PC VOC calculation

GERALD RICH

USEPA has issued Control Techniques Guidelines (CTG) for a number of surface coatings including can coating, metal coil coating, paper coating, fabric coating, automobiles, light-duty trucks, metal furniture, large appliances, magnet wire, miscellaneous metal parts, graphic arts and flatwood paneling. Included in these CTGs are recommendations for emission limits. These recommendations have been adopted by many state and local agencies.

In addition to the CTGs are New Source Performance Standards (NSPS) for many of the same operations. Confusion arises when the emissions from these sources are calculated, because the calculation is on a solids-applied basis and excludes both water and negligibly photochemically reactive materials (NPR). An additional calculation problem involves the use of improved transfer efficiency (TE) in coating operations.

This article attempts to reduce the confusion some environmental managers may have by providing a computer program based on the various guidances provided by USEPA. It can be used with any spreadsheet program such as Lotus. (As an alternative to calculating the emissions, USEPA has developed Reference Method 24 to test the actual emission).

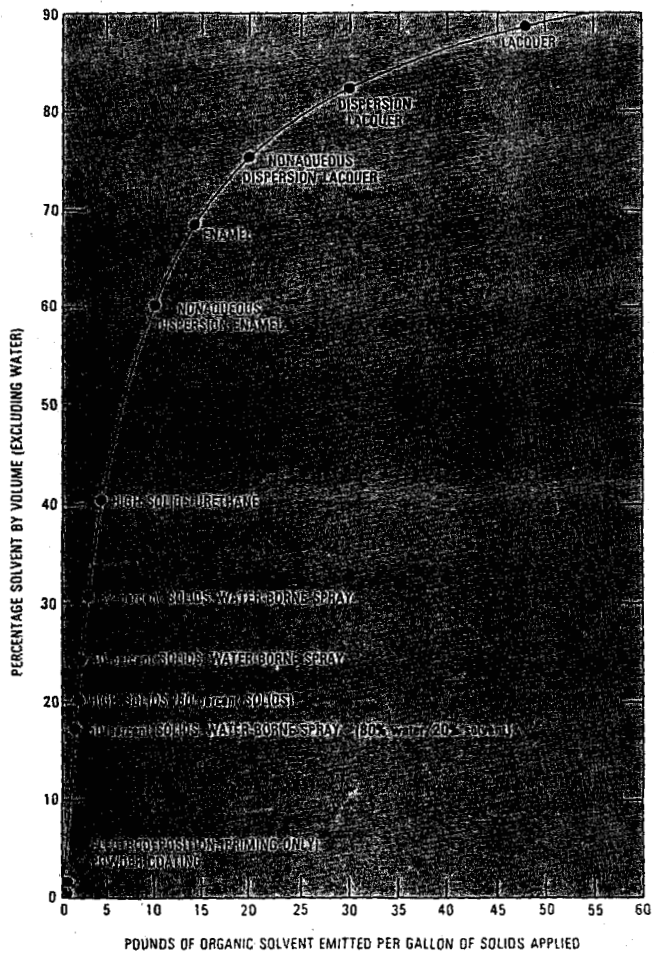


Figure 1. Solvent emissions from various coating formulas.

As noted above, the emissions are calculated on a solids-applied basis excluding water and negligibly photochemically reactive materials (NPR). The NPR organic compounds established by USEPA include:

Methane
Ethane
1,1,1-trichloroethane (methyl chloroform)
Methylene chloride
Trichlorofluoromethane (CFC-11)
Dichlorodifluoromethane (CFC-12)
Chlorodifluoromethane (CFC-22)
Trifluoromethane (CFC-23)
Trichlorotrifluoroethane (CFC-113)
Dichlorotetrafluoroethane (CFC-114)
Cholorpentafluoroethane (CFC-115)

These compounds were established by USEPA in 42 FR 35314, July 8, 1977; 45 FR 32042, June 4, 1979; and 45 FR 48941, July 22, 1980. Any of these compounds is considered "exempt" or "NPR" if used in a coating and, as such, is added to the water content for calculation purposes. Of these 11 only 2, (1,1,1-trichloroethane and methylene chloride) are typically used as solvents in coatings. "Rule 66" compounds should not be assumed to be NPR compounds unless specifically stated as such in state or local regulations, as per 42 FR 35314, July 8, 1977.

