VOLUME III: CHAPTER 3

ARCHITECTURAL SURFACE COATING

November 1995

Prepared by:
Radian Corporation
Post Office Box 13000
Research Triangle Park, North Carolina
27709

Prepared for:
Area Sources Committee
Emission Inventory Improvement Program

DISCLAIMER

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

ACKNOWLEDGEMENT

This document was prepared by Lucy Adams and Donna Lee Jones of Radian Corporation for the Area Sources Committee of the Emission Inventory Improvement Program and for Charles Mann of the Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency. Members of the Area Sources Committee contributing to the preparation of this document are:

Charles Mann, Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency
Dennis Goodenow, California Air Resources Board
Kwame Agyei, Puget Sound Air Pollution Control Agency
Mike Fishburn, Texas Natural Resource Conservation Commission
Larry Jones, Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency
Gwen Judson, Wisconsin Department of Natural Resource
Jo Crumbaker, Maricopa County Air Pollution Control
Linda Murchison, California Air Resources Board
Sally Otterson, Washington Department of Ecology
Lee Tooly, Emission Factor and Inventory Control, U.S. Environmental Protecton Agency
Chris Mulcahy, Connecticut Department of Environmental Protection
Jim Wilkinson, Maryland Department of the Environment
George Leney, Allegheny County Health Department

CONTENT

CONTENT

Section Page

FIGURES AND TABLES

1

INTRODUCTION

This chapter describes the procedures and recommended approaches for estimating emissions from architectural surface coating. Section 2 of this chapter contains a general description of the architectural surface coating category, and an overview of available control technologies. Section 3 of this chapter provides an overview of available emission estimation methods. Section 4 presents the preferred emission estimation method for architectural surface coatings, while Section 5 presents alternative emission estimation techniques. Quality assurance and control procedures are described in Section 6. Coding procedures used for data input and storage are discussed in Section 7, and Section 8 is the reference section.

This page is intentionally left blank.

2

SOURCE CATEGORY DESCRIPTION

Architectural surface coating operations (SIC 17) consist of applying a thin layer of coating such as paint, paint primer, varnish, or lacquer to architectural surfaces, and the use of solvents as thinners and for cleanup. Architectural surface coatings protect the substrates to which they are applied from corrosion, abrasion, decay, ultraviolet light damage, and/or the penetration of water. Some architectural coatings also increase the aesthetic value of a structure by changing the color or texture of its surface. Architectural coatings are also important in construction of structures. Examples of the latter are concrete form release compounds, which prevent concrete from sticking to forms, and concrete curing compounds, which allow concrete to cure properly (Brandau, 1990). It should be noted that this category does not include auto refinishing, traffic marking, surface coating during manufacturing, industrial maintenance coatings, special purpose coatings, or paints used in graphic arts applications.

A wide range of coatings are used to cover both the interior and exterior surfaces of architectural structures. The majority of architectural surface coatings are applied by homeowners and painting/surface coating contractors to domestic, industrial, institutional, and governmental structures throughout a geographic area. Because the emissions from this source category are likely to be scattered throughout the inventory region, it is recommended that this source category usually be treated as an area source. However, emissions from this category may also be estimated as one of many processes occurring at a point source, for the purposes of permitting and emission trade offs.

Because the coated architectural surface dries or cures in the ambient air, the use of exterior architectural coatings may be limited to periods when local climatic conditions facilitate acceptable coating curing. Although interior coating applications are less influenced by outdoor conditions, complete curing of these coatings also can be hampered by cool, moist weather (i.e., when evaporation rates are reduced).

EMISSION SOURCES

Volatile organic compounds (VOCs) that are used as solvents in the coatings are emitted during application of the coating and as the coating dries.[a] The amount of coating used and the VOC content of the coating are the factors that primarily determine emissions from architectural surface coating operations. Secondary sources of VOC emissions are from the solvents used to clean the architectural coating application equipment and VOC released as reaction byproducts while the coating drys and hardens. VOC emitted from this chemical reaction is determined by the resins used in a particular coating. The VOC emitted from any of these sources could include HAP (EPA, 1993a).

Emission factors and area source estimation methods have been developed for VOC and HAP emissions but not for PM emissions. If all architectural surface coatings are applied using brushes and rollers, then it is reasonable not to consider PM emissions. However, many commercial paints use spray guns; if a significant amount of the paint is applied in this manner (particularly to exterior surfaces), then inventories of PM may need to address emissions from this source category. Point source methods and factors can be used to estimate PM emissions from architectural surface coatings.

FACTORS INFLUENCING EMISSIONS

PROCESS OPERATING FACTORS

Structural maintenance practices indirectly influence VOC emissions by controlling the total coating consumption on a long-term basis. Regular inspection and maintenance programs can be used to reduce the need for entire surface recoating (Brandau, 1990).

CONTROL TECHNIQUES

Since the use of organic solvents in architectural surface coatings is the primary source of emissions, control techniques for this source category involve either product substitution or product reformulation. These alternate formulations include low-solvent-content coatings, waterborne coatings, and powder coatings. In certain situations, recycling of unused coatings may also be considered a form of control.

---

[a] There are many solvents that may be used in architectural surface coating operations. Some compounds may be considered nonreactive and should not be counted in an ozone (VOC) inventory, but would need to be quantified for air modeling, or HAP inventory.

Coating types may be considered to be solvent based or water based, depending on whether the principle flow controller is an organic solvent or is water. Solvent based coatings are defined by the U.S. EPA as coatings that only contain organic solvents, with water, if it is present at all, only present in trace quantities. Water based coatings have more than 5 weight percent water as their volatile fraction. Another way of looking at the distinction between the two types of coatings is that solvent based coatings have resins dissolved in organic solvents and water based coatings have resin systems suspended in water as liquid emulsions of solid dispersion (EPA, 1993a).

The EPA is using regulatory negotiation to prepare a national rulemaking for controlling VOC emissions from architectural and industrial coatings. Currently, no federal EPA regulations are in place to limit VOC content or VOC emissions from architectural surface coatings. However, since Occupational Safety and Health Administration (OSHA) regulations limit worker exposure to solvents, OSHA rules can indirectly affect the VOC content of coatings and the solvents used in them. The OSHA exposure limits vary with compound toxicity and as a result, manufacturers must consider the composition of coatings during product development to minimize the exposure hazards (EPA, 1993a).

