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OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: Spray Coating Generic Scenario - Research Project

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TO: CEB Staff

The purpose of this project was to obtain information about occupational exposures and environmental releases associated with the spray application of coatings, and to present it in a way that would facilitate its use in PMN reviews.

The attached document presents generic scenarios for automotive finishing and refinishing, metal and wood furniture finishing, large appliance finishing, non-automotive transportation, and heavy machinery finishing.

Attachment

Generic Engineering Assessment
Spray Coating
Occupational Exposure and Environmental Release

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I. Introduction

Under the Toxic Substances Control Act, any person who intends to manufacture or import a new chemical substance for commercial purposes in the United States is required to submit a Premanufacture Notice (PMN) at least 90 days prior to it's manufacture or importation. The Chemical Engineering Branch is responsible for assessing workplace exposures and environmental releases of these new chemicals.

A wide variety of coating materials is available today. These are applied onto substrates for protective, decorative and functional purposes. Spray coating is a widely used and convenient application method because of being relatively quick and simple in comparison with other coating techniques. Consequently, a large number of PMNs are submitted for chemicals used in coating formulations designed or intended for spray application. The purpose of this report is to present generic spray coating scenarios that contain readily available information about the occupational exposures and environmental releases associated with this type of operation. This is intended to facilitate consistent PMN reviews and efficient analysis of each case.

Several generic spray coating scenarios were characterized according to industry of application: automotive finishing and refinishing, metal furniture and wood furniture finishing, large appliance finishing, non-automotive transportation, and heavy machinery finishing. Common variables across scenarios were identified and typical values for each scenario were obtained. The information is presented in a matrix for each industry so that it can be easily extracted when needed.

The information presented was obtained from the following sources: a) Environmental Protection Agency (EPA) and National Institute of Occupational Safety and Health (NIOSH) technical publications, b) contractor reports, c) communications with various industry representatives, d) non-CBI information included in PMN submissions, e) product literature, and f) general technical publications.

The information presented is limited in its dermal exposure characterization for spraying operations. No specific information was found regarding this exposure, other than the fact that, compared to other coating processes, the major dermal exposure comes from airborne spray mist, when the coatings are applied by spray without adequate protection.

It is very difficult to generically describe any type of coating operation. In each industry category, every facility is somewhat different in terms of product, coatings, application techniques, ventilation practices, work practices, health and

safety precautions, controls, etc. The values presented represent the high degree of variability associated with each parameter and should be used cautiously for making exposure/release estimations.

II. Variables

The following describes each variable included in the matrices and how they can be used for PMN assessments.

1. Coating Components

   Lists common components (not all-inclusive) encountered in each industry (generic names and/or examples) by resins, solvents and pigments.[a]

2. Coating Classifications

   Lists common types of formulations encountered in each industry, not exclusive of other formulation types.

3. Coating Compositions

   Gives the percentage of solids (resins, pigments, additives) typically found in a specific type of coating formulation. The values are reported as percent solids by weight, "as applied" (i.e., after any dilution the user may need to do before spraying the coating), unless otherwise indicated.

[a] Examples for additives that aid in the formulation and/or application of coatings are not included. For estimation purposes it can be assumed that additives comprise less than 2 percent by weight of the formulations.

4. Coated Area, Coating Thickness and/or Coating Volume Per Unit

Average values for coating volumes used per unit (i.e. individual item coated) are listed. Coated area and coating thickness average values per unit are given for cases where coating volume was not available. Coating thickness values are given for each coat applied (not for total thickness) and refer to dry thickness. Appendix I gives examples for using these values in estimating coating volumes.

5. Worker Activities

Lists worker activities that involve the handling of coatings.[b] An estimate of the time spent by workers during each activity is also included for most cases.

6. Days of Operation Per Year

An approximate value (or range) of the number of days per year that a typical site would be involved in spray coating operations is given. For a given PMN this value will depend on the amount of coating that could be formulated with the intended production volume of the PMN chemical. It is also likely that not only PMN-containing coatings will be used at any particular site, but that several other "non-PMN" coatings will be used as well.

[b] Where information was available, activities that precede and follow the direct handling of coatings were also included.

7. Hours of Plant Operations Per Day

Provides an approximate number of hours (based on the number of 8-hour shifts per day) during which spray coating and related operations occur in a typical plant.[c]

8. Units Coated Per Day

An average number of units coated per day in a typical plant is given. The term unit refers to the specific articles coated in each scenario (i.e., cars, desks, refrigerators, airplanes, tractor motors, etc.).

9. Number of Sites

Approximate number of existing U.S. sites that handle finishing operations for each specific scenario is given. N/A denotes this information was not available.

10. Workers Per Site

The number of workers per site involved with various aspects of the finishing operations is given. In addition, estimates of the number of workers per site involved in actual spraying operations are included.[d]

[c] This should not be mistaken for the number of hours per day a worker might be exposed when handling coatings. Refer to Worker Activities for this information.

[d] For PMN submissions where no specific scenario can be determined, rates of application of 105 liters per worker-day (compressed air spray application) or 280 liters per worker-day (airless spray application) can be used to estimate a total number of workers exposed, based on the PMN chemical's production volume (an average of 120 liters per worker-day can be assumed as a typical rate when the spraying technique is not known). These rates assume workers are spray applying paint for 80 percent of the workday (6.4 hours per 8-hour shift). This total number of workers can then be distributed among all the user sites.

11. Spray/Atomization Technique

Typical spraying techniques and the methods by which the atomization of the coating is accomplished are presented for each scenario. These are not exclusive of any new technology that could be used in any particular industry.

12. Type of Operation

A distinction between typically manual operations and automated operations is made in this section. Worker exposures are expected to be higher with manual operations.

13. Overspray

An approximate percent (or range) is given for most of the spraying techniques in the scenarios. This percent reflects the amount of solids in the coating formulation that are not deposited onto the substrate during the coating operations. It should be kept in mind that the reported values are approximations. Each system's overspray will depend on, among other things, the spray atomization technique used, the coating type and composition, and the substrate. All assumptions should be included in any assesment.

14. Solvent Discharge

Approximate percents (or ranges) for the amount of solvent discharged are given for the two major steps during spraying operations: a) appplication and flash-off and b) oven and/or air drying. Additional

information is provided for several industries on emission rates. In addition to organic solvents, other volatile organics, referred to as "cure volatiles", may be released during the drying/curing step. It should be kept in mind that new chemical substances in coatings may also yield new cure volatiles.

15. Inhalation Exposure Levels

Estimated values based on a series of field studies conducted by NIOSH (O'Brien, 1981) are given for total mist levels (mg/m^3), and for combined exposures (CE)[e] to solvents (dimensionless). For PMN chemicals that are a part of the solids in a coating, the total mist value can be used to estimate potential worker exposures.[f] The Occupational Safety and Health Administration (OSHA) established Permissible Exposure Level (PEL) for paint mists (particulates) of 15 mg/m^3 should be used when no particular scenario is representative of the PMN use. For PMN chemicals that are part of solvent systems and/or volatile compounds

[e] Combined effects of mixtures should be considered when the components cause similar exposure effects. In the absence of information to the contrary, their effects are considered as additive. The combined exposure is given by Cn/Ln, where C is the airborne concentration of the individual contaminants in air and L is the corresponding permissible level or limit. The mixture's permissible level is exceeded when the sum is greater than 1.

[f] For example: If a PMN chemical comprises 5 percent of an automotive coating which has 30 percent total solids as applied, it will then comprise 17 percent of the total solids. From the automotive spray coating matrix, the total estimated mist 8-hour TWA is 5 mg/m^3. The PMN chemical will contribute 17 percent of the total mist, or 0.85 mg/m^3, 8-hour TWA.

in the coatings, no general method to estimate potential worker exposures is available. Airborne concentration levels (mg/m^3) are listed in the NIOSH document for a variety of known solvents. The CE values reported in the matrixes are based on these measured concentrations. Solvent or volatile compounds concentrations were, in general, well below the recommended maximums. Some notion of the potential airborne concentration for a volatile PMN chemical in a coating can be obtained based on the airborne concentration of a known similar volatile compound.[g] Data from the NIOSH field studies, if available, should be used when the particular scenario is representative of the PMN use. Use caution when establishing exposure scenarios based on these studies, since they are mostly based on visits to only one facility in each industry. The study should be referenced whenever these values are used in engineering assesments.

