

**Engineering and Technical
Services for Joint Group on
Acquisition Pollution
Prevention (JG-APP) Pilot
Projects**

**Joint Test Protocol
LM-P-1-1**

**for Validation of Alternatives
to High Volatile Organic
Compound (VOC) Topcoats
and Primers**

**June 16, 1997
(Revised November 19, 1998)**

Contract No. DAAA21-93-C-0046
Task No. N.072
CDRL No. A005

*Prepared by
National Defense Center for Environmental Excellence (NDCEE)*

Operated by Concurrent Technologies Corporation

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National Defense Center for Environmental Excellence (NDCEE)
Operated by Concurrent Technologies Corporation
100 CTC Drive
Johnstown, PA 15904

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PREFACE

This report was prepared by Concurrent Technologies Corporation (CTC) through the National Defense Center for Environmental Excellence (NDCEE) under Contract Number DAAA21-93-C-0046. This report was prepared on behalf of, and under guidance provided by, the Joint Group on Acquisition Pollution Prevention (JG-APP) through the Joint Pollution Prevention Advisory Board (JPPAB). The structure, format, and depth of technical content of the report were determined by the JPPAB, Government contractors, and other Government technical representatives in response to the specific needs of this project.

The information contained in this report was leveraged from the Texas Instruments Defense Systems and Electronics Joint Test Protocol entitled *Joint Test Protocol (TI-P-1-1) for Alternatives to High Volatile Organic Compounds (VOCs) Primers and Topcoats Containing: Methyl Ethyl Ketone (MEK), Toluene, and Xylene*, dated June 20, 1996, which was also prepared under Contract Number DAAA21-93-C-0046. This document incorporates additions, deletions, modifications, and updates that reflect the performance requirements of the customers of Lockheed Martin Electronics & Missiles Company and Lockheed Martin Information Systems Company.

THIS REVISED JOINT TEST PROTOCOL (JTP) REFLECTS AMENDMENTS TO THE PREVIOUS JTP DATED JUNE 16, 1997, AS FOLLOWS:

- ADDITION OF SECTIONS 3.2.1.7 AND 3.2.2.15, WET TAPE ADHESION TESTS: THESE EXTENDED REQUIREMENTS WERE ADDED FOR NAVAL AIR SYSTEMS COMMAND (NAVAIR) ACCEPTANCE OF TESTED COATINGS.
- ADDITION OF APPENDIX A SCREENING TESTS (DRY TAPE ADHESION AND REDUCED DURATION SALT SPRAY RESISTANCE): THESE SCREENING TESTS WERE IDENTIFIED AS SCREENING TESTS TO BE USED PRIOR TO COMMON TESTS AND AGREED UPON BY PROJECT REPRESENTATIVES.
- ADDITION OF SECTION 3.2.2.13, STRIPPABILITY TEST. THE TEST WAS ADDED AS AN EXTENDED REQUIREMENT TO ENSURE THAT NO ADVERSE EFFECTS ARE IMPOSED ON THE SUSTAINMENT COMMUNITY.

THE ABOVE CHANGES ARE HIGHLIGHTED BY REVISION MARKS IN THE BORDER OF THE MODIFIED PAGES. NO OTHER CHANGES HAVE BEEN MADE.

We wish to acknowledge the invaluable contributions provided by the following organizations involved in the creation of this document:

AC-130 Gunship Program Office
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Air Force Materiel Command

Air-to-Ground Missile Systems (AGMS) Program Office
Apache Attack Helicopter Program Office
Army Materiel Command, Headquarters
Army Research Lab - Ft. Belvoir, VA
Consolidated Automated Support Systems (CASS) Program Office
Chief of Naval Operations, Environmental Protection, Safety, and Occupational Health
Comanche Program Office
Defense Contract Audit Agency - Orlando, FL
Defense Contract Management Command - Orlando, FL
Defense Logistics Agency, Headquarters
Deputy Undersecretary of Defense for Environmental Security
External Tank Program Office, National Aeronautics and Space Administration
F-14 Infrared Search and Track (IRST) Program Office
F-22 Missile Launch Detector (MLD) Program Office
Industrial Operations Command, Headquarters
JAVELIN Program Office
Joint Depot Environmental Panel
Low-Altitude Navigation and Targeting Infrared for Night (LANTIRN) Program Office
Letterkenny Army Depot
Lockheed Martin Electronics and Missiles Company - Orlando, FL
Lockheed Martin Information Systems Company - Orlando, FL
Lockheed Martin Michoud Space Systems – New Orleans, LA
Lockheed Martin Astronautics - Littleton, CO
Longbow Fire Control Radar (FCR) Program Office
National Aeronautics and Space Administration
National Defense Center for Environmental Excellence
Naval Air Systems Command
Naval Aviation Depot - Jacksonville
Naval Facilities Engineering Service Center - Port Hueneme, CA
PATRIOT Project Office
Raytheon TI Systems Inc.
Redstone Arsenal
Simulation and Training (SAT) – Armor Program Office
Stingray, Night Vision and Electronics - Ft. Belvoir, VA
Target Acquisition and Designation Site/Pilot Night Vision System (TADS/PNVS) Program Office
Tobyhanna Army Depot
United Space Alliance - Kennedy Space Center, FL
U.S. Army Aviation & Missile Command (AMCOM)
U.S. Army Simulation, Training and Instrumentation Command (STRICOM)
U.S. Army Tank-Automotive and Armaments Command - Armament Research and Development Energy Center
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Wind Corrected Munitions Dispenser (WCMD) Program Office
Wright Laboratory/Materials Laboratory

1. INTRODUCTION

On September 15, 1994, the Joint Logistics Commanders (JLC) chartered the Joint Group on Acquisition Pollution Prevention (JG-APP) to coordinate joint service activities affecting pollution prevention issues identified during a weapon system's acquisition process. The primary objectives of the JG-APP are to:

- Reduce or eliminate Hazardous Materials (HazMats) by fostering joint service cooperation
- Avoid duplication of efforts in actions required to reduce or eliminate HazMats and share technology.

The focus of JG-APP is on contractor design, manufacturing, and remanufacturing locations with technology transfer to the Sustainment Community.

This Joint Test Protocol (JTP) contains the critical technical and performance requirements and tests necessary to qualify potential alternatives to selected target HazMats and processes for a particular application.

A subsequent Joint Test Report (JTR) will document the data and results of the testing. The JTR will be made available as a reference for future pollution prevention endeavors by other Department of Defense (DoD) and commercial users to minimize duplication of effort.

At the Lockheed Martin Electronics & Missiles Company and Information Systems Company pilot site in Orlando, Florida, volatile organic compounds (VOCs) as found in topcoat and primer formulations were identified as the target HazMats to be eliminated or reduced. VOCs in the currently used topcoats and primers include methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), toluene, and xylene. The topcoats and primers of concern are currently applied by brush or by conventional wet-spray coating. Table 1 summarizes the target HazMats, the related process and material, current specifications, affected programs, and affected parts and substrates.

Table 1. Lockheed Martin Target HazMat Summary

Target HazMat	Current Process	Applications	Current Specifications	Affected Programs	Candidate Parts/ Substrates
VOCs (MEK, MIBK, Toluene, Xylene)	Conventional Wet-Spray Coating Brush Coating	Topcoats Primers	MIL-C-22750 MIL-C-46168 MIL-C-53039 MIL-C-83286 MIL-C-85285 TT-C-542 TT-E-527 TT-E-529 TT-P-2756 MIL-P-23377 MIL-P-53022 MIL-P-53030	<p><u>Air Force:</u> F-22 MLD, LANTIRN, IVACC, PT2000, CVI, ALS, Gunship LLL-TV</p> <p><u>Army:</u> Hellfire II, Javelin, Longbow Missile, Comanche, Patriot, Longbow FCR, TADS, PNVS, TDT, COFT, AGTS, LAV, CECOM</p> <p><u>Foreign:</u> Hellfire II, HAGS, AV-8B, COFT (SAUDI/KUWT)</p> <p><u>Marines:</u> AN/AAS-18, Predator</p> <p><u>NASA:</u> ET</p> <p><u>Navy:</u> IRST-F-14, DDG, UEC, RPCP, CASS Lot4, CASS Lot5+, ALS, AEGIS, F/A-18</p>	Components for a broad spectrum of applications such as electronics cabinets and cabinet parts; aluminum, steel, and stainless steel sheet and parts; and nonmetallics, painted metal surfaces, and elastomers

2. ENGINEERING, PERFORMANCE, AND TESTING REQUIREMENTS

A joint group led by the JG-APP and consisting of technical representatives from Lockheed Martin, the affected DoD Program Managers, representatives of the Sustainment Community, and other government technical representatives reached technical consensus on engineering, performance, and testing requirements for topcoats and primers. The joint group defined critical tests with procedures, methodologies, and acceptance criteria to qualify alternatives against these technical requirements.

Section 2.1. summarizes a common set of requirements and tests agreed upon by the joint group. Section 2.2. includes program-specific, or “extended,” requirements and tests identified by at least one of the affected programs.

Tests should be conducted in a manner that will eliminate duplication and maximize use of each test coupon; however, coupons may not be reused unless specifically stated so in the Statement of Tasks (SOT). The number of different tests that can be performed on any one coupon will be determined by the destructiveness of the preceding test(s).

Tests in this JTP may involve the use of hazardous materials, operations, and equipment. This JTP does not address all safety issues associated with its use. It is the responsibility of each user of this JTP to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to its use.

2.1. Summary of Common Engineering, Performance, and Testing Requirements for Topcoats and Primers

The engineering, performance, and testing requirements of candidate primers and primer/topcoat systems are listed in Table 2. These tests are required by all weapon systems previously identified in Table 1. Screening tests that are intended for use prior to common tests are described in Appendix A.

Table 2. Common Engineering, Performance, and Testing Requirements for Topcoats and Primers

Test	JTP Section	Application	Test Specimen	Acceptance Criteria	References
Filiform Corrosion Resistance	3.1.1.1	Primer	Coupon	All filaments \leq 1/4" Majority $<$ 1/8" filaments	MIL-P-23377G MIL-P-85582B
Salt Spray Resistance	3.1.1.2	Primer	Coupon	No blistering or lifting after 2,000 hours. Slight substrate corrosion only	ASTM B 117-94
Solvent (Acetone) Rub	3.1.1.3	Primer	Coupon	No exposure of substrate	ASTM D 4752-87
Wet Tape Adhesion	3.1.1.4	Primer	Coupon	No peel away	ASTM D 3359-92a Method A
Accelerated Weather	3.1.2.1	Primer/topcoat system	Coupon	Color change (ΔE) \leq 2 units	ASTM G 26-90 Method 1
Cleanability	3.1.2.2	Primer/topcoat system	Coupon	Cleaning efficiency \geq 70%	MIL-C-85285B
Fungus Resistance	3.1.2.3	Primer/topcoat system	Coupon	Adhesion per Section 3.1.2.11 of this JTP. Does not support fungal growth.	MIL-STD-810E Method 508
Gloss (High, Semi, and Low)	3.1.2.4	Primer/topcoat system	Coupon	High \geq 90 gloss units Semi = 15 - 45 gloss units Low \leq 5 gloss units	ASTM D 523-89
Heat Resistance	3.1.2.5	Primer/topcoat system	Coupon	Color change (ΔE) \leq 1 unit	MIL-C-85285B

(Table continued next page.)

Table 2. Common Engineering, Performance, and Testing Requirements for Topcoats and Primers (continued)

Test	JTP Section	Application	Test Specimen	Acceptance Criteria	References
Hiding Power	3.1.2.6	Primer/topcoat system	Cardboard or enamel-coated metal Leneta charts	Contrast ratio \geq 0.95 (test white topcoats only)	ASTM D 2805-88 PCI Procedure 3
Humidity	3.1.2.7	Primer/topcoat system	Coupon	No softening or loss of adhesion	ASTM D 2247-92
Salt Spray Resistance	3.1.2.8	Primer/topcoat system	Coupon	No blistering or lifting after 2,000 hours. Slight substrate corrosion only.	ASTM B 117-94
Solvent (Acetone) Rub	3.1.2.9	Primer/topcoat system	Coupon	No exposure of primer or substrate	ASTM D 4752-87
Tape Resistance	3.1.2.10	Primer/topcoat system	Coupon	When tape is applied at 12 hours after topcoating, no marring, loss of gloss, or change in appearance	MIL-C-85285B MIL-C-22750F
Wet Tape Adhesion	3.1.2.11	Primer/topcoat system	Coupon	No peel away	ASTM D 3359-92a Method A

2.2. Summary of Extended Engineering, Performance, and Testing Requirements for Topcoats and Primers

The additional (“extended”) test requirements for validating alternatives to high VOC topcoats and primers are listed in Table 3. These requirements are in addition to the test requirements that are identified in Table 2 and will be performed as required by specific weapon systems.

Table 3. Extended Engineering, Performance, and Testing Requirements for Topcoats and Primers

Test	JTP Section	Application	Test Specimen	Acceptance Criteria	References
Cryoflex Cryogenic Compat- ibility	3.2.1.1	Primer	Dogbone specimen	For molded ablator at 0.5 inches thick, -253°C (-423°F): Infinite radium flexure; Load ≥ 40 ksi without delamination For spray on foam insulation (SOFI), 1.2 inches thick, -253°C (-423°F): Infinite radium flexure; Load ≥ 60 ksi without delamination	--
Cryogenic Flexibility	3.2.1.2	Primer	1" x 4" x 0.040" panel with 1/8" hole drilled in each end	No adhesion loss or microcracking	--
Fluid Immersion (Hydraulic Fluid, Lubrica- ting Oil)	3.2.1.3	Primer	Coupon	No blistering, dark staining, or softening	ASTM D 1308-87

(Table continued next page.)

Table 3. Extended Engineering, Performance, and Testing Requirements for Topcoats and Primers (continued)

Test	JTP Section	Application	Test Specimen	Acceptance Criteria	References
Primer/ Insulation Foam Adhesion	3.2.1.5	Primer	2" x 2" panel	35 psi minimum stress at failure of primer-SOFI bond	ASTM D 1623-78 Type B
Solvent (MEK) Rub	3.2.1.6	Primer	Coupon	No exposure of substrate	ASTM D 4752-87
Wet Tape Adhesion	3.2.1.7	Primer	Coupon	No peel away	ASTM D 3359-92a Method A
Accelerated Weather	3.2.2.1	Primer/ topcoat system	Coupon	Color change (ΔE) \leq 1 unit	ASTM G 26-90 Method 1
Chemical Agent Resistance (Agents HD and GD)	3.2.2.2	Primer/ topcoat system	Coupon	Agent HD: desorb 180 μg maximum Agent GD: desorb 40 μg maximum	MIL-C- 46168D MIL-C- 46168C
Chroma- ticity	3.2.2.3	Primer/ topcoat system	Coupon	CARC: Color within 2.0 NBS units of chromaticity coordinates in Table 5 of this JTP. Other identified colors (refer to Table 6 of this JTP) must match the appropriate color chip from FED- STD-595B.	ASTM E 1164-91

(Table continued next page.)

Table 3. Extended Engineering, Performance, and Testing Requirements for Topcoats and Primers (continued)

Test	JTP Section	Application	Test Specimen	Acceptance Criteria	References
DS2 Decontaminant Resistance	3.2.2.4	Primer/topcoat system	Coupon	No blistering, wrinkling, or softening	MIL-C-22750F MIL-C-46168D
Primer Adhesion	3.2.1.4	Primer	Coupon	No adhesion failure at substrate/primer interface \leq 2,000 psi	ASTM D 4541-93
Gloss (Very Low)	3.2.2.5	Primer/topcoat system	Coupon	Fixed Wing Aircraft: \leq 3.0 gloss units Ground Equipment: \leq 1.0 gloss units Rotary Wing Aircraft: \leq 0.5 gloss units	ASTM D 523-89
Impact Flexibility	3.2.2.6	Primer/topcoat system	Coupon	No adhesion loss	ASTM D 2794-92
Infrared Reflectance	3.2.2.7	Primer/topcoat system	Coupon	Depends on specific color (Refer to Tables 7 and 9 of this JTP.) Field Green (34095): reflectance \leq 8% in 450-500 and 600-2700 nm wavelength ranges and reflectance \leq 10% in 500-600 nm wavelength range	MIL-C-22750F MIL-C-46168D MIL-C-53039A MIL-C-85285B FED-STD-141 Method 6242

(Table continued next page.)

