

4.2.2.9 Pressure Sensitive Tapes And Labels

4.2.2.9.1 General¹⁻⁵

The coating of pressure sensitive tapes and labels (PSTL) is an operation in which some backing material (paper, cloth, or film) is coated to create a tape or label product that sticks on contact. The term "pressure sensitive" indicates that the adhesive bond is formed on contact, without wetting, heating, or adding a curing agent.

The products manufactured by the PSTL surface coating industry may have several different types of coatings applied to them. The 2 primary types of coatings are adhesives and releases. Adhesive coating is a necessary step in the manufacture of almost all PSTL products. It is generally the heaviest coating (typically 0.051 kg/m^2 , or 0.011 lb/ft^2 and therefore has the highest level of solvent emissions (generally 85 to 95 percent of total line emissions).

Release coatings are applied to the backside of tape or to the mounting paper of labels. The function of release coating is to allow smooth and easy unrolling of a tape or removal of a label from mounting paper. Release coatings are applied in a very thin coat (typically 0.00081 kg/m^2 , or 0.00017 lb/ft^2). This thin coating produces less emissions than does a comparable size adhesive coating line.

Five basic coating processes can be used to apply both adhesive and release coatings:

- solvent base coating
- waterborne (emulsion) coating
- 100 percent solids (hot melt) coating
- calender coating
- prepolymer coating

A solvent base coating process is used to produce 80 to 85 percent of all products in the PSTL industry, and essentially all of the solvent emissions from the industry result from solvent base coating. Because of its broad application and significant emissions, solvent base coating of PSTL products is discussed in greater detail.

4.2.2.9.2 Process Description^{1-2,5}

Solvent base surface coating is conceptually a simple process. A continuous roll of backing material (called the web) is unrolled, coated, dried, and rolled again. A typical solvent base coating line is shown in Figure 4.2.2.9-1. Large lines in this industry have typical web widths of 152 centimeters (60 in.), while small lines are generally 48 centimeters (24 in.). Line speeds vary substantially, from 3 to 305 meters per minute (10 to 1000 ft/min). To initiate the coating process the continuous web material is unwound from its roll. It travels to a coating head, where the solvent base coating formulation is applied. These formulations have specified levels of solvent and coating solids by weight. Solvent base adhesive formulations contain approximately 67 weight percent solvent and 33 weight percent coating solids. Solvent base releases average about 95 weight percent solvent and 5 weight percent coating solids. Solvents used include toluene, xylene, heptane, hexane, and methyl ethyl ketone. The coating solids portion of the formulations consists of elastomers (natural rubber, styrene-butadiene rubber, polyacrylates), tackifying resins (polyterpenes, rosins, petroleum

