4.2.2.7 Polymeric Coating Of Supporting Substrates[1-8]

"Polymeric coating of supporting substrates" is defined as a web coating process other than paper coating that applies an elastomer or other polymeric material onto a supporting substrate. Typical substrates include woven, knit, and nonwoven textiles; fiberglass; leather; yarn; and cord. Examples of polymeric coatings are natural and synthetic rubber, urethane, polyvinyl chloride, acrylic, epoxy, silicone, phenolic resins, and nitrocellulose. Plants have from 1 to more than 10 coating lines. Most plants are commission coaters where coated substrates are produced according to customer specifications. Typical products include rainwear, conveyor belts, V-belts, diaphragms, gaskets, printing blankets, luggage, and aircraft and military products. This industrial source category has been retitled from "Fabric Coating" to that listed above to reflect the general use of polymeric coatings on substrate materials including but not limited to conventional textile fabric substrates.

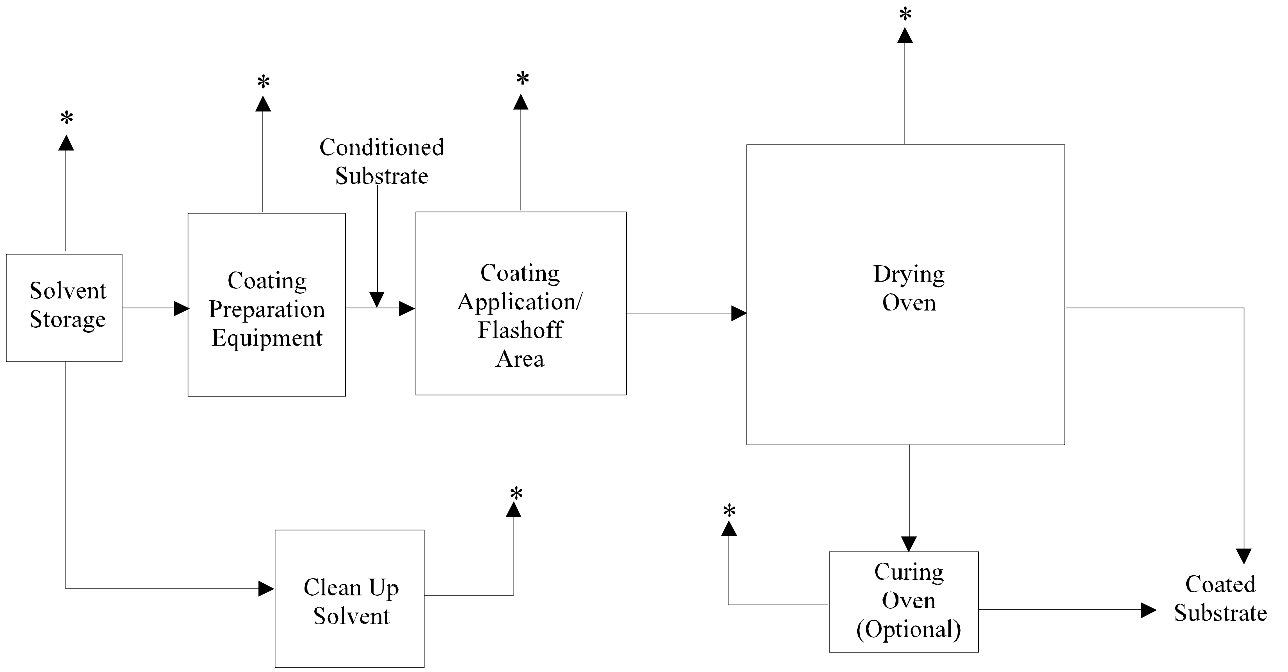
4.2.2.7.1 Process Description[1-3]

The process of applying a polymeric coating to a supporting substrate consists of mixing the coating ingredients (including solvents), conditioning the substrate, applying the coating to the substrate, drying/curing the coating in a drying oven, and subsequent curing or vulcanizing if necessary. Figure 4.2.2.7-1 is a schematic of a typical solvent-borne polymeric coating operation identifying volatile organic compound (VOC) emission locations. Typical plants have 1 or 2 small ($\leq$38 m^3 or 10,000 gallons) horizontal or vertical solvent storage tanks that are operated at atmospheric pressure; however, some plants have as many as 5. Coating preparation equipment includes the mills, mixers, holding tanks, and pumps used to prepare polymeric coatings for application. Urethane coatings typically are purchased premixed and require little or no mixing at the coating plant. The conventional types of equipment for applying organic solvent-borne and waterborne coatings include knife-over-roll, dip, and reverse-roll coaters Once applied to the substrate, liquid coatings are solidified by evaporation of the solvent in a steam-heated or direct-fired oven. Drying ovens usually are of forced-air convection design in order to maximize drying efficiency and prevent a dangerous localized buildup of vapor concentration or temperature. For safe operation, the concentration of organic vapors is usually held between 10 and 25 percent of the lower explosive limit (LEL). Newer ovens may be designed for concentrations of up to 50 percent of the LEL through the addition of monitors, alarms, and fail-safe shutdown systems. Some coatings require subsequent curing or vulcanizing in separate ovens.

