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Standard Guide for Environmental and Performance Verification of Factory-Applied Liquid Coatings[1]

This standard is issued under the fixed designation D7270; 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. 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 by 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

sequence depends on the substrate material. Following is a procedure typical for a metal substrate:

5.5.3.1 Apply alkaline cleaning solution, followed by a deionized (DI) water rinse.

5.5.3.2 Apply zinc phosphate chemicals or other recommended treatment, followed by a DI water rinse.

5.5.3.3 Apply a non-chromate or other recommended sealer rinse, followed by a DI water rinse.

5.5.3.4 Dry panels in a dryoff oven or allow to air-dry, as specified by the coating vendor.

5.5.4 One random test panel will be removed for pretreatment analysis for each verification test.

5.5.5 In the default test scenario, standard test panels (8) will be fixtured on each of five racks to minimize movement during spraying. Fixturing consists of a flat bar that connects all the hooks. The bar will minimize side-to-side rotation of the panels. A second bar is oriented near the bottom of the panels to prevent the bottom of the panels from moving away from the spray gun. The test panels will be transported to the spray booth by an overhead conveyor. A mechanical stop mechanism will align the racks of test panels in the proper position relative to the spraying mechanism. Once the racks are in position, a programmable logic controller (PLC) for the spraying mechanism will activate the motors that drive the linear motion translators. The translators will move both horizontally and vertically, enabling the application equipment to treat an area approximately 1.4 by 1.4 m (4.5 by 4.5 ft). The panels will be automatically sprayed using a specified vertical overlap of the spray pattern. The PLC will also trigger the pneumatic spray gun or a pneumatically actuated cylinder that compresses the trigger of a manual spray gun. During dwell time between passes, paint flow will be interrupted to minimize paint usage. Once the spray application is complete, the PLC will release the mechanical stop that maintains the position of the rack, enabling the overhead conveyor to move the next rack into position.

5.5.6 Before each test, a set of dummy panels will be coated to ensure that the equipment parameters are set correctly. The input air pressure will be monitored throughout the test, and the air pressure at the cap and air horns (if applicable) will be measured using a verified test cap before each run. The paint usage will be determined through gravimetric means or by the use of an in-line flow meter, as appropriate.

5.5.7 The equipment setup and operation should be checked and verified by the test facility and the liquid coatings vendor.

5.5.8 The pressure drop across the spraybooth filters will be checked before each run and at the end of the test. The pressure drop is monitored in the event that the filter bank system malfunctions. A pressure drop across the filter bank greater than 1 cm (0.4 in.) of water shall indicate that the system requires service.

5.6 *Critical and Noncritical Factors:*

5.6.1 In a designed experiment, critical and noncritical control factors must be identified. In this context, the term "critical" does not convey the importance of a particular factor. Rather, this term displays its relationship within the design of experiments. For the purposes of this guide, the following definitions will be used for critical control factors, noncritical control factors, and critical response factors.

5.6.1.1 *Critical control factor*—A factor that is varied in a controlled manner within a design of experiments matrix to determine its effect on a particular outcome of a system.

5.6.1.2 *Noncritical factors*—Factors remaining relatively constant or are randomized throughout the testing.

5.6.1.3 *Critical response factors*—The measured outcomes of each combination of critical and noncritical control factors used in the design of experiments.

5.6.2 In the case of the verification testing of a coating, there is only one critical control factor, and that is the coating itself. All other processing factors are noncritical control factors; therefore, the multiple runs and sample measurements within each run for each critical response factor will be used to determine the amount of variation expected for each critical response factor. For example, for each coating application, parameters associated with pretreatment would remain constant, and, thus, be noncritical control factors; however, a parameter, such as adhesion, would be identified as a critical response factor and could vary from run to run.

5.6.3 Table 1 and Table 2 identify the factors to be monitored during testing, as well as their acceptance criteria (where appropriate), data quality indicators, measurement locations, and measurement frequencies. The values in the Total Numbers column are based on the default test scenarios.

