4.2.2.13 Magnetic Tape Manufacturing[1-9]

Magnetic tape manufacturing is a subcategory of industrial paper coating, which includes coating of foil and plastic film. In the manufacturing process, a mixture of magnetic particles, resins, and solvents is coated on a thin plastic film or "web". Magnetic tape is used largely for audio and video recording and computer information storage. Other uses include magnetic cards, credit cards, bank transfer ribbons, instrumentation tape, and dictation tape. The magnetic tape coating industry is included in two Standard Industrial Classification codes, 3573 (Electronic Computing Equipment) and 3679 (Electronic Components Not Elsewhere Classified).

4.2.2.13.1 Process Description[1-2]

The process of manufacturing magnetic tape consists of:

1. mixing the coating ingredients (including solvents)
2. conditioning the web
3. applying the coating to the web
4. orienting the magnetic particles
5. drying the coating in a drying oven
6. finishing the tape by calendering, rewinding, slitting, testing,and packaging

Figure 4.2.2.13-1 shows a typical magnetic tape coating operation, indicating volatile organic compound (VOC) emission points. Typical plants have from 5 to 12 horizontal or vertical solvent storage tanks, ranging in capacity from 3,800 to 75,700 liters (1,000 to 20,000 gallons), that are operated at or slightly above atmospheric pressure. Coating preparation equipment includes the mills, mixers, polishing tanks, and holding tanks used to prepare the magnetic coatings before application. Four types of coaters are used in producing magnetic tapes: extrusion (slot die), gravure, knife, and reverse roll (3- and 4-roll). The web may carry coating on 1 or both sides. Some products receive a nonmagnetic coating on the back. After coating, the web is guided through an orientation field, in which an electromagnet or permanent magnet aligns the individual magnetic particles in the intended direction. Webs from which flexible disks are to be produced do not go through the orientation process. The coated web then passes through a drying oven, where the solvents in the coating evaporate. Typically, air flotation ovens are used, in which the web is supported by jets of drying air. For safe operation, the concentration of solvent vapors is held between 10 and 40 percent of the lower explosive limit. The dry coated web may be passed through several calendering rolls to compact the coating and to smooth the surface finish. Nondestructive testing is performed on up to 100 percent of the final product, depending on the level of precision required of the final product. The web may then be slit into the desired tape widths. Flexible disks are punched from the finished web with a die. The final product is then packaged. Some plants ship the coated webs in bulk to other facilities for slitting and packaging.

High performance tapes require very clean production conditions, especially in the coating application and drying oven areas. Air supplied to these areas is conditioned to remove dust particles and to adjust the temperature and humidity. In some cases, "clean room" conditions are rigorously maintained.
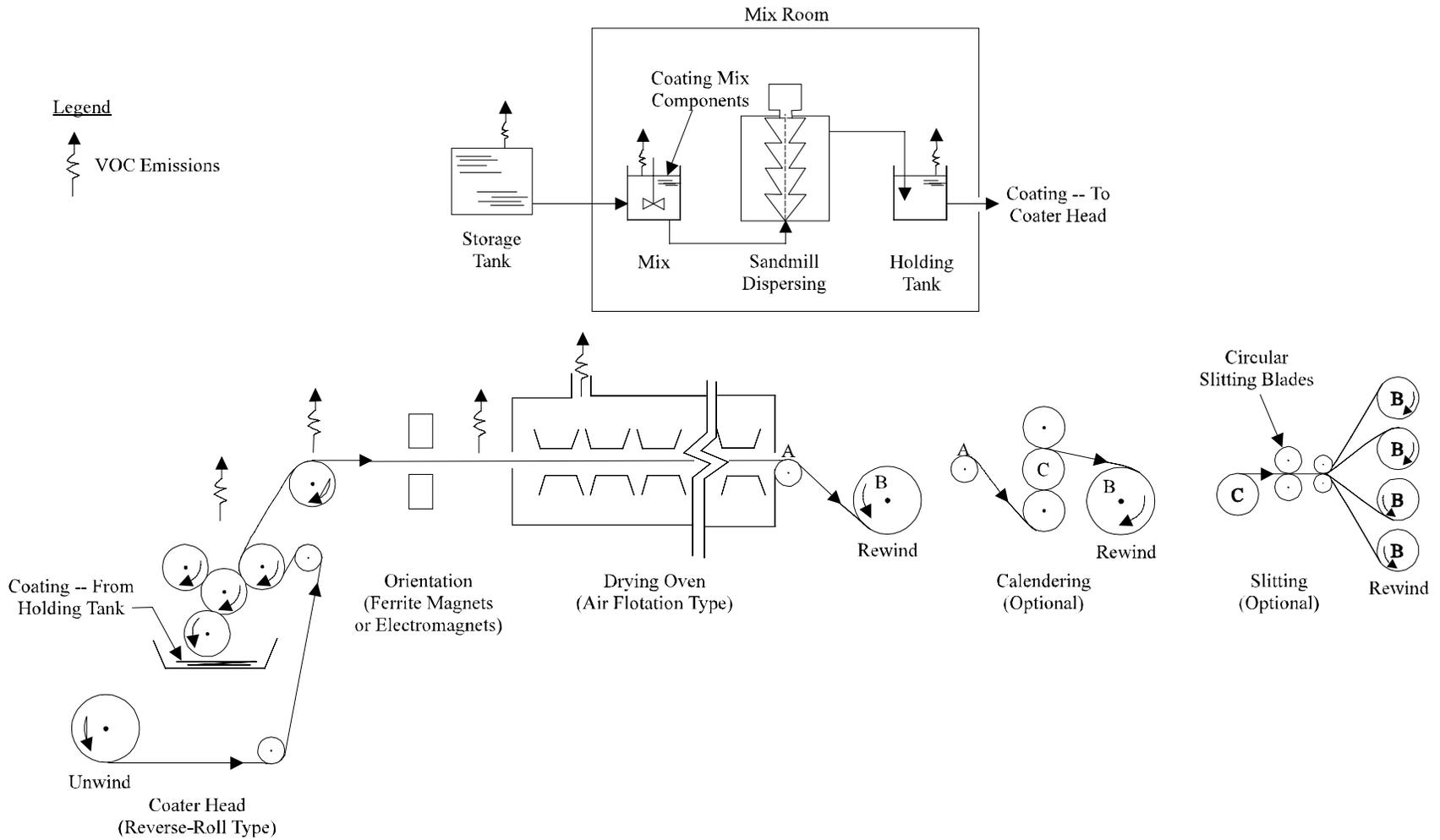
Legend

