

Everything You Wanted To Know About The VOLATILE ORGANIC COMPOUND (VOC) DATA SHEET But Were Afraid To Ask

The VOC Data Sheet was developed in early 1984 by the National Paint and Coating Association in concert with the United States Environmental Protection Agency as a compliance certification procedure to relieve users from the constant expense of analyzing the many coatings used, particularly by can manufacturers. In addition, determination of compliance with the regulations required complex calculations which could now be referenced directly to the VOC Data Sheet for a given coating material.

In December 1984, the United States Environmental Protection Agency's Emission Standards and Engineering Division issued a manual "Procedure for Certifying Quantity of Volatile Organic Compounds Emitted by Paint, Ink, and Other Coatings" EPA-450/3-84-019. This manual provided a step-by-step instruction to coating manufacturers for preparing a VOC Data Sheet for a coating "as supplied".

The calculations illustrated below are designed for the coating user to take from the VOC Data Sheet in order to calculate other physical properties of a coating that are not listed and also to help understand the compliance terms of VOC content "pounds per gallon coating less water" and "pounds per gallon of solids". Examples of calculations with both waterborne coatings and solvent-based coatings are shown.

Exhibit 1 shows the "as supplied" VOC Data Sheet. Items A through E from the VOC Data Sheet represent the following physical properties of the coating:

- A Coating Density, lb/gal
- B Total Volatiles, Weight Percent
- C1 Water Content, Weight Percent¹
- C2 Water Content, Volume Percent
- D Organic Volatiles, Weight Percent
- E Non-Volatiles (Solids), Volume Percent

To determine weight percent solids from the above:

$$\text{Solids, Weight \%} = (100 - B)$$

To determine solids, solvent and water weights per gallon of coating and the volume of each per gallon of coating:

Weight, lbs per gallon of coating of:

$$\text{Solids: } W_s = A \left(1 - \frac{B}{100} \right) \text{ lbs/gallon of coating}$$

$$\text{Solvent: } W_{\text{solvent}} = A \frac{(B - C1)}{100} = \frac{A \times D}{100} \text{ lbs/gallon of coating}$$

$$\text{Water: } W_w = \frac{C1}{100} \text{ gallon/gallon of coating}$$

Similarly:

Volume, gallon per gallon of coating of:

$$\text{Solids: } V_s = \frac{E}{100} \text{ gallon/gallon of coating}$$

$$\text{Water: } V_w = A \frac{(C2)}{100} \text{ gallon/gallon of coating}$$

$$\text{Solvent: } V_{\text{sol}} = \left(1 - \frac{E}{100} - \frac{C2}{100} \right) \text{ gallon/gallon of coating}$$

Many permit applications request the actual solvent density of the coating. Where several solvents are blended in a coating, the composite solvent density can be calculated as:

$$\delta_{\text{Solvent}} = \frac{W_{\text{solvent}}}{V_{\text{solvent}}} = A \frac{\left(\frac{B - C1}{100} \right)}{\left[1 - \frac{E}{100} - \frac{C2}{100} \right]}$$

The VOC content of a coating can be expressed three different ways. The first is straight forward:

$$\text{VOC, Lbs/Gallon of Coating} = \frac{W_{\text{solvent}}}{1 \text{ Gallon}} = \frac{A (B - C1)}{100}$$

¹Volatile compounds that the United States Environmental Protection Agency has classified as having negligible photochemical reactivity such as acetone, 1,1,1-trichloroethane and methylene chloride and listed as exempt in federal and state VOC regulations should be treated same as water.

Exhibit 1—United States Environmental Protection Agency

VOC DATA SHEET

Properties of the coating "as supplied" to the customer:

- A. Coating Density (Dc)s: _____ lb/gal _____ kg/l
 ASTM D1475 Other²
- B. Total Volatiles (Wv)s: _____ Weight Percent
 ASTM D2369 Other²
- C. Water Content: 1. (Ww)s _____ Weight Percent
 ASTM D3792 ASTM D4017 Other²
 2. (Vw)s _____ Volume Percent
 Calculated Other²
- D. Organic Volatiles (Wo)s: _____ Weight Percent
- E. Nonvolatiles Content (Vn)s: _____ Volume Percent
- F. VOC Content (VOC)s: 1. _____ lb/gal coating less water
 or _____ kg/l coating less water
 2. _____ lb/gal solids
 or _____ kg/l solids

Remarks: (use reverse side)

¹The subscript "s" denotes each value is for the coating "as supplied" by the manufacturer.

