~~Designation:D3730–98~~ Designation: D 3730 – 03

Standard Guide for Testing High-Performance Interior Architectural Wall Coatings[1]

This standard is issued under the fixed designation D 3730; 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 covers the selection and use of test methods for high-performance interior architectural wall coatings (HIPAC) that differ from more conventional coatings by being tougher, more stain-resistant, more abrasion-resistant and, ordinarily, designed to be applied to wall surfaces of steel, masonry (poured concrete, concrete block, or cinder block), and plaster or gypsum wallboard. The tests that are listed in Tables 1 and ~~Table~~ 2 are designed to measure performance properties. These tests may not all be required for each HIPAC system. Selection of the test methods to be followed must be governed by experience and the requirements in each individual case, together with agreement between the purchaser and the seller.

1.2 High-performance architectural coatings are tough, extra-durable organic coating systems that are applied as a continuous (seamless) film and cure to a hard finish. The finish can be high gloss, semigloss, or low gloss as desired. These coatings are resistant to persistent heat, humidity, abrasion, staining, chemicals, and fungus growth. They are used in areas where humidity, wear, or unusual chemical resistance requirements, particularly to soiling, are required and where strong detergents are used to maintain sanitary conditions. Halls and stairways in public buildings, lavatories, stall showers, locker areas, animal pens, and biological laboratories are typical applications. In addition, food processing plants, dairies, restaurants, schools, and transport terminals frequently use HIPAC systems. These are effective in many areas of building interiors compared with tile and are of low materials and maintenance costs. They are used as a complete system only as recommended by the manufacturer since the individual coats in a system are formulated to be compatible with each other. HIPAC systems should be applied only to properly prepared surfaces such as steel or masonry, including cinder blocks and cement blocks. They can be applied over plaster and gypsum wallboard. Ordinarily, a prime or fill coat, if required, is part of the system.

1.3 While they are excellent for walls, HIPAC are not usually intended for ceilings and floors. They would not ordinarily be used in homes, although parents with small children might want to use HIPAC coatings on some walls.

1.4 The types of resin ordinarily used are the following: epoxy-polyamide, two-package; polyester-epoxy, two-package; polyurethane, one-package or two-package. However, other resin types are not excluded provided they can meet the requirements (performance specifications) laid down by the purchaser.

1.5 The values stated in ~~inch-pound~~SI units are to be regarded as the standard. The ~~SI units~~values given in parentheses are for information only.

1.6 *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.* For a specific hazard statement, see the note in 7.6.

2. Referenced Documents

2.1 *ASTM Standards:*

D 16 Terminology for ~~Paint and~~Paint, Related Coatings, Materials and Applications[2]
D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester[3]
D 154 Guide for Testing Varnishes[4]
D 185 Test Methods for Coarse Particles in Pigments, Pastes, and Paints[4]
D 344 Test Method for Relative Hiding Power of Paints by the Visual Evaluation of Brushouts[2]
D 523 Test Method for Specular Gloss[2]

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[1] This guide 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 D01.42 on Architectural ~~Finishes.~~Coatings.

Current edition approved ~~June~~May 10, ~~1998.~~2003. Published ~~September 1998.~~June 2003. Originally ~~published as D3730–78.~~approved in 1978. Last previous edition approved in 1998 as D 3730 – 9~~4~~8.

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

[3] *Annual Book of ASTM Standards*, Vol 05.01.

[4] *Annual Book of ASTM Standards*, Vol 06.03.

