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Category: 29 – Capture Efficiency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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SUBJECT: Determination of Capture Efficiency

FROM: James Berry, Chief
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TO: Doug Cook, EPA Region IV

This is in response to your telephone call requesting an acceptable technique to measure the capture efficiency of hoods used in the control of surface coating operations. As you are aware, there is no official EPA test method for measuring capture efficiency. In fact we have gotten somewhat poor results when we have tried to measure this in actual plant tests. We have asked EPA's Office of Research and Development to develop a test method for this. Even though a standardized test method does not now exist, the technique outlined below will theoretically give an acceptable measure of capture efficiency.

A technique for measuring capture efficiency is needed because the VOC that is not captured by the hoods can represent a significant portion of the total VOC emitted to the atmosphere. The VOC not captured by the hoods could, in some cases, exceed the allowable emission rate established in the SIP's, even assuming 100 percent of the VOC which is captured by the hoods and directed to the control device is destroyed or recovered.

When carbon adsorbers are used, it is not necessary to determine capture efficiency since the VOC recovered can be compared directly to the emission standard. Our estimates for capture capability for web processes used in the CTG reports have been reinforced by observations by our engineers of overall control levels as high as 90-94 percent when carbon adsorbers are used. Since overall control is the product of the capture efficiency and the control device efficiency, even if we assume the carbon adsorbers are 100 percent efficient (which they're not), hood capture efficiencies of greater than 90 percent are demonstrated.

When incinerators are used, determination of compliance is more involved. A general procedure would be as follows. An example is provided as an attachment.

1. Calculate a potential emission rate in mass/time based on VOC content of the coating and amount of coating used.

2. Calculate an allowable emission rate in mass/time based on the SIP standard. (This can be tricky; less volume of coating is required since the solids content is greater.)

3. Determine the required reduction in VOC.

4. Measure the inlet concentration and flow rate to the incinerator and calculate the inlet emission rate in mass/time. If this is less than the required reduction, obviously the source is in violation, since enough emissions will not be destroyed in the incinerator to give the required reduction. This will result if an undesirably large portion of the emissions are emitted as fugitives.

a. If the inlet VOC mass flow rate is greater than the required reduction, measure the outlet concentration and flow rate for the incinerator and calculate the outlet emission rate in mass/time.

b. By difference, determine if the required reduction is achieved.

To measure the VOC concentration before and after the incinerator, two approaches are available: (I) FID; or (2) Reference Method 25.

If the FID is used, it must be calibrated with the solvent in the coating. This calibration will provide a good measure on the inlet to the incinerator, but it will not be accurate for the outlet. The outlet of an incinerator contains oxygenated compounds which have a depressed response in the FID. Therefore, outlet readings will be low compared to absolute values. An FID might be used for an easy to make measurement to check for non-compliance. If the FID shows the source to be in violation then, it undoubtedly will be in violation. If the FID shows that the incinerator outlet emissions are equal to or slightly less than the allowable emission level, the results will be somewhat in doubt. Method 25 may be resorted to in this case. An advantage of the FID is that measurements are easy to make and can be taken over a period of time, perhaps leading to a better measure of average emission rates compared to the short-term sampling with Reference Method 25.

If Reference Method 25 is used, VOC concentrations are made in terms of mass of carbon atoms (C). To compare the measured values with the allowable emission rates, the measured values must be corrected to mass VOC or the other terms must be corrected to mass C. This is done by obtaining formulation data for the solvents and calculating a mass VOC to C ratio. If the solvent formula is C_4H_8O, for example, the mass VOC to mass C ratio is 72/48 or 1.5. The major advantage of Reference Method 25 over the FID is that Reference Method 25 gives an accurate reading on the incinerator outlet. The need for this accuracy depends on incinerator efficiency and how close the emissions are to the standard. With low incinerator efficiency, an accurate measure of outlet emissions is more important than with a high incinerator efficiency.

Remember, however, that even a high efficiency control device would be ineffective if the capture device were very inefficient. The effectiveness of

the control system is equally dependent on its two components, the capture and control devices. Because of the large number of sources which must come into compliance with a variety of State regulations in the near future, it probably is more realistic for a State to initially plan on determining compliance with the capture requirements of their regulations on the basis of engineering judgment. Recognizing that 90% capture means that almost all emissions must be contained and delivered to the control device, it should be possible for an enforcement official to make some judgment that a system does or does not approach perfect capture. It would be well to train each enforcement person by having him inspect a web process that uses a carbon adsorber control device for which the overall recovery has actually been measured and found to be high. Its associated capture system would obviously have to be good. Ultimately, however, the enforcer and industry must recognize that achievement of emission limits based on 90% capture requires almost total containment of the emissions. Very little can be permitted to escape the control system.

