



Emission Calculation Fact Sheet

Michigan Department Of Environmental Quality ♦ Environmental Science And Services Division ♦ (800) 662-9278

COATING OPERATIONS

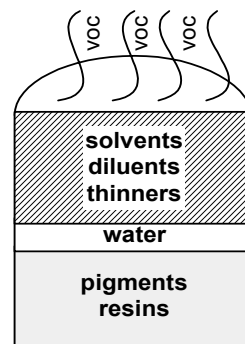
This fact sheet is designed to help those in the surface coating industry estimate annual volatile organic compound (VOC) air emissions. In addition to explaining the calculations, several examples are given to help illustrate the concepts presented. These examples demonstrate how to work through the VOC calculations and deal with some of the obstacles that are commonly encountered.

What is a VOC?

A VOC is any compound that contains carbon and participates in atmospheric photochemical (smog forming) reactions. Many compounds are VOCs and there is no definitive list. However, R 336.1122(f) or Rule 122(f) of the Michigan Air Pollution Control Rules lists several compounds that are not considered VOCs. These compounds are exempted by the Rule and referred to as “exempt VOCs”. For coatings, any organic compound that does not remain behind after curing is a VOC unless it is specifically exempted by Rule 122(f). Rule 122(f) can be viewed on the Internet at www.michigan.gov/deq (Select “Air” then “Laws & Rules”).

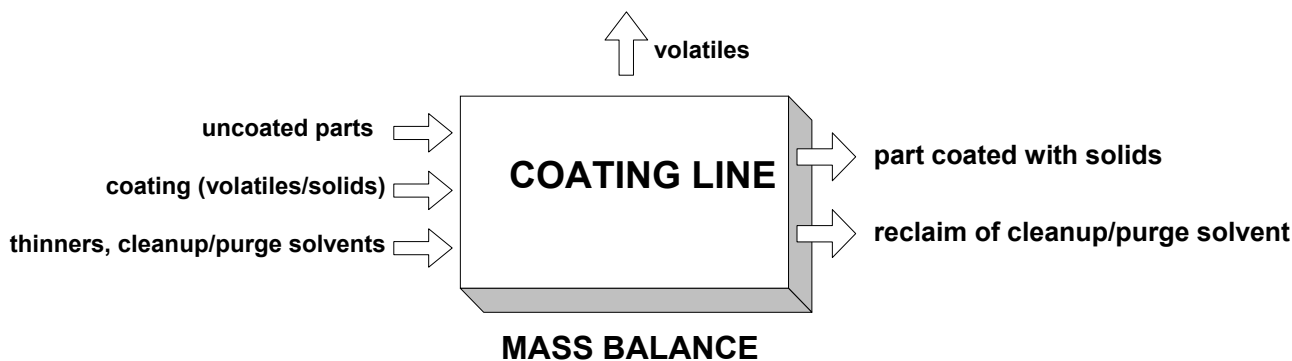
How are VOCs Emitted?

In general, coatings consist of resins (binders), pigments, solvents, diluents, reducers, and thinners. Resins and pigments usually make up the solid (non-evaporative or non-volatile) portion of the coating. Conversely, the volatile portion of the coating can consist of water, solvents, diluents, reducers, and thinners. These compounds evaporate during the mixing, application, and curing of the coating. Most solvents, diluents, and thinners are, or contain, VOCs.



How to Estimate VOC Emissions

The simplest way to estimate VOC emissions from a coating line is using the **mass balance approach**. This method assumes that all the volatiles, including VOCs that are in a particular coating, are emitted into the air. Essentially, what goes in must come out.



To use the mass balance approach, you must know how many pounds of VOC are in a gallon of coating and the total gallons of coating used during the year. The VOC content in the coating should be available from the coating supplier/manufacturer in a “Data Sheet” (i.e., Material Safety Data Sheet (MSDS), Technical Data Sheet, Technical Specifications, or Certified Material Specifications Sheet), through independent lab analysis, or Method 24 analysis*.

* Method 24 analysis refers to federal reference test method 24 – “Determination of volatile matter content, water content, density, volume solids, and weight solids of surface coatings”, described in the provisions of 40 C.F.R. 60, Appendix A.