VOC Emissions

Mix Room

Coating Mix
Components

Coating -- To
Coater Head

Storage
Tank

Mix

Sandmill
Dispersing

Holding
Tank

Coating -- From
Holding Tank

Unwind

Coater Head
(Reverse-Roll Type)

Orientation
(Ferrite Magnets
or Electromagnets)

Drying Oven
(Air Flotation Type)

A

B

Rewind

A

C

B

Rewind

Calendering
(Optional)

Circular
Slitting Blades

C

B

B

B

B

Slitting
(Optional)

Rewind

Figure 4.2.2.13-2. Schematic drawing of a magnetic tape coating plant.[1]

4.2.2.13.2 Emissions And Controls[1-8]

The significant VOC emission sources in a magnetic tape manufacturing 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 generally only a negligible percentage of total emissions.

In the mixing or coating preparation area, VOCs are emitted from the individual pieces of equipment during the following operations: filling of mixers and tanks; 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). Factors affecting emissions in the mixing areas include the capacity of the equipment, the number of pieces of equipment, solvent vapor pressure, throughput, and the design and performance of equipment covers. Emissions will be intermittent or continuous, depending on whether the preparation method is batch or continuous.

Emissions from the coating application area result from the evaporation of solvent during use of the coating application equipment and from the exposed web as it travels from the coater to the drying oven (flashoff). 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 are of the remaining solvent that is driven off in the oven. Uncontrolled emissions at this point are determined by the solvent content of the coating when it reaches the oven. Because the oven evaporates all the remaining solvent from the coating, there are no process VOC emissions after oven drying.

Solvent type and quantity are the common factors affecting emissions from all operations in a magnetic tape coating facility. The rate of evaporation or drying depends on solvent vapor pressure at a given temperature and concentration. The most commonly used organic solvents are toluene, methyl ethyl ketone (MEK), cyclohexanone, tetrahydrofuran, and methyl isobutyl ketone. Solvents are selected for their cost, solvency, availability, desired evaporation rate, ease of use after recovery, compatibility with solvent recovery equipment, and toxicity.

Of the total uncontrolled VOC emissions from the mixing area and coating operation (application/flashoff area and drying oven), approximately 10 percent is emitted from the mixing area, and 90 percent from the coating operation. Within the coating operation, approximately 10 percent occurs in the application/flashoff area, and 90 percent in the drying oven.

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. Room ventilation systems, covers, and hoods are possible capture devices from coating preparation equipment. Room ventilation systems, hoods, and partial and total enclosures are typical capture devices used in the coating application area. A drying oven can be considered a capture device, because it both contains and directs VOC process emissions. The efficiency of a capture device or a combination of capture devices is variable and depends on the quality of design and the levels of operation and maintenance.

A control device is any equipment that has as its primary function the reduction of emissions to the atmosphere. 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, because they can be used either to direct emissions to a desired point outside the equipment or to prevent potential emissions from escaping.

Carbon adsorption units use activated carbon to adsorb VOCs from a gas stream, after which the VOCs are desorbed and 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 VOCs and to 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.

Condensers control VOC emissions by cooling the solvent-laden gas to the dew point of the solvent(s) and then 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 by 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 range of 400° to 540°C (750° to 1000°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 coating preparation equipment by reducing evaporative losses. The parameters affecting the efficiency of these controls are solvent vapor pressure, cyclic temperature change, tank size, and product throughput. A good system of tightly fitting covers on coating preparation equipment reduces emissions by as much as 40 percent. Control efficiencies of 95 or 98 percent can be obtained by venting the covered equipment to an adsorber, condenser, or incinerator.

