August 29, 2006 via electronic mail

HQ AFCEE/TDE
Ms. Beth Davis
3300 Sidney Brooks
Brooks City-Base, TX 78235-5112

Subject: Final Joint Test Protocol (CDRL: A007a, SOW 9.16.3.1 Technical and Management Work Plan)
Contract No.: F41624-03-D-8614 (AFCEE 4P-AE), Task Order No: 0207
Project: Low Temperature Cure Powder Coating (LTCPC) For Non-Flight Critical Parts

Dear Ms. Davis:

Science Applications International Corporation (SAIC) is pleased to submit the final Joint Test Protocol document for the Low Temperature Cure Powder Coating (LTCPC) For Non-Flight Critical Parts as reviewed and approved by Steve Castiglia. This deliverable is submitted under the A007a CDRL guidelines, SOW 9.16.3.1. Should you have any questions regarding this submittal, please contact me at (937) 431-2239 or James Davila at (937) 431-2272.

Sincerely,

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

James A. Byron
Project Manager

Attachment: Final Joint Test Protocol

cc: D. Naguy, AFMC/A4N
T. Naguy, AFMC/MLSC
S. Castiglia, AFMC/A4BE

Environmental Security Technology Certification Program

Joint Test Protocol

For

Validation of Low Temperature Cure Powder Coating WP-0614

28 August 2006

PREFACE

This test protocol was prepared by Science Applications International Corporation under AFCEE Contract Number F41624-03-D-8614, Task Order 0091 to support the Environmental Security Technology Certification Program (ESTCP) project WP-0614.

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1.0 INTRODUCTION

Increasingly, the Air Force and Navy are seeking to eliminate coating systems that utilize volatile organic compound solvents and that release hazardous air pollutants. These initiatives are driven by tighter and tighter environmental regulations mandated by the federal government. One technology that has shown promise in solving these problems is powder coating technology.

Conventional powder coatings require curing at high temperatures, e.g. 400°F, which can impact the heat treat condition of some aluminum and magnesium alloys. Recently, powder coating technology experienced breakthroughs that allow the coatings to be cured at a reasonably low temperature (250°F) which negates the risk to aluminum and magnesium. The purpose of this effort is to test and evaluate the low temperature cure powder coating (LTCPC) process. More specifically, it is to demonstrate, validate, and implement a VOC/HAP-free low temperature cure powder coating on DoD weapon system components in a depot production environment.

This technology is of high interest to the military service depots. Those involved in this project include Ogden Air Logistics Center, UT and Whidbey Island Naval Air Station, WA.

This powder coating technology will address current wet coating processes on a number of components. Aspects of the process and hazardous material reduction related to the application of primers and topcoats are summarized in Table 1.

Table 1 - Target Process and HazMat Summary

Process	*Solvent-borne organic coatings-wet spray coating process (primers and topcoats)*
Specifications	*MIL-PRF-23377J, MIL-P-53022B Type II, MIL-PRF-85582, MIL-PRF-85285*
Applications	*Aircraft components and ground support equipment*
Target HazMat	*VOC'S and HAP'S, hexavalent chromium, MEK (9,000lb/yr), Toluene (22,000 lb/yr), Xylene (4,000 lb/yr)*
Affected Programs	*All Air Force and Navy aircraft, through components and support equipment coated with two component epoxy and polyurethane type coatings*
Candidate Parts/Substrates	*Gearboxes, battery boxes, inlet housings, tubes and other components composed of aluminum alloys, magnesium or steel*

2.0 PERFORMANCE AND TESTING REQUIREMENTS

The test requirements for this JTP were assembled by a joint service/contractor team which included representatives of one Air Force Air Logistics Center, the Naval Air Systems Command, the Air Force Research Laboratory, HQ Air Force Material

Command, Crosslink Powder Coatings, Inc., and Science Applications International Corporation (SAIC).

Based on prior SERDP testing the following test were excluded from the JTP test matrix (QUV-B Weathering and the Xenon Arc Accelerated Weathering, Fluid Resistance, MEK Double Rub, and the Mandrel Bend Flexibility tests) because these tests were performed on a production lot of powder coating material, and the results were considered dependent on the coating itself and not on the substrate/coating interactions. The matrix test requirements were included because they will be conducted on substrates different from the SERDP testing. The team decided on the following substrates: 2024-T0 (appropriate for impact testing), 2024-T3, 6061-T6 Al, Alclad 2024-T3 (for filiform testing), AZ31B Mg, and 4130 steel for testing.

Note: *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. Refer to the Health and Safety Plan developed for the demonstration plan corresponding to this JTP*.

Table 2 contains the Performance and Testing Requirements identified for validating materials under this JTP. These cover common performance requirements for all weapon systems and related Ground Support Equipment (GSE), addressing coating appearance, various corrosion resistance properties, adhesion and coating flexibility/impact resistance.

Table 2 - JTP Performance and Testing Requirements

JTP Section	***Test / Evaluation***	***Engineering Requirement***	***Acceptance Criteria***	***References***
4.1	*Coating Appearance and Quality*	*Critical detailed evaluation of coating appearance and integrity*	*Visible coating or surface defects. Presence of micro-cracks observable at 10X mag. Gloss and color retention.*	*FED-STD-595B, ASTM D 2244-05, ASTM D 523-89*
4.2	*Salt Fog Corrosion Resistance*	*Acceptable performance in aggressive salt water fog atmosphere*	*Degree of blistering, lifting, and/or substrate corrosion after 2000 hours.*	*ASTM B 117-03, ASTM D 1654-92,*
4.3	*SO_2 Corrosion Resistance*	*Acceptable performance in acidic corrosive environment.*	*Degree of blistering, lifting, and/or substrate corrosion after 500 hours.*	*ASTM G 85-98, ASTM D 1654-92*

JTP Section	Test / Evaluation	Engineering Requirement	Acceptance Criteria	References
4.4	*Cyclic Corrosion Resistance*	*Acceptable performance after exposure to varying/cycling environments of salt fog, humidity and heat*	*Degree of blistering, lifting, and/or substrate corrosion after 80 cycles*	*GM 9540P, GM 4465P ASTM D1654 ASTM D 610 ASTM D 714*
4.5	*Filiform Corrosion Resistance*	*Performance of coating system in an environment suitable for the formation of filiform corrosion*	*Measurement of corrosion filaments from scribe lines.*	*ASTM D 2803-93*
4.6	*Cross-Cut Adhesion Tape Test*	*Determine adequacy of intercoat and surface adhesion of organic coating*	*Adhesion classification based on ASTM scale.*	*FED-STD-141D, Method 6301.3, ASTM D 3359-02, Test Method B*
4.7	*Impact Flexibility*	*Performance of coating when subjected to impact, and deformation of substrate*	*Type II – 5%*	*MIL-PRF-85285D, ASTM D 6905-03*
4.8	*Strippability*	*Determine the ability to remove the LTCPC from various substrates*	*Determination of coating strip rate and removal damage appraisal **(*)***	*Air Force TO 1-1-8, Air Force Engineering Qualification Plan (AF EQP), CTIO Lab Procedure CLG-LP-043*

***** Evaluation only, not considered part of the Pass/Fail criteria.

3.0 TEST PREPARATION

This section contains information about materials and preparation common to most of the tests contained in this JTP, and indicates exceptions where they occur. Test coupons are described in Table 3.

