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Standard Test Method for Determining Amount of Volatile Organic Compound (VOC) Released from Solventborne Automotive Coatings and Available for Removal in a VOC Control Device (Abatement)[1]

This standard is issued under the fixed designation D 5087; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

[1] This test method is under the jurisdiction of ASTM Committee ~~D-1~~ D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.21 on Chemical Analysis of Paints and Paint Materials.

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1. Scope

1.1 This test method covers the determination of the amount of volatile organic compound (VOC) released from applied solventborne automotive coatings that is available for delivery to a VOC control device. This is accomplished by measuring the weight loss of a freshly coated test panel subjected to solvent evaporation or baking in a laboratory simulation of the production process.

1.2 This test method is applicable to the VOC released from flashoff and baking operations after the paint has been applied.

1.3 This test method is applicable to solventborne automotive coating materials and is intended to represent or simulate the production process. The same general principles apply to waterborne coatings that contain volatile organic compounds (VOC), although specific procedural details are not presented herein to differentiate between VOC and water.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

B 499 Test Method for Measurement of Coating Thickness by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals[2]

D 1005 Test Method~~s~~ for Measurement of Dry Film Thickness of Organic Coatings Using Micrometers[3]

D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[3]

D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base[3]

D 2369 Test Method for Volatile Content of Coatings[3]

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E 145 Specification for Gravity-Convection and Forced-Ventilation Ovens[4]

2.2 *EPA Standard:*

EPA Federal Reference Method 24—Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids, of Surface Coatings, 40 CFR, Part 60, Appendix A[5]

EPA 450/3-88-018, PB89152276—Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light Duty Truck Topcoat Operations[6]

3. Summary of Test Method

3.1 This test method simulates the loss of VOC from a freshly coated surface by using the difference in weight of a coated test

[2] *Annual Book of ASTM Standards*, Vol 02.05.

[3] *Annual Book of ASTM Standards*, Vol 06.01.

[4] *Annual Book of ASTM Standards*, Vol 14.0~~2~~4.

[5] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[6] National Technical Information Services, 5285 Port Royal Rd. Springfield, VA 22151.

panel before and after baking. Metal test panels are subjected to a simulation of the production coating process including application, flashing, and baking. The weight loss value obtained is then related to the volume of solids deposited on the test panel to compute the number of pounds of VOC per gallon (grams per litre) of solids applied that is available at the inlet of the VOC control device.

3.2 The information needed to determine the amount of VOC available for removal by the VOC control device is determined by identification of the points in the production process at which coated objects would enter flashoff/baking zones whose effluents are vented to the VOC control device.

4. Significance and Use

4.1 This test method provides basic engineering data that may be used to determine the amount of VOC available for delivery at the inlet of a VOC control device (particularly for the automobile industry).[7] Typically, the procedure is useful for establishing the quantity of VOC that is evolved from the coating in the baking oven and available to be incinerated, although the same procedure can be followed for other forms of VOC abatement (that is, carbon, adsorption, etc.).

4.2 This test method may be adaptable for use directly in a production environment if all the critical factors (for example, temperature, cleanliness, vibration, accessibility, etc.) can be adequately controlled.

4.3 The total amount of VOC removed from the process by the VOC control device is a function of the amount available as given by this test method combined with the VOC removal efficiency of the control device.

5. Apparatus

5.1 *Aluminum or Thin Steel Panels*, with a minimum area of 20 in.^{2} (129 cm^2) for each paint material evaluated.

5.2 *Laboratory Balance*, with accuracy to 0.001 g.

5.3 *Laboratory Spray Booth*, with airflow representative of production conditions for application of the test coating.

5.4 *Spray Application Equipment*, selected to represent that used in the production process or sufficiently similar so that it will produce comparable results.

5.5 *Film Thickness Gage*, for measuring paint thickness on metallic surfaces (see Test Methods B 499, D 1005, D 1186, or D 1400).

5.6 *Laboratory Forced-Draft Bake Ovens*, Type IIA or Type IIB as specified in Specification E 145.

6. Coating Materials

6.1 Make sure that the coating materials are in the “as applied” condition and are representative of the specific formulation used in the coating process to be evaluated.

7. Procedure

7.1 Determine the following processing conditions, which represent the production process, prior to beginning the test: (*1*) film thicknesses; (*2*) flash times; (*3*) airflow; and (*4*) temperature conditions for each significant step of the application, flashing, and baking sequence. Use this information to establish test parameters that represent the range of condition found in the plant. Specific application parameters such as fluid flow rate, atomizing air pressure, and voltage do not need to exactly duplicate production conditions as long as the above factors are controlled.

7.2 Identify all locations in the process sequence in which oven effluent is vented directly to a control device for VOC destruction. The number of locations will affect the number of panel weight measurements taken and the number of panels that need to be tested.

7.3 Follow this procedure for paint materials and application conditions selected to adequately represent the coating process being evaluated.

7.4 For each coating material and testing condition, prepare representative test panels in triplicate to obtain statistical validity.

8. Recording Weight Measurements

8.1 Dry the test panel to a constant weight to remove residual moisture, etc.

8.2 Weigh the dried panel, W, before the coating is applied.

8.3 Apply the coating to the panel according to the process sequence description, including that for the flashoff conditions.

