VOLUME II: CHAPTER 8

Preferred and Alternative Methods for Estimating Air Emissions from Paint and Ink Manufacturing Facilities

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DISCLAIMER

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1

INTRODUCTION

The purposes of the preferred methods guidelines are to describe emission estimation techniques for point sources in a clear and unambiguous manner and to provide concise example calculations to aid in the preparation of emission inventories. While emissions estimates are not provided, the information presented in this document may be used to select an emission estimation technique best suited to a particular application. This chapter describes the procedures and recommended approaches for estimating emissions from paint and ink manufacturing operations and is intended to assist industry as well as regulatory agency personnel. Thus, some parts of the document may be more relevant to one group than to the other.

Section 2 of this chapter contains a general description of the paint and ink manufacturing source category, common emission sources, and an overview of available control technologies. Section 3 of this chapter provides an overview of available emission estimation methods. It should be noted that the use of site-specific emissions data is always preferred over the use of default values developed through use of industry-averaged data. However, depending upon available resources, obtaining site-specific data may not be cost effective.

Section 4 presents the preferred methods for estimating emissions from paint and ink manufacturing operations, while Section 5 presents the alternative emission estimation techniques. Quality assurance (QA) and quality control (QC) procedures are described in Section 6. Coding procedures used for data input and storage are discussed in Section 7. Some states use their own unique identification codes, so individual state agencies should be contacted to determine the appropriate coding scheme to use. References are cited in Section 8. Appendix A provides example data collection forms to assist in information gathering prior to emissions calculations.

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2

SOURCE CATEGORY DESCRIPTION

2.1 PROCESS DESCRIPTION

This section provides a brief overview of paint and ink manufacturing operations. The reader is referred to *Control of VOC Emissions from Ink and Paint Manufacturing Processes*, April 1992, for more detail (EPA, 1992a).

Paint and ink are suspensions of finely separated pigment particles in a liquid that when spread over a surface in a thin layer will form a solid, cohesive, and adherent film. Types of paints that are currently manufactured include architectural coatings, product finishes (e.g., finishes for automobiles, machinery, metal and wood furniture, and appliances), and special-purpose coatings (e.g., industrial new construction and maintenance paints, traffic marking paints, and marine paints) (EPA, 1992a). More than 70 percent of architectural coatings are water-based. However, solvent-based paint is still predominantly used for product finishes and special-purpose coatings (Noyes, 1993).

Inks that are currently manufactured include letterpress, lithographic and offset, gravure, and flexographic inks (EPA, 1992a). Letterpress and lithographic inks are typically classified as paste inks. Gravure and flexographic inks are typically water- or solvent-based and are classified as liquid inks (NAPIM, 1996). Specialty ink products include textile and silk screen ink, invisible inks, powder inks, carbon paper, typewriter, and duplicating inks (EPA, 1992a).

Paint and ink manufacturing can be classified as a batch process and generally involves the blending/mixing of resins, pigments, solvents, and additives. Traditional paint and ink manufacturing consists of four major steps:

- Preassembly and premix;
- Pigment grinding/milling/dispersing;
- Product finishing/blending; and
- Product filling/packaging (Fisher et al., 1993).

These steps are described in more detail in the sections below.

2.1.1 PREASSEMBLY AND PREMIX

In the preassembly and premix step, liquid raw materials are assembled and then mixed in containers to form a viscous material to which pigments are added (EPA, 1992a). For solvent-based paints, the raw ingredients include resins, organic solvents, plasticizers, dry pigment, and pigment extenders. Raw materials used in the preassembly and premix step for water-based paints include water, ammonia, dispersant, pigment, and pigment extenders (Noyes, 1993). Raw materials for ink manufacturing include pigments, oils, resins, solvents, and driers (EPA, 1992a). The premix stage results in the formation of an intermediate product that is referred to as the base or mill base (EPA, 1992a).

The type of equipment used in the premix step depends on the batch size and the type of paint and ink being produced. Drums equipped with a portable mixer may be used for drum-sized batches. These mixers normally have an impeller with three or four blades. Other materials made in portable mix tanks may be blended using larger, permanent high-speed dispersers or variable-speed mixers fitted with paddle, propeller, turbine, or disc-type agitators (EPA, 1992a).

Paint and ink manufacturing facilities may use typical grinding equipment to accomplish the premix operations (EPA, 1992a). This approach, common with water-based paints and inks, eliminates the need to transfer the material to another type of equipment for the grinding/milling step described below.

2.1.2 PIGMENT GRINDING OR MILLING

Pigment grinding or milling entails the incorporation of the pigment into the paint and ink vehicle to yield a fine particle dispersion. The three stages of this process include wetting, grinding, and dispersion, which may overlap in any grinding operation. The wetting agent, normally a surfactant, wets the pigment particles by displacing air, moisture, and gases that are adsorbed on the surface of the pigment particles. Grinding is the mechanical breakup and separation of pigment clusters into isolated particles and may be facilitated by the use of grinding media such as pebbles, balls, or beads. Finally, dispersion is the movement of wetted particles into the body of the liquid vehicle to produce a particle suspension. (EPA, 1992a).

There is a wide array of milling equipment. The type of equipment used depends on the types of pigments being handled (Noyes, 1993). More commonly used equipment include the following: roller mills, ball and pebble mills, attritors, sand mills, bead and shot mills, high-speed stone and colloid mills, high-speed dispersers, high-speed impingement mills, and horizontal media mills (EPA, 1992a). However, it should be noted that roller and ball mills are somewhat outdated methods in current pigment base manufacturing technology. Additionally, these types of equipment are usually associated with elevated levels of volatile organic compound (VOC) emissions due to their more open design.

Roller mills may have from one to five rolls that grind pigments into vehicles. Most paint and ink facilities that use rollermills operate with conventional three-roll mills. Roller mills are

labor intensive, requiring highly skilled operators. Their lack of speed and high operating cost make them unsuitable for large-volume production. The use of roller mills is confined to the manufacture of very high quality paint and inks and viscous pigmented products that require fine dispersion and clean color (EPA, 1992a).

High-speed dispersers are the most universally used method of dispersion in the paint and ink industry. Some paint and ink blends are manufactured entirely in one piece of equipment using high-speed, disk-type impellers. Because no grinding media are present in the mixing vat, pigment disperses on itself and against the surfaces of the rotor. While high-speed disk dispersion may work well for some products such as undercoats and primers, it may not be appropriate for high-quality paints and inks. It can, however, be used for premix operations of high-quality paints and inks, thus reducing the number of passes in a media mill or reducing the amount of time spent in a ball mill (EPA, 1992a).

2.1.3 PRODUCT FINISHING

Final product specifications for color, viscosity, and other coating characteristics are achieved in the product finishing step. This process generally consists of thinning, tinting, and blending. Most of the solvents, tints, and shades are added during this operation (Fisher et al., 1993).

Product finishing activities for solvent-based paints and inks involve adding various combinations of pigments, organic solvents, and resins. For water-based paints and inks, a preservative, an antifoaming agent, a polyvinyl acetate emulsion, and water are added at this step of the manufacturing process (Noyes, 1993).

Blending is the process of mixing the added ingredients to meet product specifications. Blending may consist of additional milling in a ball mill or added mixing and dispersing in a portable mix tank/high-speed disperser setup (EPA, 1992a).

2.1.4 PRODUCT FILLING

The final step in the paint and ink manufacturing process is the product filling operation. During the filling step, filtration is performed to remove impurities and to catch small particles of grinding media (Fisher et al., 1993).

Paints and inks may be filtered in a variety of ways and the end use of the product determines the type of filtration required. Some products require only a cloth bag filter; other products require filtering equipment such as strainers or sieves (Fisher et al., 1993).

Once the material has been filtered, it can be transferred into pails, drums, totes, tank wagons, or other containers for shipment. Filling may be accomplished either manually or mechanically depending on the number and size of the containers to be filled (EPA, 1992a).

2.2 EMISSION SOURCES

Several air emission sources have been identified for paint and ink manufacturing operations; they are as follows:

- Process operations;
- Miscellaneous operations;
- Material storage;
- Equipment leaks; and
- Spills.

Each of the above emission sources is described in more detail in the following sections.

2.2.1 PROCESS OPERATIONS

Process operations cover emissions from mixing, grinding, blending, and filling activities. Emissions from these operations can generally be classified in one of the following four categories.

Material Loading Emissions

VOC emissions may occur during material loading of mixing and grinding equipment due to displacement of organic vapors. VOCs may be emitted from a mixing tank when the device is uncovered or when a lid is open. For certain grinding equipment, VOCs may be released from the chute through which ingredients are added.

Particulate matter (PM) and PM less than or equal to 10 μm in diameter (PM_{10}) emissions may also occur during the material loading process from handling of pigments and other solids. VOC and PM emissions during material loading emissions may occur as point source or fugitive, depending on whether a PM emissions collection system is in place.

Heat-up Losses

Heat-up losses occur during operation of high-speed dispersers, ball and pebble mills, and similar types of dispersing equipment. During the grinding/dispersing process, there is a rise in temperature as some of the kinetic energy of mixing is converted to thermal energy. This rise in temperature is controlled through the use of cold water jackets. As the VOCs in the mixers heat up, the vapor in the headspace expands, forcing emissions from the equipment. Heat-up losses are classified as fugitive (Fisher et al., 1993).

Surface Evaporation

Surface evaporation may occur during mixing, dispersing, and blending operations if the vessel contents are exposed to the atmosphere. For certain types of mixing and grinding equipment, VOCs may be emitted through agitator shaft openings or around the edges of a vessel lid. VOC emissions from older vertical media mills (i.e., sand mills, bead mills, and shot mills) may occur from the exposed filtering screen. Surface evaporation emissions are generally fugitive in nature (EPA, 1992a).

Filling Losses

Emissions during product filling occur during transfer and free-fall into the receiving container. Resultant losses during the filling operations are classified as fugitive.

2.2.2 MISCELLANEOUS OPERATIONS

In addition to typical process operations associated with paint and ink manufacturing, miscellaneous operations can generate emissions (primarily in the form of VOCs). These operations are discussed below:

Solvent Reclamation

Solvent reclamation refers to the purification of dirty or spent solvent through use of a distillation device. VOC emissions occur from loading solvent into the distillation equipment, operation of the distillation equipment, and spillage. Emissions from loading and spilling are classified as fugitive, while emissions from operation of the equipment are generally discharged through a condenser vent and are thus classified as point source.

Cleaning

Cleaning is an important ancillary part of the paint and ink manufacturing process. Process equipment may be cleaned with solvent as often as after each batch. VOC emissions result from charging the mixer or disperser with solvent and can be characterized as fugitive. In addition to this type of cleaning, small items used in the paint and ink manufacturing process may be cleaned by washing with solvents in a cold cleaner or open-top vapor degreaser (Fisher et al., 1993). Of the two technologies, the use of a cold cleaner is more common. VOC emissions from this type of cleaning are classified as fugitive.

Wastewater Treatment

A paint and ink manufacturing facility may use a wastewater treatment system to treat contaminated water generated during the paint and ink manufacturing process (e.g., water that has been used to clean equipment used in the production of water-based paint and ink). Wastewater treatment systems generally consist of a series of surface impoundments that are used for equalization, neutralization, aeration, and clarification of the waste stream. Fugitive

VOC emissions may occur from each type of basin. Procedures used to estimate emissions from wastewater treatment facilities are described in detail in Volume II, Chapter 5, *Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment.*

2.2.3 MATERIAL STORAGE

Various types and sizes of storage tanks are used to store solvents and resins used in the paint and ink manufacturing process. Most of these tanks have a fixed-roof design (Fisher et al., 1993).

The two significant types of emissions from fixed-roof tanks are breathing and working losses. Breathing loss is the expulsion of vapor from a tank through vapor expansion and contraction that result from changes in ambient temperature and barometric pressure. This loss occurs without any liquid level change in the tank (EPA, 1995a).

The combined loss from filling and emptying tanks is called working loss. Evaporation during filling operations results from an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the tank exceeds the relief pressure and vapors are expelled from the tank. Evaporative emissions during emptying occur when air drawn into the tank during liquid removal becomes saturated with organic vapor and expands, expelling vapor through the vapor relief valve (EPA, 1995a).

Emissions from tanks are characterized as a point source because VOCs are released through a vent.

2.2.4 EQUIPMENT LEAKS

In order to transport stored materials (i.e., organic solvents and resins) from storage tanks to the paint and ink manufacturing operation, a network of pipes, pumps, valves, and flanges is employed. As liquid material is pumped from the storage tanks to the particular process area, the pipes and supporting hardware (process line components) may develop leaks over time. When leaks occur, volatile components in the transported material are released to the atmosphere. This generally occurs from the following process line components:

- Pump seals;
- Valves;
- Compressor seals;
- Safety relief valves;
- Flanges;

- Open-ended lines; and
- Sampling connections (Fisher et al., 1993).

Emissions from equipment leaks can be characterized as fugitive and are described in detail in Volume II, Chapter 4, *Preferred and Alternative Methods for Estimating Fugitive Emissions from Equipment Leaks*.

2.2.5 SPILLS

Solvents, resins, or product may be accidentally spilled during manufacturing or cleaning activities. Materials that are spilled onto the ground may spread over an area, vaporize, and thus result in an air emission (EPA, 1987). Such an emission would be characterized as fugitive.

2.3 PROCESS DESIGN AND OPERATING FACTORS INFLUENCING EMISSIONS

VOC and PM emissions from paint and ink manufacturing may be reduced through use of add-on control systems or through equipment and process modifications. Control devices and techniques commonly used at paint and ink manufacturing facilities are presented in Table 8.2-1.

TABLE 8.2-1

TYPICAL PAINT AND INK MANUFACTURING PLANT CONTROL TECHNIQUES[a]

Emission Source	Pollutant	Control Technique	Typical Efficiency (%)
Material Loading Operations	PM and PM_{10}	Fabric Filter	95 - 99
Mixing Operations	VOCs	Tank Lid	40 - 96

[a] Source: EPA, 1992a.

2.3.1 VOC CONTROL SYSTEMS

A VOC control system consists of a capture device and a removal device. The capture device (such as a hood or enclosure) captures the VOC-laden air from the emission area and ducts the emission stream to removal equipment such as a recovery device (e.g., an adsorber) or a combustion device (e.g., an incinerator) that removes the VOCs from the air. The overall efficiency of a control system is calculated by multiplying the capture system efficiency by the removal device efficiency (EPA, 1992a).

Removal equipment available for treating VOC-containing air streams includes recovery devices (i.e., carbon adsorption, absorption, and condensation) and combustion devices(i.e., thermal incinerators, catalytic incinerators, and industrial boilers and process heaters). Control efficiencies for this equipment can range from 50 to 99 percent. Carbon adsorbers, absorbers (scrubbers), condensers, and catalytic incinerators are generally not appropriate for paint and ink manufacturing facilities because these devices are not designed to treat low VOC inlet concentrations that are typical for the paint and ink industry. In addition, the wide mixture of organics that may be emitted at a paint and ink facility will tend to reduce the efficiency of these types of control devices. Industrial and process heaters are capable of effectively treating the types and levels of VOCs generated by the paint and ink industry but are found in few, if any, paint and ink manufacturing facilities (EPA, 1992a).

Thermal incineration is an applicable control technique for the paint and ink industry but is used by a limited number of facilities. Thermal incinerators pass the emission stream through a combustion chamber where the VOCs are burned at temperatures ranging from 700 to 1,300°C. VOC removal efficiencies of 98 percent or greater may be achieved depending on the design of the equipment.

The majority of paint and ink facilities use equipment and process modifications to reduce VOC emissions. These are discussed in more detail later in Section 2.3.3.

2.3.2 PM/PM_{10} Control Systems

PM/PM_{10} control systems for the paint and ink industry consist of a capture device paired with a control device that is typically a fabric filter (baghouse). These systems are typically employed to reduce PM emissions from charging pigments and other solids into mixing and grinding devices.

With fabric filter systems, particles are caught on the surface of the bags while the cleaned gaseous stream passes through. To minimize pressure drop, the bags must be cleaned periodically as the dust layer builds up (EIIP, 1996). The captured dust may be recycled or sent for off-site disposal or treatment.

Fabric filters are least efficient with particles 0.1 to 0.3 μm in diameter and with emission streams of high moisture content. When operated under optimum conditions, they can achieve control efficiencies of up to 99+ percent (EPA, 1991). However, typical control efficiencies range from 95 to 99 percent.

2.3.3 Equipment or Process Modifications

Most paint and ink manufacturing facilities reduce VOC emissions through equipment or process modifications. Some of these techniques will also reduce PM emissions. Modifications include those discussed below.

Tank Lids

Tank lids are the most common equipment modification used during paint and ink manufacturing activities to control VOC emissions. Lids reduce the amount of VOCs emitted during mixing operations and range in control efficiency from 40 to 96 percent (EPA, 1992a).

Modified Milling Equipment

VOC and PM emissions may be reduced by converting older milling equipment to newer, more efficient closed systems such as horizontal media mills. Typically, horizontal media mills are charged by pumping material from containers or premix equipment through an enclosed piping system. Material discharge is also through enclosed pipes or hoses. VOC losses during operation of the horizontal media mill are controlled because the filtering screen is enclosed by a sheet metal cover (EPA, 1992a).