Five states—Arizona (AZ), California (CA), New Jersey (NJ), New York (NY), and Texas (TX)—have coating regulations that affect architectural surface coatings; Maryland has a draft rule. The various state regulatory limits are summarized in Table 2-1. For a coating to be in compliance with most state regulations, the VOC content when applied must be below the specified VOC limit, regardless of whether any thinning followed, or whether the manufacturer’s recommended thinning rate was exceeded (EPA, 1993a).

TABLE 2-1

STATE VOC LIMITS (GRAMS VOC/LITER COATING, LESS WATER)[a]

Coating Categories	AZ[b] (07/13/91)[c]	CA-CARB[d] (09/01/92)[c]	NJ[e] (08/08/90)[c]	NY[f] (07/01/89)[c]	TX[g] (01/01/91)[c]
All other architectural coatings			250		
Bond breakers		350	600	600	
Concrete-curing compounds	350	350	350	350	
Enamel undercoaters	350				
Flat architectural coatings			250		
Form-release compounds		250			
General primers, sealers, and undercoaters	350	350	350	350	
Lacquers	680	680	680	680	
Magnesite cement coatings		600			
Mastic texture coatings		300	200	200	
Nonflat architectural coatings			380		
Opaque stains	350	350	350	350	
Pretreatment wash primer		780			
Quick-dry enamels	400				
Quick dry primers, sealers, and undercoaters			500	500	
Roof coatings	300	300	300	300	
Sanding sealers		550			
Semitransparent stains	350	350	550	550	
Shellac (clear)		730	730	730	
Shellac (pigmented)		550	550	550	
Specialty flat products	400				

TABLE 2-1 (CONTINUED)

Coating Categories	AZ[b] (07/13/91)[c]	CA-CARB[d] (09/01/92)[c]	NJ[e] (08/08/90)[c]	NY[f] (07/01/89)[c]	TX[g] (01/01/91)[c]
Specialty primers, sealers, and undercoaters	350				
Varnishes	350	350	450	450	
Waterproof mastic coating	300		300	300	
Waterproof sealers	400	400	600	600	
Wood preservatives (all)	350		550	550	
Wood preservatives (opaque)		350			
Wood preservatives (semitransparent and clear)		350			
Wood preservatives (below ground)		600			
Alkyd varnishes					540
Epoxy paints					540
Exterior alkyd paints					480
Exterior stains					720
Interior alkyd paints					420
Interior stains					840
Nitrocellulose-based lacquers					670
Nonflat and flat latex paints					260
Urethane coatings					540

[a]Blanks indicate that no definition and/or limit exists for that category.
[b]Arizona Regulation III—Control of Air Contaminants, Rule 335-Architectural Coatings, Section 300—Standards. Applies only to Maricopa County.
[c]Effective date.
[d]ARB-CAPCOA Suggested Control Measures for Architectural Coatings; a model rule that applies to the whole state.
[e]New Jersey Administrative Code Title 7, Chapter 27, Subchapter 23—Volatile Organic Substances in Consumer Products, Section 7:27-23:3 Architectural Coatings. Applies to the whole state.

TABLE 2-1 (CONTINUED)

[f]New York Title 6, Chapter III—Air Resources, Part 205, Section 205.4, Prohibitions and Requirements. Applies only to the New York City Metropolitan Area.

[g]Texas resin categories listed at the end of the table. Texas Air Control Board, Regulation V (31 TAC Chapter 115)—Control of Air Pollution from Volatile Organic Compounds, Section 115.191. Applies to the following counties: Brazoria, Chambers, Collin, Dallas, Denton, El Paso, Fort Bend, Galveston, Hardin, Harris, Jefferson, Liberty, Montgomery, Orange, Tarrant, and Waller.

3

OVERVIEW OF AVAILABLE METHODS

EMISSION ESTIMATION METHODOLOGIES

There are several methodologies available for calculating emissions from architectural surface coatings. The method used is dependent upon the degree of accuracy required in the estimate, available data, and available resources. Since architectural surface coatings can be the largest single area source in an area source ozone inventory, this category warrants the time and effort needed to calculate emission estimates for it.

This section discusses the methods available for calculating emission estimates from architectural surface coatings and identifies the preferred calculation method. A discussion of the data elements needed for each method is also provided.

AVAILABLE METHODOLOGIES

VOLATILE ORGANIC COMPOUNDS

Most VOC released into the air by architectural surface coating use are from the evaporation of the VOC contained in the coating, coating thinners, and thinners used for cleanup. Determining the amount of the VOC in coatings and thinners should provide a good estimate of the VOC emitted by this source category. There are two approaches to estimating the amount of VOC emitted from this source category:

- Surveying architectural surface coating use in the inventory area; and
- Using one of two population-based estimation methods:
  - National average per-gallon emission factors applied to national per capita usage rates, or;
  - Regulatory state or local per-gallon emission limits applied to national per capita usage rates.

The survey method is the preferred approach for emission estimation. It will most accurately reflect the actual use and content of coatings in the inventory area, and thus also reflect any controls applied. The survey method can also be used to determine separately the amount of paint that is recycled or sent to a landfill. The level of detail provided by this method allows for control strategies to be more accurately modeled.

If off-site disposal is part of an emission reduction program, or is a potentially significant factor in estimated emissions, a survey directed at a subset of the disposal facilities could be used to estimate the emission reduction from the unused coating.

The alternate approaches—population-based estimates—do not provide the same level of detail in terms of the specific amounts and types of paints used in the inventory area as the survey method does. Calculating a per capita usage for the inventory year and applying to it national emission factors will not take into account variability between regions, but will take into account the variability of usage at the national level from year to year. This method is best used if controls are limited or nonexistent and no further controls are anticipated for the source category. The population-based method using local emission limits will create an emission factor that will probably be very conservative. This method is acceptable if the source category is judged to be less important, or if resources and time are not sufficient to allow use of the survey method.

HAZARDOUS AIR POLLUTANTS

HAP emissions from this source can be estimated using two methods:

- Surveying architectural surface coating use in the inventory area; or
- Applying speciation profiles to the VOC emission estimate, obtained by using either the preferred or alternative methods for VOC.

