused.

Cost: $2050, Waste Reduction: 3700 lbs. per year, Savings: $7450

4-Racks used to transport product are now cleaned of overspray periodically by the watchman during his free time. The racks can be reused instead of disposed of as hazardous waste.

Cost: $200, Waste Reduction: 1900 lbs. per year, Savings: $8250.

- increase productivity and lower labor costs because of reduced transfer tasks
- lower solvent cost and reduced solvent wastes because interim containers do not need to be cleaned

Use Heat to Obtain Desired Coating Viscosity

Traditionally, viscosity adjustments to coatings have been made by adding organic solvents as a reducer to the coating material. Also, as the ambient temperature of the work place changes, the viscosity of the coating being applied changes, which causes operator problems and gun adjustments. Heat, instead of solvent, can be used in some cases to adjust and maintain the incoming coating to the desired viscosity.

Benefits

- less solvent usage
- less waste solvent and VOC emissions
- more consistent viscosities
- faster curing
- allows the use of higher solids coatings
- improves coating flow and finish appearance

Ashley Furniture Industries, Inc.
Case Study
Whitehall, Wisconsin

Solvents were used to clean and flush spray application equipment between color changes and for thin coatings. Only new solvent was used and the spent solvent managed as hazardous waste.

After reviewing cost, capacity and ease of operation of distillation equipment, the company installed a batch solvent distiller, cooler for condenser water, pump and plumbing and electrical hookups.

While the project initally cost $23,000, Ashley Furniture realized a payback period in just 6-1/2 months.

Spray Equipment Maintenance

Regular care and maintenance must be performed on all equipment, especially spray equipment, to keep it in optimum working condition, prevent breakdowns or malfunctions, and waste. Some fundamental measures include:

- keep feed tanks clean of contamination such as dirt, dried coating particles, and dust, by keeping them covered whenever possible
- keep tanks agitated to prevent skim from forming and solids from settling
- locate the compressor where it can intake clean air and maintain it properly by checking filters and draining condensate
- select the appropriate spray gun attachments - needle, nozzle, air cap - for each coating utilized
- maintain proper fluid and air pressures
- correlate air pressure at the spray gun with the air pressure of the coating tank to maintain proper air pressure
- perform solvent pump maintenance to prevent leakage
- prevent spray gun leakage by placing only the front end of the gun in solvent when cleaning, lubricate bearings and packings of the spray gun daily
- do not spray and varnish in the same booth as it may cause spontaneous combustion
- whenever possible, do not spray different types of coatings in the same booth as it may make the resulting wastes mixed and more difficult and costly to dispose of or recycle
- use closed paint gun cleaning units to control VOC emissions and exposure
- equipment should be cleaned as soon as possible after use before coating cures and is more difficult to remove

Equipment Cleaning and Line Flushing

Finishing equipment cleaning is usually needed when a process is completed, for changes in coating materials or colors, and when maintenance is required. The more cleaning that takes place, the more waste that is usually generated. Also, solvents are often used to clean equipment and lines, generating waste solvents and VOC emissions.

Here are some ideas that can help you reduce waste from equipment cleaning:

- clean only as necessary rather than by schedule only
- minimize the number of cleanings of the equipment by finishing with a light coating first, then progressively use darker coatings whenever possible
- 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
- use air to blow lines free of coating back to pots
- use 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 tanks to improve drainage and minimize waste coating build-up on tank walls
- use rubber wipers to remove coatings off tank walls instead of rags

Inventory and Scheduling Management

Too much inventory or lack of inventory control for materials can result in waste in the form of material never used (inventoried more than needed) or material that deteriorates before use (exceeding shelf life). Work closely with material suppliers to provide just-in-time (JIT) material delivery and order accurate amounts needed for the job.

Managing production schedules to reduce color changes by grouping parts requiring the same finish can eliminate substantial amounts of waste from gun cleaning and line flushing. Efficient production scheduling can maximize the usage of coatings with short pot life.