Equipment Cleaning Devices

Several types of equipment can be used to reduce amounts of solvents used during vessel cleaning and thus decrease VOC emissions. These include the following:

- Rubber wipers (used to scrape the clinging paint and ink from the sides of the tank);
- High-pressure spray heads (used to clean process tanks);
- Tanks lined with Teflon™(Teflon™reduces the ability of paint and ink to cling to the sides of the tank);
- Plastic (or foam) "pigs" (a "pig" is moved through the pipes and pushes leftover paint and ink [from previous batches] through the pipe from the pipe walls); and
- Automatic tub washers.

The degree to which VOC emissions from cleaning activities are reduced will depend on the frequency of using one or more of the alternative cleaning techniques listed above. It has been reported that high-pressure spray heads can reduce cleaning material use by 80 to 90 percent (EPA, 1992a).

Use of Pigments in Paste Form

PM emissions may be reduced by using pigments that have been wetted or mixed with resins. Since these pigments are wet, less or no dust is generated when the package is opened and as pigment is dumped into mixing vessels (Noyes, 1993).

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Product Reformulation

Production of paints and inks that contain reduced or no VOCs will reduce VOC emissions from paint and ink manufacturing facilities. High-solids and water-based paints and inks contain less VOCs than traditional solvent-based paints and inks. Powder coatings and the majority of radiation-curable paints and inks contain no VOCs (EPA, 1992a).

3

OVERVIEW OF AVAILABLE METHODS

3.1 EMISSION ESTIMATION METHODS

Several methods are available for calculating emissions from paint and ink manufacturing operations. The best method to use depends upon the emission source being evaluated, available data, available resources, and the degree of accuracy required in the estimate. Although preferred methods are identified, this document does not mandate any emission estimation method. Industry personnel using this manual should contact the appropriate state or local air pollution control agency regarding suggested methods prior to their use.

This section discusses the methods available for calculating emissions from paint and ink manufacturing operations and identifies the preferred method of calculation. A discussion of the sampling and analytical methods available for monitoring each pollutant is provided in Chapter 1 of this volume, *Introduction to Point Source Emission Inventory Development.*

Estimation techniques for storage tank emissions are discussed in Chapter 1 of this volume. Equations and factors for calculating emissions from equipment leaks are discussed in Chapter 4, and procedures for estimating emissions from wastewater are described in Chapter 5. Thus, this chapter will address only process operations, miscellaneous operations, and spills.

3.1.1 EMISSION FACTORS

An emission factor can be defined as a pollutant emission rate relative to a level of source activity. Emission factors are typically based on the results of source tests performed at an individual plant or at one or more facilities within an industry. Chapter 1 of this volume contains a detailed discussion of the reliability/quality of available emission factors.

Emission factors may be used to calculate total VOC and PM emissions from a paint and ink manufacturing facility, as well as emissions from specific types of equipment typically found at such a facility. These types of equipment include the following:

- Process equipment;
- Solvent reclamation systems;
- Parts washing equipment; and
- Process piping.

EPA-approved emission factors for these sources may be found in *AP-42*, the *Locating and Estimating* series of documents, the Factor Information and Retrieval (FIRE) System, and/or *Protocol for Equipment Leak Emission Estimates* (EPA, 1995g). Emission factors may also be available through trade associations such as the National Association of Printing Ink Manufacturers, Inc. (NAPIM).

3.1.2 SOURCE-SPECIFIC MODELS

Theoretical, more complex "models" or equations can be used for estimating emissions. Emission estimating models/equations are available for the following types of emissions found at a paint or ink manufacturing facility:

- Material loading;
- Heat-up losses from dispersion/grinding activities;
- Surface evaporation during mixing/blending operations;
- Filling;
- Cleaning solvent loading;
- Material storage;
- Spills; and
- Wastewater treatment.

Inputs for theoretical models/equations generally fall into the following categories: chemical/physical properties of the material(s) involved (e.g., vapor pressure, vapor molecular weight), operating data (e.g., amount of material processed, operating hours) and physical characteristics/properties of the source (e.g., tank color, tank diameter).

3.1.3 MATERIAL (MASS) BALANCE CALCULATIONS

The material balance approach to emissions estimation considers the given facility as a sort of "black box," where one compares the total quantity of raw materials consumed versus amounts of materials leaving the facility as product or waste. Waste can consist of used filter bags or cartridges, spent solvent or still bottoms, dust collector material, pigment bags and/or drum residue, and wastewater (NPCA, 1995).

3.1.4 TEST DATA

Testing can be performed to quantify point source or fugitive emissions. In point source testing, effluent gas samples are usually collected from a stack using probes inserted through a port in the stack wall. Pollutants in the gas sample are collected in or on various media that

are subsequently sent to a laboratory for analysis. Pollutant concentrations are obtained by dividing the amount of pollutant collected during the test by the volume of gas sampled. Emission rates are then determined by multiplying the pollutant concentration by the volumetric stack gas flow rate. Because there are many steps in the stack sampling procedures where errors can occur, only experienced stack testers should perform such tests.

Industrial hygiene data (concentrations) can be used in conjunction with exhaust system flow rates to calculate fugitive emissions from a room, floor, or building. Direct-reading instruments that may be used to obtain an instantaneous reading of vapor concentrations include photoionization detectors, portable infrared spectrophotometers, and portable gas chromatographs (NPCA, 1995).

VOC losses from certain operations (e.g., filling of containers) may also be measured by performing a study using a gravimetric analysis such as American Society for Testing and Materials (ASTM) Standard D2369: *Test Method for Volatile Content of Coatings*.

Section 6 of this document, Quality Assurance/Quality Control, and Chapter 1 of Volume II in this series provide information regarding test data quality.

3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES

Table 8.3-1 identifies the preferred and alternative emission estimation approaches for selected pollutants and sources of emissions. The best method to use depends upon the emission source being evaluated, available data, available resources, and the degree of accuracy required in the estimate. In general, a more accurate method will require greater resources than a less accurate method. Case studies 8.3-1 and 8.3-2 present examples of two facilities with varying levels of resources. The emission estimation methods selected for each are driven by available resources and need for accuracy.

3.2.1 EMISSION FACTORS

Use of paint manufacturing emission factors from Section 6.4 of *AP-42* and ink manufacturing emission factors from Section 6.7 of *AP-42* is generally accepted by regulatory agencies, and their use in calculating total facility or process-specific emissions is more cost-effective than collection and analysis of air samples or use of emission models. Additionally, there are potentially significant limitations with the material balance approach.

3.2.2 EMISSION MODELS

Use of emission models/equations to estimate emissions from paint and ink manufacturing facilities is a more complex and time-consuming process than the use of emission factors. Emission models/equations require more detailed inputs than use of emission factors; however, they provide an emission estimate based on site-specific conditions.

TABLE 8.3-1

SUMMARY OF PREFERRED AND ALTERNATIVE EMISSION ESTIMATION METHODS FOR PAINT AND INK MANUFACTURING OPERATIONS

Pollutant	Emission Source	Preferred Emission Estimation Approach	Alternative Emission Estimation Approach
PM/PM_{10} (Total and Speciated)	Total Facility Emissions	Emission Factor[a]	Material Balance Testing[b]
	Process Equipment[c]	Emission Factor[a]	Material Balance Testing[b]
VOC (Total and Speciated)	Mixing: Material Loading Heat-up Losses Surface Evaporation	Emission Model[d]	Emission Factor[a] Material Balance Testing[b]
	Product Filling	Emission Model[e]	Material Balance Testing[b]
	Solvent Reclamation	Emission Factor[f]	Material Balance Testing[b]
	Cleaning; Solvent Loading	Emission Model[e]	Material Balance Testing[b]
	Cleaning; Parts Washing	Emission Factor[g]	Material Balance Testing[b]
	Wastewater Treatment	Emission Model[h]	Material Balance Testing[b]
	Material Storage	Emission Model[i]	Material Balance Testing[b]
	Equipment Leaks	Emission Factor[j]	Material Balance Testing[b]
	Spills	Emission Model[k]	Material Balance Testing[b]

[a] EPA, 1995b; in this chapter, see Sections 5.1.1 and 5.1.2 (VOC) and 4.2.4 (PM/PM_{10})for more detail.
[b] Refers to point source (stack) testing and/or fugitive testing (i.e., collection of industrial hygiene data).
[c] Refers to any equipment where pigments are handled.
[d] Fisher et al., 1993; EPA, 1995c; NPCA, 1995; EPA, 1993. Models are also available for grinding equipment.
[e] EPA, 1995c; see Section 4.1.1 of this document for more detail.
[f] EPA, 1995d; see Section 4.2.1 of this document for more detail.
[g] EPA, 1995e; see Section 4.2.2 of this document for more detail.
[h] EPA, 1994a; see Section 4.1.6 of this document for more detail.
[i] EPA, 1995a; see Section 4.1.5 of this document for more detail.
[j] EPA, 1995g; see Section 4.2.3 of this document for more detail.
[k] EPA, 1987; see Section 4.1.3 of this document for more detail.

Case Study 8.3-1: The Bright Blue Paint Company

Description

The Bright Blue Paint Company produces both water- and solvent-based industrial and consumer paints at a total rate of about 2,200,000 gallons annually. The water-based paints account for 65% of total production, with 55% being consumer products and 10% being industrial products. Solvent-based paints account for the remaining 35% of the paints manufactured of which 17% is consumer paints and of which 18% is industrial paints. The majority of the consumer products contain less than 1.5 pounds per gallon VOCs, while the industrial coatings may be as high as 3 pounds per gallon VOCs.

The four main manufacturing operations at the Bright Blue Paint Company are:

- Preassembly and premix;
- Pigment grinding/milling;
- Product finishing/blending;and
- Product filling/packaging.

The company manufactures seven different paint products that can vary in any given year. Batch sizes range from 300 to 1,600 gallons.

Liquid storage of paint ingredients and cleaning compounds is in bulk tanks ranging from 2,500 to 10,000 gallons and in 55-gallon drums. Powder ingredients are stored in paper sacks or fiber drums ranging from 10 to 200 pounds.

Equipment is cleaned after each batch. Approximately 72,000 gallons of cleaning solvents are used for equipment cleaning each year. Small parts are also cleaned as necessary using an open-top vapor degreaser.

Emission Sources

Emission sources for this facility include:

- Mixing (material loading, heat-up, surface evaporation);
- Filling losses;
- Cleaning (parts, mixers/tanks);
- Solvent reclamation;
- Material storage;
- Equipment leaks; and
- Spills.

Emissions

Emissions, the emission estimation method selected, and supporting data for this facility are summarized in Table 8.3-2.

TABLE 8.3-2

CASE STUDY 8.3-1: THE BRIGHT BLUE PAINT COMPANY EMISSIONS SUMMARY

Emission Source	Emission Estimation Method[a]	VOC Emissions	PM/PM_{10} Emissions	Supporting Data[b]
Mixing	Material Loading: VOC: loading loss model (Equation 8.4-1); PM/PM_{10}: AP-42 emission factor (Equation 8.4-24)	4,444 lb/yr	26.5 ton/yr	T = 77°F; S = 1.45; toluene = 1,008,000 gal; Methyl ethyl ketone = 564,000 gal; total solids = 5,292,000 lb
	Heat-up losses: heat-up loss model (Equation 8.4-16)	171 lb/yr	0	T1 = 77°F; T2 = 105°F; molecular weight (MW) of paint mixture = 85 lb/lb-mole; average MW = 77 lb/lb-mole; B: 1600-lb batches, 350; 1000-lb batches, 700; 600-lb batches, 1325; 300-lb batches, 500
	Surface evaporation: Clements vaporization model (Equation 8.4-18)	25 ton/yr	0	U = 0.25 mile/hr; T = 77°F; Batch size (lb/batch) / Area (ft^2) / Batchtime (hr) 1600 / 42.8 / 6 1000 / 26.8 / 8 600 / 20 / 6 300 / 13.4 / 8
Product Filling	Loading loss model (Equation 8.4-1)	293 lb/yr	0	Total product = 2,200,000 gal; T = 77°F; MW of paint and ink mixture = 85 lb/lb-mole
Cleaning	Equipment cleaning: loading loss model (Equation 8.4-1)	219 lb/yr	0	Total cleaning solvent = 72,000 gal/yr; cleaning solvent vapor pressure = 0.9 psia; MW of vapors = 100 lb/lb-mole; T = 75°F
	Small parts cleaning: AP-42 emission factor (Equation 8.4-24)	0.33 ton/yr	0	One open-top vapor degreaser is used for parts cleaning; emission factor is based on number of cleaning units
Solvent Reclamation	AP-42 emission factor (Equation 8.4-19)	990 lb/yr	0	300 tons of solvent are processed annually
Material Storage	TANKS	3 ton/yr	0	
Equipment Leaks	SOCMI[c] average emission factors	13 ton/yr	0	15 valves, 10 pump seals, and 5 connectors; hours of operation = 8,760 hr/yr

TABLE 8.3-2

CASE STUDY 8.3-1: THE BRIGHT BLUE PAINT COMPANY EMISSION SUMMARY (CONTINUED)

Emission Source	Emission Estimation Method[a]	VOC Emissions	PM/PM_{10} Emissions	Supporting Data[b]
Spills	Clements vaporization model (Equation 8.4-15)	7 lb/yr	0	One spill of heptane; vapor pressure = 0.9 psia; MW = 100 lb/lb-mole; T = 75°F; area of spill = 15 ft^2; cleanup time = 1 hour; U = 5 mile/hr
Total		36.4 ton/yr	26.5 ton/yr	

[a] Equation numbers refer to those used in Section 4 of this chapter.
[b] Symbols used are defined in Table 8.4-1.
[c] SOCMI = Synthetic organic chemical manufacturing industry.

Case Study 8.3-2: The Hot Pink Paint Company

Description

The Hot Pink Paint Company produces specialty coatings for a variety of surface coating industries. The facility produces 500,000 gallons solvent-based coatings annually. The facility operates 8,760 hours per year.

The four main manufacturing operations are:

- Preassembly and premix;
- Pigment grinding/milling;
- Product finishing/blending; and
- Product filling/packaging.

The company manufactures 5,000 different paint products that can vary in any given year. Batch sizes range from 100 to 2,000 gallons.

Liquid storage of paint ingredients and cleaning compounds is in bulk tanks ranging from 2,500 to 10,000 gallons and in 55-gallon drums. Powder ingredients are stored in paper sacks or fiber drums ranging from 10 to 200 pounds.

Equipment is cleaned after each batch. Approximately 50,000 gallons of cleaning solvents are used for equipment cleaning each year. Small parts are also cleaned as necessary using an open-top vapor degreaser.

Emission Sources

Emission sources for this facility include:

- Mixing (material loading, heat-up surface evaporation);
- Filling losses;
- Cleaning (parts, mixers/tanks);
- Solvent reclamation;
- Material storage;
- Equipment leaks; and
- Spills.

Emissions

Calculated emissions, the emission estimation method selected, and supporting data for this facility are summarized in Table 8.3-3.

TABLE 8.3-3

CASE STUDY 8.3-2: THE HOT PINK PAINT COMPANY EMISSIONS SUMMARY

Emission Source	Emission Estimation Method[a]	VOC Emissions	PM/PM_{10} Emissions	Supporting Data[b]
Mixing	VOC: EPA restated emission factor (Equation 8.5-3); PM/PM_{10}: AP-42 emission factor (Equation 8.4-24)	5.6 ton/yr	6.6 ton/yr	500,000 gal produced; solvent used = 750,000 lb/yr; total solids = 1,323,000 lb
Product Filling	Loading loss model (Equation 8.4-1)	34 lb/yr	0	500,000 gal produced; molecular weight (MW) = 75 lb/lb-mole; vapor pressure = 0.34 psia; T = 77 °F; S = 1.45
Cleaning	Equipment cleaning: loading loss model (Equation 8.4-1)	151 lb/yr	0	Total cleaning solvent = 50,000 gal/yr; cleaning solvent vapor pressure = 0.9 psia; MW of vapors = 100 lb/lb-mole; T=77°F
	Small parts cleaning: AP-42 emission factor (Equation 8.4-24)	0.33 ton/yr	0	One open-top vapor degreaser is used for parts cleaning; emission factors based on number of cleaning units
Solvent Reclamation	AP-42 emission factor (Equation 8.4-19)	396 lb/yr	0	120 tons of solvent are processed annually
Material Storage	TANKS	1 ton/yr	0	
Equipment Leaks	SOCMI[c] average emission factors	6 ton/yr	0	5 valves, 5 pump seals, and 2 connectors; hours of operation = 8,760 hr/yr
Spills	Material balance (Equation 8.5-6)	400 lb/yr	0	50 gal lost; density of spilled material = 8 lb/gal; assume worst case: all spilled material evaporates
Total		11.4 ton/yr	6.6 ton/yr	

[a] Equation numbers refer to those used in Section 4 of this chapter.
[b] Symbols used are defined in Table 8.4-1.
[c] SOCMI = Synthetic organic chemical manufacturing industry.