Table 3 - Coupon Codes and Substrate Descriptions

Test Coupon Code	Substrate Description
Al -1	*2024 (0 Temper) Aluminum alloy (SAE/AMS QQ-A-250/4)* *4 in. x 6 in. x 0.020 in.* *Prepared per Section 3.2.2* *Controls prepared per Section 3.3.3*
Al-2	*2024-T3 Aluminum alloy (SAE/AMS QQ-A-250/4)* *4 in. x 6 in. x 0.032 in.** *Prepared per Section 3.2.1* *Controls prepared per Section 3.3.1*

Test Coupon Code	***Substrate Description***
Al-3	*6061-T6 Aluminum alloy (SAE/AMS QQ-A-250/11)* *4 in. x 6 in. x 0.032 in.** *Prepared per Section 3.2.1* *Controls prepared per Section 3.3.1*
Al-4	*Alclad 2024-T3 Aluminum alloy (SAE/AMS QQ-A-250/5)* *4 in. x 6 in. x 0.032 in.** *Prepared per Section 3.2.1* *Controls prepared per Section 3.3.1 & 3.3.2*
Mg	*AZ31B Magnesium alloy (SAE-AMS4375 or SAE-AMS4379* *4 in. x 6 in. x 0.063 in.** *Prepared per Section 3.2.3* *Controls prepared per Section 3.3.4*
ST	*4130 Steel alloy (SAE AMS6350)* *4 in. x 6 in. x 0.032 in.** *Prepared per Section 3.2.4* *Controls prepared per Section 3.3.5*

*3 in. x 6 in. x 0.032 in. acceptable, if test chamber size constraints dictate

3.1 Coupon Preparation (General Requirements/All Coupons)

All coupons, except Al-1 coupons for Impact Resistance Testing, shall be 4 in. x 6 in. x 0.032 in. unless test chamber size constraints preclude this, in which case 3 in. x 6 in. x 0.032 in. acceptable. Coupons for Impact Resistance Testing shall be 4 in. x 6 in. x 0.020 in. Refer to appendix A for coupon quantities.

All test coupons shall be permanently identifiable using a suitable marking technique. Identification shall include control or test designation, alloy and heat treatment (e.g., using Test Coupon Code from Table 3), and a unique coupon number. Preparation technique and test or tests performed on individual coupons shall be documented.

Subsequent to coating, all coupons designated for corrosion resistance testing require that the back and edges of the coupon be covered with paint, tape, or any other material that will prevent corrosion products from contaminating the chamber**.** It is critical that Magnesium and Steel coupons be adequately protected, as corrosion initiated on the back or edges of the coupons will aggressively degrade the coupon and render evaluation impossible.

3.2 Coupon Preparation (LTCPC Coupons)

For the Low Temperature Cure Powder Coat process, all aluminum coupons except the impact test coupons shall be prepared following the same procedure. Al-1, Magnesium and Steel coupons will each undergo customized application processes.

3.2.1 Aluminum (For Appearance, Corrosion Resistance, Adhesion and Strippability Tests)

Aluminum (Al-2, Al-3, Al-4) coupons shall be cleaned in accordance with SAE/AMS 1640 to provide a water break free surface.

3 coupons shall be coated with a chromate conversion coating conforming to MIL-C-5541 Class 1A and 3 coupons will not be conversion coated for testing.

Coupons shall be cleaned using a lint free cloth dampened with MEK prior to application of powder coating.

The low temperature cure powder coating shall be applied via gun to the face of each coupon. Final coating thickness shall be 0.002 – 0.004 in. (2 – 4 mil). Coating color shall be gloss white per FED-STD-595B, color number 17925.

3.2.2 Aluminum (For Impact Resistance Test)

Al 2024 (0 Temper) (Al-1) coupons shall be anodized in accordance with MIL-A-8625, Type I or IC.

Coupons shall be cleaned using a lint free cloth dampened with MEK prior to application of powder coating.

The low temperature cure powder coating shall be applied via gun to the face of each coupon. Final coating thickness shall be 0.002 – 0.004 in. (2 – 4 mil). Coating color shall be gloss white per FED-STD-595B, color number 17925.

3.2.3 Magnesium

All magnesium (Mg) coupon surfaces shall be prepared using the “Dow 7” process (SAE/AMS-M-3171 Type III – Dichromate Treatment).

Coupons shall be cleaned using a lint free cloth dampened with PreKote (Pantheon Chemical) solution prior to application of powder coating.

Coupons shall be coated with the low temperature cure powder. coating via gun. Powder coating thickness shall be 0.002 – 0.004 in. (2 – 4 mil). Coating color shall be gloss white per FED-STD-595B, color number 17925.

3.2.4 Steel

3 steel (ST) coupons shall be pretreated with an iron phosphate pretreatment in accordance with TT-C-490E Type II and 3 panels will not be pretreated. Coupons shall be coated with the low temperature cure powder coating via corona gun. Coating thickness shall be 0.002 – 0.004 in. (2 – 4 mil). Coating color shall be gloss white per FED-STD-595B, color number 17925.

3.3 Coupon Preparation (Control Coupons)

Test procedures for epoxy coatings on aluminum are well established and coating configuration for specific tests may vary. In this JTP, the control coupons shall be prepared per the established methods for the individual intended tests.

3.3.1 Aluminum (For Appearance, Corrosion Resistance, Adhesion, Strippability Tests)

Aluminum coupons (Al-2, Al-3, Al-4) shall be cleaned in accordance with SAE/AMS 1640 to achieve a water break free surface.

Coupons shall be coated with chromate conversion coating conforming to MIL-C-5541 Class 1A.

Coupons shall be cleaned using a lint free cloth dampened with MEK prior to application of coating.

Spray apply one cross-coat of primer coating conforming to MIL-PRF-23377 to a dry-film thickness of 0.6 – 0.9 mil in accordance with ASTM D 823 and air-dry at 68 - 77°F (20 - 25°C) for no less than one hour.