TABLE 1 List of Standards in Sectional Order

Property (or Related Test)	Section	ASTM Test Method	Federal Test Method Standard No. 141
~~Sampling:~~	~~6.2~~	~~D 3925~~	~~1022~~
Sampling:	6.2	D 3925	...
Liquid Paint Properties:			
Skinning	7.1	D 154	
Condition in container	7.2	...	3011
Coarse particles and foreign matter	7.3	D 185	
Density or weight per gallon	7.4	D 1475	
Fineness of dispersion	7.5	D 1210	
~~Odor~~	~~7.6~~	~~D 1296~~	~~4401~~ Flash point ~~7.7~~
Odor	7.7	D ~~96~~	~~4401~~3, D 3278 ~~7.7~~
Dilution stability	7.8	...	4203
~~Volatile content~~	~~7.9~~	~~D 1644~~	~~...~~
Volatile content	7.9	D 2369	...
Free diisocyanate content	7.10	D 3432	...
Package stability	7.11		
Heat stability	7.11.1	D 1849	
Settling	7.11.2	D 869	
Coating Application and Film Formation:			
Application properties	8.1	...	4541
Brush application	8.1.1	...	2141
Brush drag	8.1.1.1	D 4958	...
Roller application	8.1.2	...	2112
Roller spatter	8.1.2.1	D 4707	...
Spray application	8.1.3	...	2131
Rheological properties	8.2	...	...
Consistency (low-shear viscosity)	8.2.1	D 562	...
Rheological properties of non-Newtonian liquids	8.2.2	D 2196, D 4287	...
Sag resistance	8.2.3	D 4400	...
Leveling properties	8.2.4	D 4062	...
Curing properties	8.3	...	...
Wet-film thickness	8.4	D 1212	...
Touch-up uniformity	8.5	D 3928	
Appearance of Dry Coating:			
Color appearance	9.1.1	...	...
Color differences by visual comparison	9.1.2	D 1729	...
Color differences using instrumental measurements	9.1.3	D 2244	...
Directional reflectance	9.2	E 1347	...
Gloss, 60°	9.3	D 523	...
Hiding power	9.4	D 344, D 2805	...
Yellowness index	9.5	E 313	
Properties of Dry Film:			
Abrasion resistance	10.1	D 4060	...
Adhesion	10.2	D 4541	...
Impact resistance	10.3	D 2794	...
Chemical resistance	10.4	D 1308	...
Washability and cleansability	10.5	...	...
Washability	10.5.1	D 2486, D 4213	...
Cleansability	10.5.2	D 3450, D 4828	...
Mildew resistance	10.6	D 3273	...
Perspiration resistance	10.7	...	...
Heat and cold resistance	10.8	D 1211	...
Heat and humidity resistance	10.9	D 2247	...
Fire hazards	10.10	E 84	
Dry-film thickness	10.11	D 1005, D 1186, D 1400	

D 562~~Test Method for Consistency of Paints Using the Stormer Viscometer~~[2] Test Method for Consistency of Paints Measruing Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer[2]
D 869 Test Method for Evaluating Degree of Settling of Paint[5]
D 1005 Test ~~Methods~~Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers[2]

[5] *Annual Book of ASTM Standards*, Vol 06.02.