The survey method is the preferred method, because it will provide that most accurate information or coating usage and content. The effect of VOC controls on HAP emissions should also be apparent when using this method.

Speciation profiles can be used as an alternate approach when a detailed survey is not practical. Although specific profiles will be provided in Section 5, updated or local speciation profiles should be used when available.

DATA NEEDS

DATA ELEMENTS

The data elements used to calculate emission estimates for the architectural coatings category will depend on the methodology used for data collection. The data elements that are necessary for an emission calculation and should be requested in a survey of paint distributors include:

- Product type;
- Product amount distributed by type (gallon);
- Product density (lb/gallon);
- VOC content of product or, solvent content by type and VOC percentage of solvents (weight percent); and
- HAP content of product or solvent by type (weight percent) for all HAP in product.

A survey respondent may have information on the VOC content, but not the solvent content or VOC fraction of the various solvents in a paint type. Fewer data elements will be needed in this case, and the emission calculation, presented in Section 4, will be simplified.

A separate survey of recycling facilities should determine the type and amount of architectural coatings collected and recycled. Product types should match those used by the manufactures or distributors surveyed.

If an emission factor method is used, the following data elements are needed: local and national population, local or national coating usage, and a VOC emission factor and speciation profiles. To develop a local or updated emission factor, usage and emission factors for the individual coating types at the national or state level, or for a representative subsection of the inventory area need to be collected. National, state or sample subsection population will also be needed to complete the calculation.

APPLICATION OF CONTROLS

Since most controls will affect the content of the coating itself, a survey of coating usage and VOC content or an emission factor developed from recent data will reflect controls that are in place. Because a reformulation or substitution represents an irreversible process change, and thus, a reduction in emissions from a coating type, rule effectiveness can be assumed to be 100 percent for that coating type.

Rule penetration will be based on the percent of sources within the category that are affected by the rule.

SPATIAL ALLOCATION

Spatial allocation may be needed in two possible cases during the preparation of an inventory: (1) allocation of state or regional activity to a county level, and (2) allocation of county level emission estimates to a modeling grid cell. In each case, a surrogate for activity should be found that can approximate spatial variation for this category.

Architectural surface coatings are almost always used in and on buildings where people live or work. Therefore, building square footage is the preferred method for spatial allocation in both cases. Tax assessor's offices typically have this information, and, if it has been compiled into a computerized database or geographical information system (GIS), it should be reasonably accessible for use in an inventory. This method should be particularly worthwhile for allocating emissions to a modeling grid cell.

A less detailed alternative spatial apportioning method uses land use data from county planning departments, or population distributions, available from the Census Bureau. Using population to allocate estimated emissions or activity by county or within a grid cell is fairly straight forward, and is discussed in this volume's, Chapter 1, *Introduction to Area Source Emission Inventory Development*. Land use data can be used to generalize building size and type.

TEMPORAL RESOLUTION

Seasonal Apportioning

Architectural surface coating use is influenced by the seasons, since spreading and drying characteristics for many paints are dependant on the temperature. Temperatures below 50°F are not suitable for painting, and limit activity. The seasonal factor for ozone season activity is 1.3 or 33% of annual activity (EPA, 1991). Bureau of the Census reports on paint and allied products[a] can be used to calculate an alternative seasonal apportioning factor for a particular year. The second and third quarter usage figures cover the months of April through September. The first and fourth quarters are periods of low coating usage in most areas. Based on 1993 and 1992 Census data, the seasonal factor for ozone season architectural coating activity is 1.12, or 28 percent of annual activity for a 3-month period.

---

[a] Bureau of the Census, Manufacturing and Construction Division, Report MA28F—Paint and Allied Products, available on the Census Bureau Bulletin Board, (301) 457-2310.

Daily Resolution

Coating use may take place 7 days a week during the active season.

PROJECTING EMISSIONS

A discussion about developing growth factors and projecting emission estimates can be found in Section 4 of this volume's Chapter 1, *Introduction to Area Source Emission Inventory Development*. Projected emission estimates may need to be calculated differently in the three following cases:

Case 1) No controls and no change in emission factor;

Case 2) Controls are reflected in the emission factor; and

Case 3) Controls are expressed as a control efficiency factor, the emission factor stays the same.

Each case uses a different projection equation. If there are no controls and no changes in the emission factor, projected emissions are calculated using the following equation:

$$EMIS_{PY} = ORATE_{BY} * EMF * GF \qquad (3\text{-}1)$$

where:

$EMIS_{PY}$	=	Projection year emissions
$ORATE_{BY}$	=	Base year activity rate
EMF	=	Emission factor
GF	=	Growth factor

For Case 2, where controls are reflected in the emission factor, the equation would be:

$$EMIS_{PY} = ORATE_{BY} * EMF_{PY} * GF \qquad (3\text{-}2)$$

where:

EMF_{PY} = Projection year emission factor

When controls are expressed as an emission limit or a percent reduction, reductions are calculated using a control efficiency factor, which is Case 3. See Section 4 of this chapter for an example of how to develop and apply a control efficiency factor in a base year emission estimation equation. Projected emission estimates for Case 3 are calculated using the following equation:

$$EMIS_{PY} = ORATE_{BY} * EMF \left[1 - \left(\frac{CE_{PY}}{100} * \frac{RE_{PY}}{100} * \frac{RP_{PY}}{100} \right) \right] * GF \quad (3\text{-}3)$$

where:

CE_{PY}	=	Projection year control efficiency
RE_{PY}	=	Projection year rule effectiveness
RP_{PY}	=	Projection year rule penetration

Tools for the development and use of growth factors are discussed in Chapter 1 of this volume. Forecasts of real estate sales, available from local planning boards, can also be used to estimate future growth in architectural surface coating.

4

PREFERRED METHODS FOR ESTIMATING EMISSIONS

The preferred method for calculating emission estimates from architectural surface coating is a survey of coating manufacturers in the region, or distributors in the area. This section provides an outline for preparing and using an architectural surface coating survey, and calculating emission estimates from the information collected.

Survey methods are theoretically the most accurate approach for estimating emissions, but also are the most expensive. Advantages to using this method are that regional or area specific information about the amount and type of coatings used will be collected. Coatings surveyed will more precisely reflect the regulations for VOC that are in place in the inventory area. Emissions of HAPs can be calculated based on the specific types of coatings in use in the area. The level of detail that is possible to collect with a survey is not available when using the alternative methods.