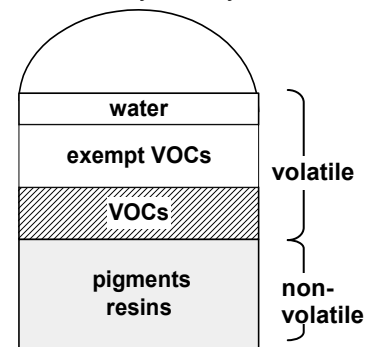
Calculate the annual emission of VOCs by multiplying the VOC content of the coating by the annual usage rate of the coating.

$$\frac{\text{Pounds of VOC}}{\text{Gallon of coating}} \times \frac{\text{Gallons of coating used}}{\text{Year}} = \frac{\text{Pounds of VOC emitted from coating}}{\text{Year}}$$

A proper data sheet should list the VOC content of a coating in terms of percent by weight, and provide the density of the coating; or should list the VOC content in terms of weight of VOC per gallon of coating. If you have this information, completing the above equation is simple; however, not all data sheets contain this information. Below is a more detailed explanation for calculating the VOC content of a coating, including some of the obstacles you may encounter along the way.

Step 1: Know What's in the Coating

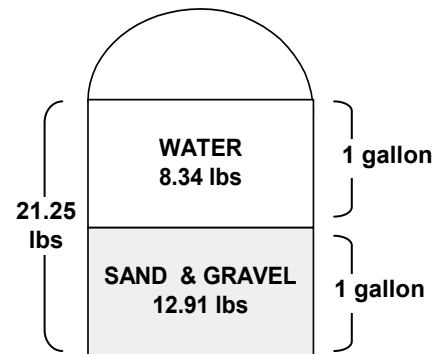
There are a number of other substances present in a coating mixture besides the VOC. Essentially, a coating can be broken down into volatiles and non-volatiles (solids). Non-volatiles or solids primarily consist of additives, pigments, and resin or binders. Volatiles include VOCs, exempt VOCs and water. Make sure VOC emissions are not over estimated due to inclusion of water and/or exempt VOCs in the estimate.



Step 2: Understanding the Difference Between "Percent by Weight" and "Percent by Volume"

To determine VOC emissions using mass balance, the pounds of VOC per gallon of coating must be known. Sometimes a data sheet will provide this number, which makes performing the calculations easy. However, sometimes calculation of the pounds of VOC per gallon of coating requires using the provided ingredient percentages. Data sheets may list ingredients in terms of percent by weight or percent by volume. It is important to make sure close attention is paid to these units. The following example illustrates how your calculations may be affected depending upon using "percent by volume" or "percent by weight".

% by Volume	Water	$\frac{1 \text{ gallon water}}{2 \text{ gallons total}}$	X 100 = 50% by volume
	Sand & Gravel	$\frac{1 \text{ gallon S\&G}}{2 \text{ gallons total}}$	X 100 = 50% by volume
% by Weight	Water	$\frac{8.34 \text{ lbs water}}{21.25 \text{ lbs total}}$	X 100 = 39.25% by weight
	Sand & Gravel	$\frac{12.91 \text{ lbs S\&G}}{21.25 \text{ lbs total}}$	X 100 = 60.75% by weight



Step 3: Calculate the VOC Content of the Coating

- **If the ingredients are listed in "percent by weight":**

Multiply the percent by weight of the VOC in the coating by the density of the coating.

$$\text{lbs VOC/gallon of coating} = (\% \text{ by weight VOC} / 100) \times (\text{density of coating [lbs/gal]})$$

- **If the ingredients are listed in "percent by volume":**

1. Calculate the pounds of each VOC in a gallon of coating.

$$\text{lbs VOC1 / gallon of coating} = (\% \text{ by volume of VOC1} / 100) \times (\text{density of VOC1 [lbs/gal]})$$

2. Calculate the pounds of Total VOC in a gallon of coating.

$$\text{Total lbs VOC / gallon of coating} = (\text{VOC1 lbs/gal} + \text{VOC2 lbs/gal} + \text{VOC3 lbs/gal} + \dots)$$