TABLE 2 Alphabetical List of Test Methods

Test Method	Section	ASTM Test Method	Federal Test Method Standard No. 141
Abrasion resistance	10.1	D 4060	
Adhesion	10.2	D 4541	...
Application properties	8.1	...	4541
Brush application	8.1.1	...	2141
Brush drag	8.1.1.1	D 4958	...
Chemical resistance	10.4	D 1308[A]	...
Cleansability	10.5.2	D 3450, D 4828	...
Coarse particles and foreign matter	7.3	D 185	
Color appearance	9.1.1	...	...
Color differences by visual comparison	9.1.2	D 1729	...
Color differences uisng instrumental measurements	9.1.3	D 2244	...
Condition in container	7.2	...	3011
Consistency (low-shear viscosity)	8.2.1	D 562	...
Curing properties	8.3	...	...
Density or weight per gallon	7.4	D 1475	...
Dilution stability	7.8	...	4203
Directional reflectance	9.2	E 1347	...
Dry-film thickness	10.11	D 1005, D 1186, D 1400	...
Fineness of dispersion	7.5	D 1210	...
Fire hazards	10.10	E 84	
Flash point	7.7	D 93, D 3278	...
Free diisocyanate content	7.10	D 3432	
Gloss (60-deg specular)	9.3	D 523	
Heat and cold resistance	10.8	D 1211[A]	...
Heat and humidity resistance	10.9	D 2247[A]	...
Heat stability	7.11.1	D 1849	
Hiding power	9.4	D 344, D 2805	...
Impact resistance	10.3	...	...
Leveling properties	8.2.4	D 4062	...
Mildew resistance	10.6	D 3273	...
~~Odor~~	~~7.6~~	~~D 1296~~	~~4401~~
Odor	7.6	D 1296	4401
Package stability	7.11		
Perspiration resistance	10.7	...	...
Rheological properties of non-Newtonian liquids	8.2.2	D 2196, D 4287	...
Roller appliation	8.1.2	...	2122
Roller spatter	8.1.2.1	D 4707	...
Sag resistance	8.2.3	D 4400	...
~~Sampling~~	~~6.2~~	~~D 3925~~	~~1022~~
Sampling	6.2	D 3925	...
Settling	7.11.2	D 869	
Skinning	7.1	D 154	
Spray application	8.3	...	2131
Touch-up uniformity	8.5	D 3928	
~~Volatile content~~	~~7.9~~	~~D 1644~~	~~...~~
Volatile content	7.9	D 2369	...
Washability	10.5.1	D 2486, D 4213	...
Wet-film thickness	8.4	D 1212	...
Yellowness index	9.5	E 313	

[A] Modified.

D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[2]
D 1210 Test Method for Fineness of Dispersion of Pigment-Vehicle Systems by Hegman-Type Gage[2]
D 1211 Test Method for Temperature-Change Resistance of Clear Nitrocellulose Lacquer Films Applied to Wood[5]
D 1212 Test Methods for Measurement of Wet Film Thickness of Organic Coatings[2]
D 1296 Test Method for Odor of Volatile Solvents and Diluents[6]
D 1308 Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes[5]
D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base[2]

[6] *Annual Book of ASTM Standards*, Vol 06.04.

D 1475~~Test Method for Density of Liquid Coatings, Ink, and Related Products~~[2]
~~D1644Test Methods for Nonvolatile Content of Varnishes~~ Test Method for Density of Liquid Coatings, Inks, and Related Products[2]
D 1729~~Practice for Visual Evaluation of Color Differences of Opaque Materials~~[2] Practice for Visual Appraisal of Colors and Differences of Diffusely-Illuminated Opaque Materials[2]
D 1849 Test Method for Package Stability of Paint[5]
D 2196 Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield type) Viscometer[2]
D 2244~~Test Method~~ Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates[2]
D~~2247Practice for Testing Water Resistance of Coatings in 100% Relative Humidity~~[2] 2369 Test Method for Volatile Content of Coatings[2]
D 2486 Test Methods for Scrub Resistance of Interior Latex Flat Wall Paints[5]
D 2794 Test Method for Resistance of Organic Coatings to Effects of Rapid Deformation (Impact)[2]
D 2805 Test Method for Hiding Power of Paints by Reflectometry[2]
D 3273 Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber[2]
D 3278 Test Methods for Flash Point of Liquids by Small Scale Closed Cup Apparatus[2]
D 3432 Test Method for Unreacted Toluene Diisocyanates in Urethane Prepolymers and Coating Solutions by Gas Chromatography[4]
D 3450 Test Method for Washability Properties of Interior Architectural Coatings[5]
D 3925 Practice for Sampling Liquid Paints and Related Pigmented Coatings[2]
D 3928 Test Method for Evaluation of Gloss or Sheen Uniformity[5]
D 4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser[2]
D 4062 Test Method for Leveling of Paints by Draw-Down Method[5]
D 4213 Test Method for Scrub Resistance of Paints by Abrasion Weight Loss[5]
D 4287~~Test Method for High-Shear Viscosity Using the ICI Cone/Plate Viscometer~~[2] Test Method for High-Shear Viscosity Using a Cone/Plate Viscometer[2]
D 4400 Test Method for Sag Resistance of Paints Using a Multinotch Applicator[5]
D 4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers[5]
D 4585 Practice for Testing Water Resistance of Coatings Using Controlled Condensation[2]
D 4707 Test Method for Measuring Paint Spatter Resistance During Roller Application[5]
D 4828 Test Methods for Practical Washability of Organic Coatings[5]
D 4958 Test Method for Comparison of the Brush Drag of Latex Paints[5]
E 84 Test Method for Surface Burning Characteristics of Building Materials[7]
E 105 Practice for Probability Sampling of Materials[8]
E 313 Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates[2]
E 1347 Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry[2]