8.4 Weigh the coated panel just prior to the location in the cycle at which exhaust air is first vented to the VOC control device (W_1). Weigh as quickly as possible to avoid further VOC evaporation.

8.5 Weigh the coated panel after it is taken from the location in the cycle at which exhaust air is no longer vented to the VOC control device (W_2).

NOTE 1—The panel should be cooled to room temperature before weighing.

[7] United States Environmental Protection Agency Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light Duty Truck Topcoat Operations, Ref EPA 450/3-88-018 dated December 1988. This protocol provides for VOC emissions reduction credit for abatement processes.

8.6 If W_2 does not represent a fully baked coating, then a duplicate coated panel should remain in the oven to complete the full bake cycle. Cool and weigh this panel, record as W_3. This weight (W_3) is used to determine the gallons solids applied (GSA) in 11.1.

9. Measurement of Film Thickness

9.1 Dry film thickness should be determined using Test Methods D 1005, D 1186, or D 1400. Measurements should be recorded as an average of three readings for each panel tested.

9.2 If desired, separate panels for the measurement of film thickness of the coating materials may be coated and baked along with the test panels.

10. Determination of Dry Solids Density

10.1 Calculate dry solids density as shown in 10.210.2. Information needed to perform this calculation includes the weight fraction nonvolatile, volume fraction nonvolatile, and density of the coating materials as applied. Determine these values using the procedures specified in EPA Federal Reference Method 24 and Test Method D 2369. The 1-h bake at 110°C must be used in the determination of the weight fraction nonvolatile.

10.2 Calculate dry solids (nonvolatile) density using the following equation:

$$D_S = \frac{W_S \times W_C}{V_S} \tag{1}$$

where:

D_S = solids density, lbs solids/gal solids (g solids/L solids),
W_S = weight fraction solids, lbs solids/lb coating (g solids/g coating) in accordance with Fed. Ref. Method 24,
W_C = weight per gallon of coating, lbs/gal (g/L) in accordance with Fed. Ref. Method 24, and
V_S = volume fraction solids, gal solids/gal coating (L solids/L coating) calculated from the formulation in accordance with Fed. Ref. Method 24.

10.3 If two layers of coating (for example, base coat and clearcoat) are applied to the same panel, determine the weighted average coating solids density, D_{CS}, by the ratio of film thickness as follows:

$$D_{CS} = \left(\frac{T_1}{T_1 + T_2} \times D_b\right) + \left(\frac{T_2}{T_1 + T_2} \times D_c\right) \tag{2}$$

where:

T_1 = basecoat film thickness, mils (μm)
T_2 = clearcoat film thickness, mils (μm)
D_b = basecoat solids density, lb/gal (g/L), and
D_c = clearcoat solids density, lb/gal (g/L).

11. Calculation

11.1 Use the following calculations to determine the amount of VOC available to a VOC control device C_L, expressed in pounds (grams) VOC per gallon (litre) solids applied:

11.1.1 The weight of coating solids deposited, W_s, is equal to the coated panel weight after full bake minus the panel weight before coating application as follows:

$$W_S = W_3 - W \tag{3}$$

or

$$W_S = W_2 - W \text{ (if } W_2 \text{ represents a fully cured paint film)}$$

where:

W_S = weight of coating solids deposited, lb (g),
W_2 = weight of panel at point which exhaust air is no longer vented to VOC control device,
W_3 = weight of panel with fully baked paint film, and
W = weight of initial unpainted test panel.

11.1.2 Determine the weight of VOC available for abatement control (W_A) by taking the difference in the weight of the panel representing the point in the process at which the exhaust air is vented to the control device (W_1) and the weight of the panel at the point where the exhaust air is no longer vented to the VOC control device (W_2) as follows:

$$W_A = W_1 - W_2 \tag{4}$$

where:

W_A = weight of VOC available for control, lb (g),
W_1 = weight of panel at point at which exhaust air is first vented to VOC control device, and
W_2 = weight of panel at point at which exhaust air is no longer vented to VOC control device.

11.1.3 Calculate the pounds VOC available for control per gallon of coating solids applied, C_L, by combining the weight of VOC available (W_A), weight of coating solids applied (W_S) and the coating solids density (D_{CS}) as follows:

$$C_L = \left(\frac{W_A}{W_S}\right) \times D_{CS} \quad (5)$$

where:
C_L = VOC loading lb/gal (g/L),
W_A = VOC available for removal, lb,
W_S = coating solids applied, lb, and
D_{CS} = coating solids density, lb/gal (g/L).

NOTE 2—Coating materials must be the specific formulations (in as-applied condition) used in the process for which the VOC loading for the VOC control device, is to be determined.

12. Precision and Bias

12.1 *Precision*—~~T~~It is not practicable to obtain the data to specify the precision of the procedure in Test Meth~~i~~od D 5087 for measuring the amount of VOC. The test method is very costly to perform. There are an insufficient number of labs available to participate ing a round robin to obtain the data because of the excessive cost and time required to perform the method. The precision statements associated with D 2369, D 1400, D 1186, and D 1005 are applicable to the portions of the method where they are used.

12.2 *Bias*—Since there is no accepted reference procedure suitable for determining the bias for the procedure in this test method, no statement on bias is being made.

13. Keywords

13.1 automotive coatings; solvent release; VOC abatement