The cost and labor effort is highest for the first time that a regional or local survey is performed. Subsequent updates to the survey may be done using fewer samples at much less cost. In the years following the baseline survey, updates on sales may be all that is needed. Periodically, changes in formulations, methods of application, and the percentages of different types of coatings used may be updated.

A specific discussion of surveys for area sources is provided in Volume I of the EIIP series and in Chapter 1 of this volume. An approach for a survey of suppliers or manufacturers of architectural coatings uses five steps: (1) survey planning, (2) survey preparation, (3) survey distribution, (4) survey compilation and scaling, and (5) emission estimation. These steps will be discussed below.

SURVEY PLANNING

During the planning phase for the survey, the following issues should be addressed:

- Identify survey data quality objectives (DQOs), information needed, and how the DQOs will be realistically reached.

- Identify the survey recipients, either suppliers or manufacturers, and the data needs, depending on either choice.

- If suppliers are chosen as the recipients, a subset of all area suppliers may be surveyed, but, the inventory DQOs should be taken into account when determining the sample size. Identify a scaling surrogate for scaling up the survey results (e.g., building square footage, number of burning units, or population).

- If manufacturers are chosen as recipients, the resulting information will probably cover a larger region than the inventory area. The information collected will need to be scaled to the inventory area. Information about distribution patterns may need to be collected from the manufacturers in the survey.

• Decide whether to prescreen recipients.

• Coordinate with other inventory areas, if necessary.

• Identify data handling needs specific to this survey.

• Identify and begin to implement survey QA/QC.

The survey package should include a cover letter explaining the program, the survey form, a list of definitions, a map defining the study area(s), and a postage-paid envelope.
Either architectural coating suppliers or manufacturers can be surveyed for the information needed for this category. Suppliers can be identified through the telephone Yellow Pages. Additional disposal information may be collected as part of a waste disposal or recycling category. The portion of emissions that correspond to recycled or discarded architectural surface coatings from the disposal or recycling category should be subtracted from the emission estimate for architectural surface coating. This is necessary to avoid double counting.

SURVEY PREPARATION

In the planning phase, the information that the survey will collect should have been identified. In this step, the survey should be put into its final form.

At a minimum, the survey should request the number of gallons of architectural surface coating distributed in the inventory area or the inventory county, listed by coating type and carrier (solvent or water), and the average VOC content of each coating. Alternatively, national averages of VOC for each coating type can be multiplied by the number of gallons of the coating type to estimate emissions. National averages of VOC content for types of coatings have been prepared by the National Paint and Coatings Association (EPA, 1993a). A more detailed survey will request:

- Product type;
- Product amount distributed by type (gallon);
- Product density (lb/gallon);
- Solvent content of each product type (weight percent);
- VOC content of product by type or of solvent by type (weight percent); and
- HAP content of product by type or of solvent by type (weight %) for all HAP in product.

The advantages of the more detailed approach are an inventory that is more specific to the locality, and information that can be more readily projected to inventories for subsequent years.

Instructions for the survey form are provided on the survey cover page, shown in Figure 4-1. As shown in Table 4-1, respondents must first estimate the annual amount of coatings and solvent used in coatings, less waste disposed of offsite. This information is then combined with the coating and solvent density to yield the pounds of product used in a given year. HAP weight-percent information is then derived from the material safety data sheets (MSDSs) provided with each coating.

Using this method for a HAP inventory would require HAP information collection. A representative sample of the HAP contents for each product type, applied to a more complete inventory of surface coating types and usage, will simplify data collection.

Since most coatings are not transported great distances from where they are manufactured, it is possible to characterize architectural surface coating use in an area by surveying regional manufacturers. These manufacturers can be identified through resources like the Paint Red Book (Commercial Channels, Inc., 1985), and the Rauch Guide (Rauch Associates, Inc., 1984), which are both commercial directories of the paint industry and should be available in university and technical libraries. A survey of manufacturers should include all manufacturers in a multi-state region surrounding the study area, as well as the major nationwide manufacturers. Before undertaking a regional manufacturers' survey, a state or local agency should consider coordinating the survey with neighboring states or localities, since repeated information requests from multiple agencies may be ignored. A regional manufacturer's survey may provide the most complete picture of coating use in an area.

Name of Manufacturer/Distributer:____

Street Address: ____

City: ____

Contact Person/Phone Number: ____

1. On the attached table, list the amount of each individual product manufactured or distributed in 1994. Products include coatings and solvent manufactured to be used in preparing coatings for use.

2. Enter the amount of any coating disposed of offsite and not used in 1994. If only total amount of liquid disposed of offsite is known, allocate the total between the different products.

3. Subtract the amount of waste or unsold coatings from the amount purchased to yield the amount of each product used in gallons.

4. From the Material Safety Data Sheet (MSDS) for each product, enter the product density in pounds per gallon (lb/gal). If the MSDS only indicates the specific gravity, calculate the density by multiplying the specific gravity by 8.34 lb/gal (the density of water).

5. Multiply the gallons of product used by the density to yield the pounds of each product used.

6. From the Material Safety Data Sheet for each product, enter the hazardous air pollutant (HAP) or VOC weight percent listed.

7. Multiply the pounds of product used by the HAP/VOC weight percent to yield pounds of each HAP/VOC emitted.

FIGURE 4-1. SURVEY REQUEST FORM FOR ARCHITECTURAL SURFACE COATING SUPPLIERS AND MANUFACTURERS

TABLE 4-1

ARCHITECTURAL SURFACE COATING REQUEST FORM

Coating Type [a]	**Amount Sold (gallon)**	**Amount Disposed of Offsite**[b] **(gallon)**	**Product Density (lb/gallon)**	**Amount Used (lb)**

TABLE 4-1 (CONTINUED)

Coating Type[a]	**Amount Sold (lb)**	**HAP Weight %**	**HAP Emitted (lb)**

[a]See Figure 4-2 for list of example architectural coating types.
[b]Colunm not applicable to survey of manufacturers.

