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Paint Testing Inspection Kit

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Development of a Portable Test Kit for Field-Screening Paints

by
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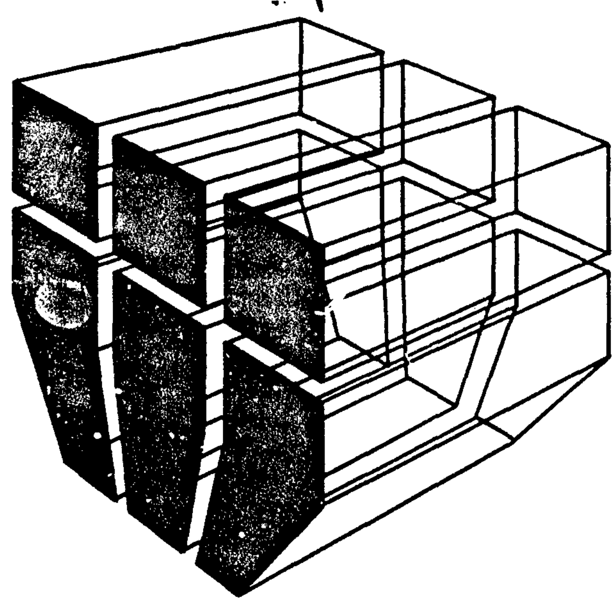
Facility engineers currently have no easy way of establishing if a paint coating is of suitable quality for satisfactory application and performance. As a result, most of the paint used is not tested for specification compliance, which can lead to premature coating failure. This research was undertaken to develop a simple, portable test kit that field personnel can use to check the basic qualities of oil-based and latex paints. The kit enables 14 properties such as drying time, hiding power, appearance, gloss, adhesion, and cleanability to be tested in the field. It is to be used as an initial screening device, so that only paints which do not appear to be equal to a standard need to be sent to a laboratory for more sophisticated testing. The kit's ease of use should encourage more testing prior to application, as well as avoiding the time and expense required for laboratory testing. Development of the kit is described, and instructions for its use are provided.



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Facility engineers currently have no easy way of establishing if a paint coating is of suitable quality for satisfactory application and performance. As a result, most of the paint used is not tested for specification compliance, which can lead to premature coating failure. This research was undertaken to develop a simple, portable test kit that field personnel can use to check the basic qualities of oil-based and latex paints. The kit enables 14 properties such as drying time, hiding power, appearance, gloss, adhesion, and cleanability to be tested in the field. It is to be used as an initial screening device, so that

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FOREWORD

This work was performed for the Office of the Assistant Chief of Engineers (OACE), under Project 4A162731AT41, "Military Facilities Engineeing Technology"; Task C, "Operations, Maintenance, and Repair"; Work Unit 047, "Paint Testing Inspection Kit." The OCE Technical Monitors were Joel Seifer and Chester Kirk, DAEN-ZCF-B.

The work was done by the Engineering and Materials Division (EM), U.S. Army Construction Engineering Research Laboratory (USA-CERL), in cooperation with the Naval Civil Engineering Laboratory (NCEL). Dr. Peter J. Hearst is with NCEL. Other USA-CERL personnel contributing to this project were Jorge Lopez and Tim Hines.

Dr. Robert Quattrone is Chief, EM. COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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1 INTRODUCTION

Background

In 1982, the U.S. Army Construction Engineering Research Laboratory (USA-CERL) surveyed Army installations' Directorate of Engineering and Housing (DEH) offices to determine major painting problems.[1] The results indicated that no more than 10 percent of the installations test paint routinely. In addition, Army installations that have paint tested on a nonroutine basis select paint for testing based on reputation of the manufacturer or contractor or, in some cases, after the paint has been applied and a failure is noted. Several problems related to paint testing were identified in the survey, including difficulty of testing commercial paints not formulated to meet Government specifications, the high cost of routine testing, and the timeliness of the test results. Seventy percent of th installations accept a large amount of their paint based on manufacturer certification; however, this does not insure that the paint used is a quality product that meets Government requirements.

These problems suggested the need for a paint test kit that DEH inspectors could use in the field. To be successful, such a kit would have to be inexpensive and easy to use. Tests would have to be general in nature and the results would have to clearly show basic paint properties. The kit could be used routinely as a screening device providing the DEH inspector a sound basis for selecting paints to receive controlled laboratory specification testing.

Objective

The objective of this work was to develop a paint test kit to be used by DEH inspectors for routine field-screening of paint samples.

Approach

In FY83, USA-CERL compiled a list of Federal and military specification paints commonly used by DEH. A second list was then developed to give the paints' basic desirable properties. Quantitative requirements commonly found in specifications—such as viscosity, weight per gallon, and total solids—were disregarded in favor of answering the basic questions: Does the paint dry? Will it sag? Does it hide the substrate? To every extent possible, does the paint provide the appearance and performance qualities desired for the particular application? Fourteen initial tests and a prototype kit were developed under contract with the Naval Civil Engineering Laboratory (NCEL) in Port Hueneme, CA. In FY84, six prototype kits were submitted to field installations for evaluation while USA-CERL continued to develop test data and refine the test procedures.

Mode of Technology Transfer

The prototype kit has been demonstrated at the Tri-Services Committee on Protective Coatings in addition to the six kits being fielded at installations. An FY85 program will provide 100 kits to Army installations to develop additional data on the kits' typical use and effectiveness. Information on the kits' availability will be disseminated through an Engineer Technical Note. Kits are available through USA-CERL-EM, P.O. Box 4005, Champaign, IL 61820-1305, telephone (217) 352-6511, ext 237 (COMM), 958-7237 (FTS).

2 TEST KIT DEVELOPMENT

The prototype paint test kit consists of 14 tests. USA-CERL evaluated each test in the laboratory and modified procedures as needed to achieve results comparable to those obtained using Federal paint inspection methods. The tests described in this chapter are those included in the fielded test kit. The kit itself is briefcase size with a handle weighing less than 14 lb for easy transportability in the field. It contains most materials required for the tests, with a few items to be supplied by testers. However, all required materials not included in the kit are generic and readily available (e.g., paper towels, mineral spirits). The appendix, an instruction manual for the kit, gives details on the test tools and chemicals. Each kit is supplied with a copy of these instructions.

Test 1: Condition in Container

After opening a can of paint and before application, the paint is inspected to determine if it is of suitable quality for satisfactory application. The paint is then stirred with a paddle to see how it mixes. This procedure is standard.

[1] S. Johnston and A. Beitelman, *Military Installation Painting Problems: Survey Analysis and Recommended Solutions*, Technical Report M-320/ADA119267 (U.S. Army Construction Engineering Research Laboratory [USA-CERL] July 1982).

Table 1 lists the general water-based and oil-based paints used on military housing and other structures. Of 120 samples tested, seven had "condition in container" failures. Specifically, TT-P-19 had three, TT-E-543 had two, and TT-P-1511 and TT-E-545 each had one. Many of these paint defects can be corrected by remedial measures.[3]

Test Development and Proof

The "condition in container" visual inspection test is required for all paints listed in Table 1. This inspection was made on numerous batches of these paints to reaffirm the test. Some were too thin or too viscous, and others had the defects listed in Table 2. Some unusual defects were noted as well, such as color pigment separation or floating. Some paints could not be used because settled material or caking could not be mixed and incorporated back to a homogeneous state; other paints were dried hard. A drawdown test on black and white paper supported some of the applicable findings in the condition in container test, such as the presence of gritty material, color pigment separation, the presence of charged particles that caused cratering, and extreme dilution.

Depending on the paint's quality, the condition in container test alone could be the basis for rejection. This test shows if a paint has heavy skinning, livering, chunky settlements (like cottage cheese), gritty material. seeds, color pigment separation or floating, a too thin or too thick consistency, or settled material or caking that cannot be redispersed. It also indicates whether the paint may have been frozen at one time because freezing causes the water (in water-based paints) to separate from the pigment and resin such that it forms a nondispersible settlement of pigment and resin that cannot be remixed to form a homogeneous mixture. The test also may reveal an unsatisfactory color. If a paint is thin, it may not pass the sag test and hiding power test later. Gritty material and coarse particles will also show up later in the application characteristics and drawdown test.

Equipment required for this visual test is a can opener and a mixing paddle or spatula.

Discussion

Although the condition in container visual test is very subjective, it must be considered a vital initial screening of a paint sample. With minimal guidance, a paint inspector will recognize paints with deficiencies such as skinning, livering, jellying, overthinning, film smoothness on a spatula, presence of gritty materials and broken skins, paint off-color, and presence of settled material that will not disperse. Additional information about the coating ability will be evident from the drawdown procedure in test 3. Note that

[3] *Paint Failures—Causes and Remedies,* Techdata Sheet 82-08 (Naval Civil Engineering Laboratory, 1982).

Table 1

Condition in Container—Test 1

Paint	Batches Acceptance-Tested	Failures
TT-P-19	12	3 (2 lumpy, 1 with sandlike particles)
TT-P-96	2	0
TT-P-650	3	0
TT-P-29	24	0 1 (high viscosity)
TT-P-1511	13	1 (foreign particles)
TT-P-002119	8	0
TT-E-489	24	0 1 (broken skins)
TT-E-543	9	2 (1 with settled dry pigment, 1 not listed)
TT-E-545	10	2 (1 thick and jelled, and 1 with broken skin)
TT-P-30	4	0
TT-E-508	4	0
TT-E-506	10	0
Total	123	10

Table 2

Explanation of Terms

Term	Definition
Skinning	Formation of a skin over the surface of the paint in the container. A light skin is not objectionable but a heavy one could be unacceptable.
Livering	A jelly-like consistency of part or all of the coating. This could be a cause for rejection.
Grit particles	Particles that will not dissolve in the paint mixture and will result in a finish that is not smooth. This condition is particularly objectionable with gloss and semigloss paints.
Seeding	A clustering of small particles.
Cratering	Also called "fish eying." Small, but distinct, round craters, usually with well defined circumferences and some material in the center, caused by the presence of some incompatible material
Large particles	Particles that have not been broken down or foreign material introduced during manufacture. Large particles in the coatings may produce drawdowns that look like brushouts with wide, uneven paths. This results in a nonsmooth dried paint surface. The particles can be seen and also felt by brushing a hand over the surface.

the presence of any of the above deficiencies is cause enough for not using the paint. No further tests are necessary.

Test 2: Determining if Oil or Latex

Paints used at military housing are usually oil- or water-based, with the type generally mentioned on the label. If a proper label is not available, it is important to know if the paint is oil- or water-based to insure other paints' compatibility and use of the proper diluent in thinning and cleaning brushes and other equipment.

Test Development and Proof

A simple, reliable test to determine if a paint is oil-based or latex is to immerse a spatula into the paint and then attempt to wash the spatula in an appropriate thinner. To test this method, when a latex coating on a spatula was immersed in water and agitated for 5 to 10 sec (until the paint on the spatula started to mix with the water), a homogeneous mixture resulted. No paint was left on the spatula. In this laboratory test, 100 ml of the test liquid was used in a 250-ml beaker. An oil-based coating on a spatula immersed in mineral spirits and agitated in the same way as the latex also resulted in a homogeneous mixture. When a spatula with coating was agitated in the opposite solvents, the coating stayed on the spatula or dropped to the bottom of the beaker and the solvent remained clear. This result indicated the incompatibility of latex paints with mineral spirits and oil-based paints with water. Table 3 shows the paints tested by this procedure and the results.

Materials and equipment required to make the test on a can of paint are a can opener, spatula, two containers—one with water and one with mineral spirits, a container for waste paint, and wiping cloths.

Discussion

For thinning and cleanup, the need to know if a paint is oil-based or latex is obvious. Experimental results verified that a spatula immersed in paint followed by swirling in water or mineral spirits is a conclusive test to determine if a paint is oil-based or latex. This test is simple and effective.

Test 3: Application Characteristics and Drawdowns

Paint sample drawdowns as applied with a doctor blade or drawdown bars are required by Federal Specifications for all paints to (1) determine their application characteristics, and (2) prepare sample

Table 3

Latex/Oil Determination—Test 2

Federal Spec Latex Paints	Compatibility*	
	Water Added	Mineral Spirits Added
TT-P-19	Yes	No
TT-P-96	Yes	No
TT-P-29	Yes	No
TT-P-002119	Yes	No
Oil-Base		
TT-E-489	No	Yes
TT-E-543	No	Yes
TT-E-545(a)	No	Yes
TT-E-545(b)	No	Yes
TT-E-545(c)	No	Yes
TT-P-30	No	Yes
TT-E-508	No	Yes
TT-E-506	No	Yes

*Yes—homogeneous mixture; No-incompatible (clear solvent).

specimens that may be used later for other tests. Twelve drawdown tests are proposed for the paint test kit. The drawdowns are made on black and white opacity charts and on black plastic sheets and will show different defects in the coatings. For the kit, uniform applications must be made in the field. Federal Test Methods and other applicable test methods are listed in Table 4.

Test Development and Proof

Laboratory workers tested 22 coatings that included the seven Federal Specification oil-based coatings, 10 Federal Specification latex coatings, and five proprietary latex coatings listed in Table 5. These coatings were drawn down on black and white opacity paper (coated Leneta Form 3B), on Penopac paper (coated black and white, and uncoated white, Leneta No. 1B), and on black plastic sheets (Leneta No. P121-10N). The paint application blades used included Bird blades of 6- and 3-mil clearances (and nominal 3- and 1.5-mil wet film thicknesses), a 40-mil wire-wound applicator bar (providing nominal 3.6-mil wet films), and Leneta Anti-Sag Meters (with 3- to 12-mil, and 4- to 24-mil clearances).

A series of wire-wound bars produced various thicknesses of coatings. Table 6 indicates the dry film thickness of four Federal Specification paints and two

Table 4

Specification Tests for Various Properties

Federal Test Method Standard (FTMS) No.	Title
141A, Test Method 4494	Sag Test (Multi-notch Blade)
141A, Test Method 6011	Immersion Resistance
141A, Test Method 6101	60-Degree Specular Gloss
141A, Test Method 6103	85-Degree Specular Gloss (Sheen)
141A, Test Method 6142	Scrub Resistance
141B, Test Method 4061	Drying Time
141B, Test Method 6141	Washability
141B, Test Method 6221	Flexibility
Federal Standard 595a	Color.
ASTM Standard Test Methods*	
D 523	Test Method for Specular Gloss
D 1308	Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes
D 1640	Test Method for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature
D 2486	Test Method for Scrub Resistance of Interior Latex Flat Wall Paints
D 2801	Test Method for Leveling Characteristics of Paints by Drawdown Method
D 2805	Test Method for Hiding Power of Paints
D 3359	Methods for Measuring Adhesion by Tape Test
D 3363	Test Method for Film Hardness by Pencil Test
D 3450	Washability Properties of Interior Architectural Coatings
ASTM Surface Preparation Method	
D 1730	Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting, Recommended Practices For

**ASTM Annual Book of Standards* (1984).

Table 5

Coatings Used in Tests

Specification	Title
Oil-Based Coatings	
TT-E-489	Enamel, Alkyd, Gloss (For Interior and Exterior Surfaces)
TT-E-543	Enamel, Interior, Undercoat, Tints and White
TT-P-30	Paint, Alkyd, Odorless, Interior, Flat, White and Tints.
TT-E-508	Enamel, Interior, Semigloss, Tints and White
TT-E-506	Enamel, Alkyd, Gloss, Tints and White (For Interior Use)
Latex Coatings	
TT-P-19	Paint, Acrylic Emulsion, Exterior
TT-P-96	Paint, Latex Base, for Exterior Surfaces (White and Tints)
TT-P-650	Primer Coating, Latex Base, Interior, White (For Gypsum Wallboard)
TT-P-29	Paint, Latex Base, Interior, Flat, White and Tints
TT-P-1511	Paint, Latex (Gloss and Semigloss, Tints and White, for Interior Use)
TT-P-002119	Paint, Latex Base, High Traffic Areas, Flat and Eggshell Finish (Low Lustre, For Interior Use)
Proprietary Coatings	
COMM 1	Topcoat, interior/exterior
COMM 2	Topcoat, interior/exterior, acrylic latex
COMM 3	Topcoat, interior (unspecified vehicle)
COMM 4	Topcoat, interior/exterior, (unspecified vehicle)
COMM 5	Interior (unspecified vehicle) ceiling paint

commercial paints when applied with wire-wound bars of wire sizes 6, 13, 14, 16, 24, and 40 mils. The dry film thicknesses obtained with a 40-mil wire-wound bar closely resembled those obtained by normal painting with a paint brush or roller for many paints. Therefore, drawdown samples were applied with this bar and it is being considered for use in the paint test kit. It was also found that a 16-mil wire-wound bar is necessary for industrial enamels like TT-E-489 since, for these materials, a thinner dry film usually is applied. Paints must be applied uniformly.

Some advantages of the wire-wound rod compared to fixed film thickness or variable thickness doctor blades are:

- Helps keep paper flat so that a vacuum plate is not required to hold the paper down.
- Better for showing a paint's flow and leveling characteristics since it spreads out the coating better. Striations and leveling-out of thick paints can be seen.

A disadvantage that can be overcome is that if the wire-wound rod is not cleaned immediately after use, the coating could dry between the wires and would be harder to clean. Water-based coatings can be rinsed off the rod easily with water and a stiff bristled brush. The rod coated with oil-based paints must be immersed in mineral spirits or other paint solvents and brushed clean. The rod must be wiped dry before reuse for another drawdown.

Equipment and materials needed for the drawdowns are black and white opacity sheets, black plastic sheets, a clipboard for holding a drawdown sheet, and 40- and 16-mil wire-wound applicator rods.

Discussion

The applications characteristics and drawdowns test is needed to determine the paint's application characteristics and to prepare sample specimens that will be used later for other tests. The 40-mil wire-wound applicator for drawdowns worked with most types of paint tested in evaluating procedures to be used for the paint test kit. The 16-mil wire-wound rod is better suited for industrial enamels.