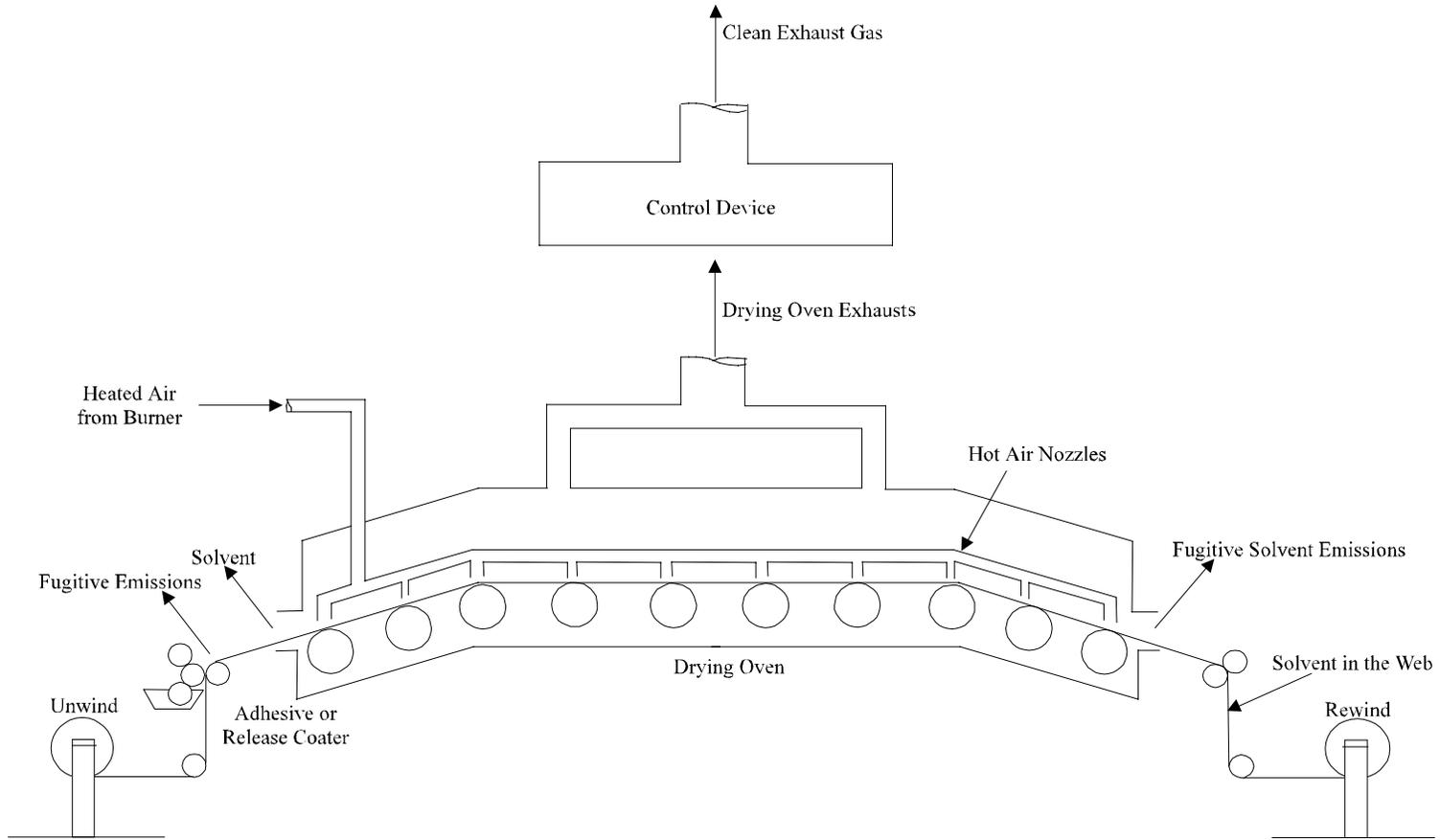


Figure 4.2.2.9-1. Diagram of a pressure sensitive tape and label coating line.

hydrocarbon resins, asphalts), plasticizers (phthalate esters, polybutenes, mineral oil), and fillers (zinc oxide, silica, clay).

The order of application is generally release coat, primer coat (if any), and adhesive coat. A web must always have a release coat before the adhesive can be applied. Primer coats are not required on all products, generally being applied to improve the performance of the adhesive.

Three basic categories of coating heads are used in the PSTL industry. The type of coating head used has a great effect on the quality of the coated product, but only a minor effect on overall emissions. The first type operates by applying coating to the web and scraping excess off to a desired thickness. Examples of this type of coater are the knife coater, blade coater, and metering rod coater. The second category of coating head meters on a specific amount of coating. Gravure and reverse roll coaters are the most common examples. The third category of coating head does not actually apply a surface coating, but rather it saturates the web backing. The most common example in this category is the dip and squeeze coater.

After solvent base coatings have been applied, the web moves into the drying oven where the solvents are evaporated from the web. The important characteristics of the drying oven operation are:

- source of heat
- temperature profile
- residence time
- allowable hydrocarbon concentration in the dryer
- oven air circulation

Two basic types of heating are used in conventional drying ovens, direct and indirect. Direct heating routes the hot combustion gases (blended with ambient air to the proper temperature) directly into the drying zone. With indirect heating, the incoming oven air stream is heated in a heat exchanger with steam or hot combustion gases but does not physically mix with them. Direct-fired ovens are more common in the PSTL industry because of their higher thermal efficiency. Indirect heated ovens are less energy efficient in both the production of steam and the heat transfer in the exchanger.

Drying oven temperature control is an important consideration in PSTL production. The oven temperature must be above the boiling point of the applied solvent. However, the temperature profile must be controlled by using multizoned ovens. Coating flaws known as "craters" or "fish eyes" will develop if the initial drying proceeds too quickly. These ovens are physically divided into several sections, each with its own hot air supply and exhaust. By keeping the temperature of the first zone low, and then gradually increasing it in subsequent zones, uniform drying can be accomplished without flaws. After exiting the drying oven, the continuous web is wound on a roll, and the coating process is complete.

4.2.2.9.3 Emissions^{1,6-10}

The only pollutants emitted in significant quantities from solvent base coating of pressure sensitive tapes and labels are volatile organic compounds (VOC) from solvent evaporation. In an uncontrolled facility, essentially all of the solvent used in the coating formulation is emitted to the atmosphere. Of these uncontrolled emissions, 80 to 95 percent are emitted with the drying oven exhaust. Some solvent (from zero to 5 percent) can remain in the final coated product, although this solvent will eventually evaporate into the atmosphere. The remainder of applied solvent is lost from a

number of small sources as fugitive emissions. The major VOC emission points in a PSTL surface coating operation are indicated in Figure 4.2.2.9-1.