Spray apply MIL-PRF-85285D Topcoat in accordance with ASTM D 823 to a dry-film thickness of 1.7 – 2.3 mil. Allow coating to air-dry for no less than 14 days at 68 - 77°F (20 - 25°C) (or air-dry at 68 - 77°F (20 - 25°C) for one hour followed by 24 hours at 150 ± 5°F), prior to testing.

3.3.2 Aluminum (For Validation of Filiform Corrosion Resistance Test)

Clad aluminum panels (Al-4) shall be cleaned in accordance with SAE/AMS 1640 to achieve a water break free surface.

Spray apply one coat of MIL-C-8514 wash primer and allow to dry for no less than 30 minutes.

Spray apply MIL-PRF-85285D Topcoat (gloss white per FED-STD-595B, color number 17925.) in accordance with ASTM D 823 to a dry-film thickness of 1.7 – 2.3 mil. Allow coating to air-dry for no less than 14 days at 68 - 77°F (20 - 25°C) (or air-dry at 68 - 77°F (20 - 25°C) for one hour followed by 24 hours at 150 ± 5°F), prior to testing.

3.3.3 Aluminum (For Impact Resistance Test)

Al 2024 (0 Temper) (Al-1) coupons shall be anodized in accordance with MIL-A-8625, Type I or IC. No primer shall be applied.

Coupons shall be cleaned using a lint free cloth dampened with MEK prior to application of coating.

Topcoat shall be applied per MIL-PRF-85285D Topcoat (gloss white per FED-STD-595B, color number 17925.) in accordance with ASTM D 823 to a dry-film thickness of 1.7 – 2.3 mil. Coatings shall be allowed to air dry at 68 - 77°F (20 - 25°C) for no less than 14 days prior to testing.

3.3.4 Magnesium

All magnesium (Mg) coupon surfaces shall be prepared using the "Dow 7" process (SAE/AMS-M-3171 Type III – Dichromate Treatment).

Coupons shall be cleaned using a lint free cloth dampened with PreKote solution prior to application of coating.

Spray apply one cross-coat of primer coating conforming to MIL-PRF-23377 to a dry-film thickness of 0.6 – 0.9 mil in accordance with ASTM D 823 and air-dry at 68 - 77°F (20 - 25°C) for no less than one hour.

Spray apply MIL-PRF-85285D Topcoat in accordance with ASTM D 823 to a dry-film thickness of 1.7 – 2.3 mil. Allow coating to air-dry at 68 - 77°F (20 - 25°C) for no less than 14 days at 68 - 77°F (20 - 25°C) (or air-dry at 68 - 77°F (20 - 25°C) for one hour followed by 24 hours at 150 ± 5°F), prior to testing.

3.3.5 Steel

The steel (ST) coupons shall be pretreated with an iron phosphate pretreatment in accordance with TT-C-490E, Type II.

Spray apply one cross-coat of primer coating conforming to MIL-P-53022B Type II to a dry-film thickness of 0.6 – 0.9 mil in accordance with ASTM D 823 and air-dry at 68 - 77°F (20 - 25°C) for no less than one hour.

Spray apply MIL-PRF-85285D Topcoat in accordance with ASTM D 823 to a dry-film thickness of 1.7 – 2.3 mil. Allow coating to air-dry at 68 - 77°F (20 - 25°C) for no less than 14 days at 68 - 77°F (20 - 25°C) (or air-dry at 68 - 77°F (20 - 25°C) for one hour followed by 24 hours at 150 ± 5°F), prior to testing.

4.0 TEST DESCRIPTIONS

The following sections describe tests included in this JTP, provide rational for inclusion, and specify procedures and parameters for individual tests.

4.1 Coating Appearance/Quality (Color, Gloss, Thickness) Test

Description and Rationale

The purpose of this test is to evaluate and compare the surface appearance of the LTCPC and control coating systems. Coating systems for weapon systems and support equipment must have a consistently uniform and high quality appearance. They must

also be able to meet specification requirements for color and gloss characteristics. This test utilized both the unaided eye and minimal magnification to examine the coating for acceptable quality and appearance, and uses laboratory equipment to determine acceptable color and gloss characteristics.

This test is conducted to provide critical detailed evaluation of coating appearance and integrity. All participants agreed a surface appearance evaluation is necessary for this phase of the powder coating study.

Test Procedures

Prepare test coupons in accordance with Section 3.2.

Examine the surface of each test coupon coated with the primer/topcoat system for coating defects with unaided eye and with 10x magnification. Micro-cracks extending no more than ¼-inch from the panel edge are acceptable. A slight orange peel appearance is acceptable.

Thickness measurements shall be taken at six different locations on each panel and recorded.

Color measurements shall be conducted on each coated coupon per ASTM D 2244-05 (Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates). Using CIELAB color coordinates, the coating shall exhibit a color difference (ΔE) of less than 1 when compared to the specified color in FED-STD-595B.

Gloss measurements shall be conducted on each coated coupon per ASTM D 523-89 (Standard Test Method for Specular Gloss). The specular gloss of the coating shall be as shown in the Test Methodology below at a 60° angle of incidence.

Test Methodology

Parameters	*Unaided eye and 10x magnification for appearance* *CIELAB color coordinates method for color measurement* *60° angle of incidence for specular gloss determination*
Coupons Per Coating System	*3 Each: Al-3 , Mg and ST* *LTCPC*
Trials Per Coupon	*One*
Control Coupons Required	*None*
Acceptance Criteria	*Appearance: No streaks, blistering, voids, air bubbles, cratering, lifting, blushing, or other surface defects/irregularities. No micro-cracks observable at 10x magnification (Micro-cracks extending no more that ¼ inch from the panel edge are acceptable).* *Color: ΔE less than one when compared to color 17925 per FED-STD-595B* *Gloss: Minimum specular gloss measurement of 90 at 60° angle of incidence per ASTM D 523-98*

Major or Unique Equipment

- 10X optical magnifier
- Thickness gage
- Hunter Lab "Miniscan" Spectrophotometer (using CIE L*a*b* Color Measurement System) or equivalent
- Hunter Lab "Progloss" Meter or equivalent

Data Analysis and Reporting

- Measure and report observation on any coating defects, original color readings, and gloss readings
- Take digital photos of test coupons upon test completion.

4.2 Salt Fog Corrosion Resistance Test

Description and Rationale

Corrosion protection is a critical performance requirement of coating systems, as substrates are often corrosion sensitive and equipment often operates in extreme environments. This test method evaluates a coating system's ability to prevent substrate corrosion in a humid salt-spray environment, and the effect that any corrosion has on the adhesion of the coating system.