Benefits

- prevent costs for unneeded materials
- prevent waste disposal costs
- increase floor space
- store less hazardous materials
- reduce waste from color changes

If you end up with an excess of coating material:

- return unused materials to the vendor (make arrangements with the vendor up-front before purchase)
- trade or give to other finishers to use
- contact a waste exchange to see if someone might be able to use the material

Boling Company Case Study
Mt. Olive, North Carolina

Until January 1993, Boling was burning spent solvents from the finishing process for fuel. Boling installed a "Little Still" to recycle spent thinners from the plant's wash off operations. Even though the quality of the solvent product from the distillation process was not the quality necessary for reuse as wash off, by mixing one part acetone with three parts reclaimed solvent, the mixture could be used as a thinner in the spray coat operation. The stills operated four times a week and generates 40 - 60 gallons per week.

The cost of the still was $4825, and operating costs are about $0.12 per gallon of solvent reclaimed. The net savings is about $ 100 per week, not including reduced waste disposal costs. The still paid for itself in one year.

Reuse and Recycling of Finishing Materials

There are many opportunities for the recycling of finishing materials. Recycling reduces the amount of waste to be treated and disposed of, and the associated disposal and compliance costs. It also reduces the amount of new materials needed.

Some ideas for recycling include:

- extend solvent life by settling, filtration of solids, and using for jobs not requiring virgin solvent (e.g., rough cleaning)
- distill solvents, either on-site or off-site
- collect and reuse staining operations overspray
- capture overspray in the spray booth wash water and returning both the coating material and the wash water back to the process (coating material that is immiscible in water can be separated from the booth water wall by settling and ultrafiltration)
- reuse clean-up solvents or solvent sludge for coating secondary surfaces, where appearance is not a factor
- exchange wastes with other companies

Thomson Crown Wood Products Case Study
Mocksville, North Carolina

Thomson Crown previously disposed of its wet spray booth wastewater as hazardous waste. The company started a system to separate paint solid from the wash water and recycle the water back to the spray booth. The change reduced hazardous waste disposal costs by $92,500.

Ethan Allen Furniture Case Study
Old Fort, North Carolina

A solvent unit was installed to recover solvents and reduce hazardous waste generation. A seven gallon batch still, which is run twice daily, recovers 5 gallons of reusable solvent for every 7 gallons of cleanup waste.

Cost: $4500, Waste Reduction: 1900 lbs. per year, Savings: $3200 per year

Medallion Kitchens Case Study
Waconia, Minnesota

Medallion Kitchens manufactures kitchen cabinets and bathroom vanities. The company's desire was to reduce raw material costs, reduce VOC emissions, minimize hazardous waste disposal costs and associated liabilities, and decrease labor costs. Overspray from sealer and topcoat applications was a problem. About 75 gallons of sealer was used per day and 50 gallons of hazardous waste sludge was generated per day.

The company invested in a reclamation system for sealer . The system consists of two holding reservoirs and some minor plumbing. The system is designed to catch most of the overspray before it falls into the wash water tank. A cooling water system is applied to the collection trays to minimize solvent evaporation, collected material is agitated to prevent "skinning", the reclamation trays are removed and replaced easily, and a non-stick coating is applied to the collection trays. After about 5 gallons of overspray is collected, the overspray is removed and solvent and catalyst is added to the material to obtain the desired coating properties. It is then added back to the spray system to be reused.

The system cost about $2500 per installed booth. Savings include $23,000 annually from reduced material usage. Waste sludge has been reduced from 50 to 25 gallons per day, saving the company $30,000.

Checklist: Using Tanks in Your Refinishing Shop

Using open tanks in your shop can have potential harmful affects on your employees. Be aware of what to watch for.

Equipment

__ Tanks of paint remover emit potentially harmful vapors. Proper ventilation is important. Make sure you know whether the vapor from your stripping material is lighter than air or heavier than air. (Some remover vapors are lighter than air. Methylene chloride vapor is heavier than air.) Exhaust fan intakes should be located accordingly--higher than the work surface or near the floor for methylene chloride.

__ Remover tanks should be tightly covered al all times when not in use. This will save loss through evaporation, and minimize your exposure to vapors.

__ Periodically remove stripped finish from your paint remover tank to promote the efficiency of the stripping process.

__ Make sure the paint remover in your tank is working as effectively as possible. Observe the temperature recommendations provided by the manufacturer. Most paint removers work most effectively at more than 70 degrees Fahrenheit--and only half as efficiently at 50 degrees.