5.6.4 Qualitative, noncritical control factors used in the verification tests include:

5.6.4.1 Equipment preparation from coating vendor,

5.6.4.2 Flash time between coats from coating vendor,

5.6.4.3 Number of passes from coating vendor,

5.6.4.4 Spray pattern from coating vendor, and

5.6.4.5 Target DFT from coating vendor.

5.7 *Design of Experiment:*

5.7.1 This test plan will verify the performance of liquid coatings submitted for this purpose. A mean value and variance (or standard deviation) will be reported for each critical response factor. If a liquid coating vendor makes a claim about a particular coating characteristic, the owner of the coating will be asked to submit a confidence limit and specification limit (acceptable quality limit) for that claim for verification purposes. If the owner does not submit a confidence and specification limit, a default 95 % confidence limit will be applied.

5.7.2 Any claims made by the coating vendor regarding particular coating characteristics will be used in the design of experiments. The appropriate number of test panels to be coated and analyzed will be based on the confidence limit, specification limit, and the appropriate statistical test to be applied to the results (that is, Student's T-test, Chi Square test, or F-test). Each verification test will consist of five runs with one rack of eight panels in a single row per run. The statistical analyses for all response factors will be carried out using statistical software.

5.7.3 Before the verification test, setup panels will be coated to ensure that the equipment parameters are correct. In an example of verification testing, one panel will be used for pretreatment analysis, and forty panels will be coated to determine the air pollution prevention benefit and performance

TABLE 2 Noncritical Control Factors

Noncritical Factor	Set Points/Acceptance Criteria	Measurement Location	Frequency	Total Number of Data Points per Test
Application method, Manufacturer/model	From coating provider	Factory floor	continuous	N/A
Input air pressure, gun/pot	From coating provider	Factory floor	continuous	N/A
Items involved in testing	Standard test panels (material TBD[A])	N/A	see default scenario in 5.5	40 panels
Pretreatment weight	TBD, g/m^2	Random uncoated panel	1 standard test panel per test	1
Surface area of each panel coated	TBD, (cm^2 or in^2)	Top and right edge of panel	1 standard test panel	1
Ambient factory Relative humidity	< 60 % RH	In the factory	once each run	5
Ambient factory temperature	21.1 – 26.7°C	In the factory	once each run	5
Spray booth relative humidity	< 60 % RH	Inside the spray booth	once each run	5
Spray booth temperature	21.1 – 26.7°C	Inside the spray booth	once each run	5
Spray booth air velocity	0.2 – 0.5 m/s (40 – 100 ft/min)	Inside the spray booth	once per test	1
Distance to panels	TBD[A] (cm or in)	Factory floor	once per test	1
Temperature of panels, as coated	21.1 – 26.7°C	Factory floor	once per run	5
Horizontal gun traverse speed	From coating vendor	Factory floor	once per test	1
Vertical drop between passes	From coating vendor	Factory floor	once per test	1
Dwell time between passes	From coating vendor	Factory floor	once per test	1
Density of applied coating	From coating vendor	Sample from coating pot	1 sample each run	5
% Solids of applied coating	From coating vendor	Sample from coating pot	1 sample each run	5
Coating temperature, as applied	From coating vendor	Sample from coating pot	1 sample each run	5
Coating viscosity, as applied	From coating vendor	Sample from coating pot	before and after run	10
Paint flow rate	From coating vendor	Factory floor	once each run	5
Total paint flow	From coating vendor	Factory floor	once each run	5
Oven temperature	From coating vendor	Factory floor	continuous	N/A
Oven cure time	From coating vendor	Factory floor	once each run	5

[A] TBD = to be determined.

characteristics. Specifically, the standard test panels coated during the verification test will be analyzed for their chemical and physical properties as well as appearance.

5.7.4 The coating vendor may supply additional test parts to be coated during each verification test run. Fixturing of parts will be determined after parts are submitted by the coating vendor.

5.8 *Performance Testing:*

5.8.1 The liquid coating vendor will provide the demonstration test facility with coating specifications and appropriate equipment settings.

5.8.2 All testing shall be conducted on the coated standard panels. All such tests shall be performed in accordance with ASTM International procedures and will provide insight to the chemical and physical properties of the coatings. A comparison will be made from panel to panel, rack to rack, and run to run.

