Surface Coating

Surface coating covers a wide range of categories and emissions. In Washington, major surface coating operations include aerospace, auto refinishing, furniture finishing, metal can coating, and paper coating. Emissions depend on the type of surface coating operation and the material used for coating. Surface coating can be treated as an area source when looking at a group of sources or as a point source when looking at a specific facility.

This chapter will begin by giving an overview of surface coating as it applies to all source categories since all surface coating processes and methods for determining emissions are similar. Subsequent sections will address surface coating operations specific to Washington and give a more detailed look at these processes and their emissions.

Description of Process

Surface coating materials are primarily organic polymers dissolved in a solvent or suspended in an emulsion. The material may be applied to the product by brush or by spraying. In the process of "drying", the solvent or emulsion carrier evaporates. The organic polymer is left behind to coat the surface. Regardless of the application technique, all the volatile constituents of the finish are released to the environment. However, the application technique can determine how much finish must be used and the corresponding amount of air emissions per product.

Throughout most of history, the solvents and emulsion carriers have been volatile organic liquids. Most of the compounds comprising these solvents are toxic air pollutants under WAC 173-460. In the 1950's, the first "latex" paints were introduced to the market. Latex paints are emulsions of organic polymers with water being the primary emulsion carrier. Volatile organic solvents may still be included in the formulation to balance necessary flow and drying rates. However, their proportion is greatly reduced from "solvent-based" products. Due largely to environmental concerns, the use of water-based finishes appears to be growing rapidly in the commercial sectors.

When a finish material is rubbed or brushed onto a product, essentially all the finish material contacts the surface. For all practical purposes, this is "100% transfer efficiency". However, it is labor-intensive and does not give a reliably high-quality finish. It is only rarely used commercially. Spray coating is faster than manual application, and gives a better finish more consistently. By far the most common commercial application technique is spray coating.

In spray coating, the finish material is propelled toward the surface. The intent is that the finish material hit and stick to the surface. In practice, much of the finish material misses the surface altogether ("overspray"). The amount of overspray depends to a great degree on the shape and size of the product. Some finish material bounces off the surface, and is swept by air currents into the general spraying area. Consequently, spray coating has substantially less than 100% transfer efficiency.

Transfer efficiency differs with spray-coating technique and equipment. Table 1 summarizes characteristics of spray-coating techniques and equipment.

Table 1: Spraying Techniques used in Surface Coating

Technique	Description	Advantages	Disadvantages	Transfer Efficiency
Compressed air atomization	Conventional: 50 to 100 psi	Fine finish	Lowest transfer efficiency. Poor application in recesses and cavities.	25%-30%
	High volume, low pressure: Under 10 psi	Fine finish. High transfer efficiency.	Requires training. Poor application in recesses and cavities.	45%-55%
Air-assisted airless (sic)	Small orifice: 450 psi	Fine finish. High transfer efficiency. Moderately fast application. Good penetration into recesses and cavities. Works on a wide variety of applications.	Best with slow to medium production line speeds. Best with low viscosity materials.	40%-50%
Airless	Small orifice: 2,000 to 3,000 psi	Fastest application. Good penetration into recesses and cavities.	Coarser finish. Moderately poor transfer efficiency.	30%-35%

Method of Determining Emissions

Estimating emissions from surface coating needs to take into account the coating material characteristics and the coating technique. VOC speciation and quantity estimation can best be done by a material balance of quantity and composition of coatings used.

Surface coating emissions are covered in *AP-42*[1] in Section 4.2, which provides a table that describes how to calculate the weight of VOC emissions per volume of coating depending on what VOC composition information is available on the coating. This could be VOC by weight percent, volume percent, or in waterborne paint, as weight percent or volume percent of total volatiles, with or without water.

All coatings manufacturers are trying to develop lower VOC coatings, minimizing HAP components. Emphasis on pollution prevention practices, combined with improved control technologies should be continued.

[1] U.S. Environmental Protection Agency, *Compilation of Air Pollutant Emissions Factors Volume 1: Stationary Point and Area Sources*, Fifth Edition with Supplements, October 1997, Document No. AP-42.