4.2.2.7.2 Emission Sources[1-3]

The significant VOC emission sources in a polymeric coating plant include the coating preparation equipment, the coating application and flashoff area, and the drying ovens. Emissions from the solvent storage tanks and the cleanup area are normally only a small percentage of the total.

In the mixing or coating preparation area, VOCs are emitted from the individual mixers and holding tanks during the following operations: filling of mixers, transfer of the coating, intermittent activities such as changing the filters in the holding tanks, and mixing (if mix equipment is not equipped with tightly fitting covers). The factors affecting emissions in the mixing area include tank size, number of tanks, solvent vapor pressure, throughput, and the design and performance of tank covers.



VOC emissions are denoted by an "*."

Figure 4.2.2.7-1. Solventborne polymeric coating operation and VOC emission locations.[1]

Emissions from the coating application area result from the evaporation of solvent around the coating application equipment during the application process and from the exposed substrate as it travels from the coater to the drying oven entrance (flashoff). The factors affecting emissions are the solvent content of the coating, line width and speed, coating thickness, volatility of the solvent(s), temperature, distance between coater and oven, and air turbulence in the coating area.

Emissions from the drying oven result from the fraction of the remaining solvent that is driven off in the oven. The factors affecting uncontrolled emissions are the solvent content of the coating and the amount of solvent retained in the finished product. Fugitive emissions due to the opening of oven doors also may be significant in some operations. Some plasticizers and reaction byproducts may be emitted if the coating is subsequently cured or vulcanized. However, emissions from the curing or vulcanizing of the coating are usually negligible compared to the total emissions from the operation.

Solvent type and quantity are the common factors affecting emissions from all the operations in a polymeric coating facility. The rate of evaporation or drying is dependent upon solvent vapor pressure at a given temperature and concentration. The most commonly used organic solvents are toluene, dimethyl formamide (DHF), acetone, methyl ethyl ketone (MEK), isopropyl alcohol, xylene, and ethyl acetate. Factors affecting solvent selection are cost, solvency, toxicity, availability, desired rate of evaporation, ease of use after solvent recovery, and compatibility with solvent recovery equipment.

4.2.2.7.3 Emissions Control[1,2,4-7]

A control system for evaporative emissions consists of 2 components: a capture device and a control device. The efficiency of the control system is determined by the efficiencies of the 2 components.

A capture device is used to contain emissions from a process operation and direct them to a stack or to a control device. Covers, vents, hoods, and partial and total enclosures are alternative capture devices used on coating preparation equipment. Hoods and partial and total enclosures are typical capture devices for use in the coating application area. A drying oven can be considered a capture device because it both contains and directs VOC emissions from the process. The efficiency of capture devices is variable and depends upon the quality of design and the level of operation and maintenance.

A control device is any equipment that has as its primary function the reduction of emissions. Control devices typically used in this industry are carbon adsorbers, condensers, and incinerators. Tightly fitting covers on coating preparation equipment may be considered both capture and control devices.

Carbon adsorption units use activated carbon to adsorb VOCs from a gas stream; the VOCs are later recovered from the carbon. Two types of carbon adsorbers are available: fixed-bed and fluidized bed. Fixed-bed carbon adsorbers are designed with a steam-stripping technique to recover the VOC material and regenerate the activated carbon. The fluidized-bed units used in this industry are designed to use nitrogen for VOC vapor recovery and carbon regeneration. Both types achieve typical VOC control efficiencies of 95 percent when properly designed, operated, and maintained.

Condensation units control VOC emissions by cooling the solvent-laden gas to the dew point of the solvent(s) and collecting the droplets. There are 2 condenser designs commercially available: nitrogen (inert gas) atmosphere, and air atmosphere. These systems differ in the design and operation of the drying oven (i. e., use of nitrogen or air in the oven) and in the method of cooling the solvent laden air (i. e., liquified nitrogen or refrigeration). Both design types can achieve VOC control efficiencies of 95 percent.