Test 4: Sagging

A sag test is necessary to determine if the paint will run when applied to a vertical surface. A high degree of sag will cause a nonuniform or uneven painted surface with flow marks on vertical surfaces. Latex coatings stored for an extensive time may develop sagging due to breakdown of the viscosity. Overthinning can cause sagging in both latex and oil-based coatings.

Laboratory results of sag tests are listed in Table 7. Federal paint specifications require sag tests for the following coatings listed in table 5: TT-P-650 (streaking test), TT-P-1511, TT-P-002119 (streaking test), TT-P-30, TT-E-508, and TT-E-506.

Table 6

Wire-Wound Bar Application Versus Paint Dry Film Thickness—Test 3*

Federal Paint Spec	Wire-Wound Bar Size (mils)					
	6	13	14	16	24	40
	Corresponding Paint Dry Film Thickness (mils)					
TT-E-489	0.48, 0.41	0.84, 0.82	0.83, 0.84	0.94, 0.95	1.44, 1.47	2.39, 2.36
TT-P-102	0.53, 0.54	0.92, 1.01	1.00, 1.01	1.12, 1.10	1.66, 1.70	2.60, 2.60
TT-P-30	0.64, 0.59	1.11, 1.07	1.16, 1.13	1.27, 1.26	1.81, 1.81	2.91, 2.91
TT-P-1511	0.39, 0.42	0.88, 0.86	0.98, 0.95	1.05, 1.07	1.58, 1.63	2.71, 2.78
COMM 1	0.59, 0.60	1.11, 1.25	1.21, 1.39	1.32, 1.34	1.90, 1.97	3.03, 3.06
COMM 2	0.47, 0.44	0.92, 0.95	0.92, 1.01	1.12, 1.06	1.71, 1.76	2.78, 2.79

*Dry film thickness were calculated from weight differences of the paper before and after coating and the weight/volume relationship of the dry paint (similar to ASTM D 2805-80).

Test Development and Proof

Sag ratings were determined according to Method 4494 of Federal Test Method Standard (FTMS) 141B. In this method, adjacent bands of coating of increasing thickness are applied with special blades (Leneta Anti-Sag Meters) and the sheets are hung vertically with the coating bands running horizontally. The smallest blade clearance (in mils) at which the resulting coating band will run into the adjacent coating band is the sag number, as listed in Table 7 under "Sagging FTMS." For an oil-based coating, a sag number of 8 or higher is generally desired to prevent sagging during brushing.

In another sag test method, a small spatula with a flat end 5/16 in. wide was drawn horizontally through fresh drawdowns held vertically (made with a 40-mil wire-wound applicator on black and white opacity sheets, Leneta Form 3B) to produce a path free of coating. Below this path, a ribbon or band of increased coating thickness formed (Figure 4 in the appendix). The widths of these bands, as formed in the drawdowns of various oil-based coatings, are listed in Table 7 under "Spatula." The more easily a coating sags, the wider the resulting band. A sag number of 8 in FTMS Method 4494 corresponds to a sagging of no more than 5/16 in. in the test kit, which is the width of the spatula used in this test. Figure 1 compares sag results using the test kit procedure with the paint specification test results (Leneta sag numbers).

Sag tests were run on batches of TT-E-543 and TT-E-545 paints using a 40-mil wire-wound rod for the drawdown. Both failed the kit's sag test because they were thin. Similar tests run on batches of TT-P-29J, TT-P-1511, TT-E-545B, and TT-E-508 were satisfactory; however, four different batches of laboratory-approved TT-E-489 failed the sag test. Note that three of these batches passed the sag test when a thinner drawdown was made with a 16-mil wire-wound rod (Table 8). Therefore, the 16-mil rod should be used for TT-E-489. Dry film thicknesses obtained for TT-E-489 using various sizes of wire-wound rods (6, 13, 14, 16, 24, and 40 mils) are listed in Table 6. The values vary from 0.45 to 2.38 mils average.

Equipment and materials needed for the sag test are black and white opacity sheets, a clipboard for holding sheets during drawdowns, 40- and 16-mil wire-wound application rods, adhesive tape, and a 5/16-in. wide spatula about 9 in. long.

Discussion

The sag test is reliable and allows the paint inspector to judge quickly whether the latex or oil-based paint is too thin or the latex paint had a viscosity breakdown.

Test 5: Drying Time

Latex coatings dry hard in 30 min to 4 hr, depending on the paint type. Oil-based paints require somewhat longer—7 to 18 hr to dry-through. For oil-based coatings that will be recoated the next day, a test needs to show only if the coating has dried properly the next day. A drying time test is required for all paints; Federal Specifications require maximum dry-through times of 30 min to 18 hr, depending on the paint (Table 9).

Table 7

Sagging and Leveling–Tests 4 and 6

	Sagging		Leveling		Wet Film
Coating[a]	FTMS[c] Blade	Spatula[d] (Wire)[b]	ASTM[e]	Visual[f]	Thickness (mils)
Spec Requirement	**3+**	**8 Max**			
Oil-Based Coatings					
TT-E-489(a)	8	8	5	5	
TT-E-489(b)	9	7	5	5	
TT-E-489(c)		37 (Failed)		5	3.2
TT-E-543(a)	>12	2	0	4	
TT-E-543(b)		3		5	3.2
TT-E-545		10 (Failed)		2	3.2
TT-P-30(a)	12	4.5	3	5	
TT-P-30(b)		3		2	4.0
TT-E-508(a)			3	4	
TT-E-508(b)	>12	2	0	3	
TT-E-508(c)		1	4 (5 Minimum)	4	3.3
TT-E-506(a)	11	4	4	4	
TT-E-506(b)		5	8 (5 Minimum)	3	3.1
Latex Coatings					
TT-P-19(a)	16		1	3	
TT-P-19(b)		1		4	3.3
TT-P-96(a)	14		0	2	
TT-P-96(b)		1		1	4.0
TT-P-29(a)	16		1	2	
TT-P-29(b)	16		0	1	
TT-P-29(c)	16		3	4	
TT-P-29(d)		1		3	3.2
TT-P-1511(a)	18		1	5	
TT-P-1511(b)			3 (5 Minimum)	4	3.5
TT-P-002119(a)	14		1	3	
TT-P-002119(b)	24		0	1	
TT-P-002119(c)	14		4	5	
TT-P-002119(d)		5		3	3.2
COMM 1	>24		0	1	
COMM 2	14		2	g	
COMM 3	14		2	3	
COMM 4	22		1	3	
COMM 5	18		1	g	

[a]The letters (a), (b), (c), and (d) designate more than one coating of the same specification.

[b]"Wire" designates a wire-wound applicator. For the sag test, "blade" designates a Leneta "Anti Sag Meter" (using a standard range for oil-based coatings and a medium range for latex coatings), and for the leveling test, designates a leveling test blade.

[c]Sag rating under "Blade" is according to Method 4494 of Federal Test Method Standard 141B except that two blades were used as described in b above. A sag number of 8 in Method 4494 corresponds to a sag of not more than 5/16 in. under "Spatula" (the kit test method). The sag value under "Blade" should be 8 or more and under "Spatula" it should be no more than 8. The six pairs of sag results are in agreement.

[d]Width in mm of the increased coating thickness under the spatula path, as described in proposed kit test method. Kit spec maximum path width is 8 mm (5/16 in. width of spatula). The lower this value, the lower the sag.

[e]Leveling rating according to ASTM D 2801. Scale is 10 to 0 (excellent to poor).

[f]Leveling rating of drawdown, as described in proposed kit test method. Scale is 5 to 0 (smooth to presence of ridges).

[g]Striations formed by impurities in coating prevented visual rating.

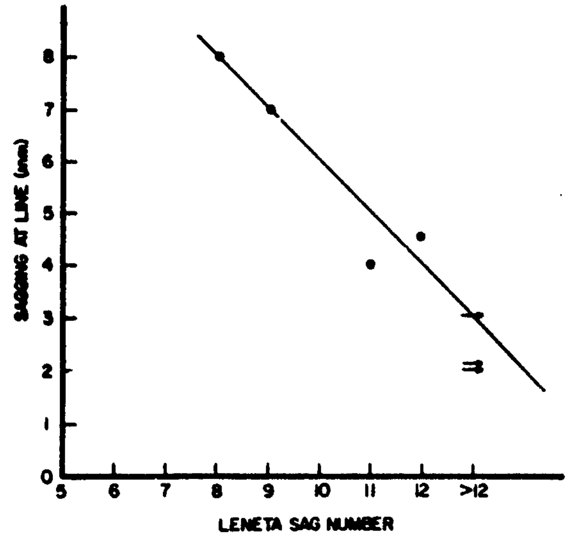

Figure 1. Comparison of sag test results—test 4.

Table 8

TT-E-489 Versus Sag and Wet Film Thickness—Test 4

		Paint Drawdown, Wire-Wound Rod (Kit Test)			
		40-mil		16-mil	
TT-E-489 Batch	Paint Spec Test	Sag (in.)	WFT*	Sag (in.)	WFT
1	OK	Failed (1.5)	3.0	OK (0.25)	2.0
2	OK	Failed (0.75)	3.4	OK (0.125)	1.8
3	OK	Failed (1.5)	3.2	Failed (0.5)	2.1
4	OK	Failed (1.0)	3.4	OK (0.188)	1.8

*WFT: wet film thickness in mils.

Table 9

Drying Time—Test 5

Paint	Spec Requirements	Paint Specs	Proposed Kit Test
TT-P-19	1 hr max	OK	OK
TT-P-29	1 hr max	OK	OK
TT-P-002119	30 min max	OK	OK
TT-E-489	8 hr max	OK	OK
TT-E-508	18 hr max	OK	OK
TT-E-506	16 hr max	OK	OK
TT-P-96	1 hr max	OK	OK
TT-E-545	12 hr max	OK	OK
TT-E-543	7 hr max	OK	OK
TT-P-30	7 hr max	OK	OK
TT-P-1511	4 hr max	OK	OK

Test Development and Proof

For the drying time test, American Society for Testing and Materials (ASTM) Method D 1640 appeared suitable for the kit.[3] This method uses a maximum downward pressure of the arm with a quarter turn of the thumb. Ordinarily, it would be necessary to determine only if the coating dries satisfactorily overnight or during the time lag anticipated before recoating. Most of the paints listed in Table 5 that were used for various tests were dried hard by the next day. Federal Specifications for the paints in Table 5 call for the use of FTMS 141B, Method 4061, but ASTM D 1640 has the same procedure for dry-hard time (Table 4).

Equipment and materials needed for determining dry-hard time for paints are black and white opacity sheets for drawdowns, a clipboard for holding the sheets during drawdowns, and 40- and 16-mil wire-wound coating application rods.

Discussion

The procedure tested for dry-through time is easy to do and gives results comparable to Federal Specification requirements for the paints evaluated (Table 9).

Test 6: Leveling

A coating's relative leveling is a measure of its ability to flow out after application and obliterate any surface irregularities such as brush marks, orange peel, or peaks or craters that have been produced during coating application.[4] In the case of sprayed coatings, the results depend on pressure, nozzle types and other factors.

A paint's leveling properties can be determined by observing the smoothness of the film. Good leveling means that brush marks level out to a smooth coating; poor leveling will show up in the wire applicator drawdowns where ridges left by the wire-wound bar will not level out. According to Table 5, Federal Specification leveling tests are required only for TT-P-1511, TT-E-508, and TT-E-506. The test is conducted 24 hr after the drawdowns are made using the procedure listed in Federal Specification TT-E-508 (4.3.12).

[3]American Society for Testing and Materials (ASTM) Method D 1640, "Dry Hard Time," *ASTM Annual Book of Standards* (1969; reapproved 1974).

[4]ASTM D 2801, "Leveling Characteristics of Paints by Drawdown Method," *ASTM Annual Book of Standards* (1969; reapproved 1981).

Test Development and Proof

The proposed kit test (similar to ASTM D 2801) is totally visual and the results depend on the analyst's judgment based on the guidance furnished. The ASTM test uses a special instrument with furrows of graduated depths for making drawdowns of varied thickness parallel stripes. The kit test has a smaller range than the ASTM method, which uses 10 (for excellent) to 0 (poor). The kit test uses as criteria the degree of striations in the dried paint surface drawdowns whereas the ASTM method is concerned with the number of parallel striped paint voids flowing together and being covered by the test paint.

Leveling ratings were determined according to ASTM D 2801, using a leveling test blade; the results are listed in Table 7 on a scale of 10 to 0 (excellent to poor). The degree of leveling was also rated for drawdowns made at the time with a 40-mil wire-wound applicator on black and white opacity sheets (Leneta Form 3B). The paints' degree of flow between the ridges was rated after drying on the proposed test scale of 5 to 0 (smooth to presence of ridges). Results also are listed in Table 7 using the ratings proposed for the paint test kit. Table 7 shows some disagreement in the ASTM method versus the kit method results. Out of 22 dual tests, however, agreement was fairly reasonable for 19 paint samples.

The sample preparation and leveling rating considered for use in the test kit consist of drawdowns made on black and white opacity sheets (Leneta Form 3B) using a wire-wound rod applicator. The dry drawdowns are then examined and the coating surface striations are rated using the 5 to 0 scale:

5–No visible striations or differences in light reflection; smooth.

4–No visible difference in vertical view, but some striations visible with properly reflected light.

3–Striations barely visible as seen vertically for light coatings on black surfaces or dark coatings on white surfaces.

2–Easily visible striations or differences in reflected light as seen vertically for light coatings on black surfaces or dark coatings on white surfaces.

1–Very easily visible striations.

0–Ridges that can be felt with the finger.

Equipment and materials needed for the leveling test are black and white opacity charts, a wire-wound rod for drawdowns, and a clipboard to hold charts during drawdowns.

Discussion

This leveling test can be used for all Federal Specification paints. Table 7 compares leveling results for paints tested by paint specification procedures with those from the test kit procedure. This test gives a fair approximation of the leveling and flow quality for the paints tested.

Test 7: Hiding Power

Hiding power can be defined qualitatively as the property of a paint that enables it to obliterate beyond recognition any background over which it can be spread. Quantitatively it can be expressed as the square feet of background that can be covered completely by a gallon of paint. It is generally agreed that complete hiding has been reached when the paint applied over a black background has a reflectance of 0.98 of that applied in equal thickness over a white background.[5] This is an important test because it tells how well the paint will cover and if one coat is adequate or two or more will be needed.

The hiding power requirement is generally expressed as a minimum contrast ratio for a film of a given wet or dry film thickness. The contrast ratio is the reflectance of the dry coating film measured over a black substrate divided by the reflectance measured over a white substrate; the Federal Specification requirements range from about 0.92 to 0.98. Contrast ratios, as calculated from reflectance measurements of coatings applied to opacity charts with the 40-mil wire-wound bar, varied from 0.86 to 1.00 for films that varied from 1.3 mils to 3.3 mils in dry film thickness.

Of the paints being tested (Table 5), only the Federal Specifications for TT-P-96, TT-E-489, TT-P-30, and TT-E-506 require that HP be determined.

Test Development and Proof

Determining hiding power by ASTM D 2805 is a complicated laboratory procedure not easily simplified for field use. Coating films of accurately determined thicknesses must be prepared on proper substrates, an expensive reflectometer must be available, and the contrast ratio that a film of the specified thickness would have must be calculated. No practical standards for visual comparisons that would eliminate the 45, 0 degree reflectometer are available.

The initial method proposed for the test kit is a type of visual standard that uses a photographic gray wedge which is nearly white and highly reflectant at one end, gradually becoming gray. The reflectances of the wedge and coating are compared in adjacent halves of a window cut in an index card.

When the method was tested, this comparison was made most easily when the coating had the same color and general tone as the photographic wedge; it was more difficult when the color and gloss differed considerably. Comparisons also appeared easier with the gray wedge on matte, rather than glossy paper. It was hoped that deviations caused by color difference would be similar for the coating over the black and white substrates and would tend to cancel each other.

To avoid having to calculate the contrast ratio and to simplify the scale, the gray wedge was calibrated according to the logarithm of the reflectance. (The reflectance scale reading is minus 1000 times the logarithm of the reflectance.) Instead of determining the ratio of two reflectances to obtain the contrast ratio, it thus became possible to subtract two readings to obtain a multiple of the logarithm of the contrast ratio. Using a nomograph which is on the gray wedge, the scale difference could be converted to the contrast ratio.

For 11 coatings with contrast ratios from 0.99 to 0.88, the scale differences as measured with the gray wedge are compared in Figure 2, with the scale differences as calculated from reflectance measurements. The average values are reasonably close to the line drawn through the data points, but the standard deviations shown by the bars are comparatively large.

Even though the reflectometer's standard CIE* illumination was chosen to represent the most sensitive range of the human eye, a simple visual device probably cannot give contrast ratios that correlate accurately with the results obtained using the reflectometer. Furthermore, the reflectometer measures the perpendicular reflection of light that impinges at a 45 degree angle, whereas the eye observing a coating will experience reflections in various directions.

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[5]G.G. Sward (Ed.), *Paint Testing Manual, Physical and Chemical Examination of Paints, Varnishes, Lacquers, and Colors*, 13th ed., ASTM Special Technical Publication 500 (ASTM, 1972), p. 22.

*Commission Internationale de l'Eclairage (International Commission on Illumination).