3.2.3 MATERIAL BALANCE CALCULATIONS

Calculating emissions from a paint or ink manufacturing facility using material balance appears to represent a straightforward approach to emissions estimations. However, few facilities track material usage and waste generation with the overall accuracy needed for application of this method, and inaccuracies associated with individual material tracking or other activities inherent to each material handling step often accumulate into large deviations. Because emissions from specific materials are typically below 1.5 percent of gross consumption, an error of only ±5.0 percent in any one step of the operation can significantly skew emissions calculations. Potential sources of error in the material balance calculation method include the following:

- The delivery of bulk raw materials at a paint or ink manufacturing facility is often tracked by volume, not by weight. Since density will vary with temperatures, the actual mass per unit volume of materials delivered in the summer may be less than that received in the winter.

- Raw materials received by paint or ink manufacturing facilities may potentially be used in hundreds or thousands of finished products. In order to complete the material balance, it is crucial that the exact quantity and speciation of each material shipped off-site in the product be known. For many facilities, it is extremely difficult, or currently impossible, to accurately track the distribution of specific raw materials across their entire product line.

- The amount of raw material contained in waste must also be considered. This may involve precise analysis of the concentration of the material of interest in each waste stream.

- Batch production of paint or ink often requires the manual addition of raw materials. Sometimes these additions are not accurately measured or recorded (NPCA, 1995).

3.2.4 TEST DATA

Use of stack and/or industrial hygiene test data is likely to be the most accurate method of quantifying air emissions from paint and ink manufacturing operations. However, collection and analysis of air samples from manufacturing facilities can be very expensive and especially complicated for paint and ink manufacturing facilities where a variety of VOCs are emitted and where most of the emissions may be fugitive in nature. Test data from one specific process may not be representative of the entire manufacturing operation and may provide only one example (a snapshot) of the facility's emissions.

To be representative, test data would need to be collected over a period of time that covers production of multiple paint and ink formulations. It may be necessary to sample multiple

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production areas. In addition, these methods do not address fugitive emissions that occur outside of a building. If testing is performed, care should be taken to ensure that a representative operational cycle has been selected. If possible, full cycles should be monitored as opposed to portions of cycles.

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4

PREFERRED METHODS FOR ESTIMATING EMISSIONS

The preferred methods for estimating VOC and PM emissions from paint and ink manufacturing operations are presented in this section. This section describes these methodologies and provides examples to illustrate the use of each calculation technique. Although the methods identified in this section are the preferred methods and the methods in Section 5 are alternative methods, the inventory preparer should determine which method is the most appropriate for each situation. For certain source types (e.g., material storage or storage tank emissions), the reader is referred to other chapters in Volume II for details on using the suggested methodology.

Table 8.4-1 lists the variables used in Equations 8.4-1 through 8.4-27.

4.1 EMISSION CALCULATION USING SOURCE-SPECIFIC EMISSION MODELS/EQUATIONS

Use of source-specific emission models/equations is the preferred technique for estimating VOC emissions from:

- Mixing operations (material loading, heat-up losses, and surface evaporation);
- Product filling;
- Vessel cleaning operations;
- Wastewater treatment processes;
- Material storage; and
- Spills.

TABLE 8.4-1

LIST OF VARIABLES AND SYMBOLS

Variable	Symbol	Units
Total VOC Emissions	E_{VOC}	lb/yr
Saturation Factor	S	dimensionless
Vapor Pressure of the Material Loaded	P	pounds per square inch absolute (psia)
Vapor Molecular Weight	M	lb/lb-mole
Volume of Material Loaded	Q	1,000 gal/yr
Temperature	T	°R
Partial Vapor Pressure of VOC Species x	P_x	psia
Liquid Mole Fraction of VOC Species x	m_x	mole/mole
True Vapor Pressure of VOC Species x	VP_x	psia
Henry's Law Constant for VOC Species x	H_x	psia
Liquid Mass Fraction of VOC Species x	z_x	lb/lb
Molecular Weight of VOC Species x	M_x	lb/lb-mole
Vapor Mole Fraction of VOC Species x	y_x	mole/mole
Loading Emissions of VOC or PM/PM_{10} Species x	E_x	lb/yr
Vapor Mass Fraction of VOC Species x	x_x	lb/lb
Initial Partial Pressure of VOC Species x	$(P_x)_{T1}$	psia
Final Partial Pressure of VOC Species x	$(P_x)_{T2}$	psia
Number of Pound-Moles of Gas Displaced	Δn	lb-moles/cycle
Vapor Molecular Weight, average	M_a	lb/lb-mole
Number of Cycles/Year	CYC	cycles/yr

TABLE 8.4-1

(CONTINUED)

Variable	Symbol	Units
Volume of Free Space in Vessel	V	ft^3
Universal Gas Constant at 1 Atmosphere of Pressure	R	10.73 psia · ft^3/lb-mole · °R
Initial Gas Pressure in Vessel	Pa_1	psia
Final Gas Pressure in Vessel	Pa_2	psia
Initial Temperature of Vessel	T1	°R
Final Temperature of Vessel	T2	°R
Molecular Weight of Liquid Mixture	M_1	lb/lb-mole
Gas-phase Mass Transfer Coefficient for VOC Species x	K_x	ft/sec
Surface Area (of Spill or Tank)	A	ft^2
Duration of Spill	HR	hr/event
Wind Speed	U	mile/hr
Diffusion Coefficient for VOC Species x in Air	D_x	ft^2/sec
Batch Time	H	hr/batch
Number of Batches per Year	B	batches/yr
VOC Emission Factor	EF_{VOC}	various
Amount of VOC in Spent Solvent Processed	Q_{VOC}	ton/yr
Concentration of VOC or PM/PM_{10} Species x in Solvent or Pigment x, Respectively	C_x	mass %
Mass Percent of Species x in Total Mixture	X_x	mass %

TABLE 8.4-1

(CONTINUED)

Variable	Symbol	Units
Volume Percent of Species x in Total Mixture	Y_x	volume %
Number of Species in Total Mixture	n	number
Operating Hours	OH	hr/yr
Number of Cleaning Units in Use	NU	cleaning units
PM/PM_{10} Emissions	E_{PM}	lb/yr
PM/PM_{10} Emission Factor	EF_{PM}	lb/ton
Amount of Pigment Containing Species x Used by the Facility	Q_x	lb/yr, ton/yr

These models are discussed with examples given below. For additional guidance on estimating emissions from wastewater collection and treatment, see Chapter 5 of this volume. See also Chapter 1 of this volume for additional guidance on material storage.

It is not recommended that paint and ink manufacturing facilities apply these models to each of the hundreds or even thousands of different formulations. Rather, formulations should be grouped based on composition and production rate, and a representative recipe and composition should be defined for each group. The emission calculations are then performed for each of the group representatives. In general, there are no specific guidelines for defining product groups except that the number of product groups chosen should be manageable (on the order of 15 to 20), and each product group composition should be fairly characteristic of its components (Fisher et al., 1993).

4.1.1 EMISSION MODEL FOR MATERIAL LOADING

VOC emissions resulting from the addition of materials to mixers, grinding equipment, and thindown tanks may be calculated using a loading loss equation (which is presented in Section 5.2 of *AP-42*; EPA, 1995c). This equation, shown below as Equation 8.4-1, is related to tank car or tank truck loading, but can be applied to any tank or vessel loading (NPCA, 1995). This equation may also be applied to estimate product filling losses.

$$E_{VOC} = 12.46 * \frac{S * P * M * Q}{T} \quad (8.4\text{-}1)$$

where:

E_{VOC}	=	Total VOC loading emissions (lb/yr);
S	=	Saturation factor (dimensionless; see Table 5.2-1 in *AP-42*);
P	=	Vapor pressure of the material loaded at temperature T (psia);
M	=	Vapor molecular weight (lb/lb-mole);
Q	=	Volume of material loaded (1,000 gal/yr); and
T	=	Temperature (°R).

Calculation of VOC emissions using Equation 8.4-1 is based on the following assumptions:

- The vapors displaced from the process vessel are identical to the vapors from the materials being loaded;
- The volume of vapor displaced is equal to the volume of material loaded into the vessel;
- The vapor within the headspace of the vessel is saturated at room temperature and remains at room temperature during loading; and
- All solvent additions are coincident at a constant temperature (in reality, solvent additions may be phased) (Fisher et al., 1993).

If multiple solvents are used, the vapor pressure (P) will need to be calculated using Equation 8.4-2:

$$P = \Sigma P_x \quad (8.4\text{-}2)$$

where:

P	=	Vapor pressure of material loaded (psia);
P_x	=	Partial pressure of VOC species x (psia).

P_x may be calculated using Raoult's Law (for ideal solutions) or using Henry's Law constants (when gases are dissolved at low concentrations in water). Raoult's Law is given in Equation 8.4-3:

$$P_x = m_x * VP_x \quad (8.4\text{-}3)$$

where:

P_x	=	Partial vapor pressure of VOC species x (psia);
m_x	=	Liquid mole fraction of VOC species x (mole/mole); and
VP_x	=	True vapor pressure of VOC species x (psia).

P_x may be calculated using Henry's Law constants and Equation 8.4-4:

$$P_x = m_x * H_x \qquad (8.4\text{-}4)$$

where:

P_x	=	Partial vapor pressure of VOC species x (psia);
m_x	=	Liquid mole fraction of VOC species x (mole/mole); and
H_x	=	Henry's Law constant for VOC species x.

The liquid mole fraction of VOC species x (m_x) may be calculated if the liquid weight fractions of all species are known. Equation 8.4-5 is used:

$$m_x = \frac{z_x/M_x}{\Sigma(z_x/M_x)} \qquad (8.4\text{-}5)$$

where:

m_x	=	Liquid mole fraction of VOC species x (mole/mole);
z_x	=	Liquid mass fraction of VOC species x (lb/lb); and
M_x	=	Molecular weight of VOC species x (lb/lb-mole).

The vapor molecular weight (M) will also need to be calculated if multiple solvents are used for a single cleaning event. Equation 8.4-6 may be used:

$$M = \Sigma(y_x * M_x) \quad (8.4\text{-}6)$$

where:

M	=	Vapor molecular weight (lb/lb-mole);
y_x	=	Vapor mole fraction of VOC species x (mole/mole); and
M_x	=	Molecular weight of VOC species x (lb/lb-mole).

The vapor mole fraction (y_x) is calculated using Equation 8.4-7:

$$y_x = \frac{P_x}{P} \quad (8.4\text{-}7)$$

where:

y_x	=	Vapor mole fraction of VOC species x (mole/mole);
P_x	=	Partial pressure of VOC species x (calculated using Equation 8.4-3 or 8.4-4) (psia); and
P	=	Vapor pressure of the material loaded (calculated using Equation 8.4-2).

Speciated VOC emissions are calculated using Equation 8.4-8:

$$E_x = E_{VOC} * x_x \quad (8.4\text{-}8)$$

where:

E_x	=	Loading emissions of VOC species x (lb/yr);
E_{VOC}	=	Total VOC loading emissions, calculated using Equation 8.4-1 (lb/yr); and
x_x	=	Vapor mass fraction of VOC species x (lb/lb).

The vapor mass fraction of VOC species x (x_x) is calculated using Equation 8.4-9:

$$x_x = \frac{y_x * M_x}{M} \qquad (8.4\text{-}9)$$

where:

x_x	=	Vapor mass fraction of VOC species x (lb/lb);
y_x	=	Vapor mole fraction of VOC species x, calculated using Equation 8.4-7 (mole/mole);
M_x	=	Molecular weight of VOC species x (lb/lb-mole); and
M	=	Vapor molecular weight, calculated using Equation 8.4-6 (lb/lb-mole).

Example 8.4-1 illustrates the use of the loading equation (Equation 8.4-1) and the supplemental equations (Equations 8.4-2 through 8.4-9).

Example 8.4-1

A mixing vessel is cleaned with a solvent mixture at the end of each day. The following data are given:

- The yearly consumption of the solvent mixture (Q) is 600,000 gal;
- The cleaning solvent is a 50/50 mixture (by weight) of toluene and heptane;
- The solvent mixture is splash loaded into the vessel (S = 1.45); and
- The temperature of the solvent is 77°F or 537°R (°R = °F + 460).

Emissions are calculated by following Steps 1 through 8 below.

Step 1: Apply Equation 8.4-5 - Calculation of Liquid Mole Fraction (m_x)

Component	Liquid Mass Fraction, z_x (lb of x/lb of liquid)	Molecular Weight, M_x (lb of x/lb-mole of x)	Liquid Mole Fraction, m_x (mole of x/mole of liquid)
Toluene	0.50	92	$\frac{z_x/M_x}{\Sigma(z_x/M_x)} = \frac{(0.5 / 92)}{[(0.5/92) + (0.5/100)]}$ = 0.52
Heptane	0.50	100	$\frac{z_x/M_x}{\Sigma(z_x/M_x)} = \frac{(0.5 / 100)}{[(0.5/92) + (0.5/100)]}$ = 0.48

Step 2: Apply Equation 8.4-3 - Calculation of Partial Vapor Pressure (P_x)

Component	Liquid Mole Fraction, m_x (mole of x/mole of liquid)	Vapor Pressure, VP_x (psia)	Partial Vapor Pressure, P_x (psia)
Toluene	0.52	0.58	$m_x * VP_x = 0.52 * 0.58$ = 0.30
Heptane	0.48	0.90	$m_x * VP_x = 0.48 * 0.90$ = 0.43

Step 3: Apply Equation 8.4-2 - Calculation of Vapor Pressure (P)

$$P = \Sigma P_x = 0.30 + 0.43 = 0.73 \text{ psia}$$

Step 4: Apply Equation 8.4-7 - Calculation of Vapor Mole Fraction (y_x)

Component	Partial Vapor Pressure, P_x (psia)	Total Vapor Pressure, P (psia)	Vapor Mole Fraction, y_x (mole of x/mole of vapor)
Toluene	0.30	0.73	$\frac{P_x}{P} = \frac{0.30}{0.73} = 0.41$
Heptane	0.43	0.73	$\frac{P_x}{P} = \frac{0.43}{0.73} = 0.59$

Step 5: Apply Equation 8.4-6 - Calculation of Vapor Molecular Weight (M)

$$M = \Sigma(y_x * M_x) = (0.41 * 92) + (0.59 * 100) = 97 \text{ lb/lb-mole}$$

Step 6: Apply Equation 8.4-9 - Calculation of Vapor Mass Fraction (x_x)

Component	Vapor Mole Fraction, y_x (mole of x/mole of vapor)	Molecular Weight, M_x (lb of x/lb-mole of x)	Vapor Molecular Weight, M (lb of vapor/lb-mole of vapor)	Vapor Mass Fraction, x_x (lb of x/lb of vapor)
Toluene	0.41	92	97	$\frac{y_x * M_x}{M} = \frac{0.41 * 92}{97} = 0.39$
Heptane	0.59	100	97	$\frac{y_x * M_x}{M} = \frac{0.59 * 100}{97} = 0.61$

Step 7: Apply Equation 8.4-1 - Calculate Total VOC Emissions (E_{VOC})

$$E_{VOC} = 12.46 * \frac{S * P * M * Q}{T}$$

$$= 12.46 * \frac{1.45 * 0.73 * 97 * 600}{537}$$

$$= 1{,}429 \text{ lb VOCs/yr}$$

Step 8: Apply Equation 8.4-8 - Calculate Speciated VOC Emissions (E_x)

Component	VOC Emissions, E_{VOC} (lb VOCs)	Vapor Mass Fraction, x_x (lb of x/lb of VOCs)	Speciated VOC Emissions, E_x (lb x)
Toluene	1,429	0.39	$E_{VOC} * x_x = 1{,}429 * 0.39 = 557$
Heptane	1,429	0.61	$E_{VOC} * x_x = 1{,}429 * 0.61 = 872$

4.1.2 HEAT-UP LOSSES

Heat-up losses that occur during the operation of high-speed dispersers, bead and ball mills, and similar types of dispersing equipment may be estimated by application of the Ideal Gas Law and vapor-liquid equilibria principles. Emissions are calculated using the following assumptions:

- Covers are closed during operation, but it is possible for vapors to be vented during operation;
- No material is added during heat-up;
- The displaced gas is always saturated with VOC vapor in equilibrium with the liquid mixture;
- The moles of gas displaced from the vessel result from the expansion of gases during heat-up and an increase in VOC vapor pressure; and
- The vapor pressure of the mixers never rises above 1 atmosphere 4 (Fisher et al., 1993).

The equation for calculating these emissions is based on equations found in *Control of Volatile Organic Compound Emissions from Batch Processes* and is shown in Equation 8.4-10 (EPA, 1994c):
where:

$$E_{VOC} = \frac{\left(\frac{\Sigma (P_x)_{T1}}{14.7 - \Sigma (P_x)_{T1}}\right) + \left(\frac{\Sigma (P_x)_{T2}}{14.7 - \Sigma (P_x)_{T2}}\right)}{2} * \Delta n * M_a * CYC \qquad (8.4\text{-}10)$$

E_{VOC}	=	VOC emissions from material heat-up in the process equipment (lb/yr);
$(P_x)_{T1}$	=	Initial partial pressure of each VOC species x in the vessel headspace at the initial temperature T1 (psia); see Equations 8.4-3 and 8.4-4;
$(P_x)_{T2}$	=	Final partial pressure of each VOC species x in the vessel headspace at the final temperature T2 (psia); see Equations 8.4-3 and 8.4-4;
Δn	=	Number of pound-moles of gas displaced (lb-mole/cycle);
M_a	=	Average vapor molecular weight (lb/lb-mole); and
CYC	=	Number of cycles per year (cycles/yr).