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(available by section on Internet at http://www.epa.gov/ttn/chief/ap42.html)

Aerospace Surface Coating

The majority of aerospace surface coating activities in Washington State take place under the jurisdiction of the Puget Sound Air Pollution Control Agency (PSAPCA), with lesser amounts of activity under other jurisdictions. Individual facilities submit annual toxic and criteria emissions inventories to their local air authority for review. The majority of emissions are estimated using material balances.

Auto Refinishing

There are approximately 2,230 auto refinishing facilities in Washington (*Air Toxics Emissions Estimation Methods Evaluation*, pg. 96). Table 2 shows the estimated number of facilities as found by Name Finders for the May 1996 edition of this report.
Facilities were organized by the following SIC Codes:
7532 Body Shops
7538-99 Misc. Body Repair
7549-02 Automotive Customizing
5511 New and Used Car Dealers

Table 2: Estimated Number of Auto Refinishing Facilities in Washington[2]

AGENCY	7532	7538-99	7549-02	5511	TOTAL	REGISTERED OR KNOWN SOURCES[3]
Ecology-NWRO	2	0	0	0	2	NA
Ecology-CRO	58	10	1	26	95	NA
Ecology-ERO	79	7	1	42	129	NA
BFCCAA	40	5	1	14	60	NA
NWAPA	90	10	4	41	145	88
OAPCA	103	16	1	47	167	160
PSAPCA	712	75	23	331	1,141	501
SCAPCA	119	15	4	63	201	80
SWAPCA	115	19	3	46	183	68
YCCAA	57	13	1	36	107	NA
TOTAL	**1375**	**170**	**39**	**646**	**2,230**	

Description of Process

Auto refinishing consists of four process steps which may generate air toxic emissions.

I. Surface Preparation (particulate and VOC)
II. Priming (particulate and VOC)
III. Top Coating Application (particulate and VOC)
IV. Equipment Cleaning (VOC)

[2]Name Finders, Inc., Seattle, WA was commissioned by the Ecology Air Quality Program to provide a list of businesses with the respective SIC codes. The numbers of businesses were derived from that list.
[3]Those sources that are registered with or known by the regulating authorities.

Surface preparation is the first step in the refinishing process. The surface to be coated is prepared (sometimes sanded) so that the primer will adhere properly. Solvents are used to remove wax and other contaminants before the primer is applied.

Primers are applied to fill surface imperfections, for corrosion protection and as a bond for the topcoat. Three types of primers are in general use in the industry: precoats, primer surfacers and primer sealers.

A series of topcoats is applied over the primer. The colors (metallic or solid colors) are determined by the application of the topcoats. Topcoats are applied in either single-stage, two-stage (basecoat/clearcoat) or three-stage (mica coating) system. Three commonly used topcoats are acrylic lacquers, acrylic enamels, and polyurethanes. Lacquers comprise 34% of the refinishing coatings applied in the industry.

Lacquers are preferred because they are quick drying (via solvent evaporation). This is important for quick jobs like spot repairs. Lacquers are also easily redissolved or removed with solvents.

Acrylic enamels comprise 54% of the refinishing coatings sold and are most typically used because they provide durable, high gloss finish.

Polyurethanes are the most recent coatings on the market and provide the best durability and gloss.

Metallic color appearance in metallic paints results from the orientation of the metallic flakes (proper depth and proper alignment) which is a function of the evaporation rate of the solvent during drying. The VOC content of metallic paints is regulated at higher rates because of these critical solvent limitations.

The two-stage (basecoat/clearcoat) and three-stage applications are color or a metallic base covered by two or three coats of clear coating. The VOC content of these systems is calculated using a weighted average of base coat and clear coats applied.

Only approximately 5% of coatings applied in body shops are specialty coatings (used for unusual job performance requirements). Here again, the VOC limits are regulated at higher rates because of critical solvent limitations.