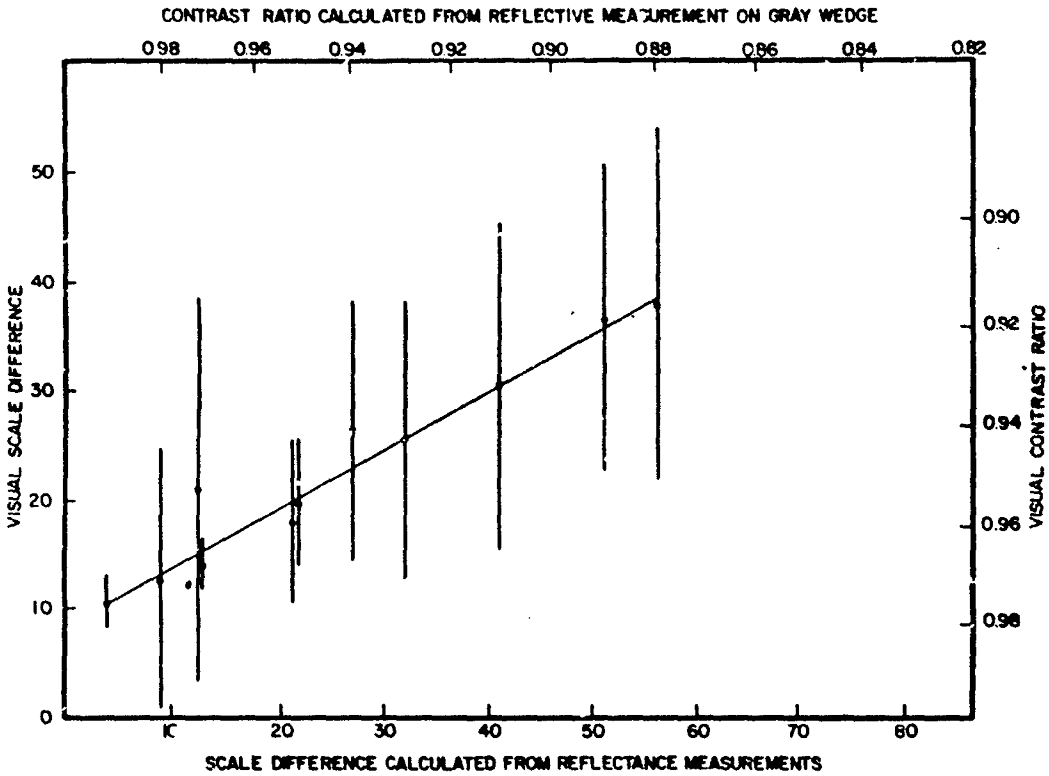

Figure 2. Comparison of contrast ratio measurements—test 7.

The practical question is how well a coating as actually applied in the field will cover adjacent light and dark areas of the substrate. Thus, it appeared useful to measure the coating's contrast difference after using the intended method of application.

The contrast ratio obtained by the method being tested is for the coating thickness applied by an applicator that would be supplied as part of the kit. This thickness cannot be determined with the proposed kit; however, even if there were a simple method to determine the dry film thickness, it would be difficult to determine, from the test film's contrast ratio, what the contrast ratio would be for the specification coating thickness. The photographic gray wedge method therefore was not recommended for the test kit because of the difficulty in interpreting results.

A simpler method was developed in which a series of standards with known contrast ratios is prepared. Drawdowns of the paint samples are then compared against the standards to find the closest match. The contrast ratio listed on the matching standard is used. Results can be obtained 1 day after the drawdown is made.

To test this method, a series of semigloss alkyd enamels—white drawdowns (similar in color to Federal Standard No. 595, "Colors," 27875) and beige drawdowns (alkyd enamel color 27855)—was prepared on black and white opacity paper (Leneta Form 14H, 11-1/4 in. by 17-1/4 in.). Drawdowns were made with an adjustable doctor blade and applied at blade settings of 1, 1.5, 2, 2.5, 3, 3.5, 4, 5, 7, 8, and 9 mils to produce a range of hiding power contrast ratios for use as standards. Some samples were sprayed, but the paint film was not uniform enough to use this method.

After drying, the hiding power was determined for the standard samples using a Hunter Lab* Color-Difference Meter D25D2. Reflectances were determined over the black and over the white or beige drawdowns on the white and black opacity paper, according to ASTM D 2805.[6] Reflectance values obtained on the coated white or beige areas were divided into the

*Hunter Associates Laboratories, Inc., 11495 Sunset Hills Rd., Reston, VA 22090.

[6] ASTM D2805, "Hiding Power of Paints," *ASTM Annual Book of Standards* (1980).

corresponding sample value over the coated black areas to obtain the contrast ratio. The range in contrast ratios for the white paint was 0.79 to 0.99, with low values representing poor hiding. For the beige, the range in contrast ratios was 0.67 to 0.99. The hiding power requirements for paints in Table 3 were noted to determine the range necessary for the test. On this basis, a range of 0.88 to 0.99 was chosen.

Drawdowns from seven different colored paints (Table 10) were compared against the beige and white standards. Results indicated that, in general, contrast ratio results obtained by using the proposed paint test kit standards compared closely with those obtained using the Hunter meter (Table 10). The average contrast ratio for seven paint samples compared against the beige standards was 0.009 less than the value obtained with the Hunter meter. Compared against the white standards, the average contrast ratio was 0.011 less than with the Hunter meter. (One sample showed a little more difference because of the standard used.) Range values in Table 10 represent the differences obtained by different individuals performing the test. Either the beige or white standards could be used based on the results obtained. Most analysts found it more difficult to compare colored samples with the standards; they stated no perference for using the beige versus white standards (i.e., there was no difference).

In another comparison test for hiding power, nine paints representing a range of gloss values were selected and one analyst determined contrast ratios using the Hunter meter and the proposed paint test kit method. There was generally close agreement between the procedures (Table 11).

Equipment and materials required for the hiding power evaluation are black and white opacity sheets, a clipboard to hold the sheet for a drawdown, a wire-wound applicator rod, and a set of standards for making the comparison.

Discussion

Experimental results indicate the procedure developed to test hiding power is satisfactory and reproducible. Work should be continued to resolve a slight problem noted when different colors are being compared with the same set of standards. Despite this minor drawback, the test gives good results.

Table 10

Hiding Power: Kit Value Versus Hunter Results by Six Individuals—Test 7

Sample and Color*	Hiding Power Contrast Ratios—Samples Compared Against:					Hunter Meter
	Beige Std/White Std	Range	Avg	Range	Avg	
1. TT-P-19 (Deep Beige) (32711)**	.94,.98,.96,.96,.96,.96/ .94,.96,.96,.96,.96,.96	.90–.98	.960	.94–.96	.957	.97
2. TT-P-29 (Lt Blue) (35526)	.94,.96,.90,.96,.94,.90/ .92,.96,.90,.94,.94,.88	.90–.96	.933	.88–.96	.923	.93
3. TT-P-19 (Lt Gray) (36622)	.93,.94,.90,.90,.87,.90/ .92,.92,.92,.90,.90,.90	.87–.94	.907	.90–.92	.910	.93
4. TT-P-19 (Lt Green) (34449)	.93,.93,.87,.87,.90,.90/ .90,.94,.90,.86,.90,.88+	.87–.93	.900	.88–.94	.900	.90
5. TT-P-29 (Lt Grn Yel) (34672)	.96,.98,.96,.96,.96,.98 .94,.98,.98,.96,.96,.96+	.96–.98	.967	.94–.98	.963	.97
6. TT-P-29 (Lt Apple Grn) (24552)	.93,.94,.94,.90,.93,.94/ .92,.96,.94,.90,.94,.94	.90–.94	.930	.90–.96	.933	.95
7. TT-P-19 (Brown) (30266)	.93,.96,.87,.90,.87,.93/ .92,.96,.90,.90,.88,.90+	.87–.96	.910	.88–.96	.910	.92

*To obtain lower hiding power values for comparison with the Hunter results, it was necessary to dilute all samples except 1 and 6. The 40-mil wire-wound rod was used to make the drawdowns.

**Federal Standard No. 595–Colors.

Table 11

Hiding Power Contrast Ratios: Hunter Meter Versus Kit Test Method—Test 7*

Sample	Contrast Ratios		Color
	Hunter Meter	Kit Test	Federal Std 595
1. TT-P-19C	0.97	0.98	White, 37875, flat
2. TT-P-19C	0.99	0.99	White, 37875, flat
3.a. TT-P-96D	0.93	0.92	White, 37875, flat
b. TT-P-96D, 80% water, 20%	0.88	0.88	White, 37875, flat
c. TT-P-96D, 60% water, 40%	0.85	0.88	White, 37875, flat
4.a. TT-P-650	0.99	0.99+	Ivory or buff, 37769, flat
b. TT-P-650, 80% water, 20%	0.98	0.98	Ivory or buff, 37769, flat
5. TT-P-29J	0.98	0.99	Offwhite, 37886, flat
6. TT-P-1511A	0.99	0.98	Offwhite, 27780, semigloss
7. TT-P-002119	0.98	0.98	White, 37875, flat
8. TT-E-489	1.00	1.00	Gray, slightly darker than 16187, gloss
9. TT-E-508	0.98	0.96	White, 27880, semigloss

*Paint drawdown was made with a wire-wound rod on black and white Leneta Form 3B opacity sheets.

Test 8: Gloss

Gloss often is described as the property responsible for an object's shiny finish and is thought to be second only to color in importance as an appearance characteristic. Gloss is related to the reflection of light from a coating surface and, therefore, to the surface texture. Glossier surfaces have more vehicle than pigment at the surface which makes them smoother and easier to clean. Eggshell or flat surfaces have more pigment than vehicle on the surface; this makes them rougher and more difficult to clean. However, glossy surfaces show surface imperfections that are less noticeable in flat surfaces.

Many types of instruments are available for assessing gloss but none can give an evaluation that agrees entirely with visual judgment. The human observer integrates the various factors involved, whereas instruments can measure only one factor at a time. For many purposes, visual assessment of gloss is enough, but for others, the more objective and reproducible evaluation using the various types of reflectometers is necessary.[7]

All Federal Specification paints listed in Table 5, except for TT-P-19, require a gloss determination. Acceptable test procedures are FTMS 141, methods #6101 and #6103, and ASTM D 523.[8]

Test Development and Proof

In development work for the paint test kit, potentially simple test methods were compared with the accepted tests (ASTM and FTMS) mainly to provide standardization for testing uniformity in different laboratories. Although the methods are designed to predict performance, they often are somewhat arbitrary and the results do not necessarily demonstrate performance.

A method giving results that correlate moderately well with those of ASTM or FTMS methods appeared useful in determining coating gloss. The method proposed for the kit determines the angle at which a given reflection can be seen. This angle of view at which the eye can see a reflection may be a better measure of coating appearance than the values of 85 or 60 degree gloss used in conjunction with an instrument. Testing and development for a suitable method was done in four parts:

1. *Gloss Measurement.* The amount of light reflected from a coated surface is very dependent on the

[7] C. J. A. Taylor, and S. Marks, *The Testing of Paints*, Part 5 (Oil and Colour Chemists' Association, 1965).

[8] ASTM D 523, "Specular Gloss," *ASTM Annual Book of Standards* (1980).

angle of reflection. Viewed at very low angles (or at angles approaching 90 degrees as measured form the perpendicular), flat coatings or even roadway surfaces may give mirror-like reflections. Therefore, the high gloss of automotive lacquers is generally measured at 20 degrees, whereas the 60 degree gloss is usually measured for gloss or semigloss coatings and the 85 degree gloss is measured for flat coatings.

The visual gloss measurement instrument proposed for the test kit essentially measures the highest angle of view at which a selected set of figures, placed in a selected way, can be recognized by the viewer's eye (Figure 7 in the appendix).

Figure 3 shows the view angles of the reflections in the visual gloss measurements. At a 30 degree angle of reflection, which is the angle for a 60 degree gloss reading, the scale reading on the gloss device is 30 degrees from horizontal. The equivalent scale reading for a 20 degree gloss reading is 70 degrees (Figure 3).

There is no direct relationship between the 60 and 85 degree coating glosses; therefore, the visual gloss measurement cannot correlate equally well with both types of gloss values. Observed scale readings near 5 degrees from horizontal would be expected to correlate better with 85 degree gloss values and observed scale readings near 30 degrees would be expected to correlate better with the 60 degree gloss values of the coatings.

A comparison of visual results with the 85 degree gloss values of nine coatings (Figure 4), and with the 60 degree gloss values of 19 coatings (Figure 5), shows that these expectations are borne out. The visual results correlate well with 85 degree gloss values of up to about 30, or possibly slightly higher. (Angles of view above 20 degrees are not compared with 85 degree gloss values in Figure 4 because the complements of these angles of view are less than 70 degrees. The values in Figures 4 and 5 are from the initial development work and are not listed in the tables).

Figure 5 shows the curve relating the scale readings to 60 degree gloss values. The visual gloss measuremets correlate well with 60 degree gloss values of 10 or higher. Therefore, the method does appear to be useful for determining the gloss of eggshell, semigloss, and gloss coatings. The 60 degree gloss values for these coating categories are about 10 to 20, 40 to 70, and 75 or higher, respectively.

2. *Paint Test Kit Method.* In developing a test for use in the paint test kit, the gloss of 19 coatings on opacity charts was determined by measuring the approximate angles at which the reflection of some symbols could be seen. Preliminary experiments were performed with the gloss-measuring device similar to the one shown in Figure 7 of the appendix using capital E's, as used in optical charts, and hollow squares of similar proportions. The angle at which the squares look hollow was determined more reproducible than the angle at which the Es could clearly be seen. For the final measurements, an L-shaped instrument was constructed that had one long leg (8 in. long by 4 in. high) and four hollow squares on a white background on the inside of the short leg.

The 0.06-in. black squares, spaced 0.06 in. apart, had 0.035-in. white squares in their centers; they were positioned 0.08 in. above the edge of the instrument that is set on the coatings. A vertical scale was affixed to the end of the instrument's long leg and was continued at the top of this leg.

When the squares placed over the coating were viewed at a low enough angle, the squares and the reflected squares are bisected by the line formed by the instrument and coating interface. The imaginary intersection of this line at the scale is read to obtain a measure of the angle of view. The reading is taken at the highest angle of view at which it was clear that the squares were hollow. (The method of measurement is as shown in Figure 7 of the appendix.)

3. *Evaluation for Use in Test Kit.* A series of gloss samples (at least 48 drawdowns) was prepared using various blends of a glossy enamel (TT-E-489G, white 17875) and flat enamel (TT-E-543A, white 37875). The finishes ranged from glossy to flat. Drawdowns were made with a fixed 3-mil opening Bird applicator on black and white opacity charts (Leneta Form 14H). After the paints dried completely, gloss values were determined at 20, 60, and 85 degrees as appropriate using a Hunter Color/Difference Meter D25D2 and accessory equipment. Figure 6 compares the results for these samples.

Nine samples (Table 12) were selected from the series to represent the range of gloss (glossy, semigloss, eggshell, flat), and the equivalent angles of view were determined with the gloss measurement device proposed for the paint test kit. The 60 degree gloss values

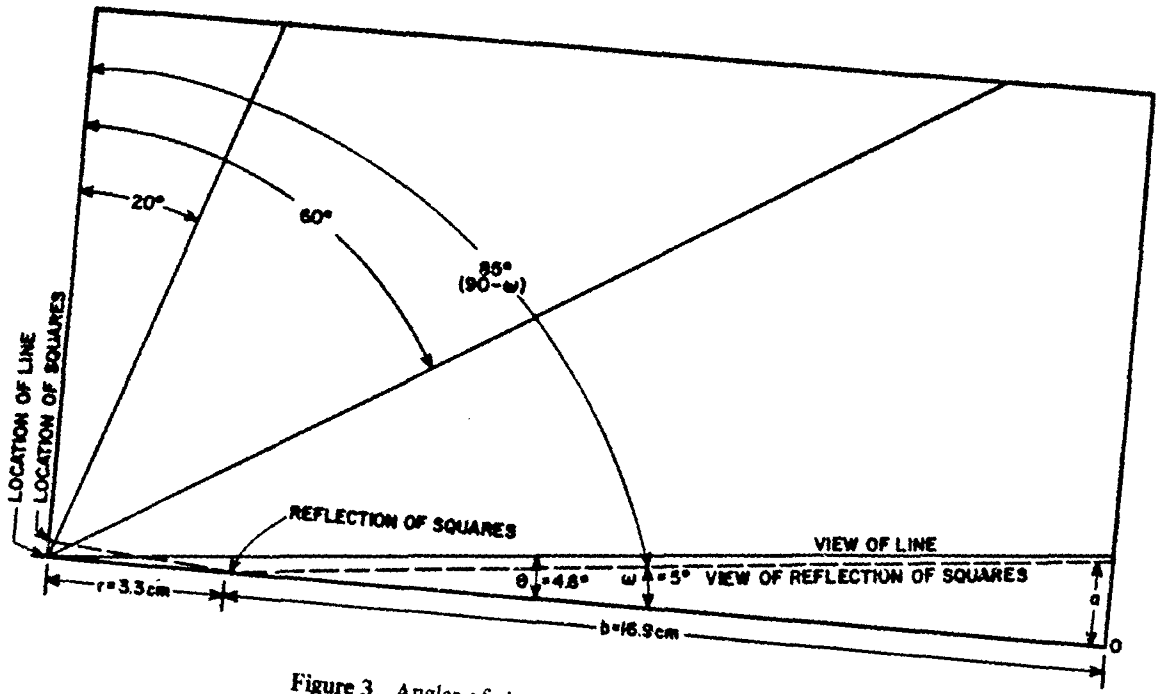

Figure 3. Angles of view of gloss measurements—test 8.