The term Δn may be calculated using Equation 8.4-11:

$$\Delta n = \frac{V}{R} * \left(\frac{Pa_1}{T1} - \frac{Pa_2}{T2} \right) \quad (8.4\text{-}11)$$

Where:

Δn	=	Number of pound-moles of gas displaced (lb-mole/cycle);
V	=	Volume of free space in the vessel (ft^3);
R	=	Universal gas constant at 1 atmosphere of pressure, 10.73 psia · ft^3/lb-mole · °R
Pa_1	=	Initial gas pressure in vessel (psia);
Pa_2	=	Final gas pressure in vessel (psia);
T1	=	Initial temperature of vessel (°R); and
T2	=	Final temperature of vessel (°R).

Pa_1 and Pa_2 may be calculated using Equations 8.4-12 and 8.4-13:

$$Pa_1 = 14.7 - \Sigma(P_x)_{T1} \quad (8.4\text{-}12)$$

$$Pa_2 = 14.7 - \Sigma(P_x)_{T2} \quad (8.4\text{-}13)$$

where:

Pa_1	=	Initial gas pressure in vessel (psia);
Pa_2	=	Final gas pressure in vessel (psia);
$(P_x)_{T1}$	=	Partial pressure of each VOC_x in the vessel headspace (psia) at the initial temperature T1; see Equations 8.4-3 and 8.4-4;
$(P_x)_{T2}$	=	Partial pressure of each VOC_x in the vessel headspace (psia) at the final temperature T2; see Equations 8.4-3 and 8.4-4.

Speciated VOC emissions would be calculated using a modified version of Equation 8.4-10 as shown in Equation 8.4-14:

$$E_x = \frac{\left(\frac{(P_x)_{T1}}{14.7 - (P_x)_{T1}}\right) + \left(\frac{(P_x)_{T2}}{14.7 - (P_x)_{T2}}\right)}{2} * \Delta n * M_a * CYC \qquad (8.4\text{-}14)$$

where:

E_x	=	VOC species x emissions from material heat-up in the process equipment (lb/yr);
$(P_x)_{T1}$	=	Partial pressure of VOC species x in the vessel headspace at the initial temperature T1 (psia); see Equations 8.4-3 and 8.4-4;
$(P_x)_{T2}$	=	Partial pressure of VOC species x in the vessel headspace at the final temperature T2 (psia); see Equations 8.4-3 and 8.4-4;
Δn	=	Number of pound-moles of gas displaced (lb-mole/cycle); see Equation 8.4-11;
M_a	=	Average vapor molecular weight (lb/lb-mole); and
CYC	=	Number of cycles/year.

Example 8.4-2 illustrates the use of Equations 8.4-10 through 8.4-13. Emissions are calculated by following Steps 1 through 6 presented on the next few pages.

Example 8.4-2

This example shows how heat-up losses from a disperser are calculated using Equations 8.4-10 through 8.4-13. Supporting equations from Section 4.1.1 (Equations 8.4-3 and 8.4-5) are also used in this example.

A 3,000-gallon, high-speed disperser contains 2,000 gallons of paint. The following data are given:

- The paint consists of 30 percent by weight toluene, 20 percent by weight methyl ethyl ketone (MEK), and 50 percent by weight pigments and nonvolatile resins;
- The initial temperature (T1) of the mixture is 77°F or 537°R (°R = °F + 460);
- The final temperature (T2) is 105°F (565°R);
- The approximate molecular weight (M) of the paint mixture is 85 lb/lb-mole;
- The average vapor molecular weight (M_a) is 77 lb/lb-mole (calculated using Equation 8.4-6); and
- The mixer goes through the given temperature cycle with this paint formulation 25 times/yr (CYC).
- The volume of free space in the vessel is 3,000 - 2,000 gal = 1,000 gal or 133.68 ft^3.

Step 1: Apply Equation 8.4-5, Calculation of Liquid Mole Fraction (m_x)

Component x	Liquid Mass Fraction, z_x (lb of x/lb of liquid)	Molecular Weight, M_x (lb of x/lb-mole of x)	Liquid Mole Fraction, m_x (mole of x/mole of liquid)
Toluene	0.3	92	$\frac{z_x/M_x}{\Sigma(z_x/M_x)} = \frac{0.3/92}{1/85^a} = 0.28$
MEK	0.2	72	$\frac{z_x/M_x}{\Sigma(z_x/M_x)} = \frac{0.2/72}{1/85^a} = 0.24$

[a] If the molecular weight of the mixture is known, the following expression can be used:

$$m_x = \frac{z_x/M_x}{\Sigma\,(z_x/M_x)} = \frac{z_x/M_x}{1/M_l}$$

where:

M_l = Molecular weight of the liquid mixture, and all other terms are defined as in Equation 8.4-5.

Step 2: Apply Equation 8.4-3, Calculation of Partial Vapor Pressure at Initial Temperature [$(P_x)_{T1}$]

Component x	Liquid Mole Fraction, m_x (mole of x/mole of liquid)	Vapor Pressure, VP_x @ 77°F (psia)	Partial Pressure at T1, $(P_x)T1$ (psia)
Toluene	0.28	0.58	$m_x * VP_x = 0.28 * 0.58 = 0.16$
MEK	0.24	1.93	$m_x * VP_x = 0.24 * 1.93 = 0.46$

Step 3: Apply Equation 8.4-3, Calculation of Partial Pressure at Final Temperature [$(P_x)_{T2}$]

Component x	Liquid Mole Fraction, m_x (mole/mole)	Vapor Pressure, VP_x @ 105°F (psia)	Partial Pressure at T2, $(P_x)_{T2}$ (psia)
Toluene	0.28	1.16	m_x * VPx = 0.28 * 1.16 = 0.32
MEK	0.24	3.75	m_x * VP_x = 0.24 * 3.75 = 0.90

Step 4: Apply Equations 8.4-12 and 8.4-13, Calculation of Initial Pressure (Pa_1) and Final Pressure (Pa_2)

$$Pa_1 = 14.7 - \Sigma(P_x)_{T1} = 14.7 - (0.16 + 0.46) = 14.1 \text{ psia}$$

$$Pa_2 = 14.7 - \Sigma(P_x)_{T2} = 14.7 - (0.32 + 0.90) = 13.5 \text{ psia}$$

Step 5: Apply Equation 8.4-11, Calculation of lb-moles Gas Displaced (Δn)

The volume of free space in the vessel (V) is 3,000 gal - 2,000 gal = 1,000 gal or 133.68 ft^3.

$$\Delta n = \frac{V}{R} * \left(\frac{Pa_1}{T_1} - \frac{Pa_2}{T_2} \right)$$

$$= \frac{133.68}{10.73} * \left(\frac{14.1}{537} - \frac{13.5}{565} \right)$$

$$= 0.03 \text{ lb-moles/CYC}$$

Step 6: Apply Equation 8.4-10, Calculation of Total VOC Emissions (E_{VOC})

$$E_{VOC} = \frac{\left(\frac{\Sigma (P_x)_{T1}}{14.7 - \Sigma (P_x)_{T1}}\right) + \left(\frac{\Sigma (P_x)_{T2}}{14.7 - \Sigma (P_x)_{T2}}\right)}{2} * \Delta n * M * CYC$$

$$= \frac{\left(\frac{(0.16 + 0.46)}{14.7 - (0.16 + 0.46)}\right) + \left(\frac{(0.32 + 0.90)}{14.7 - (0.32 + 0.90)}\right)}{2} * 0.03 * 77 * 25$$

$$= 3.9 \text{ lb VOCs/yr}$$

Step 7: Apply Equation 8.4-14, Calculation of Toluene Emissions (E_{VOC})

$$E_{VOC} = \frac{\left(\frac{(P_x)_{T1}}{14.7 - (P_x)_{T1}}\right) + \left(\frac{(P_x)_{T2}}{14.7 - (P_x)_{T2}}\right)}{2} * \Delta n * M * CYC$$

$$= \frac{\left(\frac{(0.16 + 0.46)}{14.7 - (0.16 + 0.46)}\right) + \left(\frac{(0.32 + 0.90)}{14.7 - (0.32 + 0.90)}\right)}{2} * 0.03 * 77 * 25$$

$$= 0.96 \text{ lb toluene/yr}$$

4.1.3 EMISSION MODEL FOR SPILLS

A vaporization model developed by Clements can be used to estimate the evaporation rate of a liquid chemical spill if the size (area) of the spill is known or can be estimated. This is a simple model, but other available spill models are more complex and may require more input data (EPA, 1987). Equation 8.4-15, used for the simple model, is as follows:

$$E_x = \frac{M_x * K_x * A * P_x * 3600 * HR}{R * T} \qquad (8.4\text{-}15)$$

where:

E_x	=	Emissions of VOC species x from the spill (lb/event);
M_x	=	Molecular weight of VOC species x (lb/lb-mole);
K_x	=	Gas-phase mass transfer coefficient for VOC species x (ft/sec);
A	=	Surface area of spill (ft^2);
P_x	=	Partial pressure of VOC species x (if a pure chemical is spilled) or the partial pressure of chemical x (if a mixture of VOCs is spilled) at temperature T (psia)[a];
3600	=	3600 sec/hr;
HR	=	Duration of spill (hr/event);
R	=	Universal gas constant at 1 atmosphere of pressure, 10.73 psia · ft^3/lb-mole · °R; and
T	=	Temperature of the liquid spilled, °R.

The gas-phase mass transfer coefficient (K_x) may be calculated using Equation 8.4-16:

$$K_x = 0.00438 * U^{0.78} * \left(\frac{D_x}{3.1 \times 10^{-4}} \right)^{2/3} \quad (8.4\text{-}16)$$

where:

K_x	=	Gas-phase mass transfer coefficient for VOC species x (ft/sec);
U	=	Wind speed (mile/hr);
D_x	=	Diffusion coefficient for VOC species x in air (ft^2/sec)

Diffusion coefficients (D_x) can be found in chemical handbooks and are usually expressed in units of square centimeters per second (cm^2/sec). If a diffusion coefficient is not available for a particular chemical, the gas-phase mass transfer coefficient (K_x) may be estimated using Equation 8.4-17:

$$K_x = 0.00438 * U^{0.78} * \left(\frac{18}{M_x} \right)^{1/3} \quad (8.4\text{-}17)$$

[a] The partial pressure of VOC species x (P_x) may be calculated using Equation 8.4-3 or Equation 8.4-4.

where:

K_x	=	Gas-phase mass transfer coefficient for VOC species x (ft/sec);
U	=	Wind speed (mile/hr); and
M_x	=	Molecular weight of VOC species x (lb/lb-mole).

Example 8.4-3 illustrates the use of these equations.

Example 8.4-3

Methyl ethyl ketone (MEK) is spilled onto the ground outside of a building. The following data are given:

- The spill is not detected for 1 hour; it takes an additional 2 hours to recover the remaining MEK; the duration of the spill (HR), therefore, is 3 hours.
- The average wind speed (U) is 8 mile/hr.
- The ambient temperature (T) is 77°F or 537°R (°R = °F +460).
- The surface area of the spill (A) is 100 ft^2.
- The molecular weight of MEK (M_x) is 72 lb/lb-mole.
- The partial pressure of MEK (P_x) at 77°F is approximately 1.93 psia.

Step 1: Using Equation 8.4-17, calculate the Gas-phase Mass Transfer Coefficient (K_x)

$$K_x = 0.00438 * U^{0.78} * \left(\frac{18}{M_x}\right)^{1/3}$$

$$= 0.00438 * 8^{0.78} * \left(\frac{18}{72}\right)^{1/3}$$

$$= 0.01397 \text{ ft/sec}$$

Step 2: Using Equation 8.4-15, calculate Emissions (E_x)

$$E_x = \frac{M_x * K_x * A * P_x * 3600 * HR}{R * T}$$

$$= \frac{72 * 0.01397 * 100 * 1.93 * 3600 * 3}{10.73 * 537}$$

$$= 364 \text{ lb MEK/spill}$$

4.1.4 EMISSIONS MODEL FOR SURFACE EVAPORATION

Emissions from surface evaporation during paint and ink mixing operations can be estimated using Equation 8.4-18, which is based on the Clements vaporization model.

$$E_x = \frac{M_x * K_x * A * P_x * 3600 * H}{R * T} * B \qquad (8.4\text{-}18)$$

where:

E_x	=	Emissions of VOC species x (lb/yr);
M_x	=	Molecular weight of VOC species x (lb/lb-mole);
K_x	=	Gas-phase mass transfer coefficient for VOC species x (ft/sec);
A	=	Surface area of tank (ft^2);

P_x	=	Vapor pressure of VOC x (if a pure chemical is used) or the partial pressure of chemical x (if a mixture of VOCs is used) at temperature T (psia)[a];
3600	=	3600 sec/hr;
H	=	Batch time (hr/batch);
R	=	Universal gas constant at 1 atmosphere of pressure, 10.73 psia · ft^3/lb mole · °R;
T	=	Temperature of the liquid, °R; and
B	=	Number of batches per year (batches/yr).

Equations 8.4-16 or 8.4-17 can be used to estimate K_x. Total VOC emissions would equal the sum of all VOC species emissions.

Example 8.4-4 illustrates the use of Equation 8.4-18.

Example 8.4-4

This example estimates emissions from a mixing operation due to surface evaporation. The following data are given:

- The batch time (H) is 4 hours.
- The number of batches per year (B) is 550.
- The average wind speed (U) is 0.1 miles/hr.
- The ambient temperature (T) is 77°F or 537°R (°R = °F +460).
- The surface area of the mixing tank (A) is 80 ft^2.
- The molecular weight of toluene (M_x) is 92 lb/lb-mole.
- The partial vapor pressure of toluene (P_x) at 77°F is approximately 0.58 psia.

[a] The partial pressure of VOC species x (P_x) may be calculated using Equation 8.4-3 or Equation 8.4-4.

Step 1: Using Equation 8.4-17, calculate the Gas-phase Mass Transfer Coefficient (K_x)

$$K_x = 0.00438 * U^{0.78} * \left(\frac{18}{M_x}\right)^{1/3}$$

$$= 0.00438 * 0.1^{0.78} * \left(\frac{18}{92}\right)^{1/3}$$

$$= 0.000422 \text{ ft/sec}$$

Step 2: Using Equation 8.4-15, calculate Emissions (E_x)

$$E_x = \frac{M_x * K_x * A * P_x * 3600 * H}{R * T} * B$$

$$= \frac{92 * 0.000422 * 80 * 0.58 * 3600 * 4}{10.73 * 537} * 550$$

$$= 2{,}476 \text{ lb toluene/yr}$$

4.1.5 EMISSION MODEL FOR LIQUID MATERIAL STORAGE

The preferred method for calculating emissions from storage tanks is the use of equations presented in *AP-42*. EPA has developed a software package (TANKS) for calculating these types of emissions. The reader is referred to Chapter 1 of this volume, *Introduction to Stationary Point Source Emissions Inventory Development*, for more information on using the TANKS program. Additionally, the reader should consult their state agency and/or the EPA's Clearinghouse for Inventories and Emission Factors (CHIEF) bulletin board system (BBS) or website for the most recent version of TANKS.

4.1.6 EMISSION MODEL FOR WASTEWATER TREATMENT

VOC emissions from a wastewater treatment system may be estimated using equations presented in *Air Emissions Models for Waste and Wastewater* (EPA, 1994a), and Chapter 5, *Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment Facilities*, of this volume. These documents, as well as models such as WATER8 and CHEMDAT8, are available on the EPA's CHIEF website.

4.2 EMISSION CALCULATION USING EMISSION FACTORS

Emission factors are commonly used to calculate emissions from paint and ink manufacturing facilities. EPA maintains a compilation of approved emission factors in *AP-42* for criteria pollutants and hazardous air pollutants (HAPs). Emission factors for equipment leaks may be found in *Protocol for Equipment Leak Emission Estimates* (EPA, 1995g). Chapter 4 of this volume discusses emission estimates from equipment leaks.

The most comprehensive source for toxic air pollutant emission factors is the Factor Information and Retrieval (FIRE) data system, which also contains criteria pollutant emission factors (EPA, 1995h).

Currently, emission factors are the preferred method for estimating VOC emissions from the following types of sources found in a paint and ink manufacturing facility:

- Solvent reclamation systems;
- Parts washing equipment; and
- Process piping.

Emission factors are also the preferred method for estimating PM/PM_{10} emissions from paint and ink manufacturing facilities.

VOC emission factors are also available in *AP-42* for calculating total plant emissions and mixing operation emissions from a paint manufacturing facility and for vehicle cooking and pigment mixing emissions from an ink manufacturing facility. These emission factors are discussed further in Sections 5.1.1 through 5.1.3.

4.2.1 TOTAL AND SPECIATED VOC EMISSIONS FROM SOLVENT RECLAMATION

VOC emissions from the loading and operation of a distillation device may be calculated using emission factors (EPA, 1995d). *AP-42* also presents factors for spills and the storage of materials associated with the solvent reclamation process; however, the preferred emission estimation technique for these sources is the use of models discussed previously in this section.