16. <u>Protective Equipment</u>

These descriptions of the protection used by workers during spray coating operations are based mainly on observations from the NIOSH field studies (O'Brien,

[g] The estimated PMN airborne concentration in ppm is given by : CS x (YP / YS), where CS = measured airborne concentration of known compound, YP = mole fraction of PMN in coating, and YS = mole fraction of known compound in coating (assuming most of the solvent becomes airborne during spray application)

1981).

17. Exposure/Release Controls

Mainly describes spray booths, the ventilation system most commonly used in spray coating operations. The particulate removal efficiency percentages were gathered from product literature and general technical publications. These represent the percentage of overspray captured by water curtains and/or dry filter banks in spray booths. Dry filter booths provide a mechanical means for filtering and distributing the air flow evenly through the spray booth. When paint build up restricts the air flow, the filter media is changed. Appendix 2 contains additional information on dry filter media. Water booths wash the paint out of the exhausted air stream by either a) drawing the air through a continuous curtain of moving water where the suspended paint particles are flushed out, or b) forcing the air carrying paint particles to make a sudden change in direction of flow, such that the centrifugal force will fling the solid particles from the air, through water wash chambers, into a collecting pan. The water is then treated in such a way that the spent paint particles will either float or sink, depending on the type of booth or material being used, for collection and disposal. Appendix 3 provides additional information on waste manegement for water wash booths.

Some specific design descriptions are given based on observations from NIOSH field studies (O'Brien, 1981). Additional details (such as spray booth dimensions, air flow/velocity, etc.) can be found in the above mentioned document.

Solvent vapors or fumes will not be removed in any spray booth. However, they are occasionally vented to an organic volatiles control device, before their discharge to the atmosphere.

AUTOMOTIVE SPRAY COATING

	FINISHING	REFINISHING
COATING COMPONENTS	Resins Acrylic Urethane Solvents Ketone Alcohols Esters Hydrocarbons Aromatics Ethers Pigments Similar to those listed for Refinishing	Resins Acrylic Urethane Epoxies Solvents (typical) Xylene Ethyl Acetate Toluene MEK Butyl acetate Hydrocarbons Pigments TiO_2 Talk Clay Barytes Iron oxide Organics
COATING CLASSIFICATIONS	Water-based primer (surfacer) Solvent-based primer (surfacer) Water-based topcoat (enamels and lacquers) Solvent-based topcoat (enamels and lacquers) Urethanes Powder coatings	Solvent-based lacquers and enamels 2-Component Urethanes Non-isocyanate Urethanes
COATING COMPOSITIONS	Primer/Surfacers 50% solids (purchased) 35 - 45% solids (applied) Color Basecoats 40 - 50% solids (applied) Clearcoats (Topcoats) 45 - 55% solids (applied) Non-Clearcoated, Color Basecoat 50 - 55% solids (applied)	Solvent-based Primer 40 - 50% solids (purchased) Solvent-based Enamel Topcoat 35 - 40% solids (purchased) Solvent-based Lacquers 10 - 20% solids (applied) 2-Component Urethanes 25% solids (applied)

AUTOMOTIVE SPRAY COATING

	FINISHING	REFINISHING
COATING VOLUME USED/CAR (total)	Solvent-based primer 8 liters/car Solvent-based topcoat (enamel) 12 liters/car (Details in Tables 1 & 2. Can also be estimated as shown in Appendix 1 using data from Tables 3 and 4. New technologies will will probably tend to make these amounts lower, e.g. high solids, waterborne.)	Solvent-based primer 1 liter/car Solvent-based topcoat 4 liters/car Lacquer 6 liters/car
WORKER ACTIVITIES	1) Inspecting and maintaining operations of automated equipment (6 - 7 hrs/shift) 2) Touchup/small parts coating (6 - 7 hrs/shift) 3) Cleaning	1) Mixing-Tinting (5 - 10 minutes/car) If faded or odd colors need to be matched - up to 30 minutes/car. 2) Spraying - (40 - 50 minutes per car) 3) Cleaning
DAYS/YEAR	250 (Plants usually stop production for several weeks during the summer season for inventory & model changeover)	200-250
HOURS/DAY (shifts)	10 - 24 (Shifts can last up to 10 hours. Some plants run only one shift, others up to 3 shifts, the third one dedicated to cleaning and maintenance.)	8 (1 shift)
UNITS/DAY	880 cars (640 trucks) 55 cars/hr-line (40 trucks/hr-line)	1 - 8 cars and/or trucks

AUTOMOTIVE SPRAY COATING

	FINISHING	REFINISHING
NUMBER OF SITES	40 - 50 (cars) 15 - 20 (trucks)	Thousands
WORKERS/SITE	A total of 50 - 200 in the finishing department. Between 2-8 workers/shift in each manual spraying station (The number of manual topcoat spraying stations per site will likely range between 1 and 20. A similar number can be assumed for fascia, blackout, etc. stations).	1 - 5
SPRAY/ATOMIZATION TECHNIQUE	Air Atomized Electrostatic: Air atomized Rotary atomizer (Turbo Bells)	Air Atomized
TYPE OF OPERATION	Mostly automated (There are still some manual sprayers in most auto assembly lines; touchups and small parts coating operations are likely to be manual.)	Manual
OVERSPRAY	Air Atomized 50 - 90% Electrostatic 5 - 50% (Additional information on Tables 3 and 4.)	50 - 90 %
SOLVENT DISCHARGE	Application/Flashoff 85 - 90% Oven Drying 10 - 15% See Table 5 for additional information on Emission Rates.	Refinishers usually do not have ovens - if there is one, solvent discharge during oven drying will range between 3 - 5%; the balance is lost during application/flashoff.

AUTOMOTIVE SPRAY COATING

	FINISHING	REFINISHING
INHALATION EXPOSURE LEVELS	For manual spraying operations levels are not expected to exceed the levels referenced for refinishing operations.	Total mist Estimated 8-hour TWA of 5 mgs/m^3 Organic Solvents Combined exposure of less than 0.1 Combined exposure = CE CE = ΣCn/Ln, where C = concentration of the individual contaminant L = OSHA PEL Both C & L in mgs/m^3
PROTECTIVE EQUIPMENT	Equipment similar to that described for refinishing operations can be expected to be available.	Half-facepiece, air - purifying respirator with organic vapor removing cartridges and mist prefilters. (O'Brien, 1981) Most paint companies recommend separate air supply for 2-part urethanes.
EXPOSURE/RELEASE CONTROLS	Waterwall-type or Water Washed Spray Booths: a) 1,000 - 2,000 gallons of water b) Water discarded once a year for solvent based paints; 4 times a year for water based; up to once a week if paint sludge removal efficiency is low. c) Waterwall systems in several booths are connected to 1 or more large sludge tanks. Sludge tanks are cleared yearly, the sludge removed being drummed and reclaimed. d) Particulate removal efficiency of 95 - 99%.	"Drive-through" Spray Booths with Integral Oven Cross Draft (O'Brien, 1981): a) Air supplied through filters in doors. b) 2 exhaust chambers c) Dry filters with particulate removal efficiency of 80 - 95%. Down Draft: a) Air supplied from roof top make up plenum. b) Exhaust chamber in floor. c) Dry filters with particulate removal efficiency of 80 - 95 %. Most paint shops do not have spray booths, but have instead designated paint rooms, paint areas or paint enclosures. (end)