For all substrates, coupons are scribed through the coating prior to exposure to the salt fog, and must exhibit corrosion inhibition properties rather than just barrier coat properties. Digital photography shall be taken of all scribed panels both before testing and after testing to document the tests.

Current coating specifications require materials used on military equipment to provide corrosion protection in a salt fog chamber for as much as 2,000 hours for qualification (MIL-PRF-23377J, Paragraph 3.8.2.1).

Test Procedures

Operate the fog chamber for this test in accordance with ASTM B 117-03 (Standard Practice for Operating Salt Spray (Fog) Apparatus, approved 2003).

Using a Hermes engraver, or equivalent, scribe an "X" incision through the coating so that the smaller angle of the "X" is 30 to 45 degrees, 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 four-inches. Take digital photographs of all scribed panels before and after testing to document the tests.

Ensure that steps taken to cover the back and sides of these coupons, as described in Section 3.1, provide optimum barrier protection.

Place the 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 (Al coupons) on a daily basis. Observations shall be recorded. Remove test coupons from the salt fog chamber if corrosion exceeds the acceptance criteria. Also document when coupons are removed (if they are removed prior to the end of the test).

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 100° F [38° C]), and dry them with a stream of clean, compressed air.

Evaluate the adhesion of the coating system in accordance with ASTM D 1654-92, Procedure A, Method 1 (*Air Blow-Off*). Visually examine the coupons and rate any corrosion undercut based on the numerical ratings in ASTM D 1654. Provide ratings based on maximum undercut and the average undercut length as measured perpendicular to the scribe. Corrosion oxides running down the surface of the coupon are considered evidence of severe corrosion.

Evaluate and rate any corrosion on the panel field away from the scribe based on the following ratings:

0 – no corrosion

1 – minor

2 – minor to moderate

3 – moderate

4 – moderate to severe

5 – severe corrosion

Blistering on the test panel will be rated on the density, size, and distribution of the blisters as described in ASTM D 714.

Provide digital photographs of all coupons to document coupon condition upon removal from the chamber or after 2,000 hours of exposure, as appropriate.

Test Methodology

Parameters	*Test coupons at a 15° degree angle in salt fog chamber* *Temperature of exposed salt spray zone = 95 +2 –3°F (35 +1.1 -1.7°C)* *Every 80 cm^2 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 95°F (35°C) 2,000 hours*
Coupons Per Coating System	*6 each (3 pretreated, 3 not pretreated): Al-2, Al-3, Mg and ST LTCPC*
Trials Per Coupon	*One*
Control Coupons Required	*3 coupons each alloy, coated with appropriate coating stack-up per Section 3.3*
Acceptance Criteria	*No blistering or lifting after 2,000 hours. Slight substrate (0 to 1 rating) corrosion only.*

Coupons may be 3.0 in by 6.0 in if required by chamber size constraints.

Major or Unique Equipment

- Salt fog chamber
- Salt solution reservoir
- Compressed air supply
- Atomizing nozzles
- Hermes engraver, or equivalent

Data Analysis and Reporting

- Report the condition of the scribed area of the test coupon at 2,000 hours of testing or at failure, if less then 2,000 hours (along with exposure duration at failure)

- Photograph test coupons at 2,000 hours of testing, or at failure if less than 2,000 hours

4.3 SO_2 Corrosion Resistance Test

Description and Rationale

This test relates to the ability of a coating system to prevent corrosion when exposed to corrosive conditions resulting from air pollutants (acidic environment). The test is similar to the Salt Fog Corrosion Resistance Test described above, but the coupons are exposed to a more aggressive environment.

The test evaluates corrosion protection when a coated substrate is exposed to an acidic corrosive environment such as acid rain. This test is favored by the Navy, as aircraft

and equipment on Navy vessels may be exposed to more aggressive atmospheres due to the presence and proximity of stack fumes.

Test Procedures

Using a Hermes engraver, or equivalent, scribe an "X" incision through the coating so that the smaller angle of the "X" is 30 to 45 degrees, 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 four-inches. Take digital photographs of all scribed panels both before and after testing to document the tests.

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 ASTM G 85-02 *Annex A4* (SO_2 salt spray test, cyclic). 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 500 hours.

After 500 hours total exposure time, remove the test panels from the salt spray chamber. Gently clean and dry each panel. Evaluate the adhesion of the coating system in accordance with ASTM D 1654-92, Procedure A, Method 1 (*Air Blow-Off*). Visually examine the coupons and rate any corrosion undercut based on the numerical ratings in ASTM D 1654. Provide ratings based on maximum undercut and the average undercut length as measured perpendicular to the scribe. Corrosion oxides running down the surface of the coupon are considered evidence of severe corrosion.

Evaluate and rate any corrosion on the panel field away from the scribe based on the following ratings:

0 – no corrosion

1 – minor

2 – minor to moderate

3 – moderate

4 – moderate to severe

5 – severe corrosion

Test Methodology

Parameters	*Test coupons placed at a 6° angle. Temperature of the exposed salt spray zone = 95 +2-3°F or (35 +1.1 –1.7°C) Uniform SO_2 gas dispersion throughout salt fog chamber*
Coupons Per Coating System	*6 each (3 pretreated, 3 not pretreated): Al-2, Al-3 and ST LTCPC*

Trials Per Coupon	*One*
Control Coupons Required	*3 coupons each alloy, coated with appropriate coating stack-up per Section 3.3*
Acceptance Criteria	*No blistering or lifting after 500 hours.* *Slight substrate (0 to 1 rating) corrosion acceptable.*

Major or Unique Equipment

- Salt spray (fog) chamber
- Salt solution reservoir
- Cylinder of SO_2 gas
- Compressed air supply
- Atomizing nozzles Heater for salt spray fog chambers
- Hermes engraver or equivalent

Data Analysis and Reporting

- Report the extent of corrosion or loss of the coating extending from a scribe mark as prescribed in ASTM D 1654-92, Procedure A.
- Record the representative mean, maximum, and minimum creepage from the scribe and note whether or not the maximum is an isolated spot.
- Take digital photos of test coupons after 500 hours of testing, or at failure if less than 500 hours

4.4 Cyclic Corrosion Resistance Test

Description and Rationale

These tests evaluate the ability of coating systems to prevent corrosion when exposed to a simulated neutral pH corrosive environment. Un-scribed, coated coupons are place in a cyclic corrosion chamber. The chamber cycles coupons through salt fog exposure, dwell subsequent to the salt fog, high humidity and drying, to provide a varying and aggressive environment.