2.2 *U.S. Federal Standard:*
Federal Test Method Standard No. 141[9]
2112 Application by Roller
2131 Application of Sprayed Films
2141 Application of Brushed Films
3011 Condition in Container
4203 Reducibility and Dilution Stability ~~4401Odor Test~~
4541 Working Properties and Appearance of Dried Film
6141 Washability of Paints
6142 Scrub Resistance

2.3 *U. S. Federal Specification:*
TT-F-1098 Filler, Block Solvent-Thinned for Porous Surfaces[9]

3. Terminology

3.1 *Definitions:*
3.1.1 For definitions of terms used in these practices, refer to Terminology D 16.

~~[7] Discontinued; see *1997 Annual Book of ASTM Standards* , Vol 06.01.~~
[7] *Annual Book of ASTM Standards*, Vol 04.07.
[8] *Annual Book of ASTM Standards*~~, Vol 04.07.~~, Vol 14.02.
~~[9] Annual Book of ASTM Standards, Vol 14.02.~~
[9] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

4. Conditions Affecting Performance of HIPAC Coating Systems

4.1 Practical requirements for high performance coatings may vary with:

4.1.1 Substrate type such as concrete, poured or precast block, lime-gypsum plaster, etc.

4.1.2 Climatic conditions, both generally and specifically, at the time of coating application. ASTM standard conditions for laboratory testing are 73.5 ± 3.5°F (23 ± 2°C) and 50 ± 5 % relative humidity.

5. Sampling

5.1 Prior to sampling, establish the condition of the container since damage to it may cause evaporation, skinning, or other undesirable effects. Excessive storage time and temperature fluctuations may cause settling or changes in viscosity.

5.2 Sample in accordance with Practice D 3925. Determine the density in pounds per gallon (kilograms/litre) in accordance with Test Method D 1475. Continue sampling and determining density until successive results agree within 0.1 lb (45 g) or as agreed upon between the purchaser and seller. Then take samples for testing.

5.3 Specify the amount required for a representative sample, the package sizes, and an identification code. A 1-U.S. gal (or 4-L) sample is usually sufficient for the recommended tests, but for guidance in selecting a sampling plan consult Practice E 105.

6. Laboratory Tests

6.1 *Preparation of Test Panels* :

~~6.1.1Unless otherwise specified, test panels shall be 1½~~

6.1.1 Unless otherwise specified, test panels shall be 40 by 190 by 395-mm (1½ by 7½ by 15½~~-in. (40 by 190 by 395-mm)~~-in.) masonry units made from standard lightweight concrete block, having an apparent specific gravity of 1.60 to 1.62.

6.1.2 One face only of the test panel shall be coated with the complete system, in a vertical position. The filler shall either comply with U.S. Federal Specification TT-F-1098 or be the material specified and supplied by the manufacturer. The filler coat shall be applied in conformance with the manufacturer's printed directions for surface preparation, mixing, application, coverage, and curing time under standard conditions of temperature and humidity.

7. Liquid Coating Properties

7.1 *Skinning*—Coatings that contain a binder that dries by oxidation may be subject to skin formation in a partially filled can. Since skins are insoluble in the material they must be removed before use. The referenced test in a partially filled container indicates the tendency of the material to skin. A typical minimum time for skinning in accordance with this method is 48 h. Examine the original sample for skins, both on and below the surface. Using a well-mixed skin-free portion of the sample, perform a skinning test in accordance with Guide D 154, Section 10.