FURNITURE SPRAY COATING

	WOOD	METAL
COATING COMPONENTS	Resins Urea Formaldehyde Catalyzed Urethane Nitrocellulose Acrylic Oil Based Solvents Acetates Acetone Alcohols Aromatic Hydrocarbons Ethers Glycol Ethers Ketones Mineral Spirits Pigments Silica Calcium Carbonate Iron Oxide Titanium Dioxide Talc	Resins Acrylics Amines Vinyls Cellulosics Solvents Aliphatics Xylene Toluene Other Aromatics Pigments Titanium Dioxide Iron Barytes Talc Calcium Carbonate Chromium
COATING CLASSIFICATIONS	Mostly low-solids, Solvent-based	Waterborne Solvent-borne - Conventional & High Solids
COATING COMPOSITIONS (% wt as applied)	Body Stain 1% solids Washcoat 8-10% solids Filler 40% solids Sealer (Barrier Coat) 14-23% solids Glaze 21-24% solids Clear Laquer (Topcoat) 14-15% solids	Solvent-based (conventional) 15-25% solids Solvent-based (high-solids) 40-60% solids Waterborne 15-25% solids

FURNITURE SPRAY COATING

	WOOD	METAL
OVERSPRAY	Air atomized more than 50% Airless less than 50%	Air-atomized - 50% - 75% Airless - 75% Electrostatic - Manual - 40% Nonrotational automatic - 30% Rotational (manual/automatic) - 5 - 20%
SOLVENT DISCHARGE	Application/Flashoff- 80 - 90% Oven Drying 10 - 20%	Application/Flashoff- 80% (air-atomized) 65 - 70% (electrostatic) Oven Drying 20% (air-atomized) 30 - 35% (electrostatic) See Tables 7 and 8 for Emission Rates Estimations.
INHALATION EXPOSURE LEVELS	Total mist- Estimated 8-hour TWA between 0.1 and 2.5 mg/m^3. (See Table 9 for breakout) Organic Solvents- Combined exposure (CE) of less than 0.24. $CE = \sum Cn/Ln$, where C = concentration of the individual contaminant, L = OSHA's PEL, both C&L in mg/m^3. (O'Brien, 1981)	Total mist- estimated 8-hour TWA between 0.1 and 23.5 mg/m^3 (lower values were seen for electrostatic spraying operations). Organic Solvents- Combined exposure (CE) of less than 0.83 (O'Brien, 1981)
PROTECTIVE EQUIPMENT	Coveralls, rubber or cloth gloves (at the workers option), air supplied respirators with replaceable viewing window, cloth cap & loose fitting cloth hood. (O'Brien, 1981)	Optional use of aprons or shop coats and gloves. Waterless hand cleaner available. (O'Brien, 1981)
EXPOSURE/RELEASE CONTROLS	Spray booths with disposable filters and turning vanes installed. Smaller booths are paired with these or opposite side of conveyor of a dry filter design. Filters on all booths are changed at the end of a shift. Make up air is provided. (O'Brien, 1981)	Filter bank with make-up air supplied from opposite the opposite the exhaust filter bank, and from filtered-air inlets in each conveyor exit. Water-washed spray booths are also used. Thick mesh prefilters are sometimes fitted over the water curtains (side-draft) to reduce booth cleanup time/frequency. (O'Brien, 1981)

FURNITURE SPRAY COATING

	WOOD	METAL
EXPOSURE/RELEASE CONTROLS (cont'd)	Particle removal efficiencies could range between 94 - 96%.	These prefilters are changed periodically (some shifts may not apply enough paint to clog the filters). Water-washed booths efficiencies could range from 95 - 99% for particle removal. (end)

LARGE APPLIANCE SPRAY COATING

COATING COMPONENTS	Resins Epoxies Acrylics Polyesters Alkyds Urethanes Amines Solvents Esters Ethers Aromatics Alcohols Aliphatics Terpenes Water Pigments Titanium Dioxide Iron Oxide Talc Silica Chromium
COATING CLASSIFICATIONS/ COMPOSITIONS (wt % as applied)	Conventional Solvent Borne: 25-35% solids 2-15 different solvents (usually used as topcoats) Low-Organic Solvent: 1. Waterborne 45-60% water 10-12% organic solvents 25-30% solids (usually used as primers)

LARGE APPLIANCE SPRAY COATING

COATING CLASSIFICATIONS/ COMPOSITIONS (cont'd)	2. High Solids more than 50% solids 3. Powder Usually used as topcoats. See Table 10 for additional information.
COATED AREA/UNIT	Prime coat - 0.7 to 8.4 m^2; average = 4 m^2 Top coat - 0.7 to 7 m^2; average = 3 m^2 (See Table 11 for breakout)
COATING THICKNESS	Prime coat - 0.5 to 0.6 mils Top coat - 0.8 to 1.2 mils (see Table 11 for breakout)
COATING VOLUME	See Appendix 1
WORKER ACTIVITIES	1) Preparing equipment (1 hour/shift) 2) Inspecting & maintaining operations of automated equipment (6-7 hours/shift) 3) Manual air/airless spraying for touchup operations. (6-7 hours/shift) 4) Cleaning
DAYS/YEAR	250
HOURS/DAY (shifts)	16 (two 8-hr shifts)

LARGE APPLIANCE SPRAY COATING

UNITS COATED/LINE-DAY	640 - 1600 (40 - 100 units/hour-line)
OPERATION LINES/SITE	Typically 2 related products lines (e.g. refrigerators & freezers, or washers & dryers).
NUMBER OF SITES	200
WORKERS/SITE	Up to 50 sprayers could be involved in a single topcoat application in large sites.
SPRAY/ATOMIZATION TECHNIQUE	Air-Atomized Airless Electrostatic
TYPE OF OPERATION	Mostly automated for: a) waterborne primers (air/airless spray) b) solvent-borne primers/topcoats (electrostatic bells or disks) c) powders (electrostatic) Manual equipment mainly used for touchups (air/airless spray guns)
OVERSPRAY	Air-atomized - 60% Airless - 55% Air Assisted Airless - 50% Manual electrostatic: Airless - 45% Air-atomized - 40% Air Assisted Airless - 40%

OVERSPRAY (cont'd)	Nonrotational automated electrostatic - 15-35% Rotational automated electrostatic - 10-20% Electrostatic - Powder - 1-5%
SOLVENT DISCHARGE	Application/Flashoff: 70-80% Oven Baking: 20-30% (See Appendix 4 - Estimation of Solvent Emission Rate)
INHALATION EXPOSURE LEVELS	Total mist - Estimated 8-hour TWA mean mist concentration of 35 mg/m^3. The liner operation was a heavy contributor to the average concentration (mean of 322 mg/m^3 for short term, 6.4 minutes per sample). Based on this, mist concentrations would be 15 mg/m^3 8-hour TWA during exterior painting operations. (O'Brien, 1981) Organic Solvents Combined exposure (CE) of less than 0.79. $CE = \sum Cn/Ln$, where C = Concentration of the individual contaminant, L = OSHA's PEL, both C & L in mg/m^3. (O'Brien, 1981)
PROTECTIVE EQUIPMENT	Coveralls. Respirator usage is limited to liner painting operations (manual) - NIOSH approved air supplied respirator, with replaceable plastic viewing window, cloth cap, and loose fitting, plastic coated, cloth hood. Impermeable rubber gloves. (O'Brien, 1981)

EXPOSURE/RELEASE CONTROLS	Downdraft or sidedraft spray booth with dry filters or waterwall particulate removal systems. Each booth may be up to 50 ft. long. (O'Brien, 1981) Particulate removal efficiencies: dry filters - 87-99.8% water curtains - 95-99.9% Powder spray booths - Ventilation rates are maintained high enough to keep the powder concentration safely below its lower explosive limit (LEL). The LEL used by insurance companies when no experimental data are available on the specific powder is 26 mg/m^3. Up to 99% particulate recovery/recycle efficiency can be achieved. Most booths are designed with a conveyor belt that moves across the bottom. Unadhered powder is collected and a dual vacuum system removes it from the belt, recycling it to the holding tank. For color changes/cleaning operations, the system is automatically flushed with solvent for a few seconds. The solvent can be reused or disposed of (can be directly sprayed into the spray booth). (See Table 12 - Estimated Control/Coating Technology Efficiencies)

(end)