Incinerators control VOC emissions through oxidation of the organic compounds into carbon dioxide and water. Incinerators used to control VOC emissions may be of thermal or catalytic design and may use primary or secondary heat recovery to reduce fuel costs. Thermal incinerators operate at approximately 890°C (1600°F) to ensure oxidation of the organic compounds. Catalytic incinerators operate in the rage of 325 to 430°C (600 to 800°F) while using a catalyst to achieve comparable oxidation of VOCs. Both design types achieve a typical VOC control efficiency of 98 percent.

Tightly fitting covers control VOC emissions from mix vessels by reducing evaporative losses. Airtight covers can be fitted with conservation vents to avoid excessive internal pressure or vacuum. The parameters affecting the efficiency of these controls are solvent vapor pressure, cyclic temperature change, tank size, throughput, and the pressure and vacuum settings on the conservation vents. A good system of tightly fitting covers on mixing area vessels is estimated to reduce emissions by approximately 40 percent. Control efficiencies of 95 or 98 percent can be obtained by directing the captured VOCs to an adsorber, condenser, or incinerator.

When the efficiencies of the capture device and control device are known, the efficiency of the control system can be computed by the following equation:

$$\text{(capture efficiency)} \times \text{(control efficiency)} = \text{(control system efficiency)}$$

The terms of this equation are fractional efficiencies rather than percentages. For instance, a system of hoods delivering 60 percent of VOC emissions to a 90 percent efficient carbon adsorber would result in a control system efficiency of 54 percent (0.60 x 0.90 = 0.54). Table 4.2.2.7-1 summarizes the control system efficiencies that may be used in the absence of measured data on mix equipment and coating operations.

Table 4.2.2.7-1. SUMMARY OF CONTROL EFFICIENCIES[a]

Control Technology	Overall Control Efficiency, %[b]
Coating Preparation Equipment	
Uncontrolled	0
Sealed covers with conservation vents	40
Sealed covers with carbon adsorber/condenser	95
Coating Operations[c]	
Local ventilation with carbon adsorber/condenser	81
Partial enclosure with carbon adsorber/condenser	90
Total enclosure with carbon adsorber/condenser	93
Total enclosure with incinerator	96

[a] Reference 1. To be used in the absence of measured data.
[b] To be applied to uncontrolled emissions from indicated process area, not from entire plant.
[c] Includes coating application/flashoff area and drying oven.

4.2.2.7.4 Emissions Estimation Techniques[1,4-8]

In this diverse industry, realistic estimates of emissions require solvent usage data. Due to the wide variation found in coating formulations, line speeds, and products, no meaningful inferences can be made based simply on the equipment present.

Plantwide emissions can be estimated by performing a liquid material balance in uncontrolled plants and in those where VOCs are recovered for reuse or sale. This technique is based on the assumption that all solvent purchased replaces VOC's which have been emitted. Any identifiable and quantifiable side-streams should be subtracted from this total. The general formula for this is:

$$\begin{pmatrix}\text{solvent}\\ \text{purchased}\end{pmatrix} - \begin{pmatrix}\text{quantifiable}\\ \text{solvent output}\end{pmatrix} = \begin{pmatrix}\text{VOC}\\ \text{emitted}\end{pmatrix}$$

The first term encompasses all solvent purchased including thinners, cleaning agents, and the solvent content of any premixed coatings, as well as any solvent directly used in coating formulation. From this total, any quantifiable solvent outputs are subtracted. These outputs may include solvent retained in the finished product, reclaimed solvent sold for use outside the plant, and solvent contained in waste streams. Reclaimed solvent which is reused at the plant is <u>not</u> subtracted.

The advantages of this method are that it is based on data that are usually readily available, it reflects actual operations rather than theoretical steady-state production and control conditions, and it includes emissions from all sources at the plant. However, care should be taken not to apply this method over too short a time span. Solvent purchases, production, and waste removal occur in their own cycles, which may not coincide exactly.

Occasionally, a liquid material balance may be possible on a smaller scale than the entire plant. Such an approach may be feasible for a single coating line or group of lines served by a dedicated mixing area and a dedicated control and recovery system. In this case, the computation begins with total solvent metered to the mixing area instead of solvent purchased. Reclaimed solvent is subtracted from this volume whether or not it is reused onsite. Of course, other solvent input and output streams must be accounted for as previously indicated. The difference between total solvent input and total solvent output is then taken to be the quantity of VOCs emitted from the equipment in question.

The configuration of meters, mixing areas, production equipment, and controls usually will not make this approach possible. In cases where control devices destroy potential emissions or a liquid material balance is inappropriate for other reasons, plant-wide emissions can be estimated by summing the emissions calculated for specific areas of the plant. Techniques for these calculations are presented below.

Estimating VOC emissions from a coating operation (application/flashoff area and drying oven) starts with the assumption that the uncontrolled emission level is equal to the quantity of solvent contained in the coating applied. In other words, all the VOC in the coating evaporates by the end of the drying process. This quantity should be adjusted downward to account for solvent retained in the finished product in cases where it is quantifiable and significant.