Anti-graffiti
Below ground wood preservatives
Bituminous coatings
Bond breakers
Clear wood preservatives
Concrete curing compounds
Dry fog coatings
Fire retardant/resistive coatings
Form release compounds
High performance architectural coatings
Lacquers
Magnesite cement coatings
Texture coatings
Opaque stains
Opaque wood preservatives
Pretreatment wash primers
Primers
Quick dry enamels
Quick dry primers, sealers, undercoat
Sanding sealers
Sealers
Semi-transparent stains
Semi-transparent wood preservatives
Shellacs
Swimming pool coatings
Undercoaters
Varnishes
Waterproofing sealers
Waterproofing sealers with pigment
Interior flats
Exterior flats
Interior non-flats
Exterior non-flats

FIGURE 4-2. EXAMPLE ARCHITECTURAL COATING TYPES

SURVEY DISTRIBUTION

Survey distribution will be determined by the budget for this source category. Surveys can be distributed by a mailing, or the information can be collected through a telephone survey. Initial contacts and follow up contacts may also be undertaken as part of the survey, in order to answer any questions. Survey distribution issues are discussed in Chapter 1 of this volume.

SURVEY COMPILATION AND SCALING

Survey compilation and scaling issues are discussed in Volume I of this series. A survey of surface coating manufacturers or distributors will result in information that includes many types of paints and multiple pollutants, so compilation of this information will require planning for data transfer and data management. Efficient transfer to the data handling system will benefit from inventory planner's consideration of the transfer step during the design of the survey.

Quality control checks should be in place during this phase of the work (see Volume VI for QA/QC methods). Incoming surveys should be checked for errors such as potential unit conversion errors or misidentification of products or chemicals. Survey information should be checked for reasonableness. Compiled survey information should also be subject to similar checks. Survey recipients may need to be recontacted in order to correct any errors.

Depending on the recipients of the survey, results may need to be either scaled up for all counties in the inventory area or scaled down to the inventory area. In either case, a scaling factor should have been identified in the planning phase, and any necessary requests for information from the survey respondents included in the survey form.

EMISSION ESTIMATION

Emission estimation calculations involve the calculation of emissions of individual pollutants, and then the application of any necessary spatial or temporal adjustments. Because the application of architectural surface coating is generally defined as an area source, there should not be a need to subtract point source emission estimates from the total. However, there may be cases when emission estimates from this category may be estimated as one of many processes occurring at a point source for the purposes of permitting and emission tradeoffs. These emissions must be identified and then subtracted from the area source estimates.

The equation below can be used to estimate the total amount of pollutant (P) emitted in the inventory area from architectural surface coating operations.

$$ASE_P = \sum_{c=1}^{C} \sum_{s=1}^{S} TAC_{c,s} \cdot SC_{c,s} \cdot F_{P,s} \qquad (4\text{-}1)$$

where:

ASE_P	=	Total emissions of pollutant (P) from architectural surface coating operations, for all coatings (C) with all solvents (S)
$TAC_{s,c}$	=	Total architectural surface coating consumed in the inventory area for each coating (c) with each solvent (s) containing pollutant (P)
$SC_{c,s}$	=	Amount of solvent (s) in each coating (c)
$F_{P,s}$	=	Fraction of pollutant (P) in each solvent (s)

Spatial allocation to individual counties or other inventory area units can be done using the methods described in Section 3. The methods that are available, in order of preference, are to use building square footage, land use data or population to allocate coating use.

Temporal allocation may be necessary if the inventory requires seasonal or daily emission estimates, and is discussed in Section 3 of this chapter.

Example 4-1:

Formaldehyde is reported in various weight percents for some formulations of primers, varnishes and waterproofing sealers. Reported weight percents for these coating types, and the amount delivered to the inventory area, in pounds, are presented below.

Formaldehyde Content by Weight Percent

Coating Type	Weight %	Amount Distributed (lb)
Primers	1.60	304.50
	17.50	47.85
	0.55	52.20
	7.50	5.22
Varnishes	0.55	845.50
	0.65	1330.00
Waterproofing Sealers	0.55	8.96

Emissions are calculated for varnishes:

Formaldehyde Emissions from Varnishes = [842.5 lb * 0.55%] + [1330 lb * 0.65%]

= 4.65 + 8.645

= 13.295 lb Formaldehyde

Emissions are calculated for waterproofing and primers in the same manner, and all emission estimates are summed for the final estimate.

This page is intentionally left blank.

5

ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

The alternative method for calculating emissions from architectural surface coating is to use population-based usage and emission factors. This section provides an outline for developing a per capita usage factor, and for using that usage factor and an emission factor to calculate a VOC emission estimate. Because the application of architectural surface coating is defined as an area source, there is no need to subtract point source emissions from the total, and all emissions estimated for this source are area source emissions. The procedure is as follows:

- Determine the per capita usage factor by dividing the national total architectural surface coating quantities[a] for solvent and water based coatings by the U.S. population for that year.[b] Example 5-1 shows how to sum gallons of water and solvent based paints for the year 1993.

- Determine the VOC emission factors for solvent- and water-based coatings. Emission factors based on weighted averages from a 1990 survey study are listed at the end of this section (EPA, 1993a). These emission factors are based on the weighted average VOC emission at maximum thinning. State or local emission limits also can be used to calculate an emission factor. If sufficient information is available, a more recent emission factor can be calculated. That information includes the amount used and percent VOC content of each of the architectural surface coatings.

    - When state or local emission limits are used to develop an emission factor, and those limits are a range of values for different types of coatings, a weighted average, based on real or estimated consumption of each coating type will need to be calculated.

---

[a] Total national coating usage is compiled by the Bureau of the Census, Report MA28F—Paint and Allied Products, available on the Census Bureau Bulletin Board, (301) 457-2310.

[b] U.S. Census Bureau, Department of Commerce, Washington, DC.