7.2 *Condition in Container*—Thickening, pigment settling, and separation are undesirable and objectionable if a coating, after storage, cannot be readily reconditioned and made suitable for application with a reasonable amount of stirring. The referenced method covers procedures for determining changes in properties after storage and lists characteristics that are undesirable and objectionable in a stored coating. Determine the condition in the container in accordance with Method 3011 of Federal Test Method Standard No. 141.

7.3 *Coarse Particles and Foreign Matter*—Liquid coatings must be free of coarse particles and foreign matter to be able to form uniform films of good appearance, a typical maximum being 0.5 weight % of the total material. The referenced method with a 325-mesh (45-μm) screen gives the percent of these particles. Determine content of coarse particles and foreign matter in accordance with Test Methods D 185, Section 10, except using methyl ethyl ketone, xylene or other appropriate solvent as agreed upon between the manufacturer and the purchaser.

7.4 *Density or Weight per Gallon*—The density measured in pounds per gallon (kilograms per litre = g/mL) is used to ensure product uniformity from batch to batch, provides a check against the theoretical weight calculated from the formula, and is useful for determining the similarity of two samples. The referenced method gives a procedure for measuring the density of the coating at a specified temperature. Most coatings have densities of about 10 to 12 lb/gal (1.2 to 1.4 kg/L). Determine density in accordance with Test Method D 1475, using a calibrated weight per gallon cup.

7.5 *Fineness of Dispersion*—Generally, the more finely a pigment is dispersed the more effectively it is being utilized. One method for measuring the degree of dispersion (commonly referred to as "fineness of grind") is to draw the liquid coating down a calibrated tapered groove varying in depth from 4 to 0 mils (100 to 0 μm) (0–8 Hegman units). The depth at which continuous groupings of particles or agglomerates, or both, protrude through the surface of the wet film is taken as the fineness of dispersion value. Higher readings in Hegman units or lower readings in mils or micrometres indicate finer dispersion. A typical fineness requirement for HIPAC is 1.5 mils (5 Hegman or 40 μm). Determine fineness of dispersion in accordance with Test Method D 1210.

7.6 *Odor*—Some solvent combinations produce obnoxious odors, particularly when painting indoors with inadequate ventilation and at elevated temperatures. ~~Test for odor in accordance with Method4401 of Federal Test Method Standard No. 141.~~ Although not specifically designed for liquid coatings, Test Method D 1296 may be used with the solvent-reducible type.

~~NOTE1—**Warning:**~~ (**Warning—**Even though the odor may be pleasant, the fumes may be dangerously toxic.)

7.7 *Flash Point*—Organic solvents used in coatings have characteristic temperatures at which they will support combustion.

This temperature is known as the flash point. It is often used for danger classification in shipment by common carriers. It is also used to determine conditions of storage to meet fire regulations and also the safety requirements of the U.S. Occupational Safety and Health Act (OSHA). Determine the flash point in accordance with Part B of Test Methods D 93 or Test Methods D 3278.

7.8 *Dilution Stability*—Dilution with a specific thinner shows whether the materials are compatible and whether the reduced coating is stable. Consequently the suggested diluent should be readily incorporated into the coating without excessive stirring or shaking. The referenced method evaluates the stability of the material that has been reduced by a given amount or to a specified viscosity. Determine dilution stability in accordance with Method 4203 of Federal Test Method Standard No. 141.

7.9 *Volatile Content (Weight Percent)*— ~~The percent of volatile matter indicates the thinner loss from the film as it dries. Calculate the volatile content of the coating by difference after determining the nonvolatile content in accordance with Test Methods D1644.~~ — Calculate the volatile content of the coating by difference after determining the nonvolatile content in accordance with Test Methods D 2369.

7.10 *Free Diisocyanate Content*—It is generally recognized that diisocyanate vapors from polyurethane-type HIPAC coatings are potential health hazards. Therefore, the free diisocyanate content of urethane coating systems must be controlled at an acceptable maximum level, the present accepted maximum being 0.5 % based on total coating weight, which is applicable only to toluene diisocyanate (TDI) and hexamethylene diisocyanate (HMDI). It has not been shown that this level is applicable to all diisocyanates. Determine free toluene diisocyanate content in accordance with Test Method D 3432. See Note 1 in Test Method D 3432 about other diisocyanates.