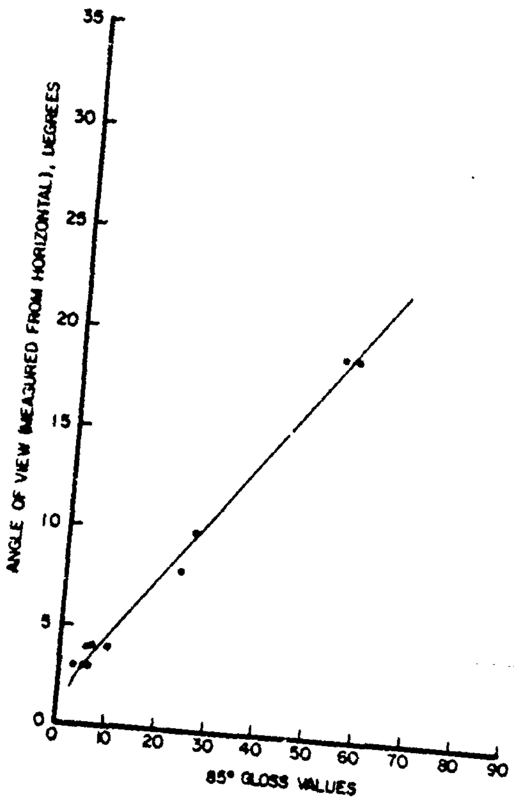

Figure 4. Comparison of visual gloss measurements with 85 degree gloss values—test 8.

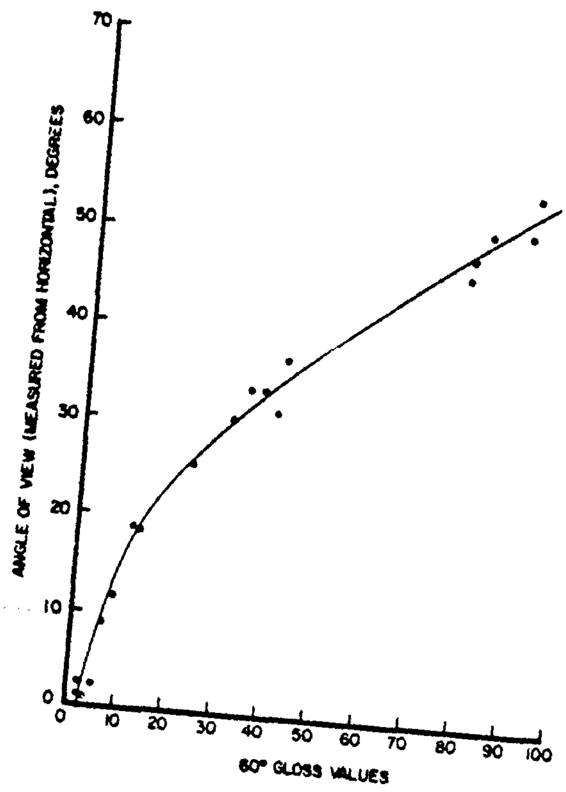

Figure 5. Comparison of visual gloss measurements with 60 degree gloss values—test 8.

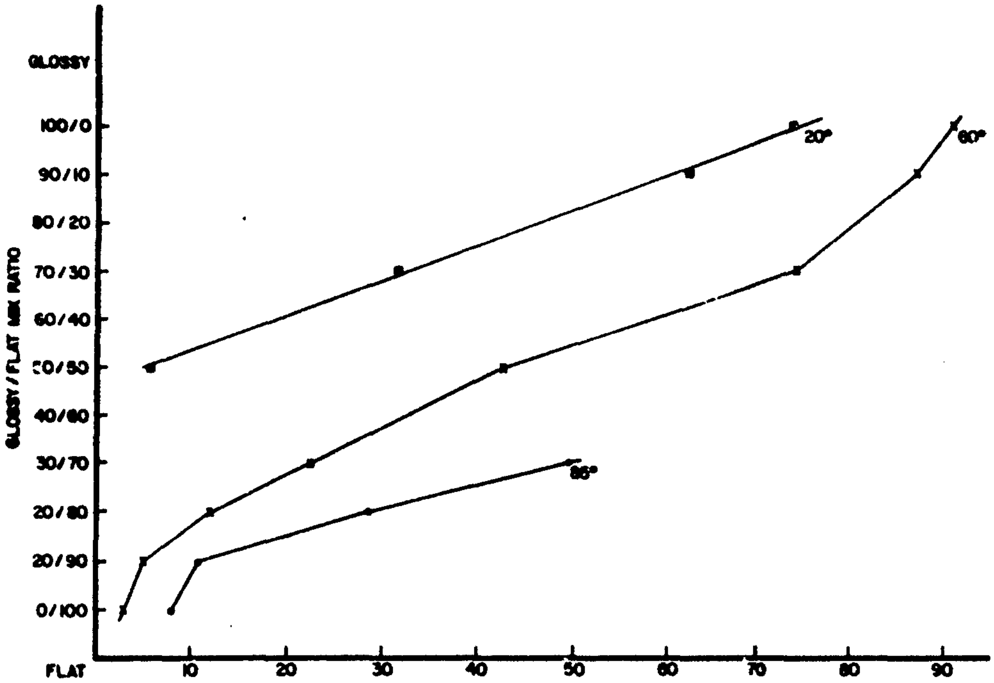

Figure 6. Gloss comparisons at 20°, 60°, and 85° angles—test 8.

are also included in Table 12. Note the ranges used for the different gloss values in Table 12.

Six analysts used the paint test kit gloss measurement device to determine gloss values for the nine samples and for comparing results. One analyst had consistently high readings (eight out of nine) whereas another analyst had six low readings out of nine. Three analysts were generally within the range. One analyst was variable (within the range but with three low values). Only two of the above individuals had some previous experience with the gloss measurement device (a and d). Their results are in fair agreement. Figure 7 is a graphical display of Table 12, showing the proposed test's gloss readings versus the 60 degree gloss values and angle of view measured from horizontal, equivalent to the paint test kit readings.

Table 13 had gloss measurements for 12 paint samples. Gloss values were determined by both the 60 degree gloss procedure and the proposed test kit procedure. Paint specification requirements also are listed. Note that flat paints classified by a gloss value of 0 to 2.5 degree angle of view from horizontal (Figure 7) by the kit test had a 60 degree gloss value average of 2.4 to 4.1. Eggshell classified paints had kit test values of 5.6 to 21.3 degrees from horizontal. The eggshell paint with a 21.3 degree value could also be classified as a semigloss paint like the paint with the 25.8 degree value. Corresponding 60 degree gloss values for the eggshell paints are 7.1 to 33.0. The glossy enamel with a kit test value of 47.5 degrees had a 60 degree gloss value of 86.5.

4. *Minimum Gloss Limits for Glossy Paints.* Specifications for glossy paints require the minimum gloss values listed in Table 14. The paint specifications in the table use 70 as a minimum value for glossy paints, with no upper limit, when applied by paint specification procedures. In terms of units used with the proposed paint test kit gloss device, the corresponding value would be about 33 degrees from horizontal.

Thus, glossy paints with 60 degree gloss values of at least 70 as required by specifications give kit test readings of at least 33 degrees from horizontal when applied with a 40-mil wire-wound rod, and are considered to meet gloss requirements. The six analysts verified this result (Table 12 and Figure 7) and Table 15 (taken from standard references) shows good agreement.

Table 12

Gloss Standards: Kit Value Versus Hunter Value
Results by Six Individuals–Test 8

	Paint Test Kit Individual Averages									60° Gloss Value***	
	Visual Angle From Horizontal, Degrees						Paint Test Kit				
Gloss Standard	a	b	c	d	e	f	Range	Average	Gloss Classification**	Average	Gloss Classification
100/0*	34.8	36.7	40.0	37.8	41.9	40.0	34.8–41.9	38.5	Gloss Not less than 33	91	
90/10	36.5	42.4	35.7	37.8	37.3	37.8	35.7–42.4	37.9		88	Gloss– not less than 70
70/30	34.4	41.2	28.0	36.7	33.9	30.7	28.0–41.2	34.2		73	
70/30	32.2	36.7	20.8	30.0	30.7	–	20.8–36.7	30.1		60	
50/50	30.1	30.7	17.0	24.1	23.7	23.0	17.0–30.7	24.8	Semi Gloss 19 to 33	36	Semi Gloss– 25 to 55
30/70	20.8	25.3	9.5	21.8	13.8	18.3	9.5–25.3	18.3		24	
20/80	7.6	10.6	3.9	6.2	3.9	5.3	3.9–10.6	6.3	Eggshell 3 to 27	12	Eggshell– 5 to 35
10/90	3.4	3.9	2.8	3.4	1.4	2.8	1.4– 3.9	3.0		5	
0/100	2.8	3.9	2.1	2.8	1.1	1.4	1.1– 3.9	2.4	Flat Below 3	2.8	Flat– below 5

*100/0 (Gloss/Flat Paints Blend Ratio).

**Values used on basis of visual examination of gloss of samples.

***Hunter Color/Difference Meter D25D2.

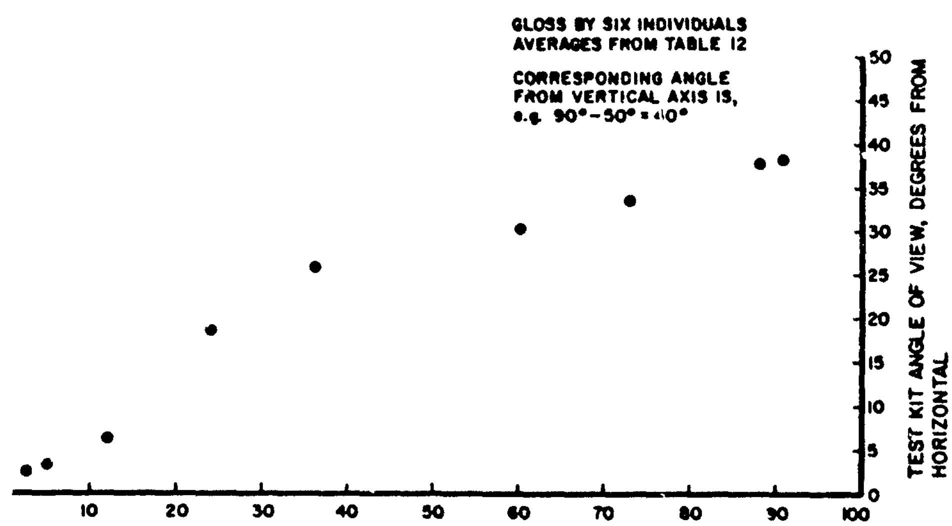

Figure 7. Sixty degree gloss value–test 8.

Table 13

Gloss Results Comparison:
Hunter 60° Versus Kit Test Method–Test 8

Paint Sample	Color	Hunter 60° Gloss	60° Spec Requirement	Kit Test Angle of View from Horizontal (degrees)
1. TT-P-19C (37875)*	White	3.6	None	0 Flat**
2. TT-P-650 (37769)	Ivory or buff	3.1	5–20	<2 Flat
3. TT-P-650 (37769)	Ivory or buff	3.0	–	<2 Flat
4. TT-P-002119 (37875)	White	2.4	35 Max	<2 Flat
5. TT-P-29J (37886)	Offwhite	2.4	None	2.3 Flat
6. TT-P-19C (37875)	White	4.1	None	2.5 Flat
7. TT-P-96D (37875)	White	7.1	8–15	5.6 Eggshell
8. TT-P-96D (37875)	White	11.3	8–15	10.3 Eggshell
9. TT-P-96D (37875)	White	17.0	8–15	16.5 Eggshell
10. TT-P-1511A (27780)	Offwhite	33.0	30–60	21.3 Eggshell
11. TT-E-508 (27880)	White	37.0	40–70	25.8 Semigloss
12. TT-E-489 (Near 16187)	Gray	86.5	None	47.5 Glossy

*Federal Standard 595–Colors.

**Classified from actual visual appearance of samples.

Table 14

Minimum Gloss Values for Glossy Paints–Specifications–Test 8

Paint	Minimum Value	Angle of Gloss Measurement
TT-E-489	70	20° Gloss
TT-E-505	70	60° Gloss
TT-E-506	80	60° Gloss
TT-P-1511 (Type II)	70	60° Gloss
	20	20° Gloss

Table 15

Gloss Range Values—Test 8

Paint	Kit Test Classification: Angle From Horizontal, °	Complementary Angle (Angle from Vertical)	Range of Gloss Values: (@60°)*	(@60°)**	(@85°)**
High gloss	Above 33	Below 57	70–95	70 minimum	–
Semigloss	19–33	71–57	30–70	25–55	–
Eggshell	3–27	87–63	10–25		–
Flat	Below 3	Higher than 87	2–10		5–15

*Charles R. Martens, *Waterborne Coatings, Emulsion and Water-Soluble Paints* (Van Nostrand Reinhold Co., 1981), p. 192.

**Abel Banov, *Paints and Coatings Handbook* (Structures Publishing Co., 1978), p. 86.

Equipment and materials required for a gloss evaluation are black and white opacity sheets, a clipboard to hold the sheet for a drawdown, a wire-wound applicator rod, and the gloss-measuring device.

Discussion

The gloss test and equipment are simple, economical, and give satisfactory, reproducible results. These results can be equated to paint specification readings in terms of 60 degree gloss as shown by test results in Figure 7 and Tables 12, 13, and 15.

Test 9: Water Resistance

Water is the solvent most likely to come into contact with paint. Some latex coatings have poor water resistance and are easily removed by finger pressure when wet; they may blister, wrinkle, or reemulsify in the presence of water. Oil-based paints may blister, whiten, dull, or lose adhesion, hardness, and gloss. To avoid using a paint with these possible deficiencies, water resistance should be evaluated. Federal Specifications listed in Table 5 require water resistance tests for paints TT-P-96, TT-P-29, TT-P-002119, TT-E-489, TT-E-508, and TT-E-506. The tests vary somewhat in detail but all include ASTM D 1308.[9]

Test Development and Proof

The pencil hardness test (ASTM D 3363)[10] was evaluated to determine if it could provide enough information about water resistance. Pencil hardnesses of 19 coatings applied on black plastic were measured according to ASTM D 3363 before immersion in water and after a 6-, 24-, and 48-hour immersion in water. For these immersions, 1.7-in. diameter areas were covered with wet cotton under small petri dishes. After removal of the wet cotton, the coatings were allowed to dry 24 hrs and the pencil hardnesses were determined again. Table 16 lists the paints tested and values obtained. The pencil hardness listed for each measurement is the hardest pencil that did not scratch the coating. Hardness numbers for the pencils ranged from 6H (hardest) to 2H, H, F, HB, B, and 2B to 6B (the softest available).

Many coatings failed the pencil hardness test after a 6-hr immersion, as shown in Table 16; some coatings failed after only 10 min of immersion. However, all coatings regained their approximate original hardness after they were allowed to recover. These experiments were found to yield inadequate information about water resistance.

A simpler test for water resistance, modified from that described in TT-P-1728A, was proposed for the paint test kit. In this procedure, (1) a drawdown is made with a 40-mil wire-wound applicator rod on black plastic sheets and the coating is dried at room temperature for 7 days. (2) Two 1-in.-diameter circles are drawn on the black coated area (a quarter dollar coin can be circled with a pencil). (3) A drop of water is placed in the center of each circle. (4) The water is spread over the selected area with a spatula or clean finger. (5) Four more drops of water are added to each area (Figure 9 in the appendix). (6) Each area is covered with a 2-in.-diameter watch glass for 2 hrs, adding more water if necessary to keep the area wet with a shiny layer of water. (7) The watch glasses are

[9] ASTM D 1308, "Effect of Household Chemicals on Clear and Pigmented Organic Finishes," *ASTM Annual Book of Standards* (1979; reapproved 1981).

[10] ASTM D 3363, "Film Hardness by Pencil Test," *ASTM Annual Book of Standards* (1974).

Table 16

Pencil Hardness and Adhesion—Tests 9 and 11

Coating***	Pencil Hardness*					Adhesion**		
	Dry	Immersed			After Recovery	To Plastic	To Paper	
		6 hr	24 hr	48 hr			coated	uncoated
Oil-Based Coatings								
TT-E-489(a)	B	3B	3B	5B	B	5	5	3
TT-E-489(b)	3B	3B	4B	4B	3B	5	5	5
TT-E-543	3H	H	3B	6B	2H	5	5	5
TT-P-30	H	H	HB	3B	B	5	4	4
TT-E-508(a)	3B	5B	5B	6B	3B	5	5	5
TT-E-508(b)	2B	5B	5B	6B	2B	5	5	5
TT-E-506	2B	6B	Fail		3B	3	5	5
Latex Coatings								
TT-P-19	5B	Fail			4B	5	5	4
TT-P-96	5B	5B	6B	6B	5B	5	5	3
TT-P-29(a)	3B	Fail			3B	5	0	3
TT-P-1511	HB	3B	5B	5B	B	5	5	5
TT-P-002119(a)	F	Fail			B	5	0	4
TT-P-002119(b)	3H	5B	5B	5B	2H	5	5	4
TT-P-002119(c)	2B	Fail			6B	5	4	5
COMM 1	5B	Fail			5B	4	5	5
COMM 2	2B	Fail			2B	4	4	5
COMM 3	5B	Fail			5B	4	4	5
COMM 4	2B	Fail			2B	4	4	4
COMM 5	3B	Fail			3B	4	4	4

*Pencil hardness is according to ASTM D 3363–coating on black plastic, dry, after 6-, 24-, and 48-hr exposures to water, and after 24-hr of recovery.

**Adhesion rating, according to the X-Cut Tape Test of ASTM D 3359 but using Scotch No. 810 Magic Tape, for the coating on black plastic, on coated white paper, and on uncoated white paper. (A rating of 5 is no coating removal; see text for other ratings.)

***Coatings were applied by a 40-mil wire-wound applicator. The letters a, b, and c indicate more than one coating of the same specification.

then removal and the areas are inspected for any degradation of the coating, as would be indicated by milkiness of the water or wrinkling of the coating film. (8) Both areas are blotted dry with a paper towel. (9) One of the areas is rubbed gently with a clean finger and the finger is observed for any coating or pigment pickup. (10) Next, the same finger is pressed down slightly on the same area and pushed away. (11) Finally, a thumb is twisted while bearing down to see whether adhesion is maintained. (12) If any defects were noted, the same tests were performed on the second area after 2 hrs of drying. If the coating was removed easily right after blotting (step 9) or could be twisted off after drying (step 11), it may not be water-resistant enough to withstand typical washing.