To calculate total VOCs from loading or operation of the distillation device, use Equation 8.4-19:

$$E_{VOC} = EF_{VOC} * Q_{VOC} \qquad (8.4\text{-}19)$$

where:

E_{VOC}	=	VOC emissions from loading or operation of the distillation device (lb/yr);
EF_{VOC}	=	VOC emission factor for loading of the distillation device or for the distillation column condenser vent (lb VOCs emitted/ton VOCs processed); and
Q_{VOC}	=	Amount of VOC in spent solvent processed through the distillation device (ton/yr).

Speciated VOC emissions are then calculated using Equation 8.4-20:

$$E_x = E_{VOC} * C_x/100 \qquad (8.4\text{-}20)$$

where:

E_x	=	Emissions of VOC species x from loading or operation of the distillation device (lb/yr);
E_{VOC}	=	VOC emissions from loading or operation of the distillation device, calculated using Equation 8.4-20 (lb/yr); and
C_x	=	Concentration of VOC species x in the solvent processed through the distillation system (mass %).

Example 8.4-5 illustrates the use of Equations 8.4-19 and 8.4-20.

If the species x concentration is provided on a volume basis, the volume percent will need to be converted to mass percent. If molecular weight of the total mixture is known, the volume percent of species x in the total mixture can be converted to mass percent using Equation 8.4-21:

$$X_x = Y_x * \frac{M_x}{M} * 100 \qquad (8.4\text{-}21)$$

where:

X_x	=	Mass percent of species x in total mixture;
Y_x	=	Volume percent of species x in total mixture;
M_x	=	Molecular weight of species x; and
M	=	Molecular weight of total mixture.

If molecular weight of the total mixture is not known, the volume percent can be converted to mass percent using Equation 8.4-22:

$$M = \sum_{x=1}^{n} \left(\frac{Y_x}{100} * M_x \right) \qquad (8.4\text{-}22)$$

where:

M	=	Molecular weight of total mixture;
n	=	Number of species in total mixture;
Y_x	=	Volume percent of species x in total mixture; and
M_x	=	Molecular weight of species x.

Example 8.4-5

First, total VOC emissions from operation of a distillation device may be calculated using an emission factor from *AP-42*, Table 4.7-1 and Equation 8.4-19.

EF_{VOC} = 3.30 lb VOCs/ton solvent processed
Q_{VOC} = 5 tons spent solvent processed/yr

E_{VOC} = $EF_{VOC} * Q_{VOC}$
= 3.30 * 5
= 16.5 lb VOCs emitted/yr

Next, total VOC emissions are speciated using the concentration of VOC species x (mass %) and Equation 8.4-20.

E_{VOC} = 16.5 lb VOCs/yr (calculated above);
C_x = 99% toluene in spent solvent

E_x = $E_{VOC} * C_x/100$
= 16.5 * 99/100
= 16.3 lb toluene emitted/yr

4.2.2 VOC EMISSIONS FROM PARTS CLEANING

VOC emission factors for parts cleaning in cold cleaners, open-top vapor degreasers, or conveyorized degreasers are presented in *AP-42*. Emission factors for cold cleaners and vapor degreasers are in units of tons VOC/yr/unit or lb VOC/hr/ft^2. Emission factors for vapor and nonboiling conveyorized degreasers are presented only in units of ton VOC/yr/unit. If using emission factors based on the surface area of the exposed solvent, use Equation 8.4-23.

$$E_{VOC} = EF_{VOC} * A * OH \qquad (8.4\text{-}23)$$

where:

E_{VOC}	=	VOC emissions from a cold cleaner or open-top vapor degreaser, (lb/yr);
EF_{VOC}[a]	=	VOC emission factor for cold cleaners or open-top vapor degreasers (lb/hr/ft^2);
A	=	Surface area of solvent exposed to the atmosphere (ft^2); and
OH	=	Hours per year that the cold cleaner or vapor degreaser is in operation (hr/yr).

If using emission factors based on the number of cleaning units, use Equation 8.4-24.

$$E_{VOC} = EF_{VOC} * NU * 2000 \qquad (8.4\text{-}24)$$

where:

E_{VOC}	=	VOC emissions from a cold cleaner, an open-top vapor degreaser, or a conveyorized degreaser (lb/yr);
EF_{VOC}	=	VOC emission factor for cold cleaners, open-top vapor degreasers, or conveyorized degreasers (ton/yr/unit);
NU	=	Number of cleaning units in use (units); and
2000	=	2,000 lb/ton.

[a] Certain halogenated solvents that are widely used for solvent cleaning (e.g., 1,1,1-trichloroethane) have been categorized as "VOC-exempt" by various state and federal regulations. However, the emission factors reported in *AP-42* are still applicable for these solvents (EPA, 1995e).

Speciated VOC emissions from parts cleaning may be calculated using Equation 8.4-25:

$$E_x = EF_{VOC} * C_x/100 \quad (8.4\text{-}25)$$

where:

E_x	=	Emissions of VOC species x from parts cleaning (lb/yr);
E_{VOC}	=	VOC emissions calculated using Equation 8.4-22 or 8.4-23 (lb/yr); and
C_x	=	Concentration of VOC species x in cleaning solvent (mass %).

Examples 8.4-6 and 8.4-7 show the application of Equations 8.4-23, 8.4-24, and 8.4-25.

Example 8.4-6

This example shows how total and speciated VOC emissions from a cold cleaner may be calculated using Equations 8.4-23 and 8.4-25 and an emission factor (from *AP-42*, Table 4.6-2) that is based on the surface area of the exposed solvent. First, total VOC emissions are calculated using Equation 8.4-23.

EF_{VOC}	=	0.08 lb/hr/ft^2
A	=	5.25 ft^2
OH	=	3,000 hr/yr

E_{VOC}	=	EF_{VOC} * A * OH
	=	0.08 * 5.25 * 3,000
	=	1,260 lb VOC/yr

Next, total VOC emissions are speciated using the concentration of VOC species x (mass %) and Equation 8.4-25.

E_{VOC}	=	1,260 lb VOCs/yr (calculated above)
C_x	=	99% trichloroethylene in cleaning solvent

E_x	=	EF_{VOC} * C_x/100
	=	1,260 * 99/100
	=	1,247 lb trichloroethylene/yr

Example 8.4-7

This example shows how total VOC emissions are calculated from several cold cleaners using Equation 8.4-24 and an emission factor from Table 4-6.2 of *AP-42*.

EF_{VOC} = 0.33 ton/yr/unit
NU = 5 units

E_{VOC} = EF_{VOC} * NU * 2,000
= 0.33 * 5 * 2,000
= 3,300 lb VOC/yr

4.2.3 VOC EMISSIONS FROM EQUIPMENT LEAKS

Emissions from equipment leaks may be calculated using emission factors established by EPA for the synthetic organic chemical manufacturing industry (SOCMI). SOCMI average and screening value range emission factors are available for various types of components (e.g., valves, pump seals, connectors, open-ended lines). Additionally, EPA has developed SOCMI correlation equations that can be used if test data are available. Calculation of emissions from equipment leaks is explained in more detail in Chapter 4 of this volume.

4.2.4 PM/PM_{10} EMISSIONS FROM A PAINT OR INK MANUFACTURING FACILITY

AP-42 also presents PM emission factors from paint and ink manufacturing, which are based on the amount of pigment used by a facility. The *AP-42* factor for paint manufacturing is 20 lb PM/ton pigment. The *AP-42* factor for pigment mixing at an ink manufacturing facility is 2 lb PM/ton pigment. To calculate PM emissions using these emission factors, use Equation 8.4-26.

$$E_{PM} = EF_{PM} * \Sigma Q_x \qquad (8.4\text{-}26)$$

where:

E_{PM} = Total PM emissions (lb/yr);
EF_{PM} = PM emission factor (lb PM/ton pigment); and
ΣQ_x = Total pigment (ton/yr).

PM_{10} can conservatively be estimated by assuming that all of the PM emitted is PM_{10}.

Speciated PM emissions are calculated using Equation 8.4-27:

$$E_x = EF_{PM} * Q_x * C_x/100 \quad (8.4\text{-}27)$$

where:

E_x	=	Total emissions of PM species x (lb/yr);
EF_{PM}	=	PM emission factor from *AP-42*, Table 6.4-1 or Table 6.7-1 (lb PM/ton pigment);
Q_x	=	Amount of pigment containing species x used by the facility (ton/yr); and
C_x	=	Concentration of PM species x in pigment x (mass %).

Use of Equation 8.4-27 is demonstrated in Example 8.4-8.

Example 8.4-8

This example demonstrates how speciated PM emissions from pigment mixing at an ink manufacturing facility may be calculated using the consumption-based PM emission factor from Table 6.7-1 of *AP-42* and Equation 8.4-27:

EF_{PM} = 2 lb PM/ton pigment
Q_x = 5 tons ZnO/yr
C_x = 80% Zn in ZnO

E_x = $EF_{PM} * Q_x * C_x/100$
= 2 * 5 * 80/100
= 8 lb Zn/yr

5

ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

Alternative methods for calculating emissions from paint and ink manufacturing facilities are presented in this section. A list of variables used in Equations 8.5-1 through 8.5-10 is given in Table 8.5-1.

5.1 EMISSION CALCULATIONS USING EMISSION FACTORS

Emission factors are commonly used to calculate emissions from paint and ink manufacturing facilities. EPA maintains a compilation of approved emission factors in *AP-42* for criteria pollutants and hazardous air pollutants (HAPs). Available emission factors for paint manufacturing can be found in Section 6.4 of *AP-42* and in a technical memorandum from EPA to the National Paint and Coatings Association (EPA, 1995f). Emission factors for ink manufacturing can be found in Section 6.7 of *AP-42*. The National Association of Printing Ink Manufacturers, Inc. (NAPIM), has also developed ink manufacturing emission factors (NAPIM, 1996). The most comprehensive source for toxic air pollutant emission factors is the Factor Information and Retrieval (FIRE) data system, which also contains criteria pollutant emission factors (EPA, 1995h).

5.1.1 TOTAL VOC EMISSIONS FROM PAINT MANUFACTURING FACILITIES

A VOC emission factor can be used for calculating total VOC emissions from paint manufacturing facilities. The emission factor presented in *AP-42* is essentially a loss factor that represents an emission rate to be applied to a production rate (NPCA, 1995). The VOC emission factor presented in *AP-42* for paint manufacturing is 30 lb total VOCs/ton product (EPA, 1995b). To calculate total VOCs using this emission factor, see Equation 8.5-1:

$$E_{VOC} = EF_{VOC} * Q_p \qquad (8.5\text{-}1)$$

where:

E_{VOC} = Total emissions of VOCs from the facility (lb/yr);
EF_{VOC} = VOC emission factor (lb VOCs/ton product); and
Q_p = Amount of product produced (ton/yr).

TABLE 8.5-1

LIST OF VARIABLES AND SYMBOLS

Variable	Symbol	Units
Total VOC Emissions	E_{VOC}	lb/yr
VOC Emission Factor	EF_{VOC}	various
Amount of Product Produced	Q_p	ton/yr
Emissions of VOC or PM Species x	E_x	lb/yr
Amount of VOC Species x Used by the Facility	Q_x	lb/yr
Total Amount of Solvents Used	Q_s	lb/yr
Partial Pressure of VOC Species x	P_x	psia
Flow Rate Through Exhaust Vent	FR	ft^3/min
Molecular Weight of VOC or PM Species x	M_x	lb/lb-mole
Operating Hours	OH	hr/yr
Universal Gas Constant at 1 Atmosphere of Pressure	R	10.73 psia · ft^3/lb-mole · °R
Temperature of Exhaust Gas	T	°R
Quantity of VOC or PM Species x that is Received as a Raw Material	Q_r	lb/yr

R5-2014-0104710000141

TABLE 8.5-1

(CONTINUED)

Variable	Symbol	Units
Quantity of VOC or PM Species x Shipped Out in Final Product	Q_p	lb/yr
Quantity of VOC or PM Species x Recovered by All Methods	Q_{rec}	lb/yr
Quantity of VOC or PM Species x Contained in All Waste Generated	Q_w	lb/yr
Quantity of VOC or PM Species x Remaining in Raw Material Inventory	Q_{xi}	lb/yr
Concentration of VOC or PM Species x	C_{xt}	ppmv or $ft^3/MMft^3$

Because the VOC emissions calculated in Equation 8.5-1 are plantwide emissions, speciated emissions can be estimated based on total solvent used. Speciated VOC emissions are calculated using Equation 8.5-2:

$$E_x = E_{VOC} * Q_x/Q_s \qquad (8.5\text{-}2)$$

where:

E_x	=	Emissions of VOC species x from the facility (lb/yr);
E_{VOC}	=	VOC emissions from the facility, calculated using Equation 8.5-1 (lb/yr);
Q_x	=	Amount of VOC species x used by the facility (lb/yr); and
Q_s	=	Total amount of solvents used by the facility (lb/yr).

With no other information available, one important assumption made in Equation 8.5-2 is that all solvents evaporate at the same rate. The amount of VOC species x used by a facility (Q_x) can be obtained by reviewing purchase and inventory records and appropriate technical data sheets. Purchase and inventory records can be used to estimate the amount of a particular material consumed.

The sum of speciated emissions for all VOC components calculated using Equation 8.5-2 cannot exceed the total VOC emissions calculated in Equation 8.5-1. The use of Equations 8.5-1 and 8.5-2 is demonstrated in Example 8.5-1.

Example 8.5-1

This example shows how total and speciated VOC emissions may be calculated for a paint manufacturing facility using the production-based VOC emission factor from *AP-42*, Table 6.4-1, and Equations 8.5-1 and 8.5-2.
Given:

EF_{VOC}	=	30 lb VOC/ton product
Q_p	=	1,250 ton of paint/yr
Q_{xylene}	=	250,000 lb used by the facility/yr
Q_s	=	1,500,000 lb solvents used by the facility/yr

Example 8.5-1 (Continued)

Total VOC emissions would be calculated using Equation 8.5-1:

$$E_{VOC} = EF_{VOC} * Q_p$$
$$= 30 * 1{,}250$$
$$= 37{,}500 \text{ lb VOCs/yr}$$

The amount of xylenes used by the facility (Q_{xylene}) was estimated by conducting a review of purchase and inventory records and technical data sheets.

Xylenes emissions would be calculated using Equation 8.5-2:

E_{VOC} = 37,500 lb VOCs emitted/yr
Q_{xylene} = 250,000 lb xylenes used by the facility/yr
Q_s = 1,500,000 lb solvents used by the facility/yr

$$E_{xylene} = E_{VOC} * Q_x/\Sigma Q$$
$$= 37{,}500 * 250{,}000/1{,}500{,}000$$
$$= 6{,}250 \text{ lb xylenes/yr}$$

In addition to the 30 lb VOCs/ton product emission factor, EPA has recently restated the emission factor for total VOC emissions for overall operations from a paint manufacturing facility based on the amount of solvent used (EPA, 1995f). Development of the new proposed factor, 0.034 lb VOCs emitted/lb solvent used, is based on the following information and assumptions:

- The emission estimates used to develop the 30 lb VOCs/ton coating emission factor appear to be based on the formulation of conventional coatings that were prevalent in the late 1950s and early 1960s.
- Densities for conventional coatings were typically 10 to 15 lb/gal (an average density of 12.5 lb/gal was used) during the late 1950s and early 1960s.
- An average solvent content of 5.5 lb VOCs/gal coating was assumed for conventional coatings (EPA, 1995f).

Use of the proposed factor by facilities that primarily manufacture water-based, low-solvent, or high-solids coatings should result in more accurate emissions than use of the 30 lb VOCs/ton coating factor.

To calculate total VOCs using this proposed emission factor, use Equation 8.5-3:

$$E_{VOC} = EF_{VOC} * Q_s \quad (8.5\text{-}3)$$

where:

E_{VOC} = Total VOC emissions from a facility (lb/yr);
EF_{VOC} = VOC emission factor (lb VOCs/lb solvent used); and
Q_s = Total amount of solvents used (lb/yr).

Speciated emissions are then calculated using Equation 8.5-4:

$$E_x = EF_{VOC} * Q_x \quad (8.5\text{-}4)$$

where:

E_x = Emissions of VOC species x from a facility (lb/yr);
EF_{VOC} = VOC emission factor (lb VOCs/lb solvent used); and
Q_x = Amount of VOC species x used by the facility (lb/yr).

The sum of speciated emissions for all VOC components calculated in Equation 8.5-4 cannot exceed the total VOC emissions calculated in Equation 8.5-3. The use of Equations 8.5-3 and 8.5-4 is demonstrated in Example 8.5-2.

5.1.2 VOC EMISSIONS FROM PAINT MIXING OPERATIONS

VOC emissions from paint mixing equipment may be calculated using emission factors. *AP-42* suggests that "about 1 or 2 percent of solvent is lost even under very well controlled conditions" (EPA, 1995b). This percentage range can be translated into an emission factor range of 0.01 to 0.02 lb solvent lost/lb solvent used. Review of background information indicates that this emission factor range applies specifically to paint mixing operations (i.e., operations where solvents are added as raw materials) (EPA, 1995f).

AP-42 states that the consumption-based emission factor of 0.01 to 0.02 lb VOCs lost/lb solvent used applies even to facilities that have emission sources that are well controlled. If a facility contains mixers or other process vessels that are uncovered or otherwise poorly controlled, an emission factor greater than 0.02 lb solvent lost/lb solvent used may need to be applied (NPCA, 1995).

