SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

SPRAY EQUIPMENT TRANSFER EFFICIENCY TEST PROCEDURE FOR EQUIPMENT USER

May 24, 1989

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I. SCOPE

Many District source-specific coating rules provide provisions to allow the use of spray equipment which are not included in the approved spray equipment list of the particular source-specific rule. The provisions require that the equipment user demonstrate 65% transfer efficiency for alternative equipment and obtain a written approval of the Executive Officer before the alternative equipment can be used. This document provides guidance for obtaining the Executive Officer's approval.

II. APPLICATION PROCEDURE

1. A source test to determine the transfer efficiency of the spray equipment is required. An application, including a transfer efficiency test plan, shall be submitted to the District by the person who requires the Executive Officer's approval.

2. The application will be reviewed by District Engineering staff according to the protocol specified herein and an approval to conduct the test will be given if the test plan is satisfactory.

3. The test will be conducted in accordance with the approved plan in the presence of a designated District staff member.

4. The test results will be submitted to the District for review by Engineering staff. A new permit will be issued if the results meet the requirements of the rule. The permit will specify the spray equipment details and the appropriate operating conditions.

III. INFORMATION REQUIRED WITH TEST PLAN

Transfer efficiency testing protocols submitted to the District shall include a complete explanation of how the test will be conducted, a detailed description of the equipment to be used to conduct the test including the precision and accuracy of any measuring equipment, a detailed description of the parts to be coated during the test and any other pertinent information. End users will also certify that the testing will be conducted under normal operating conditions and the products coated during the test will meet quality control requirements including normal finish quality requirements. The information submitted in the protocol must contain the data identified in Table I.

TABLE I

DATA TO BE SUBMITTED
WITH A TRANSFER EFFICIENCY TESTING PROTOCOL

Company Submitting Protocol	1. Company name 2. Company address 3. Company telephone number 4. Contact person 5. Telephone number of contact person
Consultants Involved with Proposed Test	1. Name of consulting firm 2. Contact person 3. Telephone number of contact person 4. Name of testing company 5. Contact person 6. Telephone number of contact person
General Test Information	1. Location of test 2. Proposed test date 3. Proposed starting time of test 4. Estimated duration of test
Spray Gun Information	1. Manufacturer 2. Model number 3. Type (airless, air-assisted airless, etc.) 4. Orifice identification 5. Nozzle size 6. Needle size 7. Air pressure at nozzle (psig) 8. Air flow rate at nozzle (acfm) 9. Air temperature at nozzle (degrees F) 10. Fluid pressure (psig) 11. Fluid flow rate (oz/min) 12. Fluid container (cup, pot, etc.) 13. Fluid container size (quarts or gallons) 14. Weight of spray gun, fluid container and any connecting fluid hoses (grams) 15. Estimated fluid volume of spray gun, fluid container and any connecting fluid hoses (ounces)

TABLE I (continued)

Coating Information	1. Type 2. Manufacturer 3. Identification number 4. Mixing ratio (coating/catalyst/thinner) 5. VOC content of coating (gm/l) (mfg. data) 6. VOC content of catalyst (gm/l) (mfg. data) 7. VOC content of thinner (gm/l) (mfg. data) 8. VOC content of coating as applied (gm/l) (calculated based on mfg. data) 9. Solids content as applied (gm/l) (mfg. data) 10. Density as applied (gm/l) (mfg. data) 11. Viscosity as applied (seconds) (mfg. data) 12. Zahn cup number used to determine viscosity 13. Temperature during application 14. Temperature required for drying or curing 15. Time required to completely dry or cure 16. Estimated quantity of coating to be sued during the test (gallons) 17. Typical wet-film thickness on parts (mils) 18. Typical dry-film thickness on parts (mils)
Parts Information	1. Type (table, desk, chair, etc.) 2. Material (oak, pine, alder, plywood, etc.) 3. Material drying method (kiln dried, etc.) 4. Material moisture content 5. Number of each part type to be coated 6. Estimated weight of each type (grams or pounds) 7. Estimated weight gain of each type from coating (gm) 8. Location of wet-film thickness tests 9. Location of dry-film thickness tests
Spray Booth Information	1. Dimensions of booth opening (inches) 2. Air velocity at part level (ft/min) 3. Pressure drop across exhaust filters (in. of water) (as measured by booth manometer) 4. Air temperature (degrees F) 5. H.P. rating of exhaust fan 6. Conveyor speed (ft/min) 7. Part spacing on conveyer (feet)

TABLE I (continued)

Measuring Equipment Information	1. Manufacturer 2. Model number 3. Serial number 4. Calibration documentation 5. Precision 6. Accuracy 7. Parameters measured
Standard Test Methods to be Used	1. Density of coating 2. VOC content of coating 3. Solids content of coating 4. Viscosity of coating

III. CALCULATIONS

Transfer Efficiency (TE)

Transfer Efficiency (TE) is the ratio of the weight of the coating solids deposited on a substrate to the total weight of coating solids used in a coating application step, expressed as a percentage.