Table 17 shows water resistance test results determined both by Federal Specification tests and the proposed test kit procedure. Results from these two procedures were in full agreement for six different paint samples requiring this test.

Equipment and materials required for a water resistance evaluation are black plastic sheets, a clipboard to hold a sheet during a drawdown, a wire-wound applicator rod, a 1-in.-diameter coin (25¢) or disk for making circles, and two 2-in.-diameter watch glasses.

Discussion

Using a water resistance test will insure against choosing (1) water-based paints that blister, wrinkle,

Table 17

Water Resistance:
Paint Specification Versus Test Kit Results—Test 9

Paint Type	Water Resistance* Paint Specs	Water Resistance* Paint Test Kit
TT-P-19	NTR**	OK
TT-P-29	OK	OK
TT-P-002119	OK	OK
TT-E-489	OK	OK
TT-E-508	OK	OK
TT-E-506	OK	OK
TT-P-96	OK	OK
TT-E-545	NTR	Large dark spot
TT-E-543	NTR	OK
TT-P-30	NTR	OK

*Above samples did not show blistering, wrinkling, whitening, dulling, loss of adhesion or hardness, or any significant change in gloss for oil-base paints.

**No test required for water resistance. However, the paint met all other requirements.

or reemulsify and (2) oil-based paints that blister, wrinkle, whiten, become dull, lose adhesion or hardness, or change in specular gloss to below 90 percent of the original. Results show that this test is satisfactory, reproducible, simple enough to be conducted by nontechnical persons in the field, and produces results comparable to those obtained by the specification procedure.

Test 10: Hydrocarbon Resistance

The hydrocarbon resistance test determines paints' resistance to solvents exposure. Some alkyd coatings (oil-based) will be used in areas where they may be exposed to lubricating oil, cooking oils, or other hydrocarbons. The test is not necessary for oil-based interior primers or latex coatings except when latex coatings are anticipated to be in contact with hydrocarbon materials. Two oil-based Federal Specification paints listed in Table 5 require the hydrocarbon resistance test (TT-E-489 and TT-E-506).

In paint specification TT-E-489, Class A (hydrocarbon resistance test), the paint is applied on an aluminum-clad panel using an applicator with a 4-mil gap clearance and the panel is dried for 7 days. Half the panel is then immersed for 4 hr in a mixture of isooctane and toluene (70/30 by volume). After immersion, the panel is removed, dried with cheesecloth, and examined immediately for signs of wrinkling or blistering on the immersed portion. After 2 hrs, there should be no softening, whitening, or dulling of this portion. After 24 hr, the dried film that was immersed must meet color, hardness, and anchorage test requirements. It also must retain 90 percent of the 60 degree specular gloss of the dried film that was not immersed.

Federal Test Method Standard 141, Method 6011, is used for testing TT-E-506 (also refer to ASTM D 1308). None of the latex paints listed in Table 5 require the hydrocarbon resistance test.

Test Development and Proof

To evaluate a hydrocarbon resistance test, three alkyd gloss coatings (TT-E-489[X], TT-E-489[Y], and TT-E-506) were applied on black plastic using a 40-mil wire-wound applicator rod, at a wet film thickness of 3.6 mils for TT-E-489 and 3.8 mils for TT-E-506. They were allowed to dry at least 7 days before testing. Strip specimens measuring 0.5-in. by 3-in. were then cut. These strips and a similar strip of black plastic without coating were immersed to half their height in four test tubes containing toluene. All coatings swelled considerably in 45 min and lost adhesion when immersed. The plastic without coating swelled from about 0.55 to 0.68 in. when immersed, which indicated swelling was due to the toluene's strong action on the plastic.

Similarly coated and control strips were placed in a mixture of 30 parts toluene and 70 parts isooctane (by volume). After 2 hrs, the immersed portion of the TT-E-489(X) was easy to scrape off the substrate with a spatula; TT-E-489(Y) appeared to have softened slightly; the TT-E-506 was not affected. Immersion of the same coatings in mineral spirits caused no change, indicating that mineral spirits does not adversely affect the black plastic or coatings.

Based on these results, the hydrocarbon resistance test was modified to propose a simpler version for the paint test kit. Mineral spirits was substituted for the isooctane in the toluene-isooctane mixture because although the black plastic was swelled by pure toluene, it was unaffected enough by the toluene-mineral spirits mixture to serve as a substrate. Softening of the immersed coating film could be detected by probing with a spatula.

The hydrocarbon resistance test proposed for the paint test kit consists of making a drawdown on black plastic with a wire-wound rod applicator. The samples are dried for 7 days. A strip of the coated plastic is cut out (0.5 in. wide and 3 in. long) and placed into a test tube containing 1.5 in. of mineral spirits or other solvents typical of the anticipated exposure. (Isooctane was judged impractical for use in the kit because this solvent is not commonly found in the field. When a solvent other than mineral spirits is to be used, the effect of that solvent on the uncoated plastic should be checked along with the coated plastic. If the plastic softens or swells, the solvent is not compatible with the test.) The test tube is then closed with a neoprene stopper and allowed to stand 2 hrs in an upright position. Finally, the coated strip is removed and inspected visually for any softening or loss of adhesion that can be seen after gently probing with the spoon end of a small spatula or with a thumbnail. If the coating is softened only slightly, its durability in a greasy environment is questionable; appreciable softening or adhesion loss and removal indicates that the coating is unsatisfactory for the environment.

Table 18 shows satisfactory kit test results for 10 paints, all of which were approved by complete paint specification testing. It may be noted that only TT-E-489 and TT-E-506 specifications require a hydrocarbon resistance test. The fact that the other paints passed the kit test shows that the test can be performed on these paints if it is anticipated that their use will include exposure to hydrocarbons.

Table 18

Hydrocarbon Resistance: Specification Test Versus Kit Results—Test 10*

Paint Type	Paint Specs	Paint Kit Test
TT-E-489	OK	OK
TT-E-506	OK	OK
TT-E-508	NTR**	OK
TT-P-29	NTR	OK
TT-P-002119	NTR	OK
TT-P-19	NTR	OK
TT-P-96	NTR	OK
TT-P-30	NTR	OK
TT-E-545	NTR	OK
TT-E-543	NTR	OK

*Mineral spirits were used in the kit test. Other solvent media can be used; however, a control strip of uncoated plastic should be included along with the coated strip to determine the solvent's effect on plastic.

**No test required; although these paints do not require a hydrocarbon test, they were found to pass other pertinent specification tests.

Equipment and materials required to conduct this test are black plastic sheets, a wire-wound drawdown bar, a clipboard for holding the black plastic sheet while making a drawdown, a razor blade, scissors, ruler, test tubes with stoppers, a small spatula, and solvents (mineral spirits or others).

Discussion

In test data available, although all the paints evaluated by this test were satisfactory, only two required paint specification hydrocarbon resistance tests; and results by both methods were in agreement. Based on the analysis, the kit test appears to be satisfactory since it gives results equal to those from the paint specification tests and could be easily done by nontechnical persons in the field.

Test 11: Adhesion

A paint with poor adhesion will eventually become loose and peel off. Poor adhesion can result from overcoating a surface with an incompatible paint or from not using a required primer, among other reasons.

In multicoat systems, adhesion may fail between coats rather than between the coating system and substrate. Since adhesion is so important, the paint test kit needed to include a way to assess this properly. It is especially critical to test adhesion for water-thinned paints, although all paint types may be evaluated. Federal Specification paints requiring an adhesion test are TT-P-29, TT-P-1511, TT-P-002119, and TT-E-489 (Table 5).

Existing paint specification tests for adhesion cannot be used for the kit since they require elaborate equipment and are variable and quite detailed. Tests often require that the paint sample be thinned and spray-applied onto a primed or unprimed aluminum-clad panel. Drying and baking may be needed, as in the case of TT-E-489. For TT-P-1511A, the test is called "wet adhesion." In this specification, the coating is applied over a previously dried, baked coating of TT-E-489 on a glass panel. The coating is then scored with a razor blade across the panel and scrubbed under water in a special machine for 5000 cycles. The paint test kit needed much simpler methods than these or other ASTM tests such as D 1730 and D 3359 to be practical for field use.[11]

[11] ASTM D 1730, "Recommended Practices for Preparation of Aluminum and Aluminum Alloy Surfaces for Painting," *ASTM Annual Book of Standards* (1967); ASTM D 3359, "Measuring Adhesion by Tape Test," *ASTM Annual Book of Standards* (1983).

Test Development and Proof

The tape adhesion test, ASTM D 3359 with X-cut, was used for coatings on black plastic Leneta sheets and on Penopac paper with coated and uncoated surfaces. The results for seven alkyd coatings and 12 latex coatings, when tested with Scotch No. 810 Magic Tape, are shown in Table 16. Note the differences between adhesions to plastic and to coated paper. It is possible that the coated opacity chart would be as suitable as the drawdown on plastic, but occasionally the tape and coating adhesion were so high that the paper was torn under the coating. The following ratings were used:

5–No peeling or removal.

4–Trace peeling or removal along incisions.

3–Jagged removal along incisions up to 1/16 in. on either side.

2–Jagged removal along most incisions up to 1/8 in. on either side.

1–Removal from most of the X area under the tape.

0–Removal beyond the X area.

Table 19 shows adhesion results using the proposed paint test kit and Federal Specification procedures. Eleven paints found acceptable in the previous tests passed the kit test for adhesion. Only four of these paints (TT-P-29, TT-P-1511, TT-P-002119, and TT-E-489) listed in Table 19 require a paint specification adhesion test. In the paint specification results, one batch of TT-P-1511 passed and three failed the adhesion test. The paint specification test calls for the wet adhesion scrubbing test, which apparently is more severe than the proposed kit test procedure.

Materials and equipment used in the proposed adhesion test are black plastic sheets for drawdowns, a clipboard, a wire-wound applicator rod, Scotch Tape No. 810, a razor blade, and a ruler.

Discussion

The agreement can be considered satisfactory for adhesion results obtained for four paints tested by both regular acceptance tests and the paint test kit procedure. The kit test provides a much simpler field test than do regular acceptance tests.

Table 19

Adhesion: Paint Specification Versus Kit Test Results–Test 11

Paint Type	Paint Specs	Paint Kit Test
TT-P-19	NTR*	OK
TT-P-29	OK	OK
TT-P-002119	OK	OK
TT-E-489	OK	OK
TT-E-508	NTR	OK
TT-E-506	NTR	OK
TT-P-96	NTR	OK
TT-E-545	NTR	OK
TT-E-543	NTR	OK
TT-P-30	NTR	OK
TT-P-1511	OK	OK
TT-P-1511	Failed**	OK

*No test required; these paints passed all other pertinent specification tests.

**Three different lots of TT-P-1511 failed in paint specification tests, including adhesion, but passed the kit test for adhesion. The paint specification test calls for wet scrubbing, which appears to be more severe than the procedure in the kit test.

Test 12: Flexibility

Flexibility of dried coatings can be important when there are differences in thermal expansion between the coating and substrate. The same principle applies to coatings on nonrigid surfaces. In addition, resultant stresses with changes in temperature may require both flexibility (elasticity) of the coating and good adhesion for optimal performance. Flexibility usually is considered more important in topcoats than in corresponding primers because slight cracking of a primer would not create the appearance problem that a cracked topcoat would.

Of the paints listed in Table 5, a flexibility test is required for all except TT-P-19. FTMS 141 Method 6221 is specified except for TT-E-489.

Test Development and Proof

Of 17 coatings listed in Table 20, only three coatings (one alkyd and two latexes) cracked when the coating was applied on a tinplate panel with a 6-mil blade and this panel was bent over a 1/8-in. mandrel (according to Method 6221 of FTMS 141B). Two of these (the TT-P-30 and a latex ceiling paint) showed fine parallel cracks and one (an exterior latex) had cracks that exposed the metal substrate. The two latex coatings applied to black plastic Leneta sheets with a 6-mil blade also cracked when the sheets were bent over a 1/8- or 1/16-in. rod. When applied to the plastic using a 40-mil wire-wound applicator, these three coatings showed cracks after the plastic was bent

Test 20

Flexibility—Test 12

	Cracking			
	FTMS**	Kit Test (Wire)***		Wet Film
Coating*	**Blade**	**Mandrels: 1/16-in.**	**1/8-in.**	**Thickness, mils**
Oil-Based Coatings				
TT-E-489	No	Yes	No	3.2
TT-E-543	No	Yes	No	3.0
TT-E-545	No	Yes	Yes	3.2
TT-P-30(a)	Yes	Yes		
TT-P-30		Yes	Yes	3.3
TT-E-508	No	Yes	No	3.0
TT-E-506(a)	No	No (Blade)****		
TT-E-506	No	Yes	No	4.0
Latex Coatings				
TT-P-19		No	No	
TT-P-29	No	Yes	No	
TT-P-1511	No	No (Blade)		
TT-P-002119	No	Yes	No	
TT-P-96	No	No	No	4.0
COMM 1	No	No (Blade)		
COMM 2	No	No (Blade)		
COMM 3–Exterior	Yes	Yes (Blade + Wire)	Yes	
COMM 4–Ceiling	Yes	Yes (Blade + Wire)	Yes	

*The letter (a) designates more than one coating of the same specification.

**Flexibility test results according to Method 6221 of Federal Test Method Standard 141B, for the coating film on a tinplate panel bent over a 1/8-inch mandrel. The "blade" was a Bird blade with a 6-mil clearance.

***Flexibility test results as described in the text for the coating applied to a plastic sheet and bent over 1/16- and 1/8-in. mandrels. The "wire" was a 40-mil wire-wound applicator.

****Blade means: Applied on plastic sheet with a blade. Others applied with a wire-wound applicator.

over a 1/16-in. rod and viewed under 10 power magnification (Table 20).

The flexibility test method proposed for the kit is very similar to Method 6221 of FTMS 141B. However, instead of using coated tinplate panels, the drawdowns are made on plastic and bent over 1/16-in.-diameter and 1/8-in.-diameter steel rods as used to generate the data in Table 20. The three coatings that failed the FTMS test also cracked using the test kit method.

Both rod sizes were used in the kit test for 12 paints in Table 20. The coatings were applied with a wire-wound drawdown bar on black plastic sheets. The 1/8-in. rod gave results more comparable to paint specification results than the 1/16-in. rod. The TT-E-545, which failed with both rod sizes, was the only exception.

Materials and equipment required for the flexibility test include black plastic drawdown sheets, a clipboard, wire-wound applicator rods, razor blades and scissors, a ruler, a stainless-steel 1/8-in.-diameter rod, and a magnifying lens.

Discussion

Test results using this procedure indicate generally good agreement with results obtained by regular paint specification tests when the 1/8-in.-diameter rod is used (see Table 20). This modified Federal Specification test is the procedure judged best for field use.

Test 13: Scrub Resistance

Interior latex and interior flat oil-based coatings often become soiled, especially near doorways, in work and play areas, on certain walls, and near windows. These areas must be cleaned by scrubbing with a cloth or sponge and an abrasive scrub medium if necessary.

However, repeated scrubbing subjects the paint to erosion, often changing the appearance (e.g., dulling the gloss, showing signs of film removal or wear, damaging color) thus shortening the paint's service life. Different paints have more or less resistance to this abrasion, so that a scrub resistance test is needed to screen out paints with lower resistance.

Of the paints listed in Table 5, a scrub resistance test is required only for TT-P-19 (FTMS 141, Method 6142), TT-P-29 (ASTM D 2486 using a sponge and 1-lb load),[12] TT-P-002119 (ASTM D 2486 using a bristle brush and 2-lb load), and TT-P-30 (ASTM D 2486).

In FTMS 141, Method 6142, a paint's scrub resistance is determined by applying it to a primed glass panel and subjecting it to the abrasive action of a bristle brush wetted with soap solution. A mounted electric motor apparatus is required, making this method impractical for field use.

In ASTM D 2486, the paint sample is applied onto a black plastic panel. After the coating has aged, the panel is placed over a 0.5-in. by 10-mil shim (raised area) and a gasketed frame holds it in place on a glass plate in a washability machine. It is then scrubbed with a sponge or a nylon bristle brush and an abrasive scrub medium until failure occurs over the shim or for a specified minimum number of scrub cycles (300 to 400, depending on the paint) without wearing through the coating. As with the previous test, this method was judged impractical for inclusion in the test kit.

Test Development and Proof

To find a scrub resistance test suited to kit use, the ASTM D 2486 procedure was first performed for eight latexes and one alkyd coating. This method uses a reciprocating brush with an abrasive scrub medium (Leneta SC-2). The cycles required to brush a clear path through the coating to the black plastic over the 0.5-in. width of the 10-mil shim varied from 1350 to 18, as shown in Table 21.

When the shim thickness was increased to 23 mils, the number of cycles required was reduced for some coatings, but increased for others—apparently because the brush tended to jump over the raised area rather than bear down on it evenly. Thus, it appeared that no advantage would be gained from using a thicker shim.

[12] ASTM D 2486, "Scrub Resistance of Interior Latex Flat Wall Paints," *ASTM Annual Book of Standards* (1979).

Manual scrub tests also were performed with a 2-in.-square gauze pad moistened only with water. The pad was moved back and forth over a 3-in. path across the coating while pressing on it with two fingers to create a force equal to about 1 lb. The scrubbing was continued until the coating was worn to the plastic substrate or for a maximum of 500 cycles. Table 21 gives results. Most coatings withstood 500 cycles; those that did not, required no more than 25 cycles to wear through the coating. The same coatings gave correspondingly poor results in the ASTM test. (For five shelf brand coatings tested, the number of cycles decreased as the price decreased, which may or may not be coincidental).

