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Standard Guide for Environmental and Performance Verification of Factory- Applied Liquid Coatings¹

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1. Scope

1.1 This guide provides a generic testing procedure to verify the air pollution-prevention characteristics and basic properties of liquid coatings applied to metal, plastic, wood, or composite substrates in a factory/manufacturing environment. Thus it may be used to evaluate these liquid coatings to verify their volatile organic compound (VOC) and organic hazardous air pollutant (HAP) content as well as basic performance properties.

1.2 This guide is adapted from a procedure used by the US Environmental Protection Agency (EPA) to establish third party verification of the physical properties and performance of coatings that have potential to reduce air emissions. The data from the verification testing is available on the internet at the EPA's Environmental Technology Verification (ETV) Program website (<http://www.epa.gov/etv/centers/center6.html>) under the "P2 Innovative Coatings and Coating Equipment Pilot."

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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 to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

B117 Practice for Operating Salt Spray (Fog) Apparatus

B499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
D522 Test Methods for Mandrel Bend Test of Attached Organic Coatings
D523 Test Method for Specular Gloss
D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
D1735 Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
D2369 Test Method for Volatile Content of Coatings
D2794 Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
D3359 Test Methods for Measuring Adhesion by Tape Test
D3363 Test Method for Film Hardness by Pencil Test
D3792 Test Method for Water Content of Coatings by Direct Injection Into a Gas Chromatograph
D3960 Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
D4017 Test Method for Water in Paints and Paint Materials by Karl Fischer Method
D4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
D4457 Test Method for Determination of Dichloromethane and 1,1,1-Trichloroethane in Paints and Coatings by Direct Injection into a Gas Chromatograph
D5402 Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs
D5767 Test Methods for Instrumental Measurement of Distinctness-of-Image Gloss of Coating Surfaces
D6133 Test Method for Acetone, *p*-Chlorobenzotrifluoride, Methyl Acetate or *t*-Butyl Acetate Content of Solvent-borne and Waterborne Paints, Coatings, Resins, and Raw Materials by Direct Injection Into a Gas Chromatograph
D6438 Test Method for Acetone, Methyl Acetate, and Parachlorobenzotrifluoride Content of Paints, and Coatings by Solid Phase Microextraction-Gas Chromatography

¹ This guide is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.55 on Factory Applied Coatings on Preformed Products.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D6695 Practice for Xenon-Arc Exposures of Paint and Related Coatings

D6886 Test Method for Determination of the Weight Percent Individual Volatile Organic Compounds in Waterborne Air-Dry Coatings by Gas Chromatography

2.2 *EPA Methods*³

EPA Method 24 Surface Coatings (Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings)

EPA Method 311 HAPS in Paints and Coatings (Analysis of Hazardous Air Pollutant Compounds in Paints and Coatings by Direct Injection Into a Gas Chromatograph)

3. Significance and Use

3.1 The primary objective of this verification guide is to determine the “air pollution-prevention potential” (possible reduction in VOC or HAP emissions) of factory-applied liquid coatings.

3.2 The overall objective of this guide is to verify the above pollution-prevention characteristics and basic performance characteristics of liquid coating technologies. Use of this guide can increase acceptance of more environmentally friendly technologies for product finishing with an accompanying reduction in emissions to the atmosphere. The specific objectives of this guide are to (1) quantify the VOC and HAP content of liquid coatings and (2) verify the basic quality and durability performance of these coatings.

3.3 The primary criteria for verification of liquid coatings will be:

3.3.1 Confirm that use of the coating will significantly reduce VOC and HAP content or emissions (or both) during application or cure, or both.

3.3.2 Confirm that the coating can provide an acceptable finish (appearance, hardness, flexibility, etc.) for the intended end use.

3.4 The test results from this guide can provide to potential users the best data available to determine whether the coating will provide a pollution-prevention benefit while meeting the finish quality requirements for its intended use. This guide intends to supply end users with unbiased technical data to assist them in this decision-making process.

3.5 The quantitative air pollution-prevention potential depends on a multitude of factors; therefore, the liquid coatings are to be applied in accordance with the coating vendor’s instructions and the resulting verification data reflect only the specific conditions of the test. To quantify the environmental benefit (air pollution-prevention potential), a test to quantify the VOC or HAP emissions from the new liquid coatings will be conducted and compared to data for existing coatings typically used in the target industry.

4. Testing Site

4.1 To accelerate the transition of environmentally friendly processes to the manufacturing base, the test facility should

offer the ability to test processes and products on representative commercial equipment. The coating application equipment in the test facility should be available for the pilot-scale testing performed in this guide (for example, surface pretreatment, powder coating, electrocoating, wet spray, and conventional forced-air and infrared ovens, as applicable). Layouts of an example of an approved test facility are shown in **Appendix X1, Figs. X1.1 and X1.2**, respectively. Examples of the various testing laboratories and their representative equipment holdings that are relevant to the approved test facility verification projects are listed in **Table X1.1**.

4.2 A test plan, referred to as a Testing and Quality Assurance Protocol (T/QAP), will be established to provide the testing details that are dependent upon the specific liquid coating being tested. Some general guidelines and procedures can be applied to each T/QAP. These include:

4.2.1 A detailed description of each part of the test will be provided. The selection of tests to be performed, test details, evaluation methods and acceptance criteria are defined by the end use requirements of the coating. These details should be incorporated into a test plan that is unique to each coating. This will include a detailed design of experiments and a schematic diagram of testing to be performed.

4.2.2 Critical and noncritical factors will be listed. Noncritical factors will remain constant throughout the testing. Critical factors will be listed as control (process) factors or response (coating product quality) factors.

4.2.3 The T/QAP will identify the testing site.

4.2.4 Regardless of where the testing is performed, the approved test facility will ensure that the integrity of third-party testing is maintained.