Two quantities are required to calculate transfer efficiency:

1. Weight of solids deposited on the substrate.

2. Total weight of solids in the coating sprayed in a coating application.

The weight of the solids deposited on the substrate (G) is determined by subtracting the weight of the uncoated substrate (E) from the weight of the dried coated substrate (F).

The amount of solids actually sprayed (Q) is determined by multiplying the total weight of the coating sprayed (N) by the solids weight fraction of the coating (P). The weight of the coating sprayed is determined by subtracting the total final weight (M) of the pressure-pot/cup containing the remaining coating, spray gun and the coating line (if applicable) from the total initial weight (J) of the pressure-pot/cup with coating, spray gun and the coating line. The solids weight fraction is determined by using syringe weight difference techniques as described in ASTM D-2369-81 Test Method.

Transfer efficiency = (G/Q) x 100

IV. EQUIPMENT

1. Scales to weigh substrates and paint pots
2. Pressure-pots/cups
3. Cans to prepare coatings
4. Viscometers (Zahn or Ford Cup)
5. Markers
6. Identification tags
7. Wet-film thickness gauge
8. Dry-film thickness gauge
9. Spray equipment to be tested
10. Coatings to be sued
11. Spray booth (if applicable)
12. Stop watch
13. Curing oven (if applicable)

VI. TEST PROCEDURE

Small- and Medium-Sized Substrates

1. The weighing apparatus shall be "zeroed" between each weighing of the substrate.

2. The deviation between substrate weighings shall be no greater than 1% of the dry coating weight.

3. Select representative examples of production coatings, capable of producing a commercially acceptable finish at a predetermined dry-film thickness. Selection of the compatible coatings must be approved by the District's Engineering Division prior to testing.

4. Put identification marks or attach tags to substrates to be coated so that each substrate can be identified after being coated. The number of substrates to be included in the test will be determined on a case by case basis and will vary according to item size and complexity (i.e., a larger sample size when the substrates are small or have a complex configuration).

5. Weigh each substrate twice. Record on Data Sheet 1.

6. Record predetermined dry-film thickness on Data Sheet 6.

7. Prepare the selected coating(s) in a can as per normal mixing procedure. On Data Sheet 2 record coating and reducer manufacturer's names, the VOC contents of the materials as supplied by the manufacturers, and the mixing ratio used.

8. Mix coating thoroughly before any samples are taken.

9. Collect coating samples in small jars with airtight lids. Label the sample jars.

10. Send samples to a certified laboratory for determination of the following physical properties:

    (a) Volatile Organic Compounds (VOC) content per ASTM D-3960, Section 8.2.4. (Determining Volatile Organic Content of Paints & Related Coatings) and/or SCAQMD Annex to ASTM D-3960 (Attachment 1).

    (b) Weight Fraction of non-volatiles (solids) per ASTM D-2369-81 (Volatile Content of Coatings).

    (c) Density of coating per ASTM D-1475 (Density of Paint, Varnishes, Lacquer, and Related Products).

    Record laboratory results on Data Sheet 3.

11. Determine viscosity of the coating with Zahn or Ford cup. Record on Data Sheet 3.

12. Pour sufficient quantity of the coating into the pressure-pot/cup to optimize the spray equipment on "trial substrates" and to coat predetermined number of "test substrates."

13. Set the spray equipment as per normal operations.

14. Try spray equipment on "trial substrates." Optimize equipment to produce acceptable finish and the required dry-film thickness by selecting and adjusting parameters such as cap size, orifice, needle, fluid and atomizing pressures. The distance between the gun and the substrate must represent reasonable manufacturing conditions. Record on Data Sheet 4.

15. Disconnect air lines to the pressure-pot/cup and the spray gun (if applicable).

16. Weigh pressure-pot/cup, coating line from pressure pot to the spray gun (if applicable), and the spray gun together twice. Record on Data Sheet 5.

17. Connect air lines to the pressure-pot/cup and the spray gun (if applicable).

18. Coat predetermined number of "test substrates" without changing operating conditions as established in the optimization step 11. Care should be exercised to coat all parts of each substrate including corners, to produce uniform required dry-film thickness. Substrates with bare surfaces or

lower dry-film thicknesses especially near the edges will be discarded and additional testing required.

19. Measure wet-film thickness at two locations approved by the District on each substrate. Record on Data Sheet 6.

20. Disconnect air lines to the pressure-pot/cup and the spray gun (if applicable).

21. Weigh pressure-pot/cup with the remaining coating, coating line from pressure-pot/cup to the spray gun (if applicable) and the gun together twice. Record on Data Sheet 5.