Data from these tests will also be compared with the filiform corrosion test data to determine whether or not a correlation exists between the two test results.

Test Procedures

Tests shall be conducted on un-scribed coated coupons in accordance with GM 9540P, (Accelerated Corrosion Test approved December 1997) with the exception of racking and evaluation procedures. Coupons will be exposed to a number of 24 hour cycles, with each cycle described in the tables below:

Table 4 - Cyclic Corrosion Test Conditions

Cycle Step Name	*Conditions*	
Salt Mist Application	*Salt Solution:*	*0.9% Sodium Chloride* *0.1% Calcium Chloride* *0.25% $NaHCO_3$ (Sodium bicarbonate)* *pH 6-9*
	Exposure Time:	*One minute*
Ambient Dwell	*Temperature:*	*25 ± 2°C*
	Humidity:	*40-50% H*
Humidity Exposure	*Conditions:*	*per GM 4465P*
	Temperature:	*49 ± 2°C*
Drying Environment	*Temperature:*	*60 ± 2°C*
	Humidity:	*< 30% RH*

Table 5 - Cyclic Corrosion - Test Cycle Steps

Cycle Step	*Cycle Step Name*	*Time*	*Comments*
1	*Salt Mist Application*	*1 minute*	*1.5 hours total time*
2	*Ambient Dwell*	*89 minutes*	
3	*Salt Mist Application*	*1 minute*	*1.5 hours total time*
4	*Ambient Dwell*	*89 minutes*	
5	*Salt Mist Application*	*1 minute*	*1.5 hours total time*
6	*Ambient Dwell*	*89 minutes*	
7	*Salt Mist Application*	*1 minute*	*3.5 hours total time*
8	*Ambient Dwell*	*209 minutes*	
9	*Humidity Exposure*	*8 hours*	*Includes 1 hour ramp to wet conditions*
10	*Drying Environment*	*8 hours*	*Includes 3 hour ramp to dry conditions*

Perform inspections after 24, (1 cycle), 48 (2 cycles), 72 (3 cycles), 96 (4 cycles), and 192 hours (8 cycles) of exposure. Perform subsequent inspections after every 192 hours (8 cycles) of exposure. Evaluate the adhesion of the coating system in accordance with ASTM D 1654-92, Procedure A, Method 1 (*Air Blow-Off*). Visually examine the coupons and rate any corrosion undercut based on the numerical ratings in ASTM D 1654. Corrosion oxides running down the surface of the coupon are considered evidence of severe corrosion.

Evaluate and rate any corrosion on the panel field away from the scribe based on the following ratings:

0 – no corrosion

1 – minor

2 – minor to moderate

3 – moderate

4 – moderate to severe

5 – severe corrosion

Blistering on the test panel will be rated based on the density, size, and distribution of the blisters as described in ASTM D 714.

When removed for inspection, test coupons on which coating failure is detected shall be removed from further testing.

Test Methodology

Parameters	*Test Duration: 80 test cycles* *One test cycle is equal to 24 hours* *Exposure conditions include salt fog, humidity, elevated temperature per Tables 4 and 5*
Coupons Per Coating System	*3 coupons each: 4130 steel, Al-1 LTCPC*
Trials Per Coupon	*One*
Control Coupons Required	*3 coupons each, coated with appropriate coating stack-up per Section 3.3*
Acceptance Criteria	*No significant blistering, softening, or lifting of coating*

Coupons may be 3 inches by 6 inches by 0.032 inches if required by chamber size constraints.

Major or Unique Equipment

- Programmable salt spray (fog) chamber

Data Analysis and Reporting

- Collect coating condition and corrosion data for candidate coating system and the control coating system(s).
- Report the density, size, and distribution of blisters based on the values from ASTM D 714.
- Take digital photos of test coupons prior to test initiation, upon each removal for inspection, upon coating failure, and upon test completion.

4.5 Filiform Corrosion Test

Description and Rationale

This test is used to evaluate the ability of a coating system to resist filiform corrosion. Scribed, coated coupons are exposed to an atmosphere of hydrochloric acid to initiate filiform-type corrosion. Filiform corrosion will undercut the coating in fine filaments growing somewhat normal to the scribe.

The filiform test, which determines the resistance of coated metals to filiform-type corrosion, is distinctly different from salt spray resistance test and is required to ensure the candidate coating(s) provide the appropriate corrosion protection.

This test is normally required for primers, not top coats. However, as this project may include single coating systems (no primer), we have included this test to ensure a full comparison of the coating system properties are examined.

Test Procedures

Tests shall be conducted as specified in ASTM D 2803-93 (Standard Guide for Testing Filiform Corrosion Resistance of Organic Coatings on Metal, approved May 15, 1993), Procedure C, except that potential filiform corrosion shall be initiated as described below, rather than by salt spray exposure.

To ensure test conditions are appropriate for the occurrence of filiform corrosion, coupons prepared per section 3.3.2, with wash primer and topcoat will also be scribed and exposed to test conditions.

Using a Hermes engraver, or equivalent, scribe an "X" incision through the coating so that the smaller angle of the "X" is 30 to 45 degrees, 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 four-inches. Take digital photographs of all scribed panels before and after testing to document the tests.

Place the scribed coupons vertically in a desiccator containing 12 N hydrochloric acid for one hour at 75 ± 5°F (24 ± 3°C). Within 5 minutes of removal from the desiccator, place the coupon in a humidity cabinet maintained at 104 ± 3°F (40 ± 1.7°C) and 80% ± 5% RH for 1,000 hours. At the end of the 1,000 hour test, measure the length of any thread-like filaments. Verify that filiform corrosion greater than ¼" has occurred on the validation coupons.

Test Methodology

Parameters	*12N HCL for one hour* *1,000 hours at 104° ± 3°F (40° ± 1.7°C) and 80% ± 5% RH*
Coupons Per Coating System	*3 coupons: Al-4* *LTCPC*
Trials Per Coupon	*One*
Control Coupons Required	*3 coupons (Al-4), coated with coating stack-up per Section 3.3.1* *3 coupons (Al-4), coated with wash primer and topcoat per Section 3.3.2*
Acceptance Criteria	*No filiform corrosion extending beyond ¼-inch from the scribe lines with the majority of filaments less than 1/8 –inch long.*

Major or Unique Equipment

- Environmental (humidity) chamber
- Hermes engraver or equivalent

Data Analysis and Reporting

- Measure and report the presence, number, and length of corrosion filaments for the candidate coating systems and for the alternative and control coating systems.

- Take digital photos of test coupons prior to test initiation and upon test completion.