RAILROAD CAR SPRAY COATING

COATING COMPONENTS	Resins Alkyd Epoxy Urethane Acrylic Amino Solvents Aliphatic Hydrocarbons Aromatics Glycol ether and ether ester Xylene n-Butanol MEK Acetone Toluene Pigments TiO_2 Talc Silica Chromium Barytes Iron Oxide
COATING CLASSIFICATIONS	Conventional Solvent based alkyd Enamels Urethanes Epoxies Phenolics Epoxy Phenolics
COATING COMPOSITIONS	(Conventional Alkyd Enamel) 50% Solids as purchased 45% Solids as applied
COATING VOLUME PER UNIT	150 to 190 liters
WORKER ACTIVITIES	1) Moving the cars in and out of the booth, applying decals, mixing paint, maintaining spray guns, and general housekeeping in the paint area. (4-5 hours/shift) 2) Spraying (2 hours/shift)

RAILROAD CAR SPRAY COATING

DAYS/YEAR	250
HOURS/DAY (shifts)	8-16 (1 to two 8-hour shifts)
UNITS/SITE-DAY	3-6 (3 units/shift)
NUMBER OF SITES	N/A
WORKERS/SITE	Two painters are required to finish a railroad car. A third painter rotates assignments with the others (e.g. activities other than spraying that are mentioned above).
SPRAY/ATOMIZATION TECHNIQUE	Airless spray
TYPE OF OPERATION	Manual
OVERSPRAY	50%
SOLVENT DISCHARGE	Assume air drying/curing - 100% released during application/flashoff.
INHALATION EXPOSURE LEVELS	Total mist - The level for paint mist exceeded that which would be allowed for a full shift's exposure. Because actual spraying time does not exceed 2 hours per shift, 8-hour time-weighed average levels of total mist would be below the legal limit (OSHA PEL of 15 mg/m^3, 8-hr TWA). (O'Brien, 1981)

RAILROAD CAR SPRAY COATING

INHALATION EXPOSURE LEVELS (cont'd)	Organic Solvents - Combined solvent concentrations range from 70 to 200 percent of the maximum allowed for a full shift exposure, based on current legal maximums. Because of the short spraying time, the 8-hr TWA concentrations would be below the legal maximums. (O'Brien, 1981)
PROTECTIVE EQUIPMENT	Heavy cotton hoods, overpants, hip-length coats, with masking tape around all opening at neck and wrists. A full-facepiece, air-supplied respirator, and rubber gloves are also worn, so that no skin is exposed (respirators are most typical when urethanes are used because of the potential diisocyanates exposure). (O'Brien, 1981)
EXPOSURE/RELEASE CONTROLS	Semi-downdraft spray booth equipped with a fresh air supply through banks of filters running from ceiling to floor and water-wash sections to scrub overspray from the air before it is discharged to the atmosphere. (O'Brien, 1981)

(end)

LIGHT AIRCRAFT SPRAY COATING

COATING COMPONENTS	Resins Urethane Epoxy Alkyd Acrylic Solvents Aliphatic hydrocarbons Aromatics Acetone Glycol Ether and Ether Esters Toluene Xylene Butanol Isopropanol Ethanol MEK MIBK Pigments TiO_2 Talc Silica Barytes Iron Oxide Chromium
COATING CLASSIFICATIONS/ COMPOSITIONS (w.% as applied)	Solvent based - 2 component system Primer - 25-65% solids Color Enamel - 40-50% solids
COATING VOLUME	Primer - Small Planes - 7 to 12 liters Large Planes - 12 to 16 liters Color Coat - Small Planes - 16 liters Large Planes - 23 liters

LIGHT AIRCRAFT SPRAY COATING

WORKER ACTIVITIES	1) Preparing equipment/coatings, masking, cleaning. (4 to 6 hours/shift) 2) Spraying operations - (less than 1 hour for any particular coating).
DAYS/YEAR	250
HOURS/DAY (shifts)	16 - 24 (Two 8-hour shifts for coating operations, an additional shift is possible for equipment cleaning/repairs.)
UNITS COATED/DAY	5 - 10
NUMBER OF SITES	N/A
WORKERS/SITE	Approximately 130 employed in the finishing department for the 3 shifts (most work the day and afternoon shifts). A maximum of 6 spray paint at any time.
SPRAY/ATOMIZATION TECHNIQUE	Conventional air atomized spray.
TYPE OF OPERATION	Mostly manual
OVERSPRAY	50 - 60%

LIGHT AIRCRAFT SPRAY COATING

SOLVENT DISCHARGE	Assume air drying/curing - 100% released during application/flashoff.
INHALATION EXPOSURE LEVELS	Airborne concentrations of total mist exceeded allowable limits for a full shift's exposure. Because of the short spraying time, levels of total mist, on a 8-hour time weighted average, is below the legal limit (OSHA PEL of 15 mg/m^3, 8-hour TWA). (O'Brien, 1981) Airborne concentrations of organic solvents in spray application of the coatings are well below any existing or proposed standards for the materials used. (O'Brien, 1981)
PROTECTIVE EQUIPMENT	Disposable coveralls and a loose-fitting hood are worn when entering a spray booth. During spraying operations, NIOSH - aproved, half facepiece respirator with organic vapor-removing cannisters and mist prefilters are used (respirators are most typical when urethanes are used because of the potential diisocyanates exposures). Rubber gloves are available but not used by all workers. (O'Brien, 1981)
EXPOSURE/RELEASE CONTROLS	Downdraft spray booths with polyester filters at the top and non fire-supporting paper folded into accordian style pleats with staggered air holes under the floor. Both filter systems are changed at 5 week intervals. (O'Brien, 1981)

(end)

HEAVY MACHINERY SPRAY FINISHING

COATING COMPONENTS	Resins Alkyds Acrylics Amino Epoxy Polyester Urethane Vinyls Silicones Plastisols Phenols Solvents Ketones Esters Alcohols Aliphatics Ethers Aromatic Terpenes Pigments TiO_2 Talc Chromium Clay
COATING CLASSIFICATIONS	Solvent-based primers/topcoats (lacquers and enamels) Water-based primers/topcoats
COATING COMPOSITIONS	Solvent-based 40 - 50% solids (purchased) Water-based 25 - 50% solids (purchased)

HEAVY MACHINERY SPRAY FINISHING

COATING VOLUME	See Appendix 5
WORKER ACTIVITIES	(1) Paint mixing, paint sludge skimming from booth water tank, spray guns maintenance (activities of short duration; do not contribute significantly to painters' exposure). (2) Primer, topcoat spraying (for manual operations) - 5-6 hours/shift. (3) Inspecting & maintaining operations (for automated operations) - 5-6 hours/shift.
DAYS/YEAR	250
HOURS/DAY (shifts)	8 - 16 (one-two 8-hour/shifts)
UNITS/SITE-DAY	See Appendix 5
NUMBER OF SITES	N/A
WORKERS/SITE	Approximately 25 - 50 in finishing department. 2 - 5 workers in charge of manual spraying operations.
SPRAY/ATOMIZATION TECHNIQUE	Air spray Airless spray Air Assisted Airless Electrostatic: Air Airless Air Assisted Airless Hot spray with all of the above
TYPE OF OPERATION	Manual Automated (with touchup operations generally done with manual equipment).