5.9 *Determination of VOCs and Organic HAPs:*

5.9.1 The VOC and organic HAP content of the liquid coatings shall be determined by laboratory methods as described in 5.9.2. To assist in VOC/HAP determinations and assessments, the vendor will be required to submit material safety data sheets (MSDSs) and coating composition information, including the following:

(a) Total volatile matter
(b) Coating density
(c) Solids content
(d) Water content (as appropriate)
(e) EPA-exempt solvents content
(f) Total VOC content
(g) Specific VOC or organic HAP identification
(h) Density of cured coating

5.9.2 Bulk analytical tests shall be performed to assess the quantity of VOCs contained in the paint using EPA Method 24 and the quantity of organic HAPs using EPA Method 311. EPA Method 24 requires separate measurements of total volatiles, water content (for waterborne coatings) and exempt solvents (if appropriate) to determine the total VOC content in the coating. The total volatile matter contained within the liquid coating is determined via gravimetric analysis using Test Method D2369. For waterborne coatings, either Test Method D3792 or D4017 is used to determine the water content of the coating. If the coating contains "exempt solvents," the amount of exempt solvents is determined by gas chromatography using Test Methods D4457, D6133, or D6438, or combinations thereof. The total VOC content is then calculated, in accordance with EPA Method 24, by subtracting the weight of water and of exempt solvents from the total volatile matter. The result is expressed as the weight fraction of VOC. Alternative VOC expressions and calculations are outlined in Practice D3960. Identification and quantification of the individual species of VOCs or organic HAPs contained in the paint may be determined using the direct-injection gas chromatographic procedure described in EPA Method 311. The total weight fraction organic HAP is obtained by summing the individual organic HAPs. These analytical tests of the coating may be conducted at an off-site laboratory.

NOTE 1—EPA Method 24 should not be used for determining the VOC content of waterborne coatings that contain very low VOC levels. This is due to the inherent increased imprecision in the determination of the VOC content as the weight percent of water increases or VOC content decreases, or both. For these coatings, a direct measurement method, such as Test Method D6886, should be used.

5.9.3 VOC or organic HAP emissions during curing may be an environmental concern. However, no industry-accepted standard is currently available to measure such emissions reliably.

6. Keywords

6.1 coatings; ETV; exempt solvents; HAP content; low VOC or HAP emissions; organic finishing processes; technology verification; VOC content

APPENDIX

(Nonmandatory Information)

X1. EXAMPLE FACTORY TESTING SITE AND LABORATORY FACILITIES

X1.1 Demonstration Factory Testing Site

X1.1.1 The following example of a demonstration test facility offers the ability to test processes and products on full-scale, commercial equipment. The coating equipment in the demonstration factory may be available for the pilot-scale testing performed in this project. Layouts of a demonstration test facility and the organic finishing line are shown in Figs. X1.1 and X1.2, respectively.

X1.1.2 It is not necessary for all the coating equipment described in the demonstration factory to be available in order to complete the testing requirements.

X1.1.3 In the event that a particular demonstration or laboratory analysis cannot be performed at the demonstration test facility, arrangements will be made to ensure that the requirements of the Testing and Quality Assurance Plan (T/QAP) and all associated Quality Assurance (QA) procedures are completed.