7.11 *Package Stability*—Since coatings are normally not used immediately after manufacture, they must remain stable in the can for some time. At normal temperatures most solvent-borne coatings can be stored for over a year with little change in properties. However, exposure in uninsulated warehouses, or during shipping to high temperatures in the summer, may cause unacceptable changes in these products. Another unsatisfactory condition that may occur during storage is excessive settling.

7.11.1 *Heat Stability*— Exposure to high temperatures can be used to test for the stability of a packaged coating that frequently encounters such conditions in service, or as an accelerated test to predict stability at normal temperatures. Although indications of long term package stability can usually be obtained in several days or weeks at an elevated temperature, such as 125 °F (50 °C) or 140 °F (60° C), occasionally the results of the accelerated test do not agree with those at prolonged normal storage conditions. In the referenced method the changes in consistency and certain other properties of the accelerated aged material are compared to those occurring in a control kept at normal temperatures for a longer period. When testing for heat stability, as such, changes in viscosity, flow, gloss, foam resistance, color uniformity, and wet adhesion are usually checked. Determine heat stability in accordance with Test Method D 1849.

7.11.2 *Settling*—Modern coatings are generally resistant to hard settling, but do at times show separation and soft settling. The referenced method covers the degree of pigment suspension in and ease of remixing of a shelf-aged specimen to a homogeneous condition suitable for the intended use. Determine settling in accordance with Test Method D 869.

8. HIPAC Application and Film Formulation

8.1 *Application Properties*—Application or working properties of a coating are generally compared to a standard or described by requirements in the product specification. Determine working properties in accordance with Method 4541 of Federal Test Method Standard No. 141.

8.1.1 *Brush Application*—Brushed films should be smooth and free of seeds and on vertical surfaces should show no sagging, color streaking, or excessive brush marks. Brush drag should not be excessive although some degree of drag may be desirable for adequate film thickness application. Wall finishes are tested on vertical surfaces and floor coatings on horizontal surfaces, although evaluation of the latter on vertical surfaces may be necessary to determine performance on stair risers, railings, posts, etc. The referenced method covers a means for the determination of the brushing properties of a coating. Even though the test is subjective, someone experienced in the art can produce quite consistent results. Determine brushing properties in accordance with Method 2141 of Federal Test Method Standard No. 141.

8.1.1.1 *Brush Drag*—As the brush drag (resistance encountered when applying a coating by brush) increases, any natural tendency of the painter to overspread the material is reduced. All other factors being constant, increased brush drag results in greater film thickness with consequent improvements in hiding and film durability. Conversely, increasing brush drag too much can cause difficulties in spreading the coating easily and uniformly, leading to excessive sagging, prolonged drying time and, in highly-pigmented coatings, possibly to “mud-cracking” due to excessive thickness. The referenced method covers the determination of relative brush drag of a series of coatings applied by brush by the same operator. The coatings in a series, however, must be all of the same type—either water-borne or solvent-borne. It has been established that the subjective ratings thus obtained correlate well with high-shear viscosities obtained instrumentally using Test Method D 4287 (see 8.2.2), provided that the materials differ in viscosity by at least 0.3 poise (0.03 Pa.s). Determine brush drag ratings in accordance with Test Method D 4958.

8.1.2 *Roller Application*—Both wall and floor coatings are frequently applied by roller. This type of application tends to produce some stipple pattern. The referenced method covers the evaluation of a material’s characteristics when applied by roller. Since foaming often occurs when water-borne coatings are roller applied, the amount of foam produced, and the number of craters that remain after the bubbles have broken should be determined during the test. Determine roller coating properties in accordance with Method 2112 of Federal Test Method Standard No. 141.

8.1.2.1 Some coatings spatter more than others when applied by roller. The degree to which a material spatters when roller