Table 3. Extended Engineering, Performance, and Testing Requirements for Topcoats and Primers (continued)

Test	JTP Section	Application	Test Specimen	Acceptance Criteria	References
Low Temperature Flexibility	3.2.2.8	Primer/topcoat system	Coupon	No adhesion loss	ASTM D 522-92
Rain	3.2.2.9	Primer/topcoat system	Coupon	No loss of adhesion. No erosion of coating.	--
Recoat-ability	3.2.2.10	Primer/topcoat system	Coupon	Adhesion per Section 3.1.2.11 of this JTP	MIL-C-46168D
Solvent (MEK) Rub	3.2.2.11	Primer/topcoat system	Coupon	No exposure of primer or substrate	ASTM D 4752-87
Specialized Fluid Resistance	3.2.2.12	Primer/topcoat system	Coupon	No blistering, dark staining, or softening	ASTM D 1308-87
Strippability	3.2.2.13	Primer/topcoat system	Coupon	90% removal of primer after 60 minutes contact with stripping chemical	ASTM G 26-90 Method 1
Temperature Shock	3.2.2.14	Primer/topcoat system	Coupon	Adhesion per Section 3.1.2.11 of this JTP	--
Wet Tape Adhesion	3.2.2.15	Primer/topcoat system	Coupon	No peel away	ASTM D 3359-92a Method A

3. TEST DESCRIPTIONS

Tests identified as common and extended requirements in Sections 2.1. and 2.2. are defined in this section to include a description of the test, the reason the test is necessary, test methodologies, and any unique equipment, instrumentation, and data analysis. Test methodology includes the definition of test parameters, test specimens, number of tests per test specimen, and acceptance criteria.

Unless otherwise required by a specific test, test coupons will be at least 3 inches wide by 6 inches long and of standard thickness. Surface roughness shall be measured in accordance with ANSI/ASME B46.1-1985 (*Surface Texture*, issued October 7, 1985) and recorded for informational purposes prior to application of the primer. All edges and corners shall be rounded prior to primer application to promote adhesion. Additionally, metal coupon surfaces must be water break-free prior to priming. Water break tests shall be performed in accordance with ASTM F 22-65 (*Standard Test Method for Hydrophobic Surface Films by the Water-Break Test*, approved August 31, 1965, reapproved March 1992). Cleanliness of non-metallic coupons shall be determined prior to priming using a contact angle test in accordance with ASTM D 724-89 [*Standard Test Method for Surface Wettability of Paper (Angle-of-Contact Method)*, approved May 26, 1989], but using distilled water instead of ink in the procedure. Results of cleanliness tests shall be reported.

If liquid coatings are being tested, test coupons shall be allowed 24 hours of unaided drying time prior to dry film thickness measurements. If powder coatings are being tested, test coupons shall be cured in accordance with manufacturer's recommendations prior to dry film thickness measurements. The dry film thickness measurements shall be made nondestructively in accordance with ASTM E 376-89 [*Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods*, approved October 27, 1989, reapproved July 1994]. If liquid coatings are being tested for a destructive test (all tests in this JTP except for chromaticity, gloss, hiding power, infrared reflectance, and recoatability tests), coupons shall be allowed to cure for an additional 14 days before they undergo any destructive testing to ensure full polymerization of the coating. Coating process parameters, including application method and cure schedule, shall be documented by the facility that prepares the test coupons.

Table 4 contains a listing of substrate types that will be used for testing and their test specimen code. When required in a test, the temper of an aluminum alloy can be determined by the facility preparing the coupons. For example, the temper of AL1 and AL2 substrate types must be zero for the impact flexibility test (Section 3.2.2.6. of this JTP) and the low temperature flexibility test (Section 3.2.2.8. of this JTP).

Table 4. Test Specimen Codes and Substrate Descriptions

Test Specimen Code	Substrate Description
AL1	<p>Aluminum alloy 2024 (QQ-A-250F/4); cleaned with a method that does not damage the surface and that provides a water-break-free surface; chromate conversion coated, conforming to Class 3 MIL-C-5541E (<i>Chemical Conversion Coatings on Aluminum and Aluminum Alloys</i>, issued November 30, 1990); then either:</p> <ul style="list-style-type: none"> (a) Primed with candidate primer to a dry film thickness of 0.6 to 0.9 mils (for testing as specified in Sections 3.1.1 and 3.2.1), or (b) Primed with candidate primers that meet engineering, performance, and testing requirements in Section 3.1.1 or with a primer conforming to MIL-P-85582B (<i>Waterborne Epoxy Primer Coatings</i>, issued August 31, 1994) if candidate primers do not meet the performance requirements in Section 3.1.1 (prime to a dry film thickness of 0.6 to 0.9 mils); and then coated with the candidate topcoat to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2 and 3.2.2), or (c) Coated only with the candidate topcoat, to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2 and 3.2.2).
AL2	<p>Aluminum alloy 6061-T6 (QQ-A-250F/11); cleaned with a method that does not damage the surface and that provides a water-break-free surface; chromate conversion coated, conforming to Class 3 MIL-C-5541E (<i>Chemical Conversion Coatings on Aluminum and Aluminum Alloys</i>, issued November 30, 1990); then either:</p> <ul style="list-style-type: none"> (a) Primed with candidate primer to a dry film thickness of 0.6 to 0.9 mils (for testing as specified in Sections 3.1.1 and 3.2.1), or (b) Primed with candidate primers that meet engineering, performance, and testing requirements in Section 3.1.1 or with a primer conforming to MIL-P-85582B (<i>Waterborne Epoxy Primer Coatings</i>, issued August 31, 1994) if candidate primers do not meet the performance requirements in Section 3.1.1 (prime to a dry film thickness of 0.6 to 0.9 mils); and then coated with the candidate topcoat to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2 and 3.2.2), or (c) Coated only with the candidate topcoat, to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2 and 3.2.2).

(Table continued next page.)

Table 4. Test Specimen Codes and Substrate Descriptions (continued)

Test Specimen Code	Substrate Description
AL3	<p>Aluminum casting alloy A356.0-T6 (AMS 4218); cleaned with a method that does not damage the surface and that provides a water-break-free surface; chromate conversion coated, conforming to Class 3 MIL-C-5541E (<i>Chemical Conversion Coatings on Aluminum and Aluminum Alloys</i>, issued November 30, 1990); then either:</p> <ul style="list-style-type: none"> (a) Primed with candidate primer to a dry film thickness of 0.6 to 0.9 mils (for testing as specified in Sections 3.1.1 and 3.2.1), or (b) Primed with candidate primers that meet engineering, performance, and testing requirements in Section 3.1.1 or with a primer conforming to MIL-P-85582B (<i>Waterborne Epoxy Primer Coatings</i>, issued August 31, 1994) if candidate primers do not meet the performance requirements in Section 3.1.1 (prime to a dry film thickness between 0.6 and 1.5 mils); and then coated with the candidate topcoat to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2 and 3.2.2), or (c) Coated only with the candidate topcoat, to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2 and 3.2.2).
AL4	<p>Aluminum alloy 2219-T87. If mill scale is present, alkaline etch. Follow with demineralized water rinse. Acid deoxidize to remove smut, then rinse with demineralized water to water-break-free condition. Air dry, hot water rinse, or force air dry. Apply primer to be tested per the manufacturer's recommendation to a thickness between 0.6 and 1.5 mils.</p>
AL5	<p>Aluminum alloy 2195-T8M4. If mill scale is present, alkaline etch. Follow with demineralized water rinse. Acid deoxidize to remove smut, then rinse with demineralized water to water-break-free condition. Air dry, hot water rinse, or force air dry. Apply primer to be tested per the manufacturer's recommendation to a thickness between 0.6 and 1.5 mils.</p>

(Table continued next page.)

Table 4. Test Specimen Codes and Substrate Descriptions (continued)

Test Specimen Code	Substrate Description
AL6	<p>Aluminum alloy 2024 (QQ-A-250F); cleaned with a method that does not damage the surface and that provides a water-break-free surface; anodized conforming to non-conductive Type F ASTM B 580-79 (<i>Standard Specification for Anodic Oxide Coatings on Aluminum</i>, approved May 25, 1979) and sealed; then either:</p> <ul style="list-style-type: none"> (a) Primed with candidate primer to a dry film thickness of 0.6 to 0.9 mils (for testing as specified in Sections 3.1.1 and 3.2.1), or (b) Primed with candidate primers that meet engineering, performance, and testing requirements in Section 3.1.1 or with a primer conforming to MIL-P-85582B (<i>Waterborne Epoxy Primer Coatings</i>, issued August 31, 1994) if candidate primers do not meet the performance requirements in Section 3.1.1 (prime to a dry film thickness between 0.6 and 1.5 mils); and then coated with the candidate topcoat to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2 and 3.2.2), or (c) Coated only with the candidate topcoat, to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2 and 3.2.2).
ST	<p>Steel alloy 1018 (or other similar low carbon steel); cleaned with a method that does not damage the surface and that provides a water-break-free surface; pretreated with zinc phosphate (150 mg/sq ft min to 500 mg/sq ft max); then either:</p> <ul style="list-style-type: none"> (a) Primed with candidate primer to a dry film thickness of 0.6 to 0.9 mils (for testing as specified in Sections 3.1.1 and 3.2.1), or (b) Primed with candidate primers that meet engineering, performance, and testing requirements in Section 3.1.1 or with a primer conforming to MIL-P-85582B (<i>Waterborne Epoxy Primer Coatings</i>, issued August 31, 1994) if candidate primers do not meet the performance requirements in Section 3.1.1 (prime to a dry film thickness of 0.6 to 0.9 mils); and then coated with the candidate topcoat to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2 and 3.2.2), or (c) Coated only with the candidate topcoat, to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2 and 3.2.2).

(Table continued next page.)

Table 4. Test Specimen Codes and Substrate Descriptions (continued)

Test Specimen Code	Substrate Description
G/E	<p>Glass/epoxy laminate, either custom fabricated in a suitable laboratory facility or purchased from a material supplier; cleaned by solvent wiping with alcohol per TT-I-735A (<i>Isopropyl alcohol</i>, issued November 5, 1991); then either:</p> <ul style="list-style-type: none"> (a) Primed with candidate primer to a dry film thickness of 0.6 to 0.9 mils (for testing as specified in Sections 3.1.1. and 3.2.1.), or (b) Primed with candidate primers that meet engineering, performance, and testing requirements in Section 3.1.1. or with a primer conforming to MIL-P-85582B (<i>Waterborne Epoxy Primer Coatings</i>, issued August 31, 1994) if candidate primers do not meet the performance requirements in Section 3.1.1. (prime to a dry film thickness of 0.6 to 0.9 mils); and then coated with the candidate topcoat to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2. and 3.2.2.), or (c) Coated only with the candidate topcoat, to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2. and 3.2.2).
C/E	<p>Carbon/epoxy laminate, either custom fabricated in a suitable laboratory facility or purchased from a material supplier, cleaned by solvent wiping with acetone per O-A-51H (<i>Acetone, Technical</i>, issued April 23, 1992); then either:</p> <ul style="list-style-type: none"> (a) Primed with candidate primer to a dry film thickness of 0.6 to 0.9 mils (for testing as specified in Sections 3.1.1. and 3.2.1.), or (b) Primed with candidate primers that meet engineering, performance, and testing requirements in Section 3.1.1. or with a primer conforming to MIL-P-85582B (<i>Waterborne Epoxy Primer Coatings</i>, issued August 31, 1994) if candidate primers do not meet the performance requirements in Section 3.1.1. (prime to a dry film thickness of 0.6 to 0.9 mils); and then coated with the candidate topcoat to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2. and 3.2.2.), or (c) Coated only with the candidate topcoat, to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2. and 3.2.2).

(Table continued next page.)

Table 4. Test Specimen Codes and Substrate Descriptions (continued)

Test Specimen Code	Substrate Description
A/E	<p>Aramid/epoxy laminate conforming to MIL-S-13949H (<i>Printed Wiring Board Sheet</i>, issued August 16, 1993), unclad, cleaned by solvent wiping with acetone per O-A-51H (<i>Acetone, Technical</i>, issued April 23, 1992); then either:</p> <ul style="list-style-type: none"> (a) Primed with candidate primer to a dry film thickness of 0.6 to 0.9 mils (for testing as specified in Sections 3.1.1. and 3.2.1.), or (b) Primed with candidate primers that meet engineering, performance, and testing requirements in Section 3.1.1. or with a primer conforming to MIL-P-85582B (<i>Waterborne Epoxy Primer Coatings</i>, issued August 31, 1994) if candidate primers do not meet the performance requirements in Section 3.1.1. (prime to a dry film thickness of 0.6 to 0.9 mils); and then coated with the candidate topcoat to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2. and 3.2.2.), or (c) Coated only with the candidate topcoat, to a thickness of 1.6 to 2.0 mils (for testing as specified in Sections 3.1.2. and 3.2.2.).

3.1. Common Test Requirements

Candidate primers and primer/topcoat systems will be tested using these common test requirements for all weapon systems listed in Table 1. The tests for candidate primers are described in Section 3.1.1. The tests for the candidate primer/topcoat systems are in Section 3.1.2. Note that for the primer/topcoat systems, the candidate topcoats will be applied over the primer(s) that passed the tests in Section 3.1.1. or, if no candidate primers meet the requirements of Section 3.1.1., over a MIL-P-85582B (*Waterborne Epoxy Primer Coatings*, issued August 31, 1994) primer.

3.1.1. Common Test Requirements for Candidate Primers

The common test requirements for all candidate primers are described in Sections 3.1.1.1. through 3.1.1.4. In addition to test coupons coated with the candidate primers, a set of baseline coupons will be prepared by priming with a coating that is qualified as a Type 1 (standard pigment) Class C (strontium chromate based corrosion inhibitor) MIL-P-23377G (*High-Solids Epoxy Primer Coatings*, issued September 30, 1994) coating. Only the substrate types that are required for testing the candidate coatings will be used for the baseline coupons (refer to Test Methodology in individual sections). For comparison purposes, the set of baseline coupons

used for each test will be subjected to the same procedure as that required for the coupons coated with candidate primers.

3.1.1.1. Filiform Corrosion Resistance Test

Test Description

This test measures the ability of a primer coating to protect the substrate against the formation of filiform corrosion.

Scribe an “X” incision through the coating so that the smaller angle of the “X” is 30° to 45°, making sure that the coating has been scribed all the way to the substrate. The scribe must have a 45 degree bevel, and each line of the “X” should be approximately 4 inches long.

Place the scribed coupons in a desiccator containing 12 N hydrochloric acid for one hour at 24 ± 3°C (75 ± 5°F). Within 5 minutes of removal from the desiccator, place the coupon in a humidity cabinet maintained at 40 ± 1.7°C (104 ± 3°F) and 80 ± 5 percent relative humidity for 1,000 hours. At the end of the test duration, measure the length of any thread-like filaments.

Rationale

This test was identified by all participating programs as a performance requirement. The filiform test, which determines the resistance of coated metals to filiform-type corrosion, is distinctly different from the salt spray resistance test (Section 3.1.1.2. of this JTP) and is required along with the salt spray test to ensure that candidate primers provide adequate corrosion protection. A filiform test is a requirement of MIL-P-23377G (*High-Solids Epoxy Primer Coatings*, issued September 30, 1994) and MIL-P-85582B (*Waterborne Epoxy Primer Coatings*, issued August 31, 1994).

Test Methodology

Parameters	12 N HCl for one hour/1,000 hours at 40°C and 80% RH
Number and Type of Test Coupons	3 AL1, 3 AL4, 3 AL5, 3 AL6
Trials Per Test Coupon	1
Acceptance Criteria	All filaments ≤ 1/4” Majority < 1/8” filaments

Unique Equipment and Instrumentation

- Desiccator
- Humidity cabinet capable of 40°C and 80% RH
- Carbide tip scribe

Data Analysis

- One color photograph of a coupon coated with each candidate primer and of a coupon coated with the baseline primer shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Report the length of any thread-like filaments.