Color matching and applications techniques are critical to the quality of work done by a shop. Color matching with the original equipment manufacturer (OEM) colors is a major concern of the industry since most jobs are panel or spot repairs. Typically it is prudent for body shops to have a color mixing system in house that will allow them to mix (according to a specified formula) just enough paint for a job to avoid the expense of wasting paint and disposing of excess paint. Manufacturers bake the coatings for short times at high temperatures in large ovens before the heat sensitive accessories are installed. The technician does not have that luxury. Repair jobs are typically dried and cured at ambient temp (and humidity) or by low-bake infrared heaters.

The application techniques are a critical function of lowering VOC emissions. Current transfer efficiency (ratio of weight of solids adhering to the surface to the weight of solids applied) reported by the application equipment vendors is up to 65%.

EPA and California (*California Air Resources Board*, 1991) describe Reasonable Available Control Technology (RACT) as (it is understood that the spray painting is conducted in a spray booth of some type):

- Using low VOC surface preparation products
- Using low VOC (high-solids or water-borne) coatings
- Using gun-cleaning equipment that recirculates gun cleaning solvent
- Improving housekeeping practices
- Using/improving training programs

Method of Determining Emissions

Particulates are generated in the form of dust from the sanding process preparing the surface for coating application. Particulates may be controlled by venting them through an exhaust filter which entrains the particulate matter. Vacuum systems are available that attach directly to the sanding equipment which contains and essentially eliminates particulate emissions.

Particulate emissions are regulated under WAC 173-400. A spray booth will control the emissions of particulate (overspray) by exhausting the overspray through a filter where it is entrained. VOCs are exhausted through the filter and into the stack then into the atmosphere where they are dispersed as a function of the meteorology at the time of emission.

Article 45 of the Uniform Fire Code requires spray coating operations to have a spray booth with filters; proper air flow and ventilation and pressure measuring devices. However, several of the local air pollution control authorities (LAPCAs) reported that generally these codes are difficult for fire officials to enforce.

EPA published Low-VOC Coating Limits as part of their RACT determination for Auto Refinishers. The National Paint Coatings Association (NPCA) is in agreement with EPA's RACT Option 1. (*California Air Resources Board*, 1991)

There are low-VOC cleaners on the market (<200 grams VOC/liter vs. 730 grams VOC/liter in a typical solvent) that work well for spot repair. However, these low-VOC solvents do not serve as all-purpose solvents.

Table 3: VOC Content of Auto Refinishing Products
(1 pound/gallon = 119.829 grams/liter)

Topcoats	Pounds of VOC/Gallon of Solids	Grams of VOC/Liter of Solids
Lacquers	73	8747
Enamels	20	2397
Polyurethanes	13	1558
Basecoat	6-6.9	827
Clear Coat	5.6	671

Table 4: VOC Emissions from Auto Refinishing

Process	VOC Emissions (%)	Particulate Emissions (%)
Base Case: No controls	100	100
Surface Preparation	8	100
Mixing, Priming and Top Coat Application	72	0
Equipment Cleaning	20	0

Insufficient data is currently available to determine emissions statewide.

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SCAQMD (Abid Latif, Rule 1151 writer)
Ventura County AQMD (Ed Cowen)
Bay Area AQMD ()

National Paint Coatings Association (Jim Sell, President)

Washington's LAPCAs:
BFCCAA (Pete Bosserman)
NWAPA (Lester Keel)
OAPCA (Jim Wilson)
PSAPCA (Tony Agyei and Larry Vaughn)
SCAPCA (Kelle Vigeland)
SWAPCA (Paul Mairose)
YCCAA (Bob Godwin)

Paint Manufacturers:
Sherwin Williams (Mark Kruzer)

Furniture Finishing

Description of Process

Wood finishing is done on a wide variety of value-added wood products. This includes at least twelve SIC codes in millwork, cabinet making, and furniture industries. Wood finishing materials encompass a wide variety of solvent- and water-based formulations. Application techniques vary widely in material use efficiencies.

In recent years, the use of water as a solvent or emulsion carrier for wood coatings has been extended to clear varnish. "Water-based" wood finishing products represent a minority of the volume of finishes being used.