Several more procedures were tried and evaluated in attempts to obtain results comparable to those using paint specification tests. These procedures included modifications to standard tests such as (1) using other wire sizes of drawdown bars, (2) increasing the number of scrub cycles, and (3) making drawdowns on plate glass using 40-, 24-, and 16-mil wire-wound applicators. The various modifications could not improve this test's reproducibility and would have added to the test kit's cost and complexity.

Table 21 shows scrub resistance data for various paints tested by paint specification procedures and some different kit test methods tried. When results did not compare between the two methods, the same samples were retested along with new sets of drawdowns. The kit test results under "gauze pad/wire" indicate only two disagreements with specification results under "ASTM" in 14 pairs of results. However, the "sponge/wire" procedure gave a perfect correlation with specification results. For TT-P-002119, the initial kit test appeared to be less severe since it indicated passing results compared to a failure by the paint specification procedure under ASTM. Using a sponge instead of gauze together with a mildly abrasive detergent corrected this difference. Satisfactory kit test results for eggshell, semigloss, and gloss paints also can be obtained using gauze and two to three drops of abrasive detergent such as SC-2 Leneta; however, a sponge and less abrasive type detergent are preferred.

Material and equipment needed for the scrub resistance test are a clipboard, a wire-wound drawdown bar, a black plastic drawdown sheet, a mildly abrasive cleaner, and a sponge.

Discussion

Although the severity of scrub resistance specification tests varies for flat paints versus paints that have

Table 21

Scrub Resistance—Test 13

Coating*	ASTM (Blade)**	Gauze Pad*** Blade	Gauze Pad*** Wire	Sponge Wire+	Wet Film Thickness (mils)
	Performance (Scrub Cycles)				
Oil-Based Coatings					
TT-E-508	-		>500	–	3.0
TT-E-506	824		>500	–	4.0
Latex Coatings					
TT-P-19	OK++		OK	OK	3.2
TT-P-29(a)	–		>500	–	–
TT-P-29(b)	1153	>800	>500	–	–
TT-P-29(c)	86	54	25	–	–
TT-P-29(d)	OK		Failed	OK	3.2
TT-P-29(e)	OK		–	OK	–
TT-P-29(f)	Failed		Failed	–	–
TT-P-1511	1350		>500	–	–
TT-P-002119(a)	–		>500	–	–
TT-P-002119(b)	–		>500	–	–
TT-P-002119(c)	–		>500	–	–
TT-P-002119(d)	Failed		OK	Failed	3.2
TT-P-002119(e)	Failed		Failed	–	–
COMM 1	210	>500	>500	–	–
COMM 2	77		10	–	–
COMM 3	41	60	10	–	–
COMM 4	28	20	7	–	–
COMM 5	18		3	–	–

*The letters a through f designate more than one coating of the same specification.

**Cycles to failure in scrub resistance tests according to ASTM D 2486, but using a 6-mil Bird blade for coating application rather than a 7-mil blade.

***Cycles to failure using a gauze pad as described in text. A 200-cycle minimum (double strokes) is proposed in the kit test. A good coating should withstand more than 500 cycles. "Blade" was a Bird blade with a 6-mil clearance; "wire" was a 40-mil wire-wound applicator.

+A sponge was used instead of a gauze pad and two to three drops of mild detergent were used instead of water. Application was by a wire-wound rod.

++For TT-P-19, FTMS Method 6142 was used to determine scrub resistance.

higher gloss properties, modifications to the kit test will compensate for these differences and give more comparable results. A sponge will be used for scrubbing instead of gauze. In addition, two to three drops of a mild abrasive will replace water in tests for eggshell, semigloss, and gloss paints.

Test 14: Washability

Interior architectural paints often are soiled by dirt and other stains. The greater the ease of soil or grease removal with a minimum of film erosion, the longer the expected useful service life for the paint. Resistance to washing, especially for flat wall paints, is therefore an important factor, making it necessary to run tests to ensure that enough washability has been built into the paint formulation. Tests for washability differ from scrub tests in that the washability test is for the paint's cleaning ability, whereas the scrub test assesses a paint's resistance to abrasion.

The washability test can be conducted on all interior topcoat paints. When a topcoat is soiled, it should be possible to clean it without much effort and without changing the coating's appearance. Some types of soiling may be removed more easily than other types. In addition, a glossy paint will clean more easily than a flat paint.

Of the paints listed in Table 5, washability specification tests are required for TT-P-96 (FTMS 141, test #6141), TT-P-29 (test #6141 with TT-E-545 as undercoat), TT-P-1511 (ASTM D 3450),[13] TT-P-002119 (similar to test #6141), TT-P-30 (test #6141), TT-E-508 (test #6141), and TT-E-506 (test #6141).

FTMS 141, Method 6141 determines a paint's washability by subjecting a soiled film of the dried paint to the cleaning action of a wet sponge and cake grit soap. Measurements of the paint film's reflectance and gloss before and after washing indicate the completeness of soil removal and the change in gloss brought about by cleaning.

Test Development and Proof

To develop a washability test for the kit, eight latexes and one alkyd coating were tested according to ASTM D 3450. This method uses a mechanical reciprocating weighted sponge wetted with a nonabrasive scrub medium (Leneta SC-1) for 100 washing cycles to remove a staining medium of carbon in mineral oil and mineral spirits (Leneta ST-1). The coating's reflectance was measured before soiling and after washing. The reflectance value after soiling and washing is compared with the original reflectance value. Typical recovery requirements are 95 percent or higher. The alkyd coating subjected to this test had a recovery of 99 percent. All latexes had lower recoveries, with six of the latexes having recoveries below 56 percent. Table 22 lists calculated recoveries of the reflectance values.

Since use of a machine would be impractical for the paint test kit, washability tests were also performed manually using a scrubbing procedure similar to the one just described. The staining medium was applied to a circular area about 3/8-in. in diameter and, after 5 min, the excess medium was removed carefully with a dry gauze pad. Three drops of the nonabrasive scrub medium were applied to the stained area, which was then scrubbed for 10 cycles with a moist gauze pad from which excess moisture had been blotted with a paper towel. Washing residues were removed with a dry and then with a moist paper towel, and the area's cleanliness was rated as: 4 = clean, 3 = almost clean, 2 = moderately clean, 1 = not clean (Table 22).

In the washability test initially proposed for the paint test kit, the washing is done with a gauze pad, but with the ASTM nonabrasive scrub medium and using only 10 cycles. To find a suitable staining method, tests were performed with a carbon staining medium and with a staining medium containing raw umber in petrolatum (prepared with 1.23 oz raw umber, 0.212 oz white petrolatum, and 1.35 fl oz mineral spirits), as specified in a discontinued version of Method 6141 of FTMS No. 141A. Because the carbon stain was very messy and because the less messy raw umber did not appear to do much staining, the test was also done using only white petrolatum. Results with this last staining procedure (using the same four-point rating) compared most favorably with the reflectance recoveries in the ASTM washability test for seven coatings, as shown in Figure 8 for the data reported in Table 22.

Table 22 also compares washability results using the Federal Specification test procedures versus the proposed paint test kit procedure (with two different wash media), under petrolatum and sponge/petrolatum columns. Of the seven specification test results available five were in agreement and two did not agree. All three oil-based paints and two water-based paints had the same results by both methods; the remaining two water-based paints in columns under "Petrolatum" and "Paint Spec Test" had different results (no agreement). This was corrected by using a sponge to replace the gauze pad and by using a mildly abrasive detergent (Table 22 under Sponge/Petrolatum).

The disagreement in results for washability of TT-P-29 and TT-P-002119 is hard to pinpoint because of all the variable factors among the test procedures (e.g., different soiling media, different abrasives and, in the case of the specification tests, a much greater number of cleaning cycles). The larger number of wash cycles in the specification tests (75 or 100) will lead to better cleaning than by the kit test (10 cycles). Failure criteria differ for the kit test compared with specification tests. In the kit test, failure is denoted by darkening that occurs due to the petrolatum or by noticeable differences in surface gloss. In specification tests, changes in measured reflectance and specular gloss are considered along with the qualification that the staining medium be removed without exposing any undercoat.

Different systems and combinations were tried for the washability test to obtain a better comparison with paint specification test results. As already described, soil media were varied. In addition, gauze pads (damp or dry) versus sponges were used to rub the soiled area on the coating. Several different detergents in varying

[13] ASTM D 3450, "Washability Properties of Interior Architectural Coatings," *ASTM Annual Book of Standards* (1980).

Table 22

Washability–Test 14

Coating*	ASTM** (Carbon)	Gauze Pad***			Sponge (Petrolatum)+	Paint Spec Test++
		Carbon	Umber	Petrolatum		
Oil-Based Coatings						
TT-E-489	–	–	–	OK	–	–
TT-E-543	–	3	3	4	–	–
TT-P-30(a)	–	2	2	3	–	–
TT-P-30(b)	–	–	–	Failed	–	Failed
TT-E-508	–	–	–	OK	–	OK
TT-E-506(a)	99.1	4	4	4	–	–
TT-E-506(b)	–	–	–	OK	–	OK
Latex Coatings						
TT-P-19	–	–	–	Failed	–	–
TT-P-29(a)	41.1	–	–	–	–	–
TT-P-29(b)	48.3	1	3	2	–	–
TT-P-29(c)	–	–	–	Failed	OK	OK
TT-P-29(d)	–	–	–	Failed	–	Failed
TT-P-96	–	–	–	OK	–	–
TT-P-1511(a)	87.2	4	4	4	–	–
TT-P-1511(b)	–	–	–	OK	OK	OK
TT-P-002119(a)	–	1	4	4	–	–
TT-P-002119(b)	–	2	4	4	–	–
TT-P-002119(c)	–	1	3	3	–	–
TT-P-002119(d)	–	–	–	Failed	OK	OK
COMM 1	74.8	1	3	4	–	–
COMM 2	37.7	1	3	1	–	–
COMM 3	55.2	2	3	2	–	–
COMM 4	40.4	1	3	1	–	–
COMM 5	50.4	–	–	–	–	–

*The letters a through d designate more than one coating of the same specification.

**Percentage reflectance recovery according to ASTM D 3450 (using a carbon and mineral oil staining medium).

***Degree of cleanliness achieved with a gauze pad, as described in text, using staining media of carbon in mineral oil, raw umber in petrolatum, or only petrolatum. The ratings are: 4=clean, 3=almost clean, 2=moderately clean, and 1=not clean.

+Sponge used instead of gauze pad along with two or three drops of mildly abrasive wash medium. Stained area was rubbed with 20 to 25 cycles (double strokes).

++Results of regular paint specification tests.

Note: Original detergent–results are under "Gauze Pad/Petrolatum". Mild abrasive wash media–results are under "Sponge/Petrolatum".

amounts were evaluated; nonabrasive (SC-1, Leneta and TSP), mildly abrasive, and abrasive (SC-2, Leneta). Raw umber soil medium was scrubbed with TSP, SC-2, and mildly abrasive detergents. Reaction time for petrolatum was varied as well as the number of rub cycles and hand pressure. These variations produced no consistent improvement in test results.

Materials and equipment needed for the washability test are a clipboard, a wire-wound drawdown bar, black plastic sheets for drawdowns, white petrolatum, a sponge, a detergent medium, and paper towels.

Discussion

Based on the results obtained for this washability test, using a sponge for rubbing, white petrolatum as the soiling agent, and a mildly abrasive detergent, should provide the best results in the field.

Implementation

USA-CERL prepared six paint test kits to distribute to interested Army installations as a field test for screening paints. Installations receiving the kits were Fort Sheridan, IL; Fort Devens, MA; Fort Gordon, GA; Fort Polk, LA; Fort Campbell, KY; and Fort Leonard

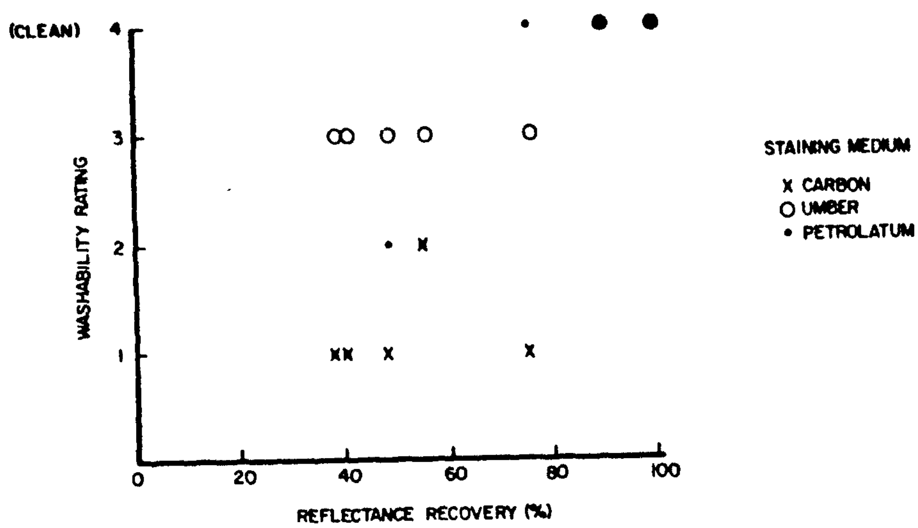

Figure 8. Comparison of washability test results—test 14.

Wood, MO. Procedures for using the kits were demonstrated at the installations. This field testing indicated the kit provides a useful screen for singling out paints that require further laboratory evaluation before use.

A second field evaluation consisting of 100 kits is still in progress. This evaluation is designed to provide additional feedback on the usefulness of the kit as well as actual cost savings.

Besides the field tests, the kits were demonstrated at the Real Property Management System (RPMS) Conference in Philadelphia in November 1984, where at least 42 Army installations requested one. The kit will be available from USA-CERL, P.O. Box 4005, Champaign, IL 61820-1305.

3 CONCLUSION

A prototype paint test kit has been developed for use by DEH in judging paint quality before application. The kit has the equipment needed to run 14 tests on paint, with an instruction manual included for easy use. The tests are simple, economical, fast, and can flag many potential paint problems. Paints furnished by a contractor or those stored for long periods can thus be evaluated in the field before application.

For an initial field evaluation, six Army installations are using the test kit. Interest is high for this kit, as was evident during the Sixth Worldwide Real Property Management System (RPMS) Conference held in Philadelphia, PA, in November 1984, where 42 CONUS and OCONUS Army installations requested one. Over 60 other installations have since requested kits and these plus the 42 have been furnished for the second field evaluation.

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APPENDIX:

INSTRUCTIONS FOR PAINT INSPECTION KIT

INSTRUCTIONS FOR PAINT INSPECTION KIT

Introduction

The paint inspection kit allows a determination in the field of the quality of oil-based and latex coatings before they are used. Results of the tests described in this kit should determine whether a coating is of satisfactory, questionable, or unsatisfactory quality. These tests demonstrate coating properties normally determined with more precision in the laboratory. Therefore, if the quality is questionable according to a kit test, laboratory tests should be performed before the coating is used.

Although no laboratory experience is required to use the kit, care must be taken to obtain good results.

Equipment and Required Materials

Equipment in the Kit

The following items are part of the test kit. They are listed in the order first mentioned in the test procedures. The test procedures in which they are used are shown in parentheses. The letter in brackets suggests potential sources for replacing the item.*

- Paint can opener (1,2,3)[A]
- Two test tubes with stoppers (2,10) [B]
- Small spatula (2,4,9,10) [B]
- Large spatula (1,3) (Ground square at bottom) [B]
- Eighty opacity charts (3,4,5,6,7,8), Black and White Leneta Forms 3B or equivalent [C]
- Forty plastic sheets (3,9,10,11,12,13,14), Black Plastic Leneta Form P121-10N or equivalent. Twenty sheets, 6½ in. x 17 in., are cut in half to make 40 6½ in. x 8½ in. sheets [C]
- Clipboard (3,7,8), 9 in. wide by 15-1/8 in. long [A]
- Teaspoon (3) [A]
- Tape (Scotch No. 810) (3,4,8,11) [A]
- Short-bristled brush (3) [A]
- Stainless steel pan (3) [B]
- Wire-wound applicators, 40-mil and 16-mil (3) [C]
- Set of hiding power standards (7) [D]
- Gloss instrument (8) [D]
- Extra squares for gloss instrument (8) [D]
- Dropper bottle (water) (9,13,14) [B]
- Two watch glasses (9) [B]
- Ruler (10,12) [A]
- Five razor blades (10,11,12) [A]
- Stainless steel rod (1/8 in.) (12) [A]
- One 3-in. test tube with cork stopper for holding above rod (12) [B]
- Magnifying lens (12) [B]
- Sponge (cellulose type) (13,14) [A]
- Dropper bottle (wash medium) for Soft Scrub® or equivalent (14)[A,B] **
- White petrolatum (14) [A]
- Small scissors, about 4 to 5 in. (10,12) [A].

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*A: item can be obtained in local hardware store; B: Fisher Scientific Co., 711 Forbes Ave., Pittsburgh, PA 15219; C: Leneta Co., Box 86, Ho-Ho-Kus, NJ 07423; D: USA-CERL, P.O. Box 4005, Champaign, IL 61820-1305, ATTN: Paint Laboratory (for more Information).

** "Soft Scrub" is a registered trademark of the Clorox Co.

Required Materials

The following items are required but are not part of the test kit:

- Pen and record book or sheets
- Paper towels for cleanup
- General-purpose detergent for cleaning equipment used with latex paints (dishwashing detergent or any other readily available product)
- Mineral spirits or other paint thinner suitable for thinning and cleaning oil-based paints (normally can be obtained from jobsite or local paint stores)
- Container for holding waste solvent, such as used mineral spirits, before disposal (should be metal or protected glass)
- Space or rack to hold test panels. Test panels with coating applied must lie flat and horizontal until dry. After coatings are dry, sheets can be taped on a wall or otherwise stored with no weight or pressure on coatings of adjacent sheets.