3.1.1.2. Salt Spray Resistance Test

Test Description

This test method evaluates a coating's ability to prevent substrate corrosion and the effect that corrosion has on the adhesion of a coating.

Operate the fog chamber for this test in accordance with ASTM B 117-94 [*Standard Practice for Operating Salt Spray (Fog) Testing Apparatus*, approved February 15, 1994].

Scribe an "X" incision through the coating so that the smaller angle of the "X" is 30° to 45°, making sure that the coating has been scribed all the way to the substrate. The scribe must have a 45 degree bevel, and each line of the "X" should be approximately 4 inches long. Cover the back and edges of the coupon with wax, paint, tape, or any other material that will prevent corrosion products from contaminating the chamber.

Place the scribed coupons into a fog chamber. The coupons may not contact other surfaces in the chamber. Prepare a salt solution and the fog chamber as specified in Test Methodology. Adjust the nozzles in the fog chamber so that sprayed salt solution does not directly impinge on the coupon surfaces.

Operate the fog chamber continuously for 2,000 hours. Evaluate coupons for surface corrosion and creepage from the scribe on a daily basis. At the end of the test duration, carefully remove the coupons. Clean the coupons by gently flushing them with running tap water, and dry them with a stream of clean, compressed air. Evaluate the adhesion of the primer in accordance with Section 3.1.1.4. of this JTP. Visually examine the

coupons. Slight corrosion in the scribe is generally acceptable, as long as it does not undercut the paint film. Corrosive salts or oxides running down the surface of the coupon are considered evidence of severe corrosion.

Rationale

This test was identified by all involved programs as a performance requirement. A salt spray test is a requirement in MIL-P-23377G (*High-Solids Epoxy Primer Coatings*, issued September 30, 1994).

Test Methodology

Parameters	<ul style="list-style-type: none"> • Test coupon at a 15 to 30° angle • Temperature of exposed salt spray zone = 35 + 1.1 - 1.7°C (95 + 2 - 3°F or 92 to 97°F) • Every 80 cm² horizontal area, two collectors gather 1.0-2.0 mL fog/h • 5% salt solution (5 ± 1 parts by weight of NaCl in 95 parts of water) • pH = 6.5-7.2 when atomized at 35°C (95°F) • 2,000 hours
Number and Type of Test Coupons	5 AL1, 1 AL2, 5 AL3, 3 AL4, 3 AL5, 5 AL6
Trials Per Test Coupon	1
Acceptance Criteria	No blistering or lifting after 2,000 hours. Slight substrate corrosion only.

Unique Equipment and Instrumentation

- Fog chamber
- Salt solution reservoir
- Compressed air supply
- Atomizing nozzles
- Heater for the fog chamber
- Carbide tip scribe

Data Analysis

- One color photograph of a coupon coated with each candidate primer and of a coupon coated with the baseline primer shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Report the adhesion test results and daily visual observations.

3.1.1.3. Solvent (Acetone) Rub Test

Test Description

This test demonstrates the effect of acetone on a primed test coupon.

Perform this test in accordance with ASTM D 4752-87 [*Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub*, approved November 27, 1987], except use acetone instead of methyl ethyl ketone (MEK).

Cure the primer according to manufacturer's specifications. Saturate cheese cloth with acetone. Double rub (back-and forth motion) a 2-inch area on the test coupon with the cloth, ensuring the cloth is saturated with acetone at all times. Examine the test coupon to determine if the coating has been worn through, exposing the substrate.

Rationale

This test is specified in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990) and is similar to ASTM D 4752-87. However, the military specification requires a cotton, terry-cloth rag and MEK as a solvent. ASTM D 4752-87 suggests the use of cheese cloth, which is specified for this test. Acetone is used in place of MEK because Lockheed Martin judges that parts will encounter acetone more often than MEK. An MEK solvent rub test for primers is specified in Section 3.2.1.6. of this JTP as an extended test.

Test Methodology

Parameters	Acetone saturated cheese cloth, 50 double rubs
Number and Type of Test Coupons	2 AL1, 2 ST, 2 C/E
Trials Per Test Coupon	3 (*)
Acceptance Criteria	No exposure of substrate

(*) Perform second and third trials on coupon areas that have not previously been rubbed.

Data Analysis

One color photograph of a coupon coated with each candidate primer and of a coupon coated with the baseline primer shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.1.1.4 Wet Tape Adhesion Test

Test Description

This test method covers a procedure for establishing adequacy of intercoat and surface adhesion of an organic coating immersed in water by applying pressure-sensitive tape over a scribed area of the coating.

Measure the cleanliness of the coating in accordance with ASTM D 724-89 [*Standard Test Method for Surface Wettability of Paper (Angle-of-Contact Method)*, approved May 26, 1989], except replace ink with distilled water.

Perform this test in accordance with Method A of ASTM D 3359-92a (*Standard Test Methods for Measuring Adhesion by Tape Test*, approved May 15, 1992), except use a roller instead of finger pressure for adhering the tape.

Scribe two “X” incisions through the coating so that the smaller angle of the “X” is 30 to 45°, making sure that the coating has been scribed all the way to the substrate. The scribe must have a 45 degree bevel, and each line of the “X” should be approximately 1.5 inches long. If a composite coupon tears while scribing it, start the test again.

Immerse the test coupon in distilled water at room temperature for 24 hours. Remove coupon from the water and dry by wiping with a soft cloth. Immediately place a piece of tape over the incisions and smooth down by passing a 4.5 pound roller over it once. Remove the tape rapidly at approximately an 180° angle. Inspect the incision area for peel away.

Rationale

A wet tape adhesion test is required by MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990). Technical representatives elected to use Method A of ASTM D 3359-92a for tape tests due to its industry acceptability. An “X” scribe is required on all coupons, including composite coupons. Technical representatives are aware that some tears may occur in the composites; additional coupons will be made so that if a composite is torn during scribing, the test can still be performed.

In Method A of ASTM D 3359-92a, the tape is smoothed down with a finger. A roller is specified in this procedure for smoothing down the tape instead of finger pressure because the pressure is more likely to be

constant across the marking and constant for all test specimens. The use of a roller is consistent with MIL-C-85285B.

Test Methodology

Parameters	24 hour immersion in distilled water at room temperature
Number and Type of Test Coupons	3 AL1, 3 AL4, 3 AL5, 3 AL6, 3 G/E, 3 C/E, 3 A/E
Trials Per Test Coupon	1
Acceptance Criteria	No peel away

Unique Equipment and Instrumentation

- 1 inch masking tape, 3M Company Type 250 or equivalent
- 4.5 pound roller
- Carbide tip scribe

Data Analysis

- One color photograph of a coupon coated with each candidate primer and of a coupon coated with the baseline primer shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Record the cleanliness of the coating by reporting the angle-of-contact of the distilled water measured during the specified contact angle test.
- Report the adhesion rating (as specified in ASTM D 3359-92a Section 7).

3.1.2. Common Test Requirements for Candidate Primer/Topcoat Systems

The common test requirements for all candidate primer/topcoat systems are described in Sections 3.1.2.1. through 3.1.2.11. In addition to test coupons coated with the candidate primer/topcoat systems, a set of baseline coupons will be prepared by priming with a coating that is qualified as a Type 1 (standard pigment) Class C (strontium chromate based corrosion inhibitor) MIL-P-23377G (*High-Solids Epoxy Primer Coatings*, issued September 30, 1994) coating and then topcoating with a coating that is qualified as a MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990) coating. Only the substrate types that are required for testing the candidate coatings will be used for the baseline coupons (refer to Test Methodology in individual sections). For comparison purposes, the set of baseline coupons used for each test will be

subjected to the same procedure as that required for the coupons coated with candidate primer/topcoat systems.

3.1.2.1. Accelerated Weather Test

Test Description

This test evaluates the ability of a coating to withstand accelerated weathering in a weather-ometer chamber.

Perform this test in accordance with Test Method 1 of ASTM G 26-90 (*Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials*, approved January 26, 1990).

Measure the initial color of the coated coupon in accordance with ASTM D 2244-89 (*Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates*, approved October 27, 1989). Place test coupons into a xenon-arc weather-ometer. Operate the weather-ometer at the conditions specified in Test Methodology. Measure the color change of the coated coupon in accordance with ASTM D 2244-89.

More stringent program-specific (extended) requirements are in Section 3.2.2.1. of this JTP.

Rationale

Accelerated weathering is included as a requirement in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990); MIL-C-22750F (*High-Solids Epoxy Coating*, issued May 31, 1994); and MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993). The accelerated weathering tests in each of these military specifications conform to ASTM G 26-90.

Test Methodology

Parameters	<ul style="list-style-type: none">• $60 \pm 3^{\circ}\text{C}$ ($140 \pm 5^{\circ}\text{F}$)• $50 \pm 5\%$ RH• One cycle: 102 minutes of light only and 18 minutes of light and water spray• 0.35 Watts/m^2 Incident at 340 nanometers• Operate for 500 hours (250 cycles)
Number and Type of Test Coupons	3 AL1, 3 AL6
Trials Per Test Coupon	1
Acceptance Criteria	Color change (ΔE) ≤ 2 units

Unique Equipment and Instrumentation

- Xenon arc weather-ometer (Apparatus Type BH in ASTM G 26-90)
- Digital colorimeter

Data Analysis

- Report results as color difference and any changes of coating that are visually observed.
- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.1.2.2. Cleanability Test

Test Description

This test evaluates the resistance of a topcoat to soil adhesion and staining.

Prepare an **artificial soil** by placing 50 ± 0.5 grams of carbon black and 500 ± 1 gram of hydraulic fluid (conforming to MIL-H-83282C (*Fire Resistant Synthetic Base Aircraft Hydraulic Fluid*, issued March 25, 1986)) into a one quart jar. Homogenize using a high-shear mixer for 15 ± 1 minutes.

Prepare a **standard formula cleaner** by mixing one part (by weight) Witconate 1260, supplied by Witco Chemical Corporation of New York,

New York, or equivalent; two parts Igepal CO-630, supplied by GAF Corporation of Wayne, New Jersey, or equivalent; one part sodium xylene sulfonate (40 percent active); and one part diethylene glycol mono-butyl ether. In a separate container, mix one part (by weight) tetrapotassium pyrophosphate with 14 parts deionized water. Complete preparation of the standard formula cleaner by combining one part (by weight) of the mixture containing Witconate 1260 or equivalent with three parts of the mixture containing the deionized water.

Lightly clean the test coupon with a detergent. Rinse the coupon three times with deionized water. Dry the coupon for 18 hours at $49 \pm 2^{\circ}\text{C}$ ($120 \pm 4^{\circ}\text{F}$). Measure the lightness value (“A”, the L-value for the unsoiled test coupon) with a colorimeter.

Hand-mix the prepared artificial soil. Using a soft bristle acid brush, coat the test coupon with the artificial soil. Remove excess soil by placing a folded absorbent tissue onto the surface and passing a 5 pound rubber roller over the tissue two times. Brush the soiled surface using ten one-directional strokes of a hog bristle brush. Bake the test coupon at $105 \pm 2^{\circ}\text{C}$ ($221 \pm 4^{\circ}\text{F}$) for 60 ± 1 minutes. Measure the lightness value (“B”, the L-value for the soiled test coupon) with a colorimeter.

Dilute the standard cleaner formula by mixing one part by volume of cleaner with nine parts by volume of deionized water. Attach a cellulose sponge to the cleaning head of the wear tester. Place the soiled test coupon in the tester at a 45° angle. Saturate the sponge with cleaner and place onto the test coupon. After the sponge and soiled coupon have been in contact for 60 ± 5 seconds, clean the soiled coupon with 5 cycles of the wear tester. Immediately turn the coupon through a 90° angle and clean for an additional 5 cycles. Rinse the coupon with room temperature tap water and allow to dry. Measure the lightness value of the coupon (“C”, the L-value for the cleaned panel) with a colorimeter.

Rationale

The procedure is contained in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990). The acceptance criteria of 70 percent cleaning efficiency is included in the October 22, 1990 Amendment 2 of the MIL-C-85285B. The original required cleaning efficiency in MIL-C-85285 issued May 13, 1988, was 90 percent. Technical representatives agreed that the 70 percent cleaning efficiency would be acceptable, but a higher cleaning efficiency would be beneficial.

Test Methodology

Parameters	None
Number and Type of Test Coupons	1 AL1
Trials Per Test Coupon	1
Acceptance Criteria	Cleaning efficiency \geq 70%

Unique Equipment and Instrumentation

- High shear mixer
- Mechanical grease worker
- Acid brush
- Rubber roller, 5 pounds
- Forced draft oven(s) capable of $49 \pm 2^\circ\text{C}$ and $105 \pm 2^\circ\text{C}$
- Colorimeter, McBeth Model MC-10TOS or equivalent
- Wear Tester, Gardner Heavy Duty Wear Tester Cat. No. WG 6700 or equivalent
- Hog bristle brushes
- Cellulose sponge (3.5 inches by 2.75 inches)

Data Analysis

- Calculate the percentage cleaning efficiency by $[(C - B)/(A - B)] * 100$. (Refer to Test Description for definitions of A, B, and C.)
- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.1.2.3. Fungus Resistance Test

Test Description

This test will be performed to measure the extent to which a primer/topcoat system will support fungal growth and how the fungal growth affects the adhesion of the topcoat.

Prepare subcultures of *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus versicolor*, and *Penicillium fungiculosum* on an appropriate medium such as potato dextrose agar. Culture *Chaetomium globosum* on strips of filter

paper overlaid on the surface of a mineral salts agar that consists of agar and a **mineral salts solution** with the following composition:

	Quantity
Potassium dihydrogen orthophosphate	0.7 gram
Potassium monohydrogen orthophosphate	0.7 gram
Magnesium sulfate heptahydrate	0.7 gram
Ammonium nitrate	1.0 gram
Sodium chloride	0.005 gram
Ferrous sulfate heptahydrate	0.002 gram
Zinc sulfate monohydrate	0.002 gram
Distilled water	1000 milliliters

Incubate subcultures at $30 \pm 1.4^{\circ}\text{C}$ ($86 \pm 2.5^{\circ}\text{F}$) for 14 to 21 days.

Prepare a spore suspension by pouring 10 milliliters of an aqueous solution containing 0.05 grams per liter of a nontoxic wetting agent (e.g., sodium dioctyl sulfosuccinate or sodium lauryl sulfate) onto each agar culture, and then pouring the mixture into an Erlenmeyer flask that contains 45 milliliters of water and 50 to 75 glass beads that have a 5 millimeter diameter. Shake the flask. Filter the mixture with glass wool to remove the large mycelial fragments and clumps of agar. Resuspend the spores three additional times, filtering each time. After the final rinsing, suspend the spores in the mineral salts solution (composition previously described), so that the solution has $1,000,000 \pm 200,000$ spores per milliliter as determined with a counting chamber. Verify the viability of each spore suspension by incubating an inoculated potato dextrose agar plate at 24 to 31°C (75 to 88°F) for 7 to 10 days and checking for fungal growth. If fungal growth does not occur, the fungal suspensions must be prepared again.

Prepare the final mixed spore suspension by combining equal volumes of each fungal suspension. Prepare an environmental chamber that has 95 ± 5 percent humidity at $30 \pm 1^{\circ}\text{C}$ ($86 \pm 2^{\circ}\text{F}$), with an air velocity between 98 and 335 feet per minute (0.5 and 1.7 meters per second). Place the test coupons and cotton strips (used for a control) in the environmental chamber for at least 4 hours immediately prior to inoculation. Inoculate the coupons with the final mixed spore suspension by spraying a mist of the suspension with an atomizer or nebulizer. After 7 days of inoculation, the cotton strips should be at least 90 percent covered with fungal growth; if not, repeat the entire test. After a total of 84 days, remove the test coupons. Evaluate the topcoat adhesion in accordance with Section 3.1.2.11. of this JTP. Visually inspect for fungal growth.

Rationale

This test was identified by all participating programs as a performance requirement. This fungus resistance test is performed in accordance with Method 508 of MIL-STD-810E (*Department of Defense Test Method Standard for Environmental Considerations and Laboratory Tests*, issued July 14, 1989).