Water Based Coatings

When calculating VOC emissions for water based coatings, it is important that water is subtracted from the usage data before multiplying by a "minus water" VOC content figure (see Example 3). Failure to subtract water from the usage data will result in an overestimation of VOC emissions. Use the following equations to calculate coating usage (minus water) and VOC emissions:

1. $\text{gallons of coating used / year} \times [1 - (\% \text{ water by volume}/100)] = \text{gallons of coating (minus water) / year}$
2. $\text{gallons of coating (minus water) / year} \times \text{lbs VOC / gallons of coating (minus water)} = \text{lbs VOC emitted / year}$

Calculating VOC Emissions from the Use of Thinner

In addition to calculating the VOCs emitted from the actual coatings, it is also important to remember to calculate the amount of VOCs emitted from any thinners added to the coating, as shown below.

$$\text{lbs VOC / gal of thinner} \times \text{gal of thinner used / year} = \text{lbs VOC emitted from thinner / year}$$

Calculating VOC Emissions from the Use of Cleanup and Purge Solvent

Another source of emissions that must be calculated and often overlooked, are VOCs that are emitted from the use of cleanup and purge solvents. Use the equation below to calculate these emissions. Note that reclaimed solvents are subtracted from the emissions calculation.

$$\frac{\text{lbs of VOC}}{\text{gal of solvent}} \times \frac{\text{actual gal solvent used} - \text{gal of solvent reclaimed}}{\text{year}} = \frac{\text{lbs VOC emitted from solvent}}{\text{year}}$$

What if Ingredients are Reported in Ranges?

Sometimes a data sheet will not give an exact percentage by weight or volume when listing the ingredients, but rather a range (e.g. 1 – 5%). In such instances, use the upper range in the calculation (e.g. 5%). When estimating emissions, it is best to be conservative; the upper range represents the worst case. It is possible using this approach to end up with a calculation showing that more than 100% of the coating is VOC. If this occurs, use only 100%.

How to Find the Density of an Individual VOC

Individual VOC densities and/or specific gravity can usually be found in chemical handbooks or on the Internet (e.g. www.chemfinder.com). In addition, density can be calculated using the VOC's specific gravity. Density equals the specific gravity of the VOC multiplied by the density of water (8.34 lbs/gal). Alternatively, contact the Department of Environmental Quality, Clean Air Assistance Program at (800) 662-9278 for assistance.

What if the Product Density is Not Provided?

Sometimes the product density for the coating is not provided on the data sheet. In these instances, the specific gravity of the coating is used to calculate the density. Usually the specific gravity is given when the density is not. To calculate density using specific gravity, multiply the specific gravity of the coating by the density of water (8.34 lbs/gal).

$$\text{Specific Gravity of Coating} \times 8.34 \text{ lbs/gal} = \text{Density of Coating}$$

What if the Percent Volatile is the Value Listed?

Some data sheets include the percent volatile by weight. When multiplying this number by the density of the coating, the VOC emissions may be over estimated. The volatile portion of the coating may contain water and exempt VOCs. Subtract water and exempt VOCs from the percent volatile to obtain a more accurate representation of the VOC content.

Control Factors

If a facility has control equipment, the actual uncontrolled emissions can be multiplied by a control factor. Calculate the control factor by subtracting the % control efficiency from 100 and then divide that number by 100. Overall control efficiency is calculated by multiplying the capture efficiency by the control efficiency. For coating operations, the following default capture efficiency values are generally assumed: 80% for manual coating booths, 85% for automated spray coating booths, and 90% for dip coating tanks. Control efficiencies may be listed on the equipment, in the equipment documentation, or by contacting the equipment supplier. A default value of 95% control efficiency is generally assumed for thermal or catalytic oxidizers. For a coating line with a capture efficiency of 85% and a control efficiency of 95% the overall control efficiency would be $0.85 \times 0.95 = \mathbf{0.8075 (80.75\%)}$. Use this number to calculate the control factor $(100 - 80.75)/100 = \mathbf{0.19}$. Therefore, if a facility has actual uncontrolled emissions of 129,600 lbs/year, the actual emissions after control would be $129,600 \text{ lbs/year} \times 0.19 = \mathbf{24,624 \text{ lbs/year}}$.