There are 2 methods of calculating coating emissions: by weight or by volume. Either should give the same result. This program allows you to calculate either independent of the other. If the density of the VOC is not known, use 7.36 lb/gal. A closer approximation for the "typical" densities and solids contents of the coatings follows:

	lb/gal	Solids %volume
Enamel, dry air	7.6	40
Enamel, baking	9.1	43
Acrylic enamel	8.9	30
Alkyd enamel	8.0	47
Primer surfacer	9.4	49
Primer, epoxy	10.5	57
Varnish, baking	6.6	35
Lacquer, spraying	7.9	26
Vinyl, roller coat	7.7	12
Polyurethane	9.2	32
Stain	7.3	22
Sealer	7.0	12
Magnet wire enamel	7.8	25
Paper coating	7.7	22
Fabric coating	7.7	22

Figure 1 shows the approximate relationship between the percentage solvent by volume (excluding wa-

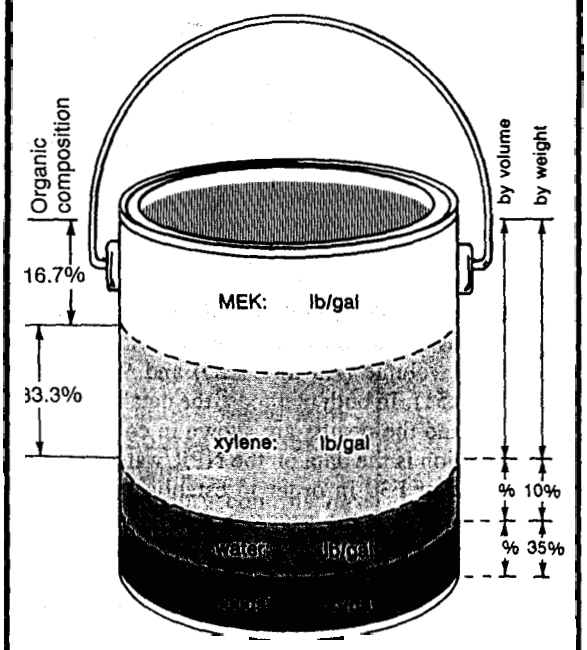
ter) and pounds of organic solvent emitted per gallon of solids applied for various coatings.

Transfer efficiencies (TE) are another area which USEPA has established baselines. Improving TE will reduce your effective emission rate on a pound per gallon solids basis (or, conversely, increase your allowable emission rate to an equivalent emission rate based on the improved TE). This program changes the allowed emission rate to the equivalent allowable emission rate. Two areas of TE are in the Metal Furniture category and Large Appliance category, as follows:

	Transfer Efficiency	
	Metal Furniture	Large Appliance
Air atomized spray	25	40
Airless spray	25	45
Manual electrostatic spray	60	60
Non-rotational automatic electrostatic spray	70	85
Rotating head electrostatic spray, manual and automatic	80	90
Dip coat	90	85
Flow coat	90	85
Electrodeposition	95	95
Powder application	95	95

Both CTG and NSPS establish VOC emissions on a pound per gallon (excluding water and NPR) basis. Additionally, in order to meet the National Ambient Air Quality Standards, USEPA has also issued RACT (Reasonably Available Control Technology) for existing sources using the CTG as guidance. If your application has higher TE, this program allows you to adjust the RACT (or NSPS) allowable to an equivalent RACT (or NSPS) allowable by entering both the baseline and the actual TE.

Figure 2



One gallon of a coating material contained the following components and illustrates what should be included (min.) in VOC calculations.

Example

In the example shown, the following is given: A coating formulation is 35% solids and 10% water (both by weight). Solids density is 29.7 lb/gal. Organic composition is Xylene = 83.3%, MEK = 16.7% (volume basis). Transfer efficiency for the source is 0.5, baseline is 0.3. At this time the data can be shown in Figure 2.

Numbers which can be inserted into this diagram are the density of water (8.34 lb/gal) and the densities of both MEK and Xylene (these can be found in standard Organic Density tables and are 6.7 and 7.5 lb/gal, respectively).