These kinds of equipment are available to apply finishes to wood products. Based on a quick survey of wood finishing businesses in OAPCA's jurisdiction, the industry is about equally split between airless, air-assisted, and HVLP equipment. As with many other elements of this sector, spray-coating technique and equipment are in a state of flux.

Table 5. Standard Industrial Categories for Coating and Finishing of Value-Added Wood Products

Industrial Category		SIC Code
Millwork (doors, trim, accessories)		2511
Kitchen cabinets		2434
Mobile homes		2451
Other prefab. buildings		2452
Other wood products except furniture		2499
Furniture		
	Not upholstered	2511
	Furniture cabinetry	2517
	Other, e.g., upholstered	2519
	Office wooden furniture	2521
	Furniture for public buildings	2531
	Shelving, lockers, fixtures	2541
	Other office furniture	2599

Wood finishing involves preparation of the wood surface by sanding and coating with some combination of “finishes”: stain, sealer, and a clear or opaque coating (i.e., varnish or paint). in the wood finishing process.

Methods of Determining Emissions

Table 6 (following page) shows the volatile organic components found in typical wood finishing products used by sources in OAPCA's jurisdiction. The "lowest found" and "highest found" columns are values indicated by material safety data sheets (MSDS) for the various finishing products.

The last column, “'normal' gallon", is an attempt at defining a “generic” wood finish. The column is the median value from the MSDS which is then weighted using a typical VOC content of about six pounds per gallon. For example, for acetone you can expect to find 0.32 pounds of acetone in a gallon of finish with a VOC content of 6.1 pounds. This represents no one wood finish, but might be used to estimate emissions from the industry as a whole.

Table 6: Volatile Organic Compound Content in Wood Finishes Based on OAPCA Source Data

Volatile Wood Finish Component	ASIL 24 hr. average g/m^3	Sources reporting using material having this component	Lbs./Gal. Finish		
			Lowest found	Highest found	Weighted to a "normal" gallon: 6.1 lbs/gal VOCs
Acetone	5,900	2	.53	1.36	.32
Butyl alcohol	500	7	.02	.44	.05
Butylacetate,n-	2,400	8	.09	.83	.11
Diethylene glycol monoethyl ether		1	.31	.43	.2
Dihydroxy Dinitroanthra-Quinone,1,8-,4		2	.43	.6	.2
Distillates (petroleuh)		1	.27	.27	.12
Ethanol	6,300	7	.15	.66	.12
Ethyl acetate	4,800	5	.06	.6	.08
Fthyl benzene	1,000	1	.36	.36	.17
Ethyl-3-ethoxy propionate		1	.36	.36	.17
Ethylene glycol monobutyl ether		3	.43	.76	.23
Ethylene glycol monopropyl ether		4	.31	.46	.15
Ethylhexyl-Phthalate,bis,2-		3	0	.09	.08
Formaldehyde	60	3	.01	.02	0
Hydrotreated heavy naphtha		1	1.13	1.13	.51
Isobutyl acetate	2,400	2	.68	2.13	.45

Volatile Wood Finish Component	ASIL 24 hr. average g/m^3	Sources reporting using material having this component	Lbs./Gal. Finish		
			Lowest found	Highest found	Weighted to a "normal" gallon: 6.1 lbs/gal VOCs
Isobutyl alcohol	510	3	.23	.93	.17
Isopropanol	3,300	15	.09	1.03	.13
Isobutyl isobutyrate		2	.17	.83	.14
Lactol spirits		8	.2	1.46	.21
Light aromatic solvent naptha		1	.43	.43	.2
Ligroine		2	.66	.66	.3
Methanol	870	7	.23	.66	.15
Methyl ethyl ketone	1,000	7	.11	.19	.15
Methyl n-amyl ketone	780	3	.22	.59	.14
Methylpentanone,4-,2-	680	12	.1	2.75	.3
Naphtha (mineral spirits)		4	.08	.15	.05
Propylacetate,n-	2,800	4	.02	.38	.04
Propylene glycol monomethyl ether acetate		3	.29	.4	.15
Toluene	400	15	.1	3.0	.33
Xylene	1500	13	.08	6.81	.69