Example 8.5-2

This example shows how total and speciated VOC emissions may be calculated for a paint manufacturing facility using the proposed solvent-based VOC emission factor, as shown in Equation 8.5-3.

EF_{VOC} = 0.034 lb VOCs/lb solvent used
Q_s = 350,000 lb solvents used by the facility/yr

E_{VOC} = $EF_{VOC} * Q_s$
= 0.034 * 350,000
= 11,900 lb VOCs/yr

Xylene emissions would be calculated using Equation 8.5-4:

EF_{VOC} = 0.034 lb VOCs/lb solvent
Q_x = 15,000 lb xylenes contained in solvents used by the facility/yr

E_x = $EF_{VOC} * Q_x$
= 0.034 * 15,000
= 510 lb xylenes/yr

Total VOC emissions can also be calculated by summing the speciated VOC emissions.

Use Equation 8.5-5 for calculating speciated VOC emissions from mixers using the consumption-based emission factor.

$$E_x = EF_{VOC} * Q_x \qquad (8.5\text{-}5)$$

where:

E_x = Emissions of VOC species x from mixing equipment (lb/yr);
EF_{VOC} = VOC emission factor (lb VOCs/lb solvent used); and
Q_x = Amount of VOC species x added to mixing equipment as a raw material (lb/yr).

The amount of VOC species x used in mixing equipment (Q_x) refers to the total amount of VOC species x that is added to mixing equipment as a raw material. Once the solvent is mixed with other materials, it is no longer considered a raw material.

The use of Equation 8.5-5 is also demonstrated in Example 8.5-3.

Example 8.5-3

This example shows how speciated VOC emissions from mixing equipment may be calculated using Equation 8.5-5 and the emission factor from Section 6.4.1 of *AP-42*. This example assumes an average level of VOC control on process equipment. Consequently, the average of the range (1 to 2 percent) reported in *AP-42* is used.

EF_{VOC} = 0.015 lb xylenes emitted/lb xylenes used
Q_x = 15,000 lb xylenes added to mixing equipment/yr

E_x = $EF_{VOC} * Q_x$
= 0.015 * 15,000
= 225 lb xylenes/yr

5.1.3 VOC Emissions from Ink Manufacturing Facilities

Emission factors are also available for VOC sources from ink manufacturing facilities. Section 6.7 of *AP-42* presents VOC emission factors for vehicle cooking. NAPIM has also developed VOC emission factors for mixing, milling, and tub wash processes for both paste and liquid inks (NAPIM, 1996). Emission factors are available for sheetfed three-roll mill and heatset paste inks, and for low-VOC and high-VOC liquid inks. Equation 8.5-6 can be used to estimate emissions using emission factors.

$$E_{VOC} = EF_{VOC} * Q_p \qquad (8.5\text{-}6)$$

where:

E_{VOC} = VOC emissions (lb/yr);
EF_{VOC} = VOC emission factor (lb VOC/ton product);
Q_p = Amount of product produced (ton/yr).

Speciated emissions can be calculated using Equation 8.5-7:

$$E_x = E_{VOC} * Q_x/\Sigma Q \qquad (8.5\text{-}7)$$

where:

E_x	=	Emissions of VOC species x (lb/yr);
E_{VOC}	=	VOC emissions calculated using Equation 8.5-6 (lb/yr);
Q_x	=	Amount of VOC species x used (lb/yr); and
ΣQ	=	Total amount of solvent used (lb/yr).

With no other information available, one important assumption made in Equation 8.5-7 is that all solvents evaporate at the same rate. The amount of VOC species x used by a facility (Q_x) can be obtained by reviewing purchase and inventory records and appropriate technical data sheets. Purchase and inventory records can be used to estimate the amount of a particular material consumed.

Example 8.5-4 illustrates the use of these equations.

Example 8.5-4

This example shows how VOC and speciated VOC emissions may be calculated for general vehicle cooking at an ink manufacturing facility using the production-based VOC emission factor from *AP-42*, Table 6.7-1, and Equations 8.5-6 and 8.5-7.

Given:

EF_{VOC}	=	120 lb VOC/ton product
Q_p	=	500 tons of ink/yr
$Q_{toluene}$	=	100,000 lb used/yr
ΣQ	=	1,000,000 lb solvents used/yr

VOC emissions would be calculated using Equation 8.5-6:

$$E_{VOC} = EF_{VOC} * Q_p$$
$$= 120 * 500$$
$$= 60{,}000 \text{ lb VOCs/yr}$$

The amount of toluene used ($Q_{toluene}$) was estimated by conducting a review of purchase and inventory records, batch records, and technical data sheets.

Toluene emissions would be calculated using Equation 8.5-7:

E_{VOC}	=	60,000 lb VOCs emitted/yr
$Q_{toluene}$	=	100,000 lb toluene used/yr
ΣQ	=	1,000,000 lb solvents used/yr
$E_{toluene}$	=	$E_{VOC} * Q_x/\Sigma Q$
	=	60,000 * 100,000/1,000,000
	=	6,000 lb toluene/yr

5.2 EMISSIONS FROM MISCELLANEOUS PROCESS EQUIPMENT WITH EXHAUST SYSTEMS

The Ideal Gas Law may be used in conjunction with vent discharge rates to calculate emissions from process equipment that are equipped with exhaust systems. Use Equation 8.5-8 for calculating these emissions:

$$E_x = \frac{P_x * FR * M_x * 60 * OH}{R * T} \qquad (8.5\text{-}8)$$

where:

E_x	=	Emissions of VOC species x (lb/yr);
P_x	=	Partial pressure of VOC species x (psia), calculated using Equations 8.4-3 and 8.4-5 or 8.4-4 and 8.4-5;
FR	=	Flow rate through the exhaust vent (ft^3/min);
M_x	=	Molecular weight of VOC species x (lb/lb-mole);
60	=	60 min/hr;
OH	=	Hours that the exhaust system is in operation (hr/yr);
R	=	Universal gas constant at 1 atmosphere of pressure (10.73 psia · ft^3/lb-mole · °R); and
T	=	Temperature of the exhaust gas (°R).

Example 8.5-5 illustrates the use of Equation 8.5-8.

Example 8.5-5

This example shows how toluene emissions are calculated for a process vessel that is equipped with an exhaust system. The following data are provided:

- The paint in the process vessel consists of 30% by weight toluene, 20% by weight MEK, and 70% by weight pigments and nonvolatile resins;
- The partial pressure of toluene (P_x) is 0.16 psia at 77°F (see Example 8.4-2, Step 2);
- The discharge rate of the vent (FR) is 5 ft^3/min;

Example 8.5-5 (Continued)

- The molecular weight of toluene (M_x) is 92 lb/lb-mole;
- The exhaust system and process vessel are operated for 1,000 hr/yr (OH); and
- The temperature of the paint and the exhaust gas is 77°F or 537°R (T).

Toluene emissions are calculated with Equation 8.5-8 as follows:

$$E_x = \frac{P_x * FR * M_x * 60 * OH}{R * T}$$

$$= \frac{0.16 * 5 * 92 * 60 * 1{,}000}{10.73 * 537}$$

$$= 766 \text{ lb toluene/yr}$$

5.3 VOC AND PM EMISSION CALCULATIONS USING MATERIAL BALANCE

The material balance method requires the totaling of all materials received at the plant and then subtracting out all of the known losses or transfers of the material off-site (including finished product and waste material). The difference is assumed to have been emitted to the atmosphere. The quantity received and the quantity lost or used should be for the same time period, typically January 1 to December 31 for the year of the inventory (NPCA, 1995).
Use Equation 8.5-9 for calculating emissions using the material balance approach.

$$E_x = Q_r - Q_p - Q_{rec} - Q_w - Q_{xi} \qquad (8.5\text{-}9)$$

where:

E_x = Emissions of VOC or PM species x (lb/yr);
Q_r = Quantity of VOC or PM species x that is received as a raw material (lb/yr);
Q_p = Quantity of VOC or PM species x that is shipped out in the final product (lb/yr);
Q_{rec} = Quantity of VOC or PM species x that is recovered by all methods (e.g., solvent recovery) (lb/yr);

Q_w = Quantity of VOC or PM species x that is contained in all waste generated during the evaluation period (e.g., wastewater, sludge, drum residue) (lb/yr); and

Q_{xi} = Quantity of VOC or PM species x that remains in the raw material inventory (lb/yr).

The use of Equation 8.5-9 is demonstrated in Example 8.5-6.

5.4 EMISSION CALCULATIONS USING TEST DATA

Because vent or stack testing is relatively uncommon for paint and ink manufacturing facilities, emissions test data for these plants are typically in the form of exposure monitoring results. Industrial hygiene data may be used in conjunction with exhaust system flow rates to calculate fugitive emissions from a room, floor, or building (NPCA, 1995). Use Equation 8.5-10 for calculating these emissions.

Example 8.5-6

This example shows how total ethylene glycol emissions for a paint manufacturing facility may be calculated using Equation 8.5-9. Data are as follows:

- In a given year, a paint facility receives 100,000 lb of ethylene glycol (Q_r).
- Based on the total amount of product shipped off-site and records of product composition, the facility estimates that the amount of ethylene glycol shipped out in final product (Q_p) is 69,000 lb;
- The amount of ethylene glycol that was recovered by the facility's distillation system (Q_{rec}) is 10,000 lb;
- Based on waste composition analyses, the amount of waste sent off-site, and wastewater discharge rates, the facility estimates that the amount of ethylene glycol that was found in all wastes generated during the year (Q_w) is 5,000 lb; and
- The amount of ethylene glycol that was found to be in the facility's inventory at the end of the evaluation period (Q_{xi}) is 15,000 lb.

Example 8.5-6 (Continued)

Emission of ethylene glycol are calculated as follows:

$E_x = Q_r - Q_p - Q_{rec} - Q_{xi}$

$= 100{,}000 - 69{,}000 - 10{,}000 - 5{,}000 - 15{,}000$

$= 1{,}000$ lb ethylene glycol/yr

$$E_x = \frac{FR * 60 * OH * C_{xt} * 0.0026 * M_x}{1 * 10^6} \qquad (8.5\text{-}10)$$

where:

E_x	=	Emissions of VOC or PM species x (lb/yr);
FR	=	Flow rate through exhaust ventilation system (ft^3/min);
60	=	60 min/hr;
OH	=	Hours per year that the exhaust system is operational (hr/yr);
C_{xt}	=	Concentration of VOC or PM species x (ppmv or ft^3/MMft^3);
0.0026	=	Molar volume of gas at 68°F (mole/ft^3);
M_x	=	Molecular weight of VOC or PM species x (lb/lb-mole); and
$1 * 10^6$	=	$1 * 10^6$ ft^3/MMft^3.

Example 8.5-7 illustrates the use of Equation 8.5-10.

VOC losses from certain operations (e.g., filling of containers) may also be measured by performing a study using a gravimetric analysis such as American Society For Testing and Materials (ASTM) Standard D2369, *Test Method for Volatile Content of Coatings*. The operation under evaluation could be simulated on a small scale, and VOC analysis would be conducted on samples taken before and after the simulated activity (EPA, 1992b).

Example 8.5-7

This example shows how Equation 8.5-10 is used to calculate fugitive emissions of xylenes from a building where several mixing vessels are located. The following data are given:

- The building exhaust flow rate (FR) is 20,000 ft^3/min;
- The exhaust system operates for 7,920 hr/yr (OH);
- Industrial hygiene data indicate that the concentration of mixed xylenes in the building (C_{xt}) is 0.1 ppmv; and
- The molecular weight of mixed xylenes (M_x) is 106 lb/lb-mole.

Xylenes emissions are calculated as follows:

$$E_x = \frac{FR * 60 * OH * C_{xt} * 0.0026 * M_x}{1 * 10^6}$$

$$= \frac{20{,}000 * 60 * 7{,}920 * 0.1 * 0.0026 * 106}{1 * 10^6}$$

$$= 262 \text{ lb xylenes/yr}$$

6

QUALITY ASSURANCE/QUALITY CONTROL

The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. QA and QC of an inventory is accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Figure 8.6-1 provides an example completeness checklist that could aid the inventory preparer at a paint and ink manufacturing plant. Volume VI, *QA Procedures*, of the EIIP series of documents describes additional QA/QC methods and tools for performing these procedures.

Volume II, Chapter 1, *Introduction to Stationary Point Source Emission Inventory Development*, also presents recommended standard procedures to follow to ensure that the reported inventory data are complete and accurate. This section discusses the use of QC checklists, QA/QC procedures for specific emission estimation methods (e.g., emission factors), and the application of the Data Attribute Rating System (DARS).

6.1 GENERAL QA/QC CONSIDERATIONS INVOLVED IN EMISSION ESTIMATION TECHNIQUES

6.1.1 EMISSION FACTORS

The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. When using emission factors, the user should be aware of the quality indicator associated with the value. Emission factors published within EPA documents and electronic tools have a quality rating applied to them. The lower the quality indicator, the more likely that a given emission factor may not be representative of the source type. When an emission factor for a specific source or category may not provide a reasonably adequate emission estimate, it is always better to rely on actual stack test data, where available. The reliability and uncertainty of using emission factors as an emission estimation technique are discussed in detail in the QA/QC section of Chapter 1 of this volume and Chapter 4 of Volume VI.

	Y/N	Corrective Action (Complete if "N"; Describe, Sign, and Date)
Have emissions from all sources been included? Potential sources include process vessels, solvent reclamation systems, cleaning activities, wastewater treatment system, storage tanks, process piping, and spills.		
Has an emission estimating technique been identified for each source?		
If toxic emissions are to be calculated using testing data, are the test methods approved?		
If toxic emissions are to be calculated using emission factors, are the emission factors from *AP-42* or FIRE?		
If toxic emissions are to be calculated using a material balance approach, have all forms of waste been included (e.g., used filter bags or cartridges, spent solvent or still bottoms, dust collector material, pigment bag and/or drum residue, and wastewater)?		
Have stack parameters been provided for each stack or vent that emits criteria or toxic air pollutants?		
If emission models are being used to calculate emissions from process vessels, has a manageable number of representative product groups been defined?		
If required by the state, has a site diagram been included with the emissions inventory? This should be a detailed plant drawing showing the location of sources/stacks with ID numbers for all processes, control equipment, and exhaust points.		
Have examples of all calculations been included?		
Have all assumptions been documented?		
Have references for all calculation methods been included?		
Have all conversions and units been reviewed and checked for accuracy?		

FIGURE 8.6-1

EXAMPLE EMISSION INVENTORY CHECKLIST FOR PAINT AND INK MANUFACTURING FACILITIES

6.1.2 EMISSION MODELS

The level of effort for using models other than emission factors is related to the complexity of the equation, the types of data that must be collected, and the diversity of products manufactured at a facility. Typically, the use of emission models involves making one or more conservative assumptions. As a result, their use may result in an overestimation of emissions. However, the accuracy and reliability of models can be improved by ensuring that data collected for emission calculations (e.g., material speciation data) are of the highest possible quality.

6.1.3 MATERIAL BALANCE

Calculating emissions from a paint and ink manufacturing facility via a material (mass) balance approach appears to represent a straightforward approach to emissions estimations. However, few facilities track material usage and waste generation with the overall accuracy needed to make the method work, and inaccuracies inherent to each material handling step often accumulate into large deviations. As emissions of specific materials are typically below 1.5 percent of gross consumption, an error of only ±5.0 percent in any one step of the operation can significantly skew emissions. Potential sources of error in the material balance calculation method include the following:

- The delivery of raw materials at a paint and ink manufacturing facility is often tracked by volume, not by weight. Since density will vary with temperature, the actual mass per unit volume of material delivered in the summer may be less than that delivered in the winter;

- Raw materials received by paint and ink facilities may potentially be used in hundreds or thousands of finished products. In order to complete the material balance, it is crucial that the exact quantity and speciation of each material shipped off-site in product be known. For many facilities, it is extremely difficult, or currently impossible, to accurately track the distribution of specific raw materials across their entire product line;

- The amount of raw material contained in waste must also be considered. This may involve precise analysis of the concentration of the material in question in each waste stream; and

- Batch production of paint and ink often requires the manual addition of raw materials. Sometimes these additions are not accurately measured or recorded (NPCA, 1995).

6.1.4 TESTING

Stack or industrial hygiene tests must meet quality objectives. Test data must be reviewed to ensure that the test was conducted under normal operating conditions, or under maximum operating conditions in some states, and that it was generated according to an acceptable method for each pollutant of interest. Calculation and interpretation of accuracy for stack

testing methods are described in detail in *Quality Assurance Handbook for Air Pollution Measurements Systems: Volume III, Stationary Source Specific Methods (Interim Edition)* (EPA, 1994b).

The acceptable criteria, limits, and values for each control parameter associated with manual sampling methods, such as dry gas meter calibration and leak rates, are summarized in tabular format in the QA/QC section of Chapter 1 of this volume. QC procedures for all instruments used to continuously collect emissions data are similar. The primary control check for precision of the continuous monitors is daily analysis of control standards.