²Explain the other method used under "remarks"

The second is often used in Reasonably Available Control Technology (RACT) as a VOC limit for can coatings:

$$\text{VOC, Lbs/Gallon Less Water} = \frac{W_{\text{solvent}}}{1 - V_w} = A \left[\frac{B - C1}{100} \right] \left[\frac{100}{1 - \frac{C2}{100}} \right]$$

This should also be the same as F1 on the VOC Data Sheet.

The third way is often used in New Source Performance Standards (NSPS) for two piece can coatings and is also often required in "bubble calculations" or alternative compliance methods:

$$\text{VOC, Lbs/Gallon Solids} = \frac{W_{\text{solvent}}}{V_s} = A \left[\frac{B - C1}{100} \right] \left[\frac{100}{E} \right]$$

Example 1 - Waterborne Coating

Given from VOC Data Sheet

- A = 8.50 lbs/gal
 B = 78.6% by Weight Total Volatiles
 C1 = 63.7% by Weight Water
 C2 = 65.0% by Volume, Water
 D = 14.9% by Weight Organic Volatiles
 E = 17.3% by Volume, Solids (Non-Volatiles)

Then:

$$\% \text{ Solids by Weight} = (100 - B) = (100 - 78.6) = 21.4\%$$

Lbs. Solids/Gallon Coating =

$$A \left[1 - \frac{B}{100} \right] = 8.5 \left[1 - \frac{78.6}{100} \right] = 1.82$$

Lbs. Solvent/Gallon Coating =

$$A \left[\frac{B - C1}{100} \right] = 8.5 \left[\frac{78.6 - 63.7}{100} \right] = 1.27$$

Lbs. Water/Gallon Coating =

$$A \left[\frac{C1}{100} \right] = 8.5 \left[\frac{63.7}{100} \right] = 5.41$$

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As a check, these should add to = A ...and...

Gallon Solid/Gallon Coating =

$$\frac{E}{100} = \frac{17.13}{100} = 0.173 \text{ Gallon}$$

Gallon Water/Gallon Coating =

$$\frac{C2}{100} = \frac{65.0}{100} = 0.650 \text{ Gallon}$$

Gallon Solvent/Gallon Coating =

$$\left[1 - \frac{E}{100} - \frac{C2}{100} \right] = (1 - .173 - .650) = 0.177 \text{ Gallon}$$

As a check, these should add to = 1 The actual composite solvent density in this coating is:

$$S_{\text{solvent}} = \frac{A \left[\frac{B - C1}{100} \right]}{\left[1 - \frac{E}{100} - \frac{C2}{100} \right]} = \frac{1.27}{.177} = 7.18 \frac{\text{lbs}}{\text{gal}}$$

The VOC content of the coating is:

$$\text{VOC} = \frac{A(B - C1)}{100} = \frac{8.50(78.6 - 63.7)}{100} = 1.27 \text{ Lbs/Gallon Coating}$$

$$\text{VOC} = A \frac{\left[\frac{B - C1}{100} \right]}{1 - \frac{C2}{100}} = \frac{1.27}{1 - .65} = 3.63 \text{ Lbs/Gallon Less Water}$$

(Same as F1)
(Same as F1)

$$\text{VOC} = A \frac{\left[\frac{B - C1}{100} \right]}{\frac{E}{100}} = \frac{1.27}{.173} = 7.34 \text{ Lbs/Gallon Solids}$$

(Same as F2)

It should be noted that the pounds VOC/gallon of solids should always be greater than the pounds VOC/gallon less water which should always be greater than the pounds VOC/gallon of coating.

Is this material a compliant coating?

For an inside body spray, the RACT allowable VOC limit is 4.2 pounds VOC/gallon less water. Since RACT is greater than 3.63, it is a compliant coating.

What is the allowable limit for this material in terms of pounds VOC/gallon solids?

The VOC limit in terms of pounds VOC/gallon less water is 4.2, however, it must be realized that we are now not talking about a gallon of coating but a

gallon of the material with the water removed. This gallon consists of only the solids and solvent portion of the coating. Therefore, we must determine the volume of solvent in this hypothetical gallon. We will calculate this in two ways, using an assumed density of solvent as 7.36 pounds/gallon and the actual density.