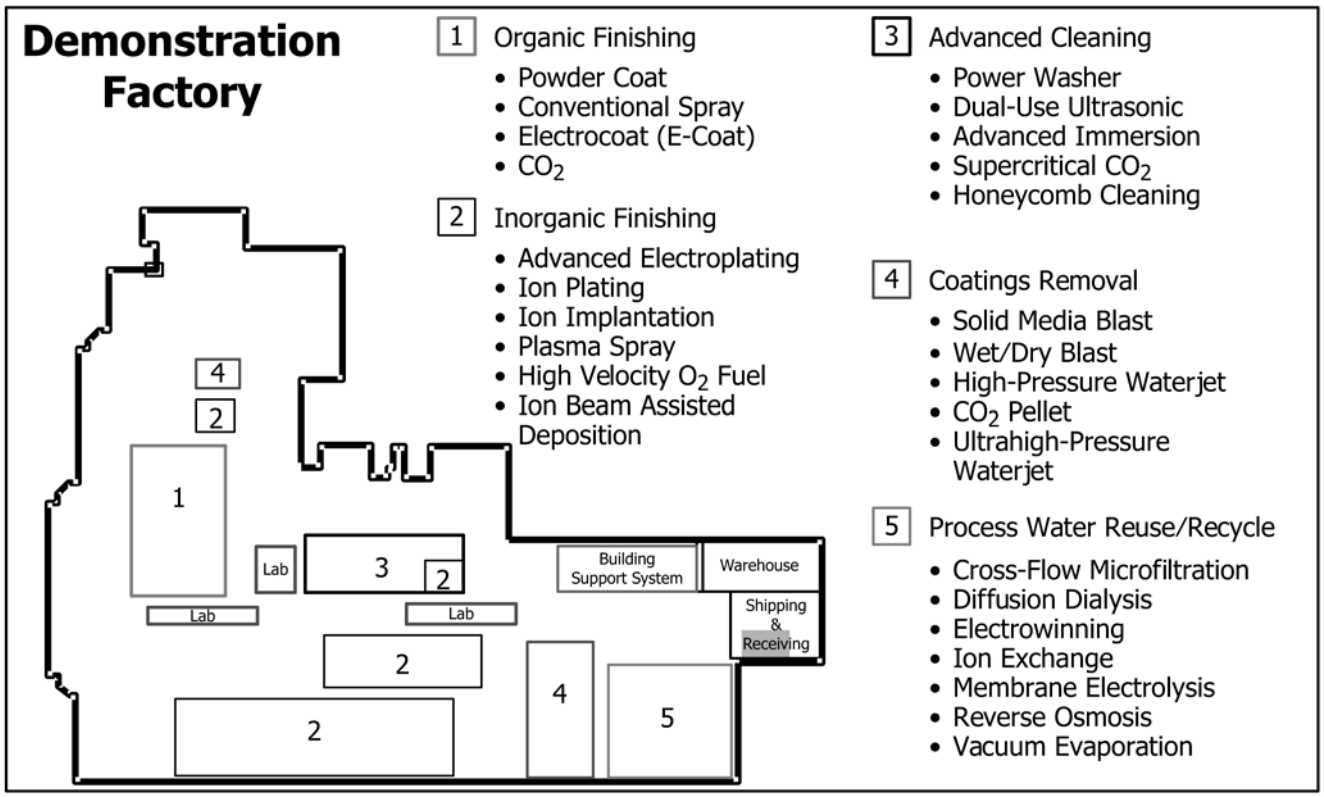

FIG. X1.1 Example of a Demonstration Factory Layout

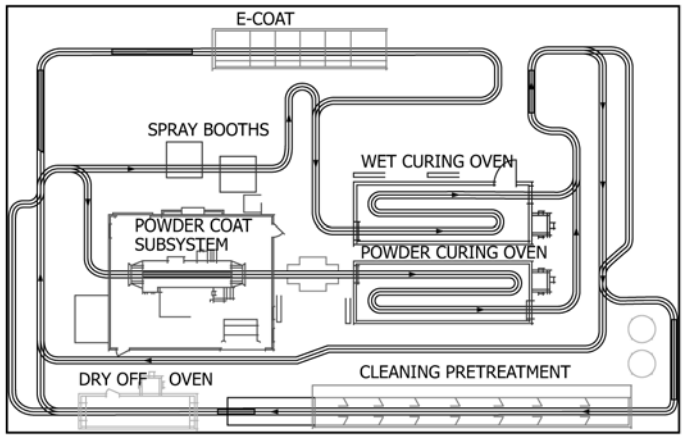

FIG. X1.2 Example of a Demonstration Factory Organic Finishing Line

TABLE X1.1 Example Testing Laboratories and Representative Laboratory Equipment Holdings

Laboratory	Focus	Laboratory Equipment
Environmental testing	1) Identification and quantification of biological, organic, and inorganic chemicals and pollutants to all media. 2) Industrial process control chemical analysis	Gas Chromatograph/Mass Spectrometer Sequential ICP Graphite Furnace Autotitrator P-E Headspace GC/ECD/FID TOC/Flashpoint/pH/Conductivity Flow Injection Analyzer
Destructive and nondestructive evaluation	Evaluation of product and process performance and surface cleanliness	Optically stimulated electron emission X-Ray/magnetic/eddy current thickness guage Salt spray corrosion chamber Microhardness/tensile/fatigue/ wear
Materials and mechanical testing	Measurement of service and processing material and mechanical properties	Electron microscopes Image Analysis System Light optical microscopes EDAX energy dispersive spectrometer MTS machines Hardness testers Impact testers
Calibration laboratory	Calibration of equipment, sensors, and components to nationally traceable standards	Signal calibrator (milliamps, millivolts) Dry block calibrator (temperature) Pressure calibrator Digital multimeter (voltage)