4.6 Cross-Cut Adhesion by Tape Test

Description and Rationale

This test method establishes the adequacy of intercoat and surface adhesion of an organic coating by the application and removal of pressure sensitive tape over a scribed area of the coating. In some instances, to increase the severity of the test, the coated panel is soaked in water for 24 hours, scribed in a lattice pattern, and then tape tested.

Coatings used in aircraft and support functions must remain adherent and provide reliable barrier protection in intense operating environments. The tape adhesion test provides a suitable evaluation of the coating system's ability to provide this protection. All participants have agreed that adhesion testing is a performance requirement.

Test Procedures

This test shall be performed in accordance with Method 6301.3 of FED-STD-141D except that the scribe pattern and evaluation shall be per ASTM D 3359-02 Test Method B – Cross-cut Tape Test.

Al and ST:

Immerse each test panel in distilled water at 68 - 77°F (20 - 25°C) for 24 hours. Remove each panel from the water and wipe dry with a soft cloth. Within one minute of removing the panel from the water, scribe six cuts 2mm apart and approximately 20mm (0.75 in) long. Make six similar cuts at 90° to the original cuts and centered on those cuts.

Mg:

Scribe six cuts 2mm apart and approximately 20mm (0.75 in) long. Make six similar cuts at 90° to the original cuts and centered on those cuts.

Apply tape over the scribed grid, smoothing it down by passing a 4.5 pound roller across the tape eight times. Quickly and smoothly pull the tape off the panel at a 45° angle to the surface. Visually examine the panel for blistering and loss of adhesion.

Evaluate the adhesion of each coating system to the substrate as specified in ASTM D 3359-02, Test Method B. Inspect the grid for removal of the coating from the substrate or intermediate coatings (on control coupons) and rate the adhesion in accordance with the scale outlined in ASTM D 3359-02, paragraph 12.9, and Figure 1, with the 0B to 5B rating. Provide digital photographs of each test coupon.

Test Methodology

Parameters	*ASTM D 3359-97 rating related to amount of coating removal*
Coupons Per Coating System	*6 each (3 pretreated, 3 non pretreated): Al-3, Steel* *3 each: Mg* *LTCPC*
Trials Per Coupon	*One*
Control Coupons Required	*3 coupons each alloy, coated with appropriate coating stack-up per Section 3.3*
Acceptance Criteria	*Adhesion classification equal or greater than 4B as specified in ASTM D 3359-02 Test Method B – Cross-cut Tape Test*

Major or Unique Equipment

- One-inch (25mm) wide semitransparent pressure-sensitive tape 3M Code 250 or equivalent
- 4.5 pound rubber-covered roller, approximately 3.5 inches diameter by one-inch wide.
- Cutting tool
- Cutting guide

Data Analysis and Reporting

- Report the results of the test using the classification guide in ASTM D 3359-02, Test Method B
- Take digital photos of test coupons prior to test initiation and upon test completion.

4.7 Impact Flexibility Test

Description and Rationale

The purpose of this test is to determine the ability of a coating film to resist shattering, cracking or chipping when the film and substrate are distended beyond their original form by impact. Areas of the coupon are subjected to impact by different diameter semispherical indenters and the affected coating in the deformed areas of the coupon is evaluated.

Coatings attached to substrates are subjected to damaging impacts during the manufacture of articles and their use in service. This impact resistance test method is useful in predicting the performance of organic coatings for their ability to resist cracking caused by impacts and moderate deformation of substrates.

Test Procedures

Prepare panels as directed in Sections 3.2.1 (test) and 3.3.3 (control). Control coupons shall be allowed to air-dry for no less than 14 days before testing.

Prior to testing, all panels shall be conditioned for at least 24 hours at 23 ± 2°C (73.5 ± 3.5°F) and 50 ± 5% relative humidity. Conduct the test in the same conditions, or immediately on removal from conditioning environment.

Three test panels shall be tested with a GE Impact-Flexibility Tester, or equivalent. Place the coated panel, film downward, on the rubber pad at the bottom of the impacter guide. Drop the impacter on the panel so that the impression of the entire rim of the impacter is made in the panel. Reverse the impacter ends; drop the impacter on the panel adjacent to the first area of impact.

After testing, examine the coating using ten-power magnification, to determine surface cracking. Measure and record the percent elongation (percent area increase) corresponding to the largest spherical impression at which no cracking occurs. Refer to ASTM D 6905-03, Table 1 for Percent Area Increase determination.

Test Methodology

Parameters	*Utilize GE Impact Tester or equivalent.* *Indenter: 3.6 lb.*
Coupons Per Coating System	*3 Al-1 coupons (0.020 x 6.0 x 4.0 in.)* *LTCPC*
Trials Per Coupon	*One*
Control Coupons Required	*3 Al-1 coupons, coated with appropriate coating stack-up per Section 3.3 and aged 14 days*
Acceptance Criteria	*5% elongation / area increase*

Major or Unique Equipment:

- G.E. Impact Flexibility Tester or equivalent with integral indenter, rubber pad and aluminum base
- 10x magnifier for visual viewing

Data Analysis and Reporting:

- Report elongation (percent area increase)
- Take digital photos of test coupons upon test completion.

4.8 Strippability

Description and Rationale

The purpose of this evaluation is to determine the strippability of the LTCPC from the various substrates using both chemical strippers not containing methylene chloride, and mechanical strippers using Plastic Media Blasting (PMB). This evaluation is not meant to be a part of the pass/fail/acceptability criteria, but rather an opportunity to evaluate other ”environmentally friendly” paint and coatings strippers.

Being able to strip the coating off substrates is an important evaluation. Aircraft and Ground Support Equipment components must occasionally require having their paint coatings removed for non destructive inspection and testing. During SERDP testing, a methylene chloride based stripper was successfully used on the LTCPC.

Test Procedures

Prepare panels as directed in Section 3.2.1 and 3.3.1 (control). Control coupons shall be allowed to air-dry for no less than 14 days before testing.

For the chemical stripping evaluation, the procedure (CLG-LP-043 attached as Appendix B) developed by the Air Force Coatings Technologies Integration Office for strippability of new coatings systems will be used. It follows MIL-R-81294D for the application of the chemical stripper to the test specimens. For this project, an exception will be made and only 3 coupons instead of the 4 mentioned in 81294D and CLG-LP-043 will be used. The chemical stripper that has been selected and will be used for the evaluation will be B&B Tritech 5095. This stripper is USAF approved for Aluminum and Steel but not Magnesium. Magnesium coated coupons will not be evaluated for chemical stripping but will be evaluated for mechanical stripping.