Method 508 of MIL-STD-810E recommends that the minimum test duration is 28 days, but suggests a longer test duration of 84 days to allow for fungal germination, breakdown of carbon molecules, and degradation of the material being tested. The longer test duration was selected for this test procedure.

Test Methodology

Parameters	5 types of fungus/84 days 95 ± 5% RH/30°C
Number and Type of Test Coupons	1 AL1
Trials Per Test Coupon	1
Acceptance Criteria	Adhesion per Section 3.1.2.11. of this JTP. Does not support fungal growth.

Unique Equipment and Instrumentation

- Environmental chamber capable of maintaining 86° ± 2°F and 95% ± 5% humidity
- 125-W Heating coil
- Psychrometer
- Counting chamber
- Atomizer or nebulizer
- Unique equipment and instrumentation required for the wet tape adhesion test (Section 3.1.2.11. of this JTP).

Data Analysis

- Report the test item identification, the presence/absence of fungal growth at a seven day check and at the end of the test, the location of the fungi, a narrative description of growth, and the length of the test period. Include a determination of the effect of fungi on performance.
- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline

primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.1.2.4. Gloss Tests (High, Semi, and Low)

Test Description

This test measures the specular gloss of surfaces for glossmeter geometries of 60°.

Perform this test in accordance with ASTM D 523-89 (*Standard Test Method for Specular Gloss*, approved March 31, 1989, reapproved October 1994).

Calibrate a glossmeter using a National Institute of Standards and Technology (NIST) traceable standard. Position the test coupon under the glossmeter. Measure the gloss at three different places on the coupon and record an average. After every thirty specular gloss measurements, check calibration and recalibrate if necessary.

The program-specific (extended) requirements for very low gloss coatings are in Section 3.2.2.5. of this JTP.

Note that each mean specular gloss reading (msgr) is taken with a particular incident light angle. The msgr, at any incident angle, is the relative luminous reflectance factor, or the ratio of the luminous flux reflected from a specimen to the luminous flux reflected from a standard.

Rationale

High gloss tests may be found in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990) and MIL-C-22750F (*High-Solids Epoxy Coating*, issued May 31, 1994). Each document requires that the minimum gloss reading for gloss colors be greater than or equal to 90 units.

Semi-gloss requirements may be found in MIL-C-85285B (15 to 45 units) and MIL-C-22750F (15 to 30 units). Technical representatives agreed that the 15 to 45 unit requirement would be acceptable for all semi-gloss coatings.

Low gloss requirements may be found in MIL-C-85285B and MIL-C-22750F. Both documents require a maximum gloss reading of 5 units.

Test Methodology

Parameters	Gloss - High	Gloss - Semi	Gloss - Low
Number and Type of Test Coupons	1 AL1 1 G/E 1 C/E 1 A/E	1 AL1 1 G/E 1 C/E 1 A/E	1 G/E 1 C/E 1 A/E
Trials Per Test Coupon	3	3	3
Acceptance Criteria	≥ 90 gloss units	15 - 45 gloss units	≤ 5 gloss units

Unique Equipment and Instrumentation

Glossmeter capable of reading at 60°

Data Analysis

Report the mean specular gloss.

3.1.2.5. Heat Resistance Test

Test Description

This test method measures the heat resistance of primer/topcoat systems.

Measure the initial color of the coated coupon in accordance with ASTM D 2244-89 (*Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates*, approved October 27, 1989). Place test coupons in oven set at $120 \pm 3^{\circ}\text{C}$ ($250 \pm 5^{\circ}\text{F}$). After one hour, remove test coupons and allow to cool to room temperature. Measure the color change of the coated coupon in accordance with ASTM D 2244-89.

Rationale

The heat resistance test is contained in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990) and MIL-C-22750F (*High-Solids Epoxy Coating*, issued May 31, 1994). ASTM D 2244-89 will be used to evaluate color changes due to heat exposure. Technical representatives selected acceptance criteria conforming to the more stringent standards contained in MIL-C-85285B (spectral color change (ΔE) ≤ 1).

Test Methodology

Parameters	120°C for 1 hour
Number and Type of Test Coupons	3 AL1, 3 AL6
Trials Per Test Coupon	1
Acceptance Criteria	Color change (ΔE) \leq 1 unit

Unique Equipment and Instrumentation

- Oven capable of maintaining $120 \pm 3^\circ\text{C}$
- Digital colorimeter

Data Analysis

- Report results as color difference and any changes of the coating that are visually observed.
- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.1.2.6. Hiding Power Test

Test Description

This test method measures the hiding power of air dried liquid coatings or oven-cured powder coatings with Y tristimulus values greater than 15 percent. The test will be performed with white topcoats only.

Perform this test in accordance with ASTM D 2805-88 (*Standard Test Method for Hiding Power of Paints by Reflectometry*, approved March 25, 1988).

Coat black and white cardboard Leneta charts (or equivalent) with the primer/topcoat system per the manufacturer's requirements. [For powder coatings, enamel-coated metal charts are available from Leneta for hiding power tests. Follow Powder Coating Institute (PCI) Procedure 3.] Measure the daylight reflectance factor of each test area and calculate the contrast ratio of the coating.

Rationale

This test is contained in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990) (contrast ratio > 0.90); MIL-C-22750F (*High-Solids Epoxy Coating*, issued May 31, 1994) (contrast ratio > 0.95); and MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993) (contrast ratio > 0.92). Technical representatives elected to adopt the highest criterion of a contrast ratio greater than or equal to 0.95 to ensure that adequate coverage can be achieved with few coats.

Test Methodology

Parameters	Daylight
Number and Type of Test Specimens	1 Cardboard or Enamel-Coated Metal Leneta Chart
Trials Per Test Specimen	3
Acceptance Criteria	Contrast ratio ≥ 0.95 (test white topcoats only)

Unique Equipment and Instrumentation

Black and white cardboard Leneta charts, or equivalent

Data Analysis

Report contrast ratio.

3.1.2.7. Humidity Test

Test Description

This test method measures the effect of humidity on primer/topcoat systems. This test is intended to be an accelerated test to identify problems in a short test duration.

Perform this test in accordance with ASTM D 2247-92 (*Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity*, approved May 15, 1992).

Place test coupons at a 15° angle from the vertical in an enclosed chamber at 100 percent relative humidity and 50 ± 3°C (120 ± 5°F). Droplets of condensation should be visible on the coupons at all times. At the end of 30 days, dry the coupons by wiping. Visually inspect the coating on the coupons for softening and loss of adhesion within 5 to 10 minutes after removal from the chamber.

Rationale

A humidity test is contained in MIL-C-83286B (*Aliphatic Isocyanate Urethane Coating for Aerospace Applications*, last amended January 21, 1994, canceled January 19, 1995) and MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990). MIL-C-83286B specifies a test procedure in accordance with Method 6201 of FED-STD-141C (*Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing*, issued January 24, 1986). Technical representatives elected to use the test procedure of ASTM D 2247-92, specified in MIL-C-85285B. MIL-C-85285B replaces MIL-C-83286B on all new weapon systems.

Test Methodology

Parameters	30 days at 50°C and 100% RH
Number and Type of Test Coupons	1 AL1, 1 AL6, 1 ST, 1 G/E, 1 C/E, 1 A/E
Trials Per Test Coupon	1
Acceptance Criteria	No softening or loss of adhesion

Unique Equipment and Instrumentation

Humidity cabinet capable of maintaining $50 \pm 3^\circ\text{C}$ and 100% relative humidity

Data Analysis

- Report procedure used, results of visual examinations, operational check outs, exposure durations, time versus temperature, and humidity.
- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.1.2.8. Salt Spray Resistance Test

Test Description

This test method evaluates a coating system's ability to prevent substrate corrosion and the effect that corrosion has on the adhesion of coating system.

Operate the fog chamber for this test in accordance with ASTM B 117-94 (*Standard Practice for Operating Salt Spray (Fog) Testing Apparatus*, approved February 15, 1994).

Scribe an “X” incision through the coating so that the smaller angle of the “X” is 30 to 45°, making sure that the coating has been scribed all the way to the substrate. The scribe must have a 45 degree bevel, and each line of the “X” should be approximately 4 inches long. Cover the back and edges of the coupon with wax, paint, tape, or any other material that will prevent corrosion products from contaminating the chamber.

Place the scribed coupons into a fog chamber. The coupons may not contact other surfaces in the chamber. Prepare a salt solution and the fog chamber as specified in Test Methodology. Adjust the nozzles in the fog chamber so that sprayed salt solution does not directly impinge on the coupon surfaces.

Operate the fog chamber continuously for 2,000 hours. Evaluate coupons for surface corrosion and creepage from the scribe on a daily basis. At the end of the test duration, carefully remove the coupons. Clean the coupons by gently flushing them with running water (water temperature less than 38°C (100°F)), and dry them with a stream of clean, compressed air. Evaluate the adhesion of the primer/topcoat system in accordance with Section 3.1.2.11 of this JTP. Visually examine the coupons. Slight corrosion in the scribe is generally acceptable, as long as it does not undercut the paint film. Corrosive salts or oxides running down the surface of the coupon are considered evidence of severe corrosion.

Rationale

This test was identified by all involved programs as a performance requirement.

Test Methodology

Parameters	<ul style="list-style-type: none">• Test coupons at a 15 to 30° angle• Temperature of exposed salt spray zone = 35 + 1.1 - 1.7°C (95 + 2 - 3°F or 92 to 97°F)• Every 80 cm² horizontal area, two collectors gather 1.0-2.0 mL fog/h• 5% salt solution (5 ± 1 parts by weight of NaCl in 95 parts of water)• pH = 6.5-7.2 when atomized at 35°C (95°F)• 2,000 hours
Number and Type of Test Coupons	5 AL1, 1 AL2, 5 AL3, 5 AL6
Trials Per Test Coupon	1
Acceptance Criteria	No blistering or lifting after 2,000 hours. Slight substrate corrosion only.

Unique Equipment and Instrumentation

- Fog chamber
- Salt solution reservoir
- Compressed air supply
- Atomizing nozzles
- Heater for fog chamber
- Carbide tip scribe

Data Analysis

- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Report the adhesion test results and daily visual observations.

3.1.2.9. Solvent (Acetone) Rub Test

Test Description

This test demonstrates the effect of acetone on a primed and topcoated test coupon.

Perform this test in accordance with ASTM D 4752-87 (*Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub*, approved November 27, 1987), except use acetone instead of MEK.

Cure the primer/topcoat system according to the manufacturer’s recommendations. Saturate cheese cloth with acetone. Double rub (back-and-forth motion) a 2-inch area on the test coupon with the cheese cloth 50 times, ensuring the cloth is saturated with acetone at all times. Examine the test coupon to determine if the coating has been worn through, exposing the primer or substrate.

Rationale

This test is specified in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990) and is similar to ASTM D 4752-87. However, this military specification requires a cotton, terry cloth rag and MEK as a solvent. ASTM D 4752-87 suggests the use of cheese cloth, which is specified for this test. Acetone is used in place of MEK because Lockheed Martin judges that parts will encounter acetone more often than MEK. An MEK solvent rub test for primer/topcoat systems is specified in Section 3.2.2.11. of this JTP as an extended test.

Test Methodology

Parameters	Acetone saturated cheese cloth, 50 double rubs
Number and Type of Test Coupons	2 AL1, 2 ST, 2 C/E
Trials Per Test Coupon	3 (*)
Acceptance Criteria	No exposure of primer or substrate

(*) Perform second and third trials on coupon areas that have not previously been rubbed.

Data Analysis

One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.1.2.10. Tape Resistance Test

Test Description

During this test, standard masking tape is applied to the coating to determine if the tape will affect the coating's adhesion during masking and subsequent painting or stenciling operations.

Measure the cleanliness of the coating in accordance with ASTM D 724-89 (*Standard Test Method for Surface Wettability of Paper (Angle-of-Contact Method)*), approved May 26, 1989), except replace ink with distilled water.

Measure the initial gloss of the coating in accordance with ASTM D 523-89 (*Standard Test Method for Specular Gloss*, approved March 31, 1989, reapproved October 1994).

Apply three tape strips to each test coupon at times specified in the following table. Press each piece of tape down with one pass of a 4.5 pound roller. Remove the tape strips at the times specified in the following table and inspect visually. Note that the tape remains in contact with the coating for one hour in all cases.

Time of tape strip application after topcoating (hrs)	Time of tape strip removal after topcoating (hrs)
1	2
4	5
8	9
9	10
10	11
11	12
12	13

Measure the final gloss of the coating in accordance with ASTM D 523-89.

A new coupon shall be used for each tape application set. If the tape is applied and removed and the coating does not have marring, a loss of gloss, or change in appearance, do not perform any subsequent tape applications; instead, report the results. Do not apply tape strips after the indicated 12 hours.

Rationale

This test is contained in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990) and MIL-C-22750F (*High-Solids Epoxy Coating*, issued May 31, 1994). The time of tape application after painting for these military specifications is 8 hours. However, the technical representatives agreed that the acceptance criteria of no marring, loss of gloss, or change of appearance when the tape strip is applied at 12 hours after painting was sufficient. The other application times are tested so that the time required before masking may be determined.

Test Methodology

Parameters	4.5 pound roller, 1 hour tape contact
Number and Type of Test Coupons	1 AL1 per tape application time
Trials Per Test Coupon	3
Acceptance Criteria	When tape is applied at 12 hours after topcoating, no marring, loss of gloss, or change in appearance.

Unique Equipment and Instrumentation

- 4.5 pound roller
- Standard masking tape, 3M Company Type 250 or equivalent

Data Analysis

- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Record the cleanliness of the coating by reporting the angle-of-contact of the distilled water measured during the specified contact angle test.
- Report the initial and final gloss of the coating.

3.1.2.11. Wet Tape Adhesion Test

Test Description

This test method covers a procedure for establishing adequacy of intercoat and surface adhesion of an organic coating immersed in water by applying pressure sensitive tape over a scribed area of the coating.

Measure the cleanliness of the coating in accordance with ASTM D 724-89 (*Standard Test Method for Surface Wettability of Paper (Angle-of-Contact Method)*), approved May 26, 1989), except replace ink with distilled water.

Perform this test in accordance with Method A of ASTM D 3359-92a (*Standard Test Methods for Measuring Adhesion by Tape Test*, approved May 15, 1992), except use a roller instead of finger pressure to apply the tape strips.

Scribe two “X” incisions through the coating so that the smaller angle of the “X” is 30 to 45°, making sure that the coating has been scribed all the way to the substrate. Each line of the “X” should be approximately 1.5 inches long. If a composite coupon tears while scribing it, start the test again.

Immerse the test coupon in distilled water at room temperature for 24 hours. Remove the coupon from the water and dry by wiping with a soft cloth. Immediately place a piece of tape over the incisions and smooth out by passing a 4.5 pound roller over it once. Remove the tape rapidly at approximately an 180° angle. Inspect the incision area for peel away.

Rationale

A wet tape adhesion test is required by MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990). Technical representatives elected to use Method A of ASTM D 3359-92a for tape tests due to its industry acceptability. An “X” scribe is required on all coupons, including composites. Technical representatives are aware that some tears may occur in the composites; additional coupons will be made so that if a composite is torn during scribing, the test can still be performed.

In Method A of ASTM D 3359-92a, the tape is smoothed down with a finger. A roller is specified in this procedure for smoothing down the tape

instead of finger pressure because the pressure is more likely to be constant across the marking and constant for all test specimens. The use of a roller is consistent with MIL-C-85285B.

Test Methodology

Parameters	24 hour immersion in distilled water at room temperature
Number and Type of Test Coupons	3 AL1, 3 AL6, 3 G/E, 3 C/E, 3 A/E
Trials Per Test Coupon	1
Acceptance Criteria	No peel away

Unique Equipment and Instrumentation

- 1 inch masking tape, 3M Company Type 250 or equivalent
- 4.5 pound roller
- Carbide tip scribe

Data Analysis

- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Record the cleanliness of the coating by reporting the angle-of-contact of the distilled water measured during the specified contact angle test.
- Report the adhesion rating (as specified in ASTM D 3359-92a Section 7).