HEAVY MACHINERY FINISHING

OVERSPRAY	Air/Airless 30 - 60% Electrostatic 10 - 30%
SOLVENT DISCHARGE	Application/Flashoff 70 - 80% Oven Drying 20 - 30% (These figures should be used only if it is known that oven drying will ocurr for a particular case. 100% solvent discharge during application/flashoff for air drying should be assumed otherwise.)
INHALATION EXPOSURE LEVELS	Total mist - Estimated airborne levels of total paint mist ranging from 2.0 ± 1.4 to 36.5 ± 1.2 mg/m^3 for <u>short-term</u> samples. 8-hour TWA values are expected to be 50% lower. Organic Solvents - Combined solvent levels did not exceed more than 5% of currently allowable levels. (O'Brien, 1981)
PROTECTIVE EQUIPMENT	Clean coveralls and safety glasses are provided at the start of each workshift. Before painting they prepare with head socks, painters' hats, gloves, and respirators. They also coat exposed face areas with petroleum jelly. When handling electorstatic guns, gloves used have palms cut out for grounding purposes. Half-facepiece respirators with twin organic vapor-removing cartridges and mist pre-filters used. (O'Brien, 1981)

EXPOSURE/RELEASE CONTROLS	Water washed downdraft spray booths, enclosed and with fresh air supply, (make-up air also supplied through dry filter banks). (O'Brien, 1981)

(end)

TABLES

TABLE 1

MATERIALS BALANCE FOR SPRAY APPLICATION
OF SOLVENT BASED PRIMER TO AUTOMOBILES

Coating application (25% solids)	Liters/Car
• Coating (40% solids as purchased)	5.0
• Thinner	3.0
• Total coating	8.0
Application Losses (40% efficiency)	
• Solids	1.2
• Solvents	5.3
• Total Application Loss	6.5
Oven Evaporation Loss	
• Solvent Discharge	0.7
Net Dry Solids on Body	0.8

TABLE 2

MATERIAL BALANCE FOR SPRAY APPLICATION
OF SOLVENT BASED ENAMEL TOPCOAT TO AUTOMOBILES

Coating Application (25% vol solids)	Liters/Car
• Coating (30% vol solids purchased)	10.0
• Thinner	2.0
•Total Coating Applied	12.0
Application Losses (40% efficiency)	
• Solids	1.8
• Solvents	7.9
• Total Application Loss	9.7
Oven Evaporation Loss	
• Solvent Discharge	1.1
Net Dry Solids on Body	1.2

Source: Automobile and Light-Duty Truck Surface Coating Operations. USEPA 1979.

TABLE 3

PARAMETERS FOR THE AUTOMOBILE SURFACE COATING INDUSTRY[a]

Application	Area Coated per vehicle, ft^2	Film Thickness, mil	VOC Content, lb/gal-H_2O	Volume Fraction Solids, gal/gal-H_2O	Transfer Efficiency, %
Prime Coat					
Solventborne spray	450	0.8	5.7	0.22	40
	(220-570)	(0.3-2.5)	(4.2-6.0)	(.20-.35)	(35-50)
Cathodic electrodeposition	850	0.6	1.2	0.84	100
	(660-1060)	(0.5-0.8)	(1.2-1.5)	(.84-.87)	(85-100)
Guide Coat					
Solventborne spray	200	0.8	5.0	0.30	40
	(170-280)	(0.5-1.5)	(3.0-5.6)	(.25-.55)	(35-65)
Waterborne spray	200	0.8	2.8	0.62	30
	(170-280)	(0.5-2.0)	(2.6-3.0)	(.60-.65)	(25-40)
Topcoat					
Solventborne spray					
Lacquer	240	2.5	6.2	0.12	40
	(170-280)	(1.0-3.0)	(5.8-6.6)	(.10-.13)	(30-65)
Dispersion lacquer	240	2.5	5.8	0.17	40
	(170-280)	(1.0-3.0)	(4.9-5.8)	(.17-.27)	(30-65)
Enamel	240	2.5	5.0	0.30	40
	(170-280)	(1.0-3.0)	(3.0-5.6)	(.25-.55)	(30-65)
Base coat/clear coat[b]	240	2.5	4.7	0.33	40
Base coat	240	1.0	5.6	0.20	40
	(170-280)	(0.8-1.0)	(3.4-6.4)	(.13-.48)	(30-50)
Clear coat	240	1.5	4.0	0.42	40
	(170-280)	(1.2-1.5)	(3.0-5.1)	(.30-.54)	(30-65)
Waterborne spray	240	2.2	2.8	0.62	30
	(170-280)	(1.0-2.5)	(2.6-3.0)	(.60-.65)	(25-40)

[a]All values for coatings as applied, except for VOC content and volume fraction solids which are for coatings as applied minus water. Ranges in parentheses. Low VOC content (high solids) base coat/clear coats are still undergoing testing and development.
[b]Composite of base coat and clear coat.

Source: AP - 42, USEPA 1985.

TABLE 4

PARAMETERS FOR THE LIGHT DUTY TRUCK SURFACE COATING INDUSTRY[a]

Application	Area Coated per vehicle, ft^2	Film Thickness, mil	VOC Content, lb/gal-H_2O	Volume Fraction Solids, gal/gal-H_2O	Transfer Efficiency, %
Prime Coat					
Solventborne spray	875	1.2	5.7	0.22	40
	(300-1000)	(0.7-1.7)	(4.2-6.0)	(0.20-.35)	(35-50)
Cathodic electrodeposition	1100	0.6	1.2	0.84	100
	(850-1250)	(0.5-0.8)	(1.2-1.5)	(.84-.87)	(85-100)
Guide Coat					
Solventborne spray	675	0.8	5.0	0.30	40
	(180-740)	(0.7-1.7)	(3.0-5.6)	(.25-.55)	(35-65)
Waterborne spray	675	0.8	2.8	0.62	30
	(180-740)	(0.5-2.0)	(2.6-3.0)	(.60-.65)	(25-40)
Topcoat					
Solventborne spray					
Enamel	750	2.0	5.0	0.30	40
	(300-900)	(1.0-2.5)	(3.0-5.6)	(.25-.55)	(30-65)
Base coat/clear coat[b]	750	2.5	4.7	0.33	40
Base coat	750	1.0	5.6	0.20	40
	(300-900)	(0.8-1.0)	(3.4-6.4)	(.13-.48)	(30-50)
Clear coat	750	1.5	4.0	0.42	40
	(300-900)	(1.2-1.5)	(3.0-5.1)	(.30-.54)	(30-65)
Waterborne spray	750	2.2	2.8	0.62	30
	(300-900)	(1.0-2.5)	(2.6-3.0)	(.60-.65)	(25-40)

[a]All values are for coatings as applied, except for VOC content and volume fraction solids which are for coatings as applied minus water. Ranges in parenthesis. Low VOC content (high solids) base coat/clear coats are still undergoing testing and development.
[b]Composite of typical base coat and clear coat.

Source: AP - 42, USEPA 1985.

TABLE 5

EMISSION FACTORS FOR AUTOMOBILE AND LIGHT DUTY TRUCKS SURFACE COATING OPERATIONS[a]

EMISSION FACTOR RATING: C

Coating	Automobile kg(lb) of VOC per vehicle	Automobile kg(lb) of VOC per hour[b]	Light Duty Truck kg(lb) of VOC per vehicle	Light Duty Truck kg(lb) of VOC per hour[c]
Prime Coat				
Solventborne spray	6.61 (14.54)	363 (799)	19.27 (42.39)	732 (1611)
Cathodic electrodeposition	.21 (.45)	12 (25)	.27 (.58)	10 (22)
Guide Coat				
Solventborne spray	1.89 (4.16)	104 229	6.38 (14.04)	243 (534)
Waterborne spray	.68 (1.50)	38 (83)	2.3 (5.06)	87 (192)
Topcoat				
Lacquer	21.96 (48.31)	1208 (2657)	NA	NA
Dispersion lacquer	14.50 (31.90)	798 (1755)	NA	NA
Enamel	7.08 (15.58)	390 (857)	17.71 (38.96)	673 (1480)
Basecoat/clear coat	6.05 (13.32)	333 (732)	18.91 (41.59)	719 (1581)
Waterborne	2.25 (4.95)	124 (273)	7.03 (15.47)	267 (588)

[a]All nonmethane VOC. Factors are calculated using the following equation and the typical values of parameters presented in Tables 3 and 4.
NA = Not applicable.

$$E_v = \frac{A_v\ c_1\ T_f\ V_c\ c_2}{S_c e_T}$$

Where: E_v = emission factor for VOC, mass per vehicle (lb/vehicle) (exclusive of any addon control devices)

A_v = area coated per vehicle (ft^2/vehicle)

c_1 = conversion factor: 1 ft/12,000 mil

T_f = thickness of the dry coating film (mil)

V_c = VOC (organic solvent) content of coating as applied, less water (lb VOC/gal coating, less water)

c_2 = conversion factor: 7.48 gallons/ft^3

S_c = solids in coating as applied, volume fraction (gal solids/gal coating)

e_T = transfer efficiency fraction (fraction of total coating solids used which remains on coated parts)

Example: The VOC emissions per automobile from a cathodic electrodeposited prime coat.

$$E_v \text{ mass of VOC} = \frac{(850\ ft^2)(1/12000)(0.6\ mil)(1.2\ lb/gal\text{-}H_2O)}{(.84\ gal/gal)(1.00)}$$

= .45 lb VOC/vehicle (.21 kg VOC/vehicle)

[b]Base on an average line speed of 55 automobiles/hr.
[c]Based on an average line speed of 38 light duty trucks/hr.