Employees

__ Be especially careful to avoid breathing vapor from a caustic tank. Most old furniture finishes contain lead. Lead is dissolved by caustics, and will be contained in caustic vapors.

__ Protect eyes and skin from contact with remover from tanks. Wear goggles, rubber gloves, long sleeves and an apron while working around a tank

__ There must be a source of clean, fresh water near the paint remover tank so that remover can be quickly and thoroughly rinsed from skin and eyes in case of accidental contact.

Checklist: Cut Costs Through Record Keeping

Here's a checklist of items to keep your record keeping in order for regulatory purposes, and cost savings.

Paper shuffle

__ Track the chemicals contained in the paint removers, solvents and finishes you are using by keeping accurate files of the Material Safety Data Sheets.

__ Record the items you strip or finish by revenue, time required for the job, date, and the customer. Do this electronically and you will have a good record for direct mail advertising.

__ Keep records of the removers, solvents, and finishes you purchase, by date and supplier. Compare those with the records of items you strip or finish in order to learn whether you are using chemicals efficiently.

Calculations

__ Total the prices you charged for the items you stripped and finished.

__ Total the costs for the quantity of paint remover you used during that same period.

__ Total the costs of finished used during the period.

__ Total your labor costs for the period.

__ Total your payments on equipment for the period.

__ Compute the percentage of your income you are spending on each of these expense items.

__ Is your price structure adequate to cover costs and provide a profit?

__ Improve your profit margin by using paint removers and solvents more efficiently and by reducing your waste disposal costs.

Keep an accurate record of any paint removers or finishes that are wasted.

__ Calculate the cost of this waste as a percentage of your operating expense.

__ Does this cost warrant action to reduce waste?

__ If you are wasting material due to deterioration, are containers available that can be sealed more tightly?

__ Buy in quantities adequate to your operation. Are they currently too large or too small?

__ Consider changing practices or purchasing new equipment in order to reduce remover and finish purchases.

Checklist: Protect Your Health in the Refinishing Shop

When using chemicals such as volatile organic compounds or hazardous air pollutants, keep on top of health issues affecting your employees.

Precautions

__ Keep Material Safety Data Sheets on hand to know what is contained in the paint removers and finishes in case of an accident.
__ Be prepared to rinse chemicals from eyes or skin in case of accidental contact.
__ If you smoke, recognize that you are particularly susceptible to injury form exposure to paint remover, solvent or finish vapors. Smoking materials are a fire hazard. Don't smoke when working in the refinishing shop.
__ Ask your suppliers, periodically, about the availability of less toxic non-flammable paint removers, solvents, and finishes.
__ Seek the advice of your physician about preventative measures, and ask about periodic blood test to assure no ill effects from exposure to chemicals.

Personal Gear

__ Always wear protective clothing and equipment
__ Do not wear contact lenses when using paint removers.
__ Some breathing masks and respirators may increase exposure by trapping harmful chemicals near the nose and mouth.

Workspace

__ Keep your area well-ventilated. An exhaust fan should vent vapors from paint removers outdoors. Give your shop a fresh air intake vent with a capacity of two cubic feet per minute per square foot of shop space.
__ When possible, close covers on tanks containing remover and return used remover to a closed container to reduce exposure to potentially harmful vapors
__ If you process a high enough volume of product to use sprayers when applying finishes, consider high volume, low pressure (HVLP) sprayers to get more of the finish onto the product and reduce employee exposure to the atomized finishes.
__ If you use sprayers, consider installing a booth with an exhaust fan.

Checklist: Refinishing Safety

When using chemicals such as volatile organic compounds or hazardous air pollutants, keep on top of safety issues affecting your employees.

Precautions

__ Carefully read all Material Safety Data Sheets that come with the stripping, rinsing and finishing materials you use in your refinishing shop.

__ Make sure you know the “flash point” of the materials you are using. The lower the flash point, the more easily a material is ignited.

__ Some materials used in stripping and rinsing -- thinners and petroleum distillates -- are a fire hazard.

__ Methylene chloride, a common stripping material, is not easily ignited, but many of the paints and other finishes that become mixed with methylene chloride as it is used are ignitable. After considerable use, methylene chloride contaminated with other materials will burn and my produce very toxic gases in the process.