3.2. Extended (Program-Specific) Test Requirements

Candidate primers and primer/topcoat systems will be tested with these extended test requirements as required by individual weapon systems. The tests for candidate primers are described in Section 3.2.1. The tests for the primer/topcoat systems are in Section 3.2.2. Note that for the candidate primer/topcoat systems, the candidate topcoats will be applied over the primer(s) that passed the tests in Section 3.1.1. or, if no candidate primers meet the performance requirements of Section 3.1.1., over a MIL-P-85582B (*Waterborne Epoxy Primer Coatings*, issued August 31, 1994) primer.

3.2.1. Extended Test Requirements for Candidate Primers

The program-specific test requirements for candidate primers are described in Sections 3.2.1.1. through 3.2.1.7. In addition to test coupons coated with the candidate primers, a set of baseline coupons will be prepared by priming with a coating that is qualified as a Type 1 (standard pigment) Class C (strontium chromate based corrosion inhibitor) MIL-P-23377G (*High-Solids Epoxy Primer Coatings*, issued September 30, 1994) coating. Only the substrate types that are required for testing the candidate coatings will be used for the baseline coupons (Refer to Test Methodology in individual sections). For comparison purposes, the set of baseline coupons used for each test will be subjected to the same procedure as that required for the coupons coated with candidate primers.

3.2.1.1. Cryoflex Cryogenic Compatibility Test

Test Description

This test evaluates the adhesion between the primer and substrate and between the spray on foam insulation (SOFI) and primer under cryogenic conditions during applied tensile loading. This test is performed on dogbone specimens of the following dimensions: 2 inches by 18 inches by 0.125 inches, narrowing to 1.5 inches in the test area of the specimen.

Apply SOFI to the dogbone specimen. After making preliminary measurements to determine the cross-sectional area of two specimens, load the specimens into a cryoflex test fixture using a zero inch anvil radius and attach the thermocouples. Preload the specimens to 500 ± 10 pounds tensile force at room temperature. Purge the system with helium for 2 minutes, then cool the apparatus to cryogenic temperature. When the anvil temperature reaches $-196 + 0 - 10^{\circ}\text{C}$ ($-320 + 0 - 20^{\circ}\text{F}$) for liquid oxygen (LO_2) or $-253 + 0 - 10^{\circ}\text{C}$ ($-423 + 0 - 20^{\circ}\text{F}$) for liquid hydrogen (LH_2), initiate a 15 minute soak. Record a load versus deflection curve during the soak. If a crack develops in either sample, stop testing and record the load limit.

Rationale

This test was identified by the National Aeronautics and Space Administration (NASA) as a performance requirement for primers.

Test Methodology

Parameters	-253 + 0 - 10°C and -196 + 0 - 10°C
Number and Type of Dogbone Specimens	3 AL4, 3 AL5
Trials Per Dogbone Specimen	1
Acceptance Criteria	For molded ablator at 0.5 inches thick, -253°C (-423°F): Infinite radius flexure; Load ≥ 40 ksi without delamination For SOFI, 1.2 inches thick, -253°C (-423°F): Infinite radius flexure; Load ≥ 60 ksi without delamination

Unique Equipment and Instrumentation

Cryoflex test fixture

Data Analysis

One color photograph of a dogbone specimen coated with each candidate primer and of a dogbone specimen coated with the baseline primer shall be taken before the test. One color photograph of each tested dogbone specimen shall be taken after the test.

3.2.1.2. Cryogenic Flexibility Test

Test Description

This test evaluates the flexibility and adhesion of the primer at the interface between the primer and substrate under cryogenic conditions. This test shall be performed on test panels with 1 inch by 4 inch by 0.040 inch dimensions and one 1/8 inch diameter hole drilled in each end.

Place the test panel face down over a 1 inch mandrel. Cool the fixture and the sample to -196 + 0 - 10°C (-320 + 0 - 20°F) or -253 + 0 - 10°C (-423 + 0 - 20°F). Bend the sample over the mandrel so the panel ends move at a rate of 0.1 inch per minute. Stop applying pressure when the force on the test panel reaches 100 to 125 pounds. Visually inspect for adhesion loss. Using a 28X microscope, inspect for microcracking.

Rationale

This test was identified by NASA as a performance requirement for primers.

Test Methodology

Parameters	-253 + 0 - 10°C and -196 + 0 - 10°C; 100 to 125 pound force
Number and Type of Test Panels	3 AL4, 3 AL5
Trials Per Test Panel	1
Acceptance Criteria	No adhesion loss or microcracking

Unique Equipment and Instrumentation

- 28X microscope for inspection of microcracking
- 12K Tinius Olsen/Unite-O-Matic
- 1 inch Mandrel

Data Analysis

One color photograph of a coupon coated with each candidate primer and of a coupon coated with the baseline primer shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.2.1.3. Fluid Immersion Tests (Hydraulic Fluid, Lubricating Oil)

Test Description

This test method determines the effects of hydraulic fluid and lubricating oil on organic finishes. Effects may include objectionable alteration of the surface such as discoloration, change in gloss, blistering, softening, swelling, loss of adhesion, or other special conditions.

Perform this test in accordance with ASTM D 1308-87 (*Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes*, approved May 29, 1987), using hydraulic fluid and lubricating oil instead of the chemicals listed in the standard.

Immerse test coupons separately in lubricating oil conforming to MIL-L-23699E (*Synthetic Base Aircraft Turbine Engine Oil*, issued November 23, 1994) at $65 \pm 3^\circ\text{C}$ ($150 \pm 5^\circ\text{F}$) and in hydraulic fluid conforming to MIL-H-83282C (*Fire Resistant Synthetic Base Aircraft Hydraulic Fluid*, issued March 25, 1986) at $120 \pm 3^\circ\text{C}$ ($250 \pm 5^\circ\text{F}$).

Twenty-four hours after immersion, remove coupons. Four hours after removal, examine the coupons for blistering, softening, dark staining, or other film defects.

Rationale

Fluid resistance tests are contained in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990); MIL-C-22750F (*High-Solids Epoxy Coating*, issued May 31, 1994); and MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993). MIL-C-46168D requires an exposure of seven days at room temperature. Technical representatives elected to adopt the parameters contained in MIL-C-85285B and MIL-C-22750F. The test procedure conforms to ASTM D 1308-87.

Test Methodology

	Hydraulic Fluid	Lubricating Oil
Parameters	24 hour immersion, 65°C	24 hour immersion, 120°C
Number and Type of Test Coupons	6 AL1	6 AL1
Trials Per Test Coupon	1	1
Acceptance Criteria	No blistering, dark staining, or softening	No blistering, dark staining, or softening

Data Analysis

- One color photograph of a coupon coated with each candidate primer and of a coupon coated with the baseline primer shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Report visual observations including blistering, softening, dark staining, and other film defects.

3.2.1.4. Primer Adhesion Test

Test Description

This test method evaluates the pull-off strength (adhesion) of a coating at room temperature.

The procedure is contained in ASTM D 4541-93 (*Standard Test Method for Pull-off Strength of Coatings Using Portable Adhesion Testers*, approved October 15, 1993).

Place the coupon in the adhesion tester and clean the surfaces of both the coupon and the fixture. Apply an appropriate adhesive between the fixture and the coated surface and allow enough time for the adhesive to cure. Connect the central grip of the detaching assembly to the loading fixture without bumping, bending, or otherwise pre-stressing the sample. Smoothly increase the load on the fixture at a rate less than 150 pounds per square inch per second (psi/s) so that failure occurs within approximately 100 seconds. Record the force attained at failure or the maximum force applied.

Rationale

This test was identified by NASA as a requirement for primers.

Test Methodology

Parameters	Loads from zero to failure, rate of increase not to exceed 150 psi/s
Number and Type of Test Coupons	3 AL4, 3 AL5
Trials Per Test Coupon	1
Acceptance Criteria	No adhesion failure at substrate/primer interface at $\leq 2,000$ psi

Unique Equipment and Instrumentation

- Adhesion tester
- Force indicator and calibration information
- Adhesive

Data Analysis

- One color photograph of a coupon coated with each candidate primer and of a coupon coated with the baseline primer shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Report the force attained at failure or the maximum force applied.

3.2.1.5. Primer/Insulation Foam Adhesion Test

Test Description

This test method is used to determine the ultimate tensile strength of the primary bondline between the primer and SOFI. This test shall be performed on test panels with dimensions of 2 inches by 2 inches by 0.125 inches.

The procedure is performed in accordance with Type B of ASTM D 1623-78 (*Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics*, approved May 26, 1978).

Coat a 2 inch by 2 inch test panel on one side with the candidate primer, followed by a coat of SOFI. The total thickness of the panel with primer and SOFI should be 0.75 inches. Bond one 2-inch cube test block to each side of the test panel (refer to Figure 1). Condition the test specimen at $23 \pm 2^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$) and 50 ± 5 percent relative humidity for at least 40 hours. Measure the exact cross-sectional dimensions. Perform the test at each of the three temperatures specified in Test Methodology. Zero the load indicator. Place test panel in the assembly and align it to central axis. Pull the test blocks apart at a rate of 0.02 inches per minute while continuously recording the tensile load. Failure of the cohesive bonds within the SOFI is not considered failure of this test.

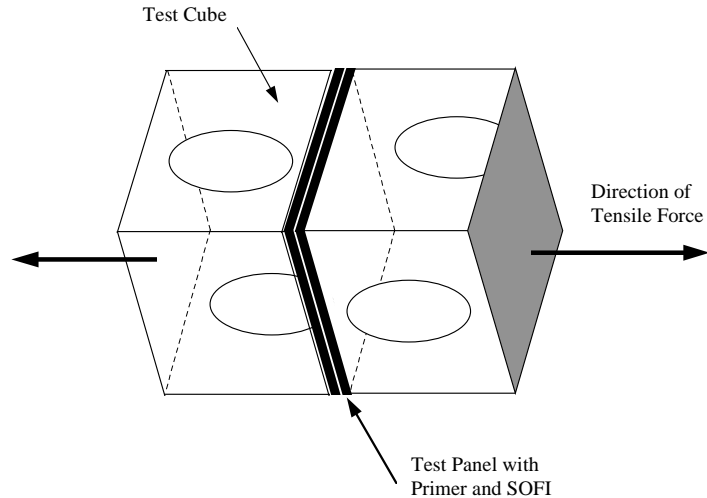


Figure 1. Configuration for Primer/Insulation Foam Adhesion Test

Rationale

This test was identified by NASA as a requirement for primers.

Test Methodology

Parameters	-253°C, Room Temperature, and 150°C
Number and Type of Test Panels	5 AL4, 5 AL5
Trials Per Test Panel	1
Acceptance Criteria	35 psi minimum stress at failure of primer-SOFI bond

Unique Equipment and Instrumentation

- Testing machine of the constant-rate-of-crosshead-movement type comprised of grips, load indicator, and extension indicator
- Specimen cutter

Data Analysis

- One color photograph of a coupon coated with each candidate primer and of a coupon coated with the baseline primer shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Report the stress at failure.

3.2.1.6. Solvent (MEK) Rub Test

Test Description

This test demonstrates the effect of MEK on a primed test coupon.

Perform this test in accordance with ASTM D 4752-87 [*Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub*, approved November 27, 1987].

Cure the primer according to manufacturer's specifications. Saturate cheese cloth with MEK. Double rub (back-and-forth motion) a 2-inch area on the test coupon with the cloth, ensuring the cloth is saturated with MEK at all times. Examine the test coupon to determine if the coating has been worn through, exposing the substrate.

Rationale

This test is specified in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990) and is similar to ASTM D 4752-87. The military specification requires a cotton, terry-cloth rag; however, ASTM D 4752-87 suggests the use of cheese cloth, which is specified for this test. An MEK solvent rub test is required by some programs in addition to the acetone solvent rub test (Section 3.1.1.3. of this JTP) because the MEK solvent rub test is more stringent.

Test Methodology

Parameters	MEK saturated cheese cloth, 50 double rubs
Number and Type of Test Coupons	2 AL1, 2 ST, 2 C/E
Trials Per Test Coupon	3 (*)
Acceptance Criteria	No exposure of substrate

(*) Perform second and third trials on coupon areas that have not previously been rubbed.

Data Analysis

One color photograph of a coupon coated with each candidate primer and of a coupon coated with the baseline primer shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.2.1.7. Wet Tape Adhesion Test

Test Description

This test method covers a procedure for establishing adequacy of intercoat and surface adhesion of an organic coating immersed in water by applying pressure-sensitive tape over a scribed area of the coating.

Perform this test as described in Section 3.1.1.4., except immerse coupons for 4 days (instead of 24 hours) and immerse in water that is at $49 \pm 3^{\circ}\text{C}$ ($120 \pm 5^{\circ}\text{F}$) (instead of room temperature).

Rationale

NAVAIR requires this test for validation of the candidate primers.

Test Methodology

Parameters	4 day immersion in distilled water at $49 \pm 3^{\circ}\text{C}$ ($120 \pm 5^{\circ}\text{F}$)
Number and Type of Test Coupons	3 AL1, 3 AL4, 3 AL5, 3 AL6, 3 G/E, 3 C/E, 3 A/E
Trials Per Test Coupon	1
Acceptance Criteria	No peel away

Unique Equipment and Instrumentation

- Refer to Section 3.1.1.4.

Data Analysis

- Refer to Section 3.1.1.4.

3.2.2. Extended Test Requirements for Candidate Primer/Topcoat Systems

Program-specific requirements for candidate primer/topcoat systems are described in Sections 3.2.2.1. through 3.2.2.15. At least two of these tests (chromaticity and infrared reflectance) are dependent upon the color of the topcoat. A representative list of topcoat colors currently applied by Lockheed Martin for the Air Force, Army, and Navy is in Appendix B.

In addition to test coupons coated with the candidate primer/topcoat systems, a set of baseline coupons will be prepared by priming with a coating that is qualified as a Type 1 (standard pigment) Class C (strontium

chromate based corrosion inhibitor) MIL-P-23377G (*High-Solids Epoxy Primer Coatings*, issued September 30, 1994) coating and topcoating with a coating that conforms to either MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990) or MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993). Only the substrate types that are required for testing the candidate coatings will be used for the baseline coupons (Refer to Test Methodology in individual sections). For comparison purposes, the set of baseline coupons used in each test will be subjected to the same procedure as that required for the coupons coated with candidate primer/topcoat systems. Refer to the below table for baseline coating systems that will be used for tests in Sections 3.2.2.1. through 3.2.2.15. of this JTP. |

JTP Section	Test Name	Baseline Coupons	
		MIL-P-23377G/ MIL-C-85285B	MIL-P-23377G/ MIL-C-46168D
3.2.2.1	Accelerated Weather	X	
3.2.2.2	Chemical Agent Resistance (Agents HD and GD)		X
3.2.2.3	Chromaticity		X
3.2.2.4	DS2 Decontaminant Resistance		X
3.2.2.5	Gloss (Very Low)		X
3.2.2.6	Impact Flexibility	X	
3.2.2.7	Infrared Reflectance	X	X
3.2.2.8	Low Temperature Flexibility	X	
3.2.2.9	Rain	X	
3.2.2.10	Recoatability	X	
3.2.2.11	Solvent (MEK) Rub	X	
3.2.2.12	Specialized Fluid Resistance	X	
3.2.2.13	Strippability Test	X	X
3.2.2.14	Temperature Shock	X	
3.2.2.15	Wet Tape Adhesion	X	

3.2.2.1. Accelerated Weather Test

Test Description

This test measures the ability of a coating to withstand accelerated weathering in a weather-ometer chamber.

Perform this test in accordance with Test Method 1 of ASTM G 26-90 (*Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials*, approved January 26, 1990).

Measure the initial color of the coated coupon in accordance with ASTM D 2244-89 (*Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates*, approved October 27, 1989). Place test coupons into a xenon-arc weather-ometer. Operate the weather-ometer at the conditions specified in Test Methodology. Measure the color change of the coated coupon in accordance with ASTM D 2244-89.

Rationale

Accelerated weathering is included as a requirement in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990); MIL-C-22750F (*High-Solids Epoxy Coating*, issued May 31, 1994); and MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993). The accelerated weathering tests in each of these military specifications conform to ASTM G 26-90.

The acceptance criteria for this section are more stringent than those in Section 3.1.2.1. of this JTP; these more stringent criteria are required by at least one of the affected programs.