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

$$\begin{array}{ccc} \text{capture} & & \text{control device} & & \text{control system} \\ \text{efficiency} & \text{x} & \text{efficiency} & = & \text{efficiency} \end{array}$$

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 have a control system efficiency of 54 percent (0.60 x 0.90 = 0.54). Table 4.2.2.13-1 summarizes control system efficiencies, which may be used to estimate emissions in the absence of measured data on equipment and coating operations.

Table 4.2.2.13-1. TYPICAL OF CONTROL EFFICIENCIES[a]

Control Technology	Control Efficiency %[b]
Coating Preparation Equipment	
Uncontrolled	0
Tightly fitting covers	40
Sealed covers with carbon adsorber/condenser	95
Coating Operation[c]	
Local ventilation with carbon adsorber/condenser	83
Partial enclosure with carbon adsorber/condenser	87
Total enclosure with carbon adsorber/condenser	93
Total enclosure with incinerator	95

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

4.2.2.13.3 Emission Estimation Techniques[1,3-9]

In this industry, realistic emission estimates require solvent consumption data. The variations found in coating formulations, line speeds, and products mean that no reliable inferences can be made otherwise.

In uncontrolled plants and in those where VOCs are recovered for reuse or sale, plantwide emissions can be estimated by performing a liquid material balance based on the assumption that all solvent purchased replaces that which has been emitted. Any identifiable and quantifiable side streams should be subtracted from this total. The liquid material balance may be performed using the following general formula:

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

The first term encompasses all solvent purchased, including thinners, cleaning agents, and any solvent directly used in coating formulation. From this total, any quantifiable solvent outputs are subtracted. Outputs may include reclaimed solvent sold for use outside the plant or solvent contained in waste streams. Reclaimed solvent that is reused at the plant is not 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. Care should be taken not to apply this method over too short a time span. Solvent purchase, production, and waste removal occur in cycles that may not coincide exactly.

Occasionally, a liquid material balance may be possible on a scale smaller than the entire plant. Such an approach may be feasible for a single coating line or group of lines, if 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 with solvent purchased. Reclaimed solvent is subtracted from this volume, whether or not it is reused on the site. 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.

Frequently, the configuration of meters, mixing areas, production equipment, and controls will make the liquid material balance approach impossible. In cases where control devices destroy potential emissions, or where a liquid material balance is inappropriate for other reasons, plantwide 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.

Two factors are necessary to calculate the quantity of solvent applied: solvent content of the coating and the quantity of coating applied. Coating solvent content can be either directly measured using EPA Reference Method 24 or estimated using coating formulation data usually available from the plant owner/operator. The amount of coating applied may be directly metered. If it is not, it must be determined from production data. These data 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. In cases where plant-specific data cannot be obtained, the information in Table 4.2.2.13-2 may be useful in approximating the quantity of solvent applied.

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

$$(\text{uncontrolled VOC}) \times (1 - \text{control system efficiency}) = (\text{VOC emitted})$$

As previously explained, the control system efficiency is the product of the efficiencies of the capture device and of the control device. If these values are not known, typical efficiencies for some combinations of capture and control devices are presented in Table 4.2.2.13-1. It is important to note that these control system efficiencies apply only to emissions that occur within the areas serviced by the systems. Emissions from sources such 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 consist of 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, very approximately, that 10 percent of the total solvent entering the mixing area is emitted during the mixing process. When an estimate of uncontrolled mixing area emissions has been made, the controlled emission rate can be calculated as discussed previously. Table 4.2.2.13-1 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 (130 kilograms [285 lb] per year or less). If an emissions estimate is desired, it can be computed using the equations, tables, and figures provided in Chapter 7.

Table 4.2.2.13-2 (Metric And English Units). SELECTED COATING MIX PROPERTIES[a]

Parameter	Unit	Range
Solids	weight % volume %	15 - 50 10 - 26
VOC	weight % volume %	50 - 85 74 - 90
Density of Coating	kg/L lb/gal	1.0 - 1.2 8 - 10
Density of Coating Solids	kg/L lb/gal	2.8 - 4.0 23 - 33
Resins/binder	weight % of solids	15 - 21
Magnetic particles	weight % of solids	66 - 78
Density of magnetic material	kg/L lb/gal	1.2 - 4.8 10 - 40
Viscosity	Pa • s $1b_f$ • s/ft^2	2.7 - 5.0 0.06 - 0.10
Coating thickness Wet	 μm mil	 3.8 - 54 0.15 - 2.1
Dry	μm mil	1.0 - 11 0.04 - 0.4

[a] Reference 9. To be used when plant-specific data are unavailable.

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3.   C. Beall, *"Distribution Of Emissions Between Coating Mix Preparation Area And The Coating Line"*, Memorandum file, Midwest Research Institute, Raleigh, NC, June 22, 1984.

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9.   C. Beall, "Summary Of Nonconfidential Information On U.S. Magnetic Tape Coating Facilities", Memorandum, with attachment, to file, Midwest Research Institute, Raleigh, NC, June 22, 1984.