Example 5-1:

Table 5-1 shows a portion of Table 2 from the U.S. Bureau of Census MA28F - Paint and Allied Products. This section of the table summarizes the market information available on architectural coatings for the years of 1993 and 1992. In the table, types of paints are identified as being either solvent or water based paints, except for the two types listed as Architectural Lacquers and Architectural Coatings N.S.K. These latter types of paints can be assumed to be entirely solvent based coatings. The calculation to obtain the number of gallons of solvent based paints totals the gallons for Exterior Solvent Type, Interior Solvent Type, Architectural Lacquers and Architectural Coatings N.S.K:

Solvent Based Paints = 70,109 + 56,442 + 5,793 + 13,957

= 146,301 thousand gallons of paints

The calculation to obtain the number of gallons of water based paints totals the gallons for Exterior Water Type and Interior Water Type:

Water Based Paints = 154,777 + 297,729

= 452,506 thousand gallons of paints

The per capita usage factor is calculated by dividing the total usage of solvent based paints by the U.S. population, and the total usage of water based paint by the U.S. population.

Per Capita Solvent Based Usage Factor = Gallons of Solvent Based Paints/Population

= 146,301,000/248,709,873

= 0.59 gallons per person

For water based paints:

Per Capita Water Based Usage Factor = Gallons of Water Based Paints/Population

= 452,506,000/248,709,873

= 1.82 gallons per person

TABLE 5-1
QUALITY AND VALUE OF SHIPMENTS OF PAINT AND ALLIED PRODUCTS: 1993 AND 1992

Product Code	Product Description	1993 Quantity	Value	1992 Quantity	Value
2851 --	Paint and allied products[a]	1,103,693	14,140,288	1,228,531	13,538,654
	Architectural coatings	598,807	5,504,636	571,022	5,252,250
	Exterior solvent type	70,109	779,207	71,238	799,293
28511 12	Solvent thinned paints and tinting bases, including barn and roof paints	15,058	166,880	15,787	183,423
28511 15	Solvent thinned enamels and tinting bases, including exterior-interior floor enamels				
28511 25	Solvent thinned undercoaters and primers	8,636	91,568	8,360	85,959
28511 35	Solvent thinned clear finishes and sealers	6,725	71,569	5,598	60,905
28511 37	Solvent thinned stains, including shingle and shake	14,086	138,787	16,183	159,863
28511 39	Other exterior solvent thinned coatings, including bituminous paints	11,884	136,797	11,576	140,629
	Exterior water-type	154,777	1,402,586	143,065	1,285,217
28511 41	Water thinned paints and tinting bases, including barn and roof paints	109,947	1,050,478	103,649	976,944
28511 42	Water thinned exterior-interior deck and floor enamels	1,674	17,755	1,633	17,011
28511 44	Water thinned undercoaters and primers	7,642	74,489	6,281	60,614
28511 49	Water thinned stains and sealers	7,724	66,570	6,520	53,907
28511 55	Other exterior water thinned coatings	27,790	193,294	24,982	176,741
	Interior solvent type	56,442	650,240	53,612	630,792
28511 63	Flat solvent thinned wall paints and tinting bases, including mill white paints	6,661	80,014	6,614	78,016
28511 65	Gloss and quick drying enamels and other gloss solvent thinned paints and enamels	4,330	59,199	3,842	52,274

TABLE 5-1

(CONTINUED)

Product Code	Product Description	1993 Quality	Value	1992 Quality	Value
28511 69	Semigloss, eggshell, satin solvent thinned paints and tinting bases	14,491	152,759	14,191	151,072
28511 71	Solvent thinned undercoaters and primers	9,558	84,326	8,240	77,790
28511 75	Solvent thinned clear finishes and sealers	9,426	124,693	9,334	133,820
28511 77	Solvent thinned stains	5,272	73,401	5,701	75,529
28511 79	Other interior solvent thinned coatings	6,704	75,848	5,690	62,291
	Interior water-type	297,729	2,451,662	284,098	2,328,621
28511 81	Flat water thinned paints and tinting bases	142,557	1,012,016	141,039	1,042,288
28511 83	Semigloss, eggshell, satin, and other water thinned paints and tinting bases				
28511 86	Water thinned undercoaters and primers	17,759	129,322	17,348	126,399
28511 88	Other interior water thinned coatings, stains, and sealers	26,434	232,847	24,232	213,271
28511 93	Architectural lacquers	5,793	56,856	5,879	56,817
28511 00	Architectural coatings N.S.K.	13,957	164,085	13,130	151,510

Source: Bureau of the Census Report MA 28F - Paint and Allied Products
N.S.K. = Not specified by kind.
[a]Represents total shipments for those establishments producing paint and allied product that have 20 or more employees. These establishments represent approximately 95 percent of the total value of shipments for SIC industry 2851, paint, varnishes, lacquers, enamels, and allied products based on relationships observed in the 1992 Census of Manufactures preliminary report.

The following is a description of how emission factors for different coatings may be developed:

- Multiply the VOC content percentage times the amount used for each of the types of architectural surface coatings to produce an emission estimate for each of the types of coatings.

- Separately sum the VOC emission estimates for the solvent based coating types, and the water based coating types. Separately sum the amounts used of the solvent and the water based coatings.

- Divide the two VOC emission estimates by the total amounts of either solvent based or water based coating used. The result, in the form of emissions per gallon, is the emission factor for either solvent or water based coatings (see Example 5-2).

Example 5-2:

The equation to develop an emission factor for water-based architectural surface coatings is:

$$EF_W = \left[\sum_{C=1}^{i} ef_C * SC_i \right] \div \left[\sum_{C=1}^{i} SC_C \right]$$

where:

EF_W	=	Emission factor for all water based surface coatings
ef_C	=	Emission factor for each coating (c) in lb/gal
SC_C	=	Amount of coating (c) used in gal

- For solvent based paints, the equation to calculate emissions is:

$$\text{VOC Emissions From Solvent Based Coatings} = \text{Population} * \text{Solvent Usage Factor} * \text{Solvent VOC Emission Factor}$$

- For water based paints, the equation to calculate emissions is:

$$\text{VOC Emissions from Water Based Coatings} = \text{Population} * \text{Water Based Usage Factor} * \text{Water Based VOC Emission Factor}$$

- Add the two emission estimates to get the total VOC emissions from the category.

- When an emission factor is being calculated using regulatory limits, it is possible that the limits are expressed as a range rather than a single value. In that case, the upper bound of the limit should be used to calculate the emission factor. This is in keeping with the very conservative approach that this methodology represents.

- Use the speciation profiles at the end of this section to calculate HAP emissions from architectural surface coatings.
  - Multiply the percentage of the individual HAP for either solvent- or water-based paints with the amount of VOC calculated for that type of coating (see Example 5-3).