Tests With Same-Day Results

Results for tests in this category can be obtained rapidly upon inspection or after application. These tests include: (1) condition in container, (2) determination if oil or latex, (3) application characteristics and drawdowns, and (4) sagging.

Test 1: Condition in Container

This is a test to detect skinning or livering, film smoothness on a spatula, presence of gritty particles or clustering of particles and broken skins, or presence of settled material. Freezing causes the water (in water-based paints) to separate from the pigment and resin such that it forms a nondispersible settlement of pigment and resin that cannot be mixed to form a homogeneous mixture. Use the following procedure:

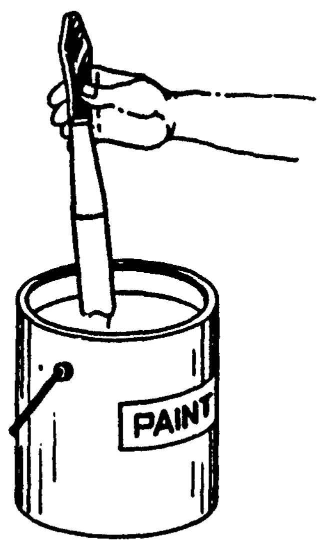

Figure 1. Draining the spatula for the condition-in-container test.

1. Open the can and look for any visible defects in the paint.
2. Dip a spatula or wooden stirring paddle into the coating to detect skinning (formation of a skin over the surface) or livering (a jelly-like consistency of part or all of the coating). If the paint is skinned, gently cut the skin loose from the side of the can and remove it.
3. Pull out the spatula and let it drain (Figure 1). A smooth film should result.
4. Look for any gritty particles, seediness (a cluster of small particles), or pieces of broken skins.
5. Dip the spatula to the bottom of the can to make sure there is no settled material that cannot be dispersed easily.
6. Mix the paint with the large spatula or wooden stirring paddle, or use a shaker. When a shaker is used with latex coatings, air can be entrained, so the coating should stand overnight and be stirred with a spatula before testing.

A light skin is not objectionable (step 2); however, a heavy skin could be cause for rejection. If grit particles or chunks of skins are noted (steps 3 through 5), the paint may not produce a smooth, uniform appearance when applied. A painter may be able to filter out pieces of skins but not particles of grit. Paint should be stirred easily (step 5) to form a smooth material of uniform consistency and appearance. Any paint found to have a heavy skin on the surface, particles of grit, hard settling or any other defect that might cause the applied paint to have an unsightly appearance should be submitted to a laboratory for thorough evaluation. Additional information about the paint's condition will be evident from the drawdown procedure in Test 3.

Some paint conditions discussed in these instructions are defined in the box.

Paint Conditions—Definitions

Skinning	Formation of a skin over the surface of the paint in the container. A light skin is not objectionable but a heavy one could be unacceptable.
Livering	A jelly-like consistency in part or all of the coating. Could be a cause for rejection.
Grit particles	Particles that will not dissolve in the paint mixture and would result in a rough finish. This condition is particularly objectionable for gloss and semigloss paints.
Seeding	A clustering of small particles.
Cratering	Also called "Fish-Eying." Small, but distinct, round craters in coated surfaces, usually with well defined circumferences and some material in the center caused by the presence of an incompatible material.
Large particles	Particles that have not been broken down or foreign material introduced during the coating's manufacture. Large particles in the coatings may produce drawdowns that look like brushouts with wide, uneven paths. This results in a rough dried paint surface. The particles can be seen and felt when running a hand over the surface.

Test 2: Determination if Oil or Latex

This information generally will be mentioned on the label. An oil paint will mix with mineral spirits but not water; latex paints will mix with water but not mineral spirits. This can be confirmed easily:

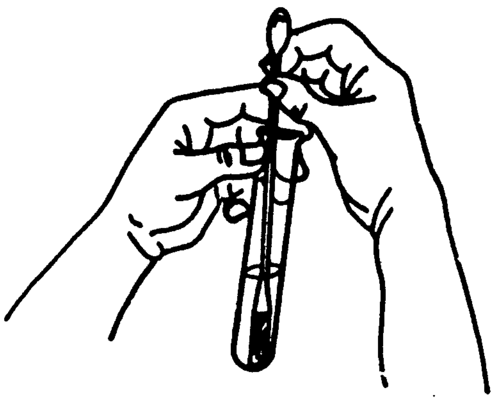

Figure 2. Paint on the spatula is incompatible with the solvent in the test tube.

1. Fill one test tube to a 2-in. height with mineral spirits and the other tube to 2 in. with tapwater. (Disposable containers such as paper cups also may be used.)

2. Dip the square end of the small stainless steel spatula 1 in. into the stirred coating.

3. Pull the spatula up and let it drain a little.

4. Place it into the test tube containing mineral spirits if you suspect an oil-based coating or into the tube containing water if you suspect a latex coating.

5. Move the spatula in the liquid by twirling the shank between the thumb and forefinger.

If the correct assumption has been made, the paint will begin to disperse evenly in the liquid. If the assumption was wrong, globs of the paint will drop to the bottom of the test tube, leaving the liquid clear, or the paint may just cling to the spatula as in Figure 2. This test should give very obvious results. If there is any indication of incompatibility of latex paints with water or oil-based paints with mineral spirits, the paint should be submitted to a laboratory for compliance testing.

Clean the test tubes and spatula immediately. Pour off the liquid and use warm detergent water to remove a latex coating or mineral spirits or other suitable thinner to remove oil-based coatings.

Test 3: Application Characteristics and Drawdowns

Drawdowns applied with a wire-wound applicator are required to determine a paint's application characteristics and to prepare sample sheets that will later be used for 12 of the 14 tests. The drawdowns are made on black-and-white opacity charts and on black plastic sheets and may show defects in the coating at this point. If there is any question, the paint also should be brushed, rolled, or sprayed onto a test surface—whichever is the intended method of application.

Drawdowns should be made in a clear area free of dust and drafts. The temperature should be between 65 and 80°F and the humidity should not be excessively high. High temperatures will speed the drying process whereas high humidity may slow it down.

Make drawdowns with the wire-wound applicator (which has a 40-mil wire wound on a ½-in.-diameter rod) on two black-and-white opacity charts and on one black plastic sheet. For industrial equipment enamels like TT-E-489, make drawdowns using the 16-mil wire-wound rod. Use the following steps:

1. Clip the chart or sheet on a clipboard lying on a flat, horizontal surface.

2. Lay the bar (which must be clean and dry) near the clip across the chart.

3. Place a paper towel under the end of the chart to catch any runoff coating.

4. Spread one teaspoonful of coating in front of and along the bar, but without touching the bar.

5. Hold both ends of the bar, press down slightly, and pull it forward uniformly without turning to spread the coating (Figure 3). Pressing too hard will cause a jerky movement and produce an uneven coating.

6. Place drawdown bar in a stainless steel pan containing water for latex paints or mineral spirits for oil-based paints. (See the cleaning procedures described below.)

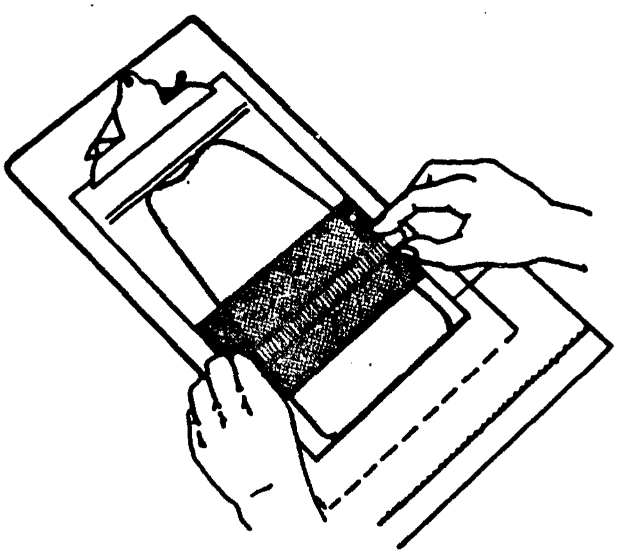

Figure 3. Procedure for making a drawdown.

7. Record the time on one of the drawdown charts to check the drying time.

8. After making a drawdown on one of the black-and-white charts, proceed immediately to the sagging test (Test 4).

9. Clean and dry the bar thoroughly before making the next drawdown.

Keep the charts flat and undisturbed until they are dry, except for the one used in the sag test (see Test 4). The charts should not be placed on top of each other until all tests are completed. After they are thoroughly dry, they may touch each other loosely with free access to air; for example, they may be taped to a wall or hung from a nail.

The drawdown coating should be smooth and uniform with no visible particles or streaks (except for minor visible striation marks from the wire coil as discussed under Test 6, Leveling). Refer to the "Definitions" box to identify some common paint defects. If the surface of the coating film is not acceptable for a finished job, the paint should be submitted to a laboratory for compliance testing.

The wire-wound applicator must be cleaned thoroughly. If not, paint will build up between adjacent wires, reducing the film thickness of subsequent drawdowns. Use the following procedure:

1. In the covered tray provided, soak the drawdown bar in warm detergent water for latex coatings or in paint thinner for oil-based coatings.

2. Using the cutoff paint brush supplied (or another stiff, fine-bristled brush), clean thoroughly between all adjacent wire surfaces.

3. Rinse with water (for latex) or thinner (for oil-based coatings).

4. Blot dry with a paper towel and allow any residual water or thinner to dry before the next application.

5. If paint is inadvertently allowed to dry on the bar, it will be necessary to obtain a chemical paint stripper to clean between the wires.

Test 4: Sagging

Sagging is a property not desirable in paints. A coating that sags too readily will develop runs when applied to a vertical surface. To test for sagging:

1. Use a fresh, wet drawdown on black-and-white opacity paper *immediately* (from Test 3).

2. Tape the chart onto a vertical surface with the drawdown running horizontally.

3. With the squared end of the small spatula (about 0.313 in. wide) press against the chart at the middle of one end of the drawdown and pull the spatula horizontally through the coating film to make an almost clear path (Figure 4). (Take about 2 sec for this operation.)

4. Both above and below this path for short distances, the coating will become noticeably thicker. Wait until it is dry and if the width of the extra thickness below the path is no wider than the spatula, the sagging is not excessive.

5. If the width of this extra thickness is wider than the width of the spatula, the coating is unsatisfactory.

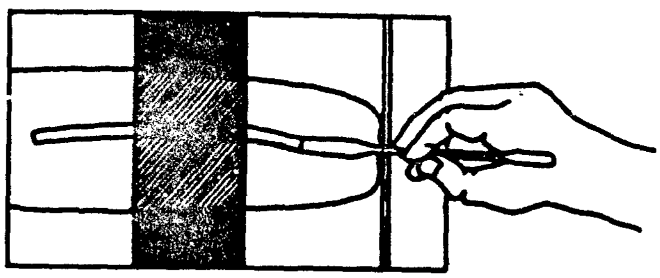

Figure 4. Procedure for testing sag on a drawdown.

Sagging usually is no problem for latex coatings unless the coatings are defective. Latex coatings stored for a long time may develop sagging due to viscosity breakdown. The viscosity does not change in oil-based paints during storage. However, overthinning could cause sagging in both latex and oil-based coatings. If the results of this test show a failure, the painter should be informed that the paint has been overthinned. If a failure occurs on a paint that has not been thinned, the paint should be submitted to a laboratory for compliance testing.

Tests With Next-Day Results

Tests in this category are drying time, leveling, hiding power, and gloss. Drawdown samples on black-and-white opacity paper (Test 3) have been prepared earlier for these tests. The paint must be dry before tests can be conducted. It may be possible to perform some of these tests on the same day for fast-drying latexes; however, oil-based paints and some latexes will require overnight drying.

Test 5: Drying Time

Latex coatings dry in several minutes to several hours. Oil-based types require more time. To test the drying time:

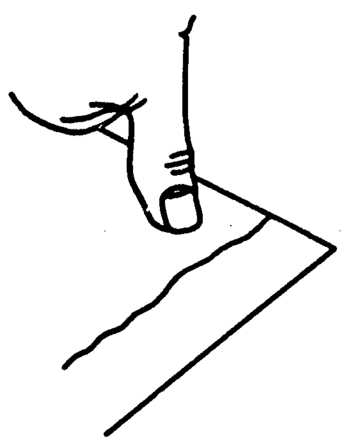

Figure 5. Testing a drawdown sample for dry-through time.

1. Use a drawdown sample (Test 3) on black-and-white opacity paper.
2. The sample should be allowed to dry at a temperature between 65 and 80°F with moderate humidity.
3. Hold the opacity chart from the sag test horizontally on a table so it is almost at arms' length.
4. Press down firmly with the thumb and turn it a quarter turn (in the plane of the chart, as shown in Figure 5).
5. If there is no loosening or distortion of the film, the dry-through time has been reached.
6. If the coating does not dry overnight, it is unsatisfactory.

Latex coatings may dry through in about 30 min to 4 hr, but should nevertheless be checked the next morning. Oil-based coatings generally require 7 to 18 hr to dry through. For oil-based coatings that will be recoated the next day, it is acceptable to determine if the coating has dried properly by the next day. Paints that fail this dry-through test but eventually do dry may still produce coatings with satisfactory long-term performance. Conversely, the long dry time may allow the coating to be contaminated with dirt or insects before it dries. If the longer dry time is not acceptable, the paint should be submitted to a laboratory to be tested under controlled conditions.

Note: specifications use various degrees of drying times, such as dust-free time, tack-free time, dry-to-touch time, dry-to-recoat time, and dry-through time. Coatings that meet the dry-through requirements are obviously dry and ready for recoating. Dry-through time is the basis for this test.

Test 6: Leveling

A paint's leveling properties can be determined by observing the smoothness of the film. When a paint with good leveling is brushed onto a surface, the brush marks will level out to a smooth coating. Poor leveling will not be as noticeable on flat or eggshell coatings as it will be on semigloss or gloss coatings. This is because reflective surfaces make irregularities more apparent. Poor leveling is present if ridges left by the bar in the wire applicator drawdowns will not level out. To conduct this test:

1. Use a dry opacity chart drawdown from Test 3 (note: defective drawdowns may interfere with the rating process).

2. Examine the drawdown and rate the coating surface striations on a numerical scale:

   5 = No visible striations or differences in light reflection; smooth.

   4 = No visible differences in vertical view, but some striations visible with properly reflected light.

   3 = Striations barely visible as seen vertically for light coatings on black surfaces or dark coatings on white backgrounds.

   2 = Easily visible striations or differences in reflected light as seen vertically for light coatings on black surfaces or dark coatings on white backgrounds.

   1 = Very easily visible striations.

   0 = Ridges can be felt with finger.

Flat latex coatings should have a rating of at least 2 to be satisfactory. Gloss and semigloss enamels should have a rating of at least 4 and are expected to be smooth and uniform. Paints with lower striation ratings are considered questionable. If a coating cannot be applied in a way that produces an acceptable appearance, the paint should be submitted to a laboratory for compliance testing.

Test 7: Hiding Power

Hiding power can be defined qualitatively as the property of a paint that enables it to obliterate beyond recognition any background over which it may be spread. Quantitatively, it can be expressed as square feet covered per gallon of paint. The paint usually is applied over a background containing areas of different reflectances, such as one with black and white, black and gray, or gray and white checkerboard squares. Complete hiding is reached when a light paint applied over the black background has reflectance approaching that of an equal thickness over the white background. The following test provides a measure of contrast ratios for the drawdown coating samples:

1. Use a black-and-white opacity chart drawdown sample from Test 3.

2. Insure that the coating is dried through.

3. Compare this sample with the range of hiding power standards by slipping the drawdown under the standards to find the closest match (Figure 6).

4. Read the contrast ratio figure (a value less than 1) listed on the standard selected for the sample being tested.

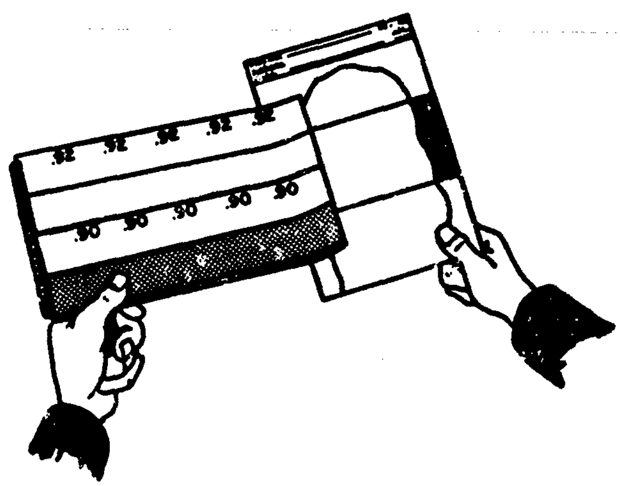

Figure 6. Comparing the drawdown sample with the standard to assess hiding power.

The wire-wound drawdown rod applies a coating of approximately the same thickness as that applied by a typical brush or roller. Coatings with contrast ratios over 0.98 will provide excellent hiding. Ratios of 0.94 to 0.96 may provide satisfactory hiding if application is slightly heavier than normal or if the previous coating is essentially the same color as the paint being tested. Contrast ratios of less than 0.92 indicate that the paint has very poor hiding power and will require additional coats to provide complete hiding, especially when dark substrates are being covered with light-colored topcoats. If the contrast ratio test produces low numbers, the painter should be informed that the paint has been overthinned. Or, if the low ratio is noted for a paint that has not been thinned, the paint should be submitted to a laboratory for compliance testing.

Test 8: Gloss

Gloss must be determined for most latex and oil-based coatings. Gloss is related to the reflection of light from the coating surface and therefore to the surface texture. Glossier surfaces have more vehicle and less pigment at the surface; this makes them smoother and easier to clean. Eggshell or flat surfaces have more pigment on the surface; this makes them rougher and more difficult to clean. Glossy surfaces tend to show surface imperfections more often than do flat surfaces.