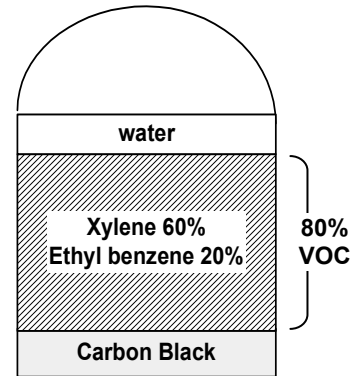
EXAMPLE 1

Company A applied 20,000 gallons of LCOAT coating last year. Determine the pounds of VOC emitted last year using the mass balance method and the MSDS below.

1. Calculate pounds of VOC per gallon of coating

$$\% \text{ by weight VOC} / 100 \times \text{density of coating} = \text{lbs VOC} / \text{gallon of coating}$$

$$80 / 100 \quad \times \quad 8.10 \text{ lbs} / \text{gal} \quad = \quad 6.48 \text{ lbs} / \text{gal}$$



2. Calculate pounds of VOC emitted last year

$$\frac{\text{lbs VOC}}{\text{gallon of coating}} \times \frac{\text{gallons of coating used}}{\text{year}} = \text{lbs VOC emitted} / \text{year}$$

$$6.48 \text{ lbs} / \text{gal} \quad \times \quad 20,000 \text{ gal} / \text{year} \quad = \quad 129,600 \text{ lbs} / \text{year}$$

MATERIAL SAFETY DATA SHEET

SECTION 1 – CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: LCOAT
 PRODUCT USE: ADHESIVE

ANYCHEM CORP
 123 W. MAIN
 ANYTOWN, MI 48800

SECTION 2 – COMPOSITION /INFORMATION ON INGREDIENTS

Chemical Name	CAS #	Percent by weight
Ethylene benzene	100-41-4	15-20%
Xylene	1330-20-7	55-60%
Carbon black	1333-86-4	<10%
Water	7732-18-5	7%

SECTION 3 – PHYSICAL AND CHEMICAL PROPERTIES

DENSITY, LBS/GAL: 8.10

PERCENT VOLATILE BY WEIGHT: 87%

EXAMPLE 2

Company B applied 5,500 gallons of KCOAT last year. Determine the pounds of VOC emitted last year using the mass balance method and the MSDS below.

1. Calculate pounds of VOC per gallon of coating for each VOC_x

$$(\% \text{ by volume of VOC}_x) \times (\text{density of VOC}_x \text{ [lbs/gal]}) = \text{lbs VOC}_x / \text{gallon coating}$$

VOC _x	% by Volume VOC _x	Density of VOC _x (lbs/gal) (density of H ₂ O x specific gravity VOC _x)	lbs VOC _x /gal coating
Xylene (X)	30%	8.34 x 0.86 = 7.17 lbs /gal	0.30 x 7.17 = 2.15 lbs X/gal KCOAT
Ethyl benzene (EB)	15%	8.34 x 0.87 = 7.26 lbs / gal	0.15 x 7.26 = 1.09 lbs EB/gal KCOAT
N-Butyl Alcohol (BA)	5%	8.34 x 0.81 = 6.76 lbs / gal	0.05 x 6.76 = 0.34 lbs BA/gal KCOAT

2. Calculate the total pounds of VOC per gallon of coating

$$\begin{array}{r} \text{lbs VOC1} \\ \text{gal of coating} \end{array} + \begin{array}{r} \text{lbs VOC2} \\ \text{gal of coating} \end{array} + \begin{array}{r} \text{lbs VOC3} \\ \text{gal of coating} \end{array} = \begin{array}{r} \text{Total lbs VOC} \\ \text{gallon of coating} \end{array}$$

$$2.15 \text{ lbs Xylene / gal} + 1.09 \text{ lbs EB / gal} + 0.34 \text{ lbs BA / gal} = 3.58 \text{ lbs VOC / gal}$$