Source: AP - 42, USEPA 1985.

TABLE 6

TYPICAL WOOD FURNITURE FINISHING SCHEDULE

Operation Number	Operation Name	Operation Time Allowed in Minutes	No. of Persons Per Operation
1	Load	5	1
2	Spray uniform stain	1.5	2
3	Dry	15	
4	Spray NGR stain	1.5	2
5	Dry	20	
6	Spray washcoat	1.5	2
7	Dry	20	
8	Sand lightly	1.5	4
9	Spray filler	1.5	2
10	Flash-off filler	2	
11	Wipe filler	4	8
12	Dry	45	
13	Spray sealer	1.5	2
14	Dry	30	
15	Sand	3	7
16	Spray sealer	1.5	2
17	Dry	30	
18	Sand	3	7
19	Spray glaze	1.5	2
20	Wipe and brush	5	13
21	Dry	60	
22	Distress	2	4
23	Spray lacquer	1.5	2
24	Dry	45	
25	Spray lacquer	1.5	2
26	Dry	75	
27	Unload	5	1
28	Return to load	15	
	TOTAL	399	63

Source: Technical paper, Society of Manufacturing Engineers, MS 75-251

TAKEN FROM: Summary of Technical Information for Selected Volatile Organic Compound Source Categories, USEPA 1981(b).

TABLE 7

OPERATING PARAMETERS FOR COATING OPERATIONS
FURNITURE SPRAY COATING

Plant size	Operating schedule (hr/yr)	Number of lines	Line speed[a] (m/min)	Surface area coated/yr (m²)	Liters of coating used[b]
Small	2,000	1 (1 spray booth)	2.5	45,000	5,000
Medium	2,000	2 (3 booths/line)	2.4	780,000	87,100
Large	2,000	10 (3 booths/line)	4.6	4,000,000	446,600

[a]Line speed is not used to calculate emissions, only to characterize plant operations.

[b]Using 35 volume % solids coating, applied by electrostatic spray at 65 % transfer efficiency.

Source: AP - 42, USEPA 1985.

TABLE 8

EMISSION FACTORS FOR VOC FROM SURFACE COATING OPERATIONS [a,b]

FURNITURE SPRAY COATING

Plant Size and Control Techniques	VOC Emissions		
	kg/m^2 coated	kg/year	kg/hour
Small			
Uncontrolled emissions	.064	2,875	1.44
65 volume % high solids coating	.019	835	.42
Waterborne coating	.012	520	.26
Medium			
Uncontrolled emissions	.064	49,815	24.90
65 volume % high solids coating	.019	14,445	7.22
Waterborne coating	.012	8,970	4.48
Large			
Uncontrolled emissions	.064	255,450	127.74
65 volume % high solids coating	.019	74,080	37.04
Waterborne coating	.012	46,000	23.00

[a]Calculated using the parameters given in Table 7. following equation. Values have been rounded off.

$$E = \frac{0.0254\ A\ T\ V\ D}{S\ Te}$$

where E = Mass of VOC emitted per hour (kg)
A = Surface area coated per hour (m^2)
T = Dry film thickness of coating applied (mils)
V = VOC content of coating; including dilution solvents added at the plant (fraction by volume)
D = VOC density (assumed to be 0.88 kg/l)
S = Solids content of coating (fraction by volume)
Te = Transfer efficiency (fraction)

The constant 0.0254 converts the volume of dry film applied per m^2 to liters.

Example: The VOC emission from a medium size plant applying 35 volume % solids coatings and the parameters given in Table 4.2.2.12-3.

$$E_{\text{Kilograms of VOC/hr}} = \frac{0.0254(390m^2/hr)(1\ mil)(0.65)(0.88\ kg/l)}{(0.35)(0.65)}$$

$$= 24.9 \text{ kilograms of VOC per hour}$$

[b]Nominal values of T, V, S and Te:

T = 1 mil (for all cases)
V = 0.65 (uncontrolled), 0.35 (65 volume % solids), 0.117 (waterborne)
S = 0.35 (uncontrolled, 0.65 (65 volume % solids), 0.35 (waterborne)
Te = 0.65 (for all cases)

Source: AP - 42, USEPA 1985.

TABLE 9

AIRBORNE LEVELS OF PAINT SPRAY MIST
IN WOOD FURNITURE FINISHING

Booth	Operation	Paint mist (mg/m^3)* GM	GSD
1	Heavy coat of barrier finish	0.8	1.4
3	Second coat of barrier finish to top and sides	0.4	1.6
4	Manual coat of glaze to top and sides	1.0	1.2
5	Robot application of heavy coat of glaze (area sample)	0.1	2.0
6	Heavy coat of lacquer	0.5	1.2
7	Second coat of lacquer to top and sides	0.4	1.8
8	Light coat of glaze	0.1	5.0
12	Barrier coating of interior surfaces	0.5	1.1
13	Veil lacquer applied to interior	0.1	1.5
14	Final heavy coat of lacquer	2.5	1.0

GM: Geometric mean
GSD: Geometric standard deviation
*8-hour time-weighted average (TWA)

Source: O'Brien, 1981.

TABLE 10

CANDIDATES FOR POWDER COATING IN APPLIANCE INDUSTRY

	Part	Conventional Finish	Proposed Powder Finish
Refrigerators and Freezers	Inner Liners & Related Parts	Porcelain, Modified Acrylic Bake Enamel	Epoxy, Polyurethane Acrylic
	Kickpanels	One or Two-Coat Acrylic Bake Enamel	Epoxy, Polyurethane Acrylic
	Shelves	Zinc Plate with Clear Dip Coating	Epoxy, Polyester Hybrid
	Cases & Doors	One or Two-Coat Acrylic or Polyester Bake Enamel	Polyurethane or Acrylic
Ranges	Range Bodies	Two-Coat, Two-Bake Acrylic; Porcelain	Polyurethane, Acrylic
	Hoods	Two-Coat, Two-Bake Acrylic	Polyurethane Acrylic
	Oven Doors	Porcelain	Polyurethane; Acrylic
Home Laundry	Washer & Dryer	Two-Coat, Two-Bake	Polyurethane, Acrylic
	Dryer Tops & Doors	Porcelain; Two-Coat, Two-Bake Acrylic	Polyurethane, Acrylic
	Dryer Drums	Porcelain; Flow Coat Epoxy	Epoxy; Polyurethane
	Washer Tops & Lids	Two-Coat Porcelain	Polyurethane, Acrylic
	Backsplash Escutcheon	Two-Coat, Two-Bake Acrylic	Polyurethane, Acrylic
Dishwasher	Tubs	Porcelain; Plastisol	Epoxy; Epoxy-Phenolic
	Bodies and Door Panels & Escutcheon Panels	One & Two-Coat, Mono-Bake Acrylic	Polyurethane; Acrylic
	Racks	PVC; Plastisol	PVC; Nylon
Heating, A.C. & Ventilation	Outer Cases	Two-Coat, Two-Bake Acrylic Flow Coat; Two-Coat, Two-Bake Electrocoat/Electrostatic Spray Polyester Topcoat	Polyester (TGIC) Polyurethane, Epoxy
	Compressors	Two-Coat, Two-Bake Dip	Epoxy (Low Temp)
Small Appliances	Phenolic Iron Handles	Two-Coat, Two-Bake Epoxy Prime/Acrylic Topcoat	Polyurethane, Epoxy
	Phenolic Blender Bases	Two-Coat, Two-Bake Epoxy Prime/Acrylic Topcoat	Polyurethane, Epoxy
	Slow Cookers/ Deep Fryers	Polyester, Acrylic	Polyurethane; Epoxy

Source: Products Finishing, November, 1986.