A very glossy coating may show a mirror-like reflection perpendicular to the coated surface. As coatings become less glossy, the line-of-sight angle at which a reflection is seen drops down from the vertical position and becomes more parallel to the coating. The gloss test uses this principle.

CAUTION! PLEASE ALWAYS HOLD ON TO THE GLOSS INSTRUMENT BECAUSE IT SLIPS OFF THE COATING EASILY AND WILL BE DAMAGED IF DROPPED. To test for glossiness, use the following procedure:

1. Use a dry coated opacity chart prepared in Test 3.
2. Place the coated chart on a clipboard.
3. Place the gloss instrument on the coating so that the hollow squares are about 11 in. in from the end of the clipboard (Figure 7).
4. Look at the coating with good lighting coming from behind you and over your left shoulder.
5. Lower or raise the clipboard to alter the angle of your eyes with the plane of the coating until, at the highest angle of view to vertical, the spots are reflected in the coating to a point where it first becomes clear that the spots are hollow squares.

Figure 3

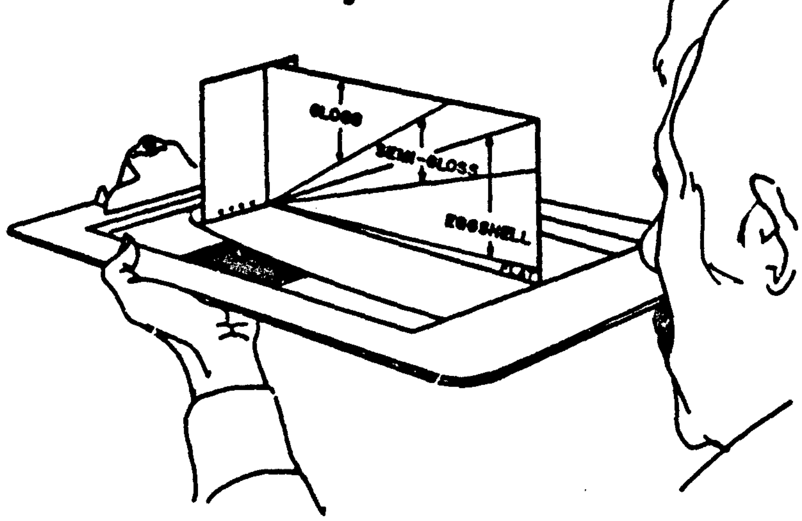

Figure 7. Focusing on the line of sight to determine coating gloss.

6. At this point, the line of sight from your eyes to the intersection line of the instrument resting on the coating will also intersect some point (and angle area representing a gloss reading) on the top horizontal side of the instrument (for glossier coatings). For eggshell or flat coatings, this line of sight will intersect some point and angle area on the vertical side of the instrument (the side nearest your eyes). The angle areas for semigloss and eggshell overlap in the upper section of the eggshell angle area. Figure 7 shows the line of sight.

In this test, the reading for glossy coatings should fall within the angle area assigned on the gloss instrument. Similarly, for semigloss, eggshell, and flat coatings, the readings should fall within their assigned areas. If the gloss readings are outside their assigned angle areas, the gloss may not be as good as desired and further laboratory tests should be conducted.

Note: if the paper with the four squares becomes damaged or soiled, attach one of the replacement papers provided. Lay it on the short portion of the device, flush against the long portion, and hold the crease exactly on the bottom edge of the instrument. While continuing to hold it, pull the bottom of the paper up the back of the instrument and tape it on with Scotch Magic tape; then fold the top of the paper down the back of the instrument and tape it over the other end.

Tests With 7-Day Results

For these tests (9 through 14), the coating films must have reached their full strength. They should, therefore, dry a full week. During this time, the test charts should be separated from each other to allow free access to air.

Figure 8 shows a suitable method for laying out all these tests on one plastic drawdown sheet. As some test procedures indicate, it may not be necessary to run every test on some coatings.

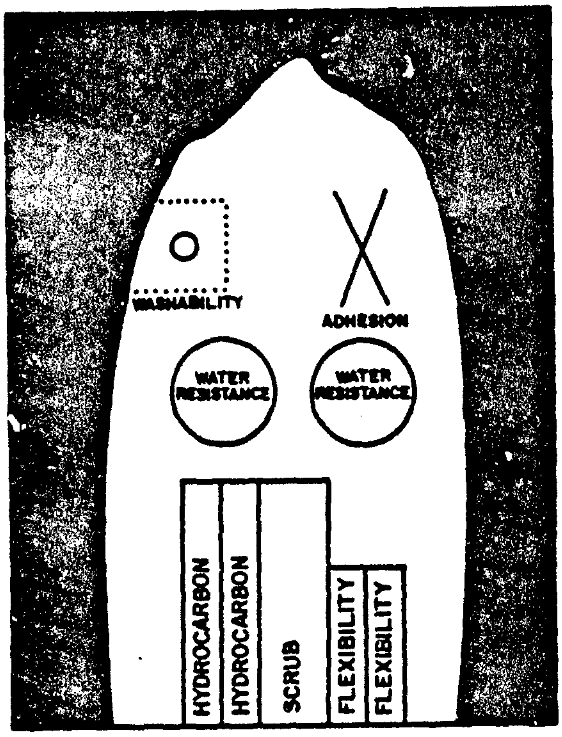

Figure 8. Possible arrangement of drawdowns for Tests 9 through 14.

Test 9: Water Resistance

Some latex coatings may blister, wrinkle, or reemulsify in the presence of water; oil-based paints also can whiten, dull, or lose adhesion and gloss. To do this test:

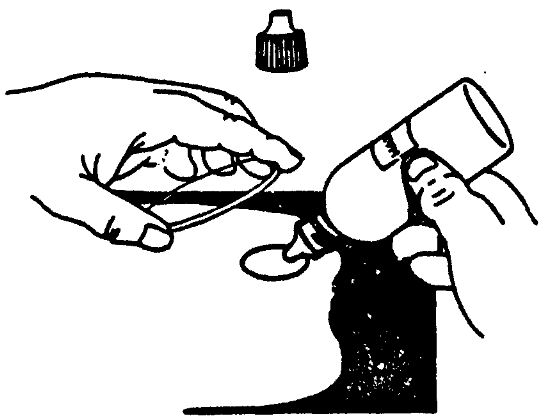

Figure 9. Adding water drops to a drawdown to test for water resistance.

1. Use a 1-week-old drawdown on black plastic from Test 3.
2. Visualize two 1-in.-diameter areas (or draw in two such areas by circling a quarter-dollar coin with a pencil).
3. Place one drop of water in the center of each circle.
4. Spread the water over the selected area with a spatula or a clean finger.
5. Add four more drops of water to each area (Figure 9).
6. Cover each area with a 2-in.-diameter watch glass for 2 hr (if necessary, add more water during this time to keep the area wet with a shiny layer of water).
7. Remove the watch glass and check for any removal of the coating, as indicated by milkiness of the water (hard to see if paint is white) or wrinkles in the coating film.
8. Blot both areas dry with a paper towel.
9. Gently rub one of the areas with a clean finger and check to make sure no coating or pigment has rubbed off.
10. Next, press down slightly with the same finger on the same area and push away.
11. Finally, bear down with a thumb and twist to see if adhesion is maintained.
12. If any defects are noted, perform the same tests on the second area after 2 hr of drying.

If the coating comes off easily right after blotting (step 9) or can be twisted off after drying (step 11), it is questionable whether it is water-resistant enough to withstand typical washing. The paint should be submitted to a laboratory for a thorough evaluation.

Test 10: Hydrocarbon Resistance

Some alkyd coatings (oil-based) are intended for areas that may be exposed to lubricating oil, cooking oils, or other hydrocarbons. This test is not necessary on oil-based interior primers or on latex coatings except when latex coatings are anticipated to be in contact with solvents. To conduct the kit test for hydrocarbon resistance:

1. Use a 1-week-old drawdown on black plastic from Test 3.

2. Cut a strip of coated plastic about 0.5 in. wide and 3 in. long.

3. Place it into a test tube containing about 1.5 in. of mineral spirits. If the coating is to be used on a surface that will be exposed to more aggressive solvents, this test can be performed with solvents typical of the anticipated exposure.

4. Gently close the test tube with a neoprene stopper (Figure 10) and let it stand for 2 hr. (The test tube can be held upright in an empty water glass.)

5. Remove the coated strip and note any visual effects, softening, or loss of adhesion evident from gently probing with the spoon end of the small spatula or a thumbnail.

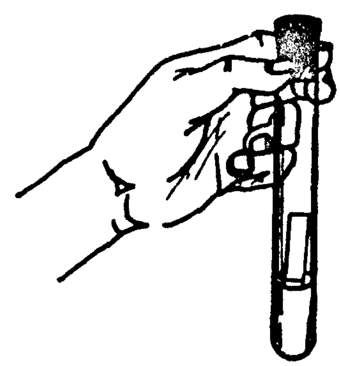

Figure 10. Immersing a coated strip into solvent to test for hydrocarbon resistance.

If the coating is softened only slightly, its durability in a greasy environment is questionable. If the coating softens appreciably or loses adhesion and is removed, it is unsatisfactory for the environment. In either case, the paint should be submitted to a laboratory for compliance testing.

Test 11: Adhesion

This test can be run on all paints but is most important for water-thinnable types. Use the following procedure:

1. Use a 1-week-old drawdown on black plastic from Test 3.

2. Through the dried coating (but not completely through the plastic), cut an X with a razor blade by making two cuts each 1.5 in. long and generally in the direction of the drawdown. The two cuts should intersect each other at an angle of about 45 degrees. Clean or lightly brush away any loose particles formed as a result of the cut.

3. Place a 4-in. piece of 0.75-in. Scotch No. 810 Magic Transparent Tape lengthwise over the X-cut (Figure 11).

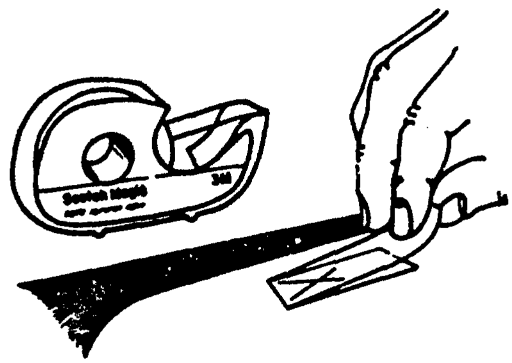

Figure 11. Using Scotch tape to test for adhesion.

4. Rub the tape with the ball of the thumb to insure maximum adhesion in the area of the cut.

5. Pick up one end of the tape and pull it back over itself in one smooth motion, requiring about 1 sec.

There should be no loss of coating (pickup on the Scotch tape), and no loss of adhesion along the cuts. If poor adhesion is evident, the paint should be submitted to a laboratory for compliance testing.

Test 12: Flexibility

Even for coatings applied to rigid surfaces, flexibility can be an important property when there are thermal expansion differences between the coating and substrate. The stresses resulting from changes in temperature may require the paint to have both flexibility and good adhesion for optimal performance.

1. Use a 1-week-old drawdown on black plastic from Test 3.

2. Cut a strip with evenly applied coating about 0.5 in. wide and 2 in. long (with scissors or razor blade) in the direction of the drawdown.

3. Hold the 1/8-in. wire rod between the thumb and the index finger of one hand. With the other hand, bend the strip around the rod, keeping the rod perpendicular to the 2-in. length and the coated side out, so that the thumb and index finger of the second hand hold the strip securely against the rod.

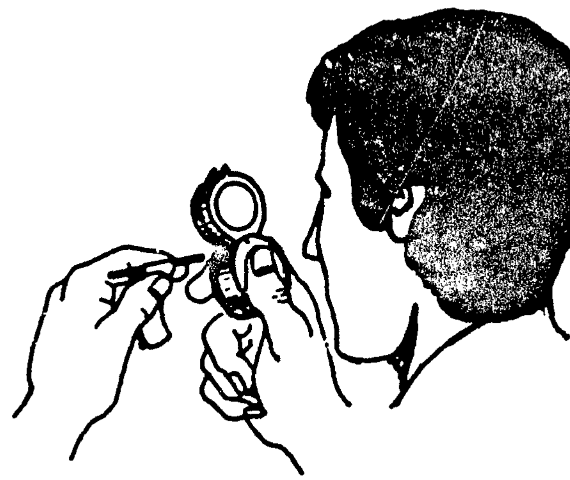

Figure 12. Using a double hand lens to inspect for cracks in the flexibility test.

4. With the strip still wrapped around the rod, examine the coating for any small cracks using the 10-power double hand lens (Figure 12).

Very fine cracks on oil-based primers are acceptable. If cracks are evident for any other coating, the paint is questionable and should be submitted to a laboratory for thorough evaluation.

Test 13: Scrub Resistance

This test should be performed on all interior latex and interior flat oil-based coatings. When a topcoat is scrubbed, it should remain intact, and after drying, its appearance should not change. Check the scrub resistance using the following procedure:

1. Select a test area on the 1-week-old drawdown on black plastic from Test 3, about 1 in. wide and 3 in. long in the direction of the drawdown.

2. Wet a sponge and blot out excess water with a paper towel.

3. On the test area, place about five drops of water. For eggshell, semigloss, and gloss paints, substitute two to three drops of mildly abrasive wash medium (Soft Scrub® or equivalent) for the water.

4. Rub the sponge back and forth across the test area while pressing it down with two fingers. The pressure should be approximately 1 lb. (A feel for the 1-lb pressure can be obtained from pushing on a scale at a grocery store if no scale is available locally.)

5. Continue rubbing with the sponge until the coating wears through or 200 cycles (double strokes) have been completed.

6. Examine the sponge for any removed coating.

7. Let the coating dry and examine it for any increase or reduction in gloss. When the abrasive is used instead of water, rinse the sponge with water and gently wipe off the residue. Do this twice, then blot the area with a paper towel and let the coating dry.

If large amounts of coating are on the sponge or if there is a visible change in gloss (either an increase or decrease), the coating should be submitted to a laboratory for thorough evaluation. (A good coating should withstand more than 500 cycles.)

Test 14: Washability

This test can be performed on all topcoats, but is particularly important on interior paints. When a topcoat is soiled, it should be possible to clean it without much effort and without changing the coating's appearance. Some types of soiling may be removed more easily than others. Moreover, a glossy coating will be cleaned more easily than a similar flat coating. The following method tests ease of grease removal:

1. Use a 1-week-old drawdown on a black plastic sheet from Test 3.
2. Open the tube of white petrolatum and squeeze very slightly so that the petrolatum barely extends past the opening.
3. Wipe the excess off flat with a paper towel.
4. With the tube held vertically, set the opening on a test area of the coated plastic sheet for about 2 sec, then remove and recap the tube.
5. Allow to stand 2 to 5 sec longer, then use a dry paper towel to gently wipe up the bulk of petrolatum from the surface in a single motion (Figure 13).
6. Fold the soiled area into the paper towel and use a clean area of the towel to again wipe the soiled area so that no excess petrolatum remains on the coating sample.

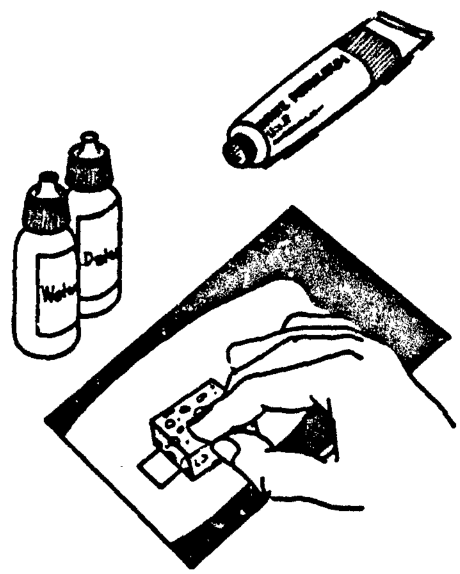

Figure 13. Blotting excess petrolatum used to stain the sample being tested for washability.

7. Immediately apply two or three drops of a mildly abrasive wash medium (Soft Scrub® or equivalent) on the stained area.
8. Wet the sponge and squeeze or wring it until it is damp.
9. With the moist sponge, rub the stained area with 20 to 25 cycles (double strokes) as was done in the scrub test. (Adjust the pressure as necessary to clean the stain completely.)
10. Wipe the test area gently with a moist paper towel and then blot excess water with a dry paper towel.
11. Allow the test area to dry and inspect the coating.

For gloss and semigloss paints, if the test area has darkened due to penetration by the staining medium, if the glossy coating surface becomes dull, flat, or worn, or if the staining medium is not cleaned satisfactorily, the coating should be submitted to a laboratory for compliance testing.

For flat paints, slight shadows can be expected due to coating penetration by the petrolatum. However, if the shadows appear excessively dark, if the flat coating surface becomes glossy or is worn through by the washing, or if the staining medium is not cleaned satisfactorily, the coating should be submitted to a laboratory for compliance testing.

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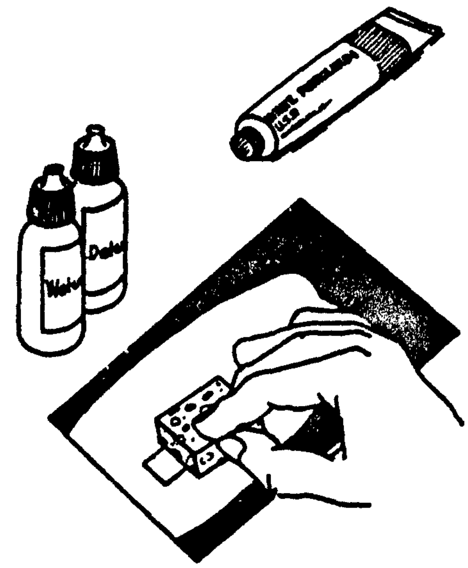

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