22. Cure/dry coatings in accordance with the test plan.

23. Measure dry-film thickness at two locations approved by the District on each substrate. Record on Data Sheet 6.

24. Weigh each substrate twice. Record on Data Sheet 1.

25. Repeat steps 2 to 22 for each coating type (e.g., primer, topcoat, etc.) or spray equipment to be tested under this test method.

26. Cover identification marks on tags on all "test substrates" coating by all spray equipment for finish inspection by an independent judge to be mutually agreed upon by the District and the applicant. The substrates should be arranged for inspection in a random manner so that the judge is not able to recognize which substrates are coated by which spray equipment.

27. After inspection of each substrate, determine the identification mark or tag and record finish quality on Data Sheet 6.

28. All substrates coated by a spray equipment must have an acceptable finish. Even one substrate with an unacceptable finish is enough to disqualify the test for that particular spray equipment.

29. Calculate transfer efficiency on Data Sheet 7.

Large-Sized Substrates

Large-sized and heavier substrates may pose precision problems in weighing the substrates before and after the coating due to relatively smaller weight of the coating films compared to that of the substrate. In such cases, although the general philosophy of the test will be similar to that for small and medium-sized substrates, specific details of the test method will be decided no a case by case basis between the Engineering Division of the District and the applicant. For

example, foil may be applied to the test substrate, and transfer efficiency measurements made by foil and foil plus coating weighings.

VII. ADDITION OF SPRAY EQUIPMENT TO APPROVED LIST

The addition of new equipment to approved spray equipment lists contained in District coating rules requires a greater body of evidence than that required from individual facility operators. In general, multiple tests utilizing a range of coatings applied to a variety of substrates will be required to provide adequate documentation of transfer efficiency. Also, back to back testing against already approved equipment may be required for comparative purposes. Test methods will be determined on a case by case basis through mutual agreement between the manufacturer and District staff. Agreed upon test methods will be based primarily on the general principles specified herein for equipment users.

ATTACHMENT 1
STANDARD METHOD ASTM D-3960 ANNEX
VOC CALCULATIONS

Grams of VOC per liter of Coating

Grams of VOC per liter of coating is the mass of VOC per volume of VOC and coating solids and can be calculated by the following equation:

$$\text{VOC per liter of coating:} \quad \frac{M_s - M_w - M_{es}}{V_m - V_w - V_{es}}$$

Grams of VOC per Liter of Material

Grams of VOC per liter of material is the mass of VOC per volume of material and is calculated by the following equation:

$$\text{VOC per liter of material:} \quad \frac{M_s - M_w - M_{es}}{V_m}$$

Where:

M_s = **mass of volatile compounds**

M_w = **mass of water**

M_{es} = **mass of exempt solvent**

V_m = **volume of material**

V_w = **volume of water**

V_{es} = **volume of exempt solvent**

DATA SHEET 1
WEIGHTS OF SUBSTRATES BEFORE AND AFTER COATING

***Date of Test:** _____

***Spray Equipment Used:**

Manufacturer's Name: _____

Type of Equipment: _____

Model No.: _____

***Coating Used**

Manufacturer's Name: _____

Coating Name: _____

Code No.: _____

WEIGHTS OF SUBSTRATES

Identification Mark or Tag on Substrate	Weight Before Coating (gm)		Weight After Coating & Drying (gm)	
	1st Weight	2nd Weight	1st Weight	2nd Weight
Total	**A =_____**	**B =_____**	**C =_____**	**D =_____**

Avg. total weight of substrates before coating (E): $\frac{\text{A + B gm}}{2}$ **= E = ____ gm**

Avg. total weight of substrates after coatings (F): $\frac{\text{C + D gm}}{2}$ **= F = ____ gm**

Weight of solids deposited on substrates (G): **F – E gm = G = ____ gm**

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DATA SHEET 2
COATING SPECIFICATIONS
(SUPPLIED BY MANUFACTURER)

***Date of Test:** _____

***Spray Equipment Used:**

Manufacturer's Name: _____

Type of Equipment: _____

Model No.: _____

***Specifications of Coatings as Supplied:**

Manufacturer's Name: _____

Coating Name: _____

Code No.: _____

VOC **= _____ gm/L (less water and exempt solvents)**

= _____ gm/L (including water and exempt solvents)

***Specifications of Reducer:**

Manufacturer's Name: _____

Reducer Name: _____

Code No.: _____

VOC **= _____ gm/L (less water and exempt solvents)**

= _____ gm/L (including water and exempt solvents)