6.2 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Four examples are given here to illustrate DARS scoring using the preferred and alternative methods. DARS provides a numerical ranking on a scale of 0 to 1.0 for individual attributes of the emission factor and the activity data. Each score is based on what is known about the factor and activity data, such as the specificity to the source category and the measurement technique employed. The composite attribute score for the emissions estimate can be viewed as a statement of the confidence that can be placed in the data. For a complete discussion of DARS and other rating systems, see the *QA Procedures* (Volume VI, Chapter 4), and the QA/QC section of Volume II, Chapter 1, *Introduction to Stationary Point Source Emission Inventory Development*.

Each of the examples below is hypothetical. A range is given where appropriate to cover different situations. Table 8.6-1 gives a set of scores for an estimate made with an *AP-42* emission factor. The activity data are assumed to be measured directly. Table 8.6-2 shows scores developed for the use of emission models. Tables 8.6-3 and 8.6-4 demonstrate scores determined for material balance and testing data, respectively. The reader should note that although the composite score for the material balance method is good, this technique will not practically be applied or used by many paint and ink manufacturing facilities. Because few facilities track material usage and waste generation with the overall accuracy needed to make the material balance approach work, use of emission factors and other emission models may provide the best choice when selecting an appropriate method for estimating emissions.

These examples are given as an illustration of the relative quality of each method. If the same analysis were done for an actual site, the scores could be different but the relative ranking of methods should stay the same. Note, however, that if the source is not truly a member of the population used to develop the EPA correlation equations or the emission factors, these approaches are less appropriate and the DARS scores will drop.

If sufficient data are available, the uncertainty in the estimate should be evaluated. Qualitative and quantitative methods for conducting uncertainty analyses are described in the *QA Procedures* (Volume VI, Chapter 4).

TABLE 8.6-1

DARS SCORES: *AP-42* EMISSION FACTORS

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.3 - 06	1.0	0.3 - 0.6	Lower score reflects a factor of poor quality; upper score reflects a factor of high quality.	Data are based on direct and continuous measurement of activity.
Source Specificity	0.8	1.0	0.8	Factor developed from a superset of intended source category with expected low variability.	Activity data represent the emission process exactly.
Spatial Congruity	0.1 - 0.9	1.0	0.1 - 0.9	Lower score reflects a factor of low quality developed for an unknown spatial scale; upper score reflects a high quality factor developed from a source of similar size.	Activity data are developed for and specific to the inventory area.
Temporal Congruity	0.1 - 0.9	0.7 - 0.9	0.7 - 0.81	Lower score reflects a low quality factor, temporal basis unknown; upper score reflects a high quality factor derived from an average of numerous tests.	Lower score reflects activity data representative of a short period of time with low to moderate temporal variability; upper score reflects activity data measured numerous times over the year.
Composite Scores	0.33 - 0.80	0.93 - 0.98	0.48 - 0.78		

TABLE 8.6-2

DARS SCORES: EMISSION MODELS

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	0.3	1.0	0.3	Factors (inputs to model) are based on mass balances, known principles, etc.	Data are based on direct and continuous measurement of surrogate activity.
Source Specificity	0.9 - 1.0	1.0	0.9 - 1.0	Lower score reflects model inputs developed for subset or superset of the intended category; upper score reflects inputs developed specifically for the intended source.	Activity data represent the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Model inputs are developed for and are specific to the given spatial scale.	Activity data are developed for and are specific to the area included in the inventory.
Temporal Congruity	1.0	1.0	1.0	Model inputs are developed for and applicable to the same temporal scale.	Activity data are specific for the temporal period represented in the inventory.
Composite Scores	0.80 - 0.83	1.0	0.80 - 0.83		

TABLE 8.6-3

DARS SCORES: MATERIAL BALANCE

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	0.5	1.0	0.5	Factor is based on mass balance; all/or most endpoints are accounted for.	Direct continuous measurement of activity surrogate.
Source Specificity	1.0	1.0	1.0	Factor is developed specifically for the intended source.	Activity data represent the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor is developed for and specific to the given spatial scale.	Activity data are developed for and specific to the geographic region of the inventory.
Temporal Congruity	1.0	1.0	1.0	Factor is developed for and applicable to the same temporal scale.	Activity data are specific for the temporal period represented in the inventory.
Composite Scores	0.88	1.0	0.88		

TABLE 8.6-4

DARS SCORES: TESTING DATA

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	0.6 - 1.0	0.6 - 1.0	0.36 - 1.0	Lower score reflects a factor developed from a small sample of data representative of typical loads; upper score reflects a factor based on continuous or near continuous measurement of intended pollutant from all relevant sites, with data capture greater than 90%.	Lower score reflects activity rate derived from a different measured surrogate associated with original activity surrogate; upper score reflects direct continuous measurement of activity surrogate.
Source Specificity	1.0	1.0	1.0	Factor is developed specifically for the intended source category.	Activity data represent the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor is developed for and specific to the given spatial scale.	Activity data are developed for and specific to the region of the inventory.
Temporal Congruity	0.7 - 1.0	0.7 - 1.0	0.49 - 1.0	Lower score reflects a factor derived for longer/shorter time period, or from a different period; upper score reflects a factor developed for and applicable to the same temporal scale.	Lower score reflects activity representative of a longer/shorter period, or a different period; upper score reflects activity data specific for the temporal period represented in the inventory.
Composite Scores	0.83 -1.0	0.83 - 1.0	0.72 - 1.0		

7

DATA CODING PROCEDURES

This section describes the methods and codes available for characterizing emission sources at paint and ink manufacturing facilities. Consistent categorization and coding will result in greater uniformity among inventories. In addition, the procedures described here will assist the reader who is preparing data for input to the Aerometric Information Retrieval System (AIRS) or a similar database management system. For example, the use of the Source Classification Codes (SCCs) provided in Table 8.7-1 are recommended for describing paint and ink manufacturing operations. Refer to the CHIEF bulletin board for a complete listing of SCCs for paint and ink facilities.

7.1 SOURCE CLASSIFICATION CODES

SCCs for paint and ink manufacturing operations are presented in Table 8.7-1. A brief description of each source description listed in the table is given below.

7.1.1 PAINT AND INK MANUFACTURING EMISSIONS

Traditional paint and ink manufacturing consists of preassembly and premix, pigment grinding/dispersing, product finishing/blending, and product filling/packaging. The SCCs that correspond to these activities appear in Table 8.7-1 under the "Paint Manufacture" and "Ink Manufacture" source descriptions. This source category also includes SCCs for cleaning of equipment.

7.1.2 COLD SOLVENT CLEANING AND DEGREASING

Small items used in the paint and ink manufacturing process may be cleaned by washing with solvents in a cold cleaner or vapor degreaser. SCCs that correspond to these types of cleaning operations appear under the "Cold Solvent Cleaning" and "Degreasing" source descriptions in Table 8.7-1.

7.1.3 SOLVENT RECLAMATION

Emissions from the solvent reclamation process occur from loading solvent into distillation equipment, operation of the distillation equipment, and spillage. The codes in Table 8.7-1 under the "Waste Solvent Recovery Operations" process description are recommended to describe these emissions.

7.1.4 MATERIAL STORAGE

In paint and ink manufacturing facilities, solvents are typically stored in fixed roof storage tanks. The SCCs that correspond to emissions of various types of organic solvents are presented in Table 8.7-1 under the "Fixed Roof Tank" process description.

7.2 AIRS CONTROL DEVICE CODES

Control device codes applicable to the paint and ink manufacturing industry are presented in Table 8.7-2. These should be used to enter the type of applicable emission control device into the AIRS Facility Subsystem (AFS). The "099" control code may be used for miscellaneous control devices that do not have a unique identification code.

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TABLE 8.7-1

SOURCE CLASSIFICATION CODES FOR PAINT AND INK MANUFACTURING OPERATIONS (SIC CODE 2851)

Source Description	Process Description	SCC	Units
Paint Manufacture	General Mixing and Handling	30101401	Tons paint produced
	Pigment Handling	30101402	Tons pigment processed
	Solvent Loss: General	30101403	Tons of solvent lost
	Raw Material Storage	30101404	1,000 gallons stored
	Premix/Preassembly	30101415	Tons paint produced
	Premix/Preassembly: Mix Tanks and Agitators	30101416	Tons paint produced
	Premix/Preassembly: Drums	30101417	Tons paint produced
	Premix/Preassembly: Material Loading	30101418	Tons paint produced
	Pigment Grinding/Milling	30101430	Tons pigment processed
	Pigment Grinding/Milling: Roller Mills	30101431	Tons pigment processed
	Pigment Grinding/Milling: Ball and Pebble Mills	30101432	Tons pigment processed
	Pigment Grinding/Milling: Attritors	30101433	Tons pigment processed
	Pigment Grinding/Milling: Sand Mills	30101434	Tons pigment processed
	Pigment Grinding/Milling: Bead Mills	30101435	Tons pigment processed
	Pigment Grinding/Milling: Shot Mills	30101436	Tons pigment processed

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Paint Manufacture (Cont.)	Pigment Grinding/Milling: Stone Mills	30101437	Tons pigment processed
	Pigment Grinding/Milling: Colloid Mills	30101438	Tons pigment processed
	Pigment Grinding/Milling: Kady Mills	30101439	Tons pigment processed
	Pigment Grinding/Milling: Impingement Mills	30101440	Tons pigment processed
	Pigment Grinding/Milling: Horizontal Media Mills	30101441	Tons pigment processed
	Product Finishing	30101450	Tons paint produced
	Product Finishing, Tinting: Mix Tank and Disperser	30101451	Tons paint produced
	Product Finishing, Tinting: Fixed Blend Tank	30101452	Tons paint produced
	Product Finishing, Thinning: Mix Tank and Disperser	30101453	Tons paint produced
	Product Finishing, Thinning: Fixed Blend Tank	30101454	Tons paint produced
	Product Filling	30101460	Tons paint produced
	Product Filling: Scale System	30101461	Tons paint produced
	Product Filling: Product Filtering	30101462	Tons paint produced
	Product Filling: Filling Operations	30101463	Tons paint produced
	Equipment Cleaning	30101470	Tons paint produced

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Paint Manufacture (Cont.)	Equipment Cleaning: Hand Wipe	30101471	Tons paint produced
	Equipment Cleaning: Tanks, Vessels, etc.	30101472	Tons paint produced
	Other Not Classified	30101498	Tons processed
	Other Not Classified	30101499	Tons product
Ink Manufacture	Vehicle Cooking: General[a]	30102001	Tons produced
	Vehicle Cooking: Oils[a]	30102002	Tons produced
	Vehicle Cooking: Oleoresin[a]	30102003	Tons produced
	Vehicle Cooking: Alkyds[a]	30102004	Tons produced
	Pigment Mixing	30102005	Tons Pigment
	Other Not Classified	30102099	Tons produced
Cold Solvent Cleaning/Stripping	Methanol	40100301	Tons solvent consumed
	Methylene Chloride	40100302	Tons solvent consumed
	Stoddard (Petroleum) Solvent	40100303	Tons solvent consumed
	Perchloroethylene	40100304	Tons solvent consumed
	1,1,1-Trichloroethane (Methyl Chloroform)	40100305	Tons solvent consumed
	Trichloroethylene	40100306	Tons solvent consumed
	Isopropyl Alcohol	40100307	Tons solvent consumed

[a] These processes typically occur in a chemical plant rather than an ink manufacturing plant (EPA, 1992a).

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Cold Solvent Cleaning/Stripping (Cont.)	Methyl Ethyl Ketone	40100308	Tons solvent consumed
	Freon®	40100309	Tons solvent consumed
	Acetone	40100310	Tons solvent consumed
	Glycol Ethers	40100311	Tons solvent consumed
	Entire Unit	40100335	Cold cleaners in operation
	Degreaser: Entire Unit	40100336	1,000 sq. ft. product surface area
	Other Not Classified	40100398	Gallons solvent consumed
	Other Not Classified	40100399	Tons solvent consumed
Degreasing	Stoddard (Petroleum) Solvent: Open-top Vapor Degreasing	40100201	Tons make-up solvent used
	1,1,1-Trichloroethane (Methyl Chloroform): Open-top Vapor Degreasing	40100202	Tons make-up solvent used
	Perchloroethylene: Open-top Vapor Degreasing	40100203	Tons make-up solvent used
	Methylene Chloride: Open top Vapor Degreasing	40100204	Tons make-up solvent used
	Trichloroethylene: Open-top Vapor Degreasing	40100205	Tons make-up solvent used
	Toluene: Open-top Vapor Degreasing	40100206	Tons make-up solvent used

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Degreasing (Cont.)	Trichlorotrifluoroethane (Freon®): Open-top Vapor Degreasing	40100207	Tons make-up solvent used
	Chlorosolve: Open-top Vapor Degreasing	40100208	Tons make-up solvent used
	Butyl Acetate	40100209	Tons make-up solvent used
	Entire Unit: Open-top Vapor Degreasing	40100215	Degreasing units in operation
	Degreaser: Entire Unit	40100216	1,000 sq. ft. product surface area
	Entire Unit	40100217	Sq. ft. surface area x hours operated
	Stoddard (Petroleum) Solvent: Conveyorized Vapor Degreasing	40100221	Tons make-up solvent used
	1,1,1-Trichloroethane (Methyl Chloroform): Conveyorized Vapor Degreasing	40100222	Tons make-up solvent used
	Perchloroethylene: Conveyorized Vapor Degreasing	40100223	Tons make-up solvent used
	Methylene Chloride: Conveyorized Vapor Degreasing	40100224	Tons make-up solvent used
	Trichloroethylene: Conveyorized Vapor Degreasing	40100225	Tons make-up solvent used

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Degreasing (Cont.)	Entire Unit: with Vaporized Solvent: Conveyorized Vapor Degreasing	40100235	Degreasing units in operation
	Entire Unit: with Non-boiling Solvent: Conveyorized Vapor Degreasing	40100236	Degreasing units in operation
	Stoddard (Petroleum) Solvent: General Degreasing Units	40100251	Gallons solvent consumed
	1,1,1-Trichloroethane (Methyl Chloroform): General Degreasing Units	40100252	Gallons solvent consumed
	Perchloroethylene: General Degreasing Units	40100253	Gallons solvent consumed
	Methylene Chloride: General Degreasing Units	40100254	Gallons solvent consumed
	Trichloroethylene: General Degreasing Units	40100255	Gallons solvent consumed
	Toluene: General Degreasing Units	40100256	Gallons solvent consumed
	Trichlorotrifluoroethane (Freon®): General Degreasing Units	40100257	Gallons solvent consumed
	Trichlorofluoromethane: General Degreasing Units	40100258	Gallons solvent consumed
	1,1,1-Trichloroethane (Methyl Chloroform): General Degreasing Units	40100259	Gallons solvent consumed
	Other Not Classified: General Degreasing Units	40100295	Gallons solvent consumed

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Degreasing (Cont.)	Other Not Classified: General Degreasing Units	40100296	Gallons solvent consumed
	Other Not Classified: Open-top Vapor Degreasing	40100297	Gallons solvent consumed
	Other Not Classified: Conveyorized Vapor Degreasing	40100298	Tons make-up solvent used
	Other Not Classified: Open-top Vapor Degreasing	40100299	Tons make-up solvent used
Waste Solvent Recovery Operations	Storage Tank Vent	49000201	Tons reclaimed solvent
	Condenser Vent	49000202	Tons reclaimed solvent
	Incinerator Stack	49000203	Tons reclaimed solvent
	Solvent Spillage	49000204	Tons reclaimed solvent
	Solvent Loading	49000205	Tons reclaimed solvent
	Fugitive Leaks	49000206	Process unit-year
	Distillation Vent	49000207	Tons reclaimed solvent
	Decanting	49000208	Tons reclaimed solvent
	Salting	49000209	Tons reclaimed solvent
	Other Not Classified	49000299	Tons reclaimed solvent
Fixed Roof Tanks - Alcohols	n-Butyl Alcohol: Breathing Loss	40700801	1,000 gallons storage capacity
	n-Butyl Alcohol: Working Loss	40700802	1,000 gallons throughput
	sec-Butyl Alcohol: Breathing Loss	40700803	1,000 gallons storage capacity

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks-Alcohols (Cont.)	sec-Butyl Alcohol: Working Loss	40700804	1,000 gallons throughput
	tert-Butyl Alcohol: Breathing Loss	40700805	1,000 gallons storage capacity
	tert-Butyl Alcohol: Working Loss	40700806	1,000 gallons throughput
	Cyclohexanol: Breathing Loss	40700807	1,000 gallons storage capacity
	Cyclohexanol: Working Loss	40700808	1,000 gallons throughput
	Ethyl Alcohol: Breathing Loss	40700809	1,000 gallons storage capacity
	Ethyl Alcohol: Working Loss	40700810	1,000 gallons throughput
	Isobutyl Alcohol: Breathing Loss	40700811	1,000 gallons storage capacity
	Isobutyl Alcohol: Working Loss	40700812	1,000 gallons throughput
	Isopropyl Alcohol: Breathing Loss	40700813	1,000 gallons storage capacity
	Isopropyl Alcohol: Working Loss	40700814	1,000 gallons throughput
	Methyl Alcohol: Breathing Loss	40700815	1,000 gallons storage capacity
	Methyl Alcohol: Working Loss	40700816	1,000 gallons throughput
	n-Propyl Alcohol: Breathing Loss	40700817	1,000 gallons storage capacity