Solvent Density

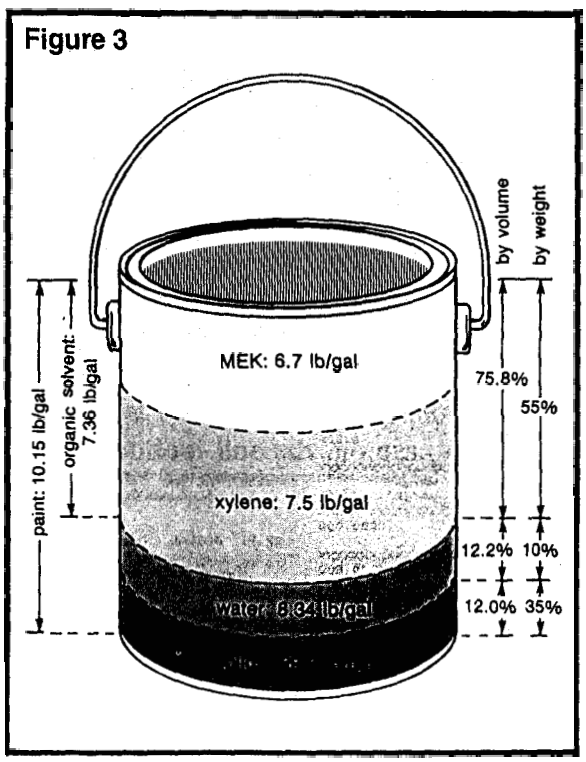
Calculating the organic solvent density can be done by finding the proportional density of each organic and summing the components:

xylene = 7.5 lb/gal (0.833) = 6.25
MEK = 6.7 lb/gal (0.167) = 1.11
7.36 lb/gal

Paint Density

First, convert weight basis to volume basis by assuming 100 lb of coating is applied, divide by the appropriate density, and sum the components. Dividing the 100 lb by the sum gives the paint density. *Note:* Dividing the component gallons by the sum gives the percent by volume.

Figure 3

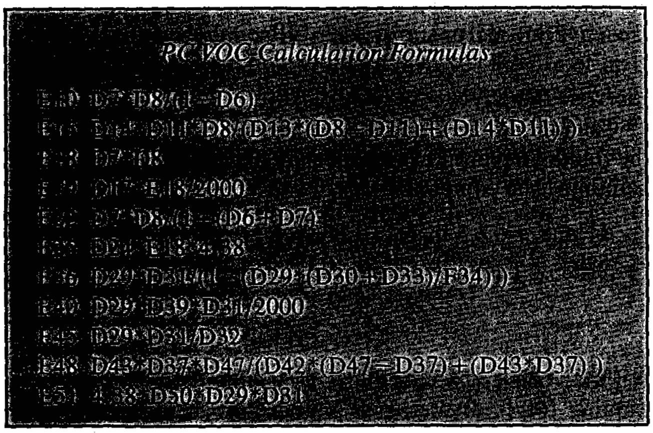


					% by Volume
35 lb	solids	÷ 29.7	=	1.18 gal	12.0
10 lb	water	÷ 8.34	=	1.20 gal	12.2
55 lb	solvent	÷ 7.36	=	7.47 gal	75.8
100 lb				9.85 gal	

$$\frac{100 \text{ lb}}{9.85 \text{ gal}} = 10.15 \text{ lb/gal}$$

The coating diagram, Figure 3, can now be completed.

RACT Density (lb VOC/gal excluding water, NPR)