***Mixing Ratio:**

Number of Volume Parts of Coating = _____

Number of Volume Parts of Reducer = _____

***Specification of Coating, As Applied:**

VOC **= _____ gm/L (less water and exempt solvents)**

= _____ gm/L (including water and exempt solvents)

DATA SHEET 3
LABORATORY RESULTS

***Date of Test:** _____

***Coating as Supplied:**

Manufacturer's Name: _____

Coating Name: _____

Code No.: _____

*** Reducer:**

Manufacturer's Name: _____

Reducer Name: _____

Code No.: _____

***Mixing Ratio:**

Number of Volume Parts of Coating = _____

Number of Volume Parts of Reducer = _____

***Coating As Applied:**

VOC (ASTM D-3960) = _____ gm/L (less water and exempt solvents)

Weight Fraction Solids (ASTM D-2369-81) **P =** _____

Density (ASTM – D-1475) = _____ gm/L

DATA SHEET 4
SPRAY EQUIPMENT SPECIFICATIONS AND OPERATING CONDITIONS

***Date of Test:** _____

_____

***Spray Equipment Specifications:**

Manufacturer's Name: _____

Type of Equipment: _____

Equipment Name: _____

Model No.: _____

Cap Size: _____

Orifice: _____

Needle: _____

Type of Fluid Supply (Pressure-Pot or Cup): _____

Size of Pressure-Pot or Cup: _____

***Operating Conditions:**

Fluid Pressure at Pressure-Pot, PSIG = _____

Fluid Pressure at Gun Tip, PSIG = _____

Air Supply Pressure, PSIG = _____

Air Pressure at Gun Tip, PSIG = _____

Approximate Distance Between the Gun and the Substrate, Inches = _____

Air Flow Rate at Tip = _____ cfm

Air Temperature at Tip = _____ ^{o}F

Source of Air: _____

***Viscosity:**

Viscosity (ASTM D-1200) = _____ seconds Ford Cup @ _____ ^{o}F

Viscosity (ASTM D-3794), Part 6 = _____ seconds Zahn Cup @ _____ ^{o}F

DATA SHEET 5
AMOUNT OF COATINGS USED

***Date of Test:** _____

***Coating Used:**

Manufacturer's Name: _____

Coating Name: _____

Code No.: _____

***Spray Equipment Used:**

Manufacturer's Name: _____

Type of Equipment: _____

Model No.: _____

***Weight of Pressure-Pot/Cup, Gun and Paint Line (If Applicable) Before Coating:**

1st Weight (H) _____ **gm**

2nd Weight (I) _____ **gm**

***Average Weight of Pressure-Pot/Cup, Gun and Paint Line (If Applicable) Before Coating:**

$$J = \frac{H + I \text{ gm}}{2}$$

= _____ gm

***Weight of Pressure-Pot/Cup, Gun and Paint Line (If Applicable) After Coating:**

1st Weight (K) = _____ **gm**

2nd Weight (L) = _____ **gm**

***Average Weight of Pressure-Pot/Cup, Gun and Paint Line (If Applicable) After Coating:**

$$M = \frac{K + L \text{ gm}}{2}$$

= _____ gm

***Amount of Coating Used:**

N = (J – M) gm

= _____ gm

DATA SHEET 6
COATING FILM THICKNESS

***Date of Test:** _____

***Spray Equipment Used:**

Manufacturer's Name: _____

Type of Equipment: _____

Model No.: _____

***Coating Used**

Manufacturer's Name: _____

Coating Name: _____

Code No.: _____

Predetermined Dry Film Thickness = _____ Mils to _____ Mils

Identification Mark or Tag on Substrate	Wet Film Thickness, Mils		Dry Film Thickness, Mils		Coating Finish: Acceptable or Unacceptable
	1st Reading	2nd Reading	1st Reading	2nd Reading	

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DATA SHEET 7
TRANSFER EFFICIENCY CALCULATION

***Date of Test:** _____

***Spray Equipment Used:**

Manufacturer's Name: _____

Type of Equipment: _____

Model No.: _____

_____

***Coating Used:**

Manufacturer's Name: _____

Coating Name: _____

Code No.: _____

VOC As Applied (From Data Sheet 3) = _____**gm/L (Less Water and Exempt Solvents)**

Weight Fraction Solids (From Data Sheet 3) **P = _____**

Weight of Coatings Used (From Data Sheet 5) **N = _____ gm**

Weight of Solids Sprayed **Q = (N)(P)gm = _____ gm**

Weight of Solids Deposited (From Data Sheet 1) **G = _____ gm**

Transfer Efficiency = $\frac{\text{Weight of Solids Deposited}}{\text{Weight of Solids Sprayed}} \times 100$

$= \frac{\frac{G \times}{100}}{Q}$

= _____

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