3. Calculate pounds of VOC emitted last year

$$\begin{array}{r} \text{lbs VOC} \\ \text{gallon of coating} \end{array} \times \begin{array}{r} \text{gallons of coating used} \\ \text{year} \end{array} = \text{lbs VOC emitted / year}$$

$$3.58 \text{ lbs / gal} \times 5,500 \text{ gal / year} = 19,690 \text{ lbs / year}$$

MATERIAL SAFETY DATA SHEET**SECTION 1 – CHEMICAL PRODUCT AND COMPANY IDENTIFICATION**

PRODUCT NAME: KCOAT

ANYCHEM CORP
123 W. MAIN
ANYTOWN, MI 48000

SECTION 2 – COMPOSITION /INFORMATION ON INGREDIENTS

Chemical Name	CAS #	Percent by volume
Ethyl benzene	100-41-4	10-15%
Xylene	1330-20-7	25-30%
N-Butyl Alcohol	71-36-3	2-5%
Water	7732-18-5	5-10%
Carbon Black	1333-86-4	35-40%

SECTION 3 – PHYSICAL AND CHEMICAL PROPERTIES

Density, lbs/gal: 7.73

Percent, volatile by volume: 60%

EXAMPLE 3

Company C applied 5,450 gallons of ZCOAT water based coating last year. They also used 225 gallons of SuperSolve purge solvent, of which 180 gallons were reclaimed. Determine the pounds of VOC emitted last year using the mass balance method and the data sheets below.

1. Since this is a water based coating, calculate the gallons of coating used last year, minus water

$$\frac{\text{gallons of coating used}}{\text{year}} \times [1 - (\% \text{ volume water}/100)] = \text{gallons coating (minus water) / year}$$

$$5,450 \text{ gal / year} \quad \times \quad 1 - 0.61 \quad = \quad 2,126 \text{ gallons of coating (minus water) / year}$$

2. Calculate pounds of VOC emitted from coating last year

$$\frac{\text{lbs VOC}}{\text{gallon of coating (minus water)}} \times \frac{\text{gallons of coating used (minus water)}}{\text{year}} = \text{lbs VOC emitted / year}$$

$$2.87 \text{ lbs / gal} \quad \times \quad 2,126 \text{ gal / year} \quad = \quad 6,102 \text{ lbs / year}$$

3. Calculate the pounds of VOC emitted from cleanup solvent last year

$$\frac{\text{lbs of VOC}}{\text{gal of solvent}} \times \frac{\text{actual gal solvent used} - \text{gal of solvent reclaimed}}{\text{year}} = \text{lbs VOC emitted / year}$$

$$7.02 \text{ lbs / gal} \quad \times \quad (225 \text{ gal} - 180 \text{ gal}) / \text{year} \quad = \quad 316 \text{ lbs / year}$$

4. Total the pounds of VOC emitted from coating and solvent

$$\text{lbs VOC from coating emitted / year} + \text{lbs VOC from solvent emitted / year} = \text{total lbs VOC emitted / year}$$

$$6,102 \text{ lbs / year} \quad + \quad 316 \text{ lbs / year} \quad = \quad 6,418 \text{ lbs / year}$$

**ANYCHEM CORP
ENVIRONMENTAL DATA SHEET**

ANYCHEM CORP ● 123 W. MAIN ● ANYTOWN, MI 48000

PRODUCT: ZCOTE COATING

PRODUCT COMPOSITION

Density: 11.26 lbs/gal

Non-Volatile: 45% by weight

Volatile: 55% by weight

% Water: 61% by volume

VOC Content

VOC per gallon (with water): 1.13 lbs/gal

VOC per gallon (minus water): 2.87 lbs/gal

**ANYCHEM CORP
ENVIRONMENTAL DATA SHEET**

ANYCHEM CORP ● 123 W. MAIN ● ANYTOWN, MI 48000

PRODUCT: SuperSolve Purge Solvent

PRODUCT PHYSICAL CHARACTERISTICS

Density: 7.02 lbs/gal

% VOC (minus water): 100% by weight

% Water: 0% by weight

VOC Content

VOC per gallon (with water): 7.02 lbs/gal

VOC per gallon (minus water): 7.02 lbs/gal