Chemical Stripper Test Methodology

Parameters	*Chemical stripper dwell time of 30 minutes* *Stripping surface area (ft^2)* *Reapply up to 3 times until substrate is clean.*
Coupons Per Coating System	*Three of each substrate: Al-2, Al-3, Al-4, ST, and aged 7 days at 66°C±3°C.*
Trials Per Coupon	*One (examine the entire surface of the coupon). The coupons will be examined after each removal cycle.*
Control Coupons Required	*Three of each substrate: Al-2, Al-3, Al-4, ST, coated with appropriate coating stack-up per Section 3.3.2 and aged 7 days at 66°C±3°C.*
Evaluation of Efficiency	*Percentage of coating removed after each dwell period.*

The mechanical strippability of the LTCPC material be tested using PMB per the procedures found in TO 1-1-8 paragraph 2.11.1.5 for Type V media. The objective of this evaluation is to determine the relative ease of removing the LTCPC by mechanical means.

Mechanical Stripper Test Methodology

Parameters	*Total stripping time (minutes)* *Stripping surface area (ft^2)*
Coupons Per Coating System	*Three of each substrate: Al-2, Al-3. Al-4, Mg, ST, and aged 7 days at 66°C±3°C.*
Trials Per Coupon	*One (examine the entire surface of the coupon).*
Control Coupons Required	*Three of each substrate: Al-2, Al-3. Al-4, Mg, ST, coated with appropriate coating stack-up per Section 3.3.2 and aged 7 days at 66°C±3°C.*
Evaluation of Efficiency	*Time required to remove 100% of the coating from coupon, not to exceed 90 minutes.*

Following the de-paint process for either chemical or mechanical stripping; the substrates should be examined for potential damage related to the stripping method. Any warping, denting, erosion, or pitting should be so noted along with the method used.

Data Analysis and Reporting:

- Report the results of the testing.
- Take digital photos of test coupons upon test completion.

5.0 REFERENCE DOCUMENTS

The following materials, processing, performance and testing documents and standards are referenced in this JTP.

Table 6 - Reference Documents

Reference Document	Title	Applicable Sections	JTP Sections
SAE/AMS QQ-A-250/4	Aluminum Alloy 2024, Plate and Sheet		3.0
SAE/AMS QQ-A-250/11	Aluminum Alloy 6061, Plate and Sheet		3.0
SAE/AMS QQ-A-250/5	Aluminum Alloy Alclad 2024, Plate and Sheet		3.0
SAE/AMS4375	Sheet and Plate, Magnesium Alloy 3.0Al-1.0Zn-0.20Mn (AZ31B) Annealed and Recrystallized		3.0
SAE/AMS6350	Steel Sheet, Strip, and Plate, 0.95Cr - 0.20Mo (0.28 - 0.33C) (SAE 4130), Annealed		3.0
FED-STD-595B	Colors used in Government Procurement	17925, Gloss White	3.1, 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.3.2, 3.3.3, 4.1

Reference Document	Title	Applicable Sections	JTP Sections
SAE/AMS 1640	Compound, Corrosion Removing for Aircraft Surfaces		3.2.1, 3.3.1, 3.3.2
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys	Class 1A	3.2.1, 3.3.1
MIL-A-8625	Anodic Coatings for Aluminum and Aluminum Alloys	Type I or IC	3.2.2, 3.3.3
SAE/AMS-M-3171	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on	Type III – Dichromate Treatment	3.2.3, 3.3.4
MIL-PRF-23377J	Primer Coatings: Epoxy, High-Solids	All	3.3.1, 3.3.4, 3.3.5, 4.2
MIL-P-53022B Type II	Primer, Epoxy Coating, Corrosion Inhibiting, Lead and Chromate Free	All	3.3.5
ASTM D 823	Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels		3.3.1, 3.3.2, 3.3.3, 3.3.4, 3.3.5
MIL-PRF-85285	Coating: Polyurethane, Aircraft And Support Equipment	All	3.3.1, 3.3.2, 3.3.3, 3.3.4, 3.3.5, 4.7
MIL-C-8514	Coating Compound, Metal Pretreatment, Resin-Acid	All	3.3.2
ASTM D 2244-05	Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates	CIELAB Metric	4.1
ASTM D 523-89	Standard Test Method for Specular Gloss	60° Geometry	4.1
ASTM B 117-03	Standard Practice for Operating Salt Spray (Fog) Apparatus	All	4.2
ASTM D 1654-92	Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments	Procedure A, Method 1 (*Air Blow Off*)	4.2, 4.3
ASTM D 610	Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces		4.2, 4.3, 4.4
ASTM D 714	Standard Test Method for Evaluating Degree of Blistering of Paints		4.2, 4.3, 4.4

Reference Document	Title	Applicable Sections	JTP Sections
ASTM G 85-02	Standard Practice for Modified Salt Spray (Fog) Testing	Annex 4	4.3
GM 9540P	Accelerated Corrosion Test	All	4.4
GM 4465P	Water Fog Humidity Test		4.4 (Table 4)
ASTM D 2803-93	Standard Guide for Testing Filiform Corrosion Resistance of Organic Coatings on Metal	Procedure C	4.5
FED STD 141D	Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing	Method 6301.3	4.6
ASTM D 3359-02	Standard Test Methods for Measuring Adhesion by Tape Test	Test Method B	4.6
ASTM D 6905-03	Standard Test Method for Impact Flexibility of Organic Coatings	All	4.7
MIL-DTL-81706	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys	Class 1A	A-1
TT-C-490E	Chemical Conversion Coatings and Pretreatments for Ferrous Surfaces (Base for Organic Coatings)	Type I	3.2.4, 3.3.5
TO 1-1-8	Application and Removal of Organic Coatings, Aerospace and Non-Aerospace Equipment		4.8
CLG-LP-043 rev 0 (Draft)	Strippability (Chemical Strippers)		4.8
MIL-R-81294D	Remover, Paint, Epoxy, Polysulfide, and Polyurethane Systems		4.8

Acronyms

AFCEE	Air Force Center for Environmental Excellence
Al	Aluminum
ASTM	American Society for Testing Materials
DoD	Department of Defense
ESTCP	Environmental Security Technology Certification Program
GE	General Electric Corporation
GSE	Ground Support Equipment
HAP	Hazardous Air Pollutants
JTP	Joint Test Protocol
LTCPC	Low Temperature Cure Powder Coating
MEK	Methyl Ethyl Ketone
Mg	Magnesium
Mil	0.001 inches
pH	Measure of acidity or alkalinity
PMB	Plastic Media Blasting
SAE	Society of Automotive Engineers
SERDP	Strategic Environmental Research and Development Program
SO_2	Sulfur Dioxide
ST	Steel
USAF	United States Air Force
VOC	Volatile Organic Compounds