There are also VOC losses from solvent storage and handling, equipment cleaning, miscellaneous spills, and coating formulation mixing tanks. These emissions are not addressed here, as these sources have a comparatively small quantity of emissions.

Fugitive solvent emissions during the coating process come from the evaporative loss of solvent around the coating head and from the exposed wet web prior to its entering the drying oven. The magnitude of these losses is determined by the width of the web, the line speed, the volatility and temperature of the solvent, and the air turbulence in the coating area.

Two factors that directly determine total line emissions are the weight (thickness) of the applied coating on the web and the solvent/solids ratio of the coating formulations. For coating formulations with a constant solvent/solids ratio during coating, any increases in coating weight would produce higher levels of VOC emissions. The solvent/solids ratio in coating formulations is not constant industrywide. This ratio varies widely among products. If a coating weight is constant, greater emissions will be produced by increasing the weight percent solvent of a particular formulation.

These 2 operating parameters, combined with line speed, line width, and solvent volatility, produce a number of potential mass emission situations. Table 4.2.2.9-1 presents emission factors for controlled and uncontrolled PSTL surface coating operations. The potential amount of VOC emissions from the coating process is equal to the total amount of solvent applied at the coating head.

4.2.2.9.4 Controls^{1,6-18}

The complete air pollution control system for a modern pressure sensitive tape or label surface coating facility consists of 2 sections, the solvent vapor capture system and the emission control device. The capture system collects VOC vapors from the coating head, the wet web, and the drying oven. The captured vapors are directed to a control device to be either recovered (as liquid solvent) or destroyed. As an alternate emission control technique, the PSTL industry is also using low-VOC content coatings to reduce their VOC emissions. Waterborne and hot melt coatings and radiation-cured prepolymers are examples of these low-VOC-content coatings. Emissions of VOC from such coatings are negligible or zero. Low-VOC-content coatings are not universally applicable to the PSTL industry, but about 25 percent of the production in this industry is presently using these innovative coatings.

4.2.2.9.4.1 Capture Systems -

In a typical PSTL surface coating facility, 80 to 95 percent of VOC emissions from the coating process is captured in the coating line drying ovens. Fans are used to direct drying oven emissions to a control device. In some facilities, a portion of the drying oven exhaust is recirculated into the oven instead of to a control device. Recirculation is used to increase the VOC concentration of the drying oven exhaust gases going to the control device.

Another important aspect of capture in a PSTL facility involves fugitive VOC emissions. Three techniques can be used to collect fugitive VOC emissions from PSTL coating lines. The first involves the use of floor sweeps and/or hooding systems around the coating head and exposed coated web. Fugitive emissions collected in the hoods can be directed into the drying oven and on to a control device, or they can be sent directly to the control device. The second capture technique involves enclosing the entire coating line or the coating application and flashoff areas. By

Table 4.2.2.9-1 (Metric And English Units). EMISSION FACTORS FOR PRESSURE SENSITIVE TAPE AND LABEL SURFACE COATING OPERATIONS

EMISSION FACTOR RATING: C

Emission Points	Nonmethane VOC ^a		
	Uncontrolled, kg/kg (lb/lb)	85% Control, kg/kg (lb/lb)	90% Control, kg/kg (lb/lb)
Drying oven exhaust ^b	0.80 - 0.95	—	—
Fugitives ^c	0.01 - 0.15	0.01 - 0.095	0.0025 - 0.0425
Product retention ^d	0.01 - 0.05	0.01 - 0.05	0.01 - 0.05
Control device ^e	—	0.045	0.0475
Total emissions ^f	1.0	0.15	0.10

^a Expressed as the mass of volatile organic compounds (VOC) emitted per mass of total solvent used. Solvent is assumed to consist entirely of VOC.

^b References 1,6-7,9. Dryer exhaust emissions depend on coating line operating speed, frequency of line downtime, coating composition, and oven design.

^c Determined by difference between total emissions and other point sources. Magnitude is determined by size of the line equipment, line speed, volatility and temperature of the solvents, and air turbulence in the coating area.

^d References 6-8. Solvent in the product eventually evaporates into the atmosphere.

^e References 1,10,17-18. Emissions are residual content in captured solvent-laden air vented after treatment. Controlled coating line emissions are based on an overall reduction efficiency which is equal to capture efficiency times control device efficiency. For 85% control, capture efficiency is 90% with a 95% efficient control device. For 90% control, capture efficiency is 95% with a 95% efficient control device.

^f Values assume that uncontrolled coating lines eventually emit 100% of all solvents used.

maintaining a slight negative pressure within the enclosure, a capture efficiency of 100 percent is theoretically possible. The captured emissions are directed by fans into the oven or to a control device. The third capture technique is an expanded form of total enclosure. The entire building or structure which houses the coating line acts as an enclosure. The entire room air is vented to a control device. The maintenance of a slight negative pressure ensures that very few emissions escape the room.