Appendix
Alternative Methodology

Furniture Finishing Cost Analysis

This report is based on twenty-four sources in OAPCA's jurisdiction. Of these, there are 14 cabinetmakers, 4 door/millwork manufacturers, and 6 furniture makers. They vary in size on an annual revenue basis from less than $50,000 to over $5 million. Their total TAP emissions vary from less than 100 lbs. per year to over 13 tons per year. None qualify as "major sources" under Title V of the fCAAA. Their emission rates may be weakly related to the specific business sector. There is insufficient data to determine the statistical significance of these differences. The range of variation in emissions expressed against a base of annual revenue for the three sub-sectors in woodworking were

Cabinetmakers: .001 to .013 lbs. air toxics emissions per dollar revenue
(Although one was as high as .2 lbs/$)
Average about .007 lbs/$

Door/millwork: .002 to .008 lbs. air toxics emissions per dollar revenue
Average about .005 lbs/$

Furniture makers: .005 to .07 lbs. air toxics emissions per dollar revenue
Average about .04 lbs/$

In general, the larger companies had disproportionately lower emissions rates than the smaller companies. This may be an indication of better material management practices or greater advancement toward low-VOC or water-based finishes on the part of the larger businesses There is insufficient data to allow separating out industry sub-sector along with size. The following difference is statistically significant:

Wood finishing businesses having more than one million dollars annual revenue averaged about .004 lbs. air toxics emissions per dollar revenue.

Wood finishing business having less than one million dollars annual revenue averaged about .08 lbs. air toxics emissions per dollar revenue.

Data were also available on emissions from three cabinetmakers in SWAPCA's jurisdiction. Revenue data were only available on the largest of these. It is also one of the largest cabinet shops on the West Coast with about $20 million in annual revenue. Its emissions ratio of about .003 lbs/$ agrees well with the above estimates.

Data from the other two SWAPCA cabinetmakers give an indication of an emission factor in the form of lbs. air toxics per square foot of wood finished. The following details the analysis:

1. The target thickness of the dry finish is about 5 to 6 thousands of an inch (Michael Dresdner, The Woodfinishing Book, Taunton Press (1992)).
2. The average finish is about 25% non-volatile material.
3. This leads to an estimate of 65 to 80 square feet of wood coverage per gallon of finish.
4. L.J.'s Custom Cabinet Shop in SWAPCA's jurisdiction reported using 137 gallons of finish. This implies 9,000 to 11,000 square of wood coverage.
5. L.J.'s also reported 1,466 lbs. air toxics for the same period.
6. This gives an emissions factor of between 13 to 16 lbs. air toxics per 100 square feet of wood finished.
7. Lynwood Kitchens in SWAPCA's jurisdiction reported 3,611 lbs. air toxics emissions and 23,395 board feet of wood processed. Assuming single side coverage once trim and scrap are included, this gives an emissions factor of about 15 lbs. air toxics per 100 square feet of wood finished.

When dealing with an individual wood finishing operation, the best estimate of its emissions will come from a close examination of the components of the finish materials the source intends to use. This information is available from material safety data sheets. Since these are likely to change over time, the analysis should be repeated (preferably by the source) at annual reporting periods. Initially, the source can project the quantities of the finish materials it will use. In subsequent reports, the source can use purchase and inventory records. the alternative for the source is to use the factors derived above, 15 lbs. total air toxics per 100 square feet of wood finished. The quantities of individual air toxics can be taken by ratio from the "normal" gallons in Tables III or IV.

For estimating industry emissions, e.g., for rule-making, total revenue data for the wood finishing sectors of interest may be accessed from the Department of Revenue by specifying the corresponding SIC codes. The total industry air toxics emissions may then be estimated from the revenue related data, above. Individual air toxics emissions may be estimated from the "normal" gallon concentrations shown in Table 6.

Metal Can Coating

This category covers surface coating of metal of cans (SIC 3411) and metal shipping barrels, drums, kegs, and pails (SIC 3412).

Description of Process

Metal containers are made using two processes, the *two-piece can* and the *three-piece can*.

At least two can manufacturers in Washington State make two-piece aluminum beverage cans. Large rolls of aluminum sheet stock are continuously fed into a press (cupper) that forms a shallow cup. The cup is drawn and wall-ironed to form the body of the beverage can. The lid is attached after the can is filled with product, usually at another site. More recently, steel tuna fish style cans and traditionally shaped food cans have been made using the two-piece process also.

Can exteriors are often roll coated with a neutral color, like white or gray, which is then oven cured at 350-400°F. Decorative inks are then put on with a rotary printer, and a protective varnish is roll coated directly over the inks, then oven cured again.

Can interiors are spray coated with "inside spray" using airless spray nozzle. These coatings have higher VOC levels to meet tough coating requirements to protect both can contents and wall. Inside sprays are again oven cured or baked.

The three-piece can process includes traditional steel food cans, pails, and drums. These are the kind of cans that you can use a can opener on either the top or bottom. A rectangular sheet (body blank) is rolled into a cylinder and soldered, welded, or cemented at the seam. One end is attached during manufacturing. The second end is attached after the filling of the can with product.

Three-piece can emissions can come from coating the inside and outside of welded seams, from inside coatings, and from exterior base coats, inks, and over varnishes.

Method of Determining Emissions

The major source of emissions from can manufacturing is the coating process. For two-piece aluminum cans, the spraying of the interior coating and the oven curing of coatings and inks produce VOC emissions. Glycol ethers, butyl alcohol, isopropyl alcohol are among the major air toxics produced by two-piece can plants in Washington. Regulations and pollution prevention pressures are moving this industry toward aqueous based coatings with lower VOC contents. Traditional hot solvents like methyl ethyl ketone, methyl isobutyl ketone, 1,1,1-trichloroethane, and Stoddard solvent are being eliminated where possible. Three piece cans usually have an inside and outside seam coating, and sometimes have inside and outside coatings like those described for the two piece can.

Material balance is the only way to get a good estimate on emissions from can or paper coating. The parameters needed are coating usage data, coatings composition (MSDS sheets for coatings), and control equipment efficiency (if applicable),

American Can Company report that: "These facilities (three-piece cans) can use a variety of coatings on a given production day. VOC/HAP emissions are calculated from the quantity of production units and film weight of the material applied to determine the quantity of coating used. This quantity is then used to calculate actual emissions."

Emissions should be calculated individually for each facility because each facility uses a unique mix and volume of coatings.

The MACT on can coating from EPA is due out in 2000.

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Paper Coating

This category covers surface coating of packaging paper and plastics film (SIC 2671), and other non-packaging paper (SIC 2672), plastics, foil, and paper bags (SIC 2673).

Description of Process

Paper coating is usually defined as the process of putting a complete coating across the substrate, as opposed to printing a design. The word substrate is used since paper is not the only medium coated. Plastic bags (bread, frozen food, etc.), milk cartons of paper coated with polyethylene, cellophane adhesive tape, gummed labels, and resinous impregnated paper all fall in these SIC codes. The processes are all different, yet emissions calculations have a lot of similarities. For this report, resinous impregnated paper will be used as an example.

Rolls of paper are loaded on to a spool and fed through a dip coating tray. Resins are usually phenol-formaldehyde or polyester based. The resin is metered out to the desired level on the paper, then the coated paper is oven dried and packaged in either roll or sheet form for sale. The coated paper is used for overlays on plywood and particleboard.

Emissions come from the dipping/coating process and from drying ovens. Preparation areas where resin/solvent blends are prepared can cause fugitive emissions, as can resin and solvent storage tanks. Process area fumes are usually captured by hoods and ventilation systems and treated before exhaustion. Incineration is the control technology usually used.

Method of Determining Emissions

For paper coating, emission speciation and calculation varies considerably. Each source should be individually evaluated. For the resin coating example, the solvents acetone and methanol, along with resin components like phenol, formaldehyde, and styrene will be emitted.

The pollution prevention plan obtained from Dyno Overlays in Tacoma describes their paper coating process, emissions, and emissions calculations.

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