Test Methodology

Parameters	<ul style="list-style-type: none"> • 60 ± 3°C (140 ± 5°F) • 50 ± 5 % RH • One cycle: 102 minutes of light only and 18 minutes of light and water spray • 0.35 Watts/m² Incident at 340 nanometers • Operate for 500 hours (250 cycles)
Number and Type of Test Coupons	3 AL1
Trials Per Test Coupon	1
Acceptance Criteria	Color change (ΔE) ≤ 1 unit

Unique Equipment and Instrumentation

- Xenon arc weather-ometer (Apparatus Type BH in ASTM G 26-90)
- Digital colorimeter

Data Analysis

- Report results as color differences and any changes of the coating that are visually observed.
- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.2.2.2. Chemical Agent Resistance Tests (Agents HD and GD)

Test Description

This test will measure the tendency of a primer/topcoat system to retain Agents HD and GD.

Mark a 5 cm² area in the center of the test coupon and place the coupon in a fume hood. Contaminate the marked area dropwise with a syringe. Keep the area wet with the designated Agent for 30 minutes and then clean with isopropyl alcohol. Place a stainless steel permeation cell over the contaminated area and sample through the bubbler. Agent vapors will be picked up in the hexylene glycol in the bubbler. Continuously sample for 24 hours. Test the hexylene glycol for presence of Agent by an appropriate colorimetric method.

Rationale

MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993) requires the test for Agents HD and GD. At least one program requires resistance to retention of Agents HD and GD. This test will follow the procedure in the proposed revisions of MIL-C-46168C (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued March 28, 1984). These revisions do not change the test of MIL-C-46168C or MIL-C-46168D, but require additional quality control measures to ensure repeatability of tests. MIL-C-46168D does not include these proposed revisions, but they are valid and are intended to be included in the next version of the military standard.

The specified bubbler solvent, hexylene glycol, is different from the bubbler solvent required by MIL-C-46168D. This change was recommended by Dugway Proving Grounds, which is certified to perform this test. This recommendation was approved by the technical representatives.

Test Methodology

	Agent HD	Agent GD
Parameters	Bubbler apparatus, 25°C	Bubbler apparatus, 25°C
Number and Type of Test Coupons	3 ST	3 ST
Trials Per Test Coupon	1	1
Acceptance Criteria	Desorb 180 µg maximum	Desorb 40 µg maximum

Unique Equipment and Instrumentation

- Bubbler apparatus
- Colorimetric apparatus
- Stainless steel permeation cell
- Fume hood

Data Analysis

- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Report the amount of desorption of the chemical agent.

3.2.2.3. Chromaticity Test

Test Description

This test will measure whether or not the candidate topcoats meet color matching requirements.

Perform this test in accordance with ASTM E 1164-91 (*Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation*, approved February 22, 1991).

Use a color spectrophotometer to calculate the color difference in National Bureau of Standards (NBS) units. Chemical agent resistant coatings (CARCs) shall fall within 2.0 NBS units of the values listed in Table 5 of this document when calculated using the average brightness of the range specified in the same table. Figures 4 through 16 of MIL-C-53039A (*Chemical Agent Resistant Single-Component Aliphatic Polyurethane*

Coating, issued May 19, 1993) may be used as approximate guidelines for chromaticity limits. All other colors tested must match the appropriate color chip specified by FED-STD-595B (*Colors Used in Government Procurement*, issued December 15, 1989).

Rationale

At least one program identified the need for chromaticity testing for the topcoats listed in Tables 5 and 6 of this JTP. Color requirements for standard camouflage and aircraft colors must match the performance requirements of MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993) or MIL-C-53039A. Acceptance criteria are the same in these standards, except for Field Drab (33105), in which the requirement of MIL-C-46168D (0.389 for the Chromaticity y-value) was selected over the requirement for MIL-C-53039A (0.383 for the Chromaticity y-value).

Test Methodology

Parameters	None
Number and Type of Test Coupons	3 AL1
Trials Per Test Coupon	1
Acceptance Criteria	CARC: Color within 2.0 NBS units of chromaticity coordinates in Table 5 of this JTP. Other identified colors (refer to Table 6 of this JTP) must match appropriate color chip from FED-STD-595B.

Unique Equipment and Instrumentation

Spectrophotometer

Table 5. CARC Chromaticity Acceptance Criteria for Topcoat Colors Used at Lockheed Martin Electronics & Missiles Company or Lockheed Martin Information Systems Company

Color	Reference Number*	Use		Affected Military Branch at Lockheed Martin			Chromaticity Coordinates		Average Brightness (Y)
		Aircraft	Camouflage	Air Force	Army	Navy	x	y	
Brown 383	30051		X		X		0.357	0.342	0.060-0.080
Field Drab	33105		X				0.390	0.389	0.093-0.117
Earth Yellow	33245		X		X		0.420	0.395	0.228-0.263
Sand	33303		X				0.360	0.366	0.284-0.323
Tan 686	33446		X		X		0.368	0.364	0.360-0.400
Dark Green	34082	X	X				0.339	0.390	0.071-0.091
Green 383	34094	X	X		X	X	0.328	0.365	0.063-0.083
Black	37030		X		X	X	0.310	0.315	0.030-0.041

* Refer to FED-STD-595B (*Colors Used in Government Procurement*, issued December 15, 1989).

Table 6. Other Topcoat Colors Used at Lockheed Martin Electronics & Missiles Company or Lockheed Martin Information Systems Company that Must Match the Specified Color Chip

Color	Reference Number*	Affected Military Branch		
		Air Force	Army	Navy
Gloss White	17925	X		X
Aircraft Red	31136		X	
Dark Sandstone	33510		X	
Aircraft Yellow	33538		X	
Aircraft Green	34031		X	
Field Green	34059	X		X
Olive Drab	34088		X	
Field Green	34095	X		
Aircraft Insignia Blue	35044		X	
Light Gray	36173	X		X
Interior Aircraft Gray	36231		X	
Aircraft Gray	36300		X	
Flat Gray	36375	X		X
Interior Aircraft Green	37031		X	
Aircraft Black	37038		X	
Aircraft White	37875		X	

* Refer to FED-STD-595B (*Colors Used in Government Procurement*, issued December 15, 1989).

3.2.2.4. DS2 Decontaminant Resistance Test

Test Description

This test evaluates a primer/topcoat system's resistance to degradation by DS2.

After coating, air dry the test coupon for four days and then bake for three days at $105 \pm 3^{\circ}\text{C}$ ($221 \pm 5^{\circ}\text{F}$). Allow the coupon to return to room temperature. Place two separate spots (approximately 0.5 milliliters each) of decontaminating solution DS2 conforming to MIL-D-50030H (*Decontaminating Agent, DS2*, issued April 2, 1993) on the coupon. Let the coupon stand for 30 minutes uncovered, then thoroughly rinse it with tap water. Visually inspect the specimen for blistering, wrinkling, or softening.

Rationale

At least one program identified requirements for DS2 resistance as contained in MIL-C-22750F (*High-Solids Epoxy Coating*, issued May 31, 1994) and MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993). The test procedure is described in those documents.

The curing schedule follows that of MIL-C-22750F. MIL-C-46168D requires one day of air drying and one day of baking at $105 \pm 3^{\circ}\text{C}$ ($221 \pm 5^{\circ}\text{F}$).

Test Methodology

Parameters	2 drops DS2, 30 minutes
Number and Type of Test Coupons	3 ST
Trials Per Test Coupon	1
Acceptance Criteria	No blistering, wrinkling, or softening

Unique Equipment and Instrumentation

Oven capable of $105 \pm 3^{\circ}\text{C}$ for three days.

Data Analysis

One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.2.2.5. Gloss Tests (Very Low)

Test Description

This test measures the specular gloss of nonmetallic coatings for glossmeter geometries of 60°.

Perform this test in accordance with ASTM D 523-89 (*Standard Test Method for Specular Gloss*, approved March 31, 1989, reapproved October 1994).

Calibrate a glossmeter capable using a NIST traceable standard. Measure the gloss at three different places on the coupon and record the average. After every thirty specular gloss measurements, check calibration and recalibrate if necessary.

Rationale

The test procedure in this JTP is the same as for MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993), and the acceptance criteria were derived from MIL-C-46168D.

Test Methodology

Parameters	Gloss - Very Low		
	Fixed Wing Aircraft	Ground Equipment	Rotary Wing Aircraft
Number and Type of Test Coupons	1 G/E 1 C/E 1 A/E	1 G/E 1 C/E 1 A/E	1 G/E 1 C/E 1 A/E
Trials Per Test Coupon	3	3	3
Acceptance Criteria	≤ 3.0 gloss units	≤ 1.0 gloss units	≤ 0.5 gloss units

Unique Equipment and Instrumentation

Glossmeter capable of reading at 60°

Data Analysis

Report the mean specular gloss.

3.2.2.6. Impact Flexibility Test

Test Description

This test assesses the resistance of a coating to cracking and adhesion loss due to a sudden impact.

Perform this test in accordance with ASTM D 2794-92 (*Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)*), approved September 15, 1992).

Place one test coupon coating side up (direct) in the testing apparatus. Drop a two pound weight with a 0.625 inch diameter indenter so the full outline of the mandrel is indented onto the coupon. Visually inspect the coupon for cracks where the impact occurred.

Place another test coupon coated side down (reverse) in the testing apparatus. Drop a two pound weight with a 0.5 inch diameter indenter so the full outline of the mandrel is indented onto the coupon. Visually inspect the coupon for cracks where the impact occurred.

Rationale

This extended flexibility test was identified by at least one program as a technical requirement. The reverse and direct impact tests conform to ASTM D 2794-92.

This test requires that the aluminum test coupons be zero-temper. The formability of zero-temper coupons will ensure that the coupon is easily deformed to the exact dimensions of the mandrel when impacted.

Test Methodology

Parameters	Direct impact: 0.625" mandrel
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	Reverse impact: 0.5” mandrel
Number and Type of Test Coupons	2 AL1 (*)
Trials Per Test Coupon	1
Acceptance Criteria	No adhesion loss

(*) This must be a zero-temper alloy for appropriate results. Use one test coupon for the direct impact and one test coupon for the reverse impact.

Unique Equipment and Instrumentation

Impact tester with 0.625 inch and 0.5 inch diameter indenters

Data Analysis

One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.2.2.7. Infrared Reflectance Test

Test Description

This testing method measures the infrared (IR) reflectance of a candidate topcoat.

Measure the total reflectance (specular and diffuse) of the test coupon within the specified wavelength range (refer to Test Methodology) relative to barium sulfate using a Perkin-Elmer LAMBDA 9 spectrophotometer or equivalent.

Rationale

IR reflectance is critical for some topcoats, such as CARCs used on aircraft exteriors and ground support equipment.

At least one program identified requirements for IR reflectance as contained in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990); MIL-C-22750F (*High-Solids Epoxy Coating*, issued May 31, 1994); MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993); and MIL-C-53039A (*Chemical Agent Resistant Single-Component Aliphatic Polyurethane Coating*, issued May 19, 1993). Test procedures are also described in Method 6242 of FED-STD-141C (*Paint, Varnish, Lacquer and Related*

Materials: Methods of Inspection, Sampling and Testing, issued January 24, 1986). Reflectance values are based on the military specifications and colors. The requirement stated in this document for Field Green (34095) is based on MIL-C-85285B and MIL-C-22750F.

Test Methodology

Parameters	Refer to Table 8 for selected wavelengths for determining IR reflectance values for Table 7.
Number and Type of Test Coupons	2 AL1
Trials Per Test Coupon	1
Acceptance Criteria (*)	Depends upon specific color. Refer to Tables 7 and 9 of this JTP. Field Green (34095): reflectance \leq 8% reflectance in 450-500 and 600-2700 nm wavelength ranges and reflectance \leq 10% in 500-600 nm wavelength range

(*) Individual weapon systems may have acceptance criteria that can not be listed in this JTP; these needs will take preference over the above acceptance criteria and will be considered when reviewing the results from this test.

Table 7. IR Reflectance Acceptance Criteria for Specific Colors¹

Color	Reference Number ²	Acceptance Criteria % IR Reflectance	
		Minimum ³	Maximum IR ³
Brown 383	30051	8.0	20.0
Field Drab	33105	25.0	35.0
Earth Yellow	33245	30.0	40.0
Sand	33303	55.0	65.0
Tan 686A	33446	40.0	50.0
Dark Sandstone	33510	--	45.0
Aircraft Green	34031	--	7.0
Dark Green ⁴	34082	--	60.0
Green 383 ⁴	34094	--	60.0
Aircraft Gray	36300	--	15.0
Interior Aircraft Black	36301	--	7.0
Black	37030	0.0	15.0

¹ Refer to Table 8 for the specified wavelengths.

² Refer to FED-STD-595B (*Colors Used in Government Procurement*, issued December 15, 1989).

³ Mean specular gloss, based on refractive index of the coating and the geometry used.

⁴ Refer to Table 9 for additional IR reflectance criteria.

**Table 8. Selected Wavelengths for Determining IR Reflectance Values from Spectrophotometric Curves
(in nanometers)**

714	769	816
725	773	821
730	777	826
737	783	831
742	787	836
747	793	842
751	797	848
756	802	855
760	807	862
764	811	873

Table 9. Additional IR Reflectance Acceptance Criteria for Dark Green 34082* and Green 383, 34094*

Wavelength	Acceptance Criteria % IR Reflectance	
	Minimum	Maximum
600	--	10.2
610, 620, 630	--	9.8
640, 650	--	9.5
660	--	10.0
670	4.0	10.5
680	5.8	13.0
690	8.5	21.5
700	11.0	28.0
710	15.0	35.8
720	19.0	41.0
730	25.0	48.5
740	30.0	51.8
750	36.3	56.0
760	40.0	59.5
770	42.0	61.5
780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900	42.0	--

* Refer to FED-STD-595B (*Colors Used in Government Procurement*, issued December 15, 1989).

Unique Equipment and Instrumentation

Perkin-Elmer LAMBDA 9 spectrophotometer or equivalent

Data Analysis

Record color of primer and topcoat and report all IR reflectance measurements.

3.2.2.8. Low Temperature Flexibility Test

Test Description

This test assesses the resistance of a coating to cracking or adhesion loss when bent over a mandrel at low temperature.

Perform this test in accordance with ASTM D 522-92 (*Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings*, approved March 15, 1992).

Place test coupon into a cold chamber at $-50 \pm 3^{\circ}\text{C}$ ($-60 \pm 5^{\circ}\text{F}$) for 30 minutes. Remove from cold chamber. Within one minute, place the test coupon over a two-inch (low gloss coatings) or one-inch (semi and high gloss coatings) diameter mandrel and bend. Visually inspect the coupon for cracking and adhesion loss.

Rationale

This flexibility test was identified by at least one program as a technical requirement. It is included in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990). Uniform mandrels are used instead of tapered mandrels to prevent adhesion loss due to crack propagation.

The test durations were chosen to be similar to test durations for the thermal shock resistance test in the *Joint Test Protocol (LM-P-1-2) for Validation of Alternatives to Solvent-Based Ink Stenciling for Identification Marking*. Thirty minute test durations were believed to be sufficient due to the simple geometry and low thermal mass of the test coupons. This test requires that the aluminum test coupons be zero-temper so that the rigidity of the coupon will not interfere with the bending of the coupon and coating around the mandrel.

Test Methodology

Parameters	-50 ± 3°C High gloss and semi gloss: 1” mandrel Low gloss: 2” mandrel
Number and Type of Test Coupons	3 AL2 (*)
Trials Per Test Coupon	1
Acceptance Criteria	No adhesion loss

(*) This must be a zero-temper alloy for appropriate results.

Unique Equipment and Instrumentation

- Cold chamber capable of maintaining -50 ± 3°C
- 1 inch and 2 inch mandrels

Data Analysis

One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.2.2.9. Rain Test

Test Description

This rain test will simulate an outside environment to measure the resistance that a coating has to erosion and adhesion loss caused by rain.