Appendix A – Materials Summary

Coupon Quantities (Test/Control)

	Substrate												
	Test / Control	Al-1 (2024 0 Temper) 4”x6”x 0.020”		Al-2 (2024-T3) 4”x6”x 0.032”		Al-3 (6061-T6) 4”x6”x 0.032”		Al-4 (2024-T3 clad) 4”x6”x 0.032”		Mg (AZ31B) 4”x6”x 0.063”		ST (4130) 4”x6”x 0.032”	
Test	**4.1 - Appearance**					3	0			3	0	3	0
Test	**4.2 – Salt Fog**			6	3	6	3			6	3	6	3
Test	**4.3 – SO_2 Salt Fog**			3	3	6	3					6	3
Test	**4.4 – Cyclic Corrosion**							3	3			3	3
Test	**4.5 – Filiform Corrosion**							3	3				
Test	**4.6 – Cross Cut Adhesion**					**3***	3			**3***	3	**3***	3
Test	**4.7 – Impact Flexibility**	3	3										
	4.8 – Strip ability			6	6	6	6	6	6	3	3	6	6
	Total	**3**	**3**	**15**	**12**	**21**	**15**	**12**	**12**	**12**	**9**	**24**	**18**
	Combined Total		**6**		**27**		**36**		**24**		**21**		**42**

***Coupons for Appearance evaluation shall also be used for tape adhesion tests**

Consumables

MIL-DTL-81706 Chromated Conversion Coating
PreKote (Pantheon Chemical)
MIL-PRF-23377 or MIL-P-53022B Epoxy Primer
MIL-C-8514 Wash Primer
MIL-PRF-85285 Polyurethane Topcoat
Low Temperature Cure Powder Coating, P/N #6191-61003, White 17925
Aluminum Alloy 2024 – T0 sheet
Aluminum Alloy 2024 – T3 sheet
Aluminum Alloy 2024 –T3 Alclad
Aluminum Alloy 6061 – T6 sheet
Magnesium Alloy AZ31B sheet
Steel Alloy 4130 sheet

University of Dayton Research Institute Corrosion Control Group	LABORATORY PROCEDURES	CLG-LP-043 rev 00
	Strippability (Chemical Strippers)	Page 1 of 31
Issuing Authority: David W. Barrington, Coatings Lab Group Leader		
Location of copies: C-110; C-123; B-129		

SUMMARY: *Since there is a broad window of acceptable performance for modern, environmentally acceptable chemical strippers, this is a generic procedure for assessing both the performance of a new stripper as well as the strippability of a new coating system. It follows MIL-R-81294D for artificial aging of test coatings and the application of the chemical stripper to the test specimens. Other parameters such as the acceptable dwell time of the stripper on the specimen, and the acceptable number of allowable reapplications of stripper are specific to a particular intended use and must be specified in each test plan.*

1.0 REFERENCES

MIL-R-81294D Remover, Paint, Epoxy, Polysulfide and Polyurethane Systems

2.0 SAFETY

This procedure poses LOW risk, use standard PPE, and work within a fume hood.

Hazard Descriptions

Working with corrosive chemicals. Wear solvent resistant gloves and work in a fume hood to avoid breathing chemical vapors.

3.0 REQUIRED EQUIPMENT

- Laboratory Oven (Capable of maintaining a temperature of 66° C ± 3° C)
- Temperature controlled exposure room with laminar air flow not greater than 100 LFM.

4.0 REQUIRED SUPPLIES

- Chemical stripper(s) conforming to test plan requirements
- Test panel support rack designed to hold the test panels at a 60° ± 5° angle.
- Paraffin wax or aluminum tape to seal edges of test panels
- Stiff bristled brush for scrubbing panels after stripper exposure.

- 1000-ml glass beakers (or other glass containers for securing panels in the oven)

- Glass rods to separate panels within the beakers during oven exposure.

5.0 SET UP AND CALIBRATION

1. Ensure lab oven is properly calibrated before proceeding. If not, consult lab/project manager.

2. Set oven to 66° C and operate for a minimum of 24-hours. If the oven holds stable for 24-hours at 66 ± 3° C, proceed. If not, consult lab/project manager.

3. Check bristles of brush, replace brush if worn.

6.0 PROCEDURE

1. Unless otherwise specified in the test plan, use 4” x 5” test panels, and perform all tests in quadruplicate.

2. Ensure test panels have been coated and cured according to the test plan before proceeding.

3. Artificially age the test panels according to the following:

   a. Place test panels back-to-back and separated by glass rods into clean dry 1,000 ml glass beakers or equivalent.

   b. Place the beakers in an oven operating at 66 ± 3° C for 7-days.

4. After 7-days, remove beakers from the oven and allow panels to cool to room temperature.

5. Seal 5 mm of each edge of each test panel using aluminum adhesive tape or melted paraffin wax.

6. Randomly place each panel in a test rack designed to hold each panel at a 60° angle with the long dimension (5-inch) up, and the short dimension (4-inch) horizontal.

7. Place the racks and test panels into a temperature controlled room operating at the desired exposure temperature(s) (see test plan) and with a laminar air flow no greater than 100 LFM.

8. Pour sufficient stripper across the top edge of each panel such that the entire surface is covered within 15-seconds.

9. Allow the stripper to dwell for the length of time specified in the test plan then remove the bulk of the loosened coating with a spatula into a shallow pan, followed by scrubbing with a stiff bristled brush under running water.

10. Visually inspect each test panel and record the approximate percentage of the coating removed from each panel. Indicate both the percentage of complete removal down to the substrate and the percentage of partial removal to the primer. If required, take photographs to document removal.

11. If required by the test plan, repeat the application of the stripper as many times as indicated, recording the percentages of removal after each application.

12. If additional exposure temperatures are required, repeat steps 1 through 11 for a separate set of panels for each additional application temperature.

13. After testing is finished, dispose of all used stripper and removed coating material properly, and clean and dry all glassware and return to storage.

14. Contact the lab/project manager for sample disposition instructions. Use care in storing/delivering samples, because additional tests, and/or photographs may be desired.

7.0 REPORTS/RECORDS

Record the following data for each sample in the laboratory notebook:

1. The oven number and dates of exposure in the oven for artificial aging.

2. The date(s) and operator performing the stripper application and removal.

3. For each application of stripper to a test panel, record the panel number, stripper used, the exposure temperature, the length of exposure, and the removal results in percentages of removal.

4. Any unusual observations made. The operator performing the thermal aging and any unusual observations noted after thermal aging is completed.