Two factors are necessary to calculate the quantity of solvent applied: the solvent content of the coating and the quantity of coating applied. Coating solvent content can be directly measured using EPA Reference Method 24. Alternative ways of estimating the VOC content include the use of either data on coating formulation that are usually available from the plant owner/operator or premixed coating manufacturer or, if these cannot be obtained, approximations based on the information in Table 4.2.2.7-2. The amount of coating applied may be directly metered. If it is not, it must be determined from production data. These should be available from the plant owner/operator. Care should be taken in developing these 2 factors to ensure that they are in compatible units.

Table 4.2.2.7-2. SOLVENT AND SOLIDS CONTENT OF POLYMERIC COATINGS[a]

	Typical Percentage, By Weight	
Polymer Type	% solvent	% solids
Rubber	50 - 70	30 - 50
Urethanes	50 - 60	40 - 50
Acrylics	—[b]	50
Vinyl[c]	60 - 80	20 - 40
Vinyl plastisol	5	95
Organisol	15 - 40	60 - 85
Epoxies	30 - 40	60 - 70
Silicone	50 - 60	40 - 50
Nitrocellulose	70	30

[a] Reference 1.
[b] Organic solvents are generally not used in the formulation of acrylic coatings. Therefore, the solvent content for acrylic coatings represents nonorganic solvent use (i. e., water).
[c] Solventborne vinyl coating.

When an estimate of uncontrolled emissions is obtained, the controlled emissions level is computed by applying a control system efficiency factor:

$$\begin{pmatrix}\text{uncontrolled}\\ \text{VOC}\end{pmatrix} \times \left(1 - \text{control system efficiency}\right) = \begin{pmatrix}\text{VOC}\\ \text{emitted}\end{pmatrix}$$

As previously explained, the control system efficiency is the product of the efficiencies of the capture device and the control device. If these values are not known, typical efficiencies for some combinations of capture and control devices are presented in Table 4.2.2.7-1. It is important to note that these control system efficiencies are applicable only to emissions that occur within the areas served by the systems. Emissions from such sources as process wastewater or discarded waste coatings may not be controlled at all.

In cases where emission estimates from the mixing area alone are desired, a slightly different approach is necessary. Here, uncontrolled emissions will be only that portion of total solvent that evaporates during the mixing process. A liquid material balance across the mixing area (i. e., solvent entering minus solvent content of coating applied) would provide a good estimate. In the absence of any measured value, it may be assumed that approximately 10 percent of the total solvent entering the mixing area is emitted during the mixing process, but this can vary widely. When an estimate of uncontrolled mixing area emissions has been made, the controlled emission rate can be calculated as discussed previously. Table 4.2.2.7-1 lists typical overall control efficiencies for coating mix preparation equipment.

Solvent storage tanks of the size typically found in this industry are regulated by only a few States and localities. Tank emissions are generally small (<125 kg/yr [275 lb/yr]). If an estimate of emissions is desired, it can be computed using the equations, tables, and figures provided in Chapter 7.

References For Section 4.2.2.7

1. *Polymeric Coating Of Supporting Substrates, Background Information For Proposed Standards*, EPA-450/3-85-022a, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1985.

2. *Control Of Volatile Organic Emissions From Existing Stationary Sources — Volume II: Surface Coating Of Cans, Coils, Paper, Fabrics, Automobiles, and Light Duty Trucks*, EPA-450/2-77-008, U. S. Environmental Protection Agency, Research Triangle Park, NC, May 1977.

3. E. J. Maurer, "Coating Operation Equipment Design And Operating Parameters", Memorandum To Polymeric Coating Of Supporting Substrates File, MRS, Raleigh, NC, April 23, 1984.

4. *Control Of Volatile Organic Emissions From Existing Stationary Sources, Volume I: Control Methods For Surface-Coating Operations*, EPA-450/2-76-028, U. S. Environmental Protection Agency, Research Triangle Park, NC, November 1976.

5. G. Crane, *Carbon Adsorption For VOC Control*, U. S. Environmental Protection Agency, Research Triangle Park, NC, January 1982.

6. D. Moscone, "Thermal Incinerator Performance For NSPS", Memorandum, Office Of Air Quality Planning And Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 11, 1980.

7. D. Moscone, "Thermal Incinerator Performance For NSPS, Addendum", Memorandum, Office Of Air Quality Planning And Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 22, 1980.

8. C. Beall, "Distribution Of Emissions Between Coating Mix: Preparation Area And The Coating Line", Memorandum To Magnetic Tape Coating Project File, MRS, Raleigh, NC, June 22, 1984.