4.2.5 Regardless of where the testing is performed, the Quality Assurance (QA) portion of the guide will be strictly adhered to.

4.2.6 A statistically significant number of samples will be analyzed for each critical response factor (see **Table 1**). Variances (or standard deviations) of each critical response factor will be reported for all results.

4.3 The test facility will be selected and must meet the standards of the individual T/QAP and the test facility’s Quality Management Plan (QMP). Example QMPs can be found at the ETV Website (<http://epa.gov/etv>). Testing personnel will document all critical and noncritical control factors and qualitative noncritical control factors.

5. Procedure

5.1 *Test Approach*—The following approach for verification of coating performance will be used in the test protocol:

5.1.1 Determine the performance parameters to be verified.

5.1.2 Choose a standard test panel (and possibly other items) that will enable thorough testing of coating performance.

5.1.3 Select the test coating and the optimum equipment settings for application and curing based on information furnished by the coating manufacturer.

5.1.4 Complete the verification test.

5.1.5 Analyze the results using a statistically valid test program that efficiently accomplishes the required objectives.

³ US EPA, Office of Air Quality Planning and Standards (OAQPS), TTN EMC Webmaster (C304-03), Research Triangle Park, NC 27711(website, www.epa.gov/ttn/emc).

TABLE 1 Critical Response Factors (5 Panels per Test)

Critical Response Factor	Measurement Location	Frequency	Total Number of Data Points
Environmental			
Volatile Organic Compound (VOC) Content of liquid coating	See 5.9	5 samples from liquid coating lot to be used during test	5
Hazardous Air Pollutant (HAP) Content of liquid coating	See 5.9	5 samples from liquid coating lot to be used during test	5
Quality/Durability (Mandatory)			
Dry Film Thickness (DFT)	From B499 (magnetic)	9 points on 1 standard test panel per run	45
Visual Appearance	Entire test panel and entire rack	1 standard test panel per run and 1 per test	6
Quality/Durability (Optional)			
Gloss	From D523	3 points on 1 standard test panel per run	15
Color ^A	From D1729	1 randomly selected panel per run, 1 test per panel	5
Color ^A	From D2244	1 randomly selected panel per run, 1 test per panel	5
Distinctness of Image (DOI) ^B	From D5767 Test Method B	1 randomly selected panel per run, 3 tests per panel	15
Adhesion ^C	From D3359	1 randomly selected panel per run, 1 test per panel	5
Pencil Hardness ^C	From D3363	1 randomly selected panel per run, 1 test per panel	5
Salt Spray	From B117	1 randomly selected panel per run, 1 test per panel	5
Impact	From D2794	1 randomly selected panel per run, 1 test per panel	5
Flexibility (Mandrel Bend)	From D522	1 randomly selected panel per run, 1 test per panel	5
MEK Rub	From D5402	1 randomly selected panel per run, 1 test per panel	5
Humidity Resistance	From D1735	1 sample per test	5
Artificial Weathering Resistance	From D6695 ^D	3 samples per test	15
Abrasion Resistance	From D4060	1 sample per test	5

^A Both color analyses with the same panel.

^B Except that the sliding combed shutter is replaced by a rotating eight-bladed disk.

^C The adhesion and pencil hardness tests will be performed on the same panel as the DFT test.

^D Practice D6695 provides a description of procedures for operating the artificial weathering device. It does not indicate the duration of exposure or the physical property tests required to determine accelerated weathering resistance. These will be specified in the test plan for each liquid coating.

5.2 Verification Test Objectives—The objectives of the verification tests performed using this guide are to determine the VOC and HAP content and to verify the basic quality and durability characteristics of selected liquid coatings. In addition, the VOC and HAP emissions generated during the curing of the coating may be checked using an agreed upon method for determining those emissions. The coated test panels will be checked for dry film thickness (DFT), visual appearance, and at least three of the following performance attributes: gloss, color, distinctness-of-image (DOI), adhesion, corrosion resistance, impact resistance, flexibility, hardness, humidity resistance, weather resistance, wear resistance, and resistance to methyl ethyl ketone (MEK). The tests may be selected based on the end use of the coating.

5.3 Standard Test Panel—The actual test panels may be fabricated from steel, stainless steel, glass, plastic, alloys, wood, composite, or other substrate based on the liquid coating vendor’s recommendations for the target industry. The default standard test panels will be cold-rolled steel, 30.5 cm (12 in.) long and 10.2 cm (4 in.) wide with a 0.6-cm (0.25-in.) hole in one end so that it may be suspended from a hook. Other shapes (parts) may be treated and tested as required to complete the verification.

5.4 Coating Specification:

5.4.1 The liquid coating submitted for verification testing should provide an environmental benefit (that is, reduced air

pollution) over coatings currently in use in the liquid coating’s target industry. It should be considered as an “innovative coating.”

5.4.2 The coating vendor will supply its test coating and respective specifications for the verification test program. The coating vendor will also supply a sufficient amount of coating material to complete the verification tests, the exact preparation instructions, and the application parameters. The application procedures and conditions must be representative of real world processes in the target industry.

5.5 Standard Coating Application Apparatus:

5.5.1 This guide outlines the default application apparatus to be used for liquid coating verification tests. The default application method atomizes the liquid coating via automated spray application equipment. The information contained in this guide describes a standard apparatus setup for verification tests conducted at the test facility.

5.5.2 The coating vendor will determine the operating parameters of the spray equipment (for example, input air pressure, gun-to-target distance, horizontal gun speed, flash time, and dwell time).

5.5.3 Panel pretreatment is specific to the substrate material and will be specified by the liquid coating vendor. If panels are not purchased in a pretreated condition, pretreatment will be performed at the approved test facility. The pretreatment