Using $\delta = 7.36$ Pounds/Gallon

(The default value used by United States Environmental Protection Agency when actual density is not known)

Limit = 4.2 Lbs/Gallon Less Water

Then:

$$\text{Solvent Volume} = \frac{4.2}{7.36} \times 100 = 57.1\%$$

Then:

$$\text{Allowable VOC} = \frac{4.2}{\left[1 - \frac{V_{\text{solvent}}}{100} \right]} = \frac{4.2}{(1 - .571)} = 9.78 \text{ Lbs. VOC/Gallon Solids}$$

Using $\delta = \text{Actual} = 7.18$ Pounds/Gallon

$$\text{Solvent Volume} = \frac{4.2}{7.18} \times 100 = 58.5\%$$

Then:

$$\text{Allowable VOC} = \frac{4.2}{(1 - .585)} = 10.12 \text{ Lbs. VOC/Gallon Solids}$$

As you can see in this case, using the actual solvent density provides a higher allowable VOC limit in terms of pounds VOC/gallon solids.

Example 2 - Solvent-Based Coating

Given from VOC Data Sheet

- A = 8.25 lbs/gal
- B = 52.0% by Weight Total Volatiles
- C1 = 0 _____ —No Water
- C2 = 0 _____ —No Water
- D = 52.0% by Weight Organic Volatiles
- E = 39.3% by Volume, Solids (Non-Volatiles)

Then:

$$\% \text{ Solids by Weight} = (100 - B) = (100 - 52) = 48\%$$

Lbs. Solids/Gallon Coating =

$$A \left[1 - \frac{B}{100} \right] = 8.5 \left[1 - \frac{52}{100} \right] = 3.96$$

Lbs. Solvent/Gallon Coating =

$$A \left[\frac{B - C1}{100} \right] = 8.25 \left[\frac{52.0 - 0}{100} \right] = 4.29$$

Lbs. Water/Gallon Coating = 0

As a check, these should add to = A ...and...

Gallon Solid/Gallon Coating =

$$\frac{E}{100} = \frac{39.3}{100} = 0.393$$

Gallon Solvent/Gallon Coating =

$$\left[1 - \frac{E}{100} - \frac{C2}{100} \right] = (1 - .393 - 0) = 0.607$$

Gallon Water/Gallon Coating = 0

As a check, these should add to = 1

The actual solvent density in this coating is:

$$S_{\text{solvent}} = \frac{A \left[\frac{B - C1}{100} \right]}{\left[1 - \frac{E}{100} - \frac{C2}{100} \right]} = \frac{8.25 \left[\frac{52 - 0}{100} \right]}{(1 - .393 - 0)} = 7.07 \text{ Lbs./Gallon}$$

The VOC content per gallon of coating is:

$$\text{VOC} = \frac{A (B - C1)}{100} = \frac{8.25 (52 - 0)}{100} = 4.29 \text{ Lbs/Gallon Coating}$$

$$\text{VOC} = A \left[\frac{B - C1}{1 - \frac{C2}{100}} \right] = 8.25 \left[\frac{\frac{52 - 0}{100}}{1 - \frac{0}{100}} \right] = 4.29 \text{ Lbs/Gallon Less Water}$$

$$\text{VOC} = A \left[\frac{B - C1}{\frac{E}{100}} \right] = \frac{4.29}{\frac{39.3}{100}} = 10.92 \text{ Lbs/Gallon Solids}$$

Is this material a compliant coating?

For a varnish or coating, the RACT allowable VOC limit is 2.8 pounds VOC/gallon less water. Since 4.29 is larger than this value, it is not a compliant coating!

What is the allowable limit for this material in terms of pounds VOC/gallon solids? Using the same reasoning as in the previous example:

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Using $\delta = 7.36$ Pounds/Gallon (Default Value)

$$\text{Solvent Volume} = \frac{2.8}{7.36} \times 100 = 38.0\%$$

Then:

Allowable VOC =

$$\frac{2.8}{\left[1 - \frac{V_{\text{solvent}}}{100}\right]} = \frac{2.8}{(1 - .38)} = 4.52 \text{ Lbs. VOC/Gallon Solids}$$

Using $\delta = \text{Actual} = 7.07$ Pounds/Gallon

$$\text{Solvent Volume} = \frac{2.8}{7.07} \times 100 = 39.6\%$$

Then Allowable VOC =

$$\frac{2.8}{(1 - .396)} = 4.64 \text{ Lbs. VOC/Gallon Solids}$$

As in the previous case, using the actual solvent density provides a higher allowable VOC limit in terms of pounds VOC/gallon solids.

The formulas above, hopefully, take some of the "black magic" out of compliance calculations. However, if a coating user adds solvent to the "as received" coating, these equations no longer apply. A future article will cover the calculations necessary to calculate the "as applied" VOC properties.

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