Expose the test coupon to rain produced by a water distribution device so that the water is emitted as droplets with diameters between 0.5 to 4.5 millimeters. Set the environmental chamber so that the rain is dispersed completely over the test coupon by a wind velocity no less than 18 m/s. After adjusting the rainfall rate and velocity, leave the test coupon in the chamber for 30 minutes. Visually inspect for erosion of coating and loss of coating adhesion.

Rationale

At least one affected program identified the requirements for a rain test. This test is based on the rain test in the Texas Instruments Defense Systems & Electronics Joint Test Protocol entitled *Joint Test Protocol (TI-P-1-1) for Alternatives to High Volatile Organic Compounds (VOCs)*

Primers and Topcoats Containing: Methyl Ethyl Ketone (MEK), Toluene, and Xylene, dated June 20, 1996.

Test Methodology

Parameters	0.5 to 4.5 mm droplets; 18 m/sec wind; 30 minutes
Number and Type of Test Coupons	1 AL1, 1 AL2, 1 AL3
Trials Per Test Coupon	1
Acceptance Criteria	No loss of adhesion. No erosion of coating.

Unique Equipment and Instrumentation

Environmental chamber capable of producing rain and wind

Data Analysis

- Report any erosion of coating, corrosion, or loss of adhesion.
- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.2.2.10. Recoatability Test

Test Description

This test procedure will measure the ability of a topcoat to be recoated with the same topcoat, thereby testing for compatibility with field operations.

Apply an additional layer of candidate topcoat to a fully cured test coupon that was originally coated with a primer and the same candidate topcoat. Allow the topcoat to cure in accordance with manufacturer's recommendations. Visually inspect. Evaluate adhesion in accordance with Section 3.1.2.11. of this JTP.

Rationale

At least one affected program identified this requirement for topcoats. This test is included to ensure that the coating can be touched up in the event of damage. It requires a tape adhesion test in addition to a visual inspection as specified in MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993).

Test Methodology

Parameters	None
Number and Type of Test Coupons	2 AL1
Trials Per Test Coupon	1
Acceptance Criteria	Adhesion per Section 3.1.2.11 of this JTP.

Unique Equipment and Instrumentation

Unique equipment and instrumentation required for the wet tape adhesion test (Section 3.1.2.11. of this JTP).

Data Analysis

- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Record adhesion test results and visual observations.

3.2.2.11. Solvent (MEK) Rub Test

Test Description

This test demonstrates the effect of MEK on a primed and topcoated test coupon.

Perform this test in accordance with ASTM D 4752-87 [*Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub*, approved November 27, 1987].

Cure the primer/topcoat system according to manufacturer’s specifications. Saturate cheese cloth with MEK. Double rub (back-and-forth motion) a 2-inch area on the test coupon with the cloth, ensuring the cloth is saturated with MEK at all times. Examine the test coupon to determine if the coating has been worn through, exposing the primer or substrate.

Rationale

This test is specified in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990) and is similar to ASTM D 4752-87. The military specification requires a cotton, terry-cloth rag; however, ASTM D 4752-87 suggests the use of cheese cloth, which is specified for this test. An MEK solvent rub test is required by some programs in addition to the acetone solvent rub test (Section 3.1.2.9. of this JTP) because the MEK solvent rub test is more stringent.

Test Methodology

Parameters	MEK saturated cheese cloth, 50 double rubs
Number and Type of Test Coupons	2 AL1, 2 ST, 2 C/E
Trials Per Test Coupon	3 (*)
Acceptance Criteria	No exposure of primer or substrate

(*) Perform second and third trials on coupon areas that have not previously been rubbed.

Data Analysis

One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.2.2.12. Specialized Fluid Resistance Test

Test Description

This test method determines the effects of certain fluids (i.e. Coolanol, PAO, hydraulic fluid (MIL-H-5606G and MIL-H-83282C), lubricating oil (MIL-L-23699E), Skydrol, or JP-5 (MIL-T-5624R)) on organic finishes. Effects may include objectionable alteration in the surface such as discoloration, change in gloss, blistering, softening, or swelling.

Perform this test in accordance with ASTM D 1308-87 (*Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes*, approved May 29, 1987), except use the chemicals specified in Test Methodology in place of the chemicals in the standard.

Separately immerse test coupons in chemicals listed in Test Methodology at the indicated temperatures and durations. When coupons are removed from the chemical, rinse with distilled water. Within four hours after removal, examine the coupons for blistering, softening, dark staining, or other film defects.

Rationale

At least one program has a requirement that the coating system be resistant to the listed operational chemicals that are encountered frequently. Fluid resistance tests are contained in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990); MIL-C-22750F (*High-Solids Epoxy Coating*, issued May 31, 1994); and MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993). MIL-C-46168D requires an exposure of seven days at room temperature for lubricating oil and hydraulic fluid. Technical representatives elected to adopt the parameters and chemicals contained in MIL-C-85285B and MIL-C-22750F. The test procedure in the military specifications conforms to ASTM D 1308-87.

Test Methodology

Parameters	<p>7 day immersion at room temperature</p> <ul style="list-style-type: none"> • Coolanol • PAO • Hydraulic fluid (MIL-H-5606G) • Skydrol • JP-5 (MIL-T-5624R) <p>24 hour immersion at 150 ± 5°F</p> <ul style="list-style-type: none"> • Hydraulic fluid (MIL-H-83282C) <p>24 hour immersion at 250 ± 5°F</p> <ul style="list-style-type: none"> • Lubricating oil (MIL-L-23699)
Number and Type of Test Coupons	For 7 day immersion: 1 AL1 per fluid For 24 hour immersion: 6 AL1 per fluid
Trials Per Test Coupon	1
Acceptance Criteria	No blistering, dark staining, or softening

Data Analysis

- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Report visual observations.

3.2.2.13. Strippability Test

Test Description

Expose the coated coupons as described in the Accelerated Weather test in Section 3.1.2.1. Color change measurements are not necessary for this test.

After exposure, coat the surface of the test coupon with Turco #5351 stripper or equivalent. Leave the stripping chemical on the surface for one hour. After the primer/topcoat system has been exposed to the stripping chemical for one hour, brush the coupon surface with a stiff, nonmetallic brush while rinsing with cool water. Visually examine each coupon.

Rationale

Strippability of a coating is critical to the Sustainment Community and is therefore added as an extended requirement. Some weapon system programs may not require strippability because their systems do not require maintenance.

An Accelerated Weather test was chosen for exposure because primer/topcoat systems applied to weapon systems must be removed after extended periods of use, so evaluation of the ease of chemically removing candidate primer/topcoat systems after aging is necessary to predicting operation performance.

The choice of chemical stripper, chemical stripper exposure duration, and acceptance criteria was based on *Joint Test Protocol, MD-P-1-1 for Validation of Alternatives to Chromate-Containing Primer Coatings for Aircraft Exterior Mold Line Skins*, dated December 23, 1997.

Test Methodology

Parameters	<ul style="list-style-type: none">• $60 \pm 3^{\circ}\text{C}$ ($140 \pm 5^{\circ}\text{F}$)• $50 \pm 5\%$ RH• One cycle: 102 minutes of light only and 18 minutes of light and water spray• 0.35 Watts/m^2 Incident at 340 nanometers• Operate for 500 hours (250 cycles)• One hour of chemical stripper exposure
Number and Type of Test Coupons	3 AL1
Trials Per Test Coupon	1
Acceptance Criteria	90% removal of primer after 60 minutes contact with stripping chemical

Unique Equipment and Instrumentation

- Xenon arc weather-ometer (Apparatus Type BH in ASTM G 26-90)
- Turco #5351 stripper or equivalent

Data Analysis

- Report the percentage of coating removed
- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.

3.2.2.14. Temperature Shock Test

Test Description

This is a test method for determining the effects of extreme temperature changes on the adhesion of a candidate topcoat/primer system to a substrate material.

Expose the test coupon to $-62 \pm 3^{\circ}\text{C}$ ($-80 \pm 5^{\circ}\text{F}$) for 30 minutes in a cold chamber. Remove the test coupon from the chamber and transfer it to an oven at $95 \pm 3^{\circ}\text{C}$ ($203 \pm 5^{\circ}\text{F}$) within one minute. Remove the test coupon from the oven after 30 minutes. Within 30 minutes after removal from the oven, evaluate adhesion per Section 3.1.2.11. of this JTP.

Rationale

This test was identified by at least one program as a performance requirement. The thermal shock resistance test was developed by Lockheed Martin and technical representatives to measure the ability of an ink or self-adhesive label to withstand a rapid temperature change, as documented in the *Joint Test Protocol (LM-P-1-2) for Validation of Alternatives to Solvent-Based Ink Stenciling for Identification Marking*. Thirty minute test durations were believed to be sufficient due to the simple geometry and low thermal mass of the test coupons.

Test Methodology

Parameters	30 minutes at -62°C, then 30 minutes at +95°C
Number and Type of Test Coupons	1 AL1, 1 AL2, 1 AL3, 1 ST, 1 G/E, 1 C/E, 1 A/E
Trials Per Test Coupon	1
Acceptance Criteria	Adhesion per Section 3.2.1.11 of this JTP.

Unique Equipment and Instrumentation

- Cold chamber capable of maintaining $-62 \pm 3^{\circ}\text{C}$
- Oven capable of maintaining $95 \pm 3^{\circ}\text{C}$
- Unique equipment and instrumentation required for the wet tape adhesion test (Section 3.1.2.11 of this JTP).

Data Analysis

- One color photograph of a coupon coated with each candidate primer/topcoat system and of a coupon coated with the baseline primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Report adhesion test results.

3.2.2.15. Wet Tape Adhesion Test

Test Description

This test method covers a procedure for establishing adequacy of intercoat and surface adhesion of an organic coating immersed in water by applying pressure sensitive tape over a scribed area of the coating.

Perform this test as described in Section 3.1.2.11., except immerse coupons for 4 days (instead of 24 hours) and immerse in water that is at $49 \pm 3^{\circ}\text{C}$ ($120 \pm 5^{\circ}\text{F}$) (instead of room temperature).

Rationale

NAVAIR requires this test for validation of the candidate primer/topcoat systems.

Test Methodology

Parameters	4 day immersion in distilled water at $49 \pm 3^{\circ}\text{C}$ ($120 \pm 5^{\circ}\text{F}$)
Number and Type of Test Coupons	3 AL1, 3 AL6, 3 G/E, 3 C/E, 3 A/E
Trials Per Test Coupon	1
Acceptance Criteria	No peel away

Unique Equipment and Instrumentation

- Refer to Section 3.1.2.11.

Data Analysis

- Refer to Section 3.1.2.11.

4. REFERENCE DOCUMENTS

The documents in Table 10 were referenced in the development of this JTP. In addition, this report was leveraged from the Texas Instruments Defense Systems & Electronics Joint Test Protocol entitled *Joint Test Protocol (TT-P-1-1) for Alternatives to High Volatile Organic Compounds (VOCs) Primers and Topcoats Containing: Methyl Ethyl Ketone (MEK), Toluene, and Xylene*, dated June 20, 1996.

Table 10. Reference Documents

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Test Coupon Preparation	3	AMS 4218	Aluminum Alloy Castings 7.0si 0.35MG, Solution and Precipitation Heat Treated (January 1994)	All
		ANSI/ASME B46.1-1985	Surface Texture (October 7, 1985)	All
		ASTM D 724-89	Standard Test Method for Surface Wettability of Paper (Angle-of-Contact Method) (May 26, 1989)	All
		ASTM E 376-89	Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods (October 27, 1989)	All
		ASTM F 22-65	Standard Test Method for Hydrophobic Surface Films by the Water-Break Test (August 31, 1965)	All

(Table continued next page.)

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Test Coupon Preparation <i>continued</i>	3	MIL-C-5541E	Chemical Conversion Coatings on Aluminum and Aluminum Alloys (November 30, 1990)	All
		MIL-P-85582B	Waterborne Epoxy Primer Coatings (August 31, 1994)	All
		MIL-S-13949H	Printed Wiring Board Sheet (August 16, 1993)	All
		O-A-51H	Acetone, Technical (April 23, 1992)	All
		QQ-A-250F	General Specification for Aluminum and Aluminum Alloy Plate and Sheet (September 25, 1978)	All
		TT-I-735A	Isopropyl alcohol (November 5, 1991)	All
Filiform Corrosion Resistance	3.1.1.1	MIL-P-23377G	High-Solids Epoxy Primer Coatings (September 30, 1994)	3.8.2.2 4.6.7.2
		MIL-P-85582B	Waterborne Epoxy Primer Coatings (August 31, 1994)	3.7.2.2 4.6.8.2
Salt Spray Resistance	3.1.1.2 3.1.2.8	ASTM B 117-94	Standard Practice for Operating Salt Spray (Fog) Testing Apparatus (February 15, 1994)	All
		MIL-P-23377G	High-Solids Epoxy Primer Coatings (September 30, 1994)	3.8.2.1.1 4.6.7.1.1

(Table continued next page.)

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Solvent (Acetone or MEK) Rub	3.1.1.3 3.1.2.9 3.2.1.6 3.2.2.11	ASTM D 4752-87	Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub (November 27, 1987)	All
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.8.5 4.6.11
Wet Tape Adhesion	3.1.1.4 3.1.2.11 3.2.1.7 3.2.2.15	ASTM D 724-89	Standard Test Method for Surface Wettability of Paper (Angle-of-Contact Method) (May 26, 1989)	All
		ASTM D 3359-92a	Standard Test Methods for Measuring Adhesion by Tape Test (May 15, 1992)	Method A
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.7.7 4.6
Accelerated Weather	3.1.2.1 3.2.2.1	ASTM D 2244-89	Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates (October 27, 1989)	All
		ASTM G 26-90	Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials (January 26, 1990)	Method 1
		MIL-C-22750F	High-Solids Epoxy Coating (May 31, 1994)	3.8.7 4.6.11

(Table continued next page.)

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Accelerated Weather <i>continued</i>	3.1.2.1 3.2.2.1	MIL-C-46168D	Chemical Agent Resistant Aliphatic Polyurethane Coating (May 21, 1993)	3.6.15 4.3.26
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.8.2 4.6.9
Cleanability	3.1.2.2	MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.9.3 4.6.13
		MIL-H-83282C	Fire Resistant Synthetic Base Aircraft Hydraulic Fluid (March 25, 1986)	All
Fungus Resistance	3.1.2.3	MIL-STD-810E	Department of Defense Test Method Standard for Environmental Considerations and Laboratory Tests (July 14, 1989)	Method 508
Gloss	3.1.2.4 3.2.2.5	ASTM D 523-89	Standard Test Method for Specular Gloss (March 31, 1989)	All
		MIL-C-22750F	High-Solids Epoxy Coating (May 31, 1994)	3.7.5 4.5-4.5.2
		MIL-C-46168D	Chemical Agent Resistant Aliphatic Polyurethane Coating (May 21, 1993)	4.3.10
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.7.5 4.6
Heat Resistance	3.1.2.5	ASTM D 2244-89	Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates (October 27, 1989)	All

(Table continued next page.)

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Heat Resistance <i>continued</i>	3.1.2.5	MIL-C-22750F	High-Solids Epoxy Coating (May 31, 1994)	3.8.2 4.6.6
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.8.4 4.6.10
Hiding Power	3.1.2.6	ASTM D 2805-88	Standard Test Method for Hiding Power of Paints by Reflectometry (March 25, 1988)	All
		MIL-C-22750F	High-Solids Epoxy Coating (May 31, 1994)	3.7.6 4.6.4
		MIL-C-46168D	Chemical Agent Resistant Aliphatic Polyurethane Coating (May 21, 1993)	4.3.8
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.7.6 4.6
		Powder Coating Institute Procedure 3	Contrast Ratio for Determining Hiding Power for Powder Coatings (August 1989)	All
Humidity	3.1.2.7	ASTM D 2247-92	Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity (May 15, 1992)	All
		FED-STD-141C	Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing (January 24, 1986)	Method 6201

(Table continued next page.)