The efficiency of any vapor capture system is highly dependent on its design and its degree of integration with the coating line equipment configuration. The design of any system must allow safe and adequate access to the coating line equipment for maintenance. The system must also be designed to protect workers from exposure to unhealthy concentrations of the organic solvents used in the surface coating processes. The efficiency of a well-designed combined dryer exhaust and fugitive capture system is 95 percent.

4.2.2.9.4.2 Control Devices -

The control devices and/or techniques that may be used to control captured VOC emissions can be classified into 2 categories, solvent recovery and solvent destruction. Fixed-bed carbon

adsorption is the primary solvent recovery technique used in this industry. In fixed-bed adsorption, the solvent vapors are adsorbed onto the surface of activated carbon, and the solvent is regenerated by steam. Solvent recovered in this manner may be reused in the coating process or sold to a reclaimer. The efficiency of carbon adsorption systems can reach 98 percent, but a 95 percent efficiency is more characteristic of continuous long term operation.

The primary solvent destruction technique used in the PSTL industry is thermal incineration, which can be as high as 99 percent efficient. However, operating experience with incineration devices has shown that 95 percent efficiency is more characteristic. Catalytic incineration could be used to control VOC emissions with the same success as thermal incineration, but no catalytic devices have been found in the industry.

The efficiencies of carbon adsorption and thermal incineration control techniques on PSTL coating VOC emissions have been determined to be equal. Control device emission factors presented in Table 4.2.2.9-1 represent the residual VOC content in the exhaust air after treatment.

The overall emission reduction efficiency for VOC emission control systems is equal to the capture efficiency times the control device efficiency. Emission factors for 2 control levels are presented in Table 4.2.2.9-1. The 85 percent control level represents 90 percent capture with a 95 percent efficient control device. The 90 percent control level represents 95 percent capture with a 95 percent efficient control device.

References For Section 4.2.2.9

1. *The Pressure Sensitive Tape And Label Surface Coating Industry—Background Information Document*, EPA-450/3-80-003a, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1980.
2. *State Of California Tape And Label Coaters Survey*, California Air Resources Board, Sacramento, CA, April 1978. Confidential.
3. M. R. Rifi, "Water Based Pressure Sensitive Adhesives, Structure vs. Performance", presented at Technical Meeting On Water Based Systems, Chicago, IL, June 21-22, 1978.
4. *Pressure Sensitive Products And Adhesives Market*, Frost and Sullivan Inc., Publication No. 614, New York, NY, November 1978.
5. Silicone Release Questionnaire, Radian Corporation, Research Triangle Park, NC, May 4, 1979. Confidential.
6. Written communication from Frank Phillips, 3M Company, to G. E. Harris, Radian Corporation, Research Triangle Park, NC, October 5, 1978. Confidential.
7. Written communication from R. F. Baxter, Avery International, to G. E. Harris, Radian Corporation, Research Triangle Park, NC, October 16, 1978. Confidential.
8. G. E. Harris, "Plant Trip Report, Shuford Mills, Hickory, NC", Radian Corporation, Research Triangle Park, NC, July 28, 1978.
9. T. P. Nelson, "Plant Trip Report, Avery International, Painesville, OH", Radian Corporation, Research Triangle Park, NC, July 26, 1979.

10. *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.
11. Ben Milazzo, "Pressure Sensitive Tapes", *Adhesives Age*, 22:27-28, March 1979.
12. T. P. Nelson, "Trip Report For Pressure Sensitive Adhesives—Adhesives Research, Glen Rock, PA", Radian Corporation, Research Triangle Park, NC, February 16, 1979.
13. T. P. Nelson, "Trip Report For Pressure Sensitive Adhesives—Precoat Metals, St. Louis, MO", Radian Corporation, Research Triangle Park, NC, August 28, 1979.
14. G. W. Brooks, "Trip Report For Pressure Sensitive Adhesives—E. J. Gaisser, Incorporated, Stamford, CT", Radian Corporation, Research Triangle Park, NC, September 12, 1979.
15. Written communication from D. C. Mascone to J. R. Farmer, Office Of Air Quality Planning And Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC, June 11, 1980.
16. Written communication from R. E. Miller, Adhesives Research, Incorporated, to T. P. Nelson, Radian Corporation, Research Triangle Park, NC, June 18, 1979.
17. A. F. Sidlow, *Source Test Report Conducted At Fasson Products, Division Of Avery Corporation, Cucamonga, CA*, San Bernardino County Air Pollution Control District, San Bernardino, CA, January 26, 1972.
18. R. Milner, *et al.*, *Source Test Report Conducted At Avery Label Company, Monrovia, CA*, Los Angeles Air Pollution Control District, Los Angeles, CA, March 18, 1975.