Example 5-3:

$$\text{Benzene Emissions from Water Based Coatings} = \text{VOC Emission Estimate for Water Based Coatings} * 0.003$$

Table 5-2 lists the emission factors for architectural surface coatings. Tables 5-3 and 5-4 list the VOC species profiles for water- and solvent-based architectural surface coating species, respectively.

TABLE 5-2

EMISSION FACTORS FOR ARCHITECTURAL SURFACE COATINGS (EPA, 1993A)

Coating Type	VOC Content (lb/gal)
Water-based coatings	0.74
Solvent-based coatings	3.87

TABLE 5-3

VOC SPECIES PROFILE FOR WATER-BASED ARCHITECTURAL SURFACE COATING (CARB, 1991)

Species	Weight Fraction
Benzene[a]	0.0030
n-Butyl alcohol	0.2000
2-(2-Butoxyethoxy)-ethanol	0.0070
2-Butyltetrahydrofuran	0.0010
1-Chlorobutane	0.0220
3-(Chloromethyl)-heptane	0.0060
n-Decane	0.0020
Dibutyl ether	0.0020
Dichloromethane[a] (methylene chloride)	0.0550
Ethyl chloride[a]	0.0060
2-Ethyl-1-hexanol	0.0100
1-Ethoxy-2-propanol	0.0140
Ethylene glycol[a]	0.0050
1-Heptanol	0.0070

TABLE 5-3

(CONTINUED)

Species	Weight Fraction
Hexylene glycol	0.0140
Isoamyl isobutyrate	0.0030
Methyl chloride	0.0050
Methyl isobutyrate	0.0010
Propylcyclohexanone	.0100
Substituted C7 ester (C12)	.2690
Substituted C9 ester (C12)	.2850
n-Undecane	.0010
Undecane isomers	.0100

[a]Hazardous air pollutant listed in Clean Air Act Amendments of 1990.

TABLE 5-4

VOC SPECIES PROFILE FOR SOLVENT-BASED ARCHITECTURAL SURFACE COATING (CARB, 1991)

Species	Weight Fraction
Acetone	0.0320
n-Butyl acetate	0.0250
n-Butyl alcohol	0.0160
Cyclohexane	0.2070
Dimethyl formamide[a]	0.0050
2-Ethoxyethyl acetate	0.0130
Ethyl alcohol	0.0060
Ethylbenzene[a]	0.0430
Ethylene glycol[a]	0.0060
n-Hexane	0.2070
Isobutyl acetate	0.0150
Isobutyl alcohol	0.0060
Isobutyl isobutyrate	0.0610
Isomers of xylene[a]	0.0260
Isopropyl alcohol	0.1640
Methyl alcohol	0.0390
Methyl ethyl ketone[a]	0.0560
Methyl isobutyl ketone[a]	0.0060
Methyl n-butyl ketone	0.0070
Propylene glycol	0.0080
Toluene	0.0520

[a]Hazardous air pollutant listed in Clean Air Act Amendments of 1990.

This page is intentionally left blank.

6

QUALITY ASSURANCE/QUALITY CONTROL

When using the preferred method, the survey planning, sample design, and data handling should be planned and documented in the inventory QA/QC plan. Refer to the discussion of survey planning and survey QA/QC in Chapter 1 of the volume.

Data handling for the survey data and for data collected for the alternate methods should also be planned and documented in the inventory QA/QC plan and do not involve any category-specific issues. Please consult the EIIP volume on inventory QA/QC for more information.

EMISSION ESTIMATE QUALITY INDICATORS

The preferred method gives higher quality estimates than either of the alternative methods, but requires significantly more effort. The level of effort required to calculate emissions using either of the alternative methods ranges from 8-40 hours. Conducting a survey requires between 100 to 800 hours depending on the size of inventory region and the desired level of detail of the survey. However, the resultant increase in the quality may justify this expenditure of resources, especially if this category is believed to be a significant contributor to emissions. Emissions from architectural surface coatings are typically among the top ten area sources of VOCs and HAPs in urban areas.

DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

The DARS scores for each method are summarized in Tables 6-1, 6-2, and 6-3. A range of scores is given for the preferred method because the scores are dependent on the representativeness, sample size, and other survey characteristics. All scores assume that good QA/QC measures are performed and that no significant deviations from the prescribed methods have been made. If these assumptions are not met, new DARS scores should be developed according to the guidance (Beck, et. al., 1994).

The preferred method gives higher DARS scores than either of the alternative methods. The two alternative methods have composite scores in the 0.3-0.4 range while the preferred method scores vary from 0.64 to 0.96. Furthermore, the scores on all attributes are higher compared to the alternatives. The alternative methods have similar composite scores, but the composite measurement and source specificity attribute scores are quite different.

TABLE 6-1

PREFERRED METHOD DARS SCORES: SURVEY OF COATING USE BY TYPES IN THE INVENTORY REGION

Attribute	Scores			Comment
	Factor	Activity	Emissions	
Measurement	0.7-0.9	0.7-0.9	0.64-0.81	Sample size and representativeness of sample determine score.
Source Specificity	1.0	1.0	1.0	Assumes that survey is specific to source category and inventory region.
Spatial	0.8-1.0	0.8-1.0	0.64-1.0	A 1.0 is appropriate if survey is region specific; lower value given if factor or activity extrapolated from a larger or smaller region.
Temporal	0.7-1.0	0.7-1.0	0.49-1.0	High value applies if sample uses data from inventory target year; lower value if sample data are from a different year.
Composite Scores	0.80-0.98	0.80-0.98	0.69-0.95	

TABLE 6-2

ALTERNATIVE METHOD DARS SCORES: NATIONAL FACTORS APPLIED TO NATIONAL PER CAPITA USAGE

Attribute	Scores		
	Factor	**Activity**	**Emissions**
Measurement	0.8*	0.7	0.56
Source specificity	0.7	0.5	0.35
Spatial	0.5	0.5	0.25
Temporal	0.7**	0.7**	0.49
Composite Scores	0.68	0.6	0.41

TABLE 6-3

ALTERNATIVE METHOD DARS SCORES: REGULATORY LIMITS APPLIED TO NATIONAL PER CAPITA USAGE

Attribute	Scores		
	Factor	**Activity**	**Emissions**
Measurement	0.1*	0.7	0.07
Source specificity	0.6	0.5	0.3
Spatial	0.8	0.5	0.4
Temporal	0.7**	0.7**	0.49
Composite Scores	0.55	0.6	0.32

* Score assumes total VOC factor is used; if this is speciated to get HAPs, score should be lowered.
** Assumes factor/activity data year different than inventory year but not by much.