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Humidity <i>continued</i>	3.1.2.7	MIL-C-83286B	Aliphatic Isocyanate Urethane Coating for Aerospace Applications (canceled January 21, 1994)	Humidity Requirement
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.8.3 4.6
Tape Resistance	3.1.2.10	ASTM D 523-89	Standard Test Method for Specular Gloss (March 31, 1989)	All
		ASTM D 724-89	Standard Test Method for Surface Wettability of Paper (Angle-of-Contact Method) (May 26, 1989)	All
		MIL-C-22750F	High-Solids Epoxy Coating (May 31, 1994)	3.8.4 4.6.8
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.8.6 4.6.12
Cryoflex Cryogenic Compatibility	3.2.1.1	--	--	--
Cryogenic Flexibility	3.2.1.2	--	--	--
Fluid Immersion (Hydraulic Fluid, Lubricating Oil)	3.2.1.3	ASTM D 1308-87	Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes (May 29, 1987)	7.1 7.4
		MIL-C-22750F	High-Solids Epoxy Coating (May 31, 1994)	3.8.1 4.6.5

-- indicates that the test is not based on a federal, military, or trade association standard.

(Table continued next page.)

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Fluid Immersion (Hydraulic Fluid, Lubricating Oil) <i>continued</i>	3.2.1.3	MIL-C-46168D	Chemical Agent Resistant Aliphatic Polyurethane Coating (May 21, 1993)	3.6.9 4.3.20
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.8.1 4.6.8
		MIL-H-83282C	Fire Resistant Synthetic Base Aircraft Hydraulic Fluid (March 25, 1986)	All
		MIL-L-23699E	Synthetic Base Aircraft Turbine Engine Oil (November 23, 1994)	All
Primer Adhesion	3.2.1.4	ASTM D 4541-93	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers (October 15, 1993)	All
Primer/Insulation Foam Adhesion	3.2.1.5	ASTM D 1623-78	Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics (May 26, 1978)	Type B
Chemical Agent Resistance Tests (Agents HD and GD)	3.2.2.2	MIL-C-46168C	Chemical Agent Resistant Aliphatic Polyurethane Coating (March 28, 1984)	Proposed Revisions
		MIL-C-46168D	Chemical Agent Resistant Aliphatic Polyurethane Coating (May 21, 1993)	3.6.14 4.3.25
Chromaticity	3.2.2.3	ASTM E 1164-91	Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation (February 22, 1991)	All

(Table continued next page.)

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Chromaticity <i>continued</i>	3.2.2.3	FED-STD-595B	Colors Used in Government Procurement (December 15, 1989)	All
		MIL-C-46168D	Chemical Agent Resistant Aliphatic Polyurethane Coating (May 21, 1993)	3.3 Figures 4-16
		MIL-C-53039A	Chemical Agent Resistant Single-Component Aliphatic Polyurethane Coating (May 19, 1993)	3.3.1 Figures 4-16
DS2 Decontamination	3.2.2.4	MIL-C-22750F	High-Solids Epoxy Coating (May 31, 1994)	3.8.5 4.6.9
		MIL-C-46168D	Chemical Agent Resistant Aliphatic Polyurethane Coating (May 21, 1993)	3.6.13 4.3.24
		MIL-D-50030H	Decontaminating Agent, DS2 (April 2, 1993)	All
Impact Flexibility	3.2.2.6	ASTM D 2794-92	Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact) (September 15, 1992)	All
Infrared Reflectance	3.2.2.7	FED-STD-141C	Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing (January 24, 1986)	Method 6242
		FED-STD-595B	Colors Used in Government Procurement (December 15, 1989)	All
		MIL-C-22750F	High-Solids Epoxy Coating (May 31, 1994)	3.7.4 4.6.3

(Table continued next page.)

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Infrared Reflectance <i>continued</i>	3.2.2.7	MIL-C-46168D	Chemical Agent Resistant Aliphatic Polyurethane Coating (May 21, 1993)	3.3 4.3.11
		MIL-C-53039A	Chemical Agent Resistant Single-Component Aliphatic Polyurethane Coating (May 19, 1993)	3.3.2 Table 1 4.3.11
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.7.4 4.6.6
Low Temperature Flexibility	3.2.2.8	ASTM D 522-92	Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings (March 15, 1992)	All
		LM-P-1-2	Joint Test Protocol (LM-P-1-2) for Validation of Alternatives to Solvent-Based Ink Stenciling for Identification Marking (draft as of January 6, 1997)	3.1.10 3.2.8 3.3.7
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.7.8 4.6.7
Rain	3.2.2.9	TI-P-1-1	Joint Test Protocol (TI-P-1-1) for Alternatives to High Volatile Organic Compounds (VOCs) Primers and Topcoats Containing: Methyl Ethyl Ketone (MEK), Toluene, and Xylene (June 20, 1996)	3.2.18

(Table continued next page.)

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Recoatability	3.2.2.10	MIL-C-46168D	Chemical Agent Resistant Polyurethane Coating (May 21, 1993)	3.6.7 4.3.18
Specialized Fluid Resistance	3.2.2.12	ASTM D 1308-87	Standard Test Method for Effect of Household Chemicals on Pigmented Organic Finishes (May 29, 1987)	7.1 7.4
		MIL-C-22750F	High-Solids Epoxy Coating (May 31, 1994)	3.8.1 4.6.5
		MIL-C-46168D	Chemical Agent Resistant Aliphatic Polyurethane Coating (May 21, 1993)	3.6.9 4.3.20
		MIL-C-85285B	High-Solids Polyurethane Coating (October 22, 1990)	3.8.1 4.6.8
		MIL-H-5606G	Petroleum Base Aircraft, Missile, and Ordnance Hydraulic Fluid (September 9, 1994)	All
		MIL-H-83282C	Fire Resistant Synthetic Base Aircraft Hydraulic Fluid (March 25, 1986)	All
		MIL-L-23699E	Synthetic Base Aircraft Turbine Engine Oil (November 23, 1994)	All
		MIL-T-5624R	Grades JP-4, JP-5, and JP-5/JP-8 ST Aviation Turbine Fuel (March 3, 1995)	All

(Table continued next page.)

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Strippability	3.2.2.13	MD-P-1-1	Joint Test Protocol (MD-P-1-1) for Validation of Alternatives to Chromate-Containing Primer Coatings for Aircraft Exterior Mold Line Skins (December 23, 1997)	3.6.10
Temperature Shock	3.2.2.14	LM-P-1-2	Joint Test Protocol (LM-P-1-2) for Validation of Alternatives to Solvent-Based Ink Stenciling for Identification Marking (draft as of January 6, 1997)	3.1.10 3.2.8 3.3.7

APPENDIX A
SCREENING TESTS



SCREENING TESTS

Screening tests for all candidate primers and primer/topcoat systems will include:

Screening Test A: Dry Tape Adhesion Test

Screening Test B: Reduced Duration Salt Spray Resistance Test

These tests will screen the candidates for minimum performance requirements prior to execution of common tests.

Screening Test A: Dry Tape Adhesion Test

Test Description

This test method covers a procedure for establishing acceptability of intercoat and surface adhesion of an organic coating by applying pressure-sensitive adhesive tape over a scribed area of the coating, then removing that tape.

Measure the cleanliness of the coating in accordance with ASTM D 724-89 (*Standard Test Method for Surface Wettability of Paper (Angle-of-Contact Method)*), approved May 26, 1989), except replace ink with distilled water.

Perform this test in accordance with Method A of ASTM D 3359-92a (*Standard Test Methods for Measuring Adhesion by Tape Test*), approved May 15, 1992), except use a 4.5 lb. roller instead of finger pressure for smoothing down the tape. In performing this test, scribe two “X” incisions through the coating so that the smaller angle of each “X” is 30 to 45°, making sure that the coating has been scribed all the way to the substrate. The scribe must have a 45 degree bevel, and each line of each “X” should be approximately 1.5 inches long. Immediately place a piece of tape over the intersection of each “X” and smooth down by passing a 4.5 lb. roller over it once. Remove the tape rapidly at approximately an 180° angle. Inspect the incision area for peel away.

Rationale

A wet tape adhesion test is required by Sections 3.1.1.4. and 3.1.2.11. of this JTP. This test has been modified to a dry tape adhesion test, which is less stringent than a wet tape adhesion test, to screen candidate primers and primer/topcoat systems. In addition, the dry tape adhesion test will be performed using only AL1 coupons. This test was agreed upon by participating project representatives.

Test Methodology

Parameters	None
Number and Type of Test Coupons	3 AL1
Trials Per Test Coupon	1
Acceptance Criteria	No peel away

Unique Equipment and Instrumentation

- 1 inch masking tape, 3M Company Type 250 or equivalent 4.5 pound roller
- Carbide tip scribe

Data Analysis

- One color photograph of a coupon coated with each candidate primer or primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Record the cleanliness of the coating by reporting the angle-of-contact of the distilled water measured during the specified contact angle test.
- Report the adhesion rating (as specified in ASTM D 3359-92a Section 7).

Screening Test B: Reduced Duration Salt Spray Resistance Test

Test Description

This test method evaluates a coating's ability to prevent substrate corrosion and the effect that corrosion has on the adhesion of a coating.

Operate the fog chamber and prepare the test coupons for this test in accordance with ASTM B 117-94 (*Standard Practice for Operating Salt Spray (Fog) Testing Apparatus*, approved February 15, 1994). The following summarizes these procedures and adds details specific to this evaluation.

Scribe an "X" incision through the coating so that the smaller angle of the "X" is 30 to 45°, making sure that the coating has been scribed all the way to the substrate. The scribe must have a 45° bevel, and each line of the "X" should be approximately 4 inches long. Cover the back and edges of the coupon with wax, paint, tape, or any other material that will prevent corrosion products from contaminating the chamber.

Place the scribed coupons into a fog chamber. The coupons may not contact other surfaces in the chamber. Prepare a salt solution and the fog chamber as specified in Test Methodology. Adjust the nozzles in the fog chamber so the sprayed salt solution does not directly impinge on the coupon surfaces.

Operate the fog chamber continuously for 250 hours. Evaluate coupons for surface corrosion and creepage from the scribe on a daily basis. At the end of the test duration, carefully remove the coupons. Clean the coupons by gently flushing them with running tap water, and dry them with a stream of clean, compressed air. Evaluate the adhesion of the coating in accordance with Screening Test A. Visually examine the coupons for corrosion.

Rationale

A 2,000 hour salt spray resistance test is included in Sections 3.1.1.2. and 3.1.2.8. of this JTP. The salt spray resistance test has been modified to a 250 hour test to screen candidates. The acceptance criteria have been modified so that no corrosion is acceptable in the scribe, and adhesion is measured with a dry tape adhesion test instead of a wet tape adhesion test. In addition, the types of coupons tested have been reduced. This test was agreed upon by participating project representatives.

Test Methodology

Parameters	<ul style="list-style-type: none">• Test coupon at a 15 to 30° angle• Temperature of exposed salt spray zone = 35 + 1.1 - 1.7°C (95 + 2 - 3°F or 92-97°F)• Every 80 cm² horizontal area, two collectors gather 1.0-2.0 mL fog/hr• 5% salt solution (5 ± 1 parts by weight of NaCl in 95 parts of water)• pH = 6.5-7.2 when atomized at 35°C (95°F)• 250 hours
Number and Type of Test Coupons	3 AL1
Trials Per Test Coupon	1
Acceptance Criteria	No blistering or lifting or corrosion in scribe after 250 hours.

Unique Equipment and Instrumentation

- Fog chamber
- Salt solution reservoir
- Compressed air supply
- Atomizing nozzles
- Heater for the fog chamber
- Carbine tip scribe

Data Analysis

- One color photograph of a coupon coated with each candidate primer or primer/topcoat system shall be taken before the test. One color photograph of each tested coupon shall be taken after the test.
- Report the adhesion test results and daily visual observations.

APPENDIX B

TOPCOATS APPLIED BY LOCKHEED MARTIN FOR THE AIR FORCE, ARMY, AND NAVY

Note: This Appendix is a representative list of some identified topcoat colors currently applied by Lockheed Martin Electronics & Missiles Company or Lockheed Martin Information Systems Company and may be used for guidance by weapon systems or Lockheed Martin when selecting topcoat colors to be tested. It is not intended to limit the topcoat colors tested for the weapon systems affected by the topcoat/primer initiative at the Lockheed Martin JG-APP pilot site.

Topcoats Applied by Lockheed Martin for the Air Force

Color	Reference Number*	Affected Programs	Applicable Military Specification
Red	11136	LANTIRN	MIL-C-83286B MIL-C-85285B
Orange	12197	LANTIRN	MIL-C-83286B MIL-C-85285B
Green	14187	LANTIRN	MIL-C-83286B MIL-C-85285B
Blue	15044	LANTIRN	MIL-C-83286B MIL-C-85285B
White	17925	LANTIRN	MIL-C-83286B MIL-C-85285B
Red	21105	LANTIRN	MIL-C-83286B MIL-C-85285B
Charcoal Gray	26132	IVACC	
Light Gray	26314	IVACC	
Gray	26492	LANTIRN	MIL-C-83286B MIL-C-85285B
Beige	27722	IVACC	
Orange/Yellow	33538	LANTIRN	MIL-C-83286B MIL-C-85285B
Forest Green	34052	IVACC	
Olive Drab	34088	LANTIRN	MIL-C-85285B
Gray	36118	LANTIRN	MIL-C-83286B MIL-C-85285B
Gray	36231	LANTIRN	MIL-C-83286B MIL-C-85285B
Black	37038	LANTIRN IVACC	MIL-C-83286B MIL-C-85285B

* Refer to FED-STD-595B (*Colors Used in Government Procurement*, issued December 15, 1989).

Topcoats Applied by Lockheed Martin for the Army

Color	Reference Number*	Affected Programs	Applicable Military Specification
Gold (Gloss)	17043	Hellfire II Javelin	MIL-C-85285B
White	17925	TDT SAUDI/KUWT AGTS	
Yellow	23655	TDT SAUDI/KUWT	
Charcoal Gray	26132	TDT SAUDI/KUWT AGTS	
Light Gray	26314	AGTS	
Beige	27722	TDT SAUDI/KUWT AGTS	
Brown 383	30051		MIL-C-53039A
Tan	30372	Patriot	MIS-46150
Aircraft Red	31136	Patriot	MIL-C-46168D
Earth Yellow	33245	Javelin	MIL-C-46168D
Tan 686	33446		MIL-C-53039A
Sand	33531	Patriot	MIS-46150
Aircraft Yellow	33538	Javelin Longbow Missile Hellfire II	MIL-C-46168D
Aircraft Green	34031	TADS Longbow FCR Comanche	MIL-C-46168D
Green 383	34094	TADS Javelin Hellfire II Longbow Missile Patriot	MIL-C-46168D MIL-C-53039A
Forest Green	34052	TDT SAUDI/KUWT AGTS	
Blue	35109	Hellfire II Longbow Missile	MIL-C-85285B
Aircraft Gray	36300	Longbow FCR	MIL-C-46168D

(Table continued next page.)

Topcoats Applied by Lockheed Martin for the Army (continued)

Color	Reference Number*	Affected Programs	Applicable Military Specification
Black	37030	Patriot Longbow Missile Hellfire II	MIL-C-46168D
		Patriot Longbow Missile Hellfire II	MIL-C-53039A
Aircraft Black	37038	Patriot TADS Longbow Missile Longbow FCR Javelin Comanche	MIL-C-46168D
		Comanche	MIL-C-85285B
		TADS SAUDI/KUWT AGTS	
Aircraft White	37875	Javelin Patriot Longbow Missile Hellfire II	MIL-C-46168D
			MIL-C-53039A

* Refer to FED-STD-595B (*Colors Used in Government Procurement*, issued December 15, 1989).

Topcoats Applied by Lockheed Martin for the Navy

Color	Reference Number*	Affected Programs	Applicable Military Specification
Light Blue	25488	CASS	MIL-C-85285B
Pastel Blue	25550	CASS	MIL-C-85285B
Dark Gray	26152	DDG RPCP	MIL-E-15090
Light Gray	26307	DDG RPCP	MIL-E-15090
Semigloss Black	27038	DDG RPCP	MIL-E-15090
Aircraft Yellow	33538	Hellfire II	MIL-C-46168D
Green 383	34094	Hellfire II	MIL-C-46168D
Black	37030	Hellfire II	MIL-C-46168D MIL-C-53039A
Aircraft White	37875	Hellfire II	MIL-C-46168D

* Refer to FED-STD-595B (*Colors Used in Government Procurement*, issued December 15, 1989).