Attachment

cc: CAS
Dave Patrick
Barry Perlmutter, Region V
Tom Williams

Attachment

Determination on Compliance by a Coating Operation
Which Controls Emissions with an Afterburner

Step 1. Determine the VOC emission rate from the process based on the VOC content of the coating and the rate of coating usage. (VOC content can be taken from the coating manufacturer's formulation or it can be determined by EPA Method 24.) Then calculate the solids content of the coating.

$$\begin{bmatrix}\text{Coating}\\ \text{Feed}\\ \text{Rate}\end{bmatrix} \times \begin{bmatrix}\text{Factor to Convert Water-borne}\\ \text{Coatings to Solvent-borne}\\ \text{Equivalent}\end{bmatrix} \times \begin{bmatrix}\text{Coating}\\ \text{Solvent}\\ \text{Content}\end{bmatrix} = \begin{bmatrix}\text{Actual}\\ \text{Solvent}\\ \text{Emission Rate}\end{bmatrix} \quad \text{(Eq. 1)}$$

$$\left[\frac{\text{Gal Coating}}{\text{hr}}\right] \times \left[\frac{\text{Gal Coating less } H_2O}{\text{Gal Coating}}\right] \times \left[\frac{\text{Lbs VOC}}{\text{Gal Coating less } H_2O}\right] = \left[\frac{\text{Lbs VOC}}{\text{hr}}\right]$$

As an example, consider the case of a coater using 100 gal/hr of a conventional solvent borne coating containing 5 pounds VOC per gallon of coating. Since a solvent borne coating contains no measurable amount of water, the units "gal coating less "H2O" and "gal coating" are synonymous and equation 1 becomes:

$$100\,\frac{\text{gal coating}}{\text{hr}} \times 5\,\frac{\text{lbs VOC}}{\text{gal coating}} = 500\,\frac{\text{lbs VOC}}{\text{hr}} \quad \text{(Eq. 2)}$$

The solids content of this coating is then calculated by difference: (Assume the density of the solvent is 7.36 #/gal.)

$$5\,\frac{\text{lbs VOC}}{\text{gal coating}} \times \frac{1.0 \text{ gal VOC}}{7.36 \text{ lbs VOC}} = 0.68\,\frac{\text{gal VOC}}{\text{gal coating}} \quad \text{(Eq. 3)}$$

$$1.0 \text{ gal coating} - 0.68 \text{ gal VOC} = 0.32 \text{ gal Solids} \quad \text{(Eq. 4)}$$

Step 2. Determine the allowable exhaust rate based on use of a complying coating and calculate its solids content. Assume the regulation contains an emission limitation of 2.5 in #VOC/gal coating less H2O which, if we use the same solvent density, is equivalent to:

$$2.5\,\frac{\text{lbs VOC}}{\text{gal coating}} \times \frac{1.0 \text{ gal VOC}}{7.36 \text{ lbs VOC}} = 0.34\,\frac{\text{gal VOC}}{\text{gal coating}} \quad \text{(Eq. 5)}$$

The solids content is again calculated by difference.

$$1.0 \text{ gal coating} - 0.34 \text{ gal VOC} = 0.66 \text{ gal Solids} \qquad \text{(Eq. 6)}$$

If the facility used a complying coating with 66% solids instead of 32%, far fewer gallons of coating would be required to coat a specified article. Assuming both coatings are applied at the same transfer efficiency, the volume of complying coating required to coat at the same production rate would be:

$$100 \frac{\text{gal noncomplying coating}}{\text{hr}} \times \frac{0.32}{0.66} = 49 \frac{\text{gal complying coating}}{\text{hr}} \qquad \text{(Eq. 7)}$$

Therefore, the allowable emission rate is:

$$49 \frac{\text{gal complying coating}}{\text{hr}} \times 2.5 \frac{\text{lbs VOC}}{\text{gal complying coating}} = 121 \frac{\text{lbs VOC}}{\text{hr}} \qquad \text{(Eq. 8)}$$

Step 3. Determine the required VOC reduction.

Actual emission rate - allowable rate = reduction required

$$500 \frac{\text{lbs VOC}}{\text{hr}} - 121 \frac{\text{lbs VOC}}{\text{hr}} = 379 \frac{\text{lbs VOC}}{\text{hr}} \qquad \text{(Eq. 9)}$$

Step 4. Measure the mass flow rate of VOC to the incinerator using a flame ionization detector calibrated with the solvent in the coating feed to the coating line. If the measured VOC mass flow rate is less than or equal to 379 pounds per hour, the capture system is deficient and the source is not in compliance. (This presumes the control device could never achieve perfect control.)

Step 5. If the mass flow rate of VOC to the incinerator is greater than 379 pounds per hour, the destruction efficiency of the incinerator should be determined using the Total Gaseous Non-methane Organics detector (Reference Method 25). The incinerator must be efficient enough to destroy no less than 379 pounds per hour of VOC in order for the coater to be in compliance.