SOURCES OF UNCERTAINTY

The uncertainty of the emission estimates can be quantified if the preferred method is used (See QA Source Document, Chapter 4). However, the statistics needed to quantify the uncertainty of either alternative method are incomplete. The variability of paint use per capita is not well defined. Per capita usage may be lower than the national average in urban areas of high-density housing, in milder climates, or where wooden buildings are not common. For example, a survey of paint use in the New York City area resulted in per capita consumption 25 percent lower than the national average (Leone, et al., 1987), presumably due to the predominance of high-density housing in the city. Paint use may be higher in corrosive environments (such as near salt water) or in areas where wooden structures predominate.

The solvent content of paint is also variable. The VOC contents shown in Table 5-2 are weighted means for the two general categories shown. The unweighted mean and standard deviation for water-based coatings is 2.22 ±1.9 lb/gal; for solvent-based coatings, the unweighted mean and standard deviation is 4.0 ±1.07 lb/gal. The weighted means account for the proportions of primers, sealers, lacquers, and so forth used nationally, and if these proportions do not vary regionally, the national factor will be representative of local conditions. Therefore, the preferred method should be used wherever local conditions suggest that either the total quantity of paint used or the type of paints used are very different from the average.

The use of regulatory emission limits is likely to be biased because solvent content can be lower than the limit. The true emissions are likely to be lower than the limit. However, because the national factor is an average, it may either overestimate or underestimate emissions in a given area.

7

DATA CODING PROCEDURES

This section describes the codes available to characterize architectural surface coating emission estimates. Consistent categorization and coding will result in greater uniformity between inventories. Inventory planning for data collection calculations and inventory presentation should take the data formats presented in this section into account. Available codes and process definitions may impose constraints or requirements on the preparation of emission estimates for this category.

PROCESS AND CONTROL CODES

The source category process codes for architectural surface coating operations are shown in Table 7-1. These codes are derived from the EPA's Aerometric Information Retrieval System (AIRS) AMS source category codes (EPA, 1994). The control codes for use with AMS are shown in Table 7-2. The "099" control code can be used for miscellaneous control devices that do not have a unique identification code. The "999" code can be used for a combination of control devices where only the overall control efficiency is known.

Typically, the source category code for "total all solvent types, architectural surface coating" will be used. Low solvent or water-borne coatings will be the control method, so either control device code 101 or 103 will be used.

TABLE 7-1

AIRS AMS CODES FOR ARCHITECTURAL SURFACE COATING

Process Description	AMS Code
Total: All Solvent Types	24-01-001-000
Solvent — General	24-01-001-999
Acetone	24-01-001-030
Butyl Acetate	24-01-001-055
Butyl Alcohols: All Types	24-01-001-060
n-Butyl Alcohol	24-01-001-065
Isobutyl Alcohol	24-01-001-070
Diethylene Glycol Monobutyl Ether	24-01-001-125
Diethylene Glycol Monoethyl Ether	24-01-001-130
Diethylene Glycol Monomethyl Ether	24-01-001-135
Ethyl Acetate	24-01-001-170
Ethylene Glycol Monoethyl Ether (2-Ethoxyethanol)	24-01-001-200
Ethylene Glycol Monomethyl Ether (2-Methoxyethanol)	24-01-001-210
Ethylene Glycol Monobutyl Ether (2-Butoxyethanol)	24-01-001-215
Glycol Ether: All Types[a]	24-01-001-235
Isopropanol	24-01-001-250
Methyl Ethyl Ketone[a]	24-01-001-275
Methyl Isobutyl Ketone[a]	24-01-001-285
Special Naphthas	24-01-001-370
Xylenes[a]	N/A[b]

[a]Hazardous Air Pollutant listed in the Clean Air Act Amendments of 1990.
[b]N/A = No AMS source code assigned.

TABLE 7-2

AIRS CONTROL DEVICE CODES

Control Device	Code
Process Modification — Low Solvent Coatings	101
Process Modification — Powder Coatings	102
Process Modification — Water-Borne Coatings	103
Miscellaneous Control Device	099
Combination Control Efficiency	999

This page is intentionally left blank.

8

REFERENCES

Beck, L., Rebecca Peer, Luis Bravo, and Ying Yan. 1994. *A Data Attribute System.* U.S. Environmental Protection Agency, Air and Engineering Research Laboratory, Research Triangle Park, North Carolina.

Brandau, A., 1990. *Introduction to Coatings Technology; Federation Series on Coating Technology*. Federation of Societies for Coating Technology, Blue Bell, Pennsylvania.

California Air Resources Board (CARB). 1991. *Identification of Volatile Organic Compound Species Profile* (August 1991 version). Emission Inventory Branch, Technical Support Division. Sacramento, California.

Communication Channels, Inc., *1985 Paint Red Book*, Atlanta, Georgia.

EPA. 1994. AIRS Database. U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. 1994.

EPA. 1993a. Information provided in the regulation negotiation proceedings in support of a VOC regulation for architectural and industrial maintenance coatings. Docket No. II-E-36. VOC Emissions from Architectural and Industrial Maintenance Coatings.

EPA. 1993b. *Guidance for Growth Factors, Projections and Control Strategies for the 15 Percent Rate-of-Progress Plans*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-452/R-93-002. Research Triangle Park, North Carolina.

EPA. 1991. *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Vol. I.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-450/4-91-016. Research Triangle Park, North Carolina.

Leon, R.M., E.W. Davis, and A.D. Jones. 1987. *Updating Nontraditional VOC Source Inventories*. Prepared for New York State Department of Environmental Conservation, Bureau of Abatement Planning.

Rauch Associates, Inc. 1984. *The Rauch Guide to the U.S. Paint Industry (Data for 1983, 1984 and Projections to 1989), Bridgewater, New Jersey*.

This page is intentionally left blank.