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks - Alcohols (Cont.)	n-Propyl Alcohol: Working Loss	40700818	1,000 gallons throughput
	Xylol: Breathing Loss	40700819	1,000 gallons storage capacity
	Xylol: Working Loss	40700820	1,000 gallons throughput
	Specify Alcohol: Breathing Loss	40700897	1,000 gallons storage capacity
	Specify Alcohol: Working Loss	40700898	1,000 gallons throughput
Fixed Roof Tanks - Alkanes (Paraffins)	n-Decane: Breathing Loss	40701601	1,000 gallons storage capacity
	n-Decane: Working Loss	40701602	1,000 gallons throughput
	n-Dodecane: Breathing Loss	40701603	1,000 gallons storage capacity
	n-Dodecane: Working Loss	40701604	1,000 gallons throughput
	n-Heptane: Breathing Loss	40701605	1,000 gallons storage capacity
	n-Heptane: Working Loss	40701606	1,000 gallons throughput
	Isopentane: Breathing Loss	40701607	1,000 gallons storage capacity
	Isopentane: Working Loss	40701608	1,000 gallons throughput
	Pentadecane: Breathing Loss	40701609	1,000 gallons storage capacity

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks - Alkanes (Paraffins) (Cont.)	Pentadecane: Working Loss	40701610	1,000 gallons throughput
	Naphtha: Breathing Loss	40701611	1,000 gallons storage capacity
	Naphtha: Working Loss	40701612	1,000 gallons throughput
	Petroleum Distillate: Breathing Loss	40701613	1,000 gallons storage capacity
	Petroleum Distillate: Working Loss	40701614	1,000 gallons throughput
	Hexane: Breathing Loss	40701615	1,000 gallons storage capacity
	Hexane: Working Loss	40701616	1,000 gallons throughput
	Specify Alkane: Breathing Loss	40701697	1,000 gallons storage capacity
	Specify Alkane: Working Loss	40701698	1,000 gallons throughput
Fixed Roof Tanks - Alkenes (Olefins)	Dodecene: Breathing Loss	40702001	1,000 gallons storage capacity
	Dodecene: Working Loss	40702002	1,000 gallons throughput
	Heptenes - General: Breathing Loss	40702003	1,000 gallons storage capacity
	Heptenes - General: Working Loss	40702004	1,000 gallons throughput
	Specify Olefin: Breathing Loss	40702097	1,000 gallons storage capacity

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks - Alkenes (Olefins) (Cont.)	Specify Olefin: Working Loss	40702098	1,000 gallons throughput
Fixed Roof Tanks - Aromatics	Benzene: Breathing Loss	40703601	1,000 gallons storage capacity
	Benzene: Working Loss	40703602	1,000 gallons throughput
	Cresol: Breathing Loss	40703603	1,000 gallons storage capacity
	Cresol: Working Loss	40703604	1,000 gallons throughput
	Cumene: Breathing Loss	40703605	1,000 gallons storage capacity
	Cumene: Working Loss	40703606	1,000 gallons throughput
	Diisopropyl Benzene: Breathing Loss	40703607	1,000 gallons storage capacity
	Diisopropyl Benzene: Working Loss	40703608	1,000 gallons throughput
	Ethylbenzene: Breathing Loss	40703609	1,000 gallons storage capacity
	Ethylbenzene: Working Loss	40703610	1,000 gallons throughput
	Methyl Styrene: Breathing Loss	40703611	1,000 gallons storage capacity
	Methyl Styrene: Working Loss	40703612	1,000 gallons throughput

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks - Aromatics (Cont.)	Styrene: Breathing Loss	40703613	1,000 gallons storage capacity
	Styrene: Working Loss	40703614	1,000 gallons throughput
	Toluene: Breathing Loss	40703615	1,000 gallons storage capacity
	Toluene: Working Loss	40703616	1,000 gallons throughput
	m-Xylene: Breathing Loss	40703617	1,000 gallons storage capacity
	m-Xylene: Working Loss	40703618	1,000 gallons storage capacity
	o-Xylene: Breathing Loss	40703619	1,000 gallons storage capacity
	o-Xylene: Working Loss	40703620	1,000 gallons throughput
	p-Xylene: Breathing Loss	40703621	1,000 gallons storage capacity
	p-Xylene: Working Loss	40703622	1,000 gallons throughput
	Xylenes, Mixed: Breathing Loss	40703623	1,000 gallons storage capacity
	Xylenes, Mixed: Working Loss	40703624	1,000 gallons throughput
	Creosote: Breathing Loss	40703625	1,000 gallons storage capacity
	Creosote: Working Loss	40703626	1,000 gallons throughput

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks - Aromatics (Cont.)	Specify Aromatic: Breathing Loss	40703697	1,000 gallons storage capacity
	Specify Aromatic: Working Loss	40703698	1,000 gallons throughput
Fixed Roof Tanks - Glycol Ethers	Butyl Carbitol: Breathing Loss	40705201	1,000 gallons storage capacity
	Butyl Carbitol: Working Loss	40705202	1,000 gallons throughput
	Butyl Cellosolve: Breathing	40705203	1,000 gallons storage capacity
	Butyl Cellosolve: Working Loss	40705204	1,000 gallons throughput
	Carbitol: Breathing Loss	40705205	1,000 gallons storage capacity
	Carbitol: Working Loss	40705206	1,000 gallons throughput
	Cellosolve: Breathing Loss	40705207	1,000 gallons storage capacity
	Cellosolve: Working Loss	40705208	1,000 gallons throughput
	Diethylene Glycol: Breathing Loss	40705209	1,000 gallons storage capacity
	Diethylene Glycol: Working Loss	40705210	1,000 gallons throughput
	Methyl Carbitol: Breathing Loss	40705211	1,000 gallons storage capacity
	Methyl Carbitol: Working Loss	40705212	1,000 gallons throughput

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks - Glycol Ethers (Cont.)	Methyl Cellosolve: Breathing Loss	40705213	1,000 gallons storage capacity
	Methyl Cellosolve: Working Loss	40705214	1,000 gallons throughput
	Polyethylene Glycol: Breathing Loss	40705215	1,000 gallons storage capacity
	Polyethylene Glycol: Working Loss	40705216	1,000 gallons throughput
	Triethylene Glycol: Breathing Loss	40705217	1,000 gallons storage capacity
	Triethylene Glycol: Working Loss	40705218	1,000 gallons throughput
	Specify Glycol Ether: Breathing Loss	40705297	1,000 gallons storage capacity
	Specify Glycol Ether: Working Loss	40705298	1,000 gallons throughput
Fixed Roof Tanks - Glycols	1,4-Butanediol: Breathing Loss	40705601	1,000 gallons storage capacity
	1,4-Butanediol: Working Loss	40705602	1,000 gallons throughput
	Ethylene Glycol: Breathing Loss	40705603	1,000 gallons storage capacity
	Ethylene Glycol: Working Loss	40705604	1,000 gallons throughput
	Dipropylene Glycol: Breathing Loss	40705605	1,000 gallons storage capacity
	Dipropylene Glycol: Working Loss	40705606	1,000 gallons throughput

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks - Glycols (Cont.)	Glycerol: Breathing Loss	40705607	1,000 gallons storage capacity
	Glycerol: Working Loss	40705608	1,000 gallons throughput
	Propylene Glycol: Breathing Loss	40705609	1,000 gallons storage capacity
	Propylene Glycol: Working Loss	40705610	1,000 gallons throughput
	Specify Glycol: Breathing Loss	40705697	1,000 gallons storage capacity
	Specify Glycol: Working Loss	40705698	1,000 gallons throughput
Fixed Roof Tanks - Halogenated Organics	Benzyl Chloride: Breathing Loss	40706001	1,000 gallons storage capacity
	Benzyl Chloride: Working Loss	40706002	1,000 gallons throughput
	Caprolactam (Soln): Breathing Loss	40706003	1,000 gallons storage capacity
	Caprolactam (Soln): Working Loss	40706004	1,000 gallons throughput
	Carbon Tetrachloride: Breathing Loss	40706005	1,000 gallons storage capacity
	Carbon Tetrachloride: Working Loss	40706006	1,000 gallons throughput
	Chlorobenzene: Breathing Loss	40706007	1,000 gallons storage capacity
	Chlorobenzene: Working Loss	40706008	1,000 gallons throughput

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks - Halogenated Organics (Cont.)	o-Dichlorobenzene: Breathing Loss	40706009	1,000 gallons storage capacity
	o-Dichlorobenzene: Working Loss	40706010	1,000 gallons throughput
	p-Dichlorobenzene: Breathing Loss	40706011	1,000 gallons storage capacity
	p-Dichlorobenzene: Working Loss	40706012	1,000 gallons throughput
	Epichlorohydrin: Breathing Loss	40706013	1,000 gallons storage capacity
	Epichlorohydrin: Working Loss	40706014	1,000 gallons throughput
	Ethylene Dibromide: Breathing Loss	40706015	1,000 gallons storage capacity
	Ethylene Dibromide: Working Loss	40706016	1,000 gallons throughput
	Ethylene Dichloride: Breathing Loss	40706017	1,000 gallons storage capacity
	Ethylene Dichloride: Working Loss	40706018	1,000 gallons throughput
	Methylene Chloride: Breathing Loss	40706019	1,000 gallons storage capacity
	Methylene Chloride: Working Loss	40706020	1,000 gallons throughput
	Perchloroethylene: Breathing Loss	40706021	1,000 gallons storage capacity
	Perchloroethylene: Working Loss	40706022	1,000 gallons throughput

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks - Halogenated Organics (Cont.)	Trichloroethylene: Breathing Loss	40706023	1,000 gallons storage capacity
	Trichloroethylene: Working Loss	40706024	1,000 gallons throughput
	1,1,1-Trichloroethane: Breathing Loss	40706027	1,000 gallons storage capacity
	1,1,1-Trichloroethane: Working Loss	40706028	1,000 gallons throughput
	Chlorosolve: Breathing Loss	40706029	1,000 gallons storage capacity
	Chlorosolve: Working Loss	40706030	1,000 gallons throughput
	Methyl Chloride: Breathing Loss	40706031	1,000 gallons storage capacity
	Methyl Chloride: Working Loss	40706032	1,000 gallons throughput
	Chloroform: Breathing Loss	40706033	1,000 gallons storage capacity
	Chloroform: Working Loss	40706034	1,000 gallons throughput
	Hexachlorobenzene: Breathing Loss	40706035	1,000 gallons storage capacity
	Hexachlorobenzene: Working Loss	40706036	1,000 gallons throughput
	Specify Halogenated Organic: Breathing Loss	40706097	1,000 gallons storage capacity
	Specify Halogenated Organic: Working Loss	40706098	1,000 gallons throughput

TABLE 8.7-1 (CONTINUED)

Source Description	Process Description	SCC	Units
Fixed Roof Tanks - Ketones	Cyclohexanone: Breathing Loss	40706801	1,000 gallons storage capacity
	Cyclohexanone: Working Loss	40706802	1,000 gallons throughput
	Acetone: Breathing Loss	40706803	1,000 gallons storage capacity
	Acetone: Working Loss	40706804	1,000 gallons storage capacity
	Methyl Ethyl Ketone: Breathing Loss	40706805	1,000 gallons storage capacity
	Methyl Ethyl Ketone: Working Loss	40706806	1,000 gallons throughput
	Methyl Isobutyl Ketone: Breathing Loss	40706807	1,000 gallons storage capacity
	Methyl Isobutyl Ketone: Working Loss	40706808	1,000 gallons throughput
	Methylamyl Ketone: Breathing Loss	40706813	1,000 gallons storage capacity
	Methylamyl Ketone: Working Loss	40706814	1,000 gallons throughput
	Specify Ketone: Breathing Loss	40706897	1,000 gallons storage capacity
	Specify Ketone: Working Loss	40706898	1,000 gallons throughput
Fixed Roof Tanks - Miscellaneous	Specify in Comments: Breathing Loss	40714697	1,000 gallons storage capacity
	Specify in Comments: Working Loss	40714698	1,000 gallons throughput

TABLE 8.7-2

AIRS CONTROL TECHNIQUE CODES

Control Device	Code
Fabric Filter - High Temperature	016
Fabric Filter - Medium Temperature	017
Fabric Filter - Low Temperature	018
Venturi Scrubber	053
Miscellaneous Control Device	099

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APPENDIX A

EXAMPLE DATA COLLECTION FORMS AND INSTRUCTIONS - PAINT AND INK MANUFACTURING

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EXAMPLE DATA COLLECTION FORMS INSTRUCTIONS - PAINT AND INK MANUFACTURING FACILITIES

1. These forms may be used as a work sheet to aid the plant engineer in collecting the information necessary to calculate emissions from paint and ink manufacturing facilities. The information requested on the forms relate to the methods (described in Sections 3, 4, and 5) for quantifying emissions. These forms may also be used by the regulatory agency to assist in area-wide inventory preparation.

2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.

3. If the information requested is unknown, write "unknown" in the blank. If the information requested does not apply to a particular unit or process, write "NA" in the blank.

4. If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the Clearinghouse for Inventories and Emission Factors (CHIEF) website (www.epa.gov/ttn/chief/).

5. Collect all Manufacturer's Technical Data Sheets (TDSs) for all materials containing potential air contaminants that are used at the facility.

6. The plant engineer should maintain all material usage information and TDSs in a reference file.

EXAMPLE DATA COLLECTION FORM

FORM A: GENERAL INFORMATION

Facility/PlantName:

SIC Code:

SCC:

SCC Description:

Location:

County:

City:

State:

Plant Geographical Coordinates:
Latitude: _____
Longitude: _____
UTM Zone: _____

UTM Easting: _____
UTM Northing: _____

Contact Name:

Title:

Telephone Number:

EXAMPLE DATA COLLECTION FORM

FORM B: SOURCE INFORMATION

Unit ID:

Permit No.:

Location:

Unit Description:

Manufacturer:

Date Installed:

Date Modified:

Operating Schedule:

Hours/Day:

Days/Week:

Weeks/Year:

Raw Material Used:

Material Name	Constituents	Mass %

EXAMPLE DATA COLLECTION FORM

FORM C: CONTROL DEVICE INFORMATION

Unit ID:

Permit No.:

Location:

Pollutant Controlled:

Control Efficiency (Indicate source of information):

Type of Control Device:

☐ Baghouse

☐ Thermal Incinerator

☐ Other (indicate type)_____

Manufacturer:

Date Installed:

Date Modified:

Operating Schedule:

Hours/Day:

Days/Week:

Weeks/Year:

Source(s) Linked to this Control Device:

EXAMPLE DATA COLLECTION FORM

FORM D: STACK INFORMATION
Stack ID:
Unit ID:
Stack (Release) Height (ft):
Stack Diameter (inch):
Stack Gas Temperature (°F):
Stack Gas Velocity (ft/sec):
Stack Gas Flow Rate (ascf/min):
Source(s) Linked to this Stack:

EXAMPLE DATA COLLECTION FORM

FORM E: PRODUCTION INFORMATION

Product Name	Year	Amount Produced (lb/yr)

EXAMPLE DATA COLLECTION FORM

FORM F: SOLVENT USAGE

Solvent Name	Constituents	Mass %	Amount Used (lb/yr)

EXAMPLE DATA COLLECTION FORM

FORM G: PIGMENT USAGE

Pigment Name	Constituents	Mass %	Amount Used (lb/yr)

EXAMPLE DATA COLLECTION FORM

FORM H: DATA FOR MIXER EMISSIONS

Equipment ID	Solvent	Constituent	Mass %	Amount of Solvent Added to Mixer (lb/yr)

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EXAMPLE DATA COLLECTION FORM

FORM I: DATA FOR SOLVENT RECLAMATION EMISSIONS

Solvent	Constituent	Mass %	Amount Processed Through Distillation Device (lb/hr)

EXAMPLE DATA COLLECTION FORM

FORM J: DATA FOR PARTS CLEANING EMISSIONS

Unit ID	Hours of Operation (hr/yr)	SurfaceArea(ft^2)	Solvent Used	Solvent Constituent	Mass %

EXAMPLE DATA COLLECTION FORM

FORM K: DATA FOR EMISSIONS FROM CLEANING OF PROCESS VESSELS

Unit ID	Solvent	Constituent	Mass %	Volume Used (gal/hr)	Temp. (ºF)

EXAMPLE DATA COLLECTION FORM

FORM L: DATA NEEDED FOR EMISSIONS FROM SPILLS

Date of Spill	Material	Constituent	Mass %	Area (ft^2)	Duration of Spill (hr)	Temp (^oF)

EXAMPLE DATA COLLECTION FORM

FORM M: EMISSION ESTIMATION RESULTS

Equipment ID:_____

Pollutant[a]	Emission Estimation Method[b]	Emissions	Emissions Units	Emission Factor[c]	Emission Factor Units	Comments

[a] Pollutants include VOCs, PM/PM_{10}, and HAPs (list individually).

[b] Use the following codes to indicate which emission estimation method is used for each pollutant:

Emission Factor = EF
Material Balance = MB
Other Method (indicate) = O
Stack Test = ST
Emission Model = EM

[c] Where applicable, enter the emission factor and provide full citation of the reference or source of information from where the emission factor came. Include edition, version, table and page numbers if *AP-42* is used.

Please copy the blank form and attach additional sheets, as necessary.