PC VOC Calculator Formulas

```
E10 D7*D8/(1 – D6)
E15 D14*D11*D8/(D13*(D8 – D11)+(D14*D11))
E18 D7*D8
E19 D17*E18/2000
E22 D7*D8/(1 – (D6+D7))
E25 D24*E18*4.38
E36 D29*D31/(1 – (D29*(D30+D33)/F34)))
E40 D29*D39*D31/2000
E45 D29*D31/D32
E48 D43*D37*D47/(D42*(D47–D37)+(D43*D37))
E51 4.38*D50*D29*D31
```

```
     A           B          C          D            E          F          G          H
1  "PC VOC CALCULATION PROGRAM"
2       BY GERALD RICH
3  ©1987, POLLUTION ENGINEERING
4
5     "PERCENT BY VOLUME"
6  % VOLUME WATER + NPR                0.122
7  % VOLUME VOC                        0.758
8  DENSITY VOC                         7.360
9XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
10 COATING: # VOC/GAL-WATER                      6.35   ACTUAL
11 RACT:     # VOC/GAL-WATER           6.000            ALLOWABLE
12XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
13 RACT T.E. (BASELINE)                0.300
14 ACTUAL T.E.                         0.500
15 LB VOC/GAL-WATER,  RACT EQUIVALENT            6.48  RACT BASED ON IMPROVED TE
16XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
17 GALLONS/YEAR                    10000.000
18 LB VOC/GAL INCLUDING WATER                    5.58
19 EMISSION: TONS/YEAR                          27.89  ACTUAL EMISSION TPY
20XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
21 % VOLUME SOLIDS                     0.120
22 LB VOC/GAL SOLIDS                            46.49
23XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
24 GAL/HOUR                            7.000
25 POTENTIAL EMISSIONS, TPY                    171.05  POTENTIAL EMISSION TPY
26
27
28      "PERCENT BY WEIGHT"
29 COATING DENSITY                    10.150
30 % WATER BY WEIGHT                   0.100
31 % VOC BY WEIGHT                     0.550
32 % SOLIDS BY VOLUME                  0.120
33 % NPR BY WEIGHT                     0.000
34 DENSITY: NPR & WATER                                   8.34   LB/GAL
35XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
36 COATING: # VOC/GAL - WATER                    6.36   ACTUAL
37 RACT:    # VOC/GAL - WATER          6.000            ALLOWABLE
38XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
39 GALLONS/YEAR                    10000.000
40 EMISSION: TONS/YEAR                          27.91  ACTUAL EMISSION TPY
41XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
42 RACT T.E.(BASELINE)                 0.300
43 ACTUAL T.E.                         0.500
44XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
45 LB VOC/GAL SOLIDS                            46.52
46XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
47 VOC DENSITY                         7.360
48 LB VOC/GAL- WATER, RACT EQUIVALENT            6.48  RACT BASED ON IMPROVED TE
49XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
50 GAL/HOUR                            7.000
51 POTENTIAL EMISSIONS, TPY                    171.16  POTENTIAL EMISSION TPY
```

Figure 4. PC VOC calculation program.

$$\text{RACT} = \frac{\text{(volume fraction organic solvent)(solvent density)}}{(1.0 - \text{volume fraction water})}$$

$$= \frac{(0.758)(7.36 \text{ lb/gal})}{(1.0 - 0.122)}$$

$$= 6.35 \text{ lb/gal minus water.}$$

This is the value used in determining compliance with RACT/NSPS regulations. Obviously, if the regulation stipulates 6.0 lb VOC/gal excluding water/NPR, there is a violation. However, note what happens if the water fraction is omitted:

$$(0.758)(7.36) = 5.58 \text{ lb/gal}$$

Compliance is apparently attained.

Lb VOC/gal coating

As mentioned earlier, there are 2 ways to determine this value, either by weight or by volume:

(Solvent fraction by volume)(Solvent density) = 0.758(7.36) = 5.58 lb VOC/gal

(Solvent fraction by weight)(Paint density) = 0.55(10.15) = 5.58 lb VOC/gal

This value is used in determining the annual (or hourly) emission rate: simply multiply this value by the number of gallons applied per time unit.

Transfer Efficiency (TE)

TE is the ratio of the amount of coating solids deposited onto the surface of a part or product to the total amount of coating solids used. In the example shown, the coating is apparently out of compliance with an actual emission of 6.35 lb/gal and an allowable of 6.0 lb/gal. However, the TE for this application is 0.5 versus the baseline of 0.3, giving an equivalent RACT of 6.48 lb/gal. Since the actual is less than the equivalent allowable, the source is in compliance.

Program

The program is composed of 2 sections, based on the 2 methods available to calculate RACT/NSPS compliance: % by volume (A5 thru A25) and % by weight (A28 thru A51). In both methods, the data is entered in column D and the results are shown in column E (the only exception is the data on the NPR/water density — it is entered at F30 in order to establish a "default" value. (*Note:* while the program asks for "%," enter the decimal.) **PE**

For a copy of this already on disk, please send $10 to: Gerald Rich, 17719 Brim Rd., Bowling Green, OH 43402.