Workspace

__ Enforce a strict “No Smoking” rule in the work area of your shop.

__ Make sure that a fresh air duct in the work area is adequate to replace all the air drawn out of the room by exhaust fans located near the stripping area, the rinse area, or in a paint booth. Without adequate fresh air intake, exhaust fans may draw air from the furnace flue or the hot water heater flue. Worker exposure to combustion gases including carbon monoxide will result. Adequate ventilation with fresh air will also prevent the build-up and possible ignition of combustible gases.

Checklist: Application Equipment Requirement[1]

__ The facility does not use conventional air spray guns.

__ The facility operates conventional air spray guns, but are only used:

1. If they are using the guns to apply coatings that have a VOC content no greater than 1.0 lb VOC/lb solids, as applied;
2. If they are using the gun for touchup and repair that occurs either after the completion of the finishing operation or after the application of stain and before the application of other types of finishing materials. In addition, any materials used for touch up and repair after the stain application must be applied from a container with a volume of no more than 2.0 gallons.
3. If the guns are automatic;
4. If the guns are used in a spray booth or other application station where emission are directed to a control device;
5. If the guns are only used for applying small quantities of finishing materials. The total amount of finishing material applied with the conventional air spray gun must be no more than 5.0 percent of the total amount of finishing material used in that semiannual period; or
6. If the gun is used to apply stain and the facility has demonstrated that it is technically or economically infeasible to use another spray application technology.

Operator Training Program

__ The facility has developed an operator training program that contains:

- ! A list of job descriptions and current personnel that must be trained;
- ! An outline of the subjects to be covered for each job description;
- ! An initial and refresher training program; and
- ! A description how the facility will document personnel's successful completion of the program.

Inspection and Maintenance Plan

__ The facility has developed an inspection and maintenance plan that:

- ! Addresses equipment leaks;
- ! Includes a monthly visual inspection to ensure there are no equipment leaks of all equipment used to transfer or apply finishing materials or organic solvents;
- ! Specifies how a facility will document date, result, and repairs of an inspection; and
- ! Assures first attempt at leak repair within 5 days and final repair within 15 days, unless repair requires replacement of the equipment in which case the facility is allowed 3 months to complete repairs.

Cleaning and Washoff Solvent Accounting Program

__ The facility has developed a program that tracks:

- ! the amount of organic solvent used for cleaning and washoff each month;
- ! the quantity of spent solvent generated from each cleaning or washoff operation each month;
- ! the amount of spent solvent that is reused or disposed; and
- ! the number of pieces washed off and the reason for the washoff.

[1] Wood Furniture Manufacturing Operations NESHAP Implementation Document, United States Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-456/R-97-005, September 1997, http://www.epa.gov.ttn/uatw

Cleaning and Washoff Solvent Composition

__ The facility has discontinued the use of solvents that contains known or probable human carcinogens. (See Appendix F for list of solvents)

Checklist: Work Practice Standards[2]

Spray Booth Cleaning

__ The facility does not use cleaning compounds that contain more than 8.0 percent VOC by weight, unless operators are cleaning conveyors, continuous coaters and there enclosures, or metal filters.
__ The facility's solvent use is limited to 1.0 gallon per booth for preparation of booth surface for coating/protection.

Storage Containers

__ Containers that are used for storing finishing, cleaning, adhesive, or washoff materials are closed when not in use.

Gun and Line Cleaning

__ Gun and line cleaning solvent is collected into a closed container.
__ Containers associated with cleaning are covered when not in use.

Washoff Operations

__ Washoff tank is covered when not in use.
__ The facility minimizes dripping by tilting and/or rotating the part to drain as much solvent as possible.
__ The facility is allowing sufficient dry time for the part.

Work Practice and Implementation Plan

__ The facility has developed a plan to implement these work practice standards and maintain onsite.

Formulation Assessment Plan for Finishing Operations

__ The facility has:

- Establish a baseline level for each VHAP of potential concern
- Track annual usage VHAP of potential of concern; and
- Reported all exceedences of baseline level, if any.

[2] Ibid.