TABLE II - COATED AREA - COATING THICKNESS/UNIT
FOR LARGE APPLIANCES

Appliance	Prime Coat		Top Coat	
	A (m^2)	t (mils)	A (m^2)	t (mils)
Compactor	1.9	0.5	1.9	0.8
Dishwasher	0.9	0.5	0.9	0.8
Dryer	8.4	0.6	2.8	1.2
Freezer	7.0	0.5	7.0	0.8
Microwave Oven	0.7	0.5	0.7	0.8
Range	1.9	0.5	2.8	0.8
Refrigerator	7.0	0.5	7.0	0.8
Washing Machine	6.5	0.6	2.3	1.2
Water Heater	1.9	0.5	1.9	0.8

Source: AP-42, USEPA 1985.

TABLE 12
LARGE APPLIANCES
ESTIMATED CONTROL/COATING TECHNOLOGY EFFICIENCIES

Control Technology	Application	% VOC Emissions Reduction
Powder	Top, exterior or interior single coat.	95 - 99[a]
Waterborne (spray, dip, flowcoat)	All applications.	70 - 90[a]
Higher Solids (Spray)	Top or exterior single coat and sound deadener.	60 - 80[a]
Carbon Absorption	Prime, single or topcoat application and flashoff areas.	90[b]
Incineration	Prime, top or single coat ovens.	90[b]

[a] Base case - High organic solvent coating with 25 vol % solids. Transfer efficiency for liquid coatings assumed to be 80% for spray, 90% for dip or flowcoat; 93% for powders.

[b] Reduction is only across the control device and does not account for capture efficiency.

Source: AP-42, USEPA 1985.

APPENDICES

APPENDIX I

COATING VOLUMES

Using approximate values of coated area per unit and coating thickness, the amount of coating (liters/day) used in a site can be estimated for a particular case.

(a) Liters of Solids deposited on the units (total)/day:

(units/day) (coated area/unit) (coating Thickness)

For example -

wood furniture - 400 units/day
2 m^2/unit
2 mils coating thickness

$$\frac{400 \text{ units}}{\text{day}} \left| \frac{2 m^2}{\text{unit}} \right| 2 \text{ mils} \left| \frac{0.001 \text{ in}}{\text{mil}} \right| \frac{\text{m}}{39{,}37 \text{ in}} \left| \frac{1000 \text{ liters}}{m^3} \right.$$

= 40 liters of solids on furniture/day

(b) Liters of coating used/day:

$$\frac{\text{(Liters of solids deposited on units (total)/day)}}{\text{(transfer efficiency) (wt\% solids in coating)}}$$

For the same example -

For a clear lacquer (15% by wt solids in coating) applied by air-atomized spray (50% transfer efficiency) to wood furniture:

$$\frac{40}{(0.50)(0.15)} = 535 \text{ liters of coating used/day}$$

(c) Liters of overspray (solids)/day:

$$\text{(Liters solids on units/day)} \left[\frac{1}{\text{transfer efficiency}} - 1 \right]$$

For the same example -

$$40 \left[\frac{1}{0.5} - 1 \right] = 40 \text{ liters overspray (solids)/day}$$

(d) Liters of Volatile Organics used/day:

$$\frac{(\text{liters solids on units/day})\ (1 - \text{wt\% solids in coating})}{(\text{transfer efficiency})\ (\text{\% solids in coating})}$$

For the same example -

$$\frac{40}{(0.5)(0.15)}\ (1 - 0.15) = 455 \text{ liters of solvent/day}$$

For waterborne coatings the wt% of water in the coating needs to be substracted along with the wt% solids in the above equation.

APPENDIX 2

Characteristics of Spray Booth Dry Filters

Dry filters are classified as baffle or strainer types. The baffle types redirect air through the filtering media. The heavier particles do not readily change direction, but instead tend to strike and collect on media surfaces because of inertia. Strainer types screen overspray from the exhaust air. Particles finer than the screen get through; coarser particles do not. Baffle and strainer principles can be combined. Figure 1 illustrates a general rating of dry filters.

Figure 1

GENERAL RATING OF DRY FILTERS

	Type	Average Efficiency	Holding Capacity
Metal Panel	Baffle	Poor	Excellent
Corrugated	Baffle	Poor	Excellent
Pleated Kraft	Baffle	Fair	Excellent
Expanded Kraft	Baffle	Excellent	Good
Non-Woven Cloth	Strainer	Excellent	Poor
Fiberglass	Strainer	Good	Fair
Combination	Baffle-Strainer	Excellent	Excellent

Source: Industrial Finishing. April, 1987.

Figure 2 lists performance characteristics of several dry filters. Efficiency expresses the percentage of overpsray particulate removed from the air. Holding capacity gives the amount of overspray certain area of filter retains before the resistance to air flow affects the filter's performance.

Figure 2: Performance Characteristics of Filters

Filter/Paint Type	Average Efficiency (pct)	Holding Capacity[1] (lbs)
Standard expanded kraft:		
Air dry enamel	97 0 - 98 0	2 60
Baking enamel	96 0 - 97 0	4 30
Lacquer	87 0 - 88 0	1 40
Primer	93 5 - 94 5	7 50
Water emulsion	96 0 - 97 0	3 70
High-capacity expanded kraft:		
Air dry enamel	94 5 - 95 5	5 00
Baking enamel	93 5 - 94 5	8 00
High-efficiency Type 1[6]:		
High solids baking enamel [3,4]	99 0 - 99 8	5 30[6]
Water borne baking enamel[2]	98 0 - 99 0	4 20
High-efficiency Type 2[6]:		
High solids baking enamel [3,4]	98 5 - 99 5	5 80[6]
Water-borne baking enamel[2]	97.0 - 98.0	4 50

Resistance to Air Flow[7] (inch water column)

Air Velocity (fpm)	Standard Filter	High-Capacity Filter	High-Efficiency Filter
100	0 015	0 015	0 045
150	0 025	0 025	0.090
200	0 045	0 040	0.130
250	0 065	0 060	0 175
300	0 100	0 095	0 240
350	0 135	0 125	0.300

Parameters: Tests were conducted on 20- by 20-inch areas of filtering media using 100 pct overspray from air-atomized gun. In efficiency and capacity testing, air velocity through media was maintained at 200 fpm

Notes: 1) At 0 50 inch w c unless otherwise noted 2) Expanded kraft non-woven backed paint collector. 3) Only one paint used in test 4) Paint remained viscous, resulting in some run-off. 5) At 0.35 inch w c. 6) At 0.20 inch w c. 7) Clean filter

Source: Products Finishing. September, 1985.

APPENDIX 3: SUMMARY OF CUSTOMARY MANAGEMENT SEQUENCE FOR SPRAY BOOTH WASTE.

Total Spray Booth Contents: Accumulated paint, water, deflocculating chemical. Treated paint solids may be partially separated -- floating or settled waste.

Dispose of contents as a paint/water slurry, or separate solids from booth's water.

Separated solids, with some residual water.

Determine status of the waste, whether hazardous or not, per RCRA. See attachment (2).

Non-hazardous waste

Accumulate waste in containers, usually drums, or in a dumpster when waste is sufficiently dewatered.

Ascertain the governmental agency regulating the local non-hazardous waste disposal site (often a city or county board of health). Coordinate with them for screening of the waste to verify its status, using analyses or information supplied by the waste generator. They will provide disposal instructions.

Deposit waste in disposal site and pay their fee, or consign [illegible] disposal company.

Hazardous waste

Accumulate in waste containers, stored 90 day maximum to avoid EPA regulation as a hazardous waste storage facility.

Consign waste to approved hazardous waste specialist for his pre-treatment (when indicated), transportation, and deposition in a hazardous waste disposal site.

Paint/water slurry, or clarified water with some residual solids. Recycle clarified water to booth if possible.

Determine status of the fluid for possible sewer disposal, per clean water act. See Attachment (2).

Water or slurry within acceptable limits.

Obtain discharge permit when required by local sanitation district.

Discharge water or slurry to sewer. Pay sewer usage charge.

Water subsequently treated by publically owned treatment works (POTW).

Excessively polluted water.

Provide pretreatment on site when facilities are available, prior to sewer disposal, or consign to approved hazardous waste specialist for pretreatment and disposal.

APPENDIX 4

LARGE APPLIANCES

ESTIMATION OF SOLVENT EMISSION RATE

A material balance can be used to calculate emission rates of solvents to the atmosphere in the absence of control systems that remove or destroy a known fraction of them. When both a prime coat and a top coat are used, the emissions from each must be calculated separately and added to estimate total emissions.

$$E = \frac{(2.54 \times 10^{-2})\ P\ A\ t\ Vo\ Do}{Vs\ T} + Ld\ Dd$$

where:

- E = Mass of Volatile Organic Compounds (VOC) emissions per unit time (kg/unit time)
- P = Units of production per unit time (units/unit time)
- A = Area coated per unit (m^2)
- t = dry coating thickness (mils)
- Vo = proportion of VOC in coating as received* (volume fraction)
- Do = density of VOC in coating as received* (kg/liter)
- Vs = proportion of solids in coating as received* (volume fraction)
- T = transfer efficiency (%/100)
- Ld = Volume of VOC added per unit time* (liters/unit time)
- Dd = density of VOC added (kg/liter)

*When no data is available, the following approximations may be used:

- Vo = 0.38
- Vs = 0.62
- Do = 0.88 kg/liter
- Ld = 0 (assumes no solvent added at plant).

The constant 2.54×10^{-2} is the product of two conversion factors: 2.54×10^{-5} m/mil and 1,000 liters/m^3

Source: AP-42, USEPA 1985.

APPENDIX 5

HEAVY MACHINERY
COATING VOLUMES & NUMBER OF UNITS

The coating volumes and the number of units coated per site-day vary widely for heavy machinery spray finishing operations. Articles in this category could include, for example, from "small sized" truck engines to fairly big hay stack wagons.

(a) Truck Engines

160 units coated per day

1.3 liters of coating used per unit

approximately 210 liters of coating used day

(b) Hay Stack Wagons

5 units coated per day

38 - 46 liters of coating used per day (42 liters ave.)

190-230 liters of coating used per day (210 liters ave.)

Since the specific articles to be coated are usually not know to the engineer, an average of 210 liters of <u>coating used</u> per site-day can be used for this particular scenario.

REFERENCES

ACGIH. 1987. American Conference of Governmental Industrial Hygienists. Threshold Limit Values and Biological Exposure Indices for 1986-1987. Cincinnati, OH.: ACGIH. ISBN: 0-936712-69-4.

Adams J. (n.d.) Workshop on Spray Application Processes... Advantage and Limitation. Sponsor: Association for Finishing Processes, Society of Manufacturing Engineers, Dearborn, Michigan.

Cecil L.W. 1986 Focus: Appliance Finishing. Appliances Go Powder. Products Finishing Magazine. November, 1986: pp. 66-73

DeVILBISS. 1986. Product Literature. Industrial Spray Booths. Catalog. 520 Wharton Circle, P.O. Box 43226, Atlanta, GA 30336.

Duff W.W. 1985. MITRE Corp. Support for Premanufacturing Review for New Chemical Substances. Work Assignment No. 49, Technical Directive No. 2. Record of telephone report on January 15, 1985. Washington, D.C.: Office of Pesticides and Toxic Substances, U.S. Environmental Protection Agency. Contract 68-01-6610.

Gikis B, Fowler D, Connolly E, Boughton R. 1983. SRI Internat. Industrial Process Profiles to Support PMN Review: Paint, Varnishes and Coatings. Draft Report. Washington, DC: Office of Pesticides and Toxic Substances, USEPA. Contract 68-01-6016.

Hultgren E. 1972. Exhaustion Arrangement and Environmental Care at Spray Painting Plants. (As reported in Air Pollution Aspects of Emission Sources: Surface Coatings - Their Production and Use, a Bibliography with Abstracts. 1974. USEPA, EPA - 450/1-74-005).

InVireChem, Inc. 1986. Industrial-Environmental Chemistry. Management and Monitoring of Waste from Water Wash Paint Spray Booths. Seattle, WA 98103

Martens C.R. 197. Technology of Paints, Varnishes and Lacquers. Robert E. Krieger Publishing Co., Florida: pp. 656-689.

NIOSH. 1986. Natl. Inst. Occupational Safety and Health. Spray Painting - Good Practices for Employees: Your Health and Safety are in Your Hands. Washington, DC: NIOSH, U.S. Dept. Health, Education and Welfare. DHEW Pub. NIOSH 76-178.

O'Brien DM, Hurley DE. 1981. An Evaluation of Engineering Control Technology for Spray Painting. Cincinnati, Ohio: National Inst. for Occupational Safety and Health, Dept. of Health and Human Services. DHHS Pub. NIOSH 81-121.

Robinson G.T. 1981. Focus: Improving Productivity. Robots and Water-Borne Paint Team up at Mack Truck. Products Finishing Magazine. June 1981 reprint.

Schreberger G.L. 1985. Understanding Paint and Painting Processes. Third Edition. Hitchcock Publishing Co. Wheaton, Ill.

USEPA. 1973. U.S. Environmental Protection Agency. Air Pollution Engineering Manual. Second Edition. Research Triangle Park, N.C.: Office of Air Quality Planning and Standards, USEPA.

USEPA. 1976. U.S. Environmental Protection Agency. Guideline Series. Control of Volatile Organic Emission from Existing Stationary Sources - Volume I: Control Methods for Surface - Coating Operations. Research Triangle Park, N.C. 27711: Office of Air-Quality Planning and Standards. USEPA. EPA-450/2-76-028.

USEPA. 1977 (a). U.S. Environmental Protection Agency. Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. III. Surface Coating of Metal Furniture. Research Triangle Park, N.C.: Office of Air Quality Planning and Standards, USEPA, EPA 450/2-77-032.

USEPA. 1977(b). U.S. Environmental Protection Agency. Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. V. Surface Coating of Large Appliances. Research Triangle Park, N.C.: Office of Air Quality Planning and Standards, USEPA, EPA 450/2-77-034.

USEPA. 1978. U.S. Environmental Protection Agency. Control of Volatile Organic Emissions from Stationary Sources, Vol.VI. Surface Coating of Miscellaneous Parts and Products. Research Triangle Park, N.C.: Office of Air Quality Planning and Standards, USEPA, EPA-450/2-78-015.

USEPA. 1979. U.S. Environmental Protection Agency. Automobile and Light-Duty Truck Surface coating operations - Background Information for Proposed Standards. DEIS. Research Triangle Park, N.C. 27711: Office of Air-Quality Planning and Standards. USEPA. EPA-450/3-79-030.

USEPA. 1980(a). U.S. Environmental Protection Agency. Background Information for Proposed Standards. DEIS.

Industrial Surface Coating: Appliances. Research Triangle Park, N.C.: Office of Air Quality Planning and Standards, USEPA. EPA/450/3-80-037A.

USEPA. 1980(b). U.S. Environmental Protection Agency. Background Information for Proposed Standards. DEIS. Surface Coating of Metal Furniture. Research Triangle Park, N.C.: Office of Air Quality Planning and Standards, USEPA, EPA 450/3-80-007.

USEPA. 1981(a). Environmental Protection Agency. Directory of Volatile Organic Compound Sources covered by Reasonable Available Control Technology Requirements. Vol. I. Office of Air Quality Planning and Standards. Research Triangle Park, NC, USEPA. EPA 450/4-81-007.

USEPA. 1981(b). U.S. Environmental Protection Agency. Summary of Technical Information for Selected Volatile Organic Compound Source Categories. Research Triangle Park, NC: Office of Air Quality Planning and Standards, USEPA. EPA 450/3-81-007.

USEPA. 1985. U.S. Environmental Protection Agency. AP-42, Compilation of Air Pollution Emission Factors. Research Triangle Park, N.C.: Office of Air Quality Planning and Standards, USEPA.

Vickers W. 1985. Improving Overspray Collection in a Dry Booth. Products Finishing Magazine. September 1985: 52-57.

Vickers W. 1987. How to Calculate Required Efficiency: All About Dry Filters for Spray Booths